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Incentivizing stated preference elicitation with choice-matching in the field

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Abstract: Stated preferences should ideally be elicited in ways providing respondents with economic incentives to report them truthfully—that is, in incentive-compatible conditions. This study aims at testing empirically a novel theoretical approach, which allows for incentive-compatible elicitation of preferences. Choice-matching, proposed by Cvitanić et al. (2019), is applied here to elicit stated preferences towards a public good. While the approach has been originally designed for incentivizing responses to a multiple choice question, we illustrate its possible application to an open-ended question. We conduct an online experiment mirroring a standard stated preference survey as used for valuation of public goods. Two versions of the survey questionnaire are implemented: one employing the incentive-compatible choice-matching approach and another representing a common non-incentivized setting. We find that the open-ended willingness-to-pay values are statistically significantly higher when stated under choice-matching than when expressed in the non-incentivized conditions.

Keywords: contingent valuation, choice-matching, incentive compatibility, open-ended elicitation, stated preferences

JEL codes: D61, D82, H43, Q51

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1 Introduction

Contemporary guidance for stated preference studies suggests the use of incentive-compatible designs, which make truthful disclosure of preferences the best-response strategy for a respondent (Johnston et al. 2017). In an attempt to extend the range of available incentive-compatible means for stated preference elicitation, this paper presents an empirical application of the choice-matching mechanism recently developed by Cvitanić et al. (2019). This mechanism offers an alternative technique to eliciting preferences in an incentive-compatible manner, which in contrast to available approaches does not rely on consequentiality (that is, respondents' beliefs in their responses mattering for the final policy decision). While choice-matching has originally been proposed for eliciting truthful answers to a multiple choice question, we illustrate its possible extension to the elicitation with continuous-response formats, such as an open-ended question. To the best of our knowledge, the application presented here is novel, not only in the area of stated preferences, but also in a broader field; indeed, we are not aware of any journal publication empirically employing the theoretically proposed approach of choice-matching.[1]

In stated preference literature, a single binary (yes-no) choice question is recognized as the most straightforward approach to achieve incentive compatibility (Johnston et al. 2017). The format's simplicity and a clear incentive structure underlie the recommendation for its use, which dates back at least to the report of the National Oceanic and Atmospheric Administration panel on contingent valuation (Arrow et al. 1993). Despite the long-lasting recommendation, many other formats continue to be applied in practice. While incentive compatibility is lost, statistical efficiency of value estimation is gained as the single binary response reveals little information on preferences per respondent (e.g., Hanemann et al. 1991; Kanninen et al. 1993; Vossler and Holladay 2018).[2]

[1] The note is based on a review of all papers citing the work of Cvitanić et al. (2019) listed in Google Scholar as of January 21, 2022. One SSRN working paper is available applying choice-matching to study scientists' perceptions about the present and future disruptions to their research tied to the Covid-19 pandemic (Myers et al. 2020).

[2] For example, a Monte Carlo simulation by Vossler and Holladay (2018) illustrates that in their study case, the level of precision for a mean willingness-to-pay value estimate is the same when obtained with an open-ended sample size of about 125 respondents and when based on a single binary choice sample of 200 respondents.

Disparities in incentive structures across applied preference elicitation formats appear to contribute to significant variations in value estimates obtained through different formats (Vossler and Zawojska 2020). This undermines the validity of stated preference value measures. For instance, a well-known result from the voting literature (related to Duverger's Law, Duverger 1954) suggests that when answering to a single multiple choice question, a respondent may benefit from selecting her second-best, thus not disclosing her most preferred option. She may be inclined to do so if she believes that her second-best has a better chance of winning than her first-best and there is a substantial risk that another option which she considers as worse can win (e.g., Cain 1978; Abramson et al. 2004). No similar considerations of a distribution of preferences in society across discrete choice options apply, for instance, to a single binary (yes-no) choice or an open-ended elicitation, where no second-best option is possible. In the latter, a respondent liking the good's provision may be inclined to strategically overstate her true willingness to pay if she believes that the sum of all stated amounts will determine the provision decision or understate it if she believes that the stated amounts will be used for setting the individual cost.[3] Divergences in incentive properties such as these contribute to differences in value estimates derived from these and other formats. Indeed, numerous stated preference studies find format-related elicitation effects and some report evidence of strategic responding (e.g., Interis et al. 2016; Meginnis et al. 2018).

The influential role of differences in incentive structures across elicitation formats on value estimates emphasizes the importance of designing stated preference surveys as incentive-compatible. To accomplish incentive compatibility with formats of higher efficiency than the single binary choice question, additional conditions for the preference elicitation procedure have been developed. Vossler et al. (2012) propose conditions for a series of binary choice questions, and Vossler and Holladay (2018) indicate conditions for open-ended and payment card questions. Evidence from a lab experiment by Vossler and Zawojska (2020) suggests that when incentives are truth-inducing and kept constant across a range of common preference elicitation formats (including the single binary choice, double-bounded binary choice, payment card and open-ended questions), value estimates derived from the formats are statistically indistinguishable.

[3] Response considerations related to an open-ended preference elicitation question are in detail discussed by Carson and Groves (2007) and are briefly summarized in a later section of this paper.

The incentive compatibility conditions proposed in the stated preference literature require the valuation to be non-hypothetical (e.g., Vossler et al. 2012; Carson et al. 2014; Vossler and Holladay 2018). Carson and Groves (2007) define this feature of a survey as consequentiality, meaning that respondents perceive a positive probability that their survey answers can matter for the final decision which the preference elicitation concerns. While respondents' beliefs in consequentiality have been demonstrated to influence stated preferences and value estimates (e.g., Vossler and Watson 2013; Interis and Petrolia 2014; Zawojska et al. 2019), consequentiality is not an obvious condition to be met in surveys. Survey scripts appear not necessarily to convince respondents' about their consequentiality (e.g., Czajkowski et al. 2017; Lloyd-Smith et al. 2019), some policy projects evaluated in surveys are indeed at hypothetical stages, and finally individuals' perceptions of consequentiality are not objectively measurable and often endogenous to stated preferences (e.g., Herriges et al. 2010; Börger et al. 2021). A newly emerging line of research suggests that consequentiality might even be an undesirable survey feature leading to preference statements driven by the feeling of being responsible for policy outcomes (that is, responsibility utility; Comerford and Lades 2021). In the light of the challenges related to consequentiality, choice-matching appears as an attractive alternative, since it allows for an incentive-compatible elicitation of preferences towards a hypothetical good or policy project.

