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Simultaneous Effect of Monetary and Non-Monetary Interventions on Crowd-Funding Field Experimental Evidence: R&D in New Sources of Energy

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Synergy between Monetary and Non-Monetary Interventions:

Experimental Evidence on Crowd-Funding for R&D in New Energy Sources

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Abstract:

Crowd funding is a well-known way of financing research and development (R&D). Conducting a randomized control trial online field experiment, we investigated which participants donated toward the R&D of new energy, and which of three interventions facilitate donation: "matching", "social pressure" and "matching & pressure". Results indicate that: (1) all interventions significantly increase the donation rate, (2) the interventions have a heterogeneous effect based on gender and age, (3) the crowding out of "matching" was observed only for the participants with high intrinsic motives, and (4) the sub-additive synergy between interventions was observed only for participants with low intrinsic motives.

Keywords: Online Field Experiment; Donation; Matching Fund; Social Pressure; Crowding out

JEL codes: C72, C93, D64

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1. Introduction

Professor Shinya Yamanaka of Kyoto University, who won the Nobel Prize for medicine in 2012 for the discovery of iPS cells, called for donations to the Center for iPS Cell Research and Application on condition that he completed the Kyoto Marathon, and finally raised more than 10 million JPY.[1] Such crowd funding has recently attracted attention as an alternative method to traditional fundraising, such as soliciting donations on the street. Crowd funding is particularly applied to solicit funds for non-profit organizations (List, 2011).

Among a lot of the research and development (R&D) projects, a next-generation power plant is very important in recent Japan. After the Great East Japan Earthquake and the Fukushima Dai'ichi nuclear power plant accident in March 2011, Japan has explored a reasonable next-generation power plant. However, due to the financial difficulties of governments and power plant companies, attempts were initiated to obtain a part of the research and development (R&D) funding through private sector donations.

In this paper, we focused on the R&D of a next-generation space power plant and conducted an online field experiment on crowd funding. Such power plant is highly expected as one of the next-generation power plants. Setting the R&D of this power plant as the donation target, we investigated the condition that facilitates the donation rate.

We applied a Randomized Control Trial (RCT) to the online field experiment and ascertain the conditions promoting crowd funding. In RCTs, participants are randomly assigned to one of the treatments. Only the differences in treatment interventions explain the difference in participants' behavior between treatments. An RCT guarantees the internal validity of the treatment effects and

[1] See http://www.cira.kyoto-u.ac.jp/j/pressrelease/other/170210-150000.html.

has become one of the main approaches in empirical research on donating behavior.

We introduced three types of interventions appeal to the motives of people and elicit pro-social behavior under crowd funding.

The first is a non-monetary intervention (pressure). The disclosure of others' donation amount not only provides information about the recipient, but also exerts social pressure on those who donate.[2] Croson and Shang (2008), Croson, Hardy, and Shang (2009), and Shang and Croson (2009) conducted field experiments on the effect of social pressure on donating behavior to increase donations to radio stations in the United States. When the donation amount by others is disclosed, social pressure could be alleviated by increasing one's own donation; therefore, people donate more.[3]

The second includes monetary interventions, for example tax exemptions for the donation rate (Peloza and Steel,2005), "matching" of the donation rate by third parties,[4] and adding seed money at the startup of donations (Chen et al., 2006; Karlan and List,2007; Meier,2007; Rondeau and List, 2008; Huck and Rasul, 2011).

The third refers to simultaneous non-monetary and monetary interventions. Ariely, Bracha, and

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[2] Vesterlund (2003) demonstrated theoretically that the disclosure of the amount donated by others increases donation behavior. Smith, Windmeijer, and Right (2015) find from a natural experiment that the peer effect affects the donation amount.

[3] In experimental dictator games, participants donate more to reduce social pressure (Duffy and Kornienko, 2010; Krupka and Weber, 2009).

[4] "Matching" means that a third party adds a certain amount of money according to the "matching rate" to the donation amount by the participants. "The matching rate is *x* percent" means that the third party sends *x* percent of the donation amount to the recipient.

Meier (2009) introduced disclosure of one's own donation rate to others (image effect[5]), and monetary intervention by the matching fund. They showed that whether the monetary intervention crowded out the image effect depends on the donation target.[6]It implies that the interactions between these interventions are complicated, and further research is required.

Our participants were required to donate a part or all the endowment that they acquired through a calculation task. They were assigned to above mentioned one of the groups ("pressure", "matching", "matching & pressure" or "control").

Our study has three progresses in the literature. First, this is the first study that investigated the effect of simultaneous interventions ("matching & pressure") on donating behavior through RCTs. Second, this is the first study to investigate these intervention effects among generations and by gender. Third, this is the first study that introduced the performance pay into Internet surveys, this introduction encourages more accurate expression of the preferences of participants. These progresses contribute to the further elucidation of donating behavior.

The structure of this article is as follows. In Section 2, the hypotheses to be verified in this experiment are introduced, based on prior studies. In Section 3, the design and environment of the experiment are explained. The experimental results are provided in Section 4 and are discussed in Section 5. Section 6 concludes the article.

2. Theory and Hypotheses

[5] Bénabou and Tirole (2006) built a theoretical model of image effect generated by the observation of the third person.

[6] Deci, Koestner, and Ryan (1999) and Frey and Oberholzer-Gee (1997) discussed the possibility that monetary interventions crowd out the intrinsic motives of people.

To investigate donating behavior for the R&D funding of a next-generation space power plant with an online field RCT experiment, participants were randomly assigned to the "matching", "pressure", "matching & pressure" or "control" groups. In the "matching" group, there was a 100 percent match wherein the experimenter donated the same amount as the donation. In the "pressure" group, social pressure was imposed by notifying participants that others had donated all the endowment. In the "matching & pressure" group, 100 percent matching and pressure were undertaken simultaneously (see Section 2.3 for a description of the experimental procedure).

2.1. Conceptual Model

We explain the conceptual framework behind the behavioral predictions for donation in each group, based on dictator's utility maximization problem (see Appendix A for detail). There are three differences between the game applied in this study and the standard dictator games. (1) The initial endowment was determined by the number of correct answers in a calculation task presented in advance, such as in Hoffman et al. (1994), Cherry, Ferykblom, and Shrogen (2002) and Ogawa et al.(2012); (2) in the "matching" and "matching & pressure" groups, the donation amount was doubled and sent to a recipient; (3) participants in the "pressure" and "matching & pressure" groups were notified that some participants donated all the endowment.

The following equation expresses the utility function

$$\mathrm{U}(x_i) = \Big((\mathrm{m}+1)v_{d,m}^{i}x_i + v_{y}^{i}(1-x_i)\Big) \times 20a_i - \mathrm{C}(a_i) + S(x_i, x_{-i}=1) \tag{1}$$

a_i and $a_i \times 20$ represent the number of correct answers in the calculation task and the amount of initial endowment, respectively. $\mathrm{C}(a_i)$ represents the cost for attaining a_i; x_i is the rate of allocating the initial endowment as donation; and $v_{d,m}^{i}$ represents the utility of one unit of donation.

The variable m is 1 in the "matching" and "matching & pressure" groups, otherwise 0. It is assumed that$v^i_{d,m=0} > v^i_{d,m=1}$, which demonstrates the crowding-out of endogenous motives by presenting a monetary incentive. v^i_y represents the utility of 1 JPY, and $S(x_i, x_{-i} = 1)$ represents the disutility level of pressure caused by being notified of the existence of the participant donating all the endowment. $S(x_i, x_{-i} = 1)$ is an increasing function of $x_i$thathas a negative value in the "pressure" and in "matching & pressure" groups, and 0, otherwise. The following equation shows the marginal utility:

(2) $$\frac{\partial U(x_i)}{\partial x_i} = \left((\mathrm{m}+1)v^i_{d,m} - v^i_y\right) \times 20a_i + \frac{\partial S(x_i, x_{-i}=1)}{\partial x_i}$$

The player whose $v^i_{d,m=0}$ $(2v^i_{d,m=1})$ is higher than v^i_yhas a positive marginal utility and chooses$x_i = 1$ in the "control" or "pressure" group ("matching" or "matching & pressure" groups).

First, the utility maximization conditions in the "control" and "matching" groups were compared. Because the second term of equation (2) is set to 0 in both groups, only the first term differs. If and only if $v^i_{d,m=1} \leq v^i_{d,m=0} < 2v^i_{d,m=1}$ holds, the marginal utility in the "matching" group is larger than in the "control" group. Thus, the effect of crowding out is smaller than halving $v^i_{d,m=0}$. The donation rate in the "matching" group is expected to be higher than in the "control" group.

Second, the utility maximization conditions in the "control" and "pressure" groups were compared. The first term in equation (2) has the same value in both groups. The second term of equation (2) is 0 and positive in the "control" and "pressure" groups, respectively. Thus, the marginal utility in the "pressure" group is higher than in the "control" group. The donation rate in the "pressure" group is expected to be higher than in the "control" group.

