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A Consequential Contingent Valuation Referendum: Still Not Enough to Elicit True Preferences for Public Goods!

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Abstract: Whether respondents disclose their preferences truthfully in surveys that are used to assess the values of public goods remains a crucial question for the practical application of stated preference methods. The literature suggests that in order to elicit true preferences, respondents should see a valuation survey as consequential: they must believe in the actual consequences that may follow from the survey result. Drawing on recent empirical findings, we develop a model depicting the importance of the consequentiality requirement for truthful preference disclosure in a survey that evaluates a public policy project based on a referendum-format value elicitation question. First, we show that a respondent's belief that his vote may influence the outcome of the referendum plays a central role for revealing his preferences truthfully. Second, we find that the subjectively perceived probabilities of the successful provision of the public good and of the collection of the payment related to the project implementation not only need to be positive but also to be in a particular relationship with each other. This relationship varies in respondents' preferences towards risk.

Keywords: contingent valuation, stated preferences, incentive compatibility, advisory referendum, payment consequentiality, provision consequentiality.

JEL Codes: D11, D61, H41

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1 Introduction

Assessing the values of public goods in the fields of environment, culture, transportation, and in other areas often relies on survey-based methods, especially when the passive use of the good substantially contributes to its value. Contingent valuation (CV)[1] is a survey technique widely applied to estimate the values of public goods. CV surveys typically present respondents with a possible scenario(s) of a public good policy and use a specially designed question(s) to elicit the respondents' preferences towards the scenario(s). For the practical application of CV surveys in assessing benefits from public policies, the fundamental question is whether respondents disclose their preferences truthfully in such surveys. In this paper, we address this problem and examine the conditions under which respondents are incentivised to answer in line with their true preferences in a CV survey that involves a yes-no voting in an advisory referendum on the provision of a public good.

Recent theoretical and empirical studies suggest that survey consequentiality plays a key role in incentivising respondents to truthfully reveal their preferences. Survey consequentiality implies that respondents believe in the real consequences that may follow from the survey result. Following the recent guidelines for stated preference research (Johnston *et al.* 2017), the possible real consequences, as observed by respondents, include actual chances that their answers in the survey will affect decisions about the outcome in question related to both: whether the public good is provided and whether the payment associated with the provision of the good is collected. As postulated by Carson and Groves (2007), survey consequentiality constitutes a necessary condition for the incentive compatibility of CV studies, in the sense that it allows researchers to create such conditions in a survey under which the respondents' optimal strategy is to answer truthfully. Here, we inquire into how the incentive properties of a referendum-format CV survey are affected by respondents' subjective perceptions of the survey consequentiality.

Several empirical studies shed light on the importance of survey consequentiality for truthful preference elicitation. They either examine the influence of the information provided directly to respondents about the probability of the survey result actually being implemented on their stated preferences (for example, Carson, Groves, and List 2014; Mitani and Flores 2012) or they analyse the effect of the respondents' perceptions about the consequential nature of the survey on their responses (for example, Hwang, Petrolia, and Interis 2014; Interis and Petrolia 2014; Vossler, Doyon, and Rondeau 2012). The conclusions about the impact of consequentiality on the elicited preferences are mixed. Some researchers report that the estimates of the willingness to pay for a considered policy increase with the strength of the belief in consequentiality (Czajkowski *et. al.* 2017; Forbes *et al.* 2015; Groothuis *et al.* 2017; Herriges *et al.* 2010; Li *et al.* 2015; Vossler and Watson 2013), while others observe that the more consequential the survey, the lower the probability of a respondent accepting a policy project that involves additional costs (Cummings and Taylor 1998; Vossler *et al.* 2012). Some studies do not find a significant difference in the willingness-to-pay values estimated for respondents perceiving a survey as consequential and for those not believing in the survey consequentiality (Broadbent 2012; Broadbent, Grandy, and Berrens 2010; Drichoutis *et al.* 2015; Oehlmann and Meyerhoff 2017).

Our model offers a possible explanation of the observed incongruence in the empirical findings. The analysis is conducted in the context of a CV survey framed as an advisory referendum, in the sense that the yes-no votes declared in the survey referendum advise policymakers on the actions preferred by the voting population. The referendum format has long been recommended in CV studies (Arrow *et al.* 1993) and is often applied because it limits the respondents' possibilities to answer strategically. We find that a respondent's view of the potential impact of his vote on the referendum outcome (namely, the subjectively perceived consequentiality of one's own vote) and the respondent's views of the probabilities of the successful provision of the public good and of collection of the payment related to the policy project implementation (namely, the subjectively perceived provision consequentiality and the subjectively perceived payment consequentiality, respectively) significantly influence his voting strategy and, thus, the incentive properties of the CV survey. The model suggests that rather than controlling for respondents' perceptions of consequentiality in general, as it is typically done in the current literature (see, for instance, the studies referred to in the preceding paragraph), separate perceptions about the various aspects of consequential-

1 Here, we use the term "contingent valuation" in line with the nomenclature for stated preference research as proposed by Carson and Louviere (2011). Specifically, in our usage, "contingent valuation" is independent of any elicitation method and, thus, it encompasses, among others, single binary choice questions and discrete choice experiments consisting of a sequence of multiple choice questions.

ity should be taken into account. We argue that the relationship between these perceptions may play a crucial role for the incentive compatibility of a CV survey. Not assessing the perceptions separately could give rise to the mixed empirical findings observed in the received literature.

The main contribution of our paper is that it provides a combined theoretical framework that disentangles the effects of various aspects of perceived consequentiality on truthful preference disclosure. What further differentiates our study from the existing literature is that we conduct the analysis in the context of a survey that involves an advisory referendum with a coercive payment mechanism. A coercive mechanism imposes payment for the provision of a public good on all individuals in the population upon policy implementation. Specifically, we do not apply a voluntary contribution vehicle (used, for example, by Mitani and Flores 2014), which may be vulnerable to free-riding. Moreover, in line with the received literature (Forbes *et al.* 2015; Herriges *et al.* 2010; Hwang *et al.* 2014), we assume that the perceptions of the probabilities of the successful provision of the public good and the payment collection are not exogenous but, rather, are possibly shaped by the respondents' values of the policy project under consideration.

We show that in order for a respondent to reveal his true preferences in an advisory CV referendum, the perceived impact of his vote on the probability of the authorities undertaking the proposed policy should not be negligible. This impact may appear to be too weak to ensure the incentive compatibility of a CV survey when the respondents have good knowledge or well-defined expectations about the distribution of preferences towards the considered policy project in the voting population and when they believe that the probability of the authorities' decision to adopt the project increases non-linearly in the number of votes cast in favour of it. Moreover, our model suggests that for truthful preference disclosure, the subjectively perceived probabilities of the successful provision of the public good and the payment collection should be in a particular relationship to each other, which varies across respondents' risk preferences. We find that risk-neutral respondents vote in line with their actual preferences if, in their perception, the probability of successful provision and the probability of payment collection do not differ significantly from each other, whereas risk-averse respondents vote truthfully if the probability of successful provision exceeds the probability of payment collection.

The conditions for the incentive compatibility of a CV study postulated in the literature also include other aspects in addition to consequentiality (Carson and Groves 2007; Carson *et al.* 2014). The conditions require that respondents understand the value elicitation question and answer exactly it. Respondents should also see the voting in the survey as the only way for them to express their interest in having the public good provided; in other words, there are no alternative sources for the public good provision. Furthermore, the payment levied in the wake of the project implementation needs to be coercive (that is, be imposed on everyone in the population for which the public good is provided), and the value elicitation question format should be of a referendum-style yes-no voting.[2] The CV survey considered in this paper satisfies all the incentive-compatibility conditions and modifies only the degree of fulfilling the consequentiality requirement, as this constitutes the subject of our investigation.