Choice-matching has been theoretically proposed by Cvitanić et al. (2019) as a mechanism to elicit honest responses to a multiple choice question when the truth is not verifiable (e.g., opinions, judgements). Despite the need for elicitation of honest responses in settings where outcomes of interest cannot be objectively verified, these environments have received limited attention in the experimental literature (Charness et al. 2021). Incentives for eliciting non-verifiable truth were introduced by Prelec (2004) with the Bayesian Truth Serum, which was followed by a peer-prediction method (Miller et al. 2005). More recent approaches in this domain include choice-matching (Cvitanić et al. 2019), Bayesian markets (Baillon 2017), and the top-flop betting (Baillon and Xu 2021), as well as extensions to the Bayesian Truth Serum (e.g., Witkowski and Parkes 2012; Radanovic and Faltings 2013). The choice-matching approach is observed to outstand

from other, particularly earlier-developed methods eliciting a non-verifiable truth as it is simple enough to explain the truth-telling incentives to participants (Charness et al. 2021).[4]

Choice-matching relies on the use of two questions: (1) one question asks about opinions, judgements, or preferences (as in our case) and based on this information, it identifies a type of each participant; and (2) an auxiliary question is employed to determine an actual outcome (which affects a participant in some way, for example, through payoffs) based on the answer of a given participant or on the answers of other participants of the same type. Specifically, there is some positive probability that the outcome—affecting a given participant—will not be determined by that participant's response to the auxiliary question, but by (averaged or differently aggregated) responses of others of the same type. The main idea behind the incentivization is that those who think alike in the question about opinions, judgements or preferences (that is, those of the same type) give similar answers to the auxiliary question, because the two questions are designed to be thematically connected. A participant wants the actual outcome to be determined by the own response to the auxiliary question. If it happens that the outcome is instead determined by the responses of others, it is desirable that these others are of the same type because they are more likely to give similarly good answers to the auxiliary question than the different-type participants are. This implies that it pays off to reveal own true opinions, judgements or preferences in order to be assigned to the right (true) type.

This paper presents an empirical application of choice-matching to elicitation of stated preferences and compares the approach's performance to a standard, non-incentivized preference elicitation. To that end, the study employs two split-sample treatments, which are equivalent in content and differ only by characteristics needed for choice-matching. Both treatments involve the elicitation of preferences towards the same hypothetical good, but the elicitation under choice-matching is incentivized using the proposed mechanism. The specific case study concerns valuation of a program of extending infrastructure for renewable energy production in Warsaw, Poland. Stated preferences are elicited with an open-ended question in an online questionnaire, which mirrors a typical contingent valuation survey application.

[4] In turn, applications of other approaches in this area often forgo explaining the (complex) incentive structures to participants and rely on providing them with simple information that truthful responses may be wise or pay off, without discussing details of the mechanism (e.g., Barrage and Lee 2010; Weaver and Prelec 2013; Loughran et al. 2014).

We believe that this paper responds to the need for developing tools for incentive-compatible preference elicitation with other formats than the single binary choice question. By illustrating an implementation of choice-matching to stated preferences, the paper provides a practical approach how the novel, incentive-compatible mechanism can be applied in valuation surveys, even when the evaluated good or project is hypothetical. This study brings additional evidence that formats other than the single binary choice do not need to be discarded based on incentive-compatibility considerations as there are ways for incentivizing respondents to truthful preference disclosure with these formats.

2 Application of choice-matching to elicitation of preferences towards renewable energy

In this section, we describe our empirical application of the choice-matching approach to the elicitation of preferences towards extension of renewable energy infrastructure. Besides explaining the practical operationalization of the approach for the purpose of our study, the aim of this section is to provide an intuitive understanding of the incentives in the mechanism's application. The technical details of the implementation are discussed in the subsequent section, and a formal derivation and proof of the truth-inducing incentives under choice-matching are presented by Cvitanić et al. (2019).

In our study, the evaluated good is a program of increasing renewable energy use in Warsaw by extending solar energy infrastructure. The considered program assumes building new solar panels that would provide electricity to the city public spaces, such as train and subway stations, and parks. Similar green energy solutions are implemented, for example, on some of the city's administration buildings. The program considers a further extension of the use of solar panels. The proposal explains to respondents that the implementation of this program would require additional funds, which could be collected through taxes designated for the program realization. The survey script describes that the tax increase for this purpose would last for five years and would apply to all residents of Warsaw.

The preference elicitation question has an open-ended format and asks respondents: "How much at most would you be willing to pay annually (for 5 years) as an increased tax for the presented program of building solar panels in Warsaw?".[5] This question is of main interest from

[5] This and other quotations from the questionnaire used in the paper are translated from Polish.

the perspective of getting a value estimate of the considered program. According to the choice-matching procedure, responses to this question are used to identify a respondent's type. Namely, based on these responses, participants are classified by a researcher into non-overlapping groups of similar willingness-to-pay amounts. These types are necessary for determining actual outcomes (involving payoffs to respondents) based on respondents' answers to the auxiliary question.

The auxiliary question is needed only for the truth-inducing mechanism and does not provide stated preference data for the valuation study. In our case, the question concerns a respondent's willingness to contribute financially to the foundation "Forever Forest". The foundation is a non-governmental organization in Poland, which aims at restoring the biological balance by planting forests. In the auxiliary question, a respondent is asked: "How would you like to split 1,000 PLN from the budget of the experiment? For the new forest [planted by "Forever Forest"]: ____ PLN. For me: ____ PLN.", where a respondent needs to insert two amounts summing up to 1,000 PLN.[6] Respondents are informed that this question will be binding for several randomly selected individuals. In addition, respondents are told that in the case of a half of the selected individuals, the amounts for the new forest and for the individual will be equal to the means of the amounts indicated by other respondents of the same type, where the type is defined based on the preference elicitation question about the renewable energy infrastructure.

To make a clear distinction between information elicited with the two questions described in the above paragraphs, we refer to answers to the preference elicitation question as willingness-to-pay amounts and to responses to the question about the foundation "Forever Forest" as contribution amounts.

