

〈研究ノート〉

# A Survey on Discounting Behavior of College Students in Japan

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## Abstract

In this paper, we analyze the time-discounting rate. The economic agents often take anomalous behavior. Behavioral Economics supposes hyperbolic discount and magnitude effect in order to explain the anomalous behavior. We conducted a questionnaire survey with college students in Japan and estimated the time-discounting rate using collected data from 323 responses. The time-discounting rate was estimated based on utility level using a Bayesian hierarchical model. From the survey, we confirmed the hyperbolic discounting behavior in that the time-discounting rate from today is the highest, followed by 3 months later, 6 months later, and then 12 months (one year) later. We also confirmed the magnitude effect. The time-discounting rate receiving 10,000 yen is the highest, followed by that receiving 30,000 yen and then that receiving 50,000 yen. This paper reaffirms the robustness of the main two phenomena in Behavioral Economics. It also finds that the marginal utility of money diminishes just as with general economic goods.

Keywords: discounting behavior, time-discounting rate, hyperbolic discount, magnitude effect, subjective discount factor, Bayesian hierarchical model

JEL Classification Codes: C91, D15, C11

## 1 Introduction

“Time discounting” means that a desired result in the future is perceived as less valuable than one in the present. It is also known as “temporal discounting” and “delay discounting”. Time-discounting

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Dear Professor Toshio Uemura

It's been a great pleasure working with you for a long time. I was lucky to have my lab right next to yours. I have learned so much from you over the years whether in life or at work. It is heartily appreciated. I wish you a wonderful retirement ahead of you.

rate is an index that indicates how much important the present is by comparing its valuation at an earlier date with one for a later date. A larger time-discounting rate means giving more importance to the present compared to the future.<sup>1)</sup> In other words, the time-discounting rate shows the degree of impatience. The time-discounting rate plays an important role in the intertemporal choice. Therefore, it also affects decisions on personal consumption and savings, and also affects a path of economic growth and a steady-state level of a country.

Standard Economics, which assumes rational economic agents (*Homo Economicus*), uses an exponential discount function in which the rate of time discounting is constant and independent of time.<sup>2)</sup> Whereas, Behavioral Economics uses hyperbolic discount functions instead in order to explain the anomalous behavior because, oftentimes, economic agents take anomalous behavior.

In Behavioral Economics, “hyperbolic discount” and “magnitude effect” are among well-known factors on the time-discounting rate: (i) “hyperbolic discount” (also known as “present bias”) suggests that values placed on rewards decrease very rapidly for small delay periods and then fall more slowly for longer delays (e.g. Thaler (1981), Benzion et.al. (1989), Laibson, (1997), O’ Donoghue and Rabin (1999), etc.) and (ii) “magnitude effect” suggests that the time-discounting rates are higher for smaller amounts, compared to higher amounts (e.g. Kirby (1997), Green et.al. (1997), etc.).<sup>3)</sup> Loewenstein (1992) and Frederick et.al. (2002) are both very informative and detail-oriented on time-discounting.

The purpose of this paper is to clarify the characteristics of the time-discounting rate. In particular, we focus on the two characteristics described above which are hyperbolic discounting and magnitude effect. Questionnaires are becoming a common method in this research field. We also conducted a survey on college students (nationals and non-nationals alike) in Japan. We analyzed the aggregated data and estimated the time-discounting rate.

This research field has extensive literature, so adding something new is not easy. However, in this paper, we use utility level (happiness level)<sup>4)</sup> to try to estimate the rate of time-discounting.<sup>4)</sup> This is our humble contribution.

<sup>1)</sup> Frederick, et.al. (2002) distinguishes “time-discounting” from “time preference”. Frederick, et.al. (2002) uses the term “time-discounting” broadly to encompass any reason and the term “time preference” to refer, more specifically, to the preference for immediate utility over delayed utility.

<sup>2)</sup> Ramsey (1928) assumes that the subjective discount rate ( $\rho$ ) is constant.

<sup>3)</sup> Interestingly, Holt and Wolf (2019) examined the magnitude effect in pigeons. There was no significant evidence for the magnitude effect.

<sup>4)</sup> Frey (2008) mentioned that the utility is used to measure the level of happiness which is an abstract variable. Happiness is not exactly the same with utility, but both happiness and utility have a close relationship in that the higher the utility level is, the higher the happiness level is. In this paper, “utility” and “happiness” will be used in the same meaning. See the footnote 4 in Shin (2018) in detail. The relationship between discount rate and time preference is shown as discount rate=time preference+1 in Rotschedla et.al. (2015).

The results of the paper can be summarized as follows: (i) we confirmed past studies on hyperbolic discounting behavior in that the time-discounting rate from today is the highest, followed by 3 months later, 6 months later, and then 12 months (one year) later. This result shows that the time-discounting rate is inversely proportionate to the length of the delay in time wherein the former decreases with the increase in the latter. (ii) we also confirmed the magnitude effect. The time-discounting rate receiving 10,000 yen is the highest, followed by that receiving 30,000 yen and then that receiving 50,000 yen. There was a tendency for the time-discounting rate to decrease as the amount increased. From the survey, we reaffirmed the robustness of the main two phenomena in Behavioral Economics. (iii) we also finds that the marginal utility of money diminishes just as with general economic goods.

