Moonshot R&D MILLENNIA* Program

*Multifaceted investigation challenge for new normal initiatives program

Appendix: “Research on Post-Anthropocentric Values, Behavioural Styles, Science and Technology” Initiative Report

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Contents

Supplementary Chapter: Results of a social survey of citizens currently living in Japan

1. Introduction

This project proposes to establish Mini SEs, a platform for experimenting various science, technology, and social systems to improve the sustainability of earth by 2030. In relation to this, we have conducted a social survey to investigate the current awareness of citizens. In this paper, we will discuss the results from several perspectives.

An overview of the survey can be found in Table S-1-1. In this study, we conducted an online survey in late May 2021, targeting 3,114 citizens between the ages of 15–70 who reside in Japan. In designing the sample, the respondents were evenly divided into age groups ranging from their teens to their 70s, as well as between male and female, in order to gain a detailed understanding of the differences in attitudes between the genders.

Table S-1-1 Survey Overview

Period of Survey	27 May 2021, to 31 May 2021	
Method	Online survey for monitors of Macromill, Inc.	
Survey subjects	Monitors aged between 15–79 years, equally sampled by age and gender in 10-year increments.	
Sample size	3114	
Breakdown of age and gender	Teenagers (15–19 years old): Male	221
	20s (20–29 years old): Male	216
	30s (30–39 years old): Male	220
	40s (40–49 years old): Male	221
	50s (50–59 years old): Male	220
	60s (60–69 years old): Male	223
	70s (70–79 years old): Male	223
	Teenagers (15–19 years old): Female	220
	20s (20–29 years old): Female	222
	30s (30–39 years old): Female	221
	40s (40–49 years old): Female	230
	50s (50–59 years old): Female	230
	60s (60–69 years old): Female	225
	70s (70–79 years old): Female	222
Details	Q1–Q5: Attitudes toward the relationship between nature and people, views on happiness, etc. Q5: The importance of human life (present and future)	

	Q6–Q7: Relationships with 13 species and the importance of their lives Q8: Frequency of altruistic behavior toward family, friends, and nature Q9–Q15: BWS-style questions about evaluation of the seven visions of society Q16: Price premium for products made from alternative sources of oil Q17: Willingness to live in a different world (Mini SE)

2. An analysis of the attitudes of citizens in Japanese society today: With a focus on altruism

2. 1. Classification of patterns of altruistic behaviour

First, we will examine the nature of citizens' altruism based on their responses to Q8 in the survey. In the survey, the targets of altruistic behaviour were classified into four categories: family, friends, strangers, and the environment, and 28 types of behaviour, seven for each category, were presented, and the frequency of respondents was asked. An example of the actual survey questionnaire is shown in Figure S-2-1. However, examining each of the 28 types of behavior is not very effective for understanding the overall trend. Therefore, the obtained behavioural frequency data were classified by the latent class model[1], and the frequencies of the behavioral types were collapsed into four patterns. The model was estimated by the maximum likelihood method, and the likelihood function was defined as shown in Equation (1).

$$L(\beta_c, p_{q,a}) = \prod_n^N \sum_c^C \pi_c(z_n|\beta_c) \prod_q^Q \prod_a^A p_{q,a}^{d_{q,a,n}} \quad (1)$$

n is the respondent, c is the behavioural type pattern (latent class), q is the behavioral type, and a is the frequency. $\pi_c(z_n)$ is the probability of occurrence of the behavioural type pattern c, defined by the respondent attribute vector z_n and expressed as a logit-type function with β_c as the coefficient parameter vector. $p_{q,a}$ is the probability that frequency a is observed in behaviour type q, and $d_{q,a,n}$ is a dummy variable that takes the value of 1 if respondent n selects frequency a in behaviour type q and is 0 if otherwise.

Using this estimated result, we attempt to analyse it from several angles. Figure S-2-2 shows the probability patterns of the frequencies in the behavioural types. PATTERN1 is a pattern with a relatively high frequency of altruistic behaviour. Of the respondents in the sample of this study, 25.0% were estimated to fall into this category. The frequency of altruistic behaviour toward family (FAM) and friends (FRI) is high. However, the frequency of altruistic behaviour toward others (OTH) and the environment (ENV) is also relatively high among the four patterns. However, it can be said that the

[1] For more information on latent class models, see, for example, Inagaki, Yusuke & Tadahiko Maeda. *Senzai kurasu bunseki ni yoru "nihonjin no kokuminsei chousa" ni okeru sinrai no imi to sono jidaiteki hensen no kentou* [An Investigation of Meanings of "Trust" and Their Transition Using Latent Class Analysis in Japanese National Character Survey]. *Proceedings of the Institute of Statistical Mathematics*, 63(2) (2015) 277-297.

more distant the relationship with the target, the more the frequency of altruistic behaviour tends to vary.

PATTERN2 is a pattern in which the frequency of altruistic behaviour is rather low. It was estimated that 32.1% of the respondents in the sample fell into this category. In terms of the frequency of altruistic behaviour toward family and friends, “Occasionally” was the most common response, but the percentages of “Almost never” and “Never” were high and varied. In terms of altruistic behaviour toward others and the environment, the percentage of “Rarely” was the highest.

PATTERN3 is the pattern with the lowest frequency of altruistic behaviour. It was estimated that 12.3% of the respondents in the sample fell into this category. For other people and the environment with whom there is little relationship, the ratio is concentrated in “Never,” and the variation is small. In the case of behaviour toward family and friends, the ratio of “Never” is relatively high, but the ratio of higher frequency is also high.

PATTERN4 is a pattern in which the frequency of altruistic behaviour is moderate. It was estimated that 30.6% of the respondents in the sample fell into this category. Regardless of the relationship, the ratio of “Occasionally” is the largest for almost all behaviour types. The frequency tends to increase slightly for family members.

		非常によくある	よくある	たまにある	ほとんどない	まったくない
家族の誰かが重い荷物を 持っているときには手伝う	→	○	○	○	○	○
家族の誰かの家事 （料理、掃除、ごみ捨てなど）を手伝う	→	○	○	○	○	○
友人や知人の悩みや愚痴を聞いてあげる	→	○	○	○	○	○
友人の誕生日を祝ってあげる	→	○	○	○	○	○
友人が行きたい場所につき合って一緒に行く	→	○	○	○	○	○

	Very frequently	Often	Occasionally	Rarely	Never
Help a family member when they are carrying heavy baggage					
Help a family member with housework (cooking, cleaning, garbage disposal, etc.)					
Listen to your friends when they have problems or complaints					
Wishing friends happy birthdays					
Accompanying friends to a place they want to go					

Figure S-2-1: Examples of questions about altruistic behaviour types in the original Japanese and translated versions

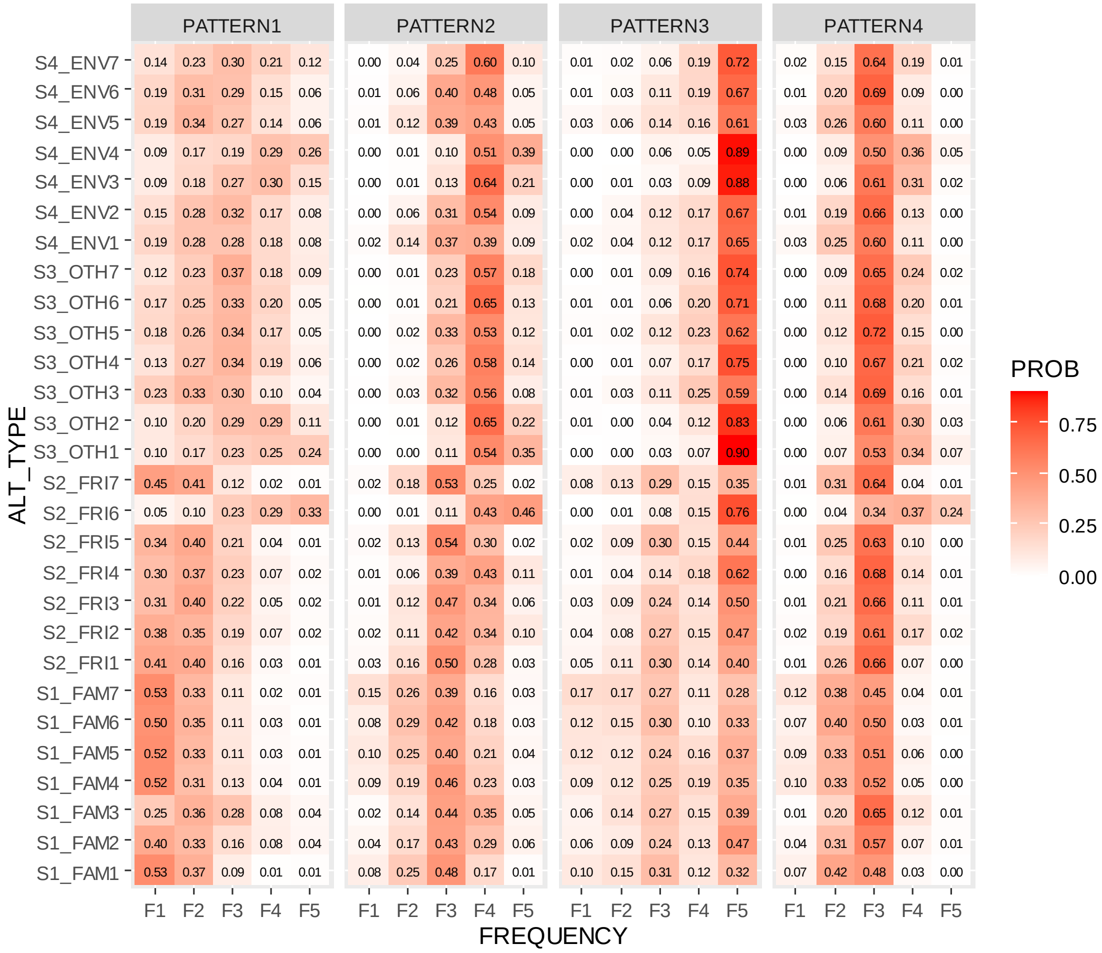


Figure S-2-2: Patterns of frequency occurrence probabilities for altruistic behaviour types

Note 1: The vertical axis (ALT_TYPE) is the type of behavior, and the horizontal axis (FREQUENCY) is the frequency of each type of behavior in each class. F1–F5 on the horizontal axis correspond to “Very frequently,” “Often,” “Occasionally,” “Rarely,” and “Never,” respectively.

Note 2: The numbers in the cells are estimates of the probability of having the relevant frequency for each type of behaviour.

Figure S-2-3 shows the estimated probabilities of the four altruistic behaviour patterns found in Figure S-2-2 for each sex and age group. In terms of gender, the ratio of PATTERN3 and PATTERN2 is higher in males, indicating that they are less likely to engage in altruistic behaviour. In terms of age, the probability of the occurrence of PATTERN1, which has more altruistic behaviour, is higher in the younger age group, and the probability of the occurrence of PATTERN4 and PATTERN2, which have moderate characteristics, is higher in the older age group. On the other hand, the probability of PATTERN4, which has less altruistic behaviour, is also higher in the younger age group. This suggests that there are various patterns of altruistic behaviour in the younger generation.