Upon the aforementioned mechanism, an individual is incentivized to truthfully disclose the preferences (that is, the willingness-to-pay value) in the hypothetical question concerning the renewable energy program. In the case of being selected to make the binding contribution to the foundation "Forever Forest", a natural assumption is that the individual wants the amounts for the new forest and for oneself to be equal or close to the individual's statements of the amounts. There is, however, the probability that the amounts will be determined by the mean contributions indicated by other individuals. To secure against this possibility, a truthful revelation of one's type (and so one's preferences) in the renewable energy preference elicitation question constitutes the

[6] At the time of the data collection, the exchange rate was approximately 1 EUR ≈ 4.5 PLN.

strategy maximizing the chances that the contribution for the new forest will be the closest to one's own declaration of the amount. Because the preference elicitation question and the auxiliary question are thematically related, it is justified to believe that those who provide similar willingness-to-pay amounts for the renewable energy infrastructure are more likely to report similar contribution amounts for the new forest than those who indicate substantially different willingness-to-pay amounts. Thus, truthful preference disclosure appears to be the best-response strategy.

For illustration of the incentives, let us consider a simple example, which was also provided to our study participants. Assume there is individual A who does not want to pay much for environmental protection. Thus, A selects a low contribution for the new forest and, thus, a large amount for oneself, out of the 1,000 PLN from the experiment's budget. However, suppose that in the question about willingness to pay for the renewable energy program, A indicates an amount substantially exceeding the true amount A wants to pay. When A is selected to make the binding contribution based on the responses of others, A will pay the mean contribution amount as reported by others of the same type, that is, those who indicate a high willingness-to-pay amount for the renewable energy program. As they are willing to pay a lot for the renewable energy program, it is highly likely that they indicate high contribution amounts for the new forest. As a result, A may pay for the new forest a higher amount than A would prefer to do. An analogous example can easily be constructed showing that it does not pay off to underreport willingness to pay for the hypothetical renewable energy program either (and it was presented to the study participants as well).

3 Survey design and implementation

The empirical data to the study is collected in an online experiment mirroring a standard stated preference survey as used for valuation of public goods. As described above, the evaluated good is a policy program of extending renewable energy infrastructure in Warsaw, by installing solar panels in public spaces of the city. An open-ended question is employed for eliciting individuals' preferences towards the program. Two versions of the survey questionnaire are implemented: one employing the incentive-compatible choice-matching approach and another representing a common, non-incentivized setting. Henceforth, we refer to the former as *a choice-matching treatment* and to the latter as *a baseline treatment*. The two survey versions differ only with respect

to necessary characteristics for implementing choice-matching. Each respondent is randomly allocated to one of the treatments and can participate in the survey only once. This study is registered in the American Economic Association's registry for randomized controlled trials (AEA RCT Registry) at the identification number AEARCTR-0006705.[7]

3.1 Questionnaire structure

The questionnaire starts with two screening questions to assure that the survey is completed only by individuals for whom the evaluated good is relevant—that is, individuals permanently living in Warsaw and paying taxes in the city.

The next part of the survey asks a respondent (regardless of the treatment) how the person wants to split 1,000 PLN from the experimental budget between oneself and the foundation "Forever Forest", which will use the money for planting a new forest. This is the auxiliary question in the choice-matching mechanism. We include this question in both treatments to keep the questionnaire as similar as possible across the treatments. In our application, the auxiliary question appears before the question of the main interest (that is, the preference elicitation question) in order to facilitate respondents' understanding of the choice-matching mechanism and descriptions of the procedures. Respondents are briefly informed about the role of forests in ecosystems and about the foundation. They are also told that once the data from all respondents is collected, three individuals will be randomly selected for whom responses to this question will be binding—namely, each of the selected individuals will be assigned 1,000 PLN, and the amount indicated by the individual will be paid to the foundation for the new forest, while the remaining amount will go the individual's bank account. Respondents are also informed that when the payment is received by the foundation, the contributing individual will receive a certificate confirming the area of the forest planted and later will be informed by the foundation about the specific location of the planted forest. Up to this point, there are no differences across the treatments.

The survey follows with a hypothetical preference elicitation question about the maximum amount a respondent would be willing to pay yearly for extending renewable energy infrastructure with new solar panels in Warsaw. It is at this point that the two treatments diverge. While all

[7] Translation of the full survey questionnaire and the data set will be made available in online supplementary materials to a published version of this paper.

individuals are provided with a short description of the proposed program, respondents in the choice-matching treatment only are also given information specific to the approach. The choice-matching respondents are explained that additional three respondents will be randomly selected and these respondents will make actual contributions to the foundation "Forever Forest" from the assigned 1,000 PLN from the experiment's budget. This time, the amount paid by an individual to the foundation will be equal to the mean of the contribution amounts indicated by other same-type individuals, where the type is determined based on the open-ended willingness-to-pay responses concerning the renewable energy program. Beyond the description of this mechanism, the script in the choice-matching treatment explains to respondents the incentives behind the survey responses. It also provides two illustrative examples to show how truthful preference disclosure pays off when the binding contributions to the foundation are made based on the contribution amounts declared by other individuals. To avoid any priming, the two examples are balanced in the sense that one describes a case of overstating the value, while the other one refers to a case of understating the value. Neither of the examples refer to specific numerical amounts to exclude a possibility of anchoring. For both treatments, this survey part ends with the open-ended willingness-to-pay question about the maximal acceptable tax increase for the program of building new solar panels for electricity generation in public spaces of Warsaw.

Further parts of the survey query about respondents' understanding of the instructions, importance of the considered programs (that is, afforestation and renewable energy extension with solar panels), pro-environmental behaviors, and socio-demographics. Throughout the whole survey, there are no back buttons, so respondents cannot revise their earlier responses.

3.2 Survey administration and study sample

The survey was administered online to individuals up to forty years old randomly selected from the panel of the Experimental Economics Laboratory of the Faculty of Economic Sciences at the University of Warsaw in Poland.[8] Individuals were invited via email to participate in the study and

[8] The panel involves a relatively small number of individuals aged more than forty registered as potential participants in economic experiments. Hence, to assure consistency of the study sample and comparability of the experimental treatment subsamples, the age limit for the participation was set to forty.

were allowed to complete the questionnaire only once. The survey was coded in Limesurvey. The data collection took place between January and March 2021.