The remainder of this paper is structured as follows. Section 2 reviews the evidence from the current literature on the impact of consequentiality on stated preferences. Section 3 develops a conceptual model that distinguishes the separate aspects of consequentiality (namely, the consequentiality of one's own vote, the provision consequentiality and the payment consequentiality) and shows how the subjective perceptions of each of the aspects of consequentiality influence the incentive properties of an advisory CV referendum. Section 4 concludes with a brief summary and recommendations on how the quality of stated preference research might be improved by correctly controlling for respondents' the perceptions of consequentiality.

2 Existing evidence on the role of consequentiality in CV surveys

The recommendations of the National Oceanic and Atmospheric Administration (NOAA; Arrow *et al.* 1993) have long set the standards in CV studies. Due to the clear and known incentive properties (Farquharson 1969), they suggest using a one-shot, binary choice referendum with a plurality voting rule as a value elic-

2 Recent advancements have defined incentive-compatibility conditions for CV surveys that employ other value elicitation formats than a single yes-no question. See, for example, Vossler *et al.* (2012) or Vossler and Holladay (2016).

itation format. However, empirical research shows that even when the recommended format is applied, the preferences inferred from stated choices may differ significantly from the actual behaviour.[3] The predominant view ascribes this divergence to the non-binding nature of CV surveys, as the outcomes of the surveys are often not explicitly linked to actual consequences, for example, by lacking a compulsory payment upon policy implementation. Making field CV surveys binding might be difficult, if not impossible, because of their common advisory character: these surveys are typically used to collect information about the public's preferences and their results rarely translate directly into the final decision.

The concept of consequentiality offers a possible solution to how to make the advisory CV surveys incentive compatible. This is because the concept extends beyond the strict division between the binding and non-binding nature, allowing for a probabilistically binding character. Respondents in a consequential survey know that the chances of implementing a public policy project increase with the number of votes in favour of it. The notion of consequentiality closely corresponds to the long-established recommendation for realism in CV research (Mitchell and Carson 1989).

Landry and List (2007) claim that consequentiality can easily be introduced in a survey by simply informing the respondents that their choices will influence the final decision of policymakers in a probabilistic way. Taking this statement as true, researchers examine the role of consequentiality by comparing the preferences of respondents elicited in probabilistic referenda that differ in the chances of being binding (Carson *et al.* 2014; Cummings and Taylor 1998; Mitani and Flores 2012). The probability of a study being binding is usually stated explicitly in the survey script. However, the impact of the script on the respondents' subjective beliefs of the survey consequentiality is doubted (Czajkowski *et al.* 2017).

An alternative approach to test whether consequentiality affects the incentive properties of a CV survey is to compare the stated preferences between groups of respondents that differ in their beliefs of the survey consequentiality. The respondents' perceptions of consequentiality are typically obtained from their self-reports to a direct question about how strongly they believe that the survey outcome will be used for future policy purposes (Czajkowski *et al.* 2017; Herriges *et al.* 2010; Vossler *et al.* 2012). Researchers raise doubts, however, about whether this single question captures well what it is intended to measure (Zawojska, Bartczak, and Czajkowski 2017). A respondent may believe that the survey result will be somewhat taken into account by policymakers and this will be expressed by his affirmative answer to the question about perceived consequentiality. Nevertheless, this answer does not inform what it means to the respondent that the survey result will actually be used by the policymakers in taking the final decision; for instance, how the respondent perceives that the survey result will be translated into policy implementation, or whether the respondent believes that he will really need to bear the cost stated in the survey in the wake of the policy implementation. The single consequentiality question does not capture these aspects.

Mitani and Flores (2014) suggest that two separate aspects of consequentiality should be distinguished: the probability of a public good provision and the probability of payment collection. Hereafter, we refer to these two probabilities as provision consequentiality and payment consequentiality, respectively. Brent *et al.* (2014) and Forbes *et al.* (2015) also invoke this distinction, pointing out that even if respondents believe that a large share of "yes" votes in the referendum will lead to the policy implementation, they might not believe that they will be involved in the payment related to it.

The distinction between provision consequentiality and payment consequentiality corresponds to the consideration in the stated preference literature about the impacts of uncertainties about provision and payment on responses in CV surveys. Krupnick and Adamowicz (2007) note the important role of uncertainty about provision and recommend excluding from the analysis respondents who do not believe that the proposed policy change will work. Several researchers address the issue of provision uncertainty empirically. Champ *et al.* (2002) inquire whether declared voluntary donations change when respondents are assured that their contributions will be returned if a specified threshold of the donated amounts is not reached, so if the good will not be provided. In an induced-value experiment, Vossler and McKee (2006) examine differences in preferences stated by two groups of respondents: those certain and those uncertain about the value of the good to be delivered. Burghart, Cameron, and Gerdes (2007) investigate how the risk of failure of the proposed project impacts on the respondents' choices.

3 See the meta-analyses of List and Gallet (2001), MacMillan (2004), Murphy *et al.* (2005) and Little, Broadbent, and Berrens (2012); and the literature review of Zawojska and Czajkowski (2017).

Bohm (1972) conducted one of the earliest stated preference empirical studies on the role of cost uncertainty. Several subsequent studies report on the importance of uncertainty about the project cost for elicited preferences in CV surveys. Champ *et al.* (2002) find that 42% of the CV referendum participants do not believe that the actual tax that will be levied in the case of the policy implementation will be equal to the stated amount. Similarly, Strong and Flores (2008) observe that over 60% of the respondents think that the policy implementation will be related to a higher cost than the amount indicated in the survey. Flores and Strong (2007) develop a theoretical model, pointing out that the limited perceived credibility of the stated cost may disturb the incentive compatibility of CV questions.

The differentiation between subjectively perceived provision and payment probabilities offers a potential explanation for the mixed empirical evidence on the direction of influence of consequentiality on elicited preferences. For instance, Herriges *et al.* (2010) and Vossler and Watson (2013) observe that compared to those not believing in the study consequentiality, the respondents believing in its consequentiality state high willingness-to-pay amounts, while Vossler *et al.* (2012) report that the willingness-to-pay estimates decrease in the degree of perceived consequentiality. Mitani and Flores (2014) postulate that both understating and overstating willingness-to-pay values may constitute optimal response strategies for CV respondents even when they view the survey as consequential. According to Mitani and Flores (2014), the strategy that appears best for a given respondent depends on the respondent's perceptions of the probabilities of the successful provision of the public good and the payment collection, namely, which of the probabilities is seen as higher / lower, even if both of them are positive (that is, even if both provision and payment are perceived as, at least somewhat, consequential). Therefore, measuring the probabilities of the successful provision of a public good and of the payment collection separately could help to more precisely control for the impact of consequentiality perceptions on elicited preferences.

Mitani and Flores (2014) develop a theoretical model that depicts the role of the perceived probabilities of the successful provision of a public good and of the payment collection on stated preferences. However, they employ voluntary contributions as a payment mechanism, which is prone to free-riding and, thereby, is not incentive compatible. In contrast, in this paper, we present the impact of the two probabilities on the incentive properties of an advisory CV referendum with a coercive payment mechanism (such as tax). The incentive properties of a referendum vehicle that is subject to consequentiality are also modelled by Mitani and Flores (2012), although their approach does not introduce the separate probabilities of provision and payment, including only the probability of the referendum being binding as a whole. We relax this assumption, exploring how the relationship between the probabilities of successful provision and payment influences the incentive compatibility of advisory CV referenda.