The same argument holds for comparison between the "matching" and "matching & pressure" groups. Because the marginal utility in the "matching & pressure" group is higher than in the "matching" group, the donation rate in the "matching & pressure" group is expected to be higher than in the "matching" group.

2.2. Hypotheses

Hypothesis 1 relates to the effect of monetary intervention on donations for which the target amount is not set.[7] Karlan and List (2007) employed an RCT and found that the introduction of "matching" funding significantly increases the donation rate to non-profit organizations. Meier (2007) demonstrated that matching funding significantly increases the donation rate immediately after an intervention. Based on these results, we submit Hypothesis 1:

Hypothesis 1: The "matching" group donates significantly more than the control group.

The theoretical background is shown in Appendix A and the illustrative explanation is given in Subsection 2.1.

Hypothesis 2 investigates the pressure effects. Prior studies found that disclosing the donation amounts of other participants affects donating behavior.

Croson and Shang (2008), Croson, Hardy, and Shang (2009), and Shang and Croson (2009) showed that if the donation amount of other participants is disclosed, participants donate closer to

[7] When the target total amount is not set, matching increased the donation amount significantly (Huck and Rasul, 2011).

the disclosed one[8]. Alpizar, Carlsson, and Johansson-Stenman (2008) found that the higher the notified donation amount of other park visitors to the management and maintenance of nature parks, the higher the donation.

Our participants were provided with the information that some participants have donated all the endowment, before they decided the donation amount. This represents social pressure on participants. Based on the results of prior studies, we submit the following hypothesis on the effects of social pressure.

Hypothesis 2: The "pressure" group donates significantly more than the control group.

The theoretical background is shown in Appendix A and the illustrative explanation is given in Subsection 2.1.

Finally, we focus on the simultaneous intervention effects of "matching & pressure". As

[8] In an RCT, social pressure also promotes prosocial behavior other than donation. Chen et al. (2010) found that disclosing the number of movie reviews by other users increased the number of reviews by the reviewer whose number is smaller than the average by online field experiments using a review site. Ferraro and Price (2013) conducted RCT field experiments to save water and found that receiving the comparative information on water service usage fee of neighbors significantly decreases the fee of the person. Margetts et al. (2011) conducted an online field experiment on the signature to a political activity and revealed that more people signed to the activity to which a lot of people had already signed. Allcott, H. (2011) revealed that, investigating electricity consumption in a natural field experiment, comparing power usage with neighbors strongly encourages energy savings for households with high power consumption before intervention.

mentioned before, only Ariely, Bracha, and Meier (2009) verified this kind of intervention with RCTs, although their intervention method is different from ours. They investigated the effects of monetary and non-monetary interventions for two donation targets, the National Rifle Association (hate) and the Red Cross (good).[9]Disclosing a participant's donation amount to others is their non-monetary intervention. This may lead participants to increase the donation amount to improve their image. Their monetary intervention of offering monetary reward depends on the donation amount. In the good target case, if there was an image effect, adding a monetary intervention did not significantly increase the donation amount.

The effects of monetary and non-monetary interventions depend on the interactions between the intrinsic and extrinsic motives of participants. Even if one of the interventions differs from prior studies, there is no guarantee that the same results as existing studies will be obtained. Thus, it is difficult to derive hypotheses directly from the results of the existing studies. It is a research consideration whether simultaneous monetary and non-monetary interventions elicit more donations than the control group.

Research consideration 1: Does the donation rate of the "matching & pressure" group differ from the control group?

Additionally, we verified whether the effects of simultaneous intervention were additive. By doing so, we investigated whether the simultaneous intervention effects surpassed or fell below the sum of the separate effects of each intervention.

[9] Crumpler and Grossman (2008) and Null (2011) investigate the donating behavior to the various kinds of recipients in the laboratory.

Research consideration 2: Does the difference between the donation rates of the "matching & pressure" and the control groups differ from the sum of the difference between the "matching" and control groups, and the difference between the "pressure" and the control groups?

A theoretical explanation of these issues is provided in Appendix A.

3. Experimental Procedure

We conducted an online RCT for solicited donations for R&D for next-generation energy from April 10 to 15, 2015, through an internet survey company.[10] The donation target was the Research Institute for a Sustainable Humanosphere at Kyoto University, which conducts research on a next-generation space power plant which attracted interest after the Great East Japan Earthquake. An Internet survey company donated the total donation amount in this experiment to this institute instead of the participants. After the experiment, all participants were notified of the total donation amount by e-mail.

Figure 1 summarizes the experimental parameters. Each group has 525 participants (in total, 2,100 participants). For assigning a participant uniformly based on gender and age groups, ten groups were divided into the five age groups (20s, 30s, 40s, 50s, and 60 years old and above) and gender.

[10] The internet survey company that we used for conducting the online experiment has survey monitors with 1,120,000 enrollments providing information on basic attributes such as age, gender, and address.

<Figure 1 here>

Figure 2 shows the experimental procedure. The internet survey company requests monitors to participate in the experiment before assigning them to one of the four conditions, and the experiment is conducted only on those who willingly agree to participate. At the beginning of the experiment, participants received an explanation on the R&D of the next-generation space power plant. The explanation was based on the home page of the research agency and the explanatory materials of the Council on the Budget Request of the Country.[11] Following the explanation, participants chose their own attitude toward the R&D of the next-generation space power plant from four options (strongly oppose, oppose, approve, or strongly approve).

<Figure 2 here>

Next, participants were asked to solve ten calculation problems within ten minutes. The problem, based on Heyman and Ariely (2004), involved selecting rows or columns such that the total of the numerical values was 10 from a 3 × 4 table in which figures were displayed to the second decimal point. They received 20 JPY[12] for each correct answer.

After their endowment was confirmed, they were randomly assigned one of four groups, and decided on the donation rate. The four groups were: 1) the "matching" group; 2) the "pressure" group; 3) the "matching &pressure" group; and 4) the control group. The percentage allocated for donation is given in increments of 10 percent, from 0–100 percent. The rest of the endowment is the participant's reward.

[11] The instruction is shown in Online Appendix.

[12] At the time of the survey, 1 USD = 120 JPY.

4. Experimental Results

4.1. Attributes of the Participants

First, we confirm whether participant attributes have been assigned uniformly among groups (the balance test). Significant differences among groups were examined with respect to the participants' gender, age, years of education, marital status, number of family members, household income, the level of approval for the donation target, and the average number of correct answers to the calculation problems, respectively (Table 1). Kruskal-Wallis test indicates that all factors were not significantly different among groups.

4.2. Investigating Intervention Effects

The average donation rates (Figure 3) were 40.64, 45.50, 48.99, and 49.33 percent for the control, "matching", "pressure" and for "matching & pressure" groups, respectively.

<Figure 3 here>

The average donation rates were significantly higher in the "matching", "pressure" and "matching & pressure" groups than in the "control" group (two-sided t-test; $p<0.05$, $p<0.05$, and $p<0.01$, respectively).

This rate is not significantly different between the "matching" and "matching & pressure," and between the "pressure" and "matching & pressure" groups (two sided t-test).

Controlling participants' attributes, regression analysis investigates each intervention effect on the donation rate (Table 2). In model (1), only the group dummies are explanatory variables. In model (2), gender (female is 1, otherwise 0), age (the mean centering variable), and household

income of the participant (the mean centering variable) were employed as additional explanatory variables.

<Table 2 here>

The significance and signs of the coefficients of the group dummy were the same between models (1) and (2) (Table 2). The intervention effects were robust with respect to gender, age, and household income. All the group dummies were significantly positive; all interventions raised the donation rates.

Therefore, we focus on the details of the coefficients in model (1). The coefficient of the "matching" dummy is 4.857 ($p<0.05$): Hypothesis 1 is supported. The coefficient of the "pressure" dummy is 8.343 and is significantly positive ($p<0.001$): Hypothesis 2 is supported. The "pressure & matching" dummy is 8.686 ($p<0.001$). The simultaneous intervention raised the donation rates.

Next, we examined the differences in the coefficients of dummy variables in model (1). The difference in the coefficients of the "matching" and "pressure" dummies is not significant. In addition, the coefficients of the "matching" is not significantly different from that of "matching &pressure". Further, the coefficients of the "pressure" is not significantly different from that of "matching & pressure".

The sum of the coefficients of "matching" and "pressure" ($4.857 + 8.343 = 13.200$) is not significantly different from that of the "matching & pressure".

Next, we focus on the effects of the participant attributes on the donation rate to the next-generation space power plant. In model (2), both the gender dummy and the age variable are significantly positive ($p<0.001$, respectively). The coefficient of household income is significantly negative ($p<0.05$). These reveal that women donate more than men; the elderly donate more than

the young; and the higher the household income, the lower the donation rate is.

