Demand for a Transgenic Food with a Medical Benefit

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Abstract: The perceived health and environmental risks of genetically modified (GM) technology have impeded its diffusion in developed countries. However, GM crops, which can provide direct consumer as well as producer value, have recently been developed. This study applies a stated choice experiment to examine whether the addition of a medical benefit can improve the welfare of the beneficiaries of the newly developed GM variety. Our results show a tradeoff between general worries over GM technology and GM food's specific health benefits. A marketing program should therefore be designed to inform and persuade consumers of these features.

Keywords: genetically modified research design, health, stated-preference method.

JEL codes: Q13, D12, I10

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1. Introduction

Most genetically modified (GM) crop varieties developed thus far have been designed to reduce farm costs, through herbicide tolerance and insect resistance, for example. Because these cost features have a direct appeal only to producers, consumers in developed countries—especially those in the European Union and Japan—generally see no particular advantage in consuming these products other than their arguably lower prices. Instead, they are concerned about these products, particularly their perceived risks to health and the environment (Costa-Font et al., 2008). As a result, mitigating their concerns has been considered crucial for the diffusion of GM technology. The risk-communication literature, for instance, has extensively analyzed consumers' risk perception to improve their understanding of GM technology (Savadori et al., 2004; Frewer et al., 1998). However, given the ever-growing concerns about GM technology, some studies (e.g., Gaskell et al., 2004) conclude that the diffusion of GM food is slow not because of consumers' misperceptions of its risks but because of the lack of perceived benefits from GM food consumption.

Recent developments in GM technology enable breeders to develop new varieties that can provide direct consumer and producer value (Sabalza et al., 2014). Golden rice, for instance, can provide vitamin A to expectant mothers, supply micronutrients to undernourished children, and help alleviate hidden hunger in developing economies (Hefferon, 2015). Recent studies (Lusk et al., 2002; Lusk, 2003; Corrigan et al., 2009; De Steur et al., 2010; Deodhar et al., 2008) examine consumers' attitudes to GM products with direct consumer benefits, such as a nutritional functionality and increased shelf life. Among health-related benefits, Gaskell (2000) concludes that the medical application of GM technology attracts most consumers' attention (see also Fischhoff and Fischhoff, 2001). Similarly, Einsiedel and Medlock (2005) find that edible vaccines from GM crops represent the most widely accepted use of the technology. Consequently, second-generation GM products, which have direct appeal to consumers, are expected to overcome consumers' concerns about the health and environmental risks of GM crops (Burton and Pearse, 2002).

Consumers can generally be classified into two groups: infected patients and non-infected consumers. The former considers both the medical benefits and the risks of GM technology when choosing between conventional and GM foods, while the latter generally do not seek medical benefits, as they do not suffer from diseases. A weakness of the aforementioned studies is that they attempt to measure consumers' preference for *hypothetical* GM products (e.g., hypothetical foods that can reduce cholesterol levels) and include both the beneficiaries and non-beneficiaries of the products as respondents in their consumer surveys. Consequently, the estimated preference for hypothetical GM crops might be underestimated due to the non-beneficiaries' weak preference for GM products with a medical functionality.

This study evaluates consumers' preferences for GM products with a specific medical benefit to clearly identify the products' potential beneficiaries. Specifically, we ask Japanese consumers suffering from a cedar pollen allergy if they would want to consume GM rice ("medical rice" hereafter) which has the same effect as immunotherapy. The study's focus on a GM food with a specific medical benefit and its limiting of survey respondents to the food's beneficiaries should ensure that its observed preference consists of the upper bound of consumers' preference for GM crops. This information should help determine if appealing to potential beneficiaries based on the merits of GM crops encourages the diffusion of GM technology. As medical rice is still in the development stage, we identify patients' preference for it through a stated-preference study in which respondents with a cedar pollen allergy indicate their preferred option among the treatments listed, including injection versus medical rice, and price.

The contribution of our study is twofold. Unlike previous studies, we identify the potential beneficiaries of a specific GM product to assess their preference for the good that provides a medical benefit, allowing us to precisely estimate consumers' preference for GM crops with direct consumer benefits. We then examine whether the addition of such a new functionality might contribute to a wider diffusion of such a GM variety. Besides its immediate contributions, our work is relevant to the debate over the leadership and future of GM technology development. In contrast to the bio-medical industry, private GM technology development (except for industrial uses) has been inhibited by consumer health and environmental concerns.

A GM product with a medical benefit represents a potential change in the agricultural and food landscape. However, its realization will depend on consumers' preferences.[1]

The remainder of this paper is organized as follows. Section 2 discusses the needs for medical rice in Japan and a framework for estimating consumers' preference for it. Section 3 outlines the empirical model specification and estimation techniques. Section 4 presents the estimation results and highlights the role of the factors affecting the willingness to pay (WTP) for medical rice. Section 5 concludes with a summary of the results and policy implications.