Additionally, we introduce endogeneity into the probabilities of successful provision and payment, making them dependent on a respondent's own valuation of the policy project, which corresponds to recent empirical evidence. Herriges *et al.* (2010) point to the potential endogeneity of consequentiality perceptions since the respondents who attach a high value to the considered project may believe (or be willing to believe) in high consequentiality of the survey because of the importance of the project for them. Forbes *et al.* (2015) employ a bivariate probit model to inquire the correlation between perceived consequentiality and stated preferences. They report that the likelihood of a respondent voting for the proposed project is related to the respondents' view of consequentiality. Groothuis *et al.* (2017) model consequentiality perceptions as a function of the cost faced by a respondent in the survey and find that the consequentiality belief weakens as the tax amount increases. This evidence may suggest that the respondents do not believe in the introduction of high taxes by the government, but it may equally imply that consequentiality perceptions are "a proxy for something else that implicitly reflects preferences" (Hwang *et al.* 2014, 485). We, thus, incorporate the endogeneity of consequentiality perceptions into our model.

3 Modelling framework

In this section, we develop a model that depicts how respondents' subjective perceptions of survey consequentiality impinge on the incentive properties of a stated preference survey which involves an advisory CV referendum.

We consider a CV study that employs a single-shot, binary (yes-no) choice, advisory referendum in which members of population P vote on a project about whether a specific public good should be provided at some cost.

Let $c_i > 0$ represent the cost faced by individual $i \in P$ in the value elicitation question; the individual will need to incur the cost when the project is implemented (a coercive payment mechanism).[4] Let $v_i > 0$ denote the value that individual i will obtain when the good is successfully provided. Every individual from P is assumed to know the value of the project to him, that is, his v,[5] but the preferences of other members of the voting population are subject to uncertainty: individuals do not know exactly how other members of P will vote in the referendum, and, thus, they can only form expectations about how the others will behave.

3.1 Expected utility from the individual's voting behaviour

The advisory character of the referendum means that the referendum advises the authorities of what decision to take about the considered project: the larger the share of votes cast in favour of the project, the more likely it is that the authorities will choose to implement the project. Let yi be individual i 's vote, and let it take values 0 and 1, standing for a "no" vote and a "yes" vote, respectively. Assuming that population P consists of N voters, where N is a positive integer number, the probability, as perceived by individual i, that the authorities will decide to undertake the project can be represented by $q_i\left(\frac{1}{N}\sum_{k=1}^{N} y_k\right)$, where $q_i(\cdot)$ is an increasing function, capturing individual i 's perception of how the share of votes cast in favour of the project is translated into the probability of the authorities' decision to implement the project. Were it not increasing, the incentive-compatibility condition postulated by Carson and Groves (2007), that the probability of the authorities' choice to adopt the project must increase in the number of "yes" votes, would be violated.

It is important to differentiate the perceived probability of the authorities choosing to implement the project (expressed by $q_i(\cdot)$) from the rule prevailing in the voting population about how the votes of the individuals will be used in decision-making. For example, the authorities may claim, or it may be generally supposed, that the project will be undertaken if 50% of the population is in favour of it. However, when it is particularly difficult to adopt the project (for instance, because of the project's rigour for some groups of the population), individuals may perceive that the authorities will be more likely to implement the project if the share of its supporters substantially exceeds 50%. This subjective perception is captured by $q_i(\cdot)$.

Due to uncertainty about the preferences of other members of P, individuals are likely to form expectations about how the preferences are distributed in the voting population and, accordingly, how the members of P will vote in the referendum.[6] Let I_{-i}^{E} denote the number of votes, as expected by individual i, cast for the project by the members of P, excluding the vote of individual i. That is, we define $I_{-i}^{E} \equiv \sum_{\forall\, k \in P \wedge k \neq i} y_k^{Ei}$, where y_k^{Ei} informs how individual i believes individual k will vote in the referendum, so $I_{-i}^{E} = \{0,1 \ldots, N-1\}$. Then, $q_i\left(\frac{I_{-i}^{E} + y_i}{N}\right)$ represents individual i 's subjective probability of the authorities' decision to undertake the project depending on his expectations of the voting behaviour of others and on his own vote. The von Neumann-Morgenstern expected utilities of individual i (von Neumann and Morgenstern 1944) from voting "yes" ($EU_{Y,i}$, that is, when $y_i = 1$) and voting "no" ($EU_{N,i}$, that is, when $y_i = 1$) are given, respectively, by

$$EU_{Y,i} = q_i\left(\frac{I_{-i}^{E}+1}{N}\right)EU_{I,i} + \left[1 - q_i\left(\frac{I_{-i}^{E}+1}{N}\right)\right]EU_{NI,i} \quad , \qquad (1)$$

and

$$EU_{N,i} = q_i\left(\frac{I_{-i}^{E}}{N}\right)EU_{I,i} + \left[1 - q_i\left(\frac{I_{-i}^{E}}{N}\right)\right]EU_{NI,i} \quad , \qquad (2)$$

4 c is indexed over i because the cost faced by individuals participating in a CV survey is assumed to differ across respondents; following the NOAA recommendation (Arrow *et al.* 1993), bids should be randomly assigned across members of the voting population.

5 Naturally, for some public goods, it may be difficult for an individual to clearly determine the value of the good to him. Then, v_i represents an approximation of the value, which individual i will use to answer the value elicitation question. Our analysis applies only to cases in which individuals are able to determine their preferences, at least approximately. Otherwise, there are no true preferences that researchers aim to elicit in a CV study.

6 Although, according to the practice of stated preference methods, questionnaires used in a CV study differ in the cost of the project presented to the respondents, the respondents are not informed about the random assignment of the cost and, thus, it does not impede them from forming expectations about the voting choices of others in the population.

where $EU_{I,i}$ and $EUN_{I,i}$ denote individual i 's expected utilities when the project is decided to be implemented and when the project is decided not to be implemented, respectively.

3.2 Expected utility from the project implementation

As a rule, the authorities' choice to undertake the project should result in each member of the population concerned being required to pay the cost of the project implementation and each obtaining the value that he assigns to the public good provided within the project. Here, we implicitly assume that when the authorities adopt the project, they do, indeed, attempt to realise it. However, the population members may hold subjective beliefs about the extent to which the project, when implemented, will accomplish its goals: whether the public good considered in the project will be successfully provided and whether the payment to cover the project costs will actually be collected. We refer to these beliefs as perceptions of provision consequentiality and payment consequentiality, respectively, and we measure them as the subjectively perceived probabilities of the successful provision of the good and the payment collection. The perceptions of the two aspects of consequentiality are likely to influence respondents' voting decisions in the advisory CV referendum, which we show in our model.

The probabilities of the successful provision of the good and the payment collection considered here are those as perceived by respondents before the referendum is complete, because perceptions formed at that time can impact on the respondents' voting choices. Naturally, these probabilities can change after the referendum outcome is announced or in the wake of other events following the referendum, however, this is not related to our inquiry into the voting behaviour. Furthermore, the two probabilities are assumed to be independent of the expected outcome of the referendum. This is because our framework assumes that when the authorities decide to undertake the project, they do, indeed, place effort into carrying it out. The expected share of "yes" votes in the referendum affects the authorities' (binary) decision of whether to implement the project but it does not affect, for example, the amount of effort the authorities will put into the project realisation. Consequently, the share of "yes" votes does not influence the probabilities of the successful provision of the good and the payment collection.

