Good-Citizen Lottery*

Duk Gyoo Kim†

March 27, 2025

Abstract

This paper examines a novel mechanism to collectively minimize the production of public bads without the burden of an external budget: a penalty-funded good-citizen lottery. Good citizens are typically not rewarded for their prosocial actions, which weakens their incentives to reduce the production of public bads. This study employs a game-theoretic model in which a lottery awards one good citizen a prize funded by penalties imposed on bad citizens. Under a reasonable set of parameters, the good-citizen lottery decreases the likelihood of prosocial behavior as the population size increases. This result theoretically aligns with the asymptotic free-riding in voluntary contributions for the production of public goods. However, experimental evidence reveals the opposite pattern: the proportion of good behavior increases with group size. This effect is especially pronounced among individuals who subjectively overestimate small probabilities of winning the good-citizen lottery.

Keywords: Lottery, Public bads, Imperfect monitoring, Laboratory experiments

1 Introduction

Good citizenship is often, if not always, unpaid. Consider a driver who wants to stop at a building that has no available parking spaces. Although it may cause various forms of social costs, parking illegally for two minutes might avoid detection, so he may be tempted to park

*This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2023S1A5A8080738). I thank Syngjoo Choi, Biung-Ghi Ju, Heechun Kim, and Jeong-Yoo Kim for their comments and seminar participants at Sungkyunkwan University and Yonsei University and conference participants of the 2024 East Asia Game Theory Conference, the 2024 Korea Experimental and Behavioral Economics Association Workshop, 2025 Korea Allied Economic Associations Annual Meeting, and 2025 Asia-Pacific Meeting of the Economic Science Association for their comments.

†School of Economics, Yonsei University, South Korea. Email: kim.dukgyoo@yonsei.ac.kr

in front of the building and sleek out from the scene shortly. Alternatively, the driver could take the time to find a legal parking spot, walk the extra distance, and pay the parking fee, all without receiving explicit acknowledgment for doing the "right thing." Good citizenship encompasses a wide range of behaviors, but this paper focuses on actions that are costly to the individual yet do not harm society.[1] In this framework, good citizens are those who voluntarily abstain from contributing to the production of public bads. Examples include reducing greenhouse gas emissions at home, recycling responsibly, refraining from littering, and paying for public transportation when monitoring is minimal.

The literature on public bads minimization has mostly focused on penalizing the bad[2] citizens, and little attention has been paid to the ways to encourage good citizenry. My broader research question is how to facilitate good-citizen behaviors without imposing additional government expenses. This paper proposes one novel way to facilitate good-citizen behaviors, or to collectively minimize the production of public bads: a good-citizen lottery, hereinafter a *citizen lottery* for short. Under the status quo, each citizen decides how to behave based on their own benefits and costs of behaviors. Under the lottery, one randomly-selected good citizen receives a lottery payment whose prize is funded by imperfectly-collected penalties from bad citizens.[3] Would it effectively decrease the proportion of bad citizens? If so, who is more likely to be affected by the introduction of a citizen lottery?

To understand the effect of the citizen lottery, I consider a game where citizens simultaneously choose one of two actions. One action, corresponding to a rent-seeking (or bad-citizen) behavior, involves a large benefit with some probability and a penalty with the complimentary probability. The other action, corresponding to a good-citizen behavior, comes with no benefits, but one of the good citizens is randomly selected to get an award whose value is the sum of the penalties collected by a fraction of bad citizens.

[1] A concept of good citizens may be innocuously extended to the law-abiding business owners and taxpayers. For example, a recent legalization of cannabis in some states of the United States makes a legal cannabis seller to overcome opportunistic benefits of being an illegal seller. News report that California's first cannabis company filed a bankrupt, mainly because they couldn't compete with illegal weed stores, more than 70 percent of the L.A. weed stores.

[2] Here the 'bad' citizen does not necessarily mean that the citizen's behavior is morally bad. Throughout this paper, I call the behavior that renders a positive expected payoff to themselves but leaves a social cost as a result of negative externality. Without a proper monitoring capacity and penalization, this 'bad' behavior can be understood as an economically 'rational' behavior.

[3] For three days in September 2010, Swedish road safety organization and Volkswagen trialed a 'speed camera lottery,' whereby drivers who drive under the speed limit are entered to win a lottery prize whose fund comes from the fines paid by drivers who were speeding (Fact check. Last access: Jan 8, 2025.) To the best of my knowledge, this trial was the incidence implementing the idea of the budget-balanced good-citizen lottery described in this paper.

With a reasonable set of parameters, the equilibrium probability of good actions monotonically decreases as the population size grows under the good-citizen lottery scheme. The intuition is straightforward: A large number of good citizens implies that the probability of winning the good-citizen lottery approaches zero, so for a sufficiently large population, each individual would essentially see the benefits of behaving badly, which lowers incentives to behave well. This theoretical prediction is consistent with the typical prediction for voluntary contributions to the production of public goods: As the number of beneficiaries of the public goods grows, each individual's incentive to contribute to society decreases, hence the individual contribution asymptotically shrinks to zero (Andreoni, 2006). The increase in the capacity for monitoring bad-citizen behaviors increases the equilibrium probability of good actions. Individual risk aversion may play a role, but it would work in the direction of shifting decisions without affecting the treatment effect of introducing the citizen lottery. Especially when the population size gets sufficiently large, the "risky" part of the citizen lottery becomes almost negligible, so the decision would be mostly based on how much one wants to avoid a penalty.

Experimental findings, however, show the opposite patterns: As the group size increases, the proportion of (neutrally framed) good-citizen behaviors does not decrease in the lab. This contrasting result is primarily driven by subjects with a stronger probability-weighting tendency. This finding implies that the citizen lottery mechanism can remain effective, or even become more so, in large populations. Furthermore, the experimental findings confirm that the proportion of good citizens increases with greater monitoring capacity and heightened risk aversion. These insights reinforce the viability of the citizen lottery, especially when paired with policies that enhance monitoring and leverage psychological biases like probability-weighting. Altogether, the experimental findings offer robust support for the efficacy of the good-citizen lottery, highlighting its potential to promote prosocial behavior even in situations where good citizenship is not expected. A supplementary online experiment with bigger group sizes (from 50 to 200) provides a similar result that the proportion of good-citizen behaviors is substantially higher than the theoretical prediction and does not decrease as the group size increases.

The remainder of this paper is organized as follows. The following subsection provides an overview of the relevant literature. Section 2 describes the model. Section 3 presents the theoretical analyses, and Section 4 describes the laboratory experiment. Section 5 reports the experimental findings, and Section 6 discusses various issues, including the supplementary evidence from an online experiment with larger group sizes. Section 7 concludes.