In total, we have 103 completed responses in the choice-matching treatment and 98 in the baseline treatment. Some of the observations are characterized by very short response time, which can signal a behavior of "clicking through" the survey without giving consideration to the questions. To account for this issue, we exclude from the analysis 3% of the observations in each treatment sample (which is equivalent to three observations per treatment) with the shortest response time to the preference elicitation question about the renewable energy program in Warsaw. This is equivalent to omitting those who responded to the question in less than 20 seconds. As a result, the data analysis is based on 100 respondents in the choice-matching treatment and 95 respondents in the baseline treatment.

The median response time for the whole survey was 6.03 minutes in the baseline treatment and 8.64 minutes in the choice-matching treatment, which is justified by the longer survey script in the latter. Out of the total sample, six individuals were randomly selected to make actual contributions for planting the forest from the assigned 1,000 PLN from the experiment budget. For three of them, each contributed exactly the amount indicated by a given individual, and for the other three, each paid the mean contribution amount of other respondents of the same type as a given individual. As a result, the binding contributions ranged from 20 PLN to 900 PLN, which implies that payments to the selected individuals ranged from 100 PLN to 980 PLN.

Based on the respondents' answers to the stated preference question, we divided them into seven types, each corresponding to one of non-overlapping willingness-to-pay intervals. This was performed only after the data collection had been completed and respondents had not been revealed information on their type at the time of completing the survey. This implies that the specific composition of the intervals could not affect their behavior.

The two treatment samples are described and compared in Table 1 with respect to the socio-demographic information collected and respondents' self-reports concerning their comprehension of the study instructions and decision certainty. The statistics along with the statistical tests indicate no significant differences in the socio-demographic characteristics, as expected, given the random allocation of respondents to the treatments. The mean age in the study sample is about 29, two thirds of the sample are females, about 80% of the respondents have attained an academic degree, more than half are full-time employed, and the mean net income in the respondents' households is slightly above 6,000 PLN per month.

Table 1. Summary statistics for the treatment samples

Variable	Definition	Baseline	Choice-matching	P-value
	Socio-demographic characteristics			
Age	Respondent's age	28.79 (4.60)	29.32 (4.66)	0.3891
Female	1 for females, 0 for males	0.66 (0.48)	0.66 (0.48)	0.9628
Secondary education	1 for respondents with secondary education, 0 otherwise	0.21 (0.41)	0.20 (0.40)	0.8627
Academic degree	1 for respondents with an academic degree, 0 otherwise	0.77 (0.42)	0.80 (0.40)	0.6105
Employed full-time	1 for respondents employed full-time, 0 otherwise	0.54 (0.50)	0.61 (0.49)	0.3194
Income	Respondent's household net monthly income in PLN[a]	6,443.46 (4,931.42)	6,034.43 (4,357.09)	0.9811
	Comprehension and decision certainty			
Forest: Sufficient information	Response to the statement "I had sufficient information to indicate well the amount in the forest planting question" on a Likert scale from 1 ("definitely no") to 5 ("definitely yes")	4.50 (0.77)	4.21 (0.91)	0.3155
Energy: Sufficient information	Response to the statement "I had sufficient information to indicate well the amount in the solar panels question" on a Likert scale from 1 ("definitely no") to 5 ("definitely yes")	3.50 (1.31)	3.65 (1.22)	0.1947
Forest: Certainty	Declaration of a respondent's certainty regarding the chosen amount on a Likert scale from 1 ("totally uncertain") to 5 ("totally certain")	4.42 (0.79)	4.53 (0.78)	0.5222
Energy: Certainty	Declaration of a respondent's certainty regarding the chosen amount on a Likert scale from 1 ("totally uncertain") to 5 ("totally certain")	3.73 (1.08)	3.62 (1.11)	0.4547
Comprehension	Response to the statement "I understood the study instructions" on a Likert scale from 1 ("definitely no") to 5 ("definitely yes")	3.80 (0.43)	3.47 (0.73)	0.0028
Choice-matching comprehension	Response to the statement "I understood how the amount given to the foundation 'Forest Forever' was determined in the second [choice-matching] draw" on a Likert scale from 1 ("definitely no") to 5 ("definitely yes")	---	4.32 (0.87)	---
Response time	Response time for the whole survey in minutes	9.86 (15.93)	15.75 (32.09)	0.0001
Sample size		100	95	

Notes: Means (and standard deviations in the brackets) are reported. P-values are for the null hypothesis of no difference between the two treatment samples with respect to a given variable. For the variables measured on a discrete scale (including the Likert-scale statements), chi-squared tests of equality of proportions are conducted. For the

variables measured on a continuous scale, the Wilcoxon signed-rank test is used to evaluate significance of the difference.

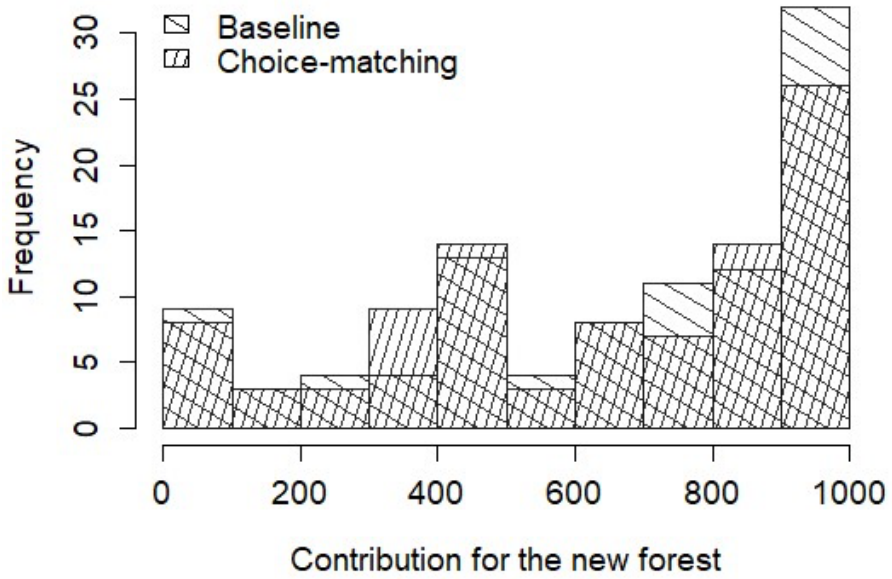
[a] Respondents were asked about their household income in an open-ended question. If they rejected providing an answer (67 respondents), they were directed to the same question with a discrete response scale, where the choice options represented different income intervals. 46 respondents stated their income in the close-ended discrete scale question. For these respondents, mid-points of the selected intervals are considered here.