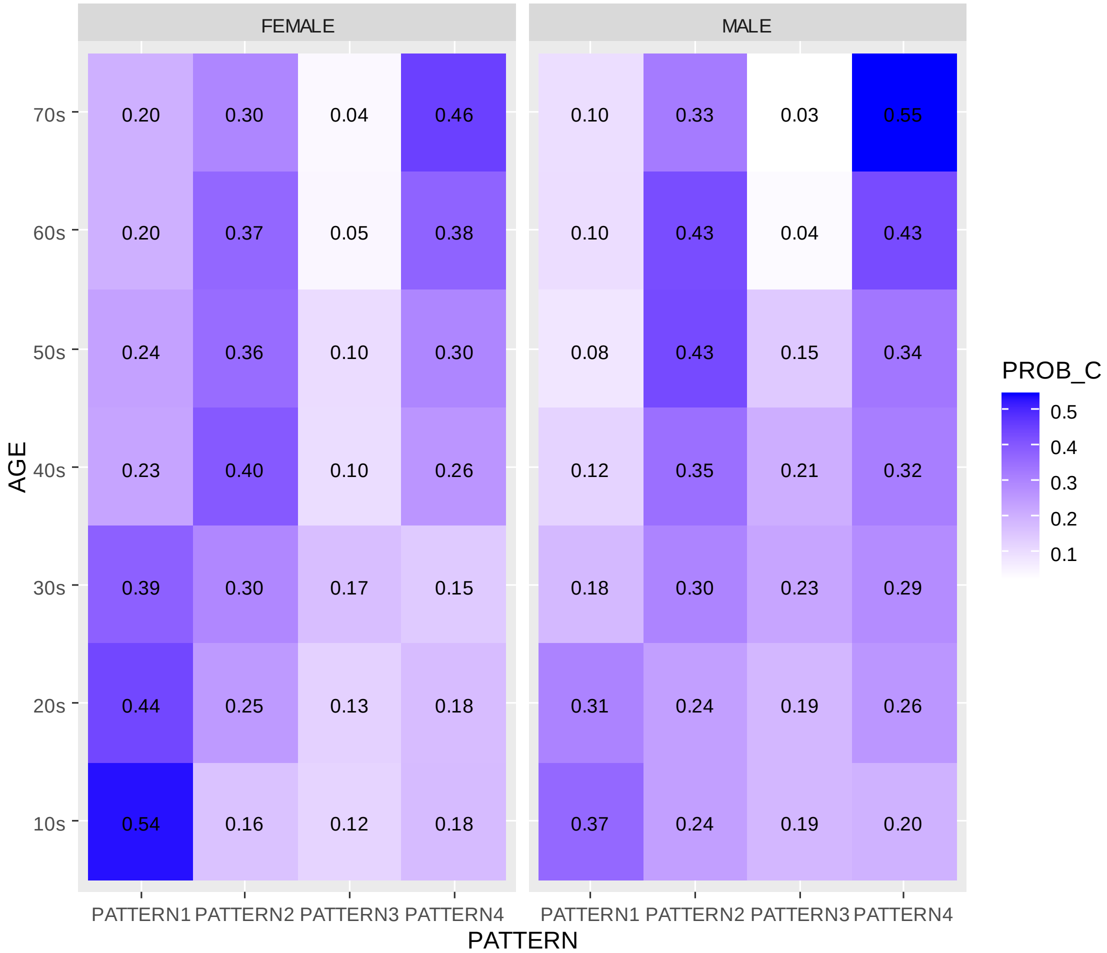


Figure S-2-3: Probability of occurrence of behavioral patterns by gender and age

Note 1: The vertical axis (AGE) indicates the age, and the horizontal axis (PATTERN) indicates the four patterns in the probability of occurrence of altruistic behaviour type frequencies.

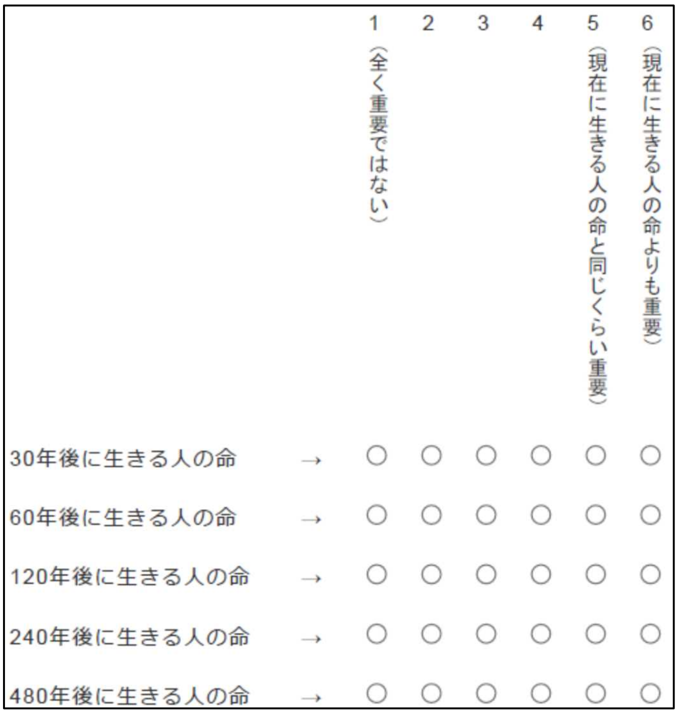
Note 2: The values in the cells are the probability of occurrence of each pattern by gender and age.

2. 2. Evaluation of the importance of life from chronological and species perspectives

In this project, we emphasise the importance of sustainability because we want to share earth, an important and rare asset, with future generations and non-human species for a long time. How do the citizens of Japan evaluate the lives of these beings today? In this survey, in Q5 and Q6, the level of importance of future people and other species was investigated.

(1) Evaluation of human life in the future

First, we would like to look at how today's citizens think about future people. In the survey, the respondents were asked to rate the importance of the lives of future people in 30, 60, 120, 240, and 480 years. The life of a person living in the present (hereafter referred to as the "present people") was set as 5, and the level of importance was expressed on a scale of 1–6. Figure S-2-4 shows an example of the questions.



		1（全く重要ではない）	2	3	4	5（現在に生きる人の命と同じくらい重要）	6（現在に生きる人の命よりも重要）
30年後に生きる人の命	→	○	○	○	○	○	○
60年後に生きる人の命	→	○	○	○	○	○	○
120年後に生きる人の命	→	○	○	○	○	○	○
240年後に生きる人の命	→	○	○	○	○	○	○
480年後に生きる人の命	→	○	○	○	○	○	○

	1 (Not important at all)	2	3	4	5 (As important as the lives of people living today)	6 (More important than the lives of people living in the present)
The lives of people who will live 30 years later						
The lives of people who will live 60 years later						
The lives of people who will live 120 years later						
The lives of people who will live 240 years later						
The lives of people who will live 480 years later						

Table S-2-4: Examples of questions about the importance of human life in the future in the original Japanese and translated versions

In order to get the overall trend, the obtained data on importance were aggregated into "Lower: Less important than present people (1–4)," "Even: Equal (5)," and "Higher: More important (6)," which were used as ordinal scale variables. The results were analysed using an ordinal logit model with this variable as the explained variable[2]. In addition to age and gender, household income and the presence or absence of children were also added as explanatory variables to examine the influence of respondents' attributes in a more multifaceted manner. The model was estimated using the maximum likelihood method. The likelihood function was defined as shown in Equation (2).

$$L(\beta, t_1, t_2) = \prod_{n}^{N} \left[\int_{-\infty}^{t_1} \lambda(s|z_n, F, \beta) ds\right]^{d_{Lower,n}} \left[\int_{t_1}^{t_2} \lambda(s|z_n, \beta) ds\right]^{d_{Even,n}} \left[\int_{t_2}^{\infty} \lambda(s|z_n, \beta) ds\right]^{d_{Higher,n}} \quad (2)$$

$\lambda(s|z_n, \beta)$ is the respondent attribute vector z_n, F is a dummy variable vector representing the degree of future, β is the density function of the logistic distribution defined by the coefficient parameter vector, t is the threshold corresponding to the response, and $d_{Lower,n}$, $d_{Even,n}$, $d_{Higher,n}$ are dummy variables that take the value of 1 if respondent n selects "Lower: Less important than present people (1–4)," "Even: Equal (5)," and "Higher: More important (6)," respectively, and it is 0 if otherwise.

In the following sections, we will use the response probabilities for Lower, Even, and Higher calculated from the estimated results as a guide for further discussion.

First, we will check how the level of importance to human life changes depending on the degree of the future (Figure S-2-5). The percentage of respondents who answered that they place equal importance on human life in the future is high in all cases. There is a tendency that more people evaluate people in the future as less important when these people are far from present. The evaluation of people in 240 years and 480 years is almost the same. Since the intervals between the degrees of future are set to increase in equal proportions, it seems that the degree of importance converges to a certain value while decreasing with the degree of future. It can be said that many people value the lives of people living in the present equally with those living in the future, but it should be noted that even in the relatively near future, 30 years from now, the value of the lives of people in the relevant period is reduced for 20% of the people. There are not that many cases where the lives of future generations are considered more important.

[2] For an ordinal logit model, see, for example, the following. Nishiyama, Yoshihiko, Mototsugu Shintani, Daiji Kawaguchi & Ryo Okui. *Keiryou Keizaigaku* [*Econometrics*]. Yuhikaku (2019) p. 327.

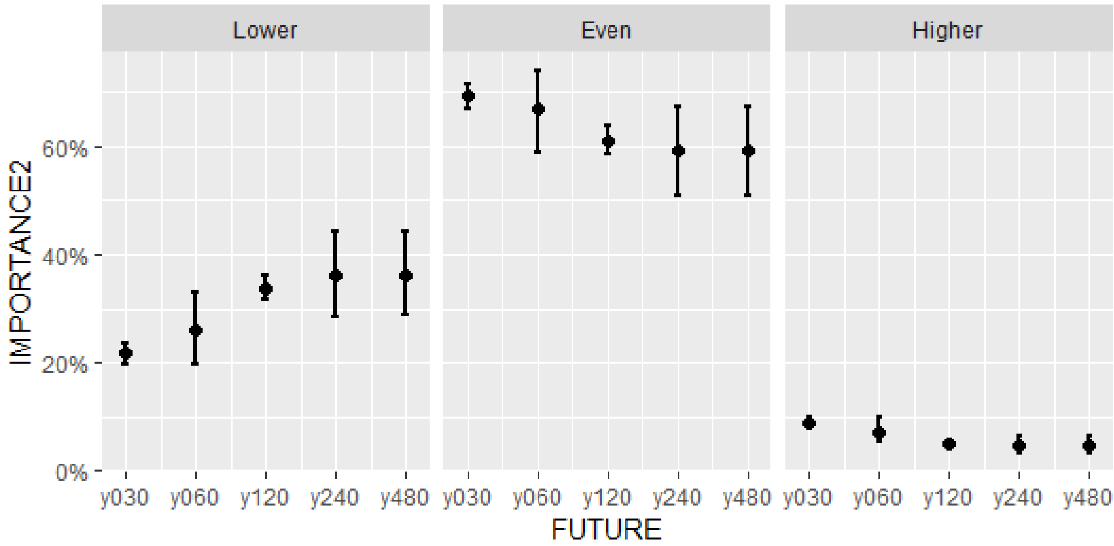


Figure S-2-5: Response probability of the importance of future human life compared to that of modern people

Note 1: Estimates are shown under the following conditions: gender is male, age is 46.6 years, income is 5,477,000 yen, and there are children. The bars indicate 95% confidence intervals.

Note 2: For the horizontal axis (FUTURE), yk indicates the number of people who will live in k years. The vertical axis (IMPORTANCE2) indicates the estimated response probability.

Next, we will examine how the content of the responses changes depending on the attributes of the respondents. Figure S-2-6 shows the relationship between age and the level of importance of future human life. Overall, older people tend to feel the importance of the future generation. In the case of 240 years and 480 years in the future, the lines overlap, and the results are almost identical. In particular, the probability of answering “Lower” decreased with increasing age, especially for 120 years in the future (y120), 240 years in the future (y240), and 480 years in the future (y480), indicating that the more distant the future, the more the evaluation depends on the age. In other words, the younger the age, the lower the importance of future human life, and the more distant the degree of future, the greater the disparity in the evaluation of the lives of present and future people.

We examine the relationship with gender. Figure S-2-7 shows the relationship between gender and the level of importance of future human life. The overall trend is that women place a greater importance on the future of human life than men do. There is not much distinctive movement by gender.

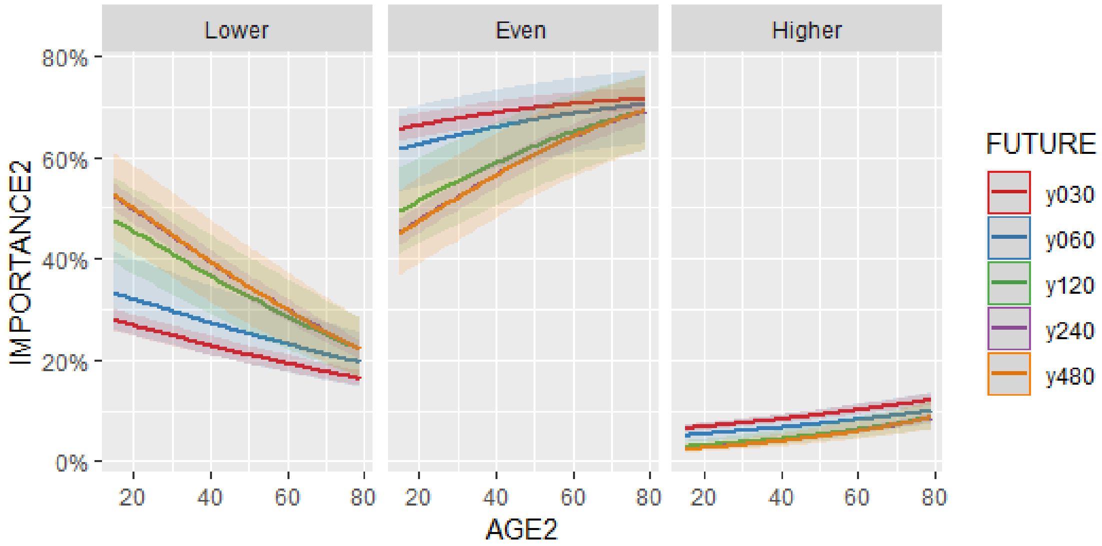


Figure S-2-6: Relationship between age and evaluation of the life of future people

Note 1: The horizontal axis (AGE2) indicates age. The vertical axis indicates the estimated response probability. In estimating the response probability, for the other explanatory variables, gender was fixed to male, income to 5,477,000 yen, and the status of having children.