A few examples are provided to facilitate the understanding of separating provision consequentiality and payment consequentiality. Subjectively perceived provision consequentiality may be low when a respondent thinks that the goals of the proposed project are set too high and, thus, are unlikely to be achieved. Say, a project assumes that in the wake of specific conservation actions, the population size of an endangered species will remain at its present level, whereas the voting individual is convinced that a climate change is leading to irreversible effects on the endangered species and no conservation actions can withhold the impact of the climate change. Provision consequentiality may also be viewed as low when a respondent expects intense protests from some groups of the population as a result of the authorities' decision to undertake the project, which may hinder the project realisation. A respondent may hold weak beliefs in payment consequentiality if he observed in relation to another project in the past that the authorities experienced difficulty in enforcing payment from population members. On the basis of empirical data, Oehlmann and Meyerhoff (2017) show that lack of trust in the authorities translates into doubts about the actual consequences (policy changes) of a survey outcome.

Finally, the distinction between the two consequentiality aspects discussed in this subsection and the perception measured by function $q_i(\cdot)$ defined in the previous subsection demands an explanation. To recall, $q_i(\cdot)$ expresses the probability of the authorities' choice to implement the project as seen by individual i. This function reveals how, in the perception of individual i, the votes of the members of the population affect the authorities' decision. However, $q_i(\cdot)$ does not contain any information about the individual's perceptions of the chances of achieving the project's goals (in particular, providing the good and collecting the payment) when it is decided to undertake the project. The two consequentiality aspects considered in this subsection allow for the measurement of the latter perceptions.

Let $p_{s,i}(v_i)$ represent individual i's subjective probability of the successful provision of the good following the authorities' decision to undertake the project, that is, how likely it is in individual i's view that the public good described in the CV referendum will be successfully provided. Let $p_{p,i}(v_i)$ denote individual i's subjective probability of payment upon the authorities' decision to undertake the project, that is, how likely it is in individual i 's view that the payment specified in the CV

Tab. 1. Individual *i* 's utility upon the authorities' decision to implement the project

	Payment collected ($p_{p,i}(v_i)$)	**Payment not collected** ($1 - p_{p,i}(v_i)$)
The good successfully provided ($p_{s,i}(v_i)$)	$U_i(v_i - c_i \mid r_i)$	$U_i(v_i \mid r_i)$
The good not successfully provided ($1 - p_{s,i}(v_i)$)	$U_i(-c_i \mid r_i)$	$U_i(0 \mid r_i)$

Source: Author's own elaboration.

referendum will actually be collected. We assume that both $p_{s,i}(v_i)$ and $p_{p,i}(v_i)$ are from the interval [0,1] and are continuously differentiable and strictly increasing functions of v_i.[7] When the two probabilities are equal to 1, the CV referendum is seen as fully consequential by individual *i*; when both are equal to zero, the CV referendum is seen as purely hypothetical by individual *i*. The two probabilities are independent of each other, in the sense that neither $p_{s,i}(v_i)$ affects $p_{p,i}(v_i)$, nor $p_{p,i}(v_i)$ affects $p_{s,i}(v_i)$. This assumption is premised on the consideration that the two probabilities pertain to different aspects of the project realisation. For instance, individuals may strongly believe that the good will be successfully provided but that they will not have to pay for it, or, conversely, individuals may be convinced that the payment will be collected but have doubts about the successful provision of the good. The latter case mirrors the situation when individuals do not believe that they will obtain the value assigned to the successful provision of the good despite collection of the financial means for the provision. This may happen when, for example, they think that the money collected will be spent on purposes other than that indicated in the CV referendum, or that the authorities will provide the good with a lower quality, which will not satisfy the individual's needs. We note, however, that $p_{s,i}(v_i)$ and $p_{p,i}(v_i)$ are correlated by assumption because both are functions of v_i. This correlation reflects the intuition that the two probabilities are related to each other.

We assume that a continuously differentiable and strictly increasing function $U_i(\pi_i \mid r_i)$ describes the utility that individual *i* derives from his payoff related to the project realisation, π_i, conditional on his risk preferences, r_i. The payoff is determined by value v_i, which the individual obtains when the good is successfully provided, and by cost c_i, incurred when the payment is collected. Tab. 1 presents individual *i* 's utility levels for all possible outcomes of the authorities' decision to implement the project, which are defined by whether the good is successfully provided and by whether the payment is collected.

Based on Tab. 1, when the decision is to undertake the project, the expected utility of individual *i* is

$$\begin{aligned} EU_{I,i} = {} & p_{p,i}(v_i)\, p_{s,i}(v_i)\, U_i(v_i - c_i \mid r_i) \\ & + p_{p,i}(v_i)\, [1 - p_{s,i}(v_i)]\, U_i(-c_i \mid r_i) \\ & + [1 - p_{p,i}(v_i)]\, p_{s,i}(v_i)\, U_i(v_i \mid r_i) \\ & + [1 - p_{p,i}(v_i)]\, [1 - p_{s,i}(v_i)]\, U_i(0 \mid r_i). \end{aligned} \tag{3}$$

When the decision is not to undertake the project, the expected utility of individual *i* is

$$EU_{NI,i} = U_i(0 \mid r_i). \tag{4}$$

3.3 Incentive properties of an advisory CV referendum

Incentive compatibility means that truthful preference revelation constitutes the optimal strategy for a respondent. In the presented framework, this implies that individual *i* will vote in favour of the project if the value of the considered public good to him is larger than the cost related to the project implementation (that is, if $v_i > c_i$); that he will vote against the project if the value of the good to him is lower than the cost (that is, if $v_i < c_i$); and that he will be indifferent between voting "yes" and "no" in the referendum if the value of the good to him is equal to the cost (that is, if $v_i = c_i$). Consequently, we define an incentive compatible CV referendum as follows.

7 The subjective probabilities are functions of the value of the project to the individual because of potential endogeneity, as pointed out in the CV literature (see, for example, Forbes *et al.* 2015; Herriges *et al.* 2010; Hwang *et al*. 2014).

Definition 1. In the defined setting, the following holds for an incentive compatible CV referendum:

$$\begin{aligned} &EU_{Y,i} > EU_{N,i} \ \ if \ \ v_i > c_i, \\ &EU_{Y,i} = EU_{N,i} \ \ if \ \ v_i = c_i, \\ &EU_{Y,i} < EU_{N,i} \ \ if \ \ v_i < c_i. \end{aligned} \tag{5}$$

Moving $EU_{N,i}$ in each line of (5) to the left-hand side of the respective inequality / equality shows that the sign of the difference $EU_{Y,i} - EU_{N,i}$ is crucial for the incentive compatibility of the referendum. Using (1) and (2), the difference in the expected utilities from voting "yes" and voting "no" is given by

$$\begin{aligned} EU_{Y,i} - EU_{N,i} &= \left[q_i\left(\frac{I^E_{-i}+1}{N}\right) - q_i\left(\frac{I^E_{-i}}{N}\right)\right]\left(EU_{I,i} - EU_{NI,i}\right) \\ &= Q_i\left(EU_{I,i} - EU_{NI,i}\right), \end{aligned} \tag{6}$$

where

$$Q_i \equiv q_i\left(\frac{I^E_{-i}+1}{N}\right) - q_i\left(\frac{I^E_{-i}}{N}\right).$$

Below, we examine whether a single-shot, binary choice, advisory CV referendum can provide incentives for a rational, expected utility-maximising individual to vote in line with his true preferences and, if so, under what conditions. In separate subsections, we inquire the impacts of the two terms of the far right-hand side of (6), namely, Q_i and $EU_{I,i} - EU_{NI,i}$, on the incentive properties of the referendum.

