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Consumer Preference on Traceable Information of Dairy Products

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Abstract: Diary industry in China has been in deep crisis since a series of quality scandals were exposed to public in 2008. Thanks to the traceability system in dairy supply chain and the growth of the internet, providing traceable dairy product information to the public is viewed as one of the best ways, mostly in terms of feasibility, to overcome the trust crisis and to promote the development of the dairy industry in China. However, among the tons of information available from the supply chain, there is a lack of knowledge on consumer preference. Based on choice-based conjoint analysis, this paper investigated consumer preference on dairy product traceable information query service. Specifically, this paper measured the value that consumers place on the dairy product traceable information. We used a multinomial logit model to estimate the preferences and offered 3 ways to explain the value of each kind of information that consumers are concerned about. Results indicate that different consumer groups hold different preferences.

Keywords: dairy product traceable information, choice-based conjoint analysis, multinomial logit model

1. INTRODUCTION

With the improvement of national living standards, consumers in China pay more and more attention to the quality and safety of food. But unfortunately, the food quality and safety issues have been exposed frequently since twenty-first century, especially about dairy products. Which has thrown the entire dairy industry of China into a serious consumer trust crisis since year 2008 [1]. In order to rebuild the reputation of the dairy industry, making quality and safety information of dairy product open to the public is taken as the prescription to address the concerns from public at large.

The internet of things technology has been researched and applied in many fields internationally for last two decades. The development of internet of things technology brings hope to solve the quality and safety issue of dairy products. The application of internet of things technology in the quality and safety management process of dairy industry, namely, the traceability system of dairy products. This system can effectively control the loopholes in the operation process of dairy industry, and effectively improve the quality and safety of dairy products by recording all information about dairy product [2] [3]. In China, more and more dairy companies began to build their traceability system, with which the entire supply chain information can be accurately recorded in real time.

Diary product information traceability effectively reduces the information asymmetry between the dairy industry and consumers. And thus will eventually relieve the trust crisis in dairy industry in China [1]. However, there are too much information available in the traceability system (about 33 kinds of information in dairy product traceability system). If dairy industry releases all information to consumers, no matter whether they understand or value, they can be easily overloaded and will not be able to process and evaluate the quality information [4]. Thus, the dairy industry should provide the appropriate kinds of information for consumers. Then the key problem is how much, and what kinds of, traceable information are valuable in consumers' perception and thus should be included.

In this paper, based on choice-based conjoint analysis method and a multinomial logit model, we quantitatively measured the value of traceable information in consumers' perception by investigating their preference for dairy product traceable information query service. The result provides a guide for the dairy

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industry about how to provide dairy products traceable information query service more effectively.

2. LITERATURE REVIEW

Food traceability system allows the consumers or governments to trace the origins or ingredients of food products [5]. In almost all developed countries, traceability system in the food supply chain is becoming mandatory [6]. With the development of traceability system, there are a lot of papers about traceability system. There are two main research directions about traceability system.

One is about the design and implementation of the system. Zhou L. et al. (2010) discussed the design and implementation of traceability management system for pigs [7]. Thompson et al. (2005) discussed the current trends, system design, and potential applications of seafood traceability system in the United States [8]. Sahin, E. et al. (2002) provided a framework for identifying principles and functionalities of a traceability system in the context of a global supply chain [9]. B Mao et al. (2016) proposed a 3D model-based food traceability system [10]. The other is about the impact of the system. Van Amstel et al. (2008) found the traceability system can reduce consumers' information asymmetries and associated information costs [11]. Ortega et al. (2011) and Ubilava and Foster (2009) found the system can increase product trust and purchase intentions [12] [13]. Young Chan Choe et al. (2009) discussed the effect of the food traceability system for building trust [14].

In order to reduce consumers' information asymmetries and increase the trust of consumers, dairy companies should provide the traceable information for consumers. With the traceability system of dairy products built, there are too much traceable information of dairy product. If the company let consumers know all the information, it would cause consumer information overload [4]. So, it is especially important to investigate consumers' preference for traceable information of dairy products.

