Estimating the WTP for GMO -and added antibiotics- free milks
—Using random nth-price auction with cheap talk and promise script—

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In this study, we assessed the value that consumers attach to milk safety from the results of a random nth-price auction experiment and investigated the role of hypothetical bias. We found that study participants were willing to pay 28.9% (or 50 yen) more for milk from cows whose diet did not include genetically modified feed and 45.6% (or 79.1 yen) more for milk that was antibiotics-free. We also confirmed the need for researchers to guard against hypothetical bias when evaluating new risks.

Keywords: WTP, Milk safety, Random nth-price auction, Hypothetical bias

1. Introduction

Food safety issues have been widely discussed in Japan (Nakashima (2012)), especially since the Snow Brand (“Yukijirushi”) food poisoning incident in June 2000 involving the sale of contaminated milk. According to Ujiie (2002), the incident was deeply damaging to the safety image of milk, whose tarnished image has persisted (J-milk (2016)).

This study seeks to clarify current consumer attitudes towards milk safety and the role of safety information regarding GMO and the presence of antibiotics in milk. Genetic recombination has for some time been perceived as a risk by consumers and has been a frequent topic of debate in Japan. On the other hand, the presence of antibiotics in food appears to be a new and lesser-known risk. Although the World Health Organization sees the antibiotics problem as a future threat, and their use in livestock products has been restricted in Europe since 2012 (MARAN (2013)), the use of antibiotics that meet government safety standards is still permitted in Japan.

Iwamoto (2004) and Ujiie (2002, 2012) analyzed the effect of certain milk safety information on consumer behavior. However, their focus was on food poisoning, HACCP labeling, and radioactive contamination. There appear to be no studies that have analyzed the impact of information on gene recombination or antibiotics.

2. Method

1) nth-price auction

A method for measuring highly reliable consumer’s willingness to pay (WTP) is an auction experiment used in experimental economics. In a general auction experiment, the winning bidder is obligating to purchase, so it is possible to get close to the actual WTP by obtaining the revealing preference data and repeatedly giving the WTP. However, the cost of such an approach can be much higher than the cost of conducting a conventional attitude survey (Matsushita (2019)). Indeed, this may be one reason why this form of experiment is not often conducted in Japan. Many previous studies using auction experiments have used second-price auctions (Vickrey (1961)). However, in a second-price auction, since there is only one successful bidder, assessing the behavior of a target person who has little interest in evaluating the target property tends to produce inaccurate results and unreliable answer data. In contrast, a random nth-price auction (Shogren et al. (2001)) has more than one successful bidder. Everyone is eligible to purchase, which makes awareness of participation in the experiment greater than in a second-price auction. Since there is the incentive to bid more sincerely, and the market-clearing price is determined endogenously (Botao (2020)), more accurate answer data can be expected.
2) Internet survey and hypothetical bias

One of the disadvantages of auctions is that it is difficult and/or expensive to increase the sample size. It is also challenging to secure geographical variation among the participants. On the other hand, internet surveys permeate our lives, and research companies tend to have a sufficient number of monitors to enable complex research. Thus, we decided to conduct an auction-type survey on the Internet.

To obtain more accurate answer price data, we used a random nth-price auction. The auction did not involve an actual purchase but rather was conducted under virtual conditions, thus making it subject to hypothetical bias. That is, the WTP indicated by a respondent may be quite different from the amount that he/she would be willing to pay if the produce were actually being purchased. There are two possible reasons for this mismatch: ① Respondents who do not incur an expense have less motivation to express the actual amount they would be willing to pay; and ② Respondents will try to give the answer that the survey sponsor wants. Thus, in order to produce a reliable WTP, it is essential to give participants a sense of ownership and encourage them to provide truthful answers. To this end, previous studies have adopted Cheap Talk (CT) (Cummings and Taylor (1999)), which alerts participants to potential bias. In addition, Batao’s Promise Script (PS) (Botao (2020)), whereby participants affirm that they will give truthful responses, can be used.

3) Survey procedure based on random nth-price auction

Details of the random nth-price auction are shown in Table 1. The procedure common to each group was as follows:

Step 1: Details of the experiment are explained, and relevant safety information is provided. In some cases, CT and PS are presented; in others, they are not (Figures 1 and 2).

Step 2: Participants bid on either non-GMO or antibiotics-free milk.

Step 3: The observer randomly selects the value of n, from 2 to k, where k is the number of participants.

Step 4: The purchase price is set as the nth highest price, and the product is “purchased” by the n-1 highest bidders.

Step 5: Bid results are presented to the participants. These include the purchase price, the previous bid price, the total number of bidders, and the bid rank.

Steps 2 to 5 are then repeated. (Due to budget constraints, the experiment consisted of four rounds.)

The PS used in the study was a simplified version that did not require a signature, as this would be difficult on the Internet. Moreover, since the effectiveness of CT has been

| n   | Group 1 | Group 2 | Group 3 | Group 4 |
|-----|---------|---------|---------|---------|
| Characteristics of the milk to be bid | Non-GMO Antibiotics Free | Non-GMO Antibiotics Free | Non-GMO Antibiotics Free | Non-GMO Antibiotics Free |
| CT & PS | with | with | with | with |
| Number of rounds | 4 | | | |
| Number of bids | One each round | | | |
| Bid method | The experiment uses sealed bids. Participants can individually access the bidding website on their computers or smartphones and bid at any time within the specified period. | | | |

Table 1. Details of the random nth-price auction

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Figure 1. Risk information

| GMO | ①Feeding dairy cows with herbicides and crops incorporating genes resistant to disease allows milk to be produced efficiently. | ② Imported feed may include crops whose safety to humans, dairy cows, and ecosystems has not been confirmed. |
|---|---|---|
| Antibiotics | ① The addition of antibiotics to the feed of dairy cows helps them to grow better, and allows milk to be produced more efficiently. | ② When humans drink milk from cows fed with antibiotics-added feed, bacteria that are resistant to drugs may be produced. |

Figure 2. Cheap Talk and Promise Script

Cheap Talk

In an Internet questionnaire survey such as this one, people tend to reply with a higher amount than the amount they would actually pay.

Therefore, please answer as though your intention is to actually purchase the product.

Promise Script

I promise to answer truthfully and honestly throughout the survey.
shown to be somewhat ambiguous (Penn and Hu (2019)), we used both CT and PS to reduce bias.

3. Data and regression models

1) Data
The data were collected on the Internet by a private research company (INTAGE) from March 8 to March 12, 2020. To avoid locality issues, we targeted consumers in Tokyo and in six prefectures in the Kanto region, Japan’s largest consumer area. “Milk” was defined as whole milk to avoid confusion with other types of milk such as low fat and non-fat milk.

2) Regression models
OLS was used to estimate the variable coefficients in the two WTP functions (see notes 1 and 2). Households with a purchase volume of at least one liter of milk per month were targeted so that the effects of constant consumption would be considered. Incorrect answers and outliers (robust z-score > 3) were excluded. In an auction experiment, participants often need to make a number of bids before they conclude that answering with their true preference is their best strategy. That is, the experience of repeating bids can lead to more sincere bidding behavior. In our study, the fourth-round results showed fewer extreme outliers and had the smallest standard deviations, leading us to consider our fourth-round results as indicative of the participants’ true preferences. Accordingly, WTP was defined as the difference between the answer price (for non-GMO and antibiotics-free milk) in the fourth round of the auction and the price of whole milk that the respondent usually pays (see note 3). (Since Japanese dairy farmers are allowed to feed their dairy cows with GMO feeds and feeds containing antibiotics, milk that is usually purchased by Japanese consumers contains GMOs and antibiotics.) The OLS estimation was performed using this difference as the dependent variable. The explanatory variables in the OLS model included household attributes and attitudes when purchasing milk. The variables were selected using the forward-backward stepwise method (for inclusion, $p = 0.1$; for removal, $p = 0.15$). The “special sale” dummy was given a value of 1 if the respondent answered “purchased at a special sale” and 0 otherwise. For “risk recognition” and “credibility of the information provided,” participants were asked to respond on a four-point scale. The results were then used to create the risk recognition and information trust dummies (for "knew well" and "somewhat knew," the value of the recognition dummy was set as 1; for "very credible" and "somewhat credible," the value of the risk dummy was set as 1). Household income, which is an indispensable variable for WTP measurement, and the CT & PS dummy, which relates to virtual bias suppression, were forcibly input as control variables.

As shown in Table 2, awareness of the risk of gene recombination was 36%, while awareness of the risk of antibiotics was only 24%, confirming that antibiotics represent a relatively new risk factor in Japan.

4. Results of the analysis

1) Results of the nth-price auction
Figure 3 shows the boxplots of the answer prices bid by study participants. It should be emphasized that these are answer prices, not WTP values. All data were analyzed in order to examine the effectiveness of the random nth-price auction. As indicated in the figure, the lower quartile values (indicating the lowest 25% of responses) in the fourth-round distributions are all greater than the first-round lower quartile values. On the other hand, the upper quartile values (i.e., the 75% markers) are smaller relative to the lower quartile values. This tends to support Shogren’s conclusion that an nth-price auction may improve the bidding motivation of those who might be less interested in the product being auctioned.

We will compare the results of the first-round and fourth-round. The mean ± standard deviation obtained are 201.44 ± 41.62 to 223.82 ± 24.12 without CT&PS of non-GMO feed milk and 204.57 ± 47.16 to 223.75 ± 28.06 with CT&PS. CT&PS of antibiotics free milk is 219.54 ± 57.93
4) The fact that the standard deviations were all found to be smaller in the fourth round than in the first round suggests that repeatedly conducting the auction may improve the attitude and motivation of less-interested consumers. Moreover, with CT&PS in both the non-GMO milk and antibiotics-free milk cases, the occurrence of clearly abnormal answer prices decreased, which should result in an increase in the reliability of the answer price data.

2) WTP estimation results

As shown in Table 3, the average WTP for non-GMO milk—that is, the premium that participants were willing to pay for non-GMO milk—was 50 yen per liter (a premium of approximately 28.9%). For antibiotics-free milk, the average WTP was 79.1 yen per liter (a 45.6% premium). These results are close to the results reported by Wolf et al. (2011), who found that the premium that consumers were willing to pay for milk that did not contain rBST, a bovine growth hormone, was in the range of 20% to 40%. The difference in the mean WTP for non-GMO milk with and without CT&PS was approximately 0.9 yen (49.54 vs. 50.46); for antibiotics, the difference was approximately 10.4 yen (73.9 vs. 84.25). This suggests the possibility of hypothetical bias.

3) OLS estimation results

Table 4 shows the OLS results. In the non-GMO model, the coefficient of the risk recognition dummy is negative ($p < 0.05$), indicating that consumers with information do not have excessive anxiety regarding genetic modification. On the other hand, the coefficient of the homemaker dummy is positive ($p < 0.05$), suggesting that homemakers...
may be less well-educated on the issue than those working outside the home and may overestimate safety. The coefficients of monthly milk purchases, the 20s-30s-40s age dummy, and the one-child dummy were not significant. It may be that since GMO is a known risk and is gaining in consumer understanding, people in their 20s, 30s, and 40s, people with low monthly milk purchases, and people with one child do not have excessive anxiety.

In the antibiotics model, the coefficient of household purchase amount is negative and significant \( p < 0.05 \). The coefficient of the one-child dummy is positive and significant \( p < 0.05 \), suggesting that a family having only one child can afford to pay a higher price for safety or that a one-child family may raise its first child with greater concern for safety. Such a family may overestimate the safety factor out of a lack of child-raising experience and uncertainty about the effects of diet on the child's growth. The coefficient of the 20s-30s-40s age dummy is positive \( p < 0.05 \), likely because awareness of food safety in this age group has increased in recent years, resulting in an elevated concern about new risks. The coefficients of the homemaker and risk recognition dummies were not significant. It may be that new risks induce anxiety in consumers regardless of education level or risk awareness.

The income variables were not significant in either model, implying that consumers, regardless of income, may be concerned about the safety of foods such as milk that have experienced a major incident. The coefficient of the dummy indicating that the respondent bought special sale milk is positive, meaning that despite being price sensitive, such consumers were willing to pay more for safety (a seemingly contradictory result). However, it was found that the average answer time for these respondents was 24.4% shorter in the non-GMO model and 1.9% shorter in the antibiotics-free model than the other respondents, perhaps indicating that they were giving less-thoughtful answers.

Finally, in the antibiotics model, the coefficient of the CT&PS dummy is negative \( p < 0.1 \), suggesting that the inclusion of CT&PS in the survey reduced hypothetical bias. However, in the non-GMO model, the CT&PS dummy was not significant. These results suggest that hypothetical bias may be more likely to occur for new risks rather than for known perceived threats.

### 5. Conclusion

The results of a random *n*th-price auction experiment were used to clarify the attitudes of Japanese consumers towards milk safety. The issue of hypothetical bias was also examined.

Our findings can be summarized as follows:

1. The average WTP for non-GMO milk is 50 yen/liter. (+28.9% compared to GMO milk). Homemakers had an especially high WTP.
2. The average WTP for antibiotics-free milk is 79.1 yen/liter (+45.6% compared to milk containing antibiotics). The 20s-30s-40s age group and households with one child had a high WTP.
3. CT&PS was effective only in the case of antibiotics, implying that when assessing new risks, hypothetical bias can be assumed and appropriate counter-measures need to be taken.

(Note 1) In each model, Breusch-Pagan/Cook-Weisberg tests show uniform dispersion, with \( p = 0.159 \) and \( p = 0.681 \). In Skewness/Kurtosis tests, \( p = 0.058 \) and \( p = 0.801 \), and the normality of the residuals was
confirming. From the above, it can be said that the results obtained by this estimation are valid.

(Note 2) The non-GMO model is estimated using the results of groups 1 and 3 (Figure 1). The antibiotics-free model uses the fourth-round results of groups 2 and 4.

(Note 3) Maruyama et al. (2004) set "the good itself with improved safety" as their auction’s target good, and defined WTP for improved safety as the difference between the bid price and the price of the item usually purchased. We used the same approach to define WTP.

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