3.3.1 Perceptions of the consequentiality of ones' own vote

Q_i, as introduced in (6), represents the difference in the subjectively perceived probabilities of the authorities' decision to implement the project depending on how individual i votes. Thus, the term reflects the importance / weight of individual i's vote for the authorities' final decision. Clearly, when this is equal to (approximately) zero, individual i is (may be) indifferent between voting "yes" and "no", regardless of his actual preferences, because his vote has no (negligible) impact on the probability of the authorities' decision. In this case, the CV study is not incentive compatible.

As inferred from the definition of Q_i, the weight of the individual's vote for the authorities' final decision as to whether to implement the project depends on several factors: the population size, N the expectations of how other members of P vote, I^E_{-i}, and the perception of how the referendum outcome is translated into the final decision, $q_i(\cdot)$. To make this weight non-negligible and, thus, to make the individual's vote potentially consequential, the factors need to satisfy certain conditions, which we formulate below. Condition 1 is sufficient when an individual does not have definite expectations about how other members of P vote. However, when an individual has some expectations about the voting choices of others, both Condition 1 and Condition 2 need to be met. By saying that an individual does not have expectations about how other members of P vote, we assume that he has no knowledge about the share of supporters / opponents of the considered project in the voting population and, thus, he treats I^E_{-i}/N as an unknown factor; in particular, the individual does not assign to I^E_{-i}/N any specific value from the possible set: $I^E_{-i}/N = \{0,1/N,...,(N-1)/N\}$, but treats the value of the terms as finite.

Condition 1. In order for an individual to view an advisory CV referendum as consequential, the size of the voting population should be finite.

When Condition 1 is violated, that is, when the voting population is (seen as) infinitely large, the weight of individual i's vote for the authorities' final decision approaches zero:

$$\lim_{N\to+\infty}\left[q_i\left(\frac{I^E_{-i}}{N}+\frac{1}{N}\right) - q_i\left(\frac{I^E_{-i}}{N}\right)\right] = 0,$$

given some expected share of the population members supporting the project, I^E_{-i}/N, which may be unknown in the individual's perception. In the opposite case, namely, when Condition 1 is satisfied, and provided that the individual does not have expectations of I^E_{-i}/N, then Q_i is positive because $q_i(\cdot)$ is an increasing function.

Condition 2. In order for an individual to view an advisory CV referendum as consequential, when the individual has expectations about how other members of the population vote, $q_i(\cdot)$ should be a *strictly* increasing function.

Let Condition 1 be met, and let $q_i(\cdot)$ not be strictly increasing: for example, an individual believes that the

authorities follow a majority voting rule, so $q_i(\cdot) = 0\%$ when the share of the project supporters in the population does not exceed one half, and $q_i(\cdot) = 100\%$ otherwise. Consider an individual with definite expectations of the share of the project supporters. The individual is likely to be indifferent between voting "yes" and "no" unless the perceived share of the project supporters is close to one half of the population because then his vote may impinge on the probability of the authorities' decision. If $q_i(\cdot)$ was strictly increasing, the individual's vote could affect the probability of the authorities' decision regardless of the expected share of the project supporters.

Given the lack of perfect rationality of survey respondents, researchers may also need to take into account individuals' perceptions of the shape of function $q_i(\cdot)$, namely, whether it is seen as convex or concave. If, in individual i 's view, $q_i(\cdot)$ is convex, Q_i becomes smaller when I^E_{-i} decreases, ceteris paribus. Consequently, I^E_{-i} approaching zero (that is, an expectation of no project supporters) largely reduces incentives to reveal preferences truthfully because Q_i becomes close to zero and the weight of the individual's vote for the authorities' final decision may be perceived as negligible. Thus, individuals with convex $q_i(\cdot)$ who believe that the population is strongly dominated by the project opponents may experience substantially weakened incentives to provide truthful responses in the referendum. In the opposite case, namely, if, in individual i's view, $q_i(\cdot)$ is concave, Q_i decreases when I^E_{-i} increases, ceteris paribus. For individuals who have concave $q_i(\cdot)$ and who see that (almost) all members of the population vote for the project, the value of Q_i may be too small to believe that their vote can play a role for the authorities' final decision. Thus, they may lack incentives to answer truthfully. In sum, the impact of individuals' expectations about the distribution of preferences towards a considered project in the voting population on incentive properties of an advisory CV referendum can be eliminated with full certainty if the individuals are plausibly assured that the probability of the authorities' decision to undertake the project, $q_i(\cdot)$, increases linearly in the number of votes in favour of it, meaning that each "yes" vote increases this probability by the same amount.

When Condition 1 and Condition 2 are met, the sign of the difference in the expected utilities between voting "yes" and "no", as given by (6), is determined solely by the sign of the difference in the expected utilities between the project implementation and the project non-implementation, $EU_{I,i} - EU_{NI,i}$. If $EU_{I,i} > EU_{NI,i}$ ($EU_{I,i} < EU_{NI,i}$), that is, if individual i likes the project (non-)implementation more, then, $EU_{Y,i} > EU_{N,i}$ ($EU_{Y,i} < EU_{N,i}$), which implies that he is strictly better off voting for (against) the project. This indicates consistency between the individual's preferences and his voting behaviour, suggesting that it is a weakly dominant strategy for an individual to disclose his preferences truthfully as long as the weight of the individual's vote for the authorities' final decision about the project implementation is not negligible; that is, as long as the individual's own vote may be consequential.

3.3.2 Perceptions of provision consequentiality and payment consequentiality

We now focus on the relationship between $EU_{I,i}$ and $EU_{NI,i}$, which relates to the second term of the far right-hand side of (6). As explained above, with a finitely large population P and no expectations about the voting preferences of others in P, or with a finitely large population P, some expectations about the voting preferences of others in P and strictly increasing $q_i(\cdot)$, the sign of the difference $EU_{I,i} - EU_{NI,i}$ determines the voting preference of individual i. For considerations in this subsection, we assume that Condition 1 and Condition 2 are met. We further omit the subscript i for the sake of brevity of the notation, implicitly focusing on a single individual from the voting population P.

Using (3) and (4), we represent the difference $EU_I - EU_{NI}$ as a function g of the net payoff (net benefit) b to the individual, where $b = v - c$, that is, the value received by the individual when the good is successfully provided reduced by the project cost:

$$\begin{aligned} g(b) &= EU_I - EU_{NI} \\ &= p_p(b+c)p_s(b+c)\{U(0 \mid r) - U(-c \mid r) \\ &\quad - [U(b+c \mid r) - U(b \mid r)] \\ &\quad + p_s(b+c)[U(b+c \mid r) - U(0 \mid r)] \\ &\quad + p_p(b+c)[U(-c \mid r) - U(0 \mid r)]. \end{aligned} \tag{7}$$

In an incentive compatible referendum, an individual is strictly better off voting for (against) the project when $b > 0$ ($b < 0$), and is indifferent between voting "yes" and "no" when $b = 0$. Provided that Condition 1 and Condition 2 are satisfied, we modify Definition 1 using function g and net payoff b, and state that for an advisory CV referendum to be incentive compatible, it must hold that

Tab. 2. Incentive properties of an advisory CV referendum when one of p_s and p_p is equal to 0 or 1 and the other probability takes a different value