1.1 Literature Review

The use of lotteries in nonstandard contexts has gained considerable attention in recent years as an innovative mechanism to address diverse societal challenges. Kim (2021) explores the use of vaccination lotteries to examine how it promotes vaccination uptakes compared to a lump-sum subsidy, while Kim (2023) introduces a penalty lottery framework that endogenously make citizens reveal their willingness to produce public bads. Gerardi et al. (2016) and Duffy and Matros (2014) examine the relationship between penalties for not turning out to vote and turnout lotteries, demonstrating their potential to incentivize voter participation. Kearney et al. (2010) and Filiz-Ozbay et al. (2015) advocate for savings lotteries as a tool to encourage financial discipline among individuals who did not have savings account. Morgan (2000) and Morgan and Sefton (2000) propose and experimentally examine the efficacy of lotteries as a method to fund public goods, showing that such mechanisms can overcome free-rider problems. The "regret lottery" that pays a randomly-selected employer who did not park in the facility worked as an effective tool to reduce car use (Gneezy, 2023), while it makes the other employers who were selected before the winner but did not earn the prize because of car use regretful. Other innovative applications include Björkman Nyqvist et al. (2019), who examine the effectiveness of a lottery to promote safer sexual behavior, and Volpp et al. (2008) and Levitt et al. (2016), who explore lotteries as a means to foster desirable habits, such as improving health outcomes and student achievement. Collectively, these studies underline the versatility of lotteries in motivating behaviors across a range of settings.

In the sense that minimization of public bads production corresponds to the provision of public goods, this study is also related to numerous experimental studies on public goods provision (Isaac et al., 1984; Isaac and Walker, 1988; Andreoni, 1990; Charness and Yang, 2014). However, this study is distinguished for two reasons in terms of the warm-glow utility. Andreoni (2007) examines how impure altruism depends on the number of recipients of the benefits from the altruistic behaviors, but in the current study, it is hard to believe that the people play the bad action to give a chance to increase the payoff of one of those played the good action. Also, I did not consider framing effects of providing public goods versus minimizing public bads, but one could examine the effects of positive and negative framing on good-citizen behaviors (Andreoni, 1995). The experiment considered in this study adopts abstract and neutral framing.

The most closely related work would be Fabbri et al. (2019), who conducted a field experiment on a bus-ride lottery aimed at improving compliance of purchasing public transportation tickets. While their study offers valuable insights, I see three significant differences. First, this paper ensures budget balancedness, which imposes a natural constraint on the expected benefits of good-citizen behaviors. Second, rather than comparing the lottery mechanism to a no-lottery baseline, this study investigates how the group size influences the effectiveness of the lottery. Finally, it delves into individual heterogeneities that drive good-citizen behaviors, providing a richer understanding of how personal attributes shape participation in the mechanism. These distinctions position the current study as a novel contribution to the literature on incentivizing prosocial behaviors through game-theoretic mechanisms.

2 Model

This section considers the simplest possible model. Although there are many avenues to extend this model, the fundamental tradeoff between two actions of each decision maker would still remain unchanged.

Suppose there are n citizens, indexed by $i \in \{1, \dots, n\} \equiv N$, making a decision simultaneously.[4] Each citizen chooses one of two actions: one action is to safely abide by law, denoted by S, and another action is to violate it to accrue private benefits, V. Thus, the action space is $A = \{S, V\}^n$.

Citizen i accrues a benefit of acting V, $B_i > 0$.[5] Although the citizen of acting V can be monitored and fined F, the monitoring capacity is limited. Specifically, with probability $p \in (0, 1)$, action V is monitored so that the citizen's payoff is $B - F < 0$, while with probability $1 - p$, she enjoys the full benefit of B. The payoff of choosing S is 0 for the 'most' cases, but when selected as a winner of the lottery, it is kF, where k is the number of players who chose V and got monitored.

I made two parametric assumptions here. I assume that the monitoring capacity is determined by the external agency, e.g., the government, so p is exogenously given. Also, I assume $B_i - pF > 0$ for all i, so bad behavior is beneficial in expectation. The model becomes trivial otherwise: If $B_i - pF \leq 0$ for some i, such citizens will find that V is strictly dominated by S.

Before we analyze the model, I illustrate the key tradeoff with an example of three homogeneous citizens, $B_i = B$ for all $i \in \{1, 2, 3\}$. It can be easily understood as a variation

[4]This assumption of simultaneity does not mean that all the citizens must act at the same time. Rather, this assumption parsimoniously captures the imperfect information about other citizens' actions.

[5]Alternatively, one can consider a cost of acting V, which essentially works the same.

of a coordination game. One clear prediction is that (S,S,S) can never be an equilibrium: Given that two other citizens play S, the expected payoff of playing V is $B-pF$, while the expected payoff of playing S is $0(=0+0F)$ since no penalties are collected. Since $B-pF>0$, the citizen has an incentive to deviate to V. Under some parametric conditions, (V,V,V) cannot be an equilibrium either. Given that two other citizens play V, the expected payoff of playing S is $2pF$, where $2p$ is the expected number of citizens who got a penalty. So, as long as $2pF \geq B-pF$, or $p > \frac{B}{3F}$, the citizen has an incentive to deviate to play S. When $p > \frac{B}{3F}$, a symmetric mixed-strategy Nash equilibrium is for each citizen to play S with probability δ, where

$$\delta = \frac{3-\sqrt{\frac{4B}{pF}-3}}{2}.$$

Note that we assume $B-pF>0$, so $\frac{4B}{pF}-3>1$ and $\delta<1$. Note also that $\delta>0$ as long as $\frac{B}{pF}<12$. In words, if the monitoring capacity p is neither too large ($p>\frac{B}{3F}$) nor too small ($p<\frac{B}{12F}$), there is a symmetric equilibrium where citizens play a good-citizen behavior with some positive probability.

3 Theoretical Analysis

For notational simplicity, suppose there are $n+1$ citizens (instead of n citizens) so that each citizen's decision takes into account n other citizens' decisions. $(\delta)_{i=1}^{n+1}$ is a symmetric mixed-strategy Nash equilibrium if the expected payoff of playing S:

$$\begin{aligned}&\binom{n}{0}\delta^n(1-\delta)^0 0F+\binom{n}{1}\delta^{n-1}(1-\delta)\frac{pF}{n}+\binom{n}{2}\delta^{n-2}(1-\delta)^2\frac{pF}{n-1}+\cdots+\binom{n}{n}\delta^0(1-\delta)^n pF\\ &=\sum_{i=1}^{n}\binom{n}{i}\delta^{n-i}(1-\delta)^i\frac{pF}{n+1-i} \qquad (1)\end{aligned}$$

is equal to the expected payoff of playing V:

$$B-pF, \qquad (2)$$

where $\binom{n}{i}\delta^{n-i}(1-\delta)^i\frac{pF}{n+1-i}$ is the expected payoff when i among n citizens playing V so the citizen playing S expects to be the winner of the good-citizen lottery with probability $\frac{1}{n+1-i}$.

$\delta \in [0,1]$ such that

$$B - pF = \sum_{i=1}^{n} \binom{n}{i} \delta^{n-i}(1-\delta)^i \frac{pF}{n+1-i}$$

is each citizen's equilibrium probability of playing S. Let $b := \frac{B}{pF} - 1 \in (0,1)$, the normalized excess benefit to the expected cost. Then, δ is such that

$$b = \sum_{i=1}^{n} \binom{n}{i} \delta^{n-i}(1-\delta)^i \frac{1}{n+1-i} := R(\delta, n) \tag{3}$$

Equation 3 demonstrates the tradeoff of playing S versus V: Playing V renders the normalized excess benefit, but as more people play V, the expected size of the good-citizen lottery prize increases, leaving the opportunity cost of not playing S larger. This equation works as a basis for the comparative statistics. Note that the left-hand side of equation 3 is constant in n, and the right-hand side of it is constant in p, the comparative statistics on these parameters are straightforward.