2. The Needs for Medical Rice and Consumers' Preference for It

According to Baba and Nakae (2008), 30 percent of the Japanese population suffers an allergic reaction to cedar pollen and other allergens. The current treatment is immunotherapy through injections or the ingestion of a diluted form of the allergen.[2] Conventional immunotherapy—injecting diluted allergen or sublingual immunotherapy—is the only immunotherapy treatment available for patients, which requires them to visit hospitals regularly.

Takaiwa (2004) developed a new recombinant-gene rice variety—medical rice—useful in the treatment of cedar pollen allergies. Although still in the development stage at the National Institute of Agrobiological Sciences, Japan, the newly developed medical rice, in

[1] Saito et al. (2009), for instance, examine the historical trend in Japanese wheat breeding and find that government research programs have developed varieties containing the characteristics Japanese consumers prefer in wheat.

[2] According to Okubo (2015), 70 percent of the patients treated with injections experienced a cure or alleviated symptoms. Medical rice is believed to work through intestinal immunity, while injection works through subcutaneous immunity.

addition to being a nourishing food, can provide allergen resistance.[3] Thus, it provides patients a tradeoff between general worries over GM technology on the one hand and the rice's specific health benefits on the other. After considering the opportunity costs of hospital visits to receive immunization injections, some allergy patients may weigh the food's allergen-immunity benefits more heavily than their concerns about GM technology. Therefore, appealing based on the merits of consuming medical GM crops might be effective for patients facing a tradeoff between general concerns about GM crops and their nutritional/health benefits.

In evaluating consumers' perceptions of GM technology, worries about GM's environmental risks, including the prospects of its crossing with local varieties or facilitating herbicide-tolerant weed mutations, must also be addressed. However, potential solutions are beginning to emerge. One is the recent development of the "plant factory," in which negative-pressure ventilation minimizes the chances of pollen or herbicide dispersal, reducing the chances of interactions with surrounding ecosystems. Presumably, consumers will compare the goods produced in such a manner with their food and medical amenities and with any remaining technological and environmental concerns: they will compare its food value to that of conventional rice and its medical value to that of conventional immunization methods.

As medical rice is not yet being marketed, we carried out a choice experiment to

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3 Following the Cartagena Protocol on Biosafety, medical rice is currently planted in an experimental field to investigate its environmental impacts. Pursuant to the Pharmaceutical Affairs Law, it must also pass clinical trials as a medicine before it can be sold commercially.

examine consumers' acceptance of it (Louviere et al., 2000).[4] Survey respondents were limited to those living in Japan and allergic to cedar pollen. We obtained 1,051 responses, half of them from females. The same number of respondents was selected from each of the five-decade categories created for an age range of 20 to 69 years. In a choice experiment, respondents indicated their preferred choice among three, including the "I do not buy" option (see Figure 1).[5] The product attributes were (a) treatment method, (b) fee per month, and (c) rice production site if the treatment is medical rice[6] (see Table 1 for the levels of each attribute[7]). As both injection and medical rice treatments always appear in choice sets by construction, only (b) fee and (c) rice production site vary across choice sets. A total of 36 choice sets were generated through orthogonal design; these were divided into six groups, each containing six choice sets. In the choice experiment, each respondent was randomly assigned to one of the six groups.

In addition to the stated-preference experiment, we asked respondents about their familiarity with immunotherapy treatment (IM_K), their familiarity with GM crops/technology (GM_K), and their concerns about the environmental risk of GM crops (ENV). We also asked about the severity of their allergic reaction ($SEVERE$) and the opportunity cost of hospital visits

[4] An online survey was carried out through Macromill in March 2015.

[5] In the survey, respondents were informed that the "I do not choose" option implied that they would continue their current treatment (see Figure 1).

[6] Patients may refer to factors such as the frequency of hospital visits and the length of the treatment when they choose a treatment method. However, those factors were not considered as an attribute here because they were simultaneously determined with the treatment method. Instead, we provided this information in the survey script.

[7] We did not include sublingual immunotherapy in a (a) treatment method because it was recently developed and was not a major treatment yet. Price levels were set based on the results of a preliminary survey.

to receive immunization injections ($BUSY$), as measured by their schedule flexibility. Definitions of the variables are provided in Table 2.[8] Using the responses, we tested four hypotheses: (a) The busier the respondent is, the higher are the opportunity costs of hospital visits; (b) The more unfamiliar with GM technology the respondent is, the stronger are the general concerns about GM technology; (c) The more severe the typical allergic reaction is and/or the more familiar with immunotherapy treatment the respondent is, the greater is the preference for immunotherapy treatment; and (d) The more pro-environmental the attitude is, the higher is the WTP for a GM crop cultivated in a plant factory. Among these, the first two constitute our key hypotheses, representing a tradeoff between general worries about GM technology and the timesaving benefits of medical rice.