Value of $g(b)$	Value of $g(b)$ for $b = 0$	Incentive properties of the referendum
Case 1: $p_s(v) = 0$ and $0 < p_p(v) \leq 1$ $g(b) = p_p(b + c)[U(-c\|r) - U(0\|r)]$	$g(0) = p_p(v)[U(-c\|r) - U(0\|r)] < 0$	$EU_Y < EU_N$, incentives to vote "no"
Case 1: $p_s(v) = 1$ and $0 \leq p_p(v) < 1$ $g(b) = [1 - p_p(b + c)]\,U(b + c\|r)$ $+ p_p(b + c)\,U(b\|r) - U(0\|r)$	$g(0) = [1 - p_p(v)][U(c\|r) - U(0\|r)] > 0$	$EU_Y > EU_N$, incentives to vote "yes"
Case 1: $p_p(v) = 0$ and $0 < p_s(v) \leq 1$ $g(b) = p_s(b + c)[U(b + c\|r) - U(0\|r)]$	$g(0) = p_s(v)[U(c\|r) - U(0\|r)] > 0$	$EU_Y > EU_N$, incentives to vote "yes"
Case 1: $p_p(v) = 1$ and $0 \leq p_s(v) < 1$ $g(b) = [1 - p_s(b + c)]\,U(-c\|r)$ $+ p_s(b + c)U(b\|r) - U(0\|r)$	$g(0) = [1 - p_s(v)][U(-c\|r) - U(0\|r)] < 0$	$EU_Y < EU_N$, incentives to vote "no"

Notes: $b = 0$ means that $v = c$. Thus, in the middle column, $p_p(c)$ is replaced with $p_p(v)$, and $p_p(c)$ is replaced with $p_p(v)$.

Source: Author's own elaboration.

$$g(b) > 0 \;\; if \;\; b > 0,$$
$$g(b) = 0 \;\; if \;\; b = 0, \tag{8}$$
$$g(b) < 0 \;\; if \;\; b < 0.$$

Claim 1 reveals the incentive properties of an advisory CV referendum in several particular cases: (*i*) when an individual is entirely convinced about the study consequentiality, that is, when both $p_s(v) = 1$ and $p_p(v) = 1$; (*ii*) when an individual does not believe at all in the study consequentiality, that is, when both $p_s(v) = 0$ and $p_p(v) = 0$; and (*iii*) when one of $p_s(v)$ and $p_p(v)$ is equal to 0 or 1 and the other of the two probabilities takes a different value.

Claim 1. (*i*) When $p_s(v) = 1$ and $p_p(v) = 1$, an advisory CV referendum is incentive compatible. (*ii*) When $p_s(v) = 0$ and $p_p(v) = 0$, an advisory CV referendum is not incentive compatible. (*iii*) When one of $p_s(v)$ and $p_p(v)$ is equal to 0 or 1 and the other probability takes a different value, an advisory CV referendum is not incentive compatible.

Proof. (*i*) For $p_s(v) = 1$ and $p_p(v) = 1$, we have that $g(b) = U(b \mid r) - U(0 \mid r)$. Because $U(\cdot)$ is a strictly increasing function and because $g(0) = 0$, the referendum fulfils the conditions for incentive compatibility specified in (8).

(*ii*) For $p_s(v) = 0$ and $p_p(v) = 0$, we have that $g(b) = 0$, which means that $EU_I - EU_{NI} = 0$ and, consequently, based on (6), that $EU_Y - EU_N = 0$. Regardless of the individual's net payoff, his expected utilities from voting "yes" and "no" do not differ, so the individual has no incentives to answer truthfully and, thus, the referendum is not incentive compatible.

(*iii*) All possible combinations of $p_s(v)$ and $p_p(v)$ such that one of them is equal to 0 or 1 and the other one takes a different value are presented in Tab. 2, along with their impact on the incentive properties of an advisory CV referendum.

As shown in Tab. 2, in each of these cases, the individual's voting preference is independent of the value he assigns to the good. Consequently, the individual does not have incentives to reveal his true preferences. QED

In the analysis that follows, we exclude the specific cases discussed in Claim 1: from now on, we assume that $0 < p_s(v) < 1$ and $0 < p_p(v) < 1$. Then, in order to ensure the incentive compatibility of the advisory CV referendum, $g(b)$ needs to be strictly increasing in b with $g(0) = 0$.

Lemma 1 demonstrates that $g(b)$ is a strictly increasing function when the perceived probability of the successful provision of the good increases in its argument (that is, in the individual's value of the project) quickly enough in comparison with the pace of increase of the perceived probability of the payment collection. This condition concurs with intuition. The assumption that the perceived probabilities depend on the individual's value of the project comes from the considerations of Herriges *et al.* (2010), Hwang *et al.* (2014) and Forbes *et al.* (2015), among others. These studies suggest that respondents believing in the survey consequentiality

tend to vote in favour of the project because the project is important to them and, hence, the consequentiality self-reports can be a form of expression of their preferences. Thus, the perceived probability of the successful provision of the good might be expected to be more strongly correlated with the individual's value of the project than it is with the perceived probability of the payment collection.

Lemma 1. If $p_s'(b + c)$ is large enough in comparison with $p_p'(b + c)$, $g(b)$ is a strictly increasing function for risk-neutral and risk-averse individuals.

Proof. Because the proof is tedious, it is relegated to the Appendix.

The condition for the incentive compatibility of an advisory CV referendum resulting from Lemma 1 is sufficient, rather than necessary. As inferred from the proof of Lemma 1, the condition is more likely to be close to necessary for risk-neutral individuals than for risk-averse individuals. In particular, the condition approaches a necessary condition for risk-neutral individuals when their beliefs in successful provision of the good are weak ($p_s(\nu)$ is close to zero); their utility increases slowly in payoff; and / or they expect negative net benefit from the project implementation ($b < 0$).

Given Lemma 1, in order to determine the incentive compatibility of the advisory CV referendum, we identify conditions under which $g(0) = 0$. Thus, we first evaluate function $g(b)$, as defined in (7), at $b = 0$:

$$g(0) = p_s(c)[1 - p_p(c)][U(c \mid r) - U(0 \mid r)] - p_p(c)[1 - p_s(c)][U(0 \mid r) - U(-c \mid r)]. \tag{9}$$

Because we now consider $0 < p_s(\nu) < 1$ and $0 < p_p(\nu) < 1$, $g(0) = 0$ if and only if the following holds:

$$\frac{U(c \mid r) - U(0 \mid r)}{U(0 \mid r) - U(-c \mid r)} = \frac{p_p(\nu)\left[1 - p_s(\nu)\right]}{p_s(\nu)\left[1 - p_p(\nu)\right]}, \tag{10}$$

where $p_s(c)$ is replaced with $p_s(\nu)$ and $p_p(c)$ is replaced with $p_p(\nu)$ because $b = 0$ means $c = \nu$.

The value of the left-hand side of (10) is clearly tied to the individual's preferences towards risk. In Claim 2, we show that for an advisory CV referendum to be incentive compatible, the probabilities of successful provision and payment must be in a particular relationship to each other, and that this relationship differs depending on individuals' risk preferences. Specifically, risk-neutral individuals reveal their preferences truthfully when $p_s(\nu) = p_p(\nu)$, while risk-averse individuals reveal their preferences truthfully when $p_s(\nu) > p_p(\nu)$. This result aligns nicely with the intuition: compared to individuals who are neutral towards taking risks, individuals who are more sceptical about taking risks need to hold a relatively strong belief that the good will be successfully provided in order to be incentivised to disclose their true preferences; a relatively high probability of payment in relation to the probability of the successful provision of the good can more easily discourage truthful preference revelation among risk-averse individuals than among risk-neutral individuals.