This paper is organized as follows: Section 2 outlines the survey. Section 3 reports the results of the analysis and interprets the results. Section 4 offers conclusions on this research. Finally, the questionnaire used in this survey are posted in Appendix.

## 2 Outline of survey

In this research, using a questionnaire, we surveyed students at Asia University in Japan in order to investigate the time-discounting rate. We collected the responses of the questionnaire via website considering the trouble of data input work if survey was to be conducted on paper. We opened the questionnaire on website. We announced the URL to the students during the classes that we teach and we asked them to cooperate with this survey.

The students could participate at any time during the survey period which runs from October 10, 2019 to December 23, 2019. Responses were obtained from 323 students from freshman (1st year student) to senior (4th year student). In light with preserving the privacy of the respondents and in keeping the research free from all prejudice and bias, the concerns of the respondents, the response rate and any data with regard to the respondents' personal information, such as name, grade, gender, income, etc., are kept anonymous. At this point, some respondents may have taken the survey lightly.<sup>5)</sup> The questionnaire used in this research is attached in the Appendix.

This is a selection experiment where the combinations of the amount of money received and the timing are used. We prepared four kinds of money they receive: 10,000 yen, 30,000 yen, 50,000 yen

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<sup>5)</sup> Especially given the purely hypothetical and unincentivized nature of the survey experiment, another common way of approaching this problem would be to include survey items checking for potential protest responses or answers that potentially have been affected by experimenter demand effects (see e.g. Bateman et al., 2002). Several studies have shown how to minimize or eliminate hypothetical bias and discussed the positive effect of honesty reminders in stated preference surveys (see e.g. Loomis (2014) or Stevens, Tabatabaei and Lass (2013)).

and 100,000 yen, and five kinds of reception timing: Today, 3-months later, 6-months later, 12-months later, and 36-months later. The number of combinations between the money and timing was 60. The questions are in a two-choice format. For example:<sup>6)</sup>

- Q3. Which one do you prefer?

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 30,000 yen if you wait for 3 months

The number of questions was 60. The correspondents don't need to answer all of them. For example, we can expect easily that if the correspondents choose the second option from Q3 then they will choose the second option from Q4. So, we don't ask them Q4 and they don't need to answer Q4. In case that the correspondents choose the second option from Q6, we don't ask them Q9, Q12 and Q14 because we can expect that they will choose the first option from Q9, Q12 and Q14. As stated by these examples, the questions are different according to what choice the correspondents pick. The correspondents answered only about 30 questions on average from the 60 questions.

We also asked about happiness level with the amount they received. We prepared eleven choices - 1, 2, 3,..., 9, 10 and over 10 - for the happiness level when they receive the money, 1 being the lowest. The questions are below.

- Let's assume that the happiness level when you get (found, received, earned) 10,000 yen is 1. Based on that, how much is the "happiness level" when you get (found, received, earned) 30,000 yen, 50,000 yen, or 100,000 yen, respectively?

Please, choose only one option for each question.

Question	1	2	3	4	5	6	7	8	9	10	over10
30,000 yen	◦	◦	◦	◦	◦	◦	◦	◦	◦	◦	◦
50,000 yen	◦	◦	◦	◦	◦	◦	◦	◦	◦	◦	◦
100,000yen	◦	◦	◦	◦	◦	◦	◦	◦	◦	◦	◦

<sup>6)</sup> The questionnaire used in the survey does not have question numbers (e.g. Q3). However, for ease of explanation, the question numbers have been assigned herein.

### 3 Results

#### 3.1 Aggregate results

We summarize the aggregate results in Table 1 and Table 2. Table 1 summarizes the results of the question on the happiness level of the money they received.

“Over 10” was uniformly evaluated as 18. Even though it is arbitrary, “over 10” was set to 18, so that the average of happiness level (8.92) when receiving 100,000 yen reaches its closest to the median (9). In Table 1, 62 students receiving 30,000 yen (Q2-1), 29 students receiving 50,000 yen (Q2-2), and 28 students receiving 100,000 yen (Q2-3) all answered that their happiness level is 1. They were equally satisfied when they received 10,000 yen or 30,000 yen or 50,000 yen or 100,000 yen. We can consider several reasons, among others: (1) that as the marginal utility of money decreases, the marginal utility would approach almost zero, then their utility level is almost the same even though the money they receive increases; (2) that the students already knew the scenarios to be fictional (they do not get the money in real), so they did not answer seriously and so on. The results have been derived from the students’ own discretion arbitrarily or whimsically or for various other reasons which remain unknown. Nevertheless, we used their data for our research.

It was found that the higher the amount received, the higher the happiness level was as shown in the table above ( $3.97 < 5.52 < 8.92$ ). As money increases, the marginal happiness level decreases. In Fig. 1, we draw the histograms and the relationship between money and happiness level using the aggregate results in Table 1. From Fig. 1 (4), it can be seen that the curve of happiness level is not linear, but becomes flatter as money increases, that is, the marginal happiness level for money gradually decreases.<sup>7)</sup>