Note 2: In the legend (FUTURE), yk indicates the person who will live in k years.

Note 3: Shading around the line indicates the 95% confidence interval.

Figure S-2-7: Relationship between gender and evaluation of the life of future people

Note 1: The horizontal axis (GENDER) indicates gender. The vertical axis indicates the estimated response probability. In estimating the response probability, the age of the respondents was fixed at 46.6 years, the household income at 5,477,000 yen, and the status of having children for the other explanatory variables.

Note 2: In the legend (FUTURE), yk indicates the person who will live in k years.

Note 3: Bars indicate 95% confidence intervals.

The relationship with household income is considered. Figure S-2-8 shows the relationship between household income and the level of importance of human life in the future. When a probability of answer to “Lower” is examined, there is almost no change in the level of importance of human life in 30 years from now depending on household income. However, after 60 years, the probability of answering “Lower” tends to increase as household income increases, and this trend becomes more pronounced in the future. A similar trend is observed after 240 and 480 years, but there is a difference of more than 10% between the case with a household income of 2.5 million yen and the case with a household income of 20 million yen. The importance of human life in the distant future is relatively low for high-income citizens and may be relatively unconsidered in decision making.

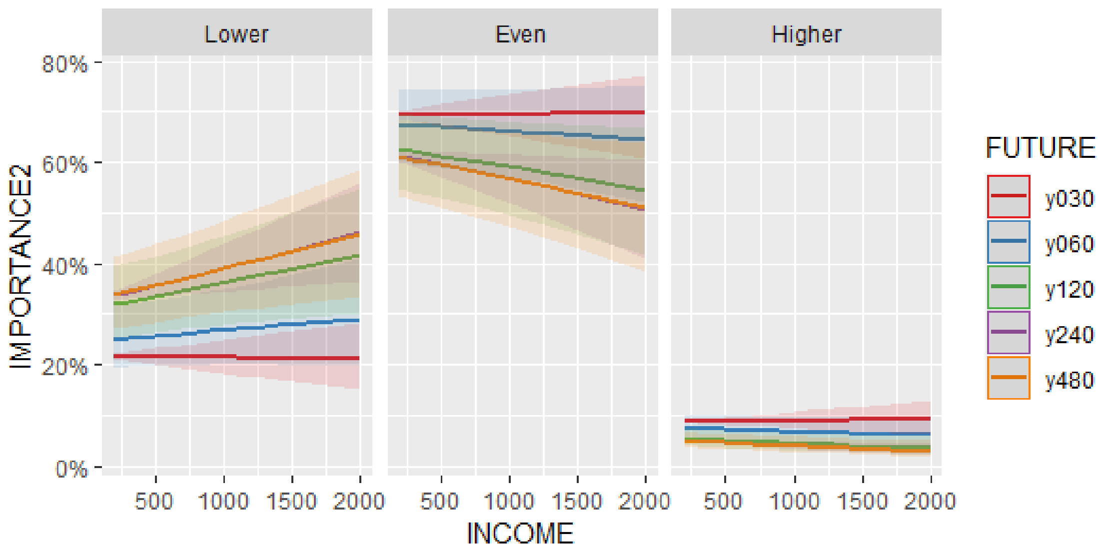


Figure S-2-8: Relationship between household income and evaluation of the life of future people

Note 1: The horizontal axis (INCOME) indicates household income in ten thousands of yen. The vertical axis indicates the estimated response probability. In estimating the response probability, gender is fixed as male, age as 46.6 years, and status as having children for the other explanatory variables.

Note 2: In the legend (FUTURE), yk indicates the person who will live in k years.

Finally, we examine the presence or absence of children. Figure S-2-9 shows the relationship between the presence or absence of children and the level of importance of the life of future people. As shown in the figure, there is no significant difference in the value of response probability between those with and those without children, indicating that the effect of having children is small.

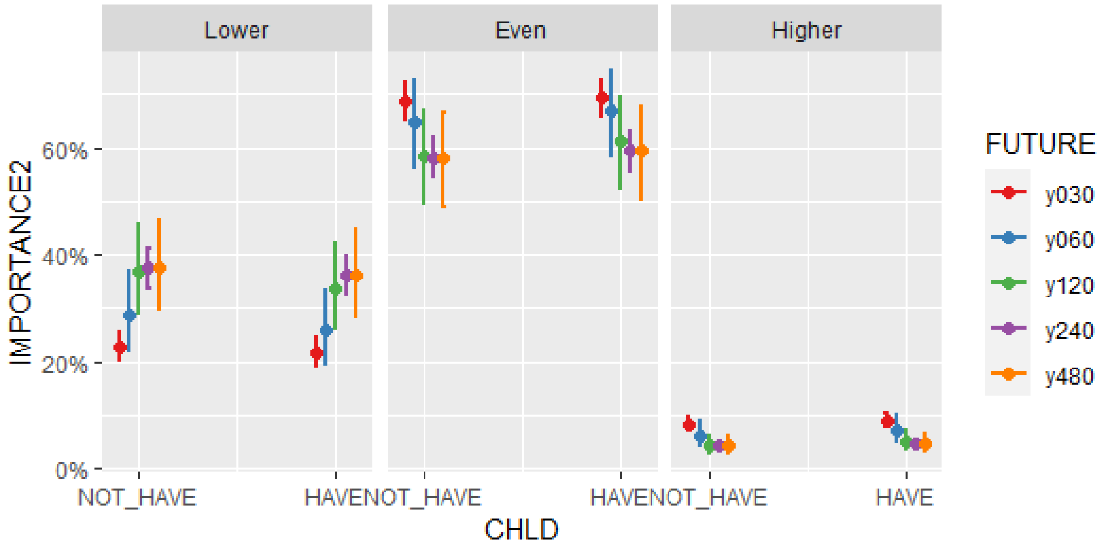


Figure S-2-9: Relationship between the presence or absence of children and the evaluation of the life of future people

Note 1: The horizontal axis (CHLD) indicates the presence or absence of children, where NOT_HAVE indicates no children and HAVE indicates the presence of children. The vertical axis indicates the estimated response probability. In estimating the response probability, we fixed gender as male, age as 46.6 years, and household income as 5,477,000 yen for the other explanatory variables.

Note 2: In the legend (FUTURE), yk indicates the person who will live in k years.

(2) Evaluation of the lives of other species

We will examine the evaluation of the lives of other species. The survey format is the same as in the case of future people. The current value of human life is 5, and the importance of the lives of other species is expressed in six levels from 1–6. Figure S-2-7 shows an example of the questions.

The data on importance were analysed using the ordinal logit model, as in the case of the future person in the previous section.

		1（全く重要ではない）	2	3	4	5（人の命と同じくらい重要）	6（人の命よりも重要）
フナの命	→	○	○	○	○	○	○
カブトムシの命	→	○	○	○	○	○	○
クモの命	→	○	○	○	○	○	○
イネの命	→	○	○	○	○	○	○
ススキの命	→	○	○	○	○	○	○
ゾウリムシの命	→	○	○	○	○	○	○
イースト（パン酵母）の命	→	○	○	○	○	○	○

	1 (Not important at all)	2	3	4	5 (As important as the lives of people living today)	6 (More important than the lives of people living in the present)
The life of a crucian carp						
The life of a beetle						
The life of a spider						
The life of rice						
The life of silver grass						
The life of weevils						
The life of yeast fungus						

Figure S-2-7: Examples of questions about the importance of the life of other species in the original Japanese and translated versions

First, let us check the evaluation of life for each species (Figure S-2-8). For any of the species, the response probability of disregard (Lower) is the highest. The overall trend is that the importance of mammals and birds, which are taxonomically close to humans, is relatively high, but the probability of a Lower response for the life of rice is remarkably low, suggesting that rice may be regarded as a special species by Japanese residents.

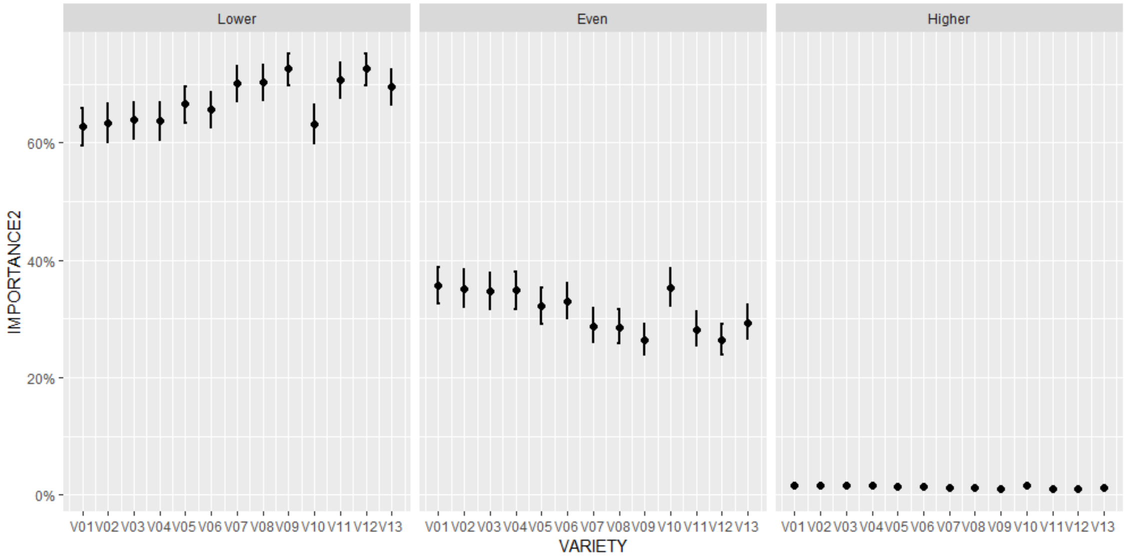


Figure S-2-8: Probability of responding to the importance of other species to life compared to current people

Note 1: Estimates are shown under the following conditions: gender is male, age is 46.6 years, income is 5,477,000 yen, and there are children. The bars indicate 95% confidence intervals.

Note 2: Horizontal axis (VRIETY) indicates species: V01 (monkey), V02 (cat), V03 (cow), V04 (chicken), V05 (parrot), V06 (salmon), V07 (crucian carp), V08 (beetle), V09 (spider), V10 (rice), V11 (silver grass), V12 (weevil), and V13 (yeast). The vertical axis (IMPORTANCE2) shows the estimated response probability.

Next, we will examine how the content of the responses changes depending on the attributes of the respondents. First, we will look at the relationship with age. Figure S-2-9 shows the relationship between age and the importance of the species to life. Looking at the response probability of Lower, the species with the greatest change is the chicken (V04), followed by salmon (V06) and cow (V03). For species that are often used as food, the change in the importance of life with age is significant. Currently, the market for plant-based meat is expanding rapidly in various countries around the world, and it has been pointed out that this is due to the high level of interest in animal life among the younger generation, and the same trend may be seen in Japan.