We also do not observe any significant differences across the treatments in the respondents' views on whether the provided information was sufficient for them to make decisions and in their certainty about the choices they made. In both treatments, the respondents more often (definitely) agreed that they had sufficient information to indicate the amount in the forest planting question than in the preference elicitation about the renewable energy program. Similarly, the respondents appeared to be more certain about their indicated values in the forest planting question than in the renewable energy preference elicitation, regardless of the treatment.

The only statistically significant differences across the treatments, as shown in Table 1, emerge with respect to the self-reported comprehension of the study instructions and the survey response time. While respondents in both treatments appear to have a good understanding of the instructions, the major difference appears in the respondents' selections of "definitely yes" and "rather yes" answers to the statement "I understood the study instructions". Specifically, in the baseline treatment, 81% of the respondents definitely understood the instructions and 18% rather understood. In turn, in the choice-matching treatment, 58% of the respondents definitely understood the instructions and 35% rather understood.

The reported contributions for planting the forest are similar across the treatments, as expected because the survey scripts did not differ up to the point of this elicitation. On average, the baseline-treatment respondents selected 690 PLN as a contribution for the forest and the choice-matching-treatment respondents indicated 668 PLN. The distributions of the amounts across the treatments are not statistically different according to the result of the Wilcoxon signed-rank test (p-value = 0.643 for the null hypothesis of no difference). Figure 1 represents the distributions of the reported contribution amounts for the foundation "Forever Forest" and illustrates high similarity of the responses across the treatments.

Figure 1. Distributions of the contribution amounts for planting the forest in the two treatments



4 Results

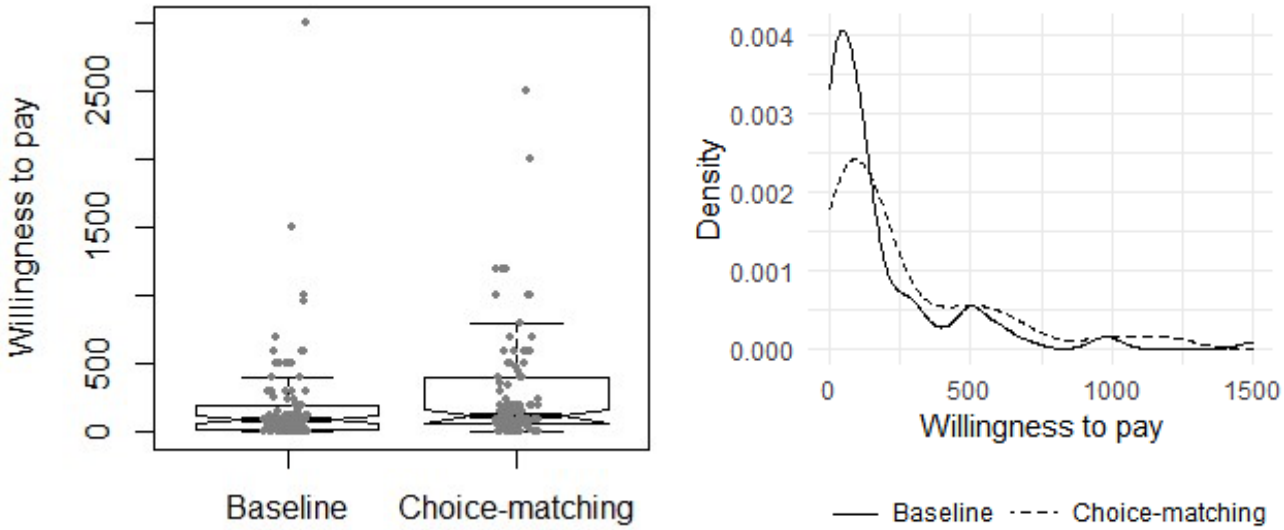
The empirical analysis is focused on whether stated preference responses are affected by the choice-matching treatment as compared to the baseline treatment. The choice-matching treatment provides incentives for truthful preference disclosure, while the baseline treatment does not and mirrors a common application of stated preference methods. The stated preference responses come from the open-ended question about willingness to pay for extending renewable energy infrastructure in Warsaw.

4.1 Statistical analysis

The open-ended willingness-to-pay responses range from 0 to 3,000 PLN, with a median of 100 PLN in the baseline treatment and 120 PLN in the choice-matching treatment. As shown in the left-hand side of Figure 2, the "middle" 50% of the responses (corresponding to the interquartile range) lies between 20 and 200 PLN for the baseline treatment and between 60 and 400 PLN for the choice-matching treatment. The left-hand side of the figure also suggests several outliers (represented by the dots illustrating individual responses), in particular, statements of 3,000 PLN in the baseline treatment and of 2,000 and 2,500 PLN in the choice-matching treatment. Upon

excluding these outliers for a clearer image, the right-hand side of Figure 2 demonstrates the Kernel densities of the responses, separately for each treatment. The figure displays that lower willingness-to-pay values are more common in the baseline treatment and higher willingness-to-pay statements appear more often in the choice-matching treatment. The result of the Wilcoxon signed-rank test indicates a statistically significant difference in the distributions of the stated willingness-to-pay amounts across the treatments (p-value = 0.006 for the null hypothesis of no difference).

Figure 2. Distributions of the willingness-to-pay amounts for the renewable energy program in the two treatments



The Kernel density estimates presented in Figure 2 also suggest that the distribution of the high willingness-to-pay responses particularly in the baseline treatment may be characterized by concentration around prominent numbers (Albers and Albers 1983), such as 500 PLN or 1,000 PLN. Although few observations in this treatment represent such high willingness to pay (as shown by the dots in the boxplots in Figure 2), we verify whether respondents in the treatments differ in the frequency of using prominent or round numbers for the value statements.

Following the definitions in Converse and Dennis (2018), we refer to round numbers as those with one digit only or dividable by 10 and to prominent numbers as "the powers of ten, their

doubles, and their halves […ˆ5, 10, 20, 50, 100, 200…]".[9] Their findings suggest that focusing on prominent numbers may be employed as a mental shortcut by individuals who experience high cognitive load in making decisions. As the cognitive load appears to be slightly higher in our choice-matching treatment (cf. Table 1), respondents might more often use decision simplification strategies in this treatment.