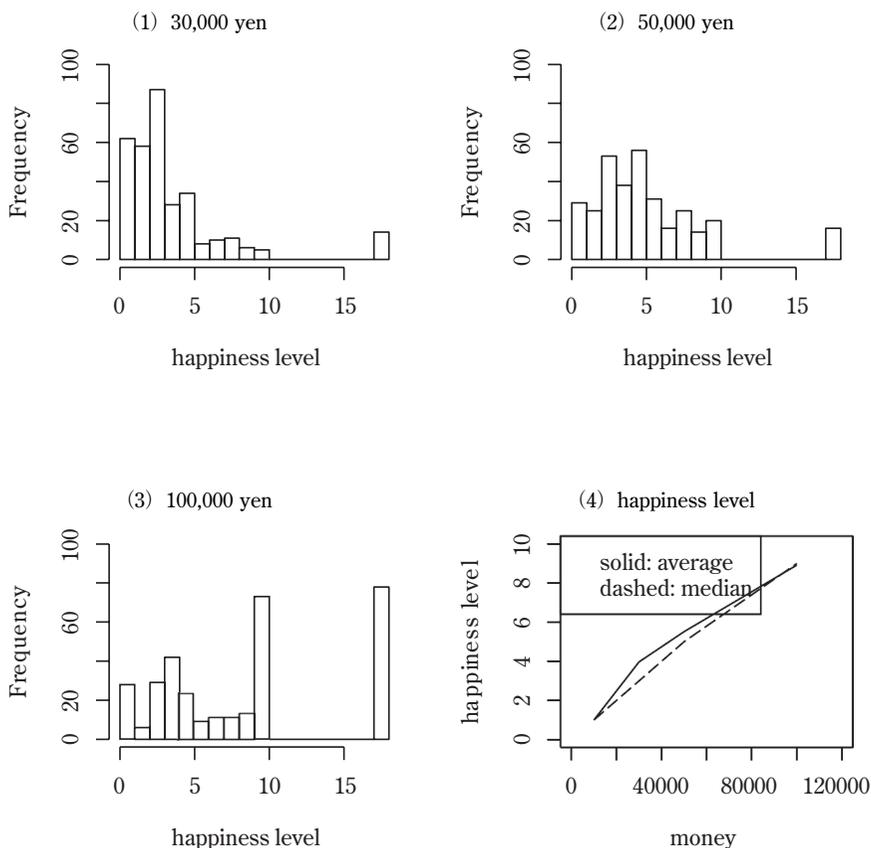
Table 2 summarizes the results from Q3 to Q62. The number of respondents for each option and

**Table 1 Aggregate results for happiness level**

Question	happiness level											average median	
	1	2	3	4	5	6	7	8	9	10	over10 (=18)		
Q2-1. 30,000 yen	62	58	87	28	34	8	10	11	6	5	14	3.97	3
Q2-2. 50,000 yen	29	25	53	38	56	31	16	25	14	20	16	5.52	5
Q2-3. 100,000 yen	28	6	29	42	23	9	11	11	13	73	78	8.92	9

<sup>7)</sup> It can be clearly seen that the marginal utility decreases gradually when viewed on average compared to when viewed on median. The degree of the curvature may depend on how the “over 10” is evaluated.

Fig. 1 Happiness level



their ratio were reported. We coded 0 if they chose the first one which opts for earlier receipt, and 1 if they chose the second one for late receipt. The question with the highest number of respondents who chose option 0 was Q11. The respondents are 291 (90.1%). It is painted in red in Table 2. Q11 is as follows:

- Q11. Which one do you prefer?
- Please, choose between the two scenarios.
- get 10,000 yen only for today
- get 30,000 yen if you wait for 36 months

On the other hand, the question with the highest number of respondents who chose option 1 was Q6. The respondents are 284 (87.9%). It is also painted in red in Table 2. Q6 is as follows:

- Q6. Which one do you prefer?
- Please, choose between the two scenarios.

**Table 2 Aggregate results for number of respondents**

Question	number of respondents		percentage of respondents (%)		Question	number of respondents		percentage of respondents (%)		Question	number of respondents		percentage of respondents (%)	
	0	1	0	1		0	1	0	1		0	1	0	1
Q3	132	191	40.9	59.1	Q23	142	181	44.0	56.0	Q43	197	126	61.0	39.0
Q4	74	249	22.9	77.1	Q24	203	120	62.8	37.2	Q44	251	72	77.7	22.3
Q5	207	116	64.1	35.9	Q25	243	80	75.2	24.8	Q45	118	205	36.5	63.5
Q6	<b>39</b>	<b>284</b>	<b>12.1</b>	<b>87.9</b>	Q26	273	50	84.5	15.5	Q46	69	254	21.4	78.6
Q7	140	183	43.3	56.7	Q27	103	220	31.9	68.1	Q47	242	81	74.9	25.1
Q8	250	73	77.4	22.6	Q28	67	256	20.7	79.3	Q48	44	279	13.6	86.4
Q9	79	244	24.5	75.5	Q29	214	109	66.3	33.7	Q49	182	141	56.3	43.7
Q10	205	118	63.5	36.5	Q30	45	278	13.9	86.1	Q50	118	205	36.5	63.5
Q11	<b>291</b>	<b>32</b>	<b>90.1</b>	<b>9.9</b>	Q31	135	188	41.8	58.2	Q51	167	156	51.7	48.3
Q12	133	190	41.2	58.8	Q32	266	57	82.4	17.6	Q52	83	240	25.7	74.3
Q13	249	74	77.1	22.9	Q33	85	238	26.3	73.7	Q53	243	80	75.2	24.8
Q14	190	133	58.8	41.2	Q34	223	100	69.0	31.0	Q54	198	125	61.3	38.7
Q15	176	147	54.5	45.5	Q35	175	148	54.2	45.8	Q55	132	191	40.9	59.1
Q16	76	247	23.5	76.5	Q36	<b>164</b>	<b>159</b>	<b>50.8</b>	<b>49.2</b>	Q56	230	93	71.2	28.8
Q17	231	92	71.5	28.5	Q37	66	257	20.4	79.6	Q57	188	135	58.2	41.8
Q18	141	182	43.7	56.3	Q38	235	88	72.8	27.2	Q58	123	200	38.1	61.9
Q19	263	60	81.4	18.6	Q39	154	169	47.7	52.3	Q59	82	241	25.4	74.6
Q20	196	127	60.7	39.3	Q40	271	52	83.9	16.1	Q60	200	123	61.9	38.1
Q21	287	36	88.9	11.1	Q41	218	105	67.5	32.5	Q61	122	201	37.8	62.2
Q22	239	84	74.0	26.0	Q42	122	201	37.8	62.2	Q62	171	152	52.9	47.1