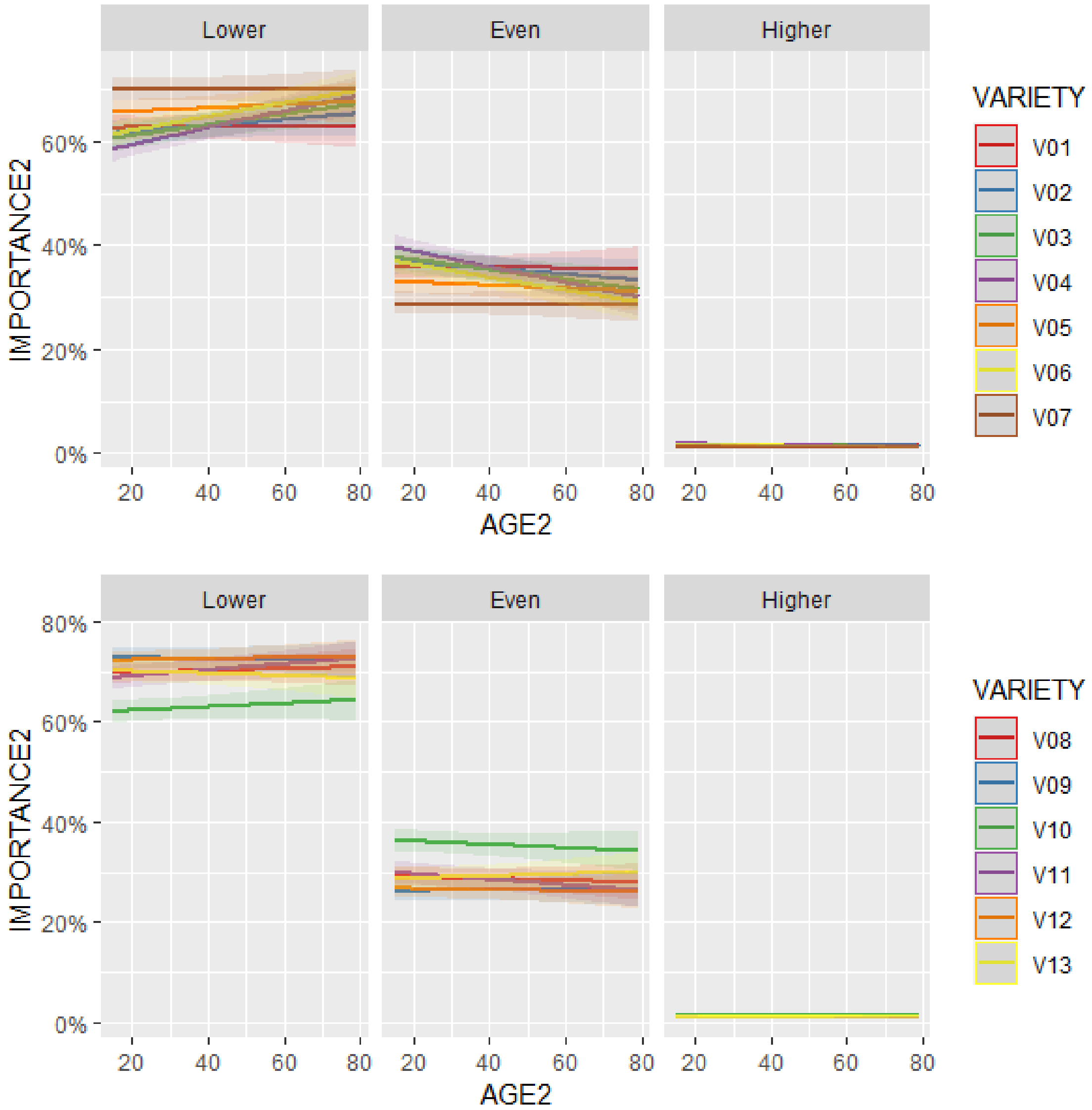


Figure S-2-9: Relationship between age and assessment of life of other species

Note 1: The horizontal axis (AGE2) indicates age. The vertical axis (IMPORTANCE) indicates the estimated response probability. In estimating the response probability, gender is fixed to male, income to 5,477,000 yen, and the status of having children for the other explanatory variables.

Note 2: The legend (FUTURE) indicates species: V01 (monkey), V02 (cat), V03 (cow), V04 (chicken), V05 (parrot), V06 (salmon), V07 (crucian carp), V08 (beetle), V09 (spider), V10 (rice), V11 (silver grass), V12 (weevil), and V13 (yeast).

Next, we will examine the relationship with gender. Figure S-2-10 shows the relationship between gender and the level of importance of the life of other species. The overall trend is that females place greater importance on the life of other species than males do. As in the case of the future person, there is not much of a characteristic relationship between gender and biological species.

Figure S-2-10: Relationship between gender and the evaluation of the life of other species

Note 1: The horizontal axis (GENDER) indicates gender. The vertical axis indicates the estimated response probability. In estimating the response probability, the other explanatory variables were fixed at 46.6 years of age, 5,477,000 yen in income, and having children.

Note 2: The legend (FUTURE) indicates species: V01 (monkey), V02 (cat), V03 (cow), V04 (chicken), V05 (parrot), V06 (salmon), V07 (crucian carp), V08 (beetle), V09 (spider), V10 (rice), V11 (silver grass), V12 (weevil), and V13 (yeast).

Figure S-2-11 shows the relationship between household income and the importance of the life of other species. A general trend is that when the income increases, the importance of the life of other species drops. Looking at the probability of answering Lower, we can see that the importance of other species to life decreases as income increases, especially for species that are useful to people, such as chicken (V04), cow (V03), rice (V10), and yeast (V13). In species with usefulness to humans, such as cattle (V03), rice (V10), and yeast (V13), the importance decreases more significantly with income. Citizens with higher incomes have relatively dry attitudes toward species with economic potential.

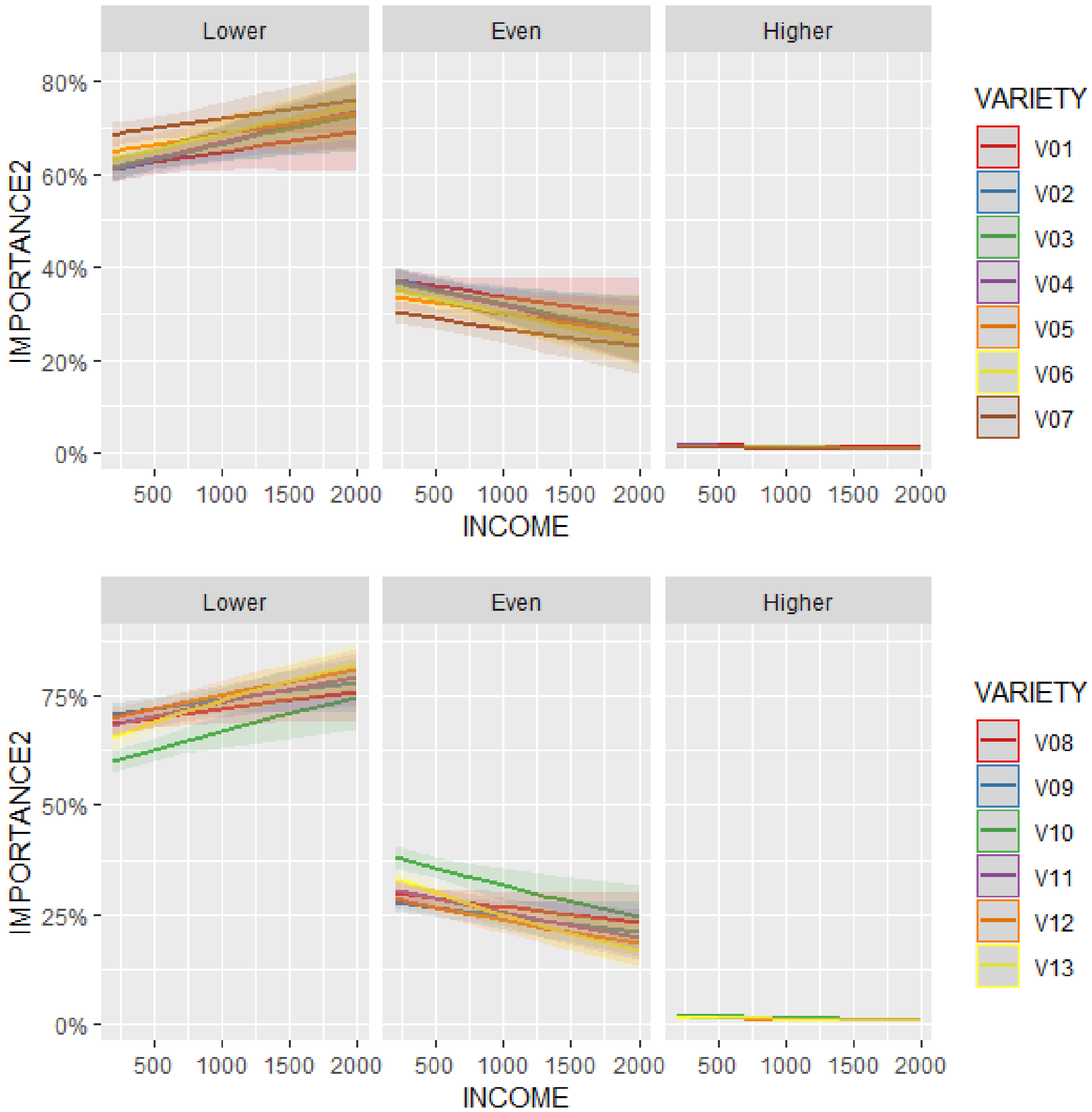


Figure S-2-11: Relationship between income and evaluation of the life of other species

Note 1: The horizontal axis (INCOME) indicates household income in ten thousands of yen. The vertical axis indicates the estimated response probability. In estimating the response probability, for the other explanatory variables, age was fixed at 46.6 years, income at 5,477,000 yen, and the status of having children.

Note 2: The legend (FUTURE) indicates species: V01 (monkey), V02 (cat), V03 (cow), V04 (chicken), V05 (parrot), V06 (salmon), V07 (crucian carp), V08 (beetle), V09 (spider), V10 (rice), V11 (silver grass), V12 (weevil), and V13 (yeast).

Finally, we examine the relationship between the presence and absence of children. Figure S-2-12 shows the relationship between the presence or absence of children and the importance of the life of other species. The overall trend is that those who have children feel less importance to the lives of other species than those who do not have children. Although the differences in the trends among species are not so large, the variation among species seems to be somewhat larger in the case of those without children, especially in vertebrates.

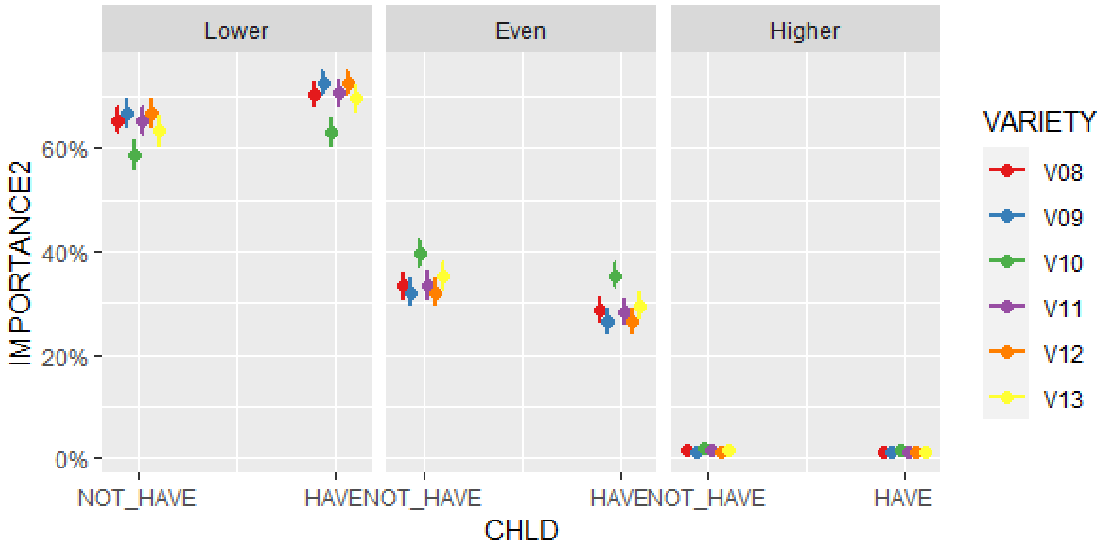


Figure S-2-12: Relationship between income and the evaluation of the life of other species

Note 1: The horizontal axis (CHLD) indicates the presence or absence of children; NOT_HAVE indicates no children, and HAVE indicates the presence of children. The vertical axis indicates the estimated response probability. In estimating the response probability, we fixed gender as male, age as 46.6, and household income as 5,477,000 yen for the other explanatory variables.

Note 2: The legend (FUTURE) indicates species: V01 (monkey), V02 (cat), V03 (cow), V04 (chicken), V05 (parrot), V06 (salmon), V07 (crucian carp), V08 (beetle), V09 (spider), V10 (rice), V11 (silver grass), V12 (weevil), and V13 (yeast).

3. Desirable visions of society

In the social survey, the following visions of society were presented, and citizens' evaluations of each were investigated by best–worst scaling. For details on the best–worst scaling, please refer to Louviere et al.[3]

(S1) The right to a better life has been extended to non-human species.
(S2) Aggressive resource development, including space and the ocean, is underway.
(S3) Resource recycling is being promoted with an emphasis on material circulation.
(S4) Socially desirable behavioural changes are being promoted through the introduction of behavioral score systems.
(S5) An economic system that emphasises fairness and sustainability over efficiency has been introduced.
(S6) Individual lifestyles and principles are mutually recognised.
(S7) The problems of inequality and imbalance of wealth among human beings have been solved.

An example question is shown in Figure S-3-1. Out of the above seven social images, four were selected using a balanced incomplete block design, and the respondents chose the most important and the least important social image.

[3] Louviere, J. Jordan., Terry N. Flynn & A. A. J. Marley. *Best-Worst Scaling: Theory, Methods and Applications*. Cambridge University Press (2015).

	物質循環を重視した資源リサイクルが推進されている。	効率性よりも公平性や持続可能性を重視した経済システムが導入されている。	個人のライフスタイルや主義主張をお互いに認め合うようになっている。	人間の間での不平等や富の不均衡の問題が解決されている。
最も重要 →	○	○	○	○
最も軽視 →	○	○	○	○

	A resource cycle that emphasises that material circulation is being promoted.	An economic system that emphasises fairness and sustainability over efficiency has been introduced.	Mutual recognition of individual lifestyles and principles.	Problems of inequality and imbalance of wealth among people are solved.
Most important				
Most neglected				

Figure S-3-1: Example of best–worst scaling questions for social image

From the response data obtained, the standardised best–worst scores for each social image were calculated for each individual using the counting method. The mean values for each gender and age group are shown in Figure S-3-2, where 0 is the standard, and a higher value means that the respondent places relatively more importance on the social image in question, while a lower value means that the respondent places relatively less importance on it.