The first comparative statistic regards the changes in n.

Proposition 1. $\frac{\Delta\delta}{\Delta n} < 0$ *if* $b \in (0,1)$.

Proof: See Appendix.

As the number of citizens gets larger, the probability of choosing S decreases. Proposition 1 implies that the proportion of good citizens decreases as the population size gets larger.

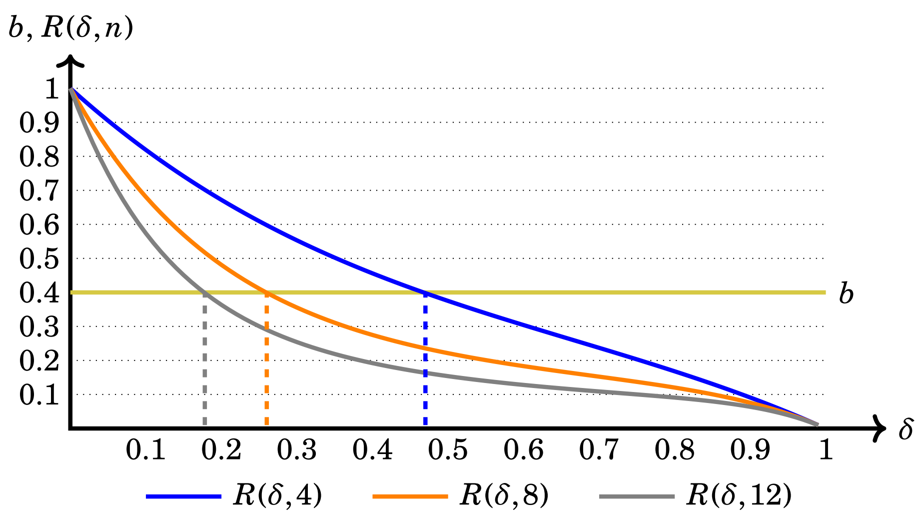


Figure 1: A larger population decreases the proportion of good citizens.

Figure 1 illustrates Proposition 1. The x-axis of the figure represents the value of δ ranging from 0 to 1, while the y-axis represents the value of the left- and right-hand sides of Equation 3. The left-hand side of it is invariant to the changes in n, so it is depicted as a horizontal line. The right-hand side of it decreases in δ: When $\delta = 0$, $b = \binom{n}{n} 0^0 1^n \frac{1}{n+1-n} = 1$ as the every term except for the last one equals zero, and when $\delta = 1$, $b = 0$ as every term equals zero. The crossing point between the decreasing curve and a horizontal line describes the equilibrium strategy δ. Illustrated in Figure 1, $\delta(n)$ decreases when n increases from 4 to 12. The intuition is straightforward: While the expected benefit of playing V is fixed, the benefit of playing S monotone decreases in n for the same δ. For illustration, suppose that $n = 100{,}000$, and all other citizens' strategy is $\delta = 0.25$. Then the probability of getting a positive payoff when playing S is $\frac{1}{25{,}000}$, which is almost negligible. Thus, a larger n pushes the citizen toward V. It is important to note that the result summarized in Proposition 1 resonates one of the key theoretical predictions for the voluntary contributions for public good provision: An equilibrium voluntary contribution level tends to decrease in n (Andreoni, 2006).[6] With interpreting that V is an action of producing public bads, the decreased proportion of playing S implies that the public goods provision decreases as the population size gets larger.

The second comparative statistic regards the changes in p.

Proposition 2. $\frac{d\delta}{dp} > 0$ *if* $b \in (0,1)$.

Proof: The right-hand side of Equation 3 is constant in p and decreasing in δ. Since the left-hand side, $\frac{B}{pF} - 1$, decreases in p, δ that equates both hands increases. □

Figure 2 illustrates Proposition 2. As b decreases to b' due to the increase in the monitoring capacity, the equilibrium probability of playing S increases for all n. Dashed lines show how the equilibrium probability of playing S increases for $n = 12$. Although it may seem too straightforward that the better monitoring capacity decreases the excessive benefit of playing V, it is worth noting that the increase in $\delta(p)$ happens only when $b \in (0,1)$. Since we start with the assumption that $B - pF > 0$, $b > 0$ is guaranteed. However, it is possible for the normalized excess benefit of V to be greater than 1: It can happen when p is too low, B is too large, or F is too small. This note implies that δ, the equilibrium probability of

[6] For illustration, consider a textbook example where n identical consumers voluntarily contribute g_i to enjoy the public goods, $G = \sum_{i=1}^{n} g_i$. If consumer i's utility function is given as $u_i(y - g_i, g_i + \sum_{j \neq i} g_j) = y - g_i + \ln(g_i + \sum_{j \neq i} g_j)$, a symmetric Nash equilibrium is described by a strategy g^* such that $\frac{1}{ng^*} = 1$, or $g^* = \frac{1}{n}$. Here the asymptotic free-riding is well captured: As n approaches infinity, individual's equilibrium contribution level converges to zero.

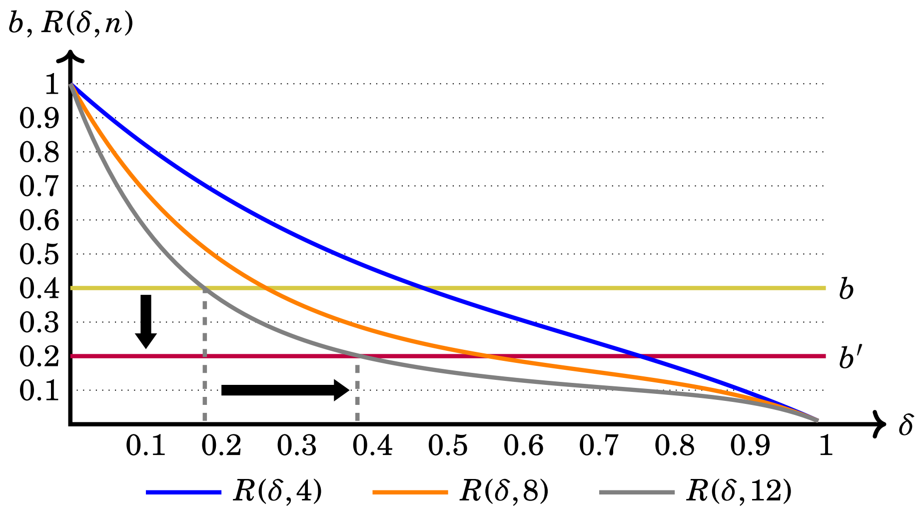


Figure 2: Monitoring capacity encourages good-citizen behaviors.

playing S is a function of n and p *only when* $b < 1$, or $\frac{B}{2F} < p$. I will use this property when choosing parameters for the laboratory experiment.

Two important factors that could affect the citizens' decision are worth mentioning: risk preferences and subjective probability weighting. When it comes to the risk preferences, it is not straightforward to tell which action is more "risky". On the one hand, action V is risky because the payoff of B comes with probability $1-p$ and $B-F$ with probability p. On the other hand, action S is risky in the sense that the payoff of 0 is more likely to occur while the payoff of kF is possible with nonzero probability. Worse yet, the number of violators who got monitored, k, is a random variable, so it is hard to tell whether S is a riskier action when the population size, n, is relatively small.[7] A relatively straightforward claim is, for sufficiently large n, risk-averse subjects' δ would be larger. This is because the winning probability of the citizen lottery is negligible, while the payoff of V is volatile.