4.3. Participant attributes and intervention effects

To investigate whether the intervention effects differ between gender and between generations, we introduce female and old dummies. The latter dummy is 1 for participants equal to or older than 45 (the median age) and 0 otherwise. We perform regression analysis with these dummy variables and the cross terms between these variables and the treatment dummy variables.

<Table 3 here>

Model (3) in Table 3 shows the intervention effects on gender groups. The coefficient of the "matching" dummy is 3.332 (n.s.) and that of the "pressure" dummy is 4.378 (n.s.). This indicates that neither matching nor pressure increases the donation rate among male participants. The coefficient of the "matching & pressure" dummy is 6.202 ($p<0.10$). This simultaneous intervention increases their donation rate.

The coefficient of the cross term between gender and "matching" dummies is 3.529 (n.s.). The coefficient of the cross term between the gender dummy and the "matching & pressure" dummy is 4.874 (n.s.). The effects of "matching" and "matching & pressure" on the male participants are not significantly different from those on the female participants. The coefficient of the cross term between gender and "pressure" dummies is 8.210 ($p<0.10$). The intervention of "pressure" promotes the donation rate among female participants more strongly than among the male participants.

The intervention effects of "matching," "pressure," and "matching & pressure" on the female participants are 6.861 (=3.332+6.202, $p<0.05$), 12.588 (=4.378+8.210, $p<0.001$), and 11.075

(=6.202+4.874, $p<0.01$), respectively. This indicates that all interventions are effective for the female participants while only "matching & pressure" is effective for the male participants.

Model (4) in Table 3 shows the intervention effects on two different age groups (younger than 45 and older than 45). The coefficient of "matching" is 6.793 ($p<0.05$), the coefficient of "pressure" is 11.747 ($p<0.001$), and the coefficient of "matching & pressure" is 12.747 ($p<0.001$). Thus, all interventions promote donation among participants younger than 45, regardless of whether the intervention is monetary or not and single or not.

The coefficient of the cross term between the elder dummy (1 if the participants are equal to or older than 45, and 0 if otherwise) and "matching" is -3.280 (n.s.). The coefficient of the cross term between the elder dummy and "pressure dummy" is -6.341 (n.s.). The effects of "matching" and "pressure" are not different between participants younger than 45 or older. The coefficient of the cross term between the elder dummy and "matching & pressure" dummy is -8.273 ($p<0.10$). "Matching & pressure" promotes donation among participants younger than 45 more strongly than among the older participants.

The sum of the coefficients of the "matching" and of the elder × "matching" is 3.513 (=6.793-3.280, n.s.). The sum of the coefficients of the "pressure" dummy and that of the elder × "pressure" dummy is 5.406 (=11.747-6.341, n.s.). The sum of the coefficients of the "matching & pressure" dummy and that of the elder × "matching & pressure" dummy is 4.473 (=12.747-8.273, n.s.). These results indicate that all the interventions on the participants equal to or older than 45 are not significant while all the interventions are effective on the participants younger than 45.

4.4. Crowding Out and Synergy between Interventions

Here, we investigate the effect of crowding out in the "matching" (monetary intervention) and

"matching & pressure" groups. "Matching" might reduce the intrinsic motivation of participants. Whether "matching" increases the donation rate depends on the level of their intrinsic motives. Additionally, whether the effect of simultaneous intervention works more strongly than the total effect of "matching" and "pressure" depends both on the influence of "matching" on intrinsic and extrinsic motives and on that of social "pressure" on these motives. To investigate the complicated effects of two motivations, we controlled the level of intrinsic motivation of participants and the intervention effects.

"Crowding out" is defined as follows: The negative effect of "matching" on intrinsic motivation cancels out the positive effect of "matching" on extrinsic motivation, and the effect of matching disappears as a whole.[13]

Participants were asked whether they approved of research and development as the donation target. 18.19 percent of the participants (382 participants) responded "strongly approve"; 68.48 percent (1,438) responded "approve"; 11.52 percent (242) responded "oppose"; and 1.81 percent (38) responded "strongly oppose" (Table 4).

<Table 4 here>

We assumed that the more strongly the participants approved of the donation target, the higher the intrinsic motives to donate were. Introducing the cross terms of the approval and the group dummies as explanatory variables, we show the difference between the intervention effects on participants with high intrinsic motives and on participants with low intrinsic motives toward the donation target (Table 5).

[13] The total effect of "matching" is negative if the negative effect of matching on intrinsic motivation outweighs the positive effect of extrinsic motivation.

<Table 5 here>

In model (5) in Table 5, the coefficients of the “matching”, “pressure” and “matching & pressure” dummies for participants with low intrinsic motives are 19.420 ($p<0.01$), 14.826 ($p<0.05$), and10.592 ($p<0.10$), respectively.

Model (6) controlled for participant attributes. The coefficients of the “matching”, “pressure” and “matching & pressure” dummies are 21.308 ($p<0.001$), 13.831 ($p<0.05$), and 15.234 ($p<0.01$), respectively.

The sum of the coefficients of the “matching” and “pressure” dummies is 19.420 + 14.826 = 34.246 in model (3). This is significantly larger than the coefficient of the “matching & pressure” dummy ($p<0.01$). Therefore, sub-additive synergy of “matching & pressure” is observed for participants with low intrinsic motives.

<Table 6 here>

The intervention effects for participants with high intrinsic motives in model (5) in Table 5 were verified in Table 6. Because the same result is confirmed for model (6) in Table 5, the focus is on the result of model (5) in Table 5.

The intervention effects of “matching” on participants with high intrinsic motives are expressed by the sum of the coefficient of the “matching” dummy and the coefficient of the cross term of the approval and “matching” dummies. This is 19.420 − 16.590 = 2.830 in model (5) and is not significant. This confirms that matching crowds out intrinsic motives for participants with high intrinsic motives.

The intervention effects of “pressure” on participants with high intrinsic motives are expressed

by the sum of the coefficients of the “pressure” dummy and of the cross term of the approval and “pressure” dummies; 14.826 − 7.523 = 7.303 ($p<0.01$) in model (5). Therefore, the effect that “pressure” increases donations is maintained for participants with high intrinsic motives.

The simultaneous intervention effects of “matching & pressure” on participants with high intrinsic motives are expressed by the sum of the coefficient of the “matching & pressure” dummy and the coefficient of the cross term of the approval and “matching & pressure” dummy; 10.592 − 2.092 = 8.500 ($p<0.01$) in model (5). Therefore, the effect of “matching & pressure” also remains unchanged for participants with high intrinsic motives.

The synergy between interventions for participants with high intrinsic motives was investigated. In model (5), the sum of the effects of “matching” and “pressure” is 2.830 + 7.303 = 10.133 for participants with high intrinsic motives. The simultaneous intervention effects for such participants are 10.592 − 2.092 = 8.500 in model (5). The corresponding difference is 10.133 − 8.500 = 1.633 (n.s.); no synergy is observed between “matching” and “pressure” for participants with high intrinsic motives.

If participants have low intrinsic motives, all interventions increase the donation rate. Therefore, the crowding out of “matching” on intrinsic motives is not observed. However, sub-additive synergy, wherein the simultaneous intervention effects are smaller than the sum of the separate intervention effects, is confirmed.

If participants have high intrinsic motives, “matching” does not significantly increase donation. “Matching” crowded out the intrinsic motives of the participants, and the intervention effect of “matching” disappeared. In contrast, “pressure” and “matching & pressure” statistically significantly increased the donation rate. Additionally, there is no significant difference between the simultaneous intervention effect and the sum of the separate intervention effects.

Therefore, if participants have low intrinsic motives, sub-additive synergy occurs between "matching" and "pressure," while this synergy no longer occurs for participants with high intrinsic motives.

5. Discussions

We have four key findings: (1) All intervention effects significantly promote the donation rate. (2) The intervention effects are heterogeneous between gender and generations. (3) The crowding out of "matching" was observed only for the participants with high intrinsic motives. (4) The sub-additive synergy between interventions was observed only for participants with low intrinsic motives. In this section, we discuss key findings (2), (3), and (4).

"Matching" and "pressure" have a significantly positive effect only on female participants while "matching & pressure" has a significantly positive ($p<0.01$) effect on both female and male participants ($p<0.10$). All intervention effects strongly promote donation rate of female participants than that of male participants. As per Crosson and Gneezy (2009)[14] and Risco and Weber (2019),[15] female participants are more context specific than male participants. Therefore, information about peers who donated the entire amount, with 50% discount in donation by the matching fund, made female participants more willing to donate than the male participants. Consistent results were confirmed in the donation behavior toward R&D for electricity. We confirm the asymmetry of the intervention effects between genders in the donation behavior

[14] Croson and Gneezy (2009) made observations in a lab where participants were faced with an ambiguous decision-making situation.

[15] Risco and Weber (2019) investigated donation behavior in a situation without control as a natural experiment.

toward the more realistic situation of donation toward R&D for electricity.