The overall tendency is to place the greatest importance on correcting inequality and wealth imbalance (S7) and accepting diversity in lifestyle (S6). On the other hand, the rejection of the behaviour change promotion by the behavioral score system (S6) is strong, regardless of gender or age. It is possible that a strong sense of rejection exists for systems that exogenously promote some kind of behaviour change. Emphasis on the development of resources in space and the oceans is also generally low.

Next, we examine the differences in the mean scores by gender and age. Resource recycling (S5) is emphasised by the older generation (generally those in their 50s and above), but not by the younger generation. The importance of active resource development (S2) is also low for women across all age groups, but for men, there is a large difference by age group, with the older generation placing less importance on it. The older generation is more concerned about the fairness of the economic system (S3).

The older generation tends to avoid aggressive resource development and emphasises resource recycling and a fair and sustainable economic system. On the other hand, younger generations place more importance on resource recycling and diversity of lifestyles and principles, and this tendency is especially pronounced among women.

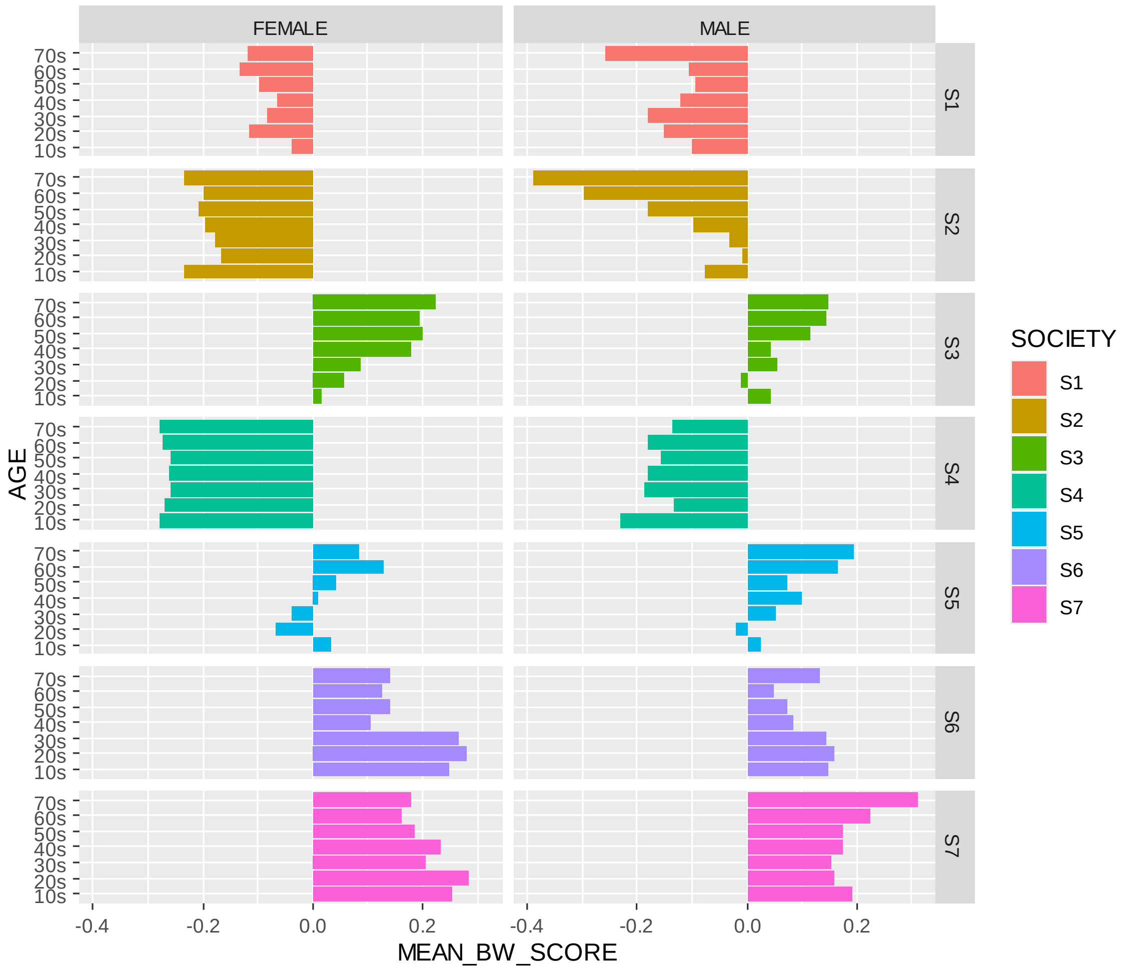


Figure S-3-2: Mean standardised best–worst scores for social image by gender and age

Note 1: The horizontal axis (MEAN_BW_SCORE) shows the average of the standardised best–worst scores. The vertical axis (AGE) shows the age in 10-year increments.

Note 2: The legend (SOCIETY) shows the social picture: (S1) The right to a better life has been extended to non-human species; (S2) Aggressive resource development, including space and the ocean, is underway; (S3) Resource recycling is being promoted with an emphasis on material circulation; (S4) Socially desirable behavioural changes are being promoted through the introduction of behavioral score systems; (S5) An economic system that emphasises fairness and sustainability over efficiency has been introduced; (S6) Individual lifestyles and principles are mutually recognised; and (S7) The problems of inequality and imbalance of wealth among human beings have been solved.

4. Citizens' price premium for sustainability-conscious products

To what extent do today's citizens find value in sustainability-conscious products? In this section, we would like to examine electricity from renewable energy sources as a case study. In the survey, we used a hypothetical valuation method to investigate the willingness to pay a price premium for electricity from renewable energy sources when compared to electricity from conventional energy sources. An example question is shown in Figure S-4-1.

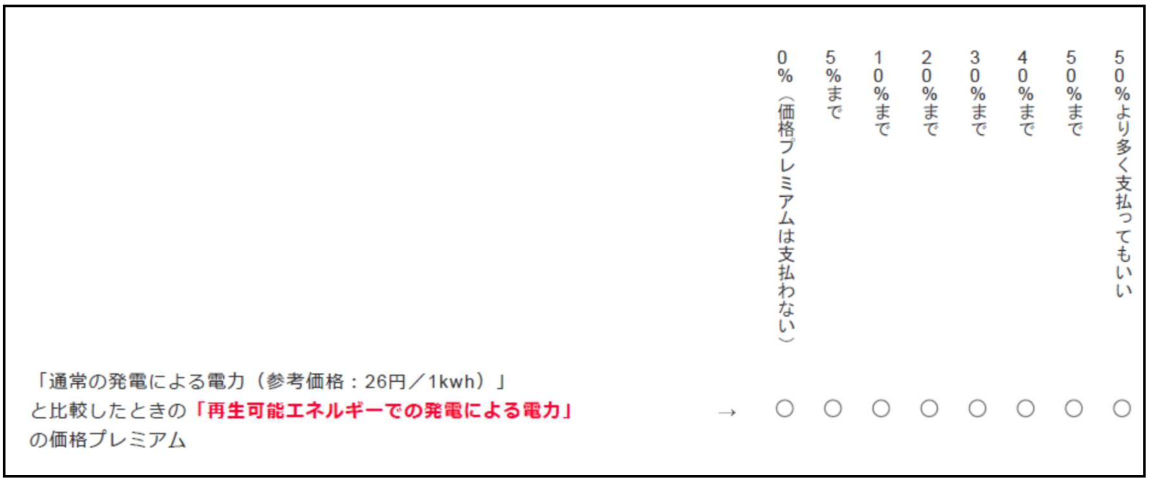


Figure S-4-1: Example of a question in the price premium survey for sustainability-conscious products

Figure S-4-2 shows the percentage of people choosing renewable energy by price premium by gender and age. The vertical axis shows the choice ratio, which is the percentage of people who chose electricity from renewable energy sources at the price premium shown on the horizontal axis.

When the price premium is about 5%, about 40% of citizens in their 20s to 40s and up to 60% of citizens in older age groups say they are willing to choose renewable energy. As the price premium increases, the choice ratio decreases, and when the price premium is around 50%, the choice probability drops to around 5%.

In order to examine the premium for products related to sustainability in more detail, the impact on the price premium was analysed using an interval regression model, with income, the presence of children, and the altruism of the respondents discussed in Section 1 of the Supplementary Chapter as explanatory variables, in addition to gender and age. The model was estimated using the maximum likelihood method, and the likelihood function was defined as in Equation (3).

$$L(\beta) = \prod_{n}^{N} \int_{L_n}^{H_n} \phi(w|z_n, \beta)dw \quad (3)$$

z_n is the respondent attribute vector, and β is the coefficient parameter vector. L_n and H_n are the interval information of the price premium answered by respondent n. For example, if the respondent answered "0% (no price premium)," $L_n = -\infty$, and H_n=0, and if the respondent answered "5%," $L_n = 0$, and $H_n = 5$. If the respondent answered, "I would be willing to pay more than 50%," $L_n = 50$, and $H_n = \infty$.

Table S-4-1 shows the estimated results. For altruism, the frequency of altruistic behaviour toward family, friends, strangers, and the environment was evaluated on a 5-point scale, and the average value was calculated for each individual and used as an explanatory variable. The higher the value, the more frequent the behaviour.

Looking at the effect of age (AGE), the premium tends to increase by 0.13% for each year of age increase. In terms of gender (GENDER), the price premium is significantly larger for males than for females, with an increase of 6.5%. However, the coefficient of the crossover effect between gender and age is significantly negative, suggesting that the difference in price premiums by gender narrows as age increases and that women will have a higher price premium after the age of about 60. On the other hand, the coefficient estimates for income (INCOME) and the presence or absence of children (CHLD) are small, and their effects on the price premium cannot be confirmed.

As for the impact of altruism, the results suggest that altruism toward family (ALTRUISM_FAM) has a significant negative impact. There is a possibility of avoiding financial burden in order to take care of family members. On the other hand, altruism toward others (ALTRUISM_OTH) and the environment (ALTRUISM_ENV) has a significant positive impact. In particular, an increase of 1 in altruism to the environment is associated with a 6% increase in the price premium, which is very influential.

As can be seen, citizens' evaluations of sustainability-conscious products vary. It is not necessarily the case that a good or valuable product will always capture the market, but the extent to which citizens are willing to pay for it needs to be clarified. In order to make an industry *sustainable*, it is necessary to clarify the target market by closely examining the price level and the profit to be gained, along with accurate cost evaluation.

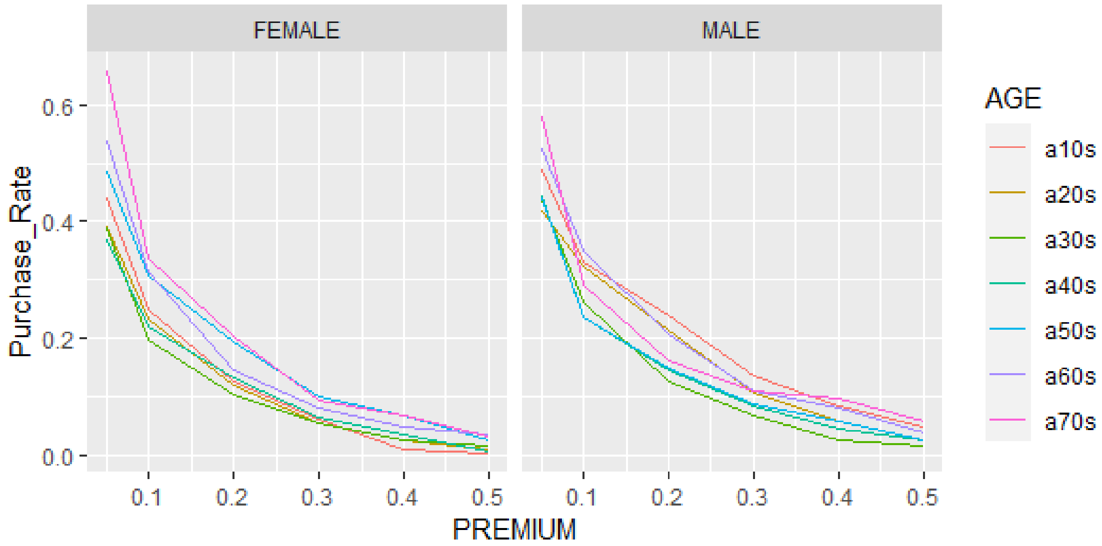


Figure S-4-2: Price premium and choice ratio for electricity from renewable energy sources

Note 1: The horizontal axis (PREMIUM) shows the additional price premium (price ratio) for electricity from renewable energy sources with respect to electricity from conventional energy sources. The vertical axis (Purchase_Rate) shows the rate at which electricity from renewable energy sources is selected.

Note 2: The legend (AGE) indicates the age.

Characteristic	Beta	95% CI[1]	p-value
GENDER			
FEMALE	—	—	
MALE	5.7	1.7, 9.7	0.005
AGE2	0.13	0.07, 0.19	<0.001
INCOME	0.00	0.00, 0.00	0.7
CHLD			
HAVE	—	—	
NOT_HAVE	0.49	-1.2, 2.2	0.6
ALTRUISM_FAM	-1.4	-2.5, -0.24	0.018
ALTRUISM_FRI	0.83	-0.65, 2.3	0.3
ALTRUISM_OTH	1.4	-0.06, 2.8	0.061
ALTRUISM_ENV	6.2	4.9, 7.5	<0.001
GENDER * AGE2			
MALE * AGE2	-0.10	-0.17, -0.02	0.015

[1] CI = Confidence Interval

Table S-4-3: Factors influencing the price premium for electricity from renewable energy sources

Note 1: Estimation results using the maximum likelihood estimation method of the interval regression model.

Note 2: Coefficients (Beta) indicate the value of the price premium (%) that changes when each explanatory variable increases by one unit.

5. Willingness to apply for Mimi SE residence

In this project, we are proposing Mini SEs, an experimental platform for science, technology, and social institutions that are more sustainable in a closed system. How many citizens would be willing to move to such an experimental environment? In the survey, the respondents were asked whether they would be willing to apply for a 5-year residency in a Mini SE (referred to as "another world" in the questionnaire). The questions used in the questionnaire are shown in Figure S-5-1.

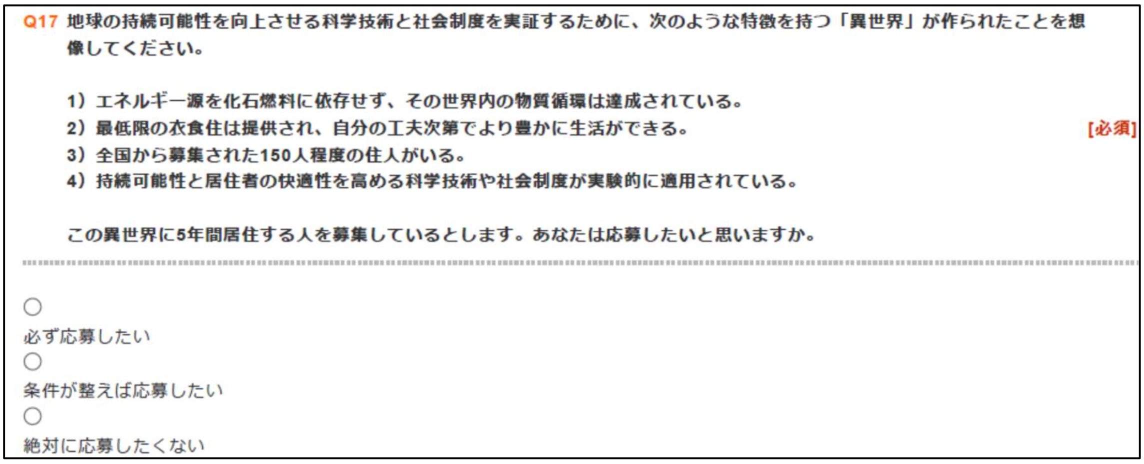
(1) Material circulation within the world is achieved without depending on fossil fuels for energy sources.

(2) A minimum of food, clothing, and shelter is provided, and people can live a more affluent life

depending on their own ingenuity.

(3) There are about 150 residents recruited throughout Japan.

(4) Science, technology, and social systems that enhance sustainability and comfort of residents are experimentally applied.


Q17 地球の持続可能性を向上させる科学技術と社会制度を実証するために、次のような特徴を持つ「異世界」が作られたことを想像してください。

1）エネルギー源を化石燃料に依存せず、その世界内の物質循環は達成されている。
2）最低限の衣食住は提供され、自分の工夫次第でより豊かに生活ができる。 [必須]
3）全国から募集された150人程度の住人がいる。
4）持続可能性と居住者の快適性を高める科学技術や社会制度が実験的に適用されている。

この異世界に5年間居住する人を募集しているとします。あなたは応募したいと思いますか。

○ 必ず応募したい
○ 条件が整えば応募したい
○ 絶対に応募したくない

Figure S-5-1: Willingness to apply for Mini SE ("another world") residency in the original Japanese version

Q17.

Imagine that "another world" with the following characteristics has been created to demonstrate science, technology, and social institutions that improve the sustainability of earth.

(1) Material circulation within the world is achieved without depending on fossil fuels for energy sources.

(2) A minimum of food, clothing, and shelter is provided, and people can live a more affluent life depending on their own ingenuity.

(3) There are about 150 residents recruited throughout Japan.

(4) Science, technology, and social systems that enhance sustainability and comfort of residents are experimentally applied.

Suppose people to reside in another world for 6 years are recruited. Would you like to apply?

- I definitely want to apply.
- If the conditions are right, I would like to apply.
- Definitely do not want to apply.

Figure S-5-2 shows the intention to apply by gender and age. In all age groups, more than half of the citizens answered "definitely want to apply" or "want to apply if conditions are met." The number of women who have no intention to apply is relatively small, and their intention to apply tends to decrease as their age increases.

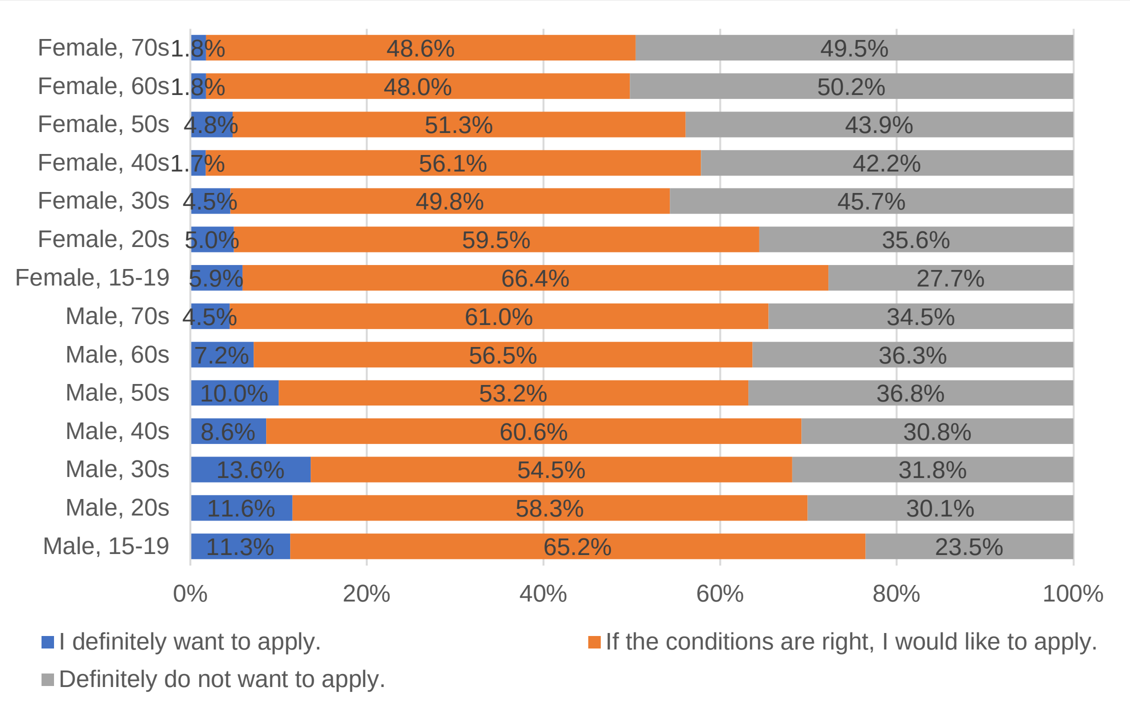


Figure S-5-2: Cross-tabulation result of willingness to apply for the recruitment of residents in a Mini SE (“another world”)

An ordinal logit model analysis was conducted to further understand the relationship between respondent attributes and intention to apply for residency in the Mini SE. The model was estimated using the maximum likelihood method. The likelihood function was defined as in Equation (4).

$$L(\beta, t_1, t_2) = \prod_{n}^{N} \left[\int_{-\infty}^{t_1} \lambda(s|z_n, \beta)ds\right]^{d_{NEVER,n}} \left[\int_{t_1}^{t_2} \lambda(s|z_n, \beta)ds\right]^{d_{DEPEND,n}} \left[\int_{t_2}^{\infty} \lambda(s|z_n, \beta)ds\right]^{d_{YES,n}} \tag{4}$$

$\lambda(s|z_n, \beta)$ is the density function of the logistic distribution defined by the respondent attribute vector z_n, β is the coefficient parameter vector, t is the threshold value corresponding to the response, and $d_{NEVER,n}$, $d_{DEPEND,n}$, $d_{YES,n}$ are dummy variables that take 1 when respondent n selects “NEVER: I never want to apply,” “DEPEND: I want to apply if the conditions are right,” and “YES: I always want to apply,” respectively, and 0 if otherwise.

We will examine the relationship between the response probability and each of the explanatory variables calculated from the estimated results. First, we examine the demographic attributes. Figure S-5-3 shows the relationship between age and intention to apply. The probability of answering “NEVER” has increased. On the other hand, the probability of answering “DEPEND” and “YES” decreases with increasing age.

Figure S-5-4 shows the relationship between gender and intention to apply. By gender, the probability of answering “NEVER” is lower for males, and the probability of answering “DEPEND” and “YES” is higher. This indicates that men tend to have a strong intention to apply.

Figure S-5-5 shows the relationship between income and intention to apply. The higher the income, the lower the probability of answering “NEVER” and the higher the probability of answering “DEPEND” and “YES.” This indicates that the higher the income, the stronger the intention to apply.

Figure S-5-6 shows the relationship between the presence of children and the intention to apply. As shown in the figure, the relationship between the presence or absence of children and the intention to apply for migration is not very strong.

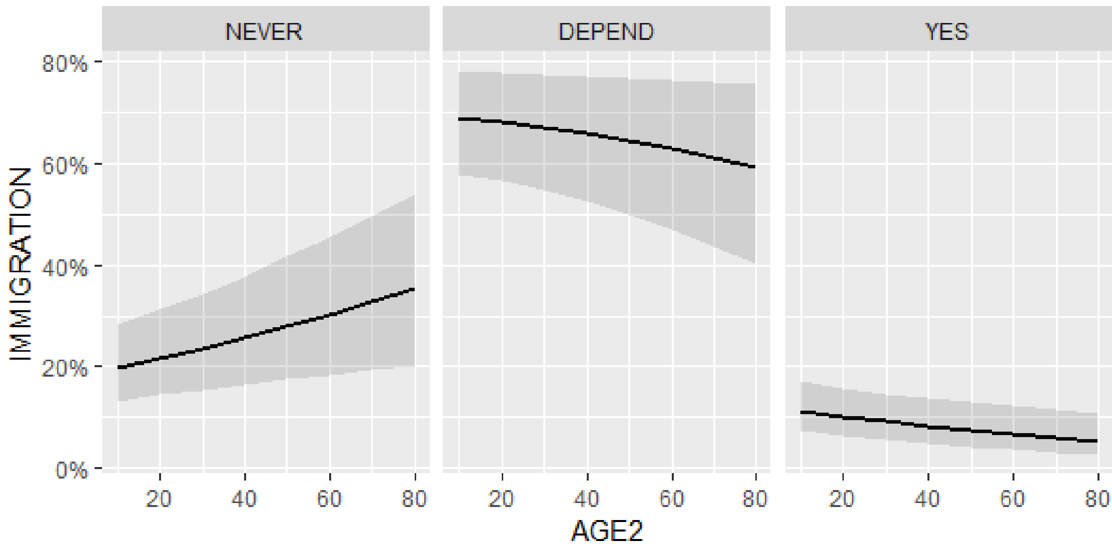


Figure S-5-3: Relationship between age and residential application probability

Note 1: The horizontal axis (AGE) indicates age. The vertical axis indicates the estimated response probability. In estimating the response probability, for the other explanatory variables, income was fixed at 5,477,000 yen, having children, altruism score for family at 3.42, altruism score for friends at 2.93, altruism score for others at 2.51, and altruism score for the environment at 2.62.