Claim 1. *The more risk averse, the more likely to play S, when n is sufficiently large.*

Another factor that the model does not take into account is the heterogeneous tendency of subjectively overestimate small probabilities (Tversky and Kahneman, 1992). Some people would buy lotteries, expecting that the chance of winning the lottery is greater than the objective probability (Blau et al., 2020). Extending this observation to the case of the citizen

[7]To illustrate, consider an extreme case where there are only two citizens. Given the other citizen's probability of playing S is δ, action S is associated with a random payment of 0 with probability $1-(1-\delta)p$ or F with probability $(1-\delta)p$. Meanwhile, action V is associated with a random payment of B with probability $1-p$, and $B-F$ with probability p. Which one gives a larger expected payoff for a risk-averse citizen depends on the size of B, F, the monitoring capacity p, and the risk-aversion parameter.

lottery, I would expect that people with a tendency of subjective probability weighting would play S more.

Claim 2. *The more overestimate small probabilities, the more likely to play S.*

4 Experiment

To examine how the citizen lottery works in practice, I conducted a laboratory experiment, varying two key parameters, n and p. I consider the theoretical predictions and claims summarized in section 2 as null hypotheses for the experiment and design the experiment to test them clearly.

4.1 Experimental Design

An experiment is designed as follows: In each session of $N \in \{18, 20\}$ participants, they play 12 similar games, wherein each subject is randomly assigned to a group whose size is $n \in \{3, 6, 9, 18\}$ when $N = 18$ or $\{2, 5, 10, 20\}$ when $N = 20$.[8] Their task is to choose one of the two items: a white ball and a box.[9] Unwrapping the box, a subject gets a red ball with probability $p \in \{0.3, 0.5\}$ and a blue ball with probability $1 - p$. By getting a blue ball, a subject earns a payoff of $B + m$. A red ball is associated with a payoff of $B - F + m$, where $m > 0$ is the base payoff to guarantee the participant's minimum earnings to be positive. Choosing the white ball earns m. On top of that, one of the group members who chose the white ball is randomly selected to get an additional payoff of kF, where k is the number of the members who got the red ball within the group of n.

Table 1 summarizes the experimental design. Each round comes with a different group size in the mixed order as shown in Table 1. The participants were told that they would know how many subjects form a group at the beginning of each round, without knowing the group sizes of the following rounds. To control for the potential order effect, the same mixed order is used for all sessions. For example, in the first round of every session with 18 participants, they were told that the group size is 6. Between subjects, there are two treatments in terms of the monitoring capacity p. I call the treatment with $p = 0.3$ as P03, and

[8] It would be ideal to have all the sessions with the same number of participants, but due to unexpected no-shows I had to prepare for two different contingencies.

[9] To avoid any unobservable responses to the framed narratives, I consider abstract framing. A white ball and a box, respectively, correspond to actions S and V in section 2, but in any part of the experiment instructions, neither normative nor judgmental descriptions were used. [Mention that my finding could be the lower bound of the estimate. comment from Syngjoo Choi]

Round	1	2	3	4	5	6	7	8	9	10	11	12
n (when $N = 18$)	6	9	18	3	9	6	18	3	9	6	3	18
n (when $N = 20$)	5	10	20	2	10	5	20	2	10	5	2	20
Choosing a box $\Rightarrow$ Red ball with prob p; Blue ball with prob $1-p$. Choosing a white ball $\Rightarrow$ Randomly selected one additionally earns kF.												
$p = 0.3$ or $p = 0.5$												

Table 1: Experimental Design, $n = 18$

P05 is denoted accordingly. After completing the 12 rounds, risk preferences and subjective probability weighting tendencies are elicited via a simple survey.[10] Post-experimental survey include some individual characteristics, which would be used as control variables later. Finally, one of the 12 rounds is randomly selected to be paid.

I set the parameters to be tightly aligned with the theoretical predictions in section 2, and to guarantee the theoretical minimum payment to be reasonably close to a typical show-up payment. The experiment currency unit used in this experiment is tokens, and I set the exchange rate at 1 token to 100KRW (about 0.07USD), the base payoff m to be 100 tokens, and B and F to be 140 and 200 tokens, respectively. This means, when a subject chooses a box, it comes with $240(=140+100)$ tokens with probability $1-p$, or with $40(=140-200+100)$ tokens with probability p. Choosing a white ball comes with a payoff of 100 tokens, and in case of the lottery winner, $200 * k$ tokens are added, where k is the number of the red balls appeared in the group. Given those parameters, $b = \frac{B}{2F} = 0.35$, which means that in P03, the monitoring capacity $p = 0.3$ is too small for the group size affect the decisions, while in P05 with $p = 0.5$, Proposition 1 works.

4.2 Hypotheses

Corresponding to the propositions and claims summarized in section 2, I primarily investigate the following four testable hypotheses. For notational consistency, I call the action of choosing a white ball in the experiment as playing S.

Hypothesis 1. *In P05, the fraction of subjects playing S decreases with the group size. In P03, no one plays S regardless of the group size.*

Hypothesis 2. *The fraction of subjects playing S is greater in P05 than in P03.*

[10] a long description about non-incentivized elicitation

Hypothesis 3. *For a sufficiently large n, the subjects with more risk aversion would prefer to play S.*

Hypothesis 4. *The subjects with a stronger tendency of overestimating small probabilities would prefer to play S.*

A few remarks on the null hypotheses are worth mentioning. These null hypotheses are not meant to be normative: I do not claim that the experimental findings must be consistent with what theory says. Instead, those must be considered as theoretical benchmarks. We can learn more from what is different from theory, not from what is as predicted.

4.3 Experimental Procedure

All sessions were conducted via the real-time online mode using Zoom. Upon arrival at the designated Zoom meeting, subjects' sign-up information were checked, and then they were instructed to rename their display name with two random alphabet letters. Profile images were disabled so that the Zoom meeting environment does not make any one of the participants distinctive. Each received a web link to the standalone experimental pages created by LIONESS (Live Interactive ONline Experimental Server Software). To induce public knowledge on the information contained in the instructions, the same instructions were presented on the participants' display, and the experimenter read them aloud. After all questions were addressed in Zoom, the participants answered comprehension check quizzes, and they started the session only when every participant passed the quizzes. The experiment was conducted at Sungkyunkwan University in South Korea and the original instructions were conveyed in Korean,[11] with a total of 8 sessions (4 sessions for each of P03 and P05) with 150 participants. To minimize any dynamic effects from the previous decision rounds, the participants were told that at the beginning of every round, the entire subjects in the session were randomly shuffled and regrouped. The subjects earned on average 18,800KRW (about 14USD) with the minimum earnings of 5,000KRW and the maximum of 75,000KRW. Due to administrative restrictions regarding the cash payments to the subjects, a Starbucks e-gift card whose balance corresponds to the subject's earning was sent mobile.

[11]The instructions translated in English are available in the Appendix B. The original Korean version is available upon request

5 Results

This section presents the experimental findings corresponding to the hypotheses presented in the previous section. The first set of findings regards the changes in the proportion of those who play S, or choose a white ball, when the size of the group or the monitoring capacity changes.