- get 10,000 yen only for today
- get 100,000 yen if you wait for 3 months

But in Q36, the ratio of respondents who chose options 0 and 1 both reach the closest to half (50%). They are 164 (50.8%) and 159 (49.2%), respectively. It is painted in blue in Table 2. Q36 is as follows:

- Q36. Which one do you prefer?

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 3 months

◦ get 50,000 yen if you wait for 6 months

In Q11, the first option “10,000 yen Today” is compared to the second option “30,000 yen 36 months later” which is deemed the worst condition among the combinations because it has the longest period (36 months) for the least amount (30,000 yen) to be received. Therefore, it is thought that many students chose the first option “10,000 yen Today”. On the other hand, in Q6, the first option “10,000 yen Today” is compared to the second option “100,000 yen 3 months later” which is deemed the best condition among the combinations because it has the shortest period (3 months) for the largest amount (100,000 yen) to be received. Therefore, it is thought that many students chose the second option “100,000 yen 3 months later”. In the case of Q36 which compares “30,000 yen 3 months later” and “50,000 yen 6 months later”, the receiving times of both cases are set in the future. Moreover, the difference in the periods (3 months vs. 6 months) is short and the difference in the amounts (30,000 yen vs. 50,000 yen) is not large. A hyperbolic discount curve has a higher discount rate in the near future and lower discount rate in the distant future. Considering the hyperbolic discount, it is probable that the respondents did not feel much difference between the happiness levels in both options.

### 3.2 Estimation model

We estimate the subjective discount factor ( $\beta$ ) instead of the time-discounting rate ( $\rho$ ). There is the relationship between the time-discounting rate ( $\rho$ ) and the subjective discount factor ( $\beta$ ) as follows:

$$\beta = \frac{1}{1+\rho} \quad \text{or} \quad \rho = \frac{1-\beta}{\beta} \quad (1)$$

When the subjective discount factor ( $\beta$ ) is low, the weight for future utility is small. In other words, the future utility is greatly discounted. Conversely, when the subjective discount factor ( $\beta$ ) is high, the weight for future utility is large. In other words, it does not discount much future utility.

Let us define the exponential discount function ( $V$ ) of individual happiness level as follows:

$$V_{i,j,t} = A_{i,j} \beta_i^t \quad (2)$$

where,  $i$  represents individual ( $i=1, 2, \dots, 323$ );  $j$  represents the amount of received money  $j \in \{10000, 30000, 50000, 100000\}$ ;  $A$  is the happiness (utility) level. For example,  $A_{100,10000}$  means the happiness level of the 100th respondent obtained from 10,000 yen today.  $\beta$  is the subjective discount factor;  $t$  is the number of months delayed.

We consider a function of softmax action selection ( $\theta$ ) in order to estimate the parameters from the option selection data (0 or 1).

$$\theta_{i,j_1,t_1,j_2,t_2} = \frac{\exp(\phi_i V_{i,j_1,t_1})}{\exp(\phi_i V_{i,j_1,t_1}) + \exp(\phi_i V_{i,j_2,t_2})} \quad (3)$$

where,  $\phi$  is an inverse temperature of softmax function. We assume that  $C$ , which is the selection result ( $C \in \{0, 1\}$ ), follows Bernoulli distribution with  $\theta$ .

$$C_{i,j_1,t_1,j_2,t_2} \sim \text{Bernoulli}(\theta_{i,j_1,t_1,j_2,t_2}) \quad (4)$$

There are two kinds of parameters –  $\beta$  and  $\phi$  – which we estimate. We set the parameters on an individual basis. We assume that each parameter follows a normal distribution as follows:

$$\begin{aligned} \beta_i &\sim \text{Normal}(\mu_\beta, \sigma_\beta) I[0, 1] \\ \phi_i &\sim \text{Normal}(\mu_\phi, \sigma_\phi) I[0, \infty] \end{aligned}$$