The data analysis indicates that the shares of prominent and round numbers in the responses to the willingness-to-pay question do not appear to differ across the treatments. Prominent numbers are selected by 46% of the respondents in the baseline treatment and 52% of the respondents in the choice-matching treatment (46 and 49 respondents, respectively). Round numbers appear in the answers of 81% of the respondents in the baseline treatment and 87% of the respondents in the choice-matching treatment (81 and 83 respondents, respectively). Chi-squared tests do not indicate any significant differences in these proportions across the treatments. In the spirit of conclusions by Converse and Dennis (2018), these results may contribute to the evidence that the behavior of focusing on prominent (and round) numbers is similarly common in incentivized as well as non-incentivized decision contexts.

In order to estimate mean willingness-to-pay values in the two treatments and to further condition them on the respondents' characteristics, we now turn to econometric modelling.

4.2 Econometric analysis

The open-ended preference elicitation question provides a continuous measure of respondents' willingness to pay. The data could be viewed as left-censored at zero, as only non-negative values were allowed in the questionnaire (although negative willingness to pay is theoretically possible here). In the study sample, 16 respondents indicated the value of zero, which may signal negative willingness to pay—11 in the baseline treatment and 5 in the choice-matching treatment. To account for the left-censoring, we consider a censored regression—a Tobit model (Tobin 1958)—for econometric modelling of the open-ended value statements.

[9] Formally, both types of numbers can be represented by $n10^i$, where (a) for round numbers, i is any non-negative integer and n is any integer {1, ..., 9}, and (b) for prominent numbers, i is any non-negative integer and n is 0.5, 1 or 2 (with the exception that for i = 0, n can be only 1 or 2).

Formally, the model can be represented by

$$WTP_i^* = x_i\beta + \varepsilon_i, \tag{1}$$

$$WTP_i = \begin{cases} 0 & \text{if } WTP_i^* \le 0 \\ WTP_i^* & \text{if } WTP_i^* > 0 \end{cases}, \tag{2}$$

where WTP_i stands for the observed willingness to pay, that is, respondent i's answer to the value elicitation question; WTP_i^* is the respondent's uncensored willingness to pay; x_i denotes a row vector of explanatory variables; β is a column vector of unknown parameters to be estimated; and ε_i is a normally distributed error term with zero mean and variance σ^2.

The model is estimated with the maximum likelihood method. Setting $D_i = 1$ if a response is uncensored (that is, a positive value statement) and $D_i = 0$ if a response is censored (that is, a zero value statement), the log-likelihood function for the model is:

$$\log L = \sum_{i=1}^{N} \left\{ D_i \cdot \log\left[\frac{1}{\sigma} \phi\left(\frac{WTP_i - x_i\beta}{\sigma} \right) \right] + (1 - D_i) \cdot \log\left[1 - \Phi\left(\frac{x_i\beta}{\sigma} \right) \right] \right\}, \tag{3}$$

where ϕ and Φ represent the probability density function and the cumulative distribution function of the standard normal distribution, respectively. As a result, the first term in equation (3) corresponds to the log-likelihood for the uncensored, observed data and the second term is related to the log-likelihood for the censored data.[10]

Results of the willingness-to-pay Tobit regressions, together with the estimated marginal effects, are provided in Table 2. Model 1 focuses on a sole effect of the treatment version (expressed with the zero-one-coded treatment indicator variable "Choice-matching"), and Model 2 includes additional explanatory variables capturing observable heterogeneity in the willingness-to-pay statements related to the respondents' characteristics and their perceptions about the valuation question. "Certain about the chosen amount" is equal to 1 for the respondents certain or totally certain about their chosen amount in the willingness-to-pay question. "Sufficient information"

[10] While the modelling approach discussed here assumes homoscedasticity, meaning that the error variance σ^2 is constant, some studies recommend accounting for potentially different error variances when preference data from different experimental treatments is jointly used (e.g., Haab et al. 1999). Results of Tobit models allowing the error variances to vary across our two treatments are presented in Appendix Table A1. We do not observe the error variance to differ statistically significantly across the treatments, and this is why a simpler, homoscedastic model is used for the main analysis.

takes the value of 1 for the respondents who (definitely) agree with the statement "I had sufficient information to indicate well the amount in the solar panels question" and 0 otherwise. Variables "Reduce car use", "Select eco-products" and "Recycle paper" are equal to 1 for the respondents (definitely) agreeing with a corresponding sentence and 0 otherwise. The respective sentences are as follows: "I limit the car/taxi use for environmental reasons", "I choose products labeled as eco-conscious", and "I recycle paper at home". The socio-demographic variables are used as defined in Table 1.

Results from both model specifications imply that the willingness-to-pay statements are statistically significantly higher in the choice-matching treatment than in the baseline treatment—the variable representing the choice-matching treatment is statistically different from zero at 1% significance level. The willingness to pay for the proposed extension of the renewable energy infrastructure is larger in choice-matching on average by 84 PLN according to Model 1 and by 97 PLN according to Model 2. Taking into account the standard errors of the two estimates, they are statistically indistinguishable.

Model 2 further demonstrates that several pro-environmental behaviors correlate with the willingness-to-pay statements. Specifically, the respondents who declare that they reduce their car use for environmental purposes and that they select ecologically labeled products are willing to pay on average by 87 PLN and 91 PLN, respectively, more for the proposed program. In turn, those who recycle paper at home are characterized by willingness to pay lower by 147 PLN on average. Other of the considered characteristics of the respondents do not appear to explain the variation in the willingness to pay in a systematic manner.

Table 2. Results of willingness-to-pay Tobit regressions

	Model 1		Model 2	
	Coefficient (st. err.)	Marginal effect (st. err.)	Coefficient (st. err.)	Marginal effect (st. err.)
Choice-matching	119.38** (60.08)	84.41** (42.55)	135.92** (59.25)	96.93** (42.34)
Certain about the chosen amount			1.23 (61.89)	0.88 (44.14)
Sufficient information			-4.97 (61.09)	-3.54 (43.57)
Reduce car use			121.93* (65.96)	86.95* (47.13)
Select eco-products			127.41** (62.42)	90.86** (44.61)

Recycle paper		-206.20***	-147.05**
		(79.28)	(56.76)
Age		-3.54	-2.52
		(6.95)	(4.96)
Female		13.56	9.67
		(63.29)	(45.12)
Academic degree		26.49	18.89
		(76.93)	(54.87)
Intercept	167.76***	271.46	
	(42.18)	(211.01)	
Logarithm of σ	6.03***	5.99***	
	(0.05)	(0.05)	
Log-likelihood	-1,347.11	-1,340.41	

Notes: Standard errors are given in the brackets. ***, ** and * imply significance at the 1%, 5% and 10% level, respectively. Both models are based on 195 observations.