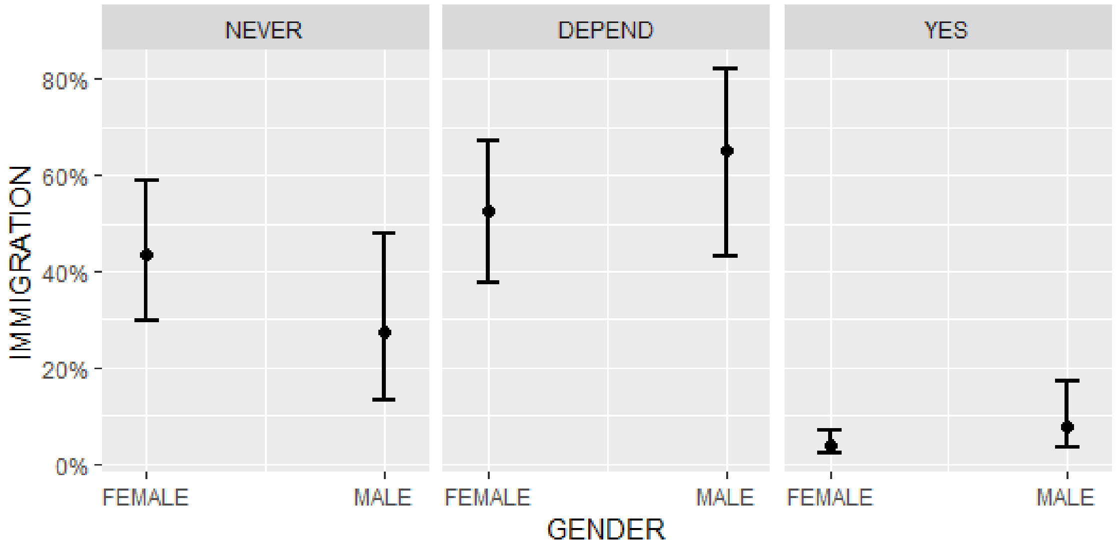


Figure S-5-4: Relationship between gender and residential application probability

Note 1: The horizontal axis (GENDER) indicates age. The vertical axis indicates the estimated response probability. In estimating the response probability, for the other explanatory variables, age was fixed at 46.6 years, income at 5,477,000 yen, having children, altruism score for family at 3.42, altruism score for friends at 2.93, altruism score for others at 2.51, and altruism score for the environment at 2.62.

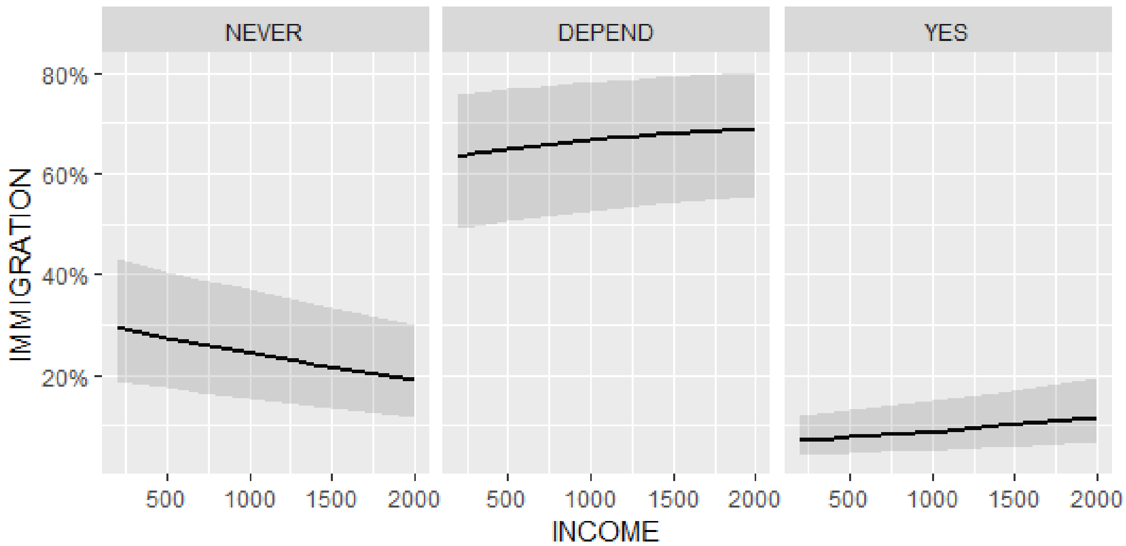


Figure S-5-5: Relationship between income and residential application probability

Note 1: The horizontal axis (INCOME) indicates income in tens of thousands of yen. The vertical axis shows the estimated response probability. In estimating the response probability, for the other explanatory variables, age was fixed at 46.6 years, income at 5,477,000 yen, having children, altruism score for family at 3.42, altruism score for friends at 2.93, altruism score for others at

2.51, and altruism score for the environment at 2.62.

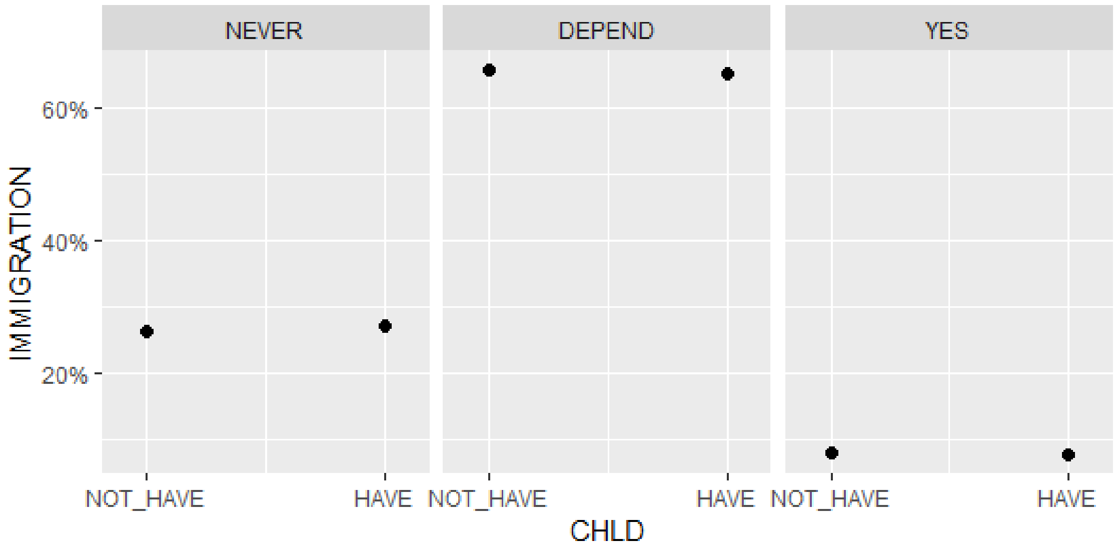


Figure S-5-6: Relationship between the presence of children and the probability of applying for residency

Note 1: The horizontal axis (CHLD) indicates the presence or absence of children. The vertical axis indicates the estimated response probability. In estimating the response probability, for the other explanatory variables, age was fixed at 46.6 years, income at 5,477,000 yen, having children, altruism score for family at 3.42, altruism score for friends at 2.93, altruism score for others at 2.51, and altruism score for the environment at 2.62.

Next, we will examine the relationship between respondents' altruism and their intention to migrate. In this section, we examine how the intention to migrate changes depending on the altruism score variable as in Section 4 of the Supplementary Chapter. The interesting point is that the effect on the intention to migrate differs depending on the strength of altruism of the target. Figure S-5-7 shows the relationship between the altruism score for family members (ALTRUISM_FAM) and the intention to apply. The higher the altruism score, the higher the probability of answering "NEVER" and the lower the probability of answering "DEPEND" and "YES." The stronger the altruism toward family members, the weaker the intention to apply.

On the other hand, the altruism score for friends (ALTRUISM_FRI) showed the opposite characteristics. The higher the score, the lower the probability of answering "NEVER" and the higher the probability of answering "DEPEND" and "YES." In particular, the probability of answering "YES" increases when the score is close to 5, suggesting a stronger willingness to apply for immigration. In addition, the altruism score for the environment (ALTRUISM_ENV) also showed a strong correlation with the intention to apply, and the higher the score, the more positive the intention to apply. As the score increases, the probability of answering “YES” increases significantly, in some cases exceeding 20%.

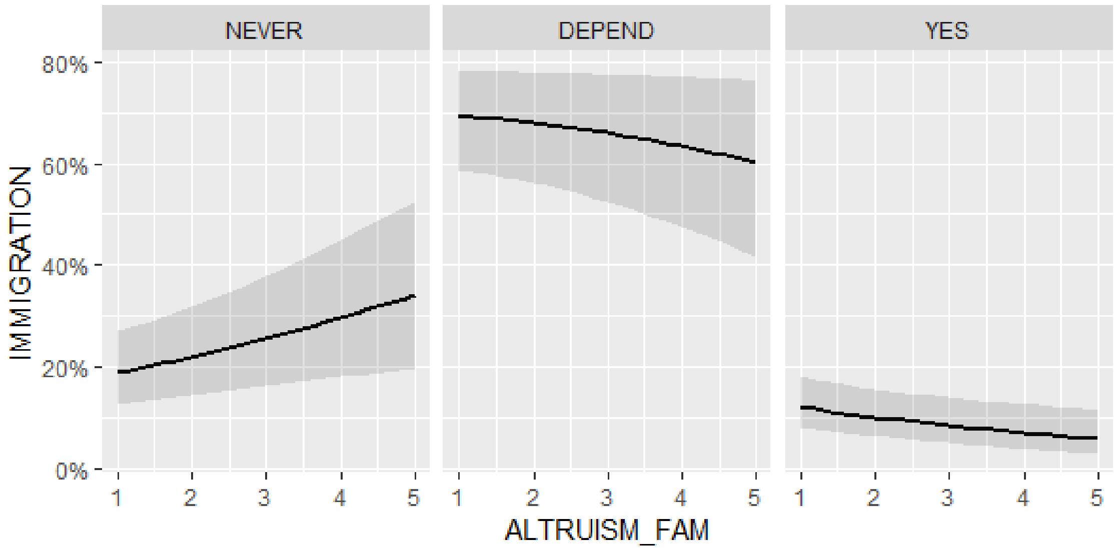


Figure S-5-7: Relationship between altruism score for family and probability of applying for residence

Note 1: The horizontal axis (ALTRUISM_FAM) indicates the altruism score for family members, and the higher the score, the higher the altruism. The vertical axis indicates the estimated response probability. In estimating the response probability, the other explanatory variables were fixed at 46.6 years of age, 5,477,000 yen income, having children, 3.42 for the altruism score for family, 2.93 for the altruism score for friends, 2.51 for the altruism score for strangers, and 2.62 for the altruism score for the environment.

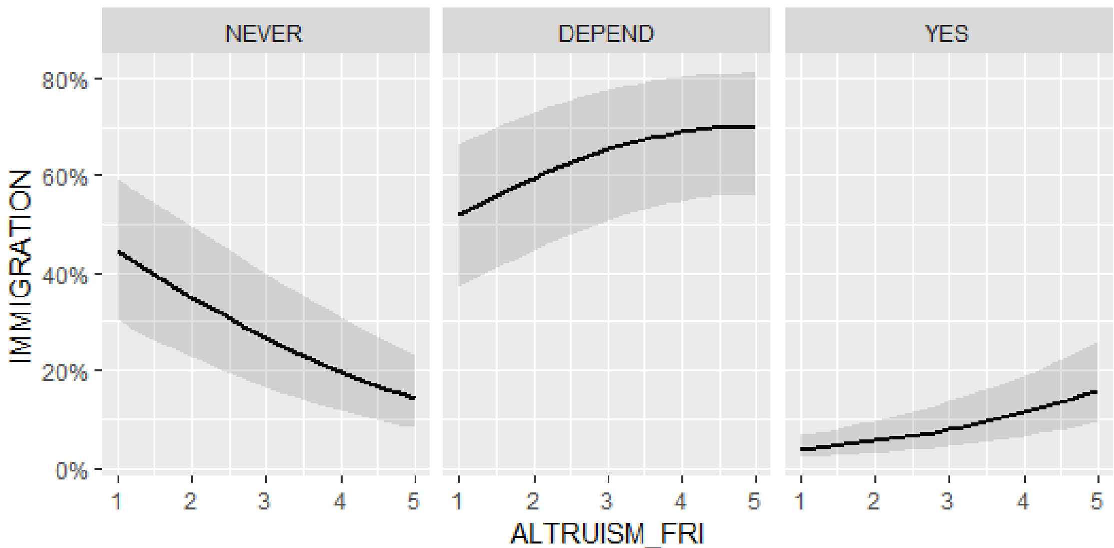


Figure S-5-8: Relationship between altruism score for friends and probability of applying for residence

Note 1: The horizontal axis (ALTRUISM_FRI) indicates the altruism score for friends, and the higher the score, the higher the altruism. The vertical axis indicates the estimated response probability. In estimating the response probability, the other explanatory variables were fixed at 46.6 years of age, 5,477,000 yen of income, having children, 3.42 for the altruism score for family, 2.93 for the altruism score for friends, 2.51 for the altruism score for strangers, and 2.62 for the altruism score for the environment.