The same asymmetries in the intervention effects are observed between young and old participants. All the interventions are significantly positive only for young participants. To the best of our knowledge, the asymmetry of the intervention effects, matching, social information, and the simultaneous intervention of these to the donation behavior between generations has been first observed in our study. This is also our contribution to the literature.

As in the case of participant attributes, the level of intrinsic motivation toward donation can be the source of heterogeneities of the intervention effects. The third finding could be because of the large room for intrinsic motives that is impeded by "matching" as a monetary intervention. By introducing "matching," it is presumed for participants with high intrinsic motives that the intrinsic motives decreased to the same extent as the level of extrinsic motives. Thus, "matching" does not have a significant intervention effect. While participants with low intrinsic motives seem to have little room to be hindered by "matching", the extrinsic motives added by "matching" exceeded the decrease in intrinsic motives. Therefore, "matching" significantly raised the donation rate.

"Matching" is (not) effective when the intrinsic motivation for the donation is low (high). Considering that the cost of "matching" depends on the total donated amount, the intervention should be avoided when the intrinsic motivation of participants is expected to be high.

Negative synergy was observed between "matching" and "pressure" for participants with low intrinsic motives. The evidence is the difference between the sum of the coefficients of the "matching" and "pressure" dummies and the coefficient of the "matching &pressure" dummy (Table 4). Dual interventions to encourage those who were opposed to the donation target may have caused psychological resistance (Brehm, 1966; Brehm and Brehm, 2013). Feeling that the simultaneous intervention of "matching & pressure" deprives them of their freedom of choice,

decreased their donation rate.

Bekkers and Crutzen (2007) and Perrine and Heather (2000) found that the intervention stimulated the psychological resistance of the participants, resulting in no positive intervention effect. Bekkers and Crutzen (2007) conducted a field experiment calling for donations to Rwanda. They found that the donation amount is not different between the cases when they send potential donors a full-color photograph of children in Rwanda, and when they do not. Perrine and Heather (2000) conducted field experiments calling for donation to activities to support the use of contraception for pets. Even when adding a message emphasizing the importance of donation in addition to a picture of the pet, the donation amount was as large as the amount when a message was not sent.

As these studies suggest, increase in the intensity of the intervention stimulates psychological resistance and raises the possibility that the intervention effects are offset. In our study, simultaneous interventions might stimulate the psychological resistance of those who opposed the R&D of the donation target. As a result, sub-additive synergy was observed for these participants.

6. Conclusions

We conducted an online RCT experiment, in which donations were solicited for the R&D of a next-generation space power plant. The effects of “matching”, “pressure”, and the simultaneous interventions of “matching & pressure” were investigated.

We find that all interventions increased the donation rate by pooling all the participants. All the intervention effects were found to be stronger on the female participants than on the male participants; likewise, younger participants were more receptive to the interventions than the older participants. The simultaneous intervention effect was not different from the total effect of

individual interventions; no synergies were observed.

Controlling for the intrinsic motives to donate, all interventions for participants with low intrinsic motives are significantly positive. However, a sub-additive synergy was found between interventions for participants with low intrinsic motives. This follows because an increase in the intervention intensity for participants with low intrinsic motivation led to the emergence of psychological reactance (Brehm, 1966; Brehm and Brehm, 2013) for such participants.

Crowding out of monetary intervention was also found for participants with low intrinsic motives. Although the intervention effect of "pressure" is lower for participants with high intrinsic motives than with low intrinsic motives, the intervention effect is still significantly positive for high intrinsic motives. However, the effect of "matching" is not significant for participants with high intrinsic motives, and crowding out of "matching" was observed for participants with high intrinsic motives.

No sub-additive synergy occurred between interventions for participants with high intrinsic motivation, and simultaneous intervention increased the donation rate to the same degree as the sum of the separate interventions.

These results suggest that an efficient combination of interventions depends on the preferences of individuals with respect to donations. If intrinsic motives are low, only a single intervention of "matching" or "pressure" is effective. On the other hand, if intrinsic motives are high, simultaneous "matching & pressure" interventions facilitate donation more than any single intervention.

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Tables and Figures

	Gender	Age	Years of education	Marital status	The number of persons living together	Household income	The attitude toward the donation target	The number of correct answers in the calculation problems
Control group	0.501	44.808	14.490	0.594	2.895	2.678	1.964	7.175
	(0.021)	(0.609)	(0.087)	(0.021)	(0.057)	(0.068)	(0.026)	(0.136)
Matching group	0.499	44.570	14.678	0.571	2.878	2.756	1.994	7.253
	(0.021)	(0.606)	(0.087)	(0.021)	(0.058)	(0.072)	(0.027)	(0.142)
Pressure group	0.501	44.714	14.516	0.579	2.809	2.665	1.947	7.30
	(0.021)	(0.614)	(0.086)	(0.021)	(0.052)	(0.071)	(0.027)	(0.140)
Matching & pressure group	0.499	44.741	14.581	0.600	2.859	2.741	1.973	7.366
	(0.021)	(0.607)	(0.082)	(0.021)	(0.058)	(0.070)	(0.026)	(0.138)
Number of observations					2100			
p-value	0.999	0.995	0.336	0.768	0.806	0.716	0.533	0.496

Table 1: Participant Attributes

Note: Average values are shown. The standard errors are in parentheses. For gender, male = 0, female = 1; for marital status, single = 0, married = 1; for educational background, 1 = graduate school graduate, 2 = college graduate, 3 = junior college / technical college graduate, 4 = vocational school graduate, 5 = high school graduate, 6 = middle school graduate; for household income, 1 = 0 JPY, 2 = 0 – 1 million JPY, 3 = 1 million – 2 million JPY, 4 = 2 million – 3 million JPY, 5 = 3 million – 4 million JPY, 6 = 4 million – 5 million JPY, 7 = 5 million – 6 million JPY, 8 = 6 million – 7 million JPY, 9 = 7 million – 8 million JPY, 10 = 8 million – 9 million JPY, 11 = 9 million – 10 million JPY, 12 = 10 million – 15 million JPY, and 13 = more than 15 million JPY; for attitude to the donation target, strongly approve=1, approve=2, disapprove=3, strongly disapprove=4. Source: Authors' calculations

Dependent variable = the donation rate	Model (1)	Model (2)
"matching" dummy	4.857	5.166
	(2.414)	(2.256)
"pressure" dummy	8.343	8.411
	(2.455)	(2.304)
"matching & pressure" dummy	8.686	8.825
	(2.478)	(2.351)
Gender		6.142
		(1.649)
Age		0.891
		(0.0579)
household income		−1.088
		(0.510)
Constant term	40.648	37.448
	(1.716)	(1.769)
Number of Observations	2,100	
R-squared	0.008	0.109

Table 2: Regression Analysis

Note: The dependent variable is the donation rate; the robust standard errors are in parentheses. The "matching," "pressure," and "matching & pressure" dummies correspond to the groups to which participants were assigned. The "matching" and "pressure" dummies are 0 in the "matching & pressure" group because the intervention method is different among groups. The figures in parentheses represent the standard deviations. The gender variable is 1 if the participant is female and 0 if otherwise. Household income is the difference from the average household income defined in Table 1. Age and household income are mean centering variables. Source: Authors' calculations

Dependent variable = the donation rate	Model (3)	Model (4)
"matching" dummy	3.332	6.793**
	(3.177)	(3.022)
"pressure" dummy	4.378	11.75***
	(3.203)	(3.203)
"matching & pressure" dummy	6.202*	12.75***
	(3.285)	(3.224)
Gender dummy × "matching" dummy	3.529	
	(4.508)	
Gender dummy × "pressure" dummy	8.210*	
	(4.600)	
Gender dummy × "matching & pressure" dummy	4.874	
	(4.696)	
Old dummy × "matching" dummy		-3.280
		(4.502)
Old dummy × "pressure" dummy		-6.341
		(4.596)
Old dummy × "matching & pressure" dummy		-8.273*
		(4.686)
Gender	2.077	6.230***
	(3.166)	(0.825)
Old	-6.393*	-1.932
	(3.407)	(4.384)
Age	1.088***	1.089***
	(0.118)	(0.118)
House hold income	-1.057**	-1.021**
	(0.512)	(0.512)
Constant	42.73***	38.372***
	(2.754)	(2.637)
Observations	2,100	2,100
R-squared	0.110	0.112

Table 3: Intervention effects on male/ female participants and on young/ old participants

Note: The dependent variable is the donation rate; the robust standard errors are in parentheses. The “matching,” “pressure,” and “matching & pressure” dummies correspond to the groups to which participants were assigned. The

"matching" and "pressure" dummies are 0 in the "matching & pressure" group because the intervention method is different among groups. The figures in parentheses represent the standard deviations. Gender variable is 1 if the participant is female and 0 if otherwise. Household income is the difference from the average household income defined in Table 1. Age and household income are mean centering variables. Source: Authors' calculations