5 Discussion

The purpose of this section is to shed some light on the validity of the results presented above. A natural question is whether the value estimates obtained from the choice-matching represent the true preferences of the respondents better than the estimates derived from the baseline-treatment data. Our experimental environment does not allow us to assess this directly, as we do not know the true preferences. Instead, we elaborate on the validity by considering if the necessary assumption for choice-matching is met in our data (that is, the assumption of a positive perceived correlation between the main and auxiliary questions) and if the finding of an increase in the willingness-to-pay amounts upon the incentivization appears to be justified in the literature context.

5.1 Are willingness-to-pay and contribution amounts positively correlated?

In the context of our application, for the incentives in choice-matching to be truth-inducing, a respondent needs to perceive that indeed those who report similar willingness-to-pay amounts for the renewable energy program indicate similar contribution amounts for the new forest. While the data supports the positive correlation between the two amounts, the essential question is whether respondents view this correlation as likely—the perceptions determine the incentive compatibility of the approach.

For this reason, we conduct a separate, brief survey to verify if the perceptions of the correlation are consistent with the required assumption. In this survey, we describe the willingness-to-pay and contribution questions using, where possible, the identical scripts as in the original study. We tell respondents that they will not answer these questions, but they are asked to predict how other respondents, from the same panel, replied to these questions in a study that was already completed. For correctly predicting the relationship observed in the empirical data, the respondents enter a random draw to win 50 PLN. Upon providing all this information, the question is the following (boldface as in the survey):

"Please consider if you expect any relationship between answers to the two questions. From the scenarios below, select the one that appears as most likely to you. Among these individuals, who indicate the correct scenario, we will randomly draw four persons and each of them will receive 50 PLN.

a) Those respondents who gave **more** money for the forest also gave on average **more** money for the solar panels.
b) Those respondents who gave **more** money for the forest also gave on average **less** money for the solar panels.
c) There was no relationship between answers to these two questions."

Two versions of the questionnaire are implemented. One version involves the full description of the choice-matching mechanism (as in the original survey), directly explaining that the contribution amount paid by a selected respondent was determined by the mean of the contribution amounts indicated by other respondents of the same type. The other version omits the detailed description and instead only informs that: "The study employed a special mechanism whereby it was in the best interest of the respondents to provide the amount they would really be willing to pay for the considered program of building the solar panels."

The survey was administered to 166 respondents from the same panel as the original sample in October and November 2021. It was assured that the respondents from the main study did not participate in this follow-up survey.

In both survey versions, the most often selected prediction of the relationship is the scenario indicating a positive correlation. This answer option is selected by 54% of the respondents in the survey version with the abbreviated description of the choice-matching mechanism and by 50% of the respondents in the version with the complete description. 25% and 29% of the respondents,

respectively, choose the answer with the opposite relationship, and the remaining individuals predict no relationship. This may serve as a suggestive evidence that on average respondents in our main survey are likely to expect the positive correlation to take place. No questions for a similar assessment are included in our main survey in order not to raise any doubts in respondents about the credibility of the employed incentivization mechanism.

5.2 Is it justified to observe an increase in the willingness to pay upon choice-matching?

The finding from our empirical data analysis points to the willingness-to-pay value statements being statistically significantly larger in choice-matching than in the typical, non-incentivized survey environment. This can lead to an obvious consideration about the results' validity, given the prevalent evidence that these are typically the hypothetical conditions that generate high value estimates compared to biding, real-payment settings (e.g., Penn and Hu 2018). To address this, we present arguments below demonstrating that the finding of increased open-ended-based willingness-to-pay estimates upon choice-matching aligns well with the existing theoretical and empirical literature.

The main difference between our two treatments is that one (choice-matching) provides detailed information about the mechanism of using the data, while the other one (baseline) does not. At the same time, the provision of this information does not change the nature of the stated preference elicitation question, which remains hypothetical across the two treatments. Hence, hypothetical-bias considerations might not be entirely applicable to our research context. The examination does not involve a comparison as commonly conducted in studies of hypothetical bias, where hypothetical and binding willingness-to-pay amounts are elicited. In our setting, neither of the willingness-to-pay responses is tied to the actual payment.

Our finding of increased willingness to pay upon the application of choice-matching to the open-ended elicitation mirrors the finding of Vossler and Holladay (2018), which we view as the investigation most closely related to our study. The authors identify conditions under which an open-ended preference elicitation format is incentive compatible. In a stated preference survey in the field, they implement the theory-driven incentive-compatible open-ended elicitation and compare its results to the estimates from a standard open-ended preference elicitation, which does not provide incentives for truthful preference disclosure. The structure of their study is similar to

ours as they also compare open-ended willingness-to-pay responses across incentive and non-incentivized settings, where the only difference between the two is the provision of information about the way how the open-ended responses will be used. Thus, the difference between the treatments lies in using an incentive-compatible mechanism versus not, and in both treatments Vossler and Holladay (2018) observe individuals who believe and who do not believe in actual consequences of the survey responses for policy making (that is, both treatments include hypothetical and consequential value statements). Similarly to us, the authors observe higher willingness-to-pay estimates from the survey version with the theory-informed incentive-compatible mechanism than from the version without this mechanism. This provides empirics-based support that the provision of information on the mechanism for the data use can yield increased value statements in the open-ended elicitation. This may signal that varying the provision of information about the data use mechanism can lead respondents to different considerations than those arising in hypothetical-bias studies. Finally, Vossler and Holladay (2018, p. 144) conclude "That the standard [open-ended] elicitation yields lower values [compared to the theory-driven, incentive-compatible preference elicitation] is consistent with the stylized fact from the literature."

On a theory side, Carson and Groves (2007) discuss various considerations that respondents in an open-ended contingent valuation survey may face when they are not explained how the stated preference data will be used. This discussion indicates that several conjectured interpretations of the mechanism of the data use can encourage understatement of the true willingness to pay.