Table 3 presents the summary statistics of the variables. Average familiarity with immunotherapy treatment is 0.31, with a standard deviation of 0.27, implying that awareness of immunotherapy as an effective treatment for cedar pollen allergies varies considerably among the patients. Average familiarity with GM products is 0.184. The risk communication literature suggests that information on the benefits and risks of GM food should have been adequately provided to consumers, but our average familiarity results indicate that consumers' understanding of GM crops is still limited. The average level of concern about the environmental risk of GM crops 0.62. As respondents worry moderately about GM's

[8] The appendix shows how we constructed these variables.

environmental risks, GM crop production in a plant factory might effectively mitigate their environmental concerns.

Average severity is 0.83, suggesting that most respondents consider their allergic reactions to cedar pollen to be very severe and that their quality of life significantly worsens during cedar pollen season. Finally, the average schedule flexibility level, a proxy for the opportunity cost of hospital visits, is 0.50, with a standard deviation of 0.28, suggesting that the dataset consists of a variety of respondents, ranging from flexible to inflexible in terms of scheduling. Hence, the timesaving advantages of medical rice may appeal to those facing high opportunity costs from hospital visits.

3. Estimation Model

Discrete choice analysis is applied to model consumers' preferences for immunotherapy treatment. Suppose that the utility cedar pollen-allergic patient *i* gains from choosing alternative treatment *j* is expressed as follows:

(1) $$U_{ij} = V_{ij} + \varepsilon_{ij},$$

where V_{ij} is the systematic components of the utility from consuming medical rice ($j = 1$), receiving injection ($j = 2$), and the opt-out option ($j = 3$). We suppose that it takes the following form:

(2) $$V_{i1} = \beta_{1i}ASC_{TR} + \beta_2 FEE_1 + (\beta_{3i} + \beta_{4i}FACTORY_1)RICE_1,$$

(3) $$V_{i2} = \beta_{1i}ASC_{TR} + \beta_2 FEE_2,$$ and

(4) $V_{i3} = 0,$

where ASC_{TR} is an alternative-specific constant, which is unity when respondents choose to receive immunotherapy treatment and 0 if they decide to continue their current treatment. FEE_j denotes the treatment fee at 1,000 yen per month. $RICE_j$ is a dummy variable, taking a value of 1 if a respondent chooses medical rice as immunotherapy treatment and 0 otherwise. $FACTORY_j$ is another dummy variable, taking a value of 1 if medical rice is produced at a closed factory and 0 if it is produced under open-field conditions.

Parameters β_{1i}, β_2, β_{3i}, and β_{4i} in equations (2) and (3) respectively measure the welfare impacts of receiving immunotherapy treatment, paying the treatment fee, consuming medical rice, and consuming medical rice produced in a plant factory. Note that parameters β_{1i}, β_{3i}, and β_{4i} are indexed as *i*, implying that the extent of the utility gain from immunotherapy treatment or medical rice consumption varies across consumers depending on their personal characteristics. They are defined as follows:

(5) $\beta_{1i} = \beta_{10} + \beta_{11}MALE_i + \beta_{12}AGE_i + \beta_{13}SEVERE_i + \beta_{14}IM\_K_i,$

(6) $\beta_{3i} = \beta_{30} + \beta_{31}MALE_i + \beta_{32}AGE_i + \beta_{33}BUSY_i + \beta_{34}GM\_IL_i$, and

(7) $\beta_{4i} = \beta_{40} + \beta_{41}ENV_i,$

where GM_IL_i, defined as $1 - GM\_K_i$, measures the level of unfamiliarity with GM food.

It is expected that the more severe the typical allergic reaction is, the greater is the preference for immunotherapy treatment. Moreover, as the patient becomes more familiar with immunotherapy treatment, preference for that treatment increases. Hence, both β_{13} and β_{14} in equation (5) are expected to have positive signs. The decision between medical rice and injection in equation (6) depends on a tradeoff between general worries about GM technology and medical rice's timesaving benefits. The busier the respondent, the higher the opportunity costs of hospital visits and the more likely the choice of medical rice. On the other hand, unfamiliarity with the technology causes serious concerns about GM technology and reduces the likelihood of choosing medical rice. Thus, β_{33} is expected to be positive, while β_{34} is expected to be negative. Finally, the more pro-environmental the patient's attitude is, the stronger the preference for the GM crop to be produced in a plant factory, indicating that β_{41} in equation (7) should be positive.

Suppose ε_{ij} follows a type I extreme-value distribution. The parameters in equations (2) to (7) can then be estimated by the conditional logit model. The underlying assumption (IIA assumption) is that the relative probability of choosing any two alternatives is independent of the availability of any other alternative. For example, the IIA assumption implies that the choice between injection and current treatment (status quo) is independent of the availability of a "medical rice" alternative. However, when medical rice is not available, an individual suffering severely from a cedar pollen allergy prefers the definitive treatment and may choose injection with a higher probability than status quo. Graphically, this is represented by the decision tree in Figure 2. The upper level of the tree represents the choice between immunotherapy treatment and status quo, while the lower level consists of two choices: medical rice and injection. If this decision tree holds empirically, conditional logit estimates are no longer consistent. In Section 4, we therefore present the estimation results of both the conditional logit model and the nested logit model based on the decision tree in Figure 2. All estimates presented in this study are obtained through NLOGIT Version 5.