where,  $\mu_\beta, \sigma_\beta, \mu_\phi$  and  $\sigma_\phi$  are hyper-parameters which the parameters set for each individual have in common and  $I[a, b]$  is an indicator function that takes the value from  $a$  to  $b$ .  $\beta_i$  and  $\phi_i$  are assumed to be truncated normal distributions. We assume that the hyper-parameters are distributed as follows:  $\mu_\beta \sim \text{Normal}(\mu_\beta^N, \sigma_\beta^N)$ ,  $\sigma_\beta \sim \text{Student } t(\nu_\beta^t, \mu_\beta^t, \sigma_\beta^t)$ ,  $\mu_\phi \sim \text{Normal}(\mu_\phi^N, \sigma_\phi^N)$ ,  $\sigma_\phi \sim \text{Student } t(\nu_\phi^t, \mu_\phi^t, \sigma_\phi^t)$ , where  $\mu_\beta^N, \sigma_\beta^N, \nu_\beta^t, \mu_\beta^t, \sigma_\beta^t, \mu_\phi^N, \sigma_\phi^N, \nu_\phi^t, \mu_\phi^t, \sigma_\phi^t$  are parameters (or arguments) required for the distribution functions. These parameters are specified to make the hyperprior vague as follows:  $\mu_\beta^N = 0.5, \sigma_\beta^N = 0.5, \nu_\beta^t = 3, \mu_\beta^t = 0, \sigma_\beta^t = 1, \mu_\phi^N = 0, \sigma_\phi^N = 10, \nu_\phi^t = 3, \mu_\phi^t = 0$  and  $\sigma_\phi^t = 1$ .

The estimation was performed using the Bayesian hierarchical model. The sampling was run with a burn-in of 10,000 iterations out of the 20,000 iterations. The estimated results are reported in Table 3 and Table 4. We used ‘‘Rstan’’ to calculate the estimation results in Table 3 and Table 4. Rstan is a generic tool that can be used in a wide variety of situations for Bayesian statistical model because it makes complex calculations easy and simple to code. To decide on convergence, we inspect the Gelman-Rubin’s convergence diagnostic which provides one measure of convergence based on multiple chains. See Gelman and Rubin (1992) in detail. Because the values are smaller than 1.1 for all parameters, it is considered that this sampling has been converged completely. We show that all estimates are significant from the HPDI (Highest Posterior Density Interval).

### 3.3 Hyperbolic discounting

Let us examine the hyperbolic discount where the time-discounting rate is smaller for bigger delays and the time-discounting rate is bigger for today. The estimation results are summarized in Table 3.

(1) to (4) are the results of estimation using all the answers from Q3 to Q62. (5) to (8) are the results of estimation using the answers to Q3 to Q26. These 24 questions compare the situations between

**Table 3 Estimation results**

I. All	mean	S.D.	X2.5.	X50.	X97.5.	Rhat
(1) $\mu_\beta$	0.855	0.008	0.839	0.855	0.871	1.000
(2) $\sigma_\beta$	0.133	0.007	0.120	0.132	0.147	1.000
(3) $\mu_\phi$	1.083	0.055	0.977	1.083	1.193	1.000
(4) $\sigma_\phi$	0.878	0.052	0.782	0.877	0.985	1.000
II. Today	mean	S.D.	X2.5.	X50.	X97.5.	Rhat
(5) $\mu_\beta$	0.811	0.010	0.791	0.811	0.831	1.000
(6) $\sigma_\beta$	0.159	0.008	0.145	0.159	0.176	1.000
(7) $\mu_\phi$	1.807	0.094	1.629	1.805	1.994	1.000
(8) $\sigma_\phi$	1.216	0.085	1.059	1.213	1.392	1.000
III. 3 months	mean	S.D.	X2.5.	X50.	X97.5.	Rhat
(9) $\mu_\beta$	0.856	0.008	0.839	0.856	0.872	1.000
(10) $\sigma_\beta$	0.127	0.008	0.112	0.127	0.142	1.000
(11) $\mu_\phi$	1.374	0.073	1.238	1.371	1.523	1.000
(12) $\sigma_\phi$	0.841	0.067	0.719	0.839	0.978	1.000
IV. 6 months	mean	S.D.	X2.5.	X50.	X97.5.	Rhat
(13) $\mu_\beta$	0.908	0.006	0.896	0.908	0.919	1.000
(14) $\sigma_\beta$	0.081	0.006	0.071	0.081	0.092	1.000
(15) $\mu_\phi$	1.384	0.092	1.214	1.380	1.574	1.000
(16) $\sigma_\phi$	0.856	0.079	0.711	0.852	1.020	1.000
V. 12 months	mean	S.D.	X2.5.	X50.	X97.5.	Rhat
(17) $\mu_\beta$	0.956	0.003	0.951	0.956	0.961	1.000
(18) $\sigma_\beta$	0.033	0.003	0.028	0.033	0.038	1.000
(19) $\mu_\phi$	0.839	0.098	0.658	0.835	1.043	1.001
(20) $\sigma_\phi$	0.398	0.066	0.280	0.393	0.536	1.001

the present and the future time periods – Today vs. 3 months, Today vs. 6 months, Today vs. 12 months and Today vs. 36 months. (9) to (12) are the results of estimation using the answers to Q27 to Q44. These 18 questions compare the situations between 3 months later and the time periods after 3 months – 3 months vs. 6 months, 3 months vs. 12 months and 3 months vs. 36 months. (13) to (16) are the results of estimation using the answers to Q45 to Q56. These 12 questions compare the situations be-

tween 6 months later and the time periods after 6 months – 6 months vs. 12 months and 6 months vs. 36 months. (17) to (20) are the results of estimation using the answers to Q57 to Q62. These 6 questions compare the situations between 12 months later and the time periods after 12 months – 12 months vs. 36 months.