Following Carson and Groves (2007), let us consider a respondent in an open-ended contingent valuation survey who has some guess about a possible individual cost for the considered good. If the respondent perceives the cost to be greater than the respondent's willingness to pay, the person may be incentivized to underreport the true willingness to pay and state a zero amount. Stating zero is simple, does not require effort to figure out one's true willingness to pay, and may reduce the probability of having the good delivered and the cost levied if the decision mechanism relies on the sum of stated willingness-to-pay amounts. In turn, if the willingness-to-pay statements are used to determine the cost per individual, then the zero statement can lower the (viewed as high) cost. Thus, Carson and Groves (2007, p. 202) conclude that the optimal response for individuals with willingness to pay smaller than the perceived cost is zero "under most plausible uses of the information provided." The optimal response strategy for those with willingness to pay greater than the perceived cost depends on individuals' beliefs how the willingness-to-pay

statements will be used in the decision-making. If the sum of the stated amounts is used to determine whether to provide the good or not, then it may pay off to overstate the true willingness to pay. In turn, if the reported amounts are seen as an indication for setting the required cost, then the value understatement may appear as the best response strategy.

As presented with the above referenced empirical evidence and theoretical considerations, the existing literature appears to provide support for the increase in the willingness to pay upon choice-matching to be potentially valid. However, we acknowledge that the cleanest test of validity would involve a comparison of the elicited preferences to the true preferences (e.g., via an induced-value experiment).

6 Conclusions

In this study, we present an empirical application of the choice-matching approach (Cvitanić et al. 2019), proposed in theory to incentivize truthful responding in conditions when the truth is not verifiable. We illustrate the use of the approach for a stated preference survey and examine how respondents behave upon facing this approach in comparison to behavior in a usual, non-incentivized survey setting.

Our preference elicitation involves an open-ended question concerning willingness to pay for extending renewable energy infrastructure in Warsaw with new solar panels. Both statistical and econometric data analysis, involving Tobit regressions, point to the willingness-to-pay value statements being statistically significantly larger in choice-matching than in the non-incentivized survey conditions. This finding aligns with earlier empirical evidence that a standard open-ended format without a mechanism incentivizing truthful responding leads to understating true willingness to pay (Vossler and Holladay 2018), as well as with theoretical considerations that willingness-to-pay understatement might be the best response strategy in an open-ended elicitation not explaining the further data use (Carson and Groves 2007). Together with our respondents' self-reports that they understood the study instructions, this provides suggestive evidence that respondents comprehended the choice-matching procedure in our application and, thus, are likely to have answered in line with the economic incentives. However, we acknowledge that we do not have an objective measure of truthfulness of the stated preferences. This could be obtained, for example, with an induced-value experiment. Instead, the intention of this study is to capture as

closely as possible typical characteristics of the stated preference methods' application environment as present in the field.

The use of incentive-compatible designs, providing respondents with economic incentives to answer survey questions truthfully, is recommended for stated preference studies (Johnston et al. 2017). Design characteristics assuring incentive compatibility have been put forward for a range of preference elicitation formats, including the single binary choice, repeated binary choice, payment card and open-ended question (references given in the introduction). One of the characteristics underlying incentive-compatible elicitation with any of these formats is consequentiality, which implies that respondents' answers are not hypothetical but can potentially matter for final decisions. Against this background, a new line of research emerges (Comerford and Lades 2021), suggesting that consequential statements of preferences might be biased as a result of respondents experiencing responsibility utility: respondents in a consequential stated preference survey may feel responsible for the final decision and, thus, answer not in line with the utility they would experience when being passive recipients of policy outcomes. Comerford and Lades (2021) argue that this consideration creates a dilemma for the stated preference survey design, where one needs to weight consequences for value estimates arisen from responsibility utility versus those arisen from a non-incentivized, hypothetical setting. We believe that the choice-matching approach proposed by Cvitanić et al. (2019) and empirically operationalized in this study can provide some solution to this dilemma.

Choice-matching offers a method for incentivizing hypothetical stated preference responses, though the incentivization does not go through consequentiality. Lack of emphasis on direct policy consequences combined with linking the preference elicitation question to a monetary payoff from the auxiliary question in the choice-matching procedure may substantially weaken the role of the responsibility utility. In particular, the responsibility utility considerations can be mitigated when the auxiliary question involves decisions affecting only the individuals themselves, without any (e.g., financial) consequences for others. Such an auxiliary question is likely the most obvious and practicable for the incentivization of preference statements with choice-matching. At the same time, the choice-matching procedure provides respondents with economic incentives to truthful statements of their preferences, not leaving stated preference researchers, who intend to mitigate the possible responsibility utility bias, with a need for conducting a non-incentivized survey.

This study illustrates the applicability of the theoretically proposed approach of choice-matching (Cvitanić et al. 2019) to a typical stated preference examination in the field. In addition, the study presents a possible extension of the choice-matching use to decision settings where the response scale is not only discrete (as originally proposed) but also continuous. With this application, the paper also operationalizes the technical requirements for choice-matching and demonstrates how they could be practically implemented in stated preference surveys. This way, this study contributes to extending the range of incentive-compatible designs for stated preference elicitation. The unique feature of the choice-matching approach is that it allows for incentive-compatible elicitation of preferences in non-consequential conditions.

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Appendix

Table A1. Results of willingness-to-pay Tobit regressions allowing for the variance heteroscedasticity across the treatments

	Model 1 Coefficient (st. err.)	Model 2 Coefficient (st. err.)
Choice-matching	117.72* (60.15)	133.64** (59.39)
Certain about the chosen amount		-1.87 (61.92)
Sufficient information		-1.96 (61.13)
Reduce car use		120.81* (65.95)
Select eco-products		129.01** (62.32)
Recycle paper		-203.52** (79.04)
Age		-3.53 (6.95)
Female		17.09 (63.37)
Academic degree		23.61 (76.99)
Intercept	168.91*** (40.92)	270.44 (210.40)
Standard deviation function (σ)		
Choice-matching	0.06 (0.11)	0.06 (0.11)
Constant	5.99*** (0.08)	5.96*** (0.08)
Log-likelihood	-1,347	-1,340

Notes: Standard errors are given in the brackets. ***, ** and * imply significance at the 1%, 5% and 10% level, respectively. Both models are based on 195 observations.

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