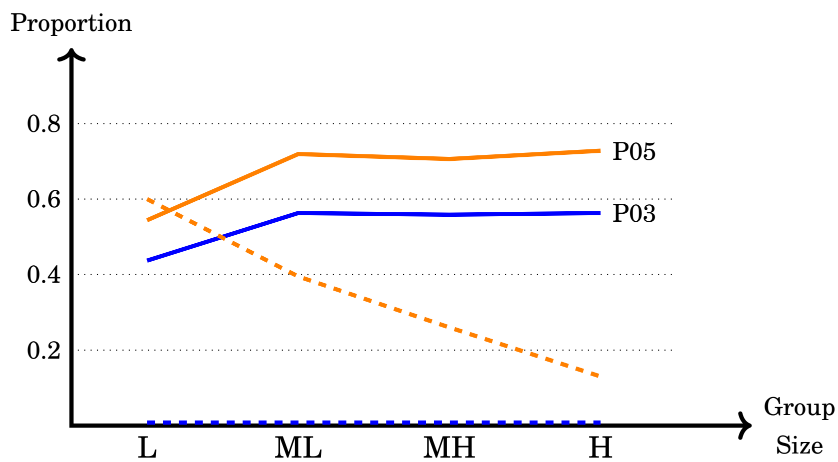


Figure 3: Proportion of playing S

Figure 3 presents several findings. The x-axis represents the size of the group. For illustrative simplicity, I collectively label the group size of 3 in the session of 18 and size of 2 in the session of 20 as L. The larger group sizes are labeled as ML, MH, and H in the same manner.[12] The y-axis represents the proportion of the subjects who played action S or chose a white ball. Solid lines are what I observed from the experimental data, and dashed lines with corresponding colors are theoretical predictions when the size of the session is 18.

In P03, where the theory predicts that no one would play S, the proportion of subjects playing S is nearly close to 50%, far greater than 0 (p <0.001)[13]. Another observation from P03 is that it is nearly irresponsive to the changes of the group size. Meanwhile, in P05, the proportion increases in the size of the group (p = 0.031). These findings strongly reject Hypothesis 1.

Result 1. *In P05, the fraction of subjects playing S increases with the group size. In P03, the significant fraction of subjects play S.*

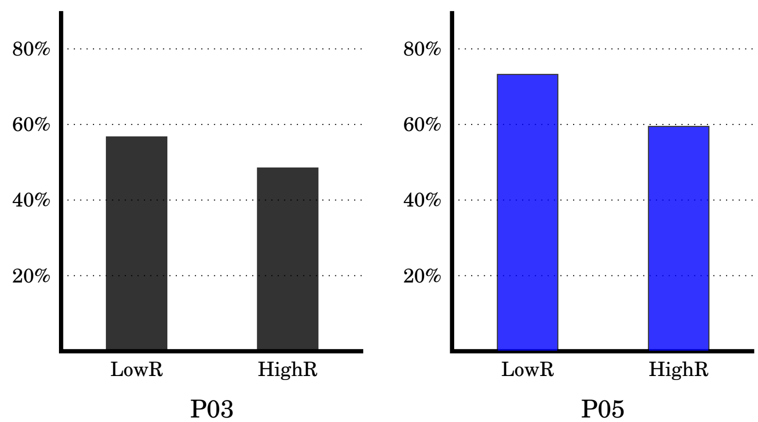
[12]This labeling is considered only for illustrative simplicity. All regression results reported here takes the group size as a continuous variable.

[13]Unless otherwise noted, I report the p-value from the linear regression with the standard errors clustered at the individual level.

Hypothesis 2 regards how subjects would respond to the changes in monitoring capacity. The proportion of playing S in P05 is significantly larger than that in P03 (p <0.001), supporting Hypothesis 2.

Result 2. *The fraction of subjects playing S is greater in P05 than in P03.*

Note that with the between-subject design, each subject only faces either $p = 0.3$ or $p = 0.5$, so Result 2 is not the outcome of the experimenter demand effect. Then what could the observations explain?



* HighR: high risk-taking tendency.

Figure 4: Proportion of Ball Choices By Risk Preference

Figure 4 shows the tendency of playing S in terms of the risk preferences. Although the difference is not statistically significant, subjects with a higher risk-taking tendency play S less in both treatments. This finding supports Hypothesis 3, even for relatively small group sizes, where the probability of winning the lottery is not negligible.

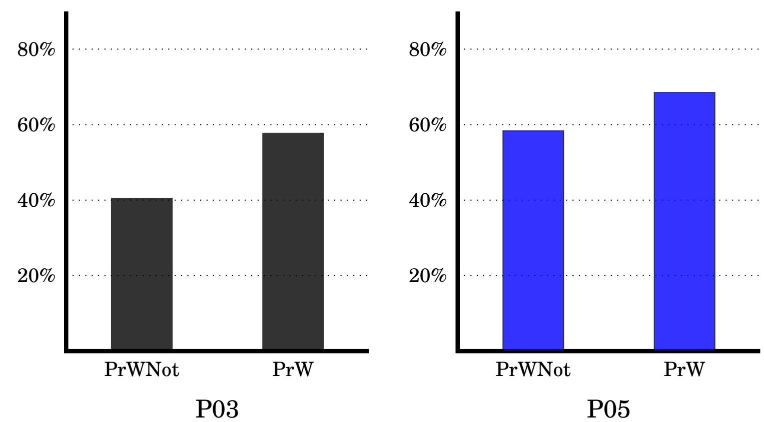
Result 3. *Subjects with more risk aversion play S more.*

If risk aversion is positively associated with aversion to strategic uncertainty, then action S could have been less frequent for subjects with a lower risk-taking tendency. This is because while action V does not involve any uncertainty associated with other subjects' strategies, action S highly depends on the belief on how other subjects behave. Result 3 corroborates that the concern for strategic uncertainty matters in a less significant manner.[14]

[14]Regarding the strategic uncertainty, it would be also possible if p is uninformed to the citizens, ambiguity-averse citizens would prefer S to avoid ambiguous outcomes from V. This speculation is beyond the scope of the current paper, but it is certainly worth of further investigation.

Last, but not least interesting observation is that the choice of action S is highly associated with the tendency of subjectively overestimating small probabilities, supporting Hypothesis 4.

Result 4. *Subjects with a stronger tendency of overestimating small probabilities play S more.*



* PrW: exhibiting a tendency of probability weighting.

Figure 5: Proportion of Ball Choices By Probability Weighting Tendency

Figure 5 shows the proportions of playing S in terms of the subject's tendency of overestimating small probabilities. I divided the subjects into two groups based on their self-reported willingness to pay for fictitious lotteries for gains and insurances for losses using the questions suggested by Rieger et al. (2017). The three questions involve the willingness to pay for a lottery with possible gains, and another three questions ask about their willingness to pay to avoid a lottery with possible losses. For instance, if a subject answered that he is willing to pay \$10 for purchasing a lottery that pays \$100 with a 5% chance and \$20 for a lottery paying \$100 with a 15% chance, then the subject's willingness to pay (and hence subjective probability to the event) is relatively larger for a small chance of winning.