Looking at the estimation results of the subjective discount factor in Table 3, the order is as follows:

$$\underbrace{(5) 0.811}_{\text{today}} < \underbrace{(9) 0.856}_{\text{3-month later}} < \underbrace{(13) 0.908}_{\text{6-month later}} < \underbrace{(17) 0.956}_{\text{12-month later}}$$

Calculating the time-discounting rate using Eq. (1) gives the following order.

$$\underbrace{0.233}_{\text{today}} > \underbrace{0.168}_{\text{3-month later}} > \underbrace{0.101}_{\text{6-month later}} > \underbrace{0.046}_{\text{12-month later}}$$

The hyperbolic discount phenomenon was confirmed, that is, the earlier the receipt timing, the greater the time-discounting rate.

Fig. 2 shows the relationship between time and time-discounting rate. The x-axis and y-axis represent time and time-discounting rate, respectively. The black solid line represents a hyperbolic discounting which is calculated using  $\beta=0.811$  from periods 0–3,  $\beta=0.856$  from periods 3–6,  $\beta=0.908$  from periods 6–12 and  $\beta=0.956$  from periods 12–30.

### 3.4 Magnitude effect

Let us examine the magnitude effect where the higher the amount to be received effects a lower time-discounting rate. The estimation results are summarized in Table 4.

(1) to (4) are the results of estimation using the answers from Q3 to Q14. These 12 questions compare the situations between 10,000 yen at present and the larger amounts received in the future – 10,000 yen vs. 30,000 yen, 10,000 yen vs. 50,000 yen and 10,000 yen vs. 100,000 yen. (5) to (8) are the results of estimation using the answers from Q15 to Q22. These 8 questions compare the situations between 30,000 yen at present and the larger amounts received in the future – 30,000 yen vs. 50,000 yen and 30,000 yen vs. 100,000 yen. (9) to (12) are the results of estimation using the answers from Q23 to Q26. These 4 questions compare the situations between 50,000 yen at present and the larger amounts received in the future – 50,000 yen vs. 100,000 yen.

Looking at the estimation results of the subjective discount factor in Table 4, the order is as follows:

$$\underbrace{(1) 0.780}_{\text{10,000 yen}} < \underbrace{(5) 0.840}_{\text{30,000 yen}} < \underbrace{(9) 0.850}_{\text{50,000 yen}}$$

Fig. 2 Hyperbolic discounting

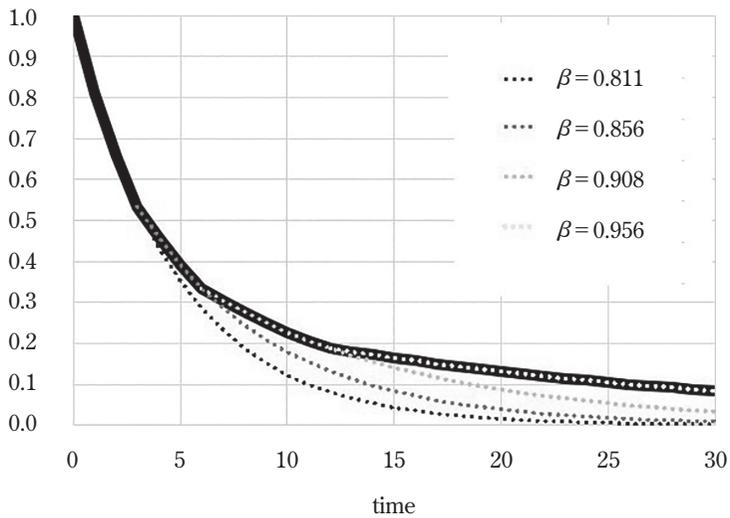


Table 4 Estimation results

I. 10,000 yen	mean	S.D.	X2.5.	X50.	X97.5.	Rhat
(1) $\mu_\beta$	0.780	0.011	0.758	0.780	0.801	1.000
(2) $\sigma_\beta$	0.181	0.009	0.165	0.181	0.200	1.000
(3) $\mu_\phi$	3.261	0.168	2.948	3.254	3.610	1.000
(4) $\sigma_\phi$	1.286	0.143	1.021	1.281	1.579	1.001
II. 30,000 yen	mean	S.D.	X2.5.	X50.	X97.5.	Rhat
(5) $\mu_\beta$	0.840	0.009	0.822	0.840	0.858	1.000
(6) $\sigma_\beta$	0.140	0.008	0.126	0.139	0.155	1.000
(7) $\mu_\phi$	2.833	0.243	2.394	2.821	3.354	1.000
(8) $\sigma_\phi$	1.470	0.173	1.162	1.458	1.830	1.000
III. 50,000 yen	mean	S.D.	X2.5.	X50.	X97.5.	Rhat
(9) $\mu_\beta$	0.850	0.010	0.830	0.850	0.868	1.000
(10) $\sigma_\beta$	0.117	0.008	0.102	0.117	0.134	1.000
(11) $\mu_\phi$	1.784	0.308	1.262	1.756	2.474	1.002
(12) $\sigma_\phi$	0.817	0.169	0.533	0.801	1.197	1.003

Calculating the time-discounting rate using Eq. (1) gives the following order.

$$\underbrace{0.282}_{10,000 \text{ yen}} > \underbrace{0.190}_{30,000 \text{ yen}} > \underbrace{0.176}_{50,000 \text{ yen}}$$

The magnitude effect was also confirmed, that is, the time-discounting rate was greater for the small gain than for the large gain.

