Effects of Health Consciousness on Oil Consumption in Japan
— Scanner Panel Data Analysis Using a Dirichlet Model —

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The Japanese edible oil market has changed substantially over the last few decades. In fact, healthy oils such as perilla, linseed (flaxseed), and olive oil are gaining popularity among consumers. Using the Dirichlet model, this study analyzed scanner and survey data to better understand how health consciousness affects oil consumption. The results of the estimation indicate that health-conscious consumers pick healthier oils over unhealthy ones. By contrast, consumers suffering from chronic diseases (high blood pressure and diabetes) reduce their oil intake, while those suffering from cholesterol consume more healthy oils.

Keywords: Japanese oil market, Scanner panel data, Survey data, Dirichlet model, Health consciousness.

1. Introduction

Consumption of vegetable fat and oil in the US increased between 1950 and 1990, while that of animal fat decreased [1]. By contrast, the Japanese diet is, unlike that of Europeans and Americans, heavily dependent on carbohydrates (rice). However, in recent decades, rice consumption per capita has been decreasing, with an increase in the westernization of eating habits [2]. The most significant of the changes in the Japanese diet has been a marked increase in per capita daily fat intake from 21 grams in 1955 to 58 grams in 1992 [3].

Based on a report on vegetable oil products in Japan that covered a five-year period (2012–2016), the edible oil market has grown by 5.6%; its retail value grew from US$ 1,213.3 million to US$ 1,509.3 million. Olive oil has jumped to first place in terms of retail sales value, with a value of US $373.2 million in 2016. Rapeseed oil (also known as canola oil) ranks second with a retail value of US $339.1 in 2016. Sales of rapeseed and soy oil both decreased in the period by 4.4% and 5.1%, respectively [4]. The sharp growth of the share of “other edible oils” suggests that Japanese consumers are seeking new types of oils. Hence, this study aimed to investigate the demand for these oils and attempted to understand how health consciousness affects the demand for each type of oil in the Japanese market.

We hypothesize that one of the reasons for the change that occurred in the Japanese oil market could be the health consciousness of consumers. Japanese consumers are likely becoming more health conscious and therefore seeking healthier alternatives such as perilla, linseed, or olive oil, the latter being one of the most consumed vegetable oils in Japan [5]. Individuals who lead a wellness-oriented lifestyle are concerned with nutrition, fitness, stress, and their environment [6]. In Japan, newspaper articles were used to analyze the relationship between health and oil consumption, the results showed that the increase in the demand for premium oils was due to increased interest in health risks [7]. Because different fats and oils have different saturated fat contents, the consumption of each of these oils may be affected differently by health risk information [8] and based on such information, consumers may assign different levels of healthiness to each product. For example, among the major seed oils, flaxseed oil contains the most (57%) omega-3 fatty acid (α-linolenic acid) [9][10][11].

By contrast, olive oil contains a considerable amount of squalene (a highly unsaturated aliphatic hydrocarbon with important biological properties), which significantly contributes to its health claims [12].

Our objective was to examine how health consciousness affects oil consumption. In other words, which oils do health conscious consumers choose?

2. Data
1) Scanner panel data

This study used scanner data that constituted a source of product-specific information [13]. Data revealed consumers’ preferences, that is, the actual choices of consumers [14].

The data were obtained from Macromille Inc., a Japanese marketing company. These data cover the oil purchase history of 13,262 households for a two-year period (2015 to 2016). After data cleaning, we only kept consumers who were part of the monitoring for the entire period and those who had purchased an oil product at least once during the period.

The market share of each type of oil was calculated using the number of items purchased for each type. According to the data, canola (rapeseed) oil has the highest market share followed by sesame then olive oil (Figure 1).

2) Survey attitudinal data

From the survey data, we selected attitudinal data to be used as variables in the model. These data represent different types of health consciousness among consumers. Moreover, we selected some health problems that may be affected by oil consumption, such as blood pressure and cholesterol. For example, in some small studies and clinical trials, olive oil has been shown to have a lowering effect on blood pressure [15].

Table 1 reports the variables used in the model as well as their descriptive statistics.

We split health consciousness into three different categories by calculating the mean of variables we extracted through Yes (1)/No (0) questions: sports activities (5 questions, e.g., jogging, walking, etc.), healthy lifestyle (7 questions, e.g., check body weight, have enough sleep, etc.), and healthy diet (9 questions, e.g., reduce salt/sugar intake, have a balanced diet, etc.). We used these attitudinal and behavioral variables as proxy variables that capture the health consciousness of consumers. As the food variable reveals a general attitude toward a healthy diet and is not specific to oil consumption, it was to be assumed independent from the oil consumption error.

Finally, the health problems category depicts illnesses that are related to fat consumption. Although health conditions can push consumers to be more health conscious, it is not a definite equivalency. This study therefore assumes that having health problems does not automatically translate to healthy behavior toward food.

3. NBD-Dirichlet model

The NBD-Dirichlet model, which was developed by Goodhardt, Ehrenberg and Chatfield, it describes how frequently branded consumer products such as instant coffee or toothpaste are purchased when the market is stationary and unsegmented [16][17]. This model has mostly been used to analyze brand loyalty among different products from the same category. For example, the beer...
market in Italy [18] and laundry detergent in France [19].

Other studies have used the NBD-Dirichlet model to examine store choice rather than brand choice. Two particularly powerful and well-known models of consumer behavior, the NBD and Dirichlet models, may usefully and successfully be transferred from their original context of brand purchasing to the analysis of purchasing patterns at individual stores in a single city [20][21][22][23].

In this study however, the Dirichlet model was used not to assess brand or store choice, but to assess the choice of type of oil (canola, olive, linseed, etc.) in the Japanese edible oil market.

The consumption of oil has a Nagative Binomial Distribution (NBD) while the choice of “type of oil” has a Dirichlet Multinomial Distribution (DMD). Both the NBD and DMD use count data as the dependent variable, which in our case is the number of items purchased.

Equation (1) is the NBD, which has two parameters that are both positive: the shape parameter $\gamma$ and the scale parameter $\beta$,

$$f_{\gamma, \beta}(k) = \frac{\Gamma(\gamma + k)}{\Gamma(\gamma) k! (1+\beta)^{\gamma+k}}$$

where $k$ is the number of items purchased and $\Gamma(\cdot)$ is the Gamma function.

NBD is used to calculate the expectation as in equation (2) of the number of items $k$ purchased.

$$E(k) = \beta \gamma$$

The DMD Model assumes that purchases of each type of oil are conditional on the category purchase rate. As shown in equation (3), the Dirichlet multinomial distribution has $h$ parameters, one for each type of oil. These are $\alpha_1, \alpha_2, ..., \alpha_h$, where each is positive.

$$f_{\alpha_1, \alpha_2, ..., \alpha_h}(r_1, r_2, ..., r_h|k) = \frac{\Gamma(\sum \alpha_j) k!}{\Gamma(\sum \alpha_j + k)} \prod_{j=1}^{h} \frac{\Gamma(\alpha_j + r_j)}{r_j \Gamma(\alpha_j)}$$

where $r_j$ is the number of items purchased of oil type $j$.

We are interested in the effect of the consumers’ characteristics (age, household size, etc.) as well as health consciousness on the choice of oil. In the Dirichlet model, consumers’ characteristics are introduced as covariates. The parameters of the Dirichlet model become functions of the covariates. The introduction of consumer characteristics as covariates in the Dirichlet model has been discussed at length in [23][19].

To introduce consumer characteristics, the parameters of the two models, NBD and DMD are respectively transformed as follows:

$$E(k_i|x_i) = \gamma \beta = e^{\delta^t x_i}$$

$$\alpha_j(x_i) = e^{\theta_j x_i}$$

where $x_i$ is a vector of consumer $i$’s characteristics, $\delta$ is a vector of the model’s parameter for the category (total of the edible oils) and $\theta_j$ is a vector of the model parameters for $j=1...h$.

4. Results

The estimation results in Table 2 show both the negative binomial model results (the first column) as well as the Dirichlet multinomial results. The independent variables were split into three groups: demographic characteristics (age, household income, household size), psychographic variables pertaining to health consciousness (sport, lifestyle, food), and chronic diseases (diabetes, blood pressure, cholesterol).

Edible oil consumption in Japan is positively affected by age and household size. However, the health consciousness psychographic variables were found to have affected oil consumption differently. While consumers who practice sports purchase less oil, those who lead a healthy lifestyle and those who are healthy purchase more oil. This could mean that those who practice sports reduce their oil intake while the others consume more healthy oils, which resulted in the increase in the total consumption of oil.

Finally, in the health status section, high cholesterol seems to have an effect on oil consumption. In fact, consumers suffering from the disease buy fewer oil products than those who do not suffer from it.

The results of the Dirichlet Multinomial model are documented from the third column onward in Table 2. The coefficients listed in this section affect the probability of purchase ($P_j$) for each type of oil $j$ by individual $i$ as
follows [17]:

\[ P(y_i) = \frac{\alpha_j(x_i)}{\sum_{m=1}^{n} \alpha_m(x_i)} = \frac{e^{\theta_j x_i}}{\sum_{m=1}^{n} e^{\theta_m x_i}} \quad (6) \]

Unlike the results for total oil consumption (NBD model), age and household size seem to have an opposite effect on each other in the DMD model. In fact, whenever the age coefficient is positive the coefficient of household size is negative. Household income negatively affected the purchase of canola oil but positively affected the purchase of coconut, linseed, and perilla oil, which are all known to be healthy oils as well as having higher prices than canola oil. This suggests that households with high incomes would reduce their consumption of canola oil but increase their consumption of healthy oils such as linseed (flaxseed) or perilla oil.

The psychographic variables corroborate previous research findings on the benefits of coconut [24][25][26], linseed [27][28], perilla [29][30], and rice bran oil [31]. Indeed, health conscious consumers have a higher purchase rate of coconut oil while having the lowest consumption of rice bran oil. On the other hand, consumers in the second group (lifestyle) have the highest purchase rate of rapeseed oil. The third group of consumers (food) have the highest consumption of rice bran oil.

Finally, the last section of the results in Table 2 illustrates how health problems affect the choice of type of oil. While consumers who suffer from diabetes predominantly have a lower consumption of all the types of oil, even those oils viewed as healthy, there is still a difference among the coefficients. Indeed, sesame oil has a higher purchase rate among these consumers, followed by olive oil. By contrast, those who suffer from high blood pressure and cholesterol have a high purchase rate of the healthy oils. Consumers suffering from high blood pressure have the highest purchase rate of perilla seed oil while those who have high cholesterol have the highest purchase rate of coconut oil.

5. Conclusion

The objective of this study was to investigate the effect of health consciousness on the choice of oil among Japanese consumers.

Although oil consumption has increased in Japan, the growth was not observed for every type of oil. In fact, the
consumption of canola oil decreased during the period while consumption of healthy oils, such as olive oil, has increased.

The estimation results indicate that health-conscious consumers would generally purchase healthy oils (i.e., olive, linseed, etc.). However, not all categories of health-conscious consumers choose the same oil. In fact, depending on how they are classified, either as health-conscious (practicing sports, leading a healthy lifestyle, or following a healthy diet) or not, their top choice of oil was different.

The effect of health status on consumption also differed depending on the presence chronic disease. While diabetic consumers have a lower purchase rate for all oil types, consumers suffering from cholesterol and hypertension have a higher consumption of healthy oils than those who are not suffering from these diseases. Another interesting result was that consumers suffering from high levels of cholesterol have the highest consumption of coconut oil. Although coconut oil has been proven to be healthier than other oils, it could increase cholesterol levels. This result shows that consumers are not very knowledgeable about the specific health effects of oils and rather have a general idea about whether an oil is healthy.

The results of this study were obtained by analyzing scanner data of a two-year period. Future research analyzing a larger database (more than two years) would shed more light on this subject. Moreover, this study only conducted an empirical analysis; as a future task, a theoretical model should be built to describe the relationship between health consciousness and oil consumption in Japan. Finally, although we assumed that the oil consumption error is independent from the health consciousness variables, the endogeneity problem must not be ignored and remains one of the tasks that needs to be solved in the future.

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