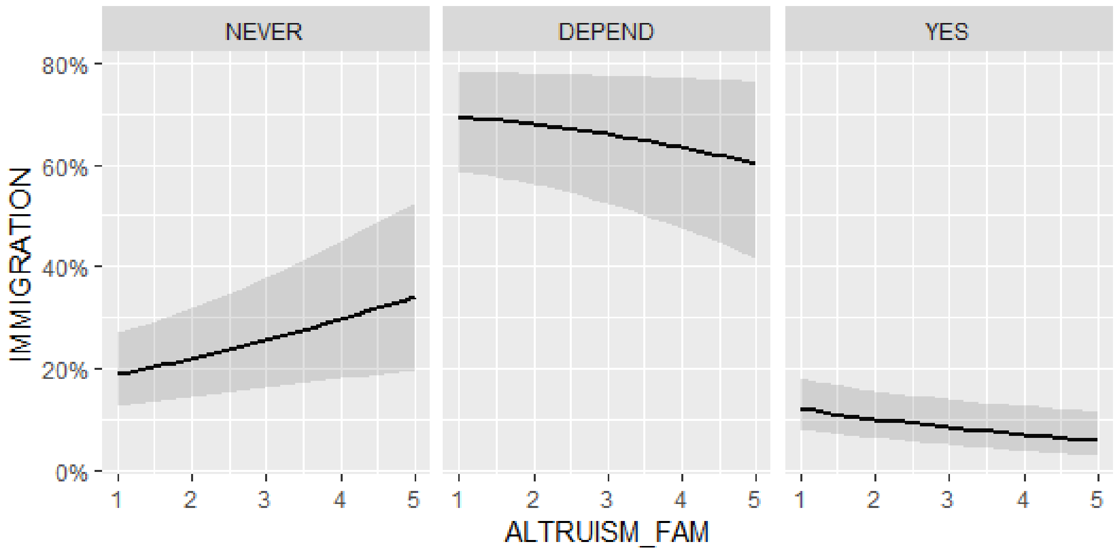


Figure S-5-9: Relationship between the altruism score for others and the probability of applying for residency

Note 1: The horizontal axis (ALTRUISM_OTH) indicates the altruism score for others, and the higher the score, the higher the altruism. The vertical axis indicates the estimated response probability. In estimating the response probability, the other explanatory variables were fixed at 46.6 years of age, 5,477,000 yen of income, having children, 3.42 for the altruism score for family, 2.93 for the altruism score for friends, 2.51 for the altruism score for strangers, and 2.62 for the altruism score for the environment.

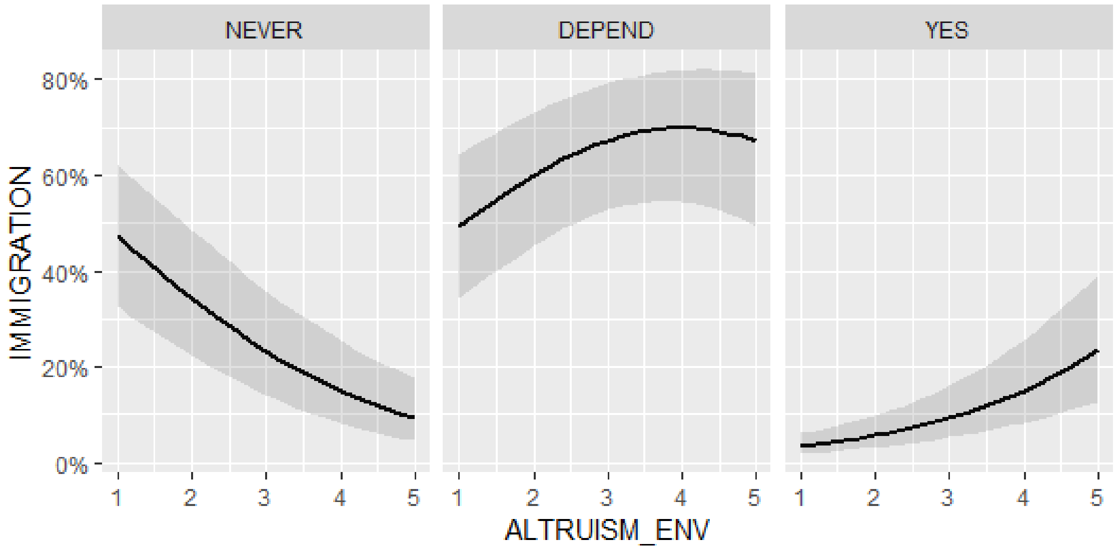


Figure S-5-10: Relationship between environmental altruism score and probability of applying for residence

Note 1: The horizontal axis (ALTRUISM_ENV) indicates the altruism score for the environment, and the higher the score, the higher the altruism. The vertical axis indicates the estimated response probability. In estimating the response probability, the other explanatory variables were fixed at 46.6 years of age, 5,477,000 yen of income, having children, 3.42 for the altruism score for family, 2.93 for the altruism score for friends, 2.51 for the altruism score for strangers, and 2.62 for the altruism score for the environment.

6. Conclusion

In this supplementary chapter, the results of the social survey conducted as part of this project are discussed in terms of (1) the nature of altruism and the evaluation of the lives of future generations and other species, (2) the visions of society that are believed to be important, (3) the amount of additional payment for sustainability-conscious products, and (4) the intention to live in the Mini SE proposed in this project by cross-tabulation by gender and age and factor decomposition using various statistical models. The motivation for the survey was to first clarify the position of the citizens living in the current Japanese society to propose the Mini SE and SE. In the analysis, we focused on gender and age but also added other attributes such as income, family structure, and altruism of the respondents.

As mentioned above, there was a certain correlation between these respondent attributes and the attitudes of citizens. For example, in terms of age, the level of importance placed on the life of future generations and the amount of additional payment for sustainability-conscious products increased with age. Additionally, in terms of social vision, avoidance of aggressive resource development and interest in material cycles and sustainable economic systems become stronger with age. However, it is not so simple to say that younger generations are less concerned about sustainability and others. Concern for the lives of animals, such as livestock, was stronger among the younger generation, and altruistic patterns of behavior were more observable among the younger generation, especially regarding closely related objects.

What we want to emphasise here is that there is a diversity in the attitudes of Japanese citizens that cannot be captured by these observable respondent attributes alone. This is especially true for the younger generation. The probability of the emergence of altruistic behavioural patterns also varied widely, suggesting the possibility that this is the case. As we saw in Section 4, the younger generation has a strong sense of respect for the diversity of individuals.

Rather than setting a certain ideal and guiding science, technology, and society in that direction, it would be necessary to implement measures that take into account the fact that the members of society have diverse values. The Mini SE proposed in this project is an experimental platform for diversifying the system of science, technology, and social institutions, while taking sustainability into consideration. The people who are most likely to participate in the Mini SE are young, have a certain level of income, and care about their friends and the environment. If we can welcome these people to the frontiers of science and society—and together increase our robustness and resilience—the future of our planet and humanity, which is full of pessimistic predictions, will become a little brighter.

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- Dr. Kengo SUZUKI (Faculty of Engineering, Information and Systems, University of Tsukuba)
- Dr. Ken TAKAI (Japan Agency for Marine-Earth Science and Technology)
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Appendix: 100 visions for 2050

The following is a selection of 100 visions for 2050 discussed by the students taking a "Post-Anthropocene" course held at the University of Tsukuba in April–May 2021, the participants of the workshop held at Nara Prefectural Kokusai High School on 13 May 2021, and the team members.

1. Make humans smaller and the environmental impact will be less.
2. A complete nutritional diet, like that of *senzu beans*, will eliminate cereals.
3. Manual transmission for electric cars is realised. A system where technology does not take away people's enjoyment will develop.
4. Individuals will be energy suppliers using ultra-power transmission technology.
5. 01 to ATGC: DNA-based information transfer technology is realised.
6. Wearing wigs will become the norm, which results in reducing the use of detergent.
7. Use earth's rotation as energy.
8. Make earth a gyroball (creating a transparent outer shell).
9. Energy becomes visible.
10. Give energy consciousness and a personality (energy with a self).
11. Optical fiber will be made from mycelium.
12. Basic income will be realised, and people will only work for altruism.
13. A methodology (pedagogy) will be developed in which the reward system in the brain is activated by "altruism."
14. Exhaustion will be the price.
15. The birth of altruistic AI.
16. Schools will be free to choose (no quizzes), and education and professions will be integrated.
17. Society with no firefighters, no police, and no ambulance service.
18. Police stations and convenience stores will be integrated for more efficient safety.
19. Crime coefficient to be calculated before birth.
20. People become homeless (nomads).
21. Owning a house and furniture becomes a pastime.
22. The MSE itself is a bit floating. Mobility MSE: Instead of going on a trip, the destination will come to us.
23. Energy becomes currency.
24. Make more ecofriendly energy methods worthwhile. Muscle training (2 coins) ⇔ solar power (1 coin).
25. A society that benefits from areas with a diversity of species.
26. Full body hair removal and vision correction made easier by genetic modification.
27. No more paper newspapers and magazines.

28. Paper bottles will be the norm.
29. Weather forecasting will be 100% accurate a year ahead.
30. No more flush toilets, and microbes will eat our waste. No more sewage in toilets.
31. Propagation will evolve into telepathy.
32. Products will be packaged only at the front of the shelf, and the rest will be immaculate.
33. The creation of a credit score society.
34. A vessel of consciousness will be created.
35. Individuals will be controlled by DNA rather than numbers.
36. Pets will become dependents.
37. Create a common language for the world.
38. Compulsory education through games.
39. Self-sufficiency with a breeding component (gamification).
40. Augmented reality to make you feel close even when you are far away.
41. Sharing emotions (pain) and empathy.
42. Blockchain of academic papers.
43. Blockchain of DNA. Real-time tracking of the evolutionary process.
44. Tracking of information on an individual basis will become easier and fake news will disappear.
45. Create a society where people do not live longer. Maximising workload versus energy consumption.
46. Visualising the state of the environment.
47. Numbers will show that we are living a life with no environmental impact.
48. No more cash (managed by DNA and blockchain).
49. Zero accidents with soft cars.
50. Euthanasia laws will be in place all over the world.
51. Egg and sperm matching app using genetic engineering.
52. 100% artificial insemination and total singlehood all over the world. The concept of separation of surname of husband and wife will disappear.
53. AI will be able to suggest what we want to eat.
54. The ingredients of Hanasaka Jiisan's magic powder to speed up evolution.
55. Incorporate proteins into machines to create life-like appliances.
56. Break away from the stereotypes of the age in which we have lived and install new values of that age.
57. Lifelong learning will become compulsory (no more "I do not know new things").
58. A society in which it is taken for granted that humans do not live alone.
59. Technology that physically shrinks MSEs that are not doing well and expands MSEs that are

doing well.

60. Digital preservation and real restoration of “beautiful” natural environments.
61. Riding a turtle into the deep sea (bio-deep sea 10,000).
62. Creating MSE dedicated for digital detox.
63. Discussing in the digital space and making the political system more likely to reflect the voices of young people.
64. Quantum computing, which can handle huge amounts of computation, will make it possible to predict the future with small prediction errors.
65. Diversification of diets and food culture, enabling people to enjoy good food with low environmental impact.
66. A database of genetic information will be developed so that the extinction of plant and animal species will no longer be a problem.
67. The establishment of international organisations to which sovereign states would transfer certain sovereignty that results in the end of international conflict.
68. All restorative materials will be replaced by bio-materials.
69. All waste recycling will be done by biotechnology.
70. Production of bioplastics will be possible on an individual basis.
71. Household appliances such as plastic from leftover food.
72. Prime ministers in their 30s and members of parliaments R35.
73. Some policymaking and decision making will be done by AI.
74. Fisheries will only be environmentally friendly.
75. Fiber capable of photosynthesis will be created, and we can get energy just from walking around.
76. A system of pre-ordering food to ensure it is consumed without waste.
77. No more transporting food, a completely self-sufficient lifestyle.
78. Sharing body and food with real Anpanman.
79. Cyborg organs for a more efficient diet.
80. Technology that allows us to extend our abilities while we sleep.
81. Technology to control sleep will become so sophisticated that the term “sleep deprivation” will disappear.
82. A system in which sleeping time can be shared with others.
83. Create a library dedicated to Japanese anime and manga.
84. Realistic paintings will disappear, and art will become completely NFT.
85. Technology that does not cause physical decline.
86. Build a house in the sea, and distribute one wave power generator per family.
87. Open sourcing of science and technology. Share technology with others to speed up

development.

88. An open society in which competition is no longer of much meaning.
89. Reduce the energy available for use by twice as much as the energy to collect litter.
90. Leave memories in mycelium. Bio storage.
91. 2~3 years in the future will be predicted to some extent by AI, and it will become a novel game of choice from freewill thinking.
92. A methodology will be established to create culture at a very high speed so that MSE can also create local festivals.
93. The concept of cities will be eliminated. A flat society with no centralisation.
94. Elimination of make-up as a social principle.
95. Full-time homemakers become illegal/abolished.
96. Society to choose gender at age 5.
97. *Shogi* (Japanese chess) to be played by both sexes.
98. The online world becomes more and more Vtuberised and avatarised, and it becomes more common for the individual to be shown as an icon.
99. Telework will become more sophisticated as senses other than audiovisual can be transmitted. Age, gender, race, and place of residence will become less relevant.
100. The integration of quantum mechanics and the theory of *Śūnyatā* and the distinction between religion and science will disappear, and the fusion of the material and spiritual worlds will be realised.