## 4 Conclusions

In this paper, we conducted a questionnaire survey to college students in Japan and examined the characteristics of the time-discounting rate. There are a lot of studies on the time-discounting rate by questionnaire survey, however, it is a new approach to estimate the time-discounting rate using utility level introduced in this paper.

In particular, this paper examines two well-known facts in behavioral economics: hyperbolic discounting and the magnitude effect. In this survey, we confirmed the hyperbolic discounting phenomenon from the aggregated data and estimated results. We can say that the difference between today and tomorrow is greater than the difference between tomorrow and the day after tomorrow. Moreover, the magnitude effect could also be confirmed from the estimation results. We can say that small gains are discounted more than large gains. This paper reaffirmed the robustness of the main two phenomena in Behavioral Economics. We also found the marginal utility of money diminishes just as with general economic goods (also known as Gossen's law).

The time-discounting rate is also affected by other factors like income, assets, age, and so on. However, these variables were not taken into account because the respondents of this research were all college students. Considering these variables and expanding the range of respondents remains to be seen in our future research.

## References

- [ 1 ] Bateman, I. J., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Özdemiroğlu, E., Pearce OBE, D. W., Sugden, R., and Swanson, J., 2002, *Economic Valuation with Stated Preference Techniques: A Manual*, 1st Edition, Edward Elgar Publishing Limited, Cheltenham, UK.
- [ 2 ] Benzion, U., Rapaport, A., and Yagil, J., 1989, Discount Rates Inferred from Decisions: An Experimental Study, *Management Science*, Vol. 35, pp. 270–284.
- [ 3 ] Frederick, S., Loewenstein, G., and O' Donoghue, T., 2002, Time Discounting and Time Preference:

- A Critical Review, *Journal of Economic Literature*, Vol. 40, pp. 351–401.
- [ 4 ] Frey, B. S., 2008, *Happiness: A revolution in economics*, Cambridge, MA: MIT Press.
- [ 5 ] Gelman, A., and Rubin, D. B., 1992, Inference from Iterative Simulation Using Multiple Sequences, *Statistical Science*, Vol. 7(4), pp. 457–472.
- [ 6 ] Green, L., Myerson, J., and McFadden, E., 1997, Rate of Temporal Discounting Decreases with Amount of Reward, *Memory and Cognition*, Vol. 25, pp. 715–723.
- [ 7 ] Holt, D. D., and Wolf, M. R., 2019, Delay discounting in the pigeon: In search of a magnitude effect, *Journal of the Experimental Analysis of Behavior*, Vol. 111(3), pp. 436–448.
- [ 8 ] Kirby, K. N., 1997, Bidding on the Future: Evidence against Normative Discounting of Delayed Rewards, *Journal of Experimental Psychology: General*, Vol. 126, pp. 54–70.
- [ 9 ] Laibson, D., 1997, Golden eggs and hyperbolic discounting, *Quarterly Journal of Economics*, Vol. 112, pp. 443–477.
- [10] Loewenstein, G., 1992, Anomalies in Intertemporal Choice: Evidence and an Interpretation, *Quarterly Journal of Economics*, Vol. 10, pp. 573–597.
- [11] Loomis, J. B., 2014, 2013 WAEA Keynote Address: Strategies for Overcoming Hypothetical Bias in Stated Preference Surveys, *Journal of Agricultural and Resource Economics*, Vol. 39(1), pp. 34–46.
- [12] O’ Donoghue, T., and Rabin, M., 1999, Doing it now or later, *American Economic Review*, Vol. 89(1), pp. 103–124.
- [13] Ramsey, F. P., 1928, Mathematical Theory of Saving, *The Economic Journal*, Vol. 38(152), pp. 543–559.
- [14] Rotschedla, J., Bozena, K. and Klara, C., 2015, Parametric discounting model of utility, *Procedia Economics and Finance*, Vol. 30, pp. 730–741.
- [15] Shin, I., 2018, Could Pension System Make Us Happier?, *Cogent Economics and Finance*, Taylor & Francis, Vol. 6(1), 1452342. <https://doi.org/10.1080/23322039.2018.1452342>
- [16] Stevens, T. H., Tabatabaei, M., and Lass, D., 2013, Oaths and hypothetical bias, *Journal of Environmental Management*, Vol. 127, pp. 135–141.
- [17] Thaler, R. H., 1981, Some Empirical Evidence on Dynamic Inconsistency, *Economic Letters*, Vol. 8, pp. 201–207.

## 5 Appendix

The questionnaire.

### Discount of Money

This is a survey for a research on “Discount of Money”. There are no right or wrong answers. Your responses are anonymous and confidential. No personal name or contact information is collected. However, if you want to know the results of my research, please, put your name and e-mail address on the last page. I will send the results when I finish this research.

There are 63 questions in this questionnaire, however, the correspondents will answer only about 30 questions. The questions are different according to what choice you pick. Don't take this survey seriously.

Thank you very much for your cooperation.