4. Estimation Results

4.1. Utility Function Estimates

Table 4 presents the utility-function parameter estimates of allergy treatment choice. The left column of Table 4 shows the parameter estimates of the conditional logit model. The parameter on the fee (β_2) is negative and significant, implying that patients incur utility loss from a higher treatment fee. Parameters β_{10} to β_{14} represent how respondents' personal characteristics impact the choice between immunotherapy treatment and status quo. Both parameters β_{13} and β_{14} are positive and significant, as expected. Thus, respondents suffering severely from allergic reaction to cedar pollen ($SEVERE$) seek definitive treatment. Thus, if they have considerable knowledge of immunotherapy treatment (IM_K), they are more likely to choose that treatment.

Parameters β_{30} to β_{34} measure the effects of personal characteristics on the choice between medical rice and injection. Key parameters, β_{33} and β_{34}, take the expected signs and are significant. The negative sign of β_{34} suggests that respondents unfamiliar with GM technology (GM_IL) have serious concerns about it and lower their utility by consuming medical rice. Most importantly, we confirm a tradeoff relationship between general concerns over GM technology and medical rice's timesaving benefits: the positive sign of β_{33} indicates that busier people ($BUSY$) pay higher opportunity costs for hospital visits and are more likely to choose medical rice. In summary, in line with previous studies, our results support the argument that improving consumers' understanding of GM technology is key to increasing their acceptance of GM food. However, improving their understanding is not so easy in reality. Approximately 20 years has passed since the first GM food (FLAVR SAVR tomato) was introduced into the market but consumers' knowledge on GM food is still very limited as we discussed in Section 2.[9] Our results, instead, recommend targeting patients with considerable schedule inflexibility as an effective alternative for the successful diffusion of medical rice.

Concerning the effects of closed factory production on the choice between medical rice and injection, the parameter β_{41} on environmental concerns about GM technology (ENV) is positive but not significant. Hence, we do not find strong evidence that growing GM crops in a closed factory mitigates consumers' environmental concerns or induces them to purchase those crops. A possible explanation for the insignificance of the parameter is that respondents might not have completely understood the benefits of closed factory production from the survey script

[9] Public perception of GM food is very low in the United States, too (Hallman et al., 2013). About half of the respondents in their survey in 2013 indicate that they know GM food very little or not at all.

(see Figure 1). Providing a picture along with the sentence might have improved their understanding and yielded a significant result.

The right column of Table 4 shows the estimation results of the nested logit model. Both estimations—the conditional logit and the nested logit—give qualitatively and quantitatively similar results. Furthermore, the inclusive value parameter for a nest "immunotherapy treatment" is not significantly different from 1 even at 10 percent, suggesting that the IIA assumption imposed by the conditional logit model holds empirically. Hence, the discussion below is based on the results of the conditional logit model.

4.2. WTP Estimates for Medical Rice

To facilitate the economic interpretation of the estimation results in Section 4.1, we estimate the WTP for medical rice and injection. The WTP, obtained as the ratio of the respective parameter to the negative of the price parameter, measures the difference between the maximum amount respondents are willing to pay for one alternative and that for the other (e.g., immunotherapy treatment vs. current treatment). Because parameters β_{1i}, β_{3i}, and β_{4i} in equations (2) and (3) are indexed as i, the WTPs differ across respondents depending on their personal characteristics. Table 5 shows how much the WTPs change when respondents' characteristics change by one unit and their estimated 95 percent confidence intervals.

Respondents with an average level of allergic reaction to cedar pollen ($SEVERE$) are willing to pay 1,506 ($= 1.826 \times 0.825 \times 1000$) yen more for immunotherapy treatment than for their current treatment (status quo). The WTP increases by 578 ($= 1.840 \times 0.314 \times 1000$) yen for respondents with an average level of knowledge of immunotherapy treatment (IM_K). Thus, severity of allergic reaction and abundant knowledge of immunotherapy treatment are the keys to inducing consumers to choose either medical rice or injection. Regarding the WTP for medical rice, gender has non-negligible impacts: male respondents are willing to pay 660 ($= 0.660 \times 1 \times 1000$) yen more for medical rice than are female respondents. This result is consistent with Kirk and McIntosh (2005), who find that men generally do not favor injections as much as women do. Most importantly, the WTP for medical rice for the average respondents is 305 ($= 0.608 \times 0.502 \times 1000$) yen greater than that for injection because of their schedule inflexibility ($BUSY$). However, it is 544 ($= -0.668 \times 0.815 \times 1000$) yen lower than that for injection due to their unfamiliarity with GM technology (GM_IL).