Attitude toward the donation target	Number of observations	Percent
Strongly positive	382	18.19
Positive	1438	68.48
Negative	242	11.52
Strongly negative	38	1.81

Table 4: Attitude of Participants toward the Donation Target

Dependent variable = the donation rate	Model (5)	Model (6)
"matching" dummy	19.420	21.308
	(5.862)	(5.240)
"pressure" dummy	14.826	13.831
	(5.971)	(5.510)
"matching & pressure" dummy	10.592	15.234
	(5.899)	(5.698)
Approval dummy	24.565	26.467
	(4.187)	(3.822)
Approval dummy × "matching" dummy	-16.590	-18.397
	(6.413)	(5.782)
Approval dummy × "pressure" dummy	-7.523	-6.316
	(6.525)	(6.030)
Approval dummy × "matching & pressure" dummy	-2.092	-7.272
	(6.468)	(6.232)
Gender		7.222
		(1.631)
Age		0.887
		(0.057)
Household income		-1.142
		(0.504)
Constant term	19.265	13.866
	(3.758)	(3.551)
Number of Observations	2,100	
R-squared	0.034	0.136

Table 5: Intervention effects representing the different attitudes toward donation

Note: The dependent variable is the donation rate; the robust standard errors are in parentheses. The approval dummy is 1 if a participant "strongly approves" or "approves" of the donation target, otherwise 0. Gender variable is 1 if the participant is female and 0 if otherwise. Household income is the difference from the average household income defined in Table 1. Age and household income are mean centering variables. Source: Authors' calculations

Panel A (Matching)	Control, approval dummy = 0 (low)	Control, approval dummy = 1 (high)	Matching, approval dummy = 0 (low)	Matching, approval dummy = 1 (high)
"Matching" × Approval dummy				−16.590
"Matching"			19.420	19.420
Approval dummy		24.565		24.565
Constant term	19.265	19.265	19.265	19.265
Sum	19.265	43.830	38.685	46.66

Panel B (Pressure)	Control, approval dummy = 0 (low)	Control, approval dummy = 1 (high)	Pressure, approval dummy = 0 (low)	Pressure, approval dummy = 1 (high)
"Pressure" × Approval dummy				−7.523
"Pressure"			14.826	14.826
Approval dummy		24.565		24.565
Constant term	19.265	19.265	19.265	19.265
Sum	19.265	43.830	34.091	51.133

Panel C (Matching & pressure)	Control, approval dummy = 0 (low)	Control, approval dummy = 1 (high)	Matching & pressure, approval dummy = 0 (low)	Matching & pressure, approval dummy = 1 (high)
"Matching & pressure" ×Approval dummy				−2.092
"Matching & pressure"			10.592	10.592
Approval dummy		24.565		24.565
Constant term	19.265	19.265	19.265	19.265
Sum	19.265	43.830	29.857	52.330

Table 6: Comparison of Regression Coefficients of Table 5, Model (5)

Note: The cells of Panel A (B) contain the coefficients of the constant term, approval dummy, "matching" ("pressure") dummy, and the cross term of the "matching" ("pressure") and approval dummies in model (5) in Table 5; the last row shows the sum of the coefficients. The cells of Panel C contain the coefficients of the constant term, approval dummy, "matching & pressure" dummy, and the cross term of the "matching & pressure" and approval dummies in model (5) of Table 5; the last row shows the sum of the coefficients. Source: Authors' calculations

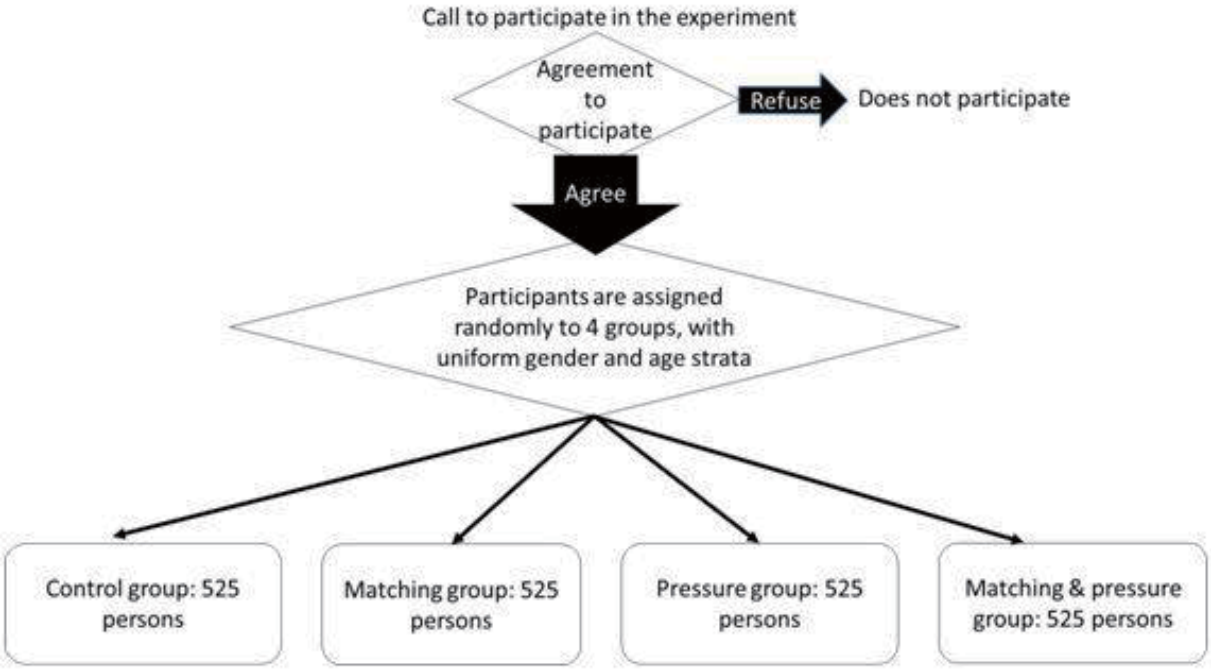

Figure 1: Flow of Participation in Experiment and Group Assignment

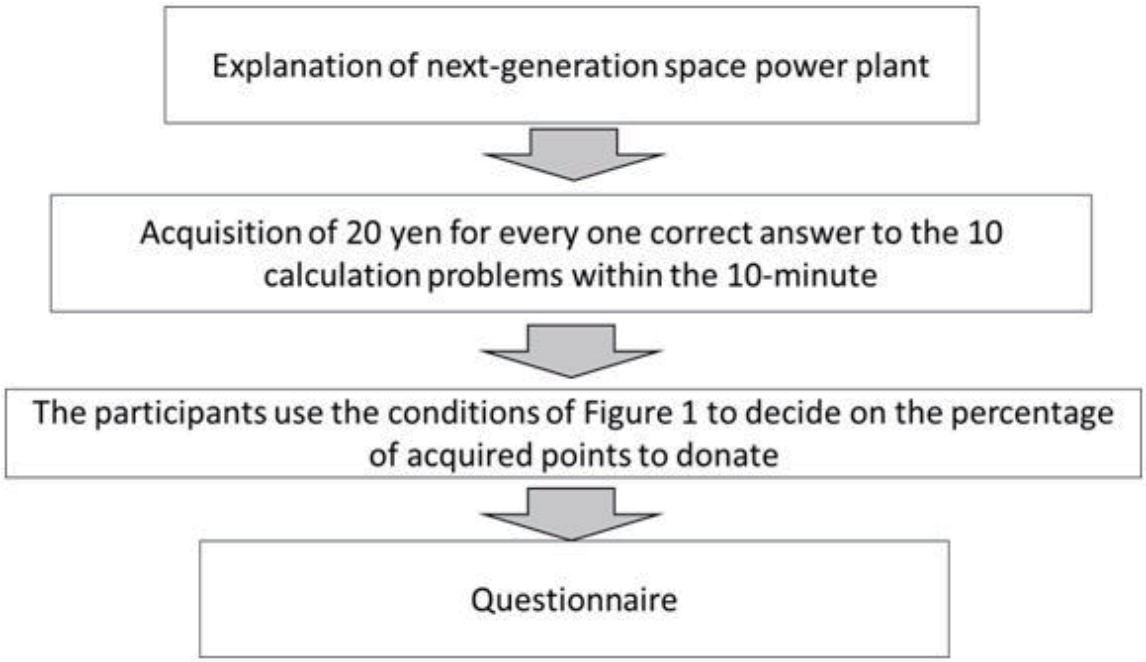

Figure 2: Flow of the Experiment

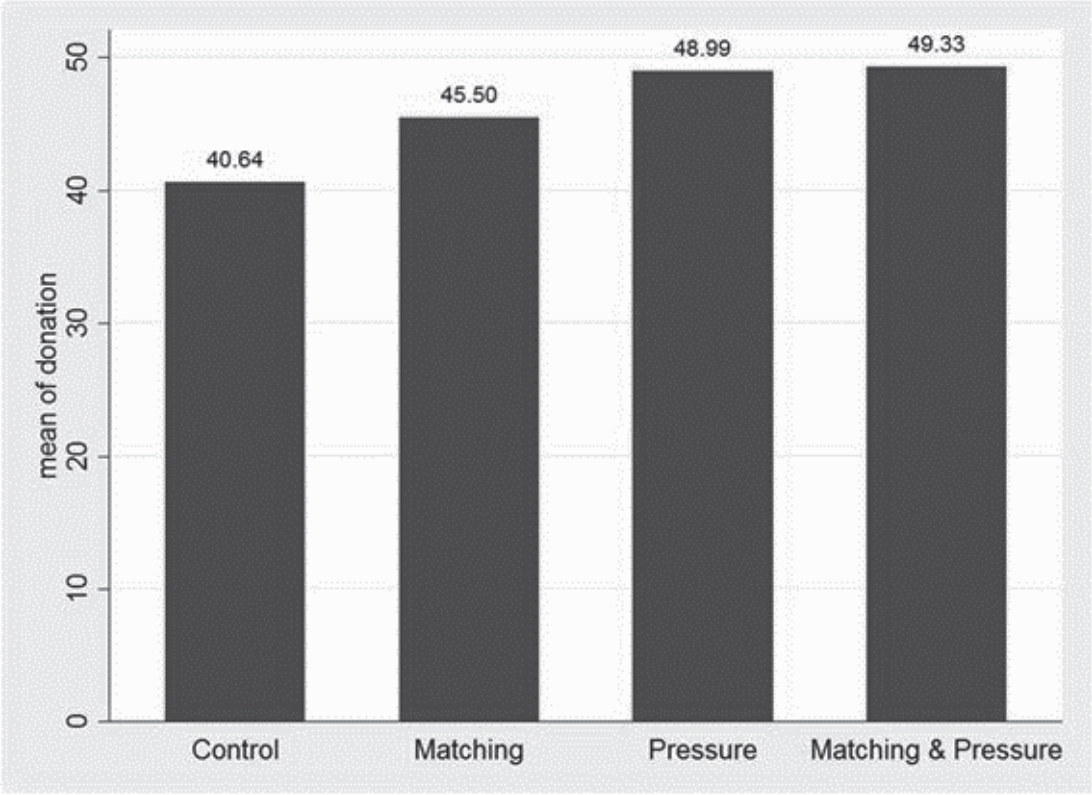

Figure 3: Average Donation Rates

Appendix A: Theoretical Model

This study's on-line field experiment consists of calculation tasks and decision-making about donations. In the task, the participants answered ten calculation problems within ten minutes, and earned 20 JPY per correct answer. After the task, they decided on the donation amount. The rest of the money represented their monetary reward.

Participants' manner of donation after completing the task and attaining the endowment was investigated. They decided how much to donate based on one of following conditions: (1) the experimenter donates the same amount as the amount donated by the participant ("matching"); (2) the participant is notified that a participant donated all of the endowment ("pressure"); (3) the experimenter donates the same amount as the amount donated by the participant, and the participant is notified that a participant donated all of the endowment ("matching & pressure"); and (4) there is no additional intervention ("control"). To simplify the notation, let a group G be expressed by M ("matching"), P ("pressure"), MP ("matching & pressure"), and C ("control").

Let the number of correct answers of a participant i in the calculation task be a_i, and let the donation rate be expressed by $0 \leq x_i \leq 1$. $C_i(a_i)$ be a cost function that is increasing ina_i.

The utility function of a participant in the "control" group is defined below, based on Bénabou and Tirole (2006).

(A.1) $$\mathrm{U}(x_i|G = C) = \left(v_{d,0}^{i} x_i + v_y^i(1 - x_i)\right) \times 20a_i - C_i(a_i)$$

$v_y^i$is defined as the utility of participant i for one unit of her own reward, and it is assumed that v_y^i follows a normal distribution $\mathrm{N}\sim(\overline{v_y}, \sigma_y^2)$, irrespective of whether there is matching with the

recipient.

Assumption 1: v_y^i= N∼$(\overline{v_y}, \sigma_y^2)$

The utility of one unit of donation depends on whether there is "matching" or not. *m* is defined as 1 if G=M or MP, otherwise 0. The utility of one unit of donation is denoted as $v_{d,0}^i$ifm = 0,andas $v_{d,1}^i$ ifm = 1; it is assumed that $v_{d,m}^i$follows a normal distributionN∼$(\overline{v_{d,m}}, \sigma_{d,m}^2)$.

Assumption 2: $v_{d,m}^i$ = N∼$(\overline{v_{d,m}}, \sigma_{d,m}^2)$

In addition, participants with high utility in donation without matching will have a high utility for donation, even with matching; it is therefore assumed that there is a positive correlation for $v_{d,0}^i$ and $v_{d,1}^i$.

Assumption 3: ∀i; $\mathrm{cov}\left(v_{d,0}^i, v_{d,1}^i\right) > 0$

Since "matching" decreases the utility of one unit of donation due to over-justification for donations, it is assumed that $v_{d,0}^i > v_{d,1}^i$holds for all i.

Assumption 4: ∀i; $v_{d,0}^i > v_{d,1}^i$

It is assumed that the effects of over-justification are not so strong as to reduce the average of the utility of one unit of donation by more than one half. Thus, it is assumed that the following

inequality holds:

Assumption 5: $\overline{v_{d,0}} < 2\overline{v_{d,1}}$

In addition, it is assumed that the respective utilities for donation and money are mutually independent for all participants.

Assumption 6: ∀i; $cov(v_y^i, v_{d,m}^i) = 0$

A.1. The intervention effect of "Matching"

A rational participant in the "control" group will choosex_i to maximize (A.1). The following equation gives the marginal utility of the donation rate of participants in the "control" group:

(A.2-1) $$\frac{dU(x_i|G=C)}{dx_i} = \left(v_{d,0}^i - v_y^i\right) \times 20a_i$$

Player *i* with$v_{d,0}^i \geq v_y^i$ selects$x_i = 1$, otherwise selects $x_i = 0$. The following formula gives the average donation rate in the control group:

(A.2-2) $$20a_i \times Pr(v_{d,0}^i - v_y^i \geq 0)$$

Given that $v_{d,0}^i - v_y^i$ follows a normal distribution N~$(\overline{v_{d,0}} - \overline{v_y}, \sigma_{d,0}^2 + \sigma_y^2)$, (A.2-2) is

normalized by the following formula:

(A.2-3) $$20a_i \times Pr(\frac{v_{d,0}^i - v_y^i - (\overline{v_{d,0}} - \overline{v_y})}{\sigma_{d,0}^2 + \sigma_y^2} \geq \frac{\overline{v_y} - \overline{v_{d,0}}}{\sigma_{d,0}^2 + \sigma_y^2})$$

Next, the utility of the participants is considered in the "matching" group. In this group, the utility of one unit of donation by a participant *i* is$v_{d,1}^i$. Because the experimenter doubles the donation amount, the utility function is as shown in the following equation:

(A.3) $$\mathrm{U}(x_i|G = M) = \left(v_{d,1}^i \times 2x_i + v_y^i(1 - x_i)\right) 20a_i - C_i(a_i)$$

The marginal utility of the donation rate of participants in the "matching" group is shown by the following equation:

(A.4-1) $$\frac{dU(x_i|G=M)}{dx_i} = \left(2v_{d,1}^i - v_y^i\right) \times 20a_i$$

Player *i* who holds$2v_{d,1}^i \geq v_y^i$ chooses $x_i = 1$, otherwise, $x_i = 0$. The average donation rate in the "matching" group is given by the following formula:

(A.4-2) $$20a_i \times Pr(2v_{d,1}^i - v_y^i \geq 0)$$

Given that $2v_{d,1}^i - v_y^i$ follows a normal distribution $\mathrm{N}\sim(2\overline{v_{d,1}} - \overline{v_y}, 4\sigma_{d,1}^2 + \sigma_y^2)$, the following formula is obtained by normalizing (A.4-2):

(A.4-3) $$20a_i \times Pr\left(\frac{2v_{d,1}^i - v_y^i - (2\overline{v_{d,1}} - \overline{v_y})}{4\sigma_{d,1}^2 + \sigma_y^2} \geq \frac{\overline{v_y} - 2\overline{v_{d,1}}}{4\sigma_{d,1}^2 + \sigma_y^2}\right)$$

The average donation rates in the "control" and "matching" groups are controlled by using equations (A.2-3) and (A.4-3). It is assumed that $\sigma_{d,0}^2 \leq 4\sigma_{d,1}^2$ holds for the variance of the utility of one unit of donation in the two groups.