Claim 2. When the condition from Lemma 1 is satisfied: (*i*) an advisory CV referendum is incentive compatible for a risk-neutral individual if $p_s(\nu) = p_p(\nu)$; and (*ii*) an advisory CV referendum is incentive compatible for a risk-averse individual if $p_s(\nu) > p_p(\nu)$.

Proof. (*i*) For a risk-neutral individual, the left-hand side of (10) is equal to 1. Then, for (10) to hold, we need to have that $p_s(\nu) = p_p(\nu)$. This implies that when there is a zero net payoff from the project under consideration, a risk-neutral individual is indifferent between voting "yes" and "no" if, in his perception, the probability of the successful provision of the good is equal to the probability of the payment collection.

(*ii*) For a risk-averse individual, the value of the left-hand side of (10) is positive but smaller than 1. Thus, for the incentive compatibility of an advisory CV referendum, the right-hand side of (10) must also be smaller than 1, that is,

$$\frac{p_p(\nu)\left[1 - p_s(\nu)\right]}{p_s(\nu)\left[1 - p_p(\nu)\right]} < 1. \tag{11}$$

The rearrangement of (11) yields $p_s(\nu) > p_p(\nu)$: encountering a project that costs the same amount as the value that it brings to an individual, a risk-averse individual is indifferent between voting "yes" and "no" if the probability of the successful provision of the good is higher than the probability of the payment collection. QED

A question remains as to how much the probability of successful provision should exceed the probability of payment for a risk-averse individual to be incentivised to reveal his true preferences. As discussed in Claim 3, this depends on the individual's degree of risk aversion.

Claim 3. Under the condition from Lemma 1, for a risk-averse individual, the stronger the risk aversion, the larger the positive difference $p_s(\nu) - p_p(\nu)$ must be for an advisory CV referendum to be incentive compatible.

Proof. As mentioned in the proof of Claim 2, for a risk-averse (*RA*) individual, the value of the left-hand side of (10) is positive but smaller than 1. We represent it in the following way:

$$\frac{U(c\,|\,RA)-U(0\,|\,RA)}{U(0\,|\,RA)-U(-c\,|\,RA)}=1-\varepsilon, \tag{12}$$

where $\varepsilon\in(0,1)$ captures the level of an individual's risk aversion: the higher the value of ε, the stronger the individual's risk aversion.[8] Combining (10) and (12), we have that an advisory CV referendum is incentive compatible for a risk-averse individual if

$$\frac{p_p(v)\left[1-p_s(v)\right]}{p_s(v)\left[1-p_p(v)\right]}=1-\varepsilon,$$

which can be rearranged into

$$p_p(v)=\frac{1-\varepsilon}{1-\varepsilon p_s(v)}\,p_s(v). \tag{13}$$

Calculating the first derivative of $\frac{1-\varepsilon}{1-\varepsilon p_s(v)}$ with respect to ε yields

$$\frac{\partial\left[\frac{1-\varepsilon}{1-\varepsilon p_s(v)}\right]}{\partial\varepsilon}=\frac{-\left[1-\varepsilon p_s(v)\right]-p_s(v)\left(1-\varepsilon\right)}{\left[1-\varepsilon p_s(v)\right]^2}<0,$$

which indicates that $\frac{1-\varepsilon}{1-\varepsilon p_s(v)}$ decreases in ε. Consequently, we infer from (13) that the larger ε (the stronger the individual's risk aversion), the smaller $p_p(v)$ needs to be in comparison with $p_s(v)$ to maintain the incentive compatibility of the referendum, and, thus, the difference $p_s(v) - p_p(v)$ needs to be larger. QED

How will a risk-neutral individual, for whom $b = 0$, vote in an advisory CV referendum if, in his perception, $p_s(v) \neq p_p(v)$? How will a risk-averse individual with $b = 0$ vote in an advisory CV referendum if he does not believe that $p_s(v) > p_p(v)$? We now briefly discuss the implications for the referendum outcome when the conditions defined in Claim 2 are not met.

We first focus on a risk-neutral individual. When $b = 0$, the individual should be indifferent between voting "yes" and "no", which means that $g(0)$, as given in (9), should be equal to zero. Claim 2 informs that in order to have $g(0) = 0$, it needs to hold that $p_s(v) = p_p(v)$. When $p_s(v) > p_p(v)$, (9) indicates that $g(0) > 0$ (because $U(c\,|\,r) - U(0\,|\,r) = U(0\,|\,r) - U(-c\,|\,r)$): the individual will be more willing to vote in favour of the project, irrespective of whether he actually values the project more than its cost. As a consequence, this will result in an upward bias of the project valuation. The opposite applies when a risk-neutral individual perceives that $p_s(v) < p_p(v)$.

We now consider a risk-averse individual. Similarly, for $b = 0$, if the individual truthfully discloses his preferences, he will be indifferent between voting "yes" and "no", so $g(0) = 0$. From Claim 2, we know that this holds when $p_s(v) > p_p(v)$. Conversely, if the individual believes that $p_s(v) < p_p(v)$, (9) implies that $g(0) < 0$ (because $U(c\,|\,r) - U(0\,|\,r) < U(0\,|\,r) - U(-c\,|\,r)$): the individual will tend to vote against the project, regardless of his actual preferences towards the project. This will result in a downward bias of the estimate of the project value. In turn, an upward bias will appear if the individual believes that $p_s(v)$ is higher than $p_p(v)$ by such a level which exceeds the condition for incentive compatibility (recall (13)).

4 Concluding remarks

The words of Schwarz (1997, 176) well summarise our paper:

> "The bottom line is simple: respondents do not value the good as described, but the good as represented in their own mental construal of the scenario… Understanding these processes may raise as well as solve problems that are crucial to CV research."

We address the issue of the distinction between what a CV survey says and what the survey respondents believe, and we show how crucial this is for the reliability of CV studies. Specifically, on the basis of a model built on recent empirical evidence, we demonstrate the importance of the subjectively perceived consequentiality of a CV survey for its incentive compatibility, in the sense that it incentivises truthful preference disclosure. Respondents' unobservable perceptions play an essential role in determining their best voting strategy in advisory CV referenda: whether or not to answer in line with

8 An individual's risk aversion is expressed by the curvature of his utility function: the more "curved" his concave utility function, the stronger his risk aversion. When the degree of risk aversion increases, the numerator on the left-hand side of (12) becomes smaller and the denominator becomes larger. As a consequence, the fraction on the left-hand-side of (12) decreases in the degree of risk aversion, which results in higher ε for more risk-averse individuals.

true preferences. Even if a CV study adheres to the best practices of stated preference research, respondents' preferences inferred from such a study could be biased when it is not taken into account that respondents' beliefs may diverge from the information conveyed to them in the survey scripts. For example, survey scripts can assure respondents about the real-life consequences that follow from the survey outcome but respondents may not believe them. In order to maintain the incentive compatibility of advisory CV referenda, respondents' subjective perceptions must be well understood. These include: (*i*) a subjective perception of the importance of a respondent's vote for the referendum outcome (that is, how strongly a respondent believes that his vote may influence the final outcome), (*ii*) a subjectively perceived probability of the successful provision of a public good (a perception of provision consequentiality), and (*iii*) a subjectively perceived probability of payment collection (a perception of payment consequentiality).