Result 4 is particularly interesting because it raises a possibility of applying the citizen lottery in a large scale. Standard theory clearly predicts that the fraction of good-citizen behaviors would decrease if every citizen is objective in appreciating small probabilities.

6 Discussions

In this section, I address some issues not discussed in the main body of the paper.

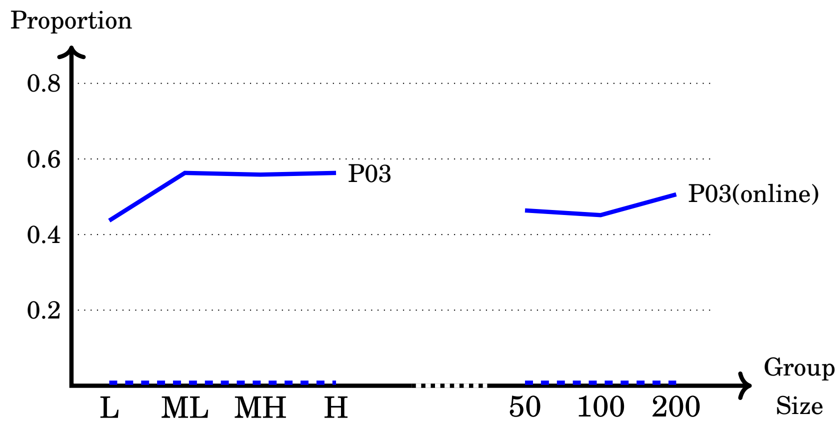


Figure 6: Proportion of playing S, extended

6.1 Supplementary Evidence from an Online Experiment

A common concern regarding laboratory experiments is that the group size, intended to represent a community or local society, is often too small. In the laboratory experiment, the largest group size was 20. Although this group size is sufficiently large for the equilibrium probability of choosing S to approach zero, some may question whether the non-decreasing pattern observed in the lab is a result of the small scale. To address this concern, I conducted an additional online experiment on Prolific in February 2025, using a larger group.[15]

The online experiment followed a similar procedure to one treatment of the laboratory study, P03, with three key differences: (1) decisions were made asynchronously, (2) participants were recruited from a representative sample of the United States, (3) and most importantly, the group sizes are 50, 100, and 200. After consenting to participate, subjects read the same instructions as in the laboratory experiment—choosing either a box or a white ball in each period, with varying payoffs associated with each decision. Participants were informed that their actual payment would be determined only after all group members had completed the study. At the start of each period, participants were randomly assigned to one of the group sizes: 50, 100, or 200. The group sizes presented to the participants were randomly ordered. Following their decision-making, participants completed post-experiment survey questions. A total of 401 subjects participated; while the target was 400 subjects, a technical glitch allowed one additional participant.

[15]This experiment was pre-registered on AsPredicted.org (registration #208968) under the same tile, 'Good-Citizen Lottery'. Since the online experiment was conducted after the laboratory data had been collected, I explicitly stated that it serves as an extension of the laboratory findings.

Figure 6 presents the results, with a portion of Figure 3 from P03 included for direct comparison. The smallest group size in the online experiment (50) is at least 2.5 times larger than the largest group size in the laboratory experiment (18 or 20). Notably, there were no significant decreases in the proportion of participants choosing the good-citizen action, while the probability of winning the good-citizen lottery in the online experiment was significantly lower than in the laboratory experiment. This finding suggests that the citizen lottery can effectively deter socially costly behaviors, even in larger groups.

6.2 Assumptions

This subsection addresses two assumptions made throughout the paper: the desirability of bad-citizen behavior and citizen homogeneity.

I assumed that $B_i - pF > 0$ for every citizen i. This assumption was made for the simplicity of the analysis and to ensure that the theoretical predictions without the citizen lottery are straightforward. It is, of course, possible to assume that citizens are distributed over the interval $[\underline{B}, \overline{B}]$, with a value $B^* \in [\underline{B}, \overline{B}]$ such that citizens with $B_i \leq B^*$ are innately good and thus find $B_i - pF \leq 0$. Introducing such innately good citizens would lower the incentives for individuals to act strategically as good citizens, but would not alter the qualitative predictions of the model. Specifically, citizens with $B_i > B^*$, who are considering whether to play either S (good-citizen behavior) or V (bad-citizen behavior), would recognize that the probability of winning the citizen lottery is already low due to the presence of innately good citizens. This, in turn, diminishes the monetary incentives to play S. However, the conflict of interest among these individuals remains unchanged, meaning their strategic decisions would align with the predictions of the model under the assumption that there are no innately good citizens.

The assumption of citizen homogeneity is another important consideration. In assuming that there are no innately good citizens, I set $B_i = B$ for all i. However, there may be other factors—particularly wealth and household income—that influence decision-making. It is well documented that relatively poor households spend a larger proportion of their income on lottery tickets. While the citizen lottery is distinctively different from a typical lottery because there is no purchase fee, if the citizen lottery were considered analogous to a typical lottery, it might imply that the citizen lottery could have stronger deterrent effects for lower-income households. Although this potential unintended consequence—encouraging poorer individuals to become good citizens—is purely theoretical and has not been substantiated, it remains an important point for further discussion.

7 Conclusions

This study bridges theoretical predictions with experimental findings to examine the citizen behaviors in a "citizen lottery" framework. While theory suggests that the proportion of "good citizens" would decrease as population size grows, my experimental results reveal the opposite and encouraging deviation. This finding implies that the citizen lottery mechanism can remain effective, or even become more so, in large populations.

Furthermore, the experimental findings confirm that the proportion of good citizens increases with greater monitoring capacity, heightened risk aversion, and a stronger probability-weighting tendency. These insights reinforce the viability of citizen lottery mechanisms, especially when paired with policies that enhance monitoring and leverage psychological biases like probability-weighting. In sum, the experimental findings offer robust support for the efficacy of the good-citizen lottery, highlighting their potential to promote prosocial behavior even in challenging scenarios. The robustness of these findings in larger group sizes from 50 to 200 in an online experimental setting bolsters the potential.

Speculatively, if a tendency to overestimate small probabilities is correlated with reckless behaviors that exacerbate public bads, the citizen lottery could serve as a counterweight, reducing such behaviors. This speculation may open up new avenues for future research to investigate the interplay between behavioral tendencies and the production of public goods and bads.

References

Andreoni, James, "Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow Giving," *The Economic Journal*, 1990, *100* (401), 464–477.

_ , "Warm-Glow Versus Cold-Prickle: The Effects of Positive and Negative Framing on Cooperation in Experiments," *The Quarterly Journal of Economics*, 1995, *110* (1), 1–21.

_ , "Chapter 18 Philanthropy," in Serge-Christophe Kolm and Jean Mercier Ythier, eds., *Applications*, Vol. 2 of *Handbook of the Economics of Giving, Altruism and Reciprocity*, Elsevier, 2006, pp. 1201–1269.

_ , "Giving Gifts to Groups: How Altruism Depends on The Number of Recipients," *Journal of Public Economics*, 2007, *91* (9), 1731–1749.

Blau, Benjamin M., R. Jared DeLisle, and Ryan J. Whitby, "Does Probability Weighting Drive Lottery Preferences?," *Journal of Behavioral Finance*, 2020, *21* (3), 233–247.