Assumption 7: $\sigma_{d,0}^2 \leq 4\sigma_{d,1}^2$

This means that the variance of the utility of the participant toward one unit of donation in a group without matching is at most four times greater than in a group with matching. Because $(\overline{v_y} - 2\overline{v_{d,1}})/(4\sigma_{d,1}^2 + \sigma_y^2) < (\overline{v_y} - 2\overline{v_{d,1}})/(\sigma_{d,0}^2 + \sigma_y^2) < (\overline{v_y} - \overline{v_{d,0}})/(\sigma_{d,0}^2 + \sigma_y^2)$ holds, the first prediction is obtained:

Prediction 1: Under Assumptions 1 to7, the average donation rate is higher in the "matching" group than in the "control" group.

Prediction 1 corresponds to Hypothesis 1. If either of Assumptions5 or 7 does not hold, it is possible that "matching" cannot increase the donation rate.

Corollary 1: If either of the Assumptions5 or 7 does not hold, crowding out may occur, in which the average donation amount of participants is not higher in the "matching" group than in the "control" group.

A.2. The intervention effect of "pressure"

In the "pressure" and "matching & pressure" groups, because participants are notified about the donation rate of others, they feel social pressure, and the greater the pressure is, the more their utility decreases.

Consider the following social pressure function $S(\ )$. The utility of the participant decreases as the notified donation rate x_{-i} minus his or her own donation rate increases. Since information that $x_{-i} = 1$ is provided, the donation rate of the other participants is always greater than or equal to his or her own donation rate; thus, it is assumed that $S(x_i, x_{-i} = 1)$ has a non-positive value.

Assumption 8: $\forall x_i;\ S(x_i, x_{-i} = 1) \leq 0$

Assume that the participant could alleviate the pressure by increasing x_i.

Assumption 9: $\forall x_i;\ \frac{dS(x_i, x_{-i}=1)}{dx_i} > 0$

Here, assume that the extent of alleviating the pressure by increasing the donation rate decreases gradually.

Assumption 10: $\forall x_i;\ \frac{dS^2(x_i, x_{-i}=1)}{dx_i{}^2} < 0$

The utility function of the pressure group is defined by the following equation:

(A.5-1) $$\mathrm{U}(x_i|G=P)=\left(v_{d,0}^{i}x_i+v_y^i(1-x_i)\right)\times 20a_i-C_i(a_i)+\mathrm{S}(x_i,x_{-i}=1)$$

A rational participant will choose x_i to maximize (A.5-1). The following equation gives the marginal utility of the donation rate in this group:

(A.5-2) $$\frac{\mathrm{dU}(x_i|G=P)}{dx_i}=\left(v_{d,0}^{i}-v_y^i\right)\times 20a_i+\frac{d\mathrm{S}(x_i,x_{-i}=1)}{dx_i}$$

The average donation rates in the "control" and "pressure" groups are compared. (A.2-2) indicates the average donation rate in the "control" group. The average donation rate of the "pressure" group is calculated from the percentage of participants whose marginal utility is always positive, and the average donation rates of the participants whose marginal utility becomes 0 at a certain $0<x_i<1$.For simplicity, some notations were introduced:

(A.6-1) $$\Delta v_0^i=v_{d,0}^{i}-v_y^i, x_i^*\left(\Delta v_0^i\right)=arg_{x_i}\left(\Delta v_0^i\times 20a_i+d\mathrm{S}(x_i,x_{-i}=1)/dx_i=0\right)$$

(A.6-2) $$\underline{\Delta \mathrm{v}}=-\frac{d\mathrm{S}(x_i=0,x_{-i}=1)}{dx_i}\frac{1}{20a_i}$$

(A.6-3) $$\overline{\Delta v}=-\frac{d\mathrm{S}(x_i=1,x_{-i}=1)}{dx_i}\frac{1}{20a_i}$$

From $d\mathrm{S}^2(x_i,x_{-i}=1)/{dx_i}^2<0$, $\underline{\Delta \mathrm{v}}$ is the minimum value of $-(d\mathrm{S}(x_i,x_{-i}=1)/dx_i)\times(1/20a_i)$, and $\overline{\Delta v}$ is the maximum value of $-(d\mathrm{S}(x_i,x_{-i}=1)/dx_i)\times(1/20a_i)$.

The average donation rate of participants in the "pressure" group is calculated by dividing into

two terms: the first term corresponds to the case wherein the marginal utility of the participant is positive, and the second term corresponds to the case where it becomes 0:

$$\text{(A.7)} \qquad \Pr\left(\Delta v_0^i \geq \overline{\Delta v}\right) + \int_{\underline{\Delta v}}^{\overline{\Delta v}} x_i^*\left(\Delta v_0^i\right) \frac{\exp\left(-\frac{\left(\Delta v_0^i - \overline{v_{d,0}} + \overline{v_y}\right)^2}{2\left(\sigma_{d,0}^2 + \sigma_y^2\right)}\right)}{\sqrt{2\pi\left(\sigma_{d,0}^2 + \sigma_y^2\right)}} d\Delta v_0^i$$

From $\overline{\Delta v} < 0$, the first term in equation (A.7) is larger than the first term in equation (A.2-2). Moreover, because the second term in equation (A.7) is positive, the following prediction is obtained:

Prediction 2: Under Assumptions 1, 2, 3, 4, 6, 8, 9 and 10, the average donation rate is larger in the "pressure" group than in the "control" group.

A.3. The simultaneous intervention effect of "Matching &Pressure"

Consider the utility of a participant in the "matching & pressure" group, in which matching and pressure are provided simultaneously. The utility function of a participant in this group is given by the following equation:

$$\text{(A.8-1)} \qquad \mathrm{U}(x_i|G = MP) = \left(2v_{d,1}^i x_i + v_y^i(1 - x_i)\right) \times 20a_i - C_i(a_i) + \mathrm{S}(x_i, x_{-i} = 1)$$

To select x_i by maximizing (A.8-1), the marginal utility of the donation rate in this group is given by the following equation:

(A.8-2) $$\frac{\mathrm{dU}(x_i|G=MP)}{dx_i} = \left(2v_{d,1}^i - v_{\mathrm{y}}^i\right) \times 20a_i + \frac{d\mathrm{S}(x_i, x_{-i}=1)}{dx_i}$$

The average donation rates in the "matching" and "matching & pressure" groups are compared. (A.4-2) indicates the average contribution rate in the "matching" group. The average donation rate in the "matching & pressure" group is calculated from the percentage of participants who donated the full amount and the average contribution rates of the participants who donated a part. For simplification, some notations are introduced: $\Delta v_1^i = 2v_{d,1}^i - v_y^i$, $x_i^*(\Delta v_1^i) = arg_{x_i}(\Delta v_1^i \times 20a_i + d\mathrm{S}(x_i, x_{-i}=1)/dx_i = 0)$. Notice that $\underline{\Delta \mathrm{v}}$ and $\overline{\Delta v}$ are defined as the same in the previous subsection, and $\overline{\Delta v} < 0$ holds.

The average donation rate of participants in the "matching & pressure" group is calculated by dividing into two terms: the first term where the marginal utility of the participant is positive, and the second term that becomes 0:

(A.9) $$Pr\left(\Delta v_1^i \geq \overline{\Delta v}\right) + \int_{\underline{\Delta \mathrm{v}}}^{\overline{\Delta v}} x_i^*(\Delta v_1^i) \frac{\exp\left(-\frac{(\Delta v_1^i - 2\overline{v_{d,1}} + \overline{v_y})^2}{2(4\sigma_{d,1}^2 + \sigma_y^2)}\right)}{\sqrt{2\pi(4\sigma_{d,1}^2 + \sigma_y^2)}} d\Delta v_1^i$$

From $\overline{\Delta v} < 0$, the first term in equation (A.9) is larger than the first term of equation (A.4-2), and because the second term in equation (A.9) is positive, the following prediction is obtained:

Prediction 3: Under assumptions 1to 10, the average donation rate is larger in the "matching & pressure" group than in the "matching" group.

Let us compare the average donation rates in the "matching & pressure" and "pressure" groups. Given that Assumptions 1-10 have been satisfied, the first term of equation (A.9) is larger than the first term of equation (A.7). However, within interval $(\underline{\Delta v}, \overline{\Delta v})$, it cannot be stated that the second term of equation (A.9) is larger than the second term of equation (A.7). Therefore, it cannot be concluded whether the donation rate is larger in the "pressure" group than in the "matching & pressure" group, based only on Assumptions 1-10.

Appendix B.

Instruction (“Matching &Pressure” Group)

This survey is part of the research activities that were contracted out by Takanori Ida in the Graduate School of Economics at Kyoto University (hereinafter, Ida laboratory) to My Voice Communications Inc.

Ida laboratory is conducting this survey for academic purposes.
The purpose is to assess awareness of support for next-generation energy research and development.

All survey results will be handled by Ida laboratory in accordance with the privacy policy of My Voice Communications Inc. No personal information whatsoever will be included.
The results will be published as an academic article after statistical processing.