There are so many studies about the preference of consumer for the information of dairy products. Kai-Brit Bechtold et al. (2014) employed a discrete choice experiment to examine preferences for functional dairy product attributes and willingness-to-pay estimates for consumers in Germany [15]. Teruaki (2010) analyzed consumers' attitudes toward traceability system of dairy products in China [16]. Mustafa Morta (2012) review the consumption preferences of milk and dairy products of undergraduate students [17]. Most of these studies focused on the features of dairy products, for example the total fat, the content of protein and other nutrition facts. However, there is few study about the consumers' preference for traceable information of dairy products. Under this situation, this paper sheds light on this theme. The findings of this paper will also guide the dairy industry to provide dairy products traceable information query service which can greatly promote the development of dairy industry.

3. RESEARCH METHODOLOGY AND MODEL DEVELOPMENT

3.1 Conjoint analysis method

Conjoint analysis method is a multivariate statistical analysis method. In 1964, Luce, a mathematical psychologist, and Tukey, a statistician, invented this method. It was applied in the marketing area by Green and Rao firstly. The conjoint analysis method mainly divided into the following several main methods: card-sort conjoint analysis, adaptive conjoint analysis, choice-based conjoint analysis (also known as discrete choice model) and menu-based choice.

The main idea of conjoint analysis is to evaluate the utility of a complex product or service by adding up strength of its attributes [18]. The utility of a product or a service here reflects consumer's psychological judgment, usually the preference. The attributes, which compose or describe the product or service, are usually the most important features to the consumers. In other words, a specific profile is made up of multiple attributes each of different number of levels [19]. Every question (or named as choice set) on the questionnaire is composed of multiple profiles, usually of the same attributes but may be at different levels. A questionnaire contains multiple

such questions. In choice-based conjoint study, each consumer needs to choose one profile from each question, By analyzing consumers' choices, researchers will be able to understand which profile is of most preference, and which attribute contributes most to such preference. Such choice-based conjoint analysis is viewed as a more scientific method to study consumer's preference since it mimics the process of how consumers making choices which is testable and endorsed by psychological theory [20].

3.2 A primary study

The research was carried out with following steps.

(1) Identify and clear up the existing kinds of information within the traceability system of dairy products.

With the assistance of a widely-known dairy enterprise and a traceability system company, a pilot investigation was conducted and relative material was obtained. According to the investigation results, with the assistance of 1 general manager from dairy enterprise and 2 project managers from traceability system company, 33 kinds of available information item from the traceability system of dairy products were identified and summarized, evenly distributed in the 4 business stages of dairy product supply chain. These items are all listed in Table 1. However, as we indicated above, it is unrealistic to display all these information to consumers to trace the quality of a diary product, because some of these items are not their concerns. Besides, if we are to investigate which information is most important in strengthening the utility (thus the confidence of the quality here) and to what extent, consumers will be cognitively overloaded if all these items are included in study. Thus we need to size down the information to be included in the study by conducting in-depth interviews, which is the second step in our study.

Table 1. Dairy products traceable information table

Stage	Items
Raw milk purchase stage	The information of pasture, the information of cow, the operation information, time information, quantity information, the information of milk station, quality information(test when purchase), storage information
Raw milk transport stage	The information of milk vehicle, the information of transporter, quantity information, milk vehicle environmental information, time information, quality information(test when transport), transport track information of raw milk
Dairy products process stage	Processing factory information, the information of relative staffs, quality information of raw milk(test before process), quantity information, time information, storage information, type of dairy product, production technical process, the information of additives, quality control standards, quality information of dairy product(test after process), the information of samples, production batch
Dairy products sales stage	Transport information of dairy product, storage information, dairy product information, the sales flow information of dairy product, dairy product current condition

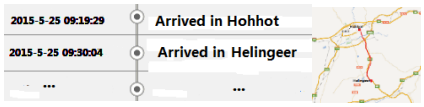
(2) Qualitative research on dairy products traceable information items that consumers care most, using the in-depth interview methodology.

One-on-one interview was conducted among consumers. For the purpose of generally reflecting the whole dairy products supply chain, the attributes to be selected are supposed to distribute within the four business stages within the dairy products supply chain. Interviewees are 25 randomly-chosen consumers of dairy products in a local supermarket, including 12 students, 1 teacher, 1 dairy industry expert and other 11 people of other occupations (9 females and 16 males). Specifically, each interviewee chose their most concerned information. Then, we can count how many interviewee concerning each information. Accordingly, the most concerned dairy product traceable information are selected.