Thus, the negative welfare impacts of general worries about GM technology exceed the positive welfare impacts of the timesaving advantages of medical rice for average respondents. However, each respondent is expected to have very different (both positive and negative) views on GM technology because both the levels of unfamiliarity with GM technology and schedule inflexibility vary greatly across respondents, as Table 3 shows. This can be confirmed in the fourth column of Table 5, which shows a change in WTPs due to a one standard deviation change in personal characteristics: the WTP for medical rice is 168 yen greater for respondents whose level of schedule inflexibility is one standard deviation greater than the average, while the

WTP is 135 yen lower for respondents whose level of unfamiliarity with GM technology is one standard deviation greater than the average. Thus, preference for medical rice is significantly different among respondents depending on their personal characteristics.

To see this more clearly, we compute for each respondent those two factors' contribution to the WTP for medical rice as $-\left(\widehat{\beta_{33}}BUSY_i + \widehat{\beta_{34}}GM\_IL_i\right)/\hat{\beta}_2$. Then, we present its kernel density estimates in Figure 3. The figure shows considerable variation among respondents due to a tradeoff between general concerns about GM technology and medical rice's timesaving benefits. For most respondents, it takes a negative value, implying that general concerns about GM technology have strongly negative impacts on the preference for medical rice. However, the timesaving benefits of medical rice improve respondents' willingness to purchase it. Indeed, the benefits' positive impacts outweigh the negative impacts of general concerns about GM technology for some respondents, suggesting that targeting allergy patients with inflexible schedules will foster the successful diffusion of medical rice.

Thus, the observed tradeoff relationship between general worries about GM technology and medical rice's specific health benefits indicates a strong potential demand for GM food with medical benefits. As discussed in the introduction, private investment in GM technology has been inhibited by consumer health and environmental concerns. To increase the public acceptance of GM technology, future research on GM technology should be directed to highlight not only cost but also the medical features of GM crops. Besides developing GM varieties with medical benefits, a marketing program should be designed to improve consumers' understanding of these features.

5. Summary and Conclusions

Perceptions of the health and environmental risks of GM technology have impeded its diffusion in developed countries. As most GM crops appeal directly only to producers, alleviating consumers' concerns about those crops—for example, through frequent communication among breeders, researchers, government agencies, and consumers—has been considered the most effective way to enhance the diffusion of the technology.

However, GM crops that can provide direct consumer as well as producer value have been recently developed. The daily consumption of medical rice, one example of such a crop, is expected to cure cedar pollen allergies. Currently, injecting diluted allergen is the only immunotherapy treatment available, and this requires regular hospital visits; the timesaving benefits of medical rice may appeal to busy patients. Consumers thus face a tradeoff between general worries about GM technology and the rice's health benefits. Explaining the advantages of medical rice to potential beneficiaries may enhance the diffusion of GM technology. This study uses a stated-choice experiment on the beneficiaries of the technology to examine whether the addition of such a new functionality might widen the diffusion of such a GM variety.

Our results clearly show a tradeoff relationship: the likelihood of choosing medical rice increases when respondents are busy but declines if they are unfamiliar with GM technology.

As it is not easy to enhance consumer knowledge of GM crops, targeting busy patients would be a more effective way of promoting medical rice. Targeting patients with severe cedar pollen allergies and/or improving their understanding of immunotherapy treatment would indirectly boost the chances that they will choose medical rice. On the other hand, we do not find strong evidence that producing GM crops in a closed factory would appeal to consumers with a strong environmental awareness.

The importance of balancing costs and medical features in GM research design will likely be part of future crop transgenics. For example, grains have long shelf lives and do not require the costly handling that most vaccines do, and can thus be shipped easily once an outbreak occurs. Efforts are already underway to engineer foods with resistance to infectious diseases such as cholera. Nevertheless, our study suggests that attention should be paid early in the research program to the envisioned technology's market acceptability, in terms of not only its cost but also its medical features, and a marketing program must be designed to inform and persuade consumers of these features.

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Table 1: Product Attributes in Choice Experiment

Product attribute	Level
Treatment	(a) Rice (b) Injection
Rice production site	(a) Open field (b) Closed factory
Treatment fee (yen per month)	(a) 500 (b) 1,000 (c) 1,500 (d) 2,000 (e) 2,500 (f) 3,000

Table 2: Definition of Variables

Variable	Definition
ASC	Dummy: 1 if respondent chooses immunotherapy treatment
FEE	Fee (1,000 yen/month) of immunotherapy treatment (injection/medical rice)
RICE	Dummy: 1 if respondent chooses medical rice
FACTORY	Dummy: 1 if respondent chooses medical rice produced in a closed factory
BUSY	Schedule flexibility: 0 (not busy) to 1 (busy)
SEVERE	Severity of allergic reaction to cedar pollen: 0 (not severe) to 1 (severe)
IM_K	Level of familiarity with immunotherapy treatment: 0 (unfamiliar) to 1 (familiar)
GM_K	Level of familiarity with GM food: 0 (unfamiliar) to 1 (familiar)
GM_IL	Level of unfamiliarity with GM food defined as $1 - GM\_K$
ENV	Environmental concerns about GM technology: 0 (none) to 1 (strong)

Table 3: Summary Statistics

Variable	Mean	Std. dev.	Min	Max
AGE	44.660	13.763	20	69
BUSY	0.503	0.277	0	1
SEVERE	0.825	0.174	0	1
IM_K	0.313	0.268	0	1
GM_K	0.184	0.202	0	1
ENV	0.616	0.249	0	1

Table 4: Utility Function Estimates of Allergy Treatment Choice

Variable	Conditional logit			Nested logit		
	Coefficient		Std. err.	Coefficient		Std. err
ASC_{TR}						
Constant (β_{10})	-0.606	***	0.187	-0.647	***	0.209
MALE (β_{11})	0.037		0.069	0.070		0.080
AGE (β_{12})	-0.006	***	0.003	-0.007	***	0.003
SEVERE (β_{13})	1.136	***	0.155	1.269	***	0.205
IM_K (β_{14})	1.144	***	0.109	1.291	***	0.170
FEE						
Constant (β_{2})	-0.622	***	0.025	-0.648	***	0.032
RICE						
Constant (β_{30})	0.649	***	0.187	0.646	***	0.193
MALE (β_{31})	0.411	***	0.071	0.415	***	0.072
AGE (β_{32})	-0.002		0.003	-0.002		0.003
BUSY (β_{33})	0.378	***	0.101	0.387	***	0.106
GM_IL (β_{34})	-0.416	***	0.142	-0.409	***	0.148
FACTORY						
Constant (β_{40})	-0.128		0.114	-0.146		0.120
ENV (β_{41})	0.154		0.162	0.184		0.172
Inclusive value						
Treatment				0.890		0.080
Status quo				1.000		
Log likelihood	-6236.995			-6236.117		
Observations	6306			6306		

Note: *** indicates statistical significance at the 1 percent level. The inclusive value parameter for a nest "status quo" is constrained to one in the nested logit estimation.

Table 5: Willingness-to-pay Estimates

Variable	WTP	95 percent confidence interval	1 std. dev. change in variable
ASC_{TR}			
Constant (β_{10})	-0.974	(-1.599, -0.375)	
MALE (β_{11})	0.059	(-0.162, 0.281)	
AGE (β_{12})	-0.010	(-0.018, -0.002)	-0.139
SEVERE (β_{13})	1.826	(1.326, 2.348)	0.317
IM_K (β_{14})	1.840	(1.481, 2.220)	0.493
RICE			
Constant (β_{30})	1.044	(0.448, 1.648)	
MALE (β_{31})	0.660	(0.430, 0.893)	
AGE (β_{32})	-0.004	(-0.012, 0.005)	-0.053
BUSY (β_{33})	0.608	(0.286, 0.936)	0.168
GM_IL (β_{34})	-0.668	(-1.123, -0.220)	-0.135
FACTORY			
Constant (β_{40})	-0.206	(-0.565, 0.161)	
ENV (β_{41})	0.248	(-0.271, 0.758)	0.062

Note: Unit is 1,000 yen per month. A 95 percent confidence interval is obtained following Krinsky and Robb (1986).

Assume a hospital at which you receive medical treatment is 20 minutes away. The medical fee is fixed no matter which treatment you choose (rice or injection). However, the treatment fee does vary. In the case of injection treatment, you will have to visit the hospital once a week or once a month, while, in the case of medical rice, you will eat one bowl of medical rice per day and visit the hospital once a month. You will have to continue this treatment for 2 to 3 years, including in the non-spreading season of cedar pollen. With regard to the rice production site, there are two options: an open field means a conventional production site, while a closed factory requires negative-pressured ventilation in the plant.

Based on this information, please choose your most preferred treatment. If you do not prefer any option, please choose [c]. Please note that the "I do not choose" option implies that you are continuing your current treatment.

	[a]	[b]	[c]
Treatment	Medical Rice	Injection	
Fee per month	1,000	500	I Do Not choose
Rice production site	Closed factory		