Charness, Gary and Chun-Lei Yang, "Starting small toward voluntary formation of efficient large groups in public goods provision," *Journal of Economic Behavior & Organization*, 2014, *102*, 119–132.

Duffy, John and Alexander Matros, "On the Use of Fines and Lottery Prizes to Increase Voter Turnout," *Economics Bulletin*, 2014, *34* (2), 966–975.

Fabbri, Marco, Paolo Nicola Barbieri, and Maria Bigoni, "Ride Your Luck! A Field Experiment on Lottery-Based Incentives for Compliance," *Management Science*, 2019, *65* (9), 4336–4348.

Filiz-Ozbay, Emel, Jonathan Guryan, Kyle Hyndman, Melissa S. Kearney, and Erkut Y. Ozbay, "Do lottery payments induce savings behavior? Evidence from the lab," *Journal of Public Economics*, 2015, *126*, 1–24.

Gerardi, Dino, Margaret A. McConnell, Julian Romero, and Leeat Yariv, "Get Out the (Costly) Vote: Institutional Design for Greater Participation," *Economic Inquiry*, 10 2016, *54* (4), 1963–1979.

Gneezy, Uri, *Mixed Signals: How Incentives Really Work*, New Haven: Yale University Press, 2023.

Isaac, R. Mark and James M. Walker, "Group Size Effects in Public Goods Provision: The Voluntary Contributions Mechanism," *The Quarterly Journal of Economics*, 1988, *103* (1), 179–199.

_, _, and Susan H. Thomas, "Divergent Evidence on Free Riding: An Experimental Examination of Possible Explanations," *Public Choice*, 1984, *43* (2), 113–149.

Kearney, Melissa S., Peter Tufano, Jonathan Guryan, and Erik Hurst, "Making Savers Winners: An Overview of Prize-Linked Savings Products," Working Paper 16433, National Bureau of Economic Research October 2010.

Kim, Duk Gyoo, "Vaccination Lottery," *Economics Letters*, 2021, *208*, 110059.

_ , "Penalty Lottery," *Scandinavian Journal of Economics*, 2023, *125* (4), 997–1026.

Levitt, Steven D., John A. List, and Sally Sadoff, "The Effect of Performance-Based Incentives on Educational Achievement: Evidence from a Randomized Experiment," NBER Working Papers 22107, National Bureau of Economic Research, Inc Mar 2016.

Morgan, John, "Financing Public Goods by Means of Lotteries," *The Review of Economic Studies*, 2000, *67* (4), 761–784.

_ **and Martin Sefton**, "Funding Public Goods with Lotteries: Experimental Evidence," *The Review of Economic Studies*, 2000, *67* (4), 785–810.

Nyqvist, Martina Björkman, Andrea Guariso, Jakob Svensson, and David Yanagizawa-Drott, "Reducing Child Mortality in the Last Mile: Experimental Evidence on Community Health Promoters in Uganda," *American Economic Journal: Applied Economics*, July 2019, *11* (3), 155–192.

Rieger, Marc Oliver, Mei Wang, and Thorsten Hens, "Estimating cumulative prospect theory parameters from an international survey," *Theory and Decision*, 2017, *82*, 567–596.

Tversky, Amos and Daniel Kahneman, "Advances in prospect theory: Cumulative representation of uncertainty," *Journal of Risk and Uncertainty*, 1992, *5*, 297–323.

Volpp, Kevin G., Leslie K. John, Andrea B. Troxel, Laurie Norton, Jennifer Fassbender, and George Loewenstein, "Financial Incentive–Based Approaches for Weight Loss: A Randomized Trial," *Journal of the American Medical Association*, 12 2008, *300* (22), 2631–2637.

A Appendix: Proofs

Proof of Proposition 1: The left-hand side of equation 3 is constant in n. The right-hand side of it, $\sum_{i=1}^{n}\binom{n}{i}\delta^{n-i}(1-\delta)^{i}\frac{1}{n+1-i} := R(n,\delta)$ monotone decreases in δ as shown in the main text. The remaining task is to show that $R(n,\delta)$ decreases in n for a given $\delta \in (0,1)$. For algebraic simplicity, I will show $\frac{R(n,\delta)}{1-\delta} = \sum_{i=1}^{n}\binom{n}{i}\delta^{n-i}(1-\delta)^{i-1}\frac{1}{n+1-i} := \hat{R}(n)$ decreases. in addition, for notational simplicity, let x and denote δ and $1-\delta$ respectively. These notations are useful when we compare $\hat{R}(n)$ with a binomial expansion of $(x+y)^n$. Note that for $i=1$, $\binom{n}{1}=n$ and $\frac{1}{n+1-i}=\frac{1}{n}$, and for $i=n$, $\binom{n}{i}=1$ and $\frac{1}{n+1-i}=1$. Thus, the first term and the last term of $\hat{R}(n)$ are x^{n-1} and y^{n-1}. Note further that $1=(x+y)^{n-1}=\sum_{i=0}^{n-1}\binom{n}{i}x^{n-i}y^{i}$. Comparing $\hat{R}(n)$ with the binomial expansion of $(x+y)^{n-1}$, one can figure out that $\hat{R}(n)$ is strictly smaller than 1 for $\delta\in(0,1)$ because except for the first and last terms, the other terms in the binomial expansion form are discounted by $\frac{1}{n+1-i}$. For illustration, consider $n=4$. $\hat{R}(4)=x^3+\binom{4}{2}x^2y\frac{1}{3}+\binom{4}{3}xy^2\frac{1}{2}+y^3=x^3+2x^2y+2xy^2+y^3$. This looks similar to the binomial expansion of $(x+y)^3$, but multipliers of the second and the third terms are smaller than $\binom{3}{2}$ and $\binom{3}{1}$. Thus, $\hat{R}(4)=[x^3+3x^2y+3xy^2+y^3]-x^2y-xy^2=[(x+y)^3]-(x^2y+xy^2)=1-xy<0$. From this illustration, we can figure out that for any $n\in\mathbb{N}$, $\hat{R}(n)$ will be simplified in the form of $1-xy[*]$, where $[*]$ is the amount discounted by $\frac{1}{n+1-i}$, and xy is a common factor for every term except for the first and the last terms. For general $n\geq 2$,

$$
\begin{aligned}
\hat{R}(n) &= x^{n-1}+x^{n-2}y^{1}\frac{\binom{n}{2}}{n-1}+x^{n-3}y^{2}\frac{\binom{n}{3}}{n-2}+\cdots+x^{2}y^{n-3}\frac{\binom{n}{n-2}}{3}+x^{1}y^{n-2}\frac{\binom{n}{n-1}}{2}+y^{n-1}\\
&= x^{n-1}+\frac{n}{2}x^{n-2}y^{1}+\frac{n(n-1)}{6}x^{n-3}y^{2}+\cdots+\frac{n(n-1)}{6}x^{2}y^{n-3}+\frac{n}{2}x^{1}y^{n-2}+y^{n-1}\\
&= x^{n-1}+\frac{\binom{n}{1}}{2}x^{n-2}y^{1}+\frac{\binom{n}{2}}{3}x^{n-3}y^{2}+\cdots+\frac{\binom{n}{2}}{3}x^{2}y^{n-3}+\frac{\binom{n}{1}}{2}x^{1}y^{n-2}+y^{n-1}\\
&= (x+y)^{n-1}-xy\left\{\frac{n-2}{2}x^{n-3}+\frac{(n-1)(n-3)}{3}x^{n-4}y+\cdots+\frac{(n-1)(n-3)}{3}xy^{n-4}+\frac{n-2}{2}y^{n-3}\right\}\\
&= 1-xy\frac{n-2}{2}\underbrace{\left\{x^{n-3}+\binom{n-1}{3}x^{n-4}y+\cdots+\binom{n-1}{3}xy^{n-4}+y^{n-3}\right\}}_{(*)},
\end{aligned}
$$

where the remaining term in the curly bracket marked as $(*)$ again has a similar form of binomial expansion of $(x+y)^{n-3}$, and can be simplified in the form of $1-xy[*]$. Therefore, as n gets larger, $\hat{R}(n)$ decreases as $\frac{n-2}{2}$ increases. The only remaining case is for $n=1$. It can be manually calculated that $\hat{R}(1)=\hat{R}(2)=1$, so it does not increase in this case either. □

B Appendix: Experimental Instructions

Welcome

Before you read this instruction, please make sure that you do not force-close this webpage. If you close the webpage, you may not log in to the same experiment again, which may make us unable to calculate your earnings from your participation.

If you have questions or need clarifications, please ask the experimenter via the concurrent Zoom meeting.

Instructions

Thank you for participating in this experiment. Please read carefully the following experiment instructions. At the end of the instructions are quizzes to check your understanding.

Your earnings from this experiment are determined by your choices, other participants' choices, and luck. The monetary unit used in this experiment is called a "token."

Overview

In this experiment, you and many other participants form a group and make simultaneous decisions for 12 times (rounds). In each round, the conditions for your decision would vary, so please be careful in checking the changes. Details follow.

Main task: Choosing a box or a white ball

Participants are randomly assigned to a new group of N people at the beginning of each session.
[Note: The number of group members (N) may vary from round to round, so please make sure to check.]

Participants then simultaneously choose either **a box** or **a white ball**.

- If you choose the box, there is a 70% chance of a blue ball inside the box and a 30% chance of a red ball. You earn 240 tokens with the blue ball, and 40 tokens with the red ball.

- If you choose the white ball, you get 100 tokens. In addition, one randomly selected group member who chose the white ball will receive additional

$$\text{total number of red balls in the group} * 200 \text{ tokens.}$$

Example: Suppose that in a group of four people, two people chose the box and the other two chose the white ball.

- If both of the box choosers get blue balls, no additional earnings go for any of the two white ball choosers.
- If one of the two box choosers gets a red ball, then one of the two white ball choosers receives additional 200 tokens.
- If both box choosers get red balls, one of the two white ball choosers receives additional 400 tokens (=2 red balls*200 tokens).

Feedback at the end of each round

At the end of each round, participants are only told what choices they made in that round. They won't be informed about who the members were or what choices they made during the experiment.

Payments

After the 12 rounds, the server computer will randomly select one round, and the tokens earned by the participant in that round will be converted to cash(*) and paid out.

(*) To be precise, the tokens will be converted into Starbucks e-Gift gift certificates.

Each round has an equal chance of being selected, so it is of your benefits to play all rounds carefully. The earnings for the selected round will be converted at the rate of 1 token = 100 Korean Won.

Comprehension Check Quiz

You must answer all quizzes correctly to move to the next stage. If necessary, please double-check the instructions above.

Q1 Suppose you belong to a group of 12 people. Which of the following earnings are you *unlikely* to get if you choose the box? (A) 40 tokens (B) 100 tokens (C) 240 tokens

Q2 Suppose you belong to a group of 4 people. Which of the following earnings are you *unlikely* to get if you choose the white ball? (A) 240 tokens (B) 100 tokens (C) 500 tokens

Q3 In a group of 4 people, suppose that members 1 and 2 chose a box and got a blue ball, member 3 chose a box and got a red ball, and member 4 chose a white ball. How much will member 4 earn? [Hint: If only one person chose the white ball, that person will be the one who receives the extra tokens (since one person is randomly selected from a group of one person).] (A) 100 tokens (B) 240 tokens (C) 300 tokens

Q4 Which of the following is a correct description of how the experiment goes? (A) Once the group members are initially determined, the experiment will continue with those members until the end of the experiment. (B) If the box is checked, there is a 60% chance of a red ball. (C) The maximum number of tokens that can be earned by checking the box is 240 tokens.

[After the participant passing the quiz]

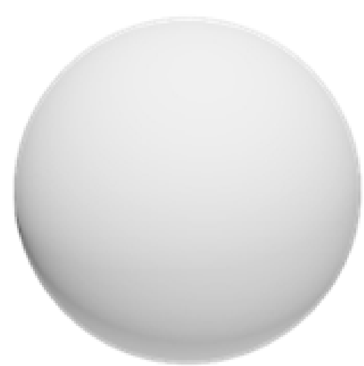
You are waiting for all participants to finish reading the instructions and solving the comprehension check quiz. While you are waiting, please review the summary of the experimental procedure below.

1. The experiment consists of 12 rounds of decision-making.
2. In each round, all participants are randomly assigned to a new group of N people.
3. Each participant simultaneously chooses either a box or a white ball.
    - The box contains a blue ball worth 240 tokens with a 70% probability and a red ball worth 40 tokens with a 30% probability.
    - If you choose the white ball, you receive 100 tokens. In addition, one randomly selected person among those who chose the white ball receives an additional reward equal to [the number of red balls in the group * 200 tokens].

[Repeat the following for 12 times, with varying N]

In this round, you belong to a group of **6** participants.

Please choose either a box or a white ball. Your choice cannot be undone, so please be careful.



- Choosing the white ball, you receive 100 tokens. In addition, one of those who chose the white ball receives an additional reward equal to [the number of red balls in the group * 200 tokens].
- Choosing the box, you receive 240 tokens if a blue ball is drawn with a 70% chance, or 40 tokens if a red ball is drawn with a 30% chance.

[After the 12 rounds]

The main part of the experiment is complete. Once you fill out the following questionnaire, you will receive the results of your experiment and your earnings.

[After the post-experiment survey]

The results: Round $\%R\%$ was selected as the payout round.

- (When the box was chosen) In this round, you chose the box and got a blue (red) ball. Your reward for this is 240 (40) tokens. The number of red balls that came out of this group is $\%TotalRed\%$. One of the group members who chose the white ball received additional $\%200 * TotalRed\%$ tokens.
- (When a white ball was chosen and the subject was not the winner of the citizen lottery) In this round, you chose the white ball, and your reward for this is 100 tokens. The number of red balls that came out of this group is $\%TotalRed\%$. Unfortunately, you are not one of the members who receive additional $\%200 * TotalRed\%$ tokens.
- (When a white ball was chosen and the subject was the winner of the citizen lottery) In this round, you chose the white ball, and your reward for this is 100 tokens. The number of red balls that came out of this group is $\%TotalRed\%$. You are the one who receives additional $\%200 * TotalRed\%$ tokens.

Your total earning is $\%TotalEarning\%$ tokens or $\%TotalEarning * 100\%$ Korean Won. A Starbucks e-Gift card worth $\%TotalEarning * 100\%$ will be sent to your registered mobile number. You will receive further instructions from Zoom regarding the payment procedure.