(3) Select final research attributes, by consulting experts.

Based on thorough consideration and discussion, we re-organized the dairy products traceable information according to the consumers' concern rank from the interviewees and their preference for information in different stages. We combined the information of pasture and the time information of raw milk purchase stage as the basic information of raw milk. Finally, we selected six different attributes, including the basic information of raw milk, the quality information of raw milk, the transport track information of raw milk, the quality information of dairy product, the sales flow information of dairy product and the dairy product information. Each attribute has two levels (show, not show). These attributes and its explanation are all listed in Table 2.

Table 2. Six dairy products traceable information and its explanation table

Items	Content	Example
The basic information of raw milk	The ID of the pasture, the name of the pasture, phone number, address, the number of cow in this pasture, the number of milk yield from this pasture daily, the time of purchasing the raw milk, the time of producing the raw milk	ID: No.1 The name of the pasture: Hulun Buir pasture Phone: 0470-12345678 The number of cow: 1000 The number of milk yield daily: 10 tons The time of purchasing the raw milk 2017-1-1 14:00 The time of producing the raw milk 2017-1-1 10:00
The quality information of raw milk(test when purchase)	The sensory index (color and smell), physicochemical index (fat content, protein content, non-fat milk solids, lactose, vitamin), microbial indicators (total bacteria, coliform bacteria etc.), pollutant index (feed residue content, antibiotics, mercury, arsenic, preservatives, melamine etc.), the index of mycotoxins (aflatoxin etc.)	
The transport track information of raw milk	The time and path information of raw milk (from the pasture to the milk station)	
The quality information of dairy product(test after process)	The sensory index (color and smell), physicochemical index (fat content, protein content, non-fat milk solids, lactose, vitamin), microbial indicators (total bacteria, coliform bacteria etc.), pollutant index (feed residue content, antibiotics, mercury, arsenic, preservatives, melamine etc.), the index of mycotoxins (aflatoxin etc.)	
The sales flow information of dairy product	The information about all distributors and retail trader that this dairy product passed	Factory 1 (2017-1-2) → Distributor 1 of Northeast of China (2017-1-4) → Distributor 2 of Liaoning province (2017-1-6) → Supermarket 1 in Shenyang (2017-1-7)
The dairy product information	Specification, price, production date, guarantee date, product security code	Price: ¥5 Production date: 2017-1-2 product security code:12345678 Guarantee date: 2018-1-2

3.3 Model specification

Assuming that consumer i evaluates dairy products traceable information query service j. According to Kenneth Train [21], the utility of service j to consumer i (U_{ij}) can not be directly observed, and can be expressed as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (3\text{-}1)$$

Where ε_{ij} expresses the randomness in consumer's preference for service j, and V_{ij} is the deterministic part of utility that can be measured by a function of attribute strength. We use dummy variables $X_1, X_2, \dots, X_6$ to represent the six items of dairy product traceable information (attributes we selected) being included or not. So the V_{ij} can be expressed as:

$$V_{ij} = V\ (X_1, X_2, \dots, X_6) \quad (3\text{-}2)$$

Where V is a function of the dummy variables. According to the hypothesis of conjoint analysis, a consumer makes his decision by maximizing his perceived utility. So, the probability that consumer i chooses service j from a choice set of services (C), $P_i(j|C)$ can be expressed as:

$$\begin{aligned} P_i(j|C) &= P(U_{ij} > U_{it}, \forall t \in C \,\&\, t \neq j) \\ &= P(\varepsilon_{it} - \varepsilon_{ij} < V_{ij} - V_{it}, \forall t \in C \,\&\, t \neq j) \end{aligned} \quad (3\text{-}3)$$

By assuming each ε independently follows Gumbel distribution (type I distribution), we can further develop the probability in (3-3) into (3-4). (See D.J. Street and L. Burgess [22] for more details).

$$P_i(j|C) = \frac{\exp(V_{ij})}{\sum_{t=1}^{n} \exp(V_{it})} \quad (3\text{-}4)$$

Where n is the number of services in the choice set C.