Thank you in advance for your cooperation.

The second half of this survey investigates support for the research and development of next-generation energy: space power.

The money that you receive during the second half of this survey may be donated to:

- the Kyoto University Research Institute for a Sustainable Humanosphere, which is used for research and development of next generation space power.

First, we will ask whether you wish to participate in this awareness survey.

- If you do wish to participate, please select “participate.”
- If you do not wish to participate, please select “will not participate.”

*For those not participating, the awareness survey ends with this question (you will receive no points).

*In addition to 60 survey reward points, those participating in the awareness survey will receive money for each “no response” reply during the second half of the survey.

*The recipients receiving a contribution will be determined beforehand by those taking the survey.

Contribution-receiving recipients cannot be changed.

Here are seven questions about electricity rates and energy policy. In response to each question, check the appropriate answer or write a reply.

1. Are you responsible for the budgeting and spending decisions in your household?

□ Yes

□ No

2. During the summer, what are your average monthly electricity rates at home?

□under 1,000 yen □11,000 yen - 11,999 yen

□1,000 yen – 1,999 yen □12,000 yen – 12,999 yen

□2,000 yen – 2,999 yen □13,000 yen – 13,999 yen

□3,000 yen – 3,999 yen □14,000 yen – 14,999 yen

□4,000 yen – 4,999 yen □15,000 yen – 15,999 yen

□6,000 yen – 6,999 yen □16,000 yen – 16,999 yen

□7,000 yen – 7,999 yen □17,000 yen – 17,999 yen

□8,000 yen – 8,999 yen □18,000 yen – 18,999 yen

□9,000 yen – 9,999 yen □19,000 yen – 19,999 yen

□10,000 yen – 10,999 yen□20,000 and above

3. Do you feel that your summer monthly electricity rates are too high?

□Definitely yes

□Yes, a bit

□ Neither high nor low

□ Not really

□ Not at all

4. To what percentage do you think the share of power generated by renewable energies (such

as solar power and wind power) should be increased?

□10 percent

□20 percent

□30 percent

□40 percent

□50 percent

□60 percent

□70 percent

□80 percent

□90 percent

□100 percent

□No change / no need to increase

5. My awareness of nuclear energy changed after the accident at the Fukushima nuclear power plant in Japan on March 11, 2011.

□Yes, absolutely

□Somewhat

□Hard to say

□Not really

□Not at all

6. What do you think the future of nuclear power generation in Japan should be?

- □ It should be aggressively increased.
- □ It should be cautiously increased.
- □ It should stay the same.
- □ It should be phased out in future.
- □ It should be phased out as a matter of urgency.
- □ I don’t know.

7. Have you fundraised for electric power in the past?
   - □ Yes
   - □ No

We appreciate your cooperation in the following awareness survey concerning next-generation energy.

Japanese government research and development into next-generation space photovoltaic power generation has been the focus of much media attention.
We will now explain these research and development initiatives. After reading this explanation, we look forward to your cooperation in the awareness survey.

Satellite Solar Power Systems (SSPS) are Space Power Stations (SPS) that create energy by

efficiently collecting sunlight in space. The energy is sent to earth, where it is used in forms such as electric power and hydrogen. The SSPS consists of power generation and transmission equipment in space, which collects sunlight, converting it into microwaves or laser light and sending it to power-receiving equipment on earth, which receives the transmission.

Source : JAXA Interview "Yasuyuki Fukumuro, *Toward Solar Power Generation in Space and its Practical Application*"
(http://www.jaxa.jp/article/interview/vol53/index_j.html)

- This is an energy supply facility in which sunlight captured in space is gathered in geostationary orbit (36,000 km altitude) and received on earth as microwaves or lasers.
- Energy is transmitted at a 1 million kW level (equivalent to one nuclear power plant) and is used after being converted on earth to electric power or hydrogen.
- In geostatic orbit, sunlight shines regardless of climate, season, or time of day, so it is possible to collect solar energy in a very efficient manner.
- Since the energy source is sunlight, there is very little possibility of the source running dry, unlike natural gas or oil. We can continue as long as there is sunlight.
- Also, since power generation takes place in space, there are only carbon dioxide emissions at the receiving facility. Since the emissions are extremely small, this is environmentally friendly.

Microwave wireless electricity transmission from the SPS to earth uses a frequency band called

the “radio wave window,” which can use solar power even in cloudy or rainy conditions.

- SPS solar cells are usually pointed toward the sun (solar orientation). In contrast, microwave transmission antennas are usually pointed toward the receiving site on earth (earthward orientation).
- 24 hours a day, stable solar power generation is possible with SPS.

Issues involving the Practical Applications of Space Photovoltaic Power Generation

Four issues remain that affect practical applications. We need to be able to:

- Establish the technology needed for large-scale transfer to space;
- Handle damage to the space power station from various sources, including debris and solar flares;
- Protect humans and electronic devices from the microwaves and lasers used in transmission; and
- Establish the economic advantage of this technology in comparison with alternative technologies.

Space photovoltaic power generation research aims to implement practical applications from 2030. It is making progress. However, to a significant extent, we are waiting for future developments in science and technology.

Prepared using JAXA (http://www.ard.jaxa.jp/research/hmission/hmi-ssps.html)

We would like to ask your views on the next-generation space energy research and development

program explained above.

- Do you
    - strongly support,
    - support,
    - oppose, or
    - strongly oppose

next-generation space energy research and development?

Please take part in this survey on the support for next-generation space photovoltaic power generation research and development. The money generated by this survey will be donated to the Kyoto University Research Institute for a Sustainable Humanosphere, which conducts research and development on this issue.

We encourage everyone to support next-generation space photovoltaic power generation research.

- The experiment below will help to raise funds for next generation space photovoltaic power generation research.
- The experiment comprises a 10-question quiz and a survey. The amount contributed increases by 20 yen for each correct answer to the quiz.
- All funds earned will be used to support the Kyoto University Research Institute for a Sustainable Humanosphere.

Practice problem:

In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

1.95	3.65	1.55	2.45
4.1	1.9	1.8	0.8
1.25	4.45	2.85	0.4

Practice Problem Answer:

The answer to the practice problem is the second column from the left, indicated in boldface.

1.95	**3.65**	1.55	2.45
4.1	**1.9**	1.8	0.8
1.25	**4.45**	2.85	0.4

Condition Checking Screen:

Recipient of funds：Kyoto University Research Institute for Sustainable Humanosphere

Participant earnings = number of correct answers×20 yen

Number of questions：10

Time limit：600 seconds

After finishing the calculations, please proceed to the survey.

Question 1：In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

3	3.65	1.2	2.15
1.25	0.9	3.55	0.9
4.25	4.3	4.9	3.8

Question 2：In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

3.8	2.35	0.5	0.65
3.35	4.85	4.3	1.55
4.35	0.95	3.9	0.8

Question 3 : In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

2.4	4.85	0.95	1.8
1.75	4.9	4.7	4.15
2.8	2.85	4.1	3.5

Question 4 : In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

0.1	0.6	4.8	3.1
0.4	1.3	1.2	3.2
2.25	3.55	4	1.8

Question 5 : In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

2.65	2.9	3.75	0.7
2.55	3.15	4.3	3.55
1.9	0.35	4.45	4.4

Question 6 : In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

2.3	4.4	2.4	2.5
0.75	0.95	4.2	0.75
0.45	1.2	3.4	4.55

Question 7 : In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

3.35	0	3.25	3.4
1.8	4.35	1.55	1.9
0.25	0.4	4.15	4.35

Question 8 : In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

2.9	1.7	1.8	4.45
2.65	4.55	2.45	4.9
0.3	0.9	3.85	4.95

Question 9 : In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

2.25	0.2	4	2.15
4.15	2.35	4.05	3.15
3.65	3.9	1.25	1.2

Question 10 : In the 3x4 below, only one row or column has a sum of 10. Select that row or column.

2.45	1.35	3.9	3.15
0.15	4.5	3.3	2.15
0.3	4.15	2.2	3.45

Results Confirmation Screen

Number of correct answers
Total monetary reward

Please check the number of correct answers and the total reward. You can choose to receive the money you earned as a reward, or to donate it.

Please decide what share of the reward money you wish to donate. Before you decide how much to share, please read the following notice:

Notice regarding Contribution Portion

A considerable number of people who participated in the same experiment contributed all the points they earned.

What is your opinion of this?

1. Surprising
2. Persuasive

We have one more notice.

We will match the amount of money that you contribute, thus doubling the donation.

What is your opinion of this?

1. It is a good idea.
2. It is not a good idea.

Contribution Portion Decision Screen

Please select from the list below the percentage that you plan to contribute.

□0 percent

□10 percent

□20 percent

□30 percent

□40 percent

□50 percent

□60 percent

□ 70 percent

□80 percent

□90 percent

□100 percent

Here is a breakdown of your contribution.

Total contribution

Additional amount contributed
Total reward