Our model is structured in such a way that represents that respondents separately evaluate the chance that their vote can influence the referendum outcome and, contingent upon the authorities' decision to implement the project, the chances of the successful provision of a public good and payment collection. Although this division may appear somewhat technical, we think that it well mirrors various aspects of the consequentiality considerations that a voting individual may have when participating in an advisory CV referendum. These considerations could be well captured by the two following questions, which justify the distinction proposed in our theoretical framework: "Can my vote have any impact on the referendum outcome? If so, what are the odds that I will actually have the good provided and that I will need to pay for it?".

Our model suggests practical recommendations for CV studies that may help to improve the quality of value assessments of public goods. First, a respondent's belief in the use of the survey results by policymakers in taking a final decision, as well as a respondent's perception of the importance of his vote for the referendum outcome, should be examined. If a respondent does not believe that votes in favour of the project increase the probability of the authorities' decision to undertake it, any answer in the referendum is equally good. Similarly, if a respondent does not see any chance that his vote can impinge on the referendum outcome, he does not have incentives to truthfully reveal his preferences. These perceptions might be affected by the respondent's view of how the share of "yes" votes translates into the probability of the authorities' decision about the project implementation, by the size of the surveyed population, and by the respondent's knowledge / expectations of the voting behaviour of other members of the population.

Second, our model highlights that a perceived probability of the successful provision of a public good and a perceived probability of payment collection should be assessed separately, rather than, as typically done in current studies, measuring a respondent's general belief in consequentiality through a single question about the extent to which he believes that the survey results will have an effect on the finally undertaken action. Moreover, in order to precisely capture perceptions of the two probabilities, respondents might be asked to indicate their perceived probability levels on a Likert scale that is broader than the one used in the existing studies, which ranges from two (Broadbent 2012) to six levels (Vossler *et al.* 2012).

Finally, our model points out that CV studies should take into account respondents' risk preferences in assessing the incentive properties of surveys. A lack of control of the effect of respondents' risk preferences on their voting behaviour may lead to biased value estimates.

Obviously, our model relies on some assumptions which could be considered to be relaxed. This indicates directions for possible extensions of the presented analysis. Here, we discuss a few possibilities, although we are aware that there are many others. First, our framework assumes that each respondent knows (approximately) the value of the considered good to him, and this value is exogenous. However, the stated value, particularly when the respondent is not certain about his preferences, may be affected by various factors, including the cost presented in the survey (see, for example, references in Burrows, Dixon, and Chan 2017). This could be acknowledged in the model by making the stated value a function of the cost. Second, in our analysis, if the authorities choose to undertake the project, they do, indeed, endeavour to realise it. An extension could discuss a case where, even if the authorities formally decide to implement the project, their actual efforts to accomplish it may be questionable; for instance, they may be seen as more likely to successfully provide the good when the share of "yes" votes is sufficiently large. Consequently, the probabilities of successful provision and payment collection could be perceived as dependent on the referendum outcome. Third, our study examines the impact of one behavioural aspect, namely, consequentiality perceptions, on the incentive compatibility of CV research. However, evidence from the empirical

literature demonstrates numerous behavioural anomalies that can disturb truthful preference elicitation: respondents may display a warm glow (they support a public policy project because the expression of support provides satisfaction by itself, regardless of actual preferences; Nunes and Schokkaert 2003), or they experience social desirability pressure (Leggett *et al.* 2003), among others. These aspects could also be potentially brought into the analysis to deepen the understanding of respondents' behaviour.

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Appendix

Proof of Lemma 1

We have that

$$\begin{aligned}\frac{\partial g(b)}{\partial b} &= p_p'(b+c)\,p_s(b+c)A + p_p(b+c)\,p_s'(b+c)A \\ &+ p_p(b+c)\,p_s(b+c)[-U'(b+c\,|\,r) + U'(b\,|\,r)] \\ &+ p_s(b+c)\,U'(b+c\,|\,r) \\ &+ p_s'(b+c)[U(b+c\,|\,r) - U(0\,|\,r)] \\ &- p_p'(b+c)[U(0\,|\,r) - U(-c\,|\,r)],\end{aligned} \tag{A1}$$

where $A = U(0\,|\,r) - U(-c\,|\,r) - [-U(b+c\,|\,r) + U(b\,|\,r)]$, and $p_p'(\cdot)$, $p_s'(\cdot)$ and $U'(\cdot)$ denote the first derivatives of the respective functions.

For a risk-neutral individual: $A = 0$ and, thus, the first two terms in (A1) cancel out; the first derivative of $U(\cdot)$ is constant, so $-U'(b+c\,|\,r) + U'(b\,|\,r) = 0$ and, thereby, the third term in (A1) also cancels out. For a risk-averse individual: $A > 0$ and, thus, the first two terms in (A1) are positive because $p_s(\cdot)$ and $p_p(\cdot)$ are increasing functions taking values from the interval (0,1); $-U'(b+c\,|\,r) + U'(b\,|\,r) > 0$ and, thereby, the third term in (A1) is positive as well. Regardless of the individual's risk preferences, because $U(\cdot)$, $p_s(\cdot)$ and $p_p(\cdot)$ are increasing functions, the fourth and the fifth terms in (A1) are positive, and the last term in (A1) is negative.

For function $g(b)$ to be strictly increasing, it must hold that $\frac{\partial g(b)}{\partial b} > 0$. Thus, we verify under what conditions the last term in (A1) does not make $\frac{\partial g(b)}{\partial b}$ negative or equal to zero. As follows from (A1), $\frac{\partial g(b)}{\partial b} > 0$ if

$$\begin{aligned}&p_p'(b+c)\,p_s(b+c)A + p_p(b+c)\,p_s'(b+c)A \\ &+ p_p(b+c)\,p_s(b+c)[-U'(b+c\,|\,r) + U'(b\,|\,r)] \\ &+ p_s(b+c)\,U'(b+c\,|\,r) + p_s'(b+c)[U(b+c\,|\,r) - U(0\,|\,r)] \\ &> p_p'(b+c)[U(0\,|\,r) - U(-c\,|\,r)].\end{aligned}$$

Thus, for $\frac{\partial g(b)}{\partial b}$ to be positive, it is enough to assure that

$$\begin{aligned}&p_s'(b+c)[U(b+c\,|\,r) - U(0\,|\,r)] \\ &> p_p'(b+c)[U(0\,|\,r) - U(-c\,|\,r)].\end{aligned} \tag{A2}$$

The rearrangement of (A2) reveals that

$$\frac{p_s'(b+c)}{p_p'(b+c)} > \frac{U(0\,|\,r) - U(-c\,|\,r)}{U(b+c\,|\,r) - U(0\,|\,r)} \equiv \alpha^*. \tag{A3}$$

The right-hand side of (A3) imposes a lower boundary on $\frac{p_s'(b+c)}{p_p'(b+c)}$, denoted by α^*, so that $\frac{\partial g(b)}{\partial b}$ is positive. Because $c > 0$, $v = b + c > 0$, and $U(\cdot)$ is an increasing function, both the numerator and the denominator of α^* are positive. Hence, α^* can take various positive levels depending on the value of b and on the individual's risk preferences. For a risk-neutral individual: $\alpha^* > 1$ when $b < 0$; $\alpha^* = 1$ when $b = 0$; and $\alpha^* < 1$ when $b > 0$. For a risk-averse individual: $\alpha^* > 1$ when $b \leq 0$; and α^* can take any positive level when $b > 0$. Consequently, $\frac{\partial g(b)}{\partial b}$ will certainly be positive if $p_s'(b+c)$ is large enough in comparison with $p_p'(b+c)$. QED