It is common to apply the additive model to explain the deterministic part of the utility. If we do not consider the interaction effect between traceable information (attributes), V_{ij} can be expressed as:

$$V_{ij} = \beta_{1i}X_{1j} + \beta_{2i}X_{2j} \dots + \beta_{6i}X_{6j} \quad (3\text{-}5)$$

Where X_{1j} to X_{6j} are dummy variables, representing whether an information item is included in service j or not (X = 1 if included) respectively. Coefficients β_{1i} to β_{6i} represent the main effect of traceable information item (attribute) that a consumer perceives respectively. In other words, these coefficients indicate the preference weight of each traceable information item. Then, by combining (3-4) and (3-5) we can get our multinomial logit model as in (3-6) which can be employed to analyze consumers preferences.

$$P_i(j|C) = \frac{\exp(\beta_{1i}X_{1j} + \beta_{2i}X_{2j} \dots + \beta_{6i}X_{6j})}{\sum_{t=1}^{n} \exp(\beta_{1i}X_{1t} + \beta_{2i}X_{2t} \dots + \beta_{6i}X_{6t})} \quad (3\text{-}6)$$

This paper is intended to investigate the consumer's preference for information on the supply chain of the dairy industry, that is, to identify the most valuable information to consumers. There are 3 ways to explain the value of information.

1. Increase or decrease in utility. The estimate of a parameter β tells us how much utility change when the service include a specific information item. This is the most simple and direct explanation. Consumer prefer to the information that can increase more utility. However, utility is a relative value, its absolute value is hard to understand.

2. Increase or decrease in the probability of selection. According to (3-6), including a certain information item will have an impact on the probability of this service being selected. Under the same condition, showing the information item i compared to not showing, the probability of this service being selected will increase by $(\exp(\beta_i) - 1)$ times. Similar to the first explanation, a preferred information can increase more probability.

3. The degree of concern. Let $B_i = (\exp(\beta_i) - 1), i = 1, \dots, 6$. Then we can define F_i as the degree of concern that consumers bear to information i as:

$$F_i = \frac{B_i}{\sum_{t=1}^{6} B_t} \quad (3\text{-}7)$$

F is a percentage, which represents the relative value of each kind of information for consumer. A larger F value indicates a more important item.

4. EXPERIMENT DESIGN AND IMPLEMENTATION

We use questionnaires to collect information from dairy product consumers. The questionnaire includes three parts.

Part 1: Introduction of dairy product traceable information. This part introduces the meaning of six traceable information items to the respondents, and for each of these item we give an example to help the respondents understand.

Part 2: This is the core part in our questionnaire. This part includes some questions, each a choice-sets, asking respondents to choose one service that he or she prefers to. The choice-sets consist of different dairy product traceable information query services each composed of different dairy product traceable information items.

Part 3: This part is to collect the demographic information of respondents, including age, gender, level of education, whether has child, monthly income and monthly frequency of purchasing dairy product.

In order to reduce the cognitive burden of the respondents, and to improve the feasibility of the experiment, and to retain the validity of the experiment, we used Sawtooth Software SSI Web (Sawtooth Software, Inc., Sequim, WA) to design the experiment. Without loss of the validity of the experiment, we compared different experiment designs by Sawtooth Software SSI Web using different seeds. Since there are 6 potential information items to consider, we keep the choice set size relatively small so that each question only compares two services, which is also the most commonly used choice set size. Then we used Sawtooth Software SSI Web to create a fractional-factorial design to divide 80 choice-sets into 10 different versions (8 choice-sets per version), and each choice-set includes 2 alternatives (each alternative is described by 6 attributes). We deliberately make sure that there is not NONE option in the design since it will never be preferred to. The reason that we divided all 80 choice-sets into 10 versions is because we need to make sure that respondents are not cognitively fatigued or overloaded. Each respondent will see a random version of questionnaire, and she only need to finish one version. A pilot experiment with 20 consumers was run to ensure the descriptions in part 1 and part 2 are clear, and on average it took 10-20 minutes to finish all questions. Figure 1 shows a choice-set example of our questionnaire of version 1.

Version 1

Part 2

Please imagine that you are buying dairy products. In order to better understand each dairy products, you use the mobile app scanning of the QR code on the package of dairy products, the app will provide 6 different traceability information.

1、if these were your only options, which service would you choose?

Traceability information	Service 1	Service 2
The quality information of raw milk	Not show	Show
The basic information of raw milk	Show	Not show
The transport track information of raw milk	Show	Not show
The quality information of dairy product	Show	Not show