### Happiness Level

Let's assume that the happiness level when you get (found, received, earned) 10,000 yen is 1. Based on that, how much is the "happiness level" when you get (found, received, earned) 30,000 yen, 50,000 yen, or 100,000 yen, respectively? Please, choose only one option for each question.

Question	1	2	3	4	5	6	7	8	9	10	over10
30,000 yen	<input type="radio"/>										
50,000 yen	<input type="radio"/>										
100,000yen	<input type="radio"/>										

**Q3. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 30,000 yen if you wait for 3 months

**Q4. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 50,000 yen if you wait for 3 months

**Q5. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 30,000 yen if you wait for 6 months

**Q6. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 100,000 yen if you wait for 3 months

**Q7. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 50,000 yen if you wait for 6 months

**Q8. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 30,000 yen if you wait for 12 months (1 year)

**Q9. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 100,000 yen if you wait for 6 months

**Q10. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 50,000 yen if you wait for 12 months (1 year)

**Q11. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 30,000 yen if you wait for 36 months (3 years)

**Q12. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 100,000 yen if you wait for 12 months (1 year)

**Q13. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 50,000 yen if you wait for 36 months (3 years)

**Q14. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen only for today
- get 100,000 yen if you wait for 36 months (3 years)

**Q15. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen only for today

- get 50,000 yen if you wait for 3 months

**Q16. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen only for today
- get 100,000 yen if you wait for 3 months

**Q17. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen only for today
- get 50,000 yen if you wait for 6 months

**Q18. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen only for today
- get 100,000 yen if you wait for 6 months

**Q19. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen only for today
- get 50,000 yen if you wait for 12 months (1 year)

**Q20. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen only for today
- get 100,000 yen if you wait for 12 months (1 year)

**Q21. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen only for today
- get 50,000 yen if you wait for 36 months (3 years)

**Q22. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen only for today
- get 100,000 yen if you wait for 36 months (3 years)

**Q23. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen only for today
- get 100,000 yen if you wait for 3 months

**Q24. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen only for today
- get 100,000 yen if you wait for 6 months

**Q25. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen only for today
- get 100,000 yen if you wait for 12 months (1 year)

**Q26. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen only for today
- get 100,000 yen if you wait for 36 months (3 years)

**Q27. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months
- get 30,000 yen if you wait for 6 months

**Q28. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months
- get 50,000 yen if you wait for 6 months

**Q29. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months
- get 30,000 yen if you wait for 12 months (1 year)

**Q30. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 6 months

**Q31. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months
- get 50,000 yen if you wait for 12 months (1 year)

**Q32. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months

- get 30,000 yen if you wait for 36 months (3 years)

**Q33. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 12 months (1 year)

**Q34. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months
- get 50,000 yen if you wait for 36 months (3 years)

**Q35. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 36 months (3 years)

**Q36. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 3 months
- get 50,000 yen if you wait for 6 months

**Q37. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 6 months

**Q38. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 3 months
- get 50,000 yen if you wait for 12 months (1 year)

**Q39. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 12 months (1 year)

**Q40. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 3 months
- get 50,000 yen if you wait for 36 months (3 years)

**Q41. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 36 months (3 years)

**Q42. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 6 months

**Q43. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 12 months (1 year)

**Q44. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen if you wait for 3 months
- get 100,000 yen if you wait for 36 months (3 years)

**Q45. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 6 months
- get 30,000 yen if you wait for 12 months (1 year)

**Q46. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 6 months
- get 50,000 yen if you wait for 12 months (1 year)

**Q47. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 6 months
- get 30,000 yen if you wait for 36 months (3 years)

**Q48. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 6 months
- get 100,000 yen if you wait for 12 months (1 year)

**Q49. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 6 months

- get 50,000 yen if you wait for 36 months (3 years)

**Q50. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 6 months
- get 100,000 yen if you wait for 36 months (3 years)

**Q51. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 6 months
- get 50,000 yen if you wait for 12 months (1 year)

**Q52. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 6 months
- get 100,000 yen if you wait for 12 months (1 year)

**Q53. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 6 months
- get 50,000 yen if you wait for 36 months (3 years)

**Q54. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 6 months
- get 100,000 yen if you wait for 36 months (3 years)

**Q55. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen if you wait for 6 months
- get 100,000 yen if you wait for 12 months (1 year)

**Q56. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen if you wait for 6 months
- get 100,000 yen if you wait for 36 months (3 years)

**Q57. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 12 months (1 year)
- get 30,000 yen if you wait for 36 months (3 years)

**Q58. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 12 months (1 year)
- get 50,000 yen if you wait for 36 months (3 years)

**Q59. Which one do you prefer?**

Please, choose between the two scenarios.

- get 10,000 yen if you wait for 12 months (1 year)
- get 100,000 yen if you wait for 36 months (3 years)

**Q60. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 12 months (1 year)
- get 50,000 yen if you wait for 36 months (3 years)

**Q61. Which one do you prefer?**

Please, choose between the two scenarios.

- get 30,000 yen if you wait for 12 months (1 year)
- get 100,000 yen if you wait for 36 months (3 years)

**Q62. Which one do you prefer?**

Please, choose between the two scenarios.

- get 50,000 yen if you wait for 12 months (1 year)
- get 100,000 yen if you wait for 36 months (3 years)

Thank you for your cooperation.

If you want to know the results of my research, please, put your name and e-mail address on the blanks. I will send the results when I finish this research.

name:

e-mail address: