CONSUMERS' PERCEPTION ON PRODUCT QUALITY: AN EMPIRICAL STUDY ON THE FUKUSHIMA NUCLEAR DISASTER

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ABSTRACT

Although it would be easy to understand that product quality is an important factor in consumers' purchasing decision, quality physically measured might be different from quality that consumers perceive. For example, many consumers have quit purchasing rice produced in Fukushima after a nuclear power plant disaster occurred there even though Japanese Government has provided supportive information on its quality. This shows that product quality that consumers perceived may play a more important role in their purchasing decision. In order to quantify the consumers' perception of product quality, we utilize a logit model to estimate the mean utility from products. The paper demonstrates that the mean utility from rice produced in Tohoku area dropped by 31.8% for consumers who purchased the rice in the Greater Tokyo area after the disaster. The drop in the mean utility implies a drop in product quality that consumers have perceived, and this could explain the decline in the consumption of rice produced in Fukushima.

Keywords: *product quality, logit model, rice, Fukushima Nuclear Disaster*

1. INTRODUCTION

Concerns about radioactive contaminations caused by the Fukushima nuclear disaster made many consumers quit purchasing agricultural goods produced in Tohoku area. Although Japanese government checked and guaranteed the quality of Tohoku products to remove the concerns while after the disaster, some consumers still worry about the quality (Shimokawa, Niiyama, Kito, Kudo, and Yamaguchi, 2018). Even though the product's quality is guaranteed by authorities, consumers would not buy the products if they don't believe it. Thus, it is worth knowing how much consumers change their evaluation of Tohoku products after the disaster. Many researches on Fukushima Nuclear Power Plant have been done, a few on effects on consumers' preference. The aim of this paper is fill the gap.

To this end, the paper estimates a discrete choice model with POS data. The data provides us a purchasing history of Tohoku products sold in shops located in the Greater Tokyo area where is the biggest market in East Japan. Consumers physically experienced how strong the earthquake was, and this would change their purchasing behavior.

This paper captures consumers' perception of product quality by the mean utility calculated from the estimate of the logit model. The mean utility consists of disutility from price and utility from product characteristics. We investigate the effects of the disaster by looking at changes in price sensitivity and coefficients on products' characteristics.

The paper demonstrates that the mean utility from rice produced in Tohoku area dropped by 31.8% for consumers who purchased the rice in the Greater Tokyo area after the disaster. The drop in the mean utility implies a drop in product quality that consumers have perceived, and this could explain the decline in consumption of rice produced in Fukushima.

The remaining sections are consisted of as follows. I survey existing literature in the next section. Section 3 and 4 explain the underlining economic model and its estimation method with data. Section 5 concludes.

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2. EXISTING LITERATURE

Many studies investigate the effects of the Fukushima nuclear disaster on economic activities[1]. Among them, the following two studies investigating effects on rice are close to the paper. Mizuta, Inui, and Matsuura (2016) focus on an effect on rice demand of negative information, which is the occurrence of the Fukushima Nuclear Disaster. By using a difference-in-difference method, that paper demonstrates that the disaster reduced the sales of rice of Fukushima, which was harvested before the disaster happened. The disaster would not change the quality of the rice in a material sense since it had been already harvested. Although that paper does not provide a consumers' behavioral model, the result implies that consumers' perception on quality rather than quality measured in a material sense plays an important role in their purchasing decision.

Shimokawa et al. (2018) investigate a willingness to pay for the Fukushima rice. That paper demonstrates the existence of no-tolerant consumers who excessively avoid Fukushima rice. This is an experimental study and does not use actual transaction data.

By using aggregated transaction data on Tokyo Wholesale market, Ota and Lee (2020) investigate the effect of the disaster on consumers' preference for Fukushima's peach. That paper estimates Stone-Geary utility function based on a multi-tier consumption model developed by Yano, Takahashi, and Mizuno (2005), and demonstrates that preference parameter drops by about 60% for peaches produced in Fukushima and Yamagata. In addition, that paper shows that theoretical prices for Fukushima's peach calculated from the estimates got lower than transaction price after the disaster. Combining the results implies that consumers might lose their trust in quality of Fukushima's peach where it was recognized as a high-quality product, and was famous for a gift in the summer season in Japan. A limitation is that that paper utilizes aggregate data on wholesale market and the data could not capture details of products. An advantage of the paper is the utilization of POS data, which contains more information on product characteristics.

Sato, Ota, Ito, and Yano (2020) estimates consumers' preference parameters after a product-harm crisis by using a mixed logit model. That paper demonstrates that social learning on product quality plays a role in purchase after a product-harm crisis. Price does not play a large role in the decision, which is consistent with existing literature such as Zhao, Zhao, and Helsen (2011).

3. THE MODEL

This paper focuses on changes in consumer perception of products' quality. In order to capture the changes, we utilize a discrete choice model for the demand side and estimate preference parameters. We define consumer i's utility from product j in market t as follows:

$$\boldsymbol{u_{ijt} = x_j\beta - \alpha p_{jt} + \xi_{jt} + \epsilon_{ijt}} \tag{1}$$

where ξ_{jt} is an unobserved product characteristic. By using dummy variables, the unobserved characteristics can be decomposed of the following factors: $\xi_{jt} = \xi_j + \xi_t + \Delta\xi_{jt}$ where ξ_j and ξ_t by brand- and market-specific dummies. The error term $\Delta\xi_{jt}$ is a factor that cannot be explained by these dummies. We follow Nevo (2001)'s specification such that the error term is the market-specific deviation from the main valuation, $\Delta\xi_{jt} \equiv \xi_{jt} - \xi_j$. Thus, the utility function should be like as followings:

[1] There are large volumes of economics studies on the Fukushima nuclear disaster. For example, Hanaoka, Shigeoka, and Watanabe (2018) investigate changes in risk preference after the Great East Japan Earthquake.

$$u_{ijt} = x_j\beta - \alpha p_{jt} + \xi_j + \Delta\xi_{jt} + \epsilon_{ijt} \quad (2)$$

The mean utility from product j purchased in market t, δ_j, is defined as $\delta_{jt} = x_j\beta - \alpha p_{jt} + \xi_j + \Delta\xi_{jt}$. This means utility can be treated as an average quality of products that consumers perceived. By assuming that ϵ_{ijt} is *i.i.d.* according to a Type I extreme-value distribution (TIEV), our model (2) is a logit model. Then, the probability that a consumer chooses product j in market t is

$$s_{jt} = \frac{\exp(\delta_{jt})}{1+\sum_{k=1}^{J}\exp(\delta_{kt})} \quad (3)$$

The probability is equal to the market share of product j in market t.

4. DATA AND ESTIMATION

4.1. Data

This paper uses POS data on rice collected by a marketing research firm, KSP-SP[2]. Our data contains JAN (Japanese Article Number) code, which is equivalent to GTIN (Global Trade Item Number), product name, sales, quantity sold, weight of package, and prefecture where the item was sold. The data originally does not contain where the item was produced. However, many items entitle its production place on its product name such as ”Fukushima Koshihikari” and ”Akita Komachi”. Therefore we can identify the production place from the product name.

Figure 1 shows the transition of the average price of each production place. As Mizuta et al. (2016) have already pointed out, the average price of Fukushima rice seems steady during the sample periods. Market share of Fukushima rice in our sample is not high. The highest place of Fukushima’s rice in the market share of each year is 80th (out of 289) in 2009; 70th (out of 401) in 2010 and 136th (out of 553) in 2011.

For the estimation, this paper makes some treatments. First, the study converts the original weekly data to monthly data. Monthly data may capture consumers’ purchasing behavior better because the average consumption per capita in a month is about 5 kilograms, which means one consumer purchases one package of 5 kg rice in a month[3].

Second, the paper focuses on consumers who purchase rice in the Great Tokyo area including Tokyo, Saitama, Chiba, and Kanagawa prefectures. Since these areas are close to Tohoku area, consumers would be more careful with Tohoku products than other consumers who live in western Japan. Our data contains data on Northern Kanto prefectures such as Ibaraki, Tochigi, and Gunma, which are closer to the Tohoku area. This paper, however, excludes these prefectures from the sample because no rice produced in Fukushima

In our data, production places vary over Japan. The purpose of this study is to estimate consumers’ perception of quality of Tohoku rice. Thus, in our model, rice produced in areas except Tohoku is the outside goods. That is, consumers choose rice between areas of Tohoku (Aomori, Akita, Iwate, Miyagi, Yamagata, and Fukushima) or the other rice.

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2 The Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF) publishes daily price changes of several food items on its website based on KSP-SP data.

3 According to the Food Balance Sheet of FY2010 published by the MAFF, the annual consumption per capita was 58.5kg that is 4.875kg per month.

Our sample data spans from October 2009 (week 40) to August 2012 (week 32). There are two reasons to restrict the sample period. Frist, the Fukushima Nuclear Disaster occurred in the second week of March 2011. Thus, our sample period includes March 2011 as its middle month. Second, newly cropped rice is distributed every autumn. It is generally recognized that consumers highly evaluate newly cropped rice. Therefore, in order to track rice cropped in the same season, our sample starts in autumn and ends in summer next year. Thus, our sample periods basically treat rice harvested in 2009, 2010, and 2011.

We define a market as a prefecture-month combination a la´ Nevo (2001). There are 68 markets in our sample. The summary statistics are in Table 1 - Table 4.

4.2. Estimation

We estimate the logit model by following Berry (1994)'s inversion steps. By taking logs on the theoretical market shares (3) with some arrangements, we can obtain:

$$\delta_{jt} = \log \widehat{s_{jt}} - \log \widehat{s_{0t}}$$

where $s\hat{}$ is the observed market share and s_0 is the market share of outside goods: $s_0 \equiv \sum_{j=1}^{J} s_j$. Then, by the definition of δ_{jt}, we obtain the following "logistic regression":

$$\left(\log \widehat{s_{jt}} - \log \widehat{s_{0t}}\right) = x_j \beta - \alpha p_{jt} + \xi_j + \Delta\xi_{jt} \tag{4}$$

By following Nevo (2001), this paper includes brand-specific dummies. Since the brand-specific dummy variable captures the characteristics, which do not vary by market, then our logistic regression (4) becomes:

$$\left(\log \widehat{s_{jt}} - \log \widehat{s_{0t}}\right) = -\alpha p_{jt} + d_j \cdot Dummy + \Delta\xi_{jt} \tag{5}$$

This is our estimation equation.

We estimate equation (5) with IVs because of a possibility of the endogeneity of p_jt and Δξ_jt. As we have mentioned before, the error term, Δξ_jt, is the market-specific deviation from the main valuation. Thus, on the one hand, the average price of other markets would not relate to the error term. On the other hand, it relates with price in market t because of sharing the same production costs, for a example.

By following the idea of Nevo (2001), as an instrumental variable, this paper uses an average price of rice produced in the same production place and sold in the other markets. For example, the IV for Koshihikari produced in Fukushima and sold in Tokyo is the average price of rice produced in Fukushima and sold in the great Tokyo area excluding Tokyo. On the one hand, this IV would relate with the product price because its production place is the same. On the other hand, this IV would not relate with the error term, which shows specific characteristics of the market, because the IV is the average price of other markets.

5. RESULTS

Our estimation shows that α, which measures the effect of price on utility, changes about ten times from $\alpha = -0.0018$ (Std.Err= 0.00049) to $\alpha = -0.0173$ (Std.Err= 0.00046). Both estimates are statistically significant. Mean utility from product j, δ_{jt}, is calculated by $\delta_{jt} =$

$-\hat{\alpha}p_{jt} + \widehat{d_J} \cdot Dummy$. Since consumers purchase rice produced in Tohoku area, the average of the mean utility over products is a general perception of quality of Tohoku products. The average mean utility is 0.0337 before the disaster and it is 0.0230 after that. The paper demonstrates that the mean utility from rice produced in Tohoku area dropped by 31.8% for consumers who purchased the rice in the Greater Tokyo area after the disaster. The drop in mean utility implies the drop in product quality that consumers have perceived, and this could explain the decline in the consumption of rice produced in Fukushima.

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APPENDIXES

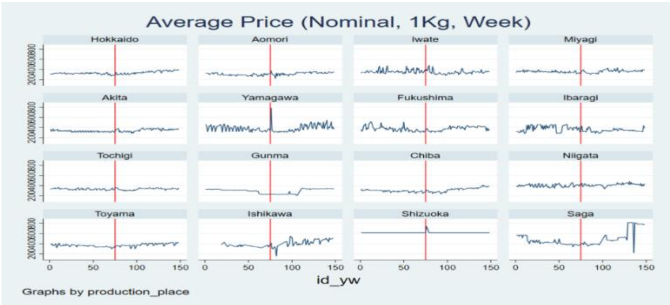

Figure 1. Average Price of Rice Sold

	Before the disaster	After the disaster
Periods	2009/9-2011/2	2011/4-2012/8
Months	17 months	17 months
Production Place	Aomori, Miyagi, Akita, Fukushima	Aomori, Iwate, Miyagi, Akita, Yamagata
Number of markets	68	68
Observations	1,509	1,980
Number of firms	22	28
Number of brands	85	120

Table 1. Descriptive Statistics

	Obs	Mean	Std. Dev.	Min	Max
Before the disaster	1,509	374.88	86.14	125.66	735.64
After the disaster	1,980	404.35	186.68	120.91	2268.91

Table 2. Average Price *(Yen per Kilogram, Deflated by CPI of Rice)*

	Before the disaster	After the disaster
Aomori	87	80
Iwate	0	250
Miyagi	480	562
Akita	656	797
Yamagata	0	291
Fukushima	286	0
Total	**1,509**	**1,980**

Table 3. Number of products purchased over markets by production place

	Before the disaster	After the disaster
Saitama	267	320
Chiba	20	46
Tokyo	563	707
Kanagawa	659	907
Total	**1,509**	**1,980**

Table 4. Number of products purchased over markets by shopping place