Figure 1: Survey Script and Sample Choice Set

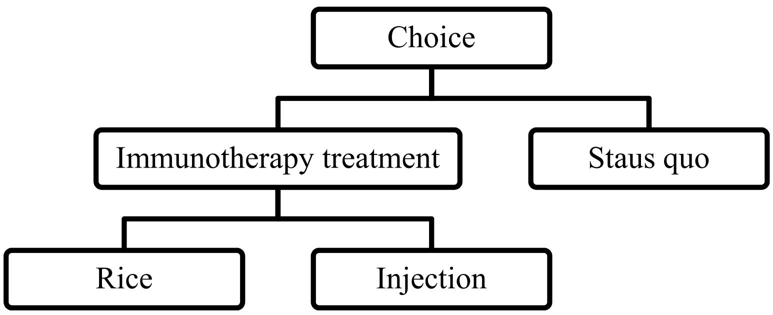

Figure 2: Tree Structure for Nested Logit Model

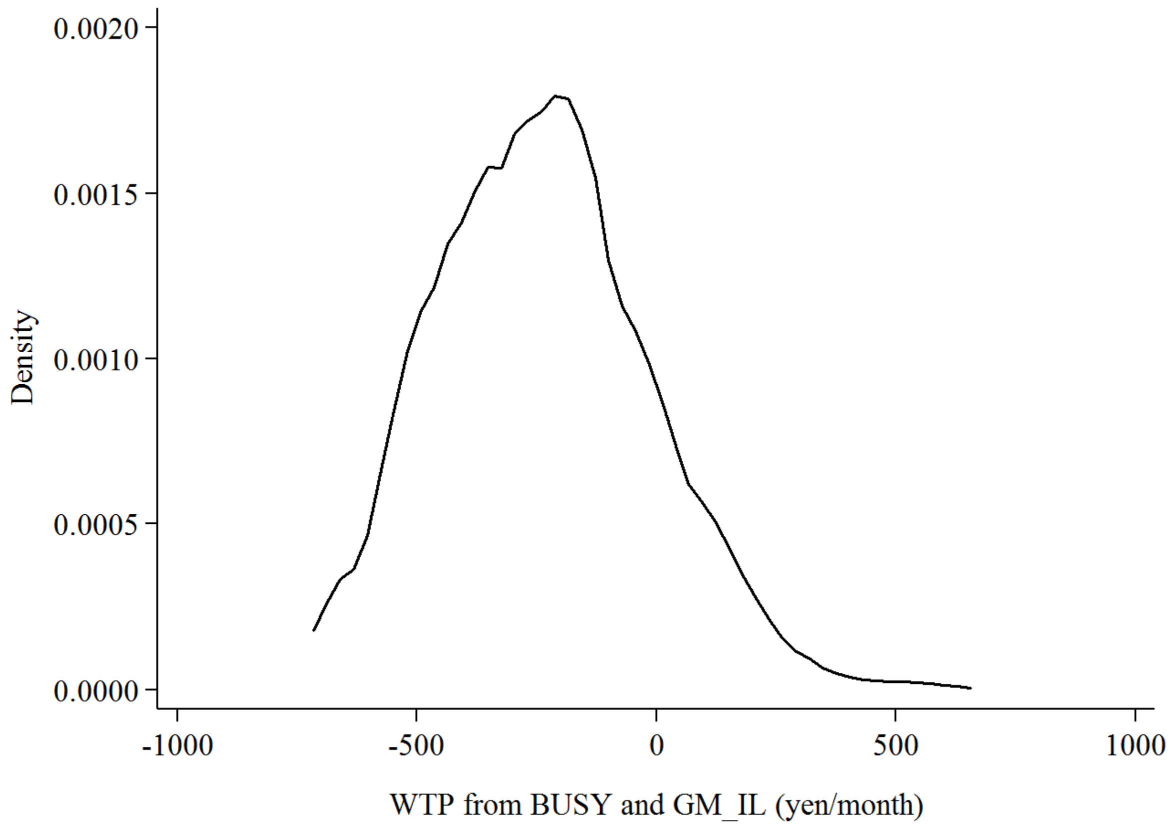

Figure 3: WTP for Medical Rice Arising from Schedule Inflexibility and General Concerns over GM Food

Appendix: Variable Construction

Here, we explain how we construct the variables used in the estimation. First, respondents are asked to indicate on a scale from 0 ("least") to 9 ("most") the extent to which they are made uncomfortable by allergic reactions to cedar pollen if they do not receive their current treatment. We also ask respondents to indicate their schedule flexibility on a scale from 0 ("enough spare time") to 4 ("very busy"). These survey results are presented in Tables A1 and A2, respectively. From the results, two variables—severity of respondents' allergic reaction ($SEVERE$) and their opportunity cost of hospital visits to receive immunization injections ($BUSY$)—are constructed by dividing the rank by 9 and 4, respectively, so that the constructed variable takes a value between 0 and 1.

In the next set of questions, we first provide information regarding immunotherapy treatment in Table A3, GM technology in Table A4, and the potential environmental risks of GM crop cultivation in Table A5. Then, we ask respondents to indicate how familiar they are with each of them on a Likert scale from 0 ("do not know at all") to 4 ("know very well") in Tables A3 and A4. In Table A5, we ask them to indicate the extent to which they are concerned about each of the environmental risks on a Likert scale from 0 ("not at all") to 4 ("very much"). To construct a composite Likert variable IM_K, we sum the ranks of all the items in Table A3 and divide the result by 24. Variables GM_K and ENV are similarly constructed by summing the ranks in Tables A4 and A5 and dividing them by 40 and 20, respectively.

Table A1: The Level of Discomfort Due to Allergic Reactions

To what extent are you made uncomfortable by allergic reactions to cedar pollen?	No.	%
0 (Least)	1	0.1
1	1	0.1
2	4	0.4
3	13	1.2
4	40	3.8
5	46	4.4
6	166	15.8
7	247	23.5
8	160	15.2
9 (Most)	373	35.5

Table A2: Respondents' Schedule Flexibility

To what extent are you flexible with your schedule?	No.	%
0 (Enough spare time)	98	9.3
1	258	24.6
2	313	29.8
3	297	28.3
4 (Very busy)	85	8.1

Table A3: The Level of Familiarity with Immunotherapy Treatment

How familiar are you with the following	Do not know at all			Know very well	
information about immunotherapy treatment?	0	1	2	3	4
In immunotherapy treatment, diluted allergen is	224	290	248	201	88
ingested to alleviate allergic reactions	(21.3)	(27.6)	(23.6)	(19.1)	(8.4)
Immunotherapy treatment occasionally causes	415	248	184	137	67
anaphylactic shock	(39.5)	(23.6)	(17.5)	(13.0)	(6.4)
Two to five years are required for a definitive cure	446	210	180	146	69
by immunotherapy treatment	(42.4)	(20.0)	(17.1)	(13.9)	(6.6)
Not all patients are necessarily cured definitively of	393	247	195	153	63
allergic reaction through immunotherapy treatment	(37.4)	(23.5)	(18.6)	(14.6)	(6.0)
Immunotherapy is the only definitive treatment for	514	209	180	108	40
allergic reaction to cedar pollen	(48.9)	(19.9)	(17.1)	(10.3)	(3.8)
Injection or sublingual immunotherapy is the only	440	252	191	125	43
immunotherapy treatment available for patients	(41.9)	(24.0)	(18.2)	(11.9)	(4.1)

Note: Numbers in parentheses represent the share of respondents.

Table A4: The Level of Familiarity with GM Food

How familiar are you with the following information about GM food?	Do not know at all 0	1	2	3	Know very well 4
GM plants with herbicide tolerance are commercially produced in foreign countries	536 (51.0)	250 (23.8)	148 (14.1)	88 (8.4)	29 (2.8)
GM crops are used in many processed products such as cooking oil in Japan	475 (45.2)	289 (27.5)	190 (18.1)	79 (7.5)	18 (1.7)
60% of cooking oil processed in Japan is made from GM crops	647 (61.6)	216 (20.6)	127 (12.1)	49 (4.7)	12 (1.1)
Japan imports a lot of GM crops for several purposes such as animal feeds	523 (49.8)	269 (25.6)	163 (15.5)	75 (7.1)	21 (2.0)
90% of soybeans produced in the U.S. and Brazil are GM crops	642 (61.1)	190 (18.1)	133 (12.7)	66 (6.3)	20 (1.9)
The use of GM crops may not be displayed on the labels of cooking oil in Japan	723 (68.8)	145 (13.8)	116 (11.0)	39 (3.7)	28 (2.7)
The use of GM soybeans must be displayed on the labels of food products in Japan	472 (44.9)	214 (20.4)	199 (18.9)	114 (10.9)	52 (5.0)
Cross-breeding has occurred between wild and GM species in Japan	760 (72.3)	136 (12.9)	104 (9.9)	38 (3.6)	13 (1.2)
Research on GM crops is regulated by law	602 (57.3)	224 (21.3)	140 (13.3)	70 (6.7)	15 (1.4)
Except for flowers, GM plants are not commercially produced in Japan	770 (73.3)	136 (12.9)	99 (9.4)	34 (3.2)	12 (1.1)

Note: Numbers in parentheses represent the share of respondents.

Table A5: The Level of Environmental Concerns about GM Technology

How much are you concerned about the following potential environmental risks of GM crop cultivation?	Not at all 0	1	2	3	Very much 4
Interactions between GM species and surrounding ecosystems may cause serious problem in nature	81 (7.7)	120 (11.4)	326 (31.0)	373 (35.5)	151 (14.4)
Diffusion of GM crop production due to cross-breeding between non-GM and GM crops	84 (8.0)	112 (10.7)	325 (30.9)	374 (35.6)	156 (14.8)
GM crops may produce and spread toxic chemicals into nature	71 (6.8)	78 (7.4)	287 (27.3)	384 (36.5)	231 (22.0)
GM crop cultivation may facilitate herbicide-tolerant weed mutations	74 (7.0)	92 (8.8)	357 (34.0)	368 (35.0)	160 (15.2)
Overuse of insect-resistant GM crops makes insects resistant to those crops	78 (7.4)	66 (6.3)	322 (30.6)	393 (37.4)	192 (18.3)

Note: Numbers in parentheses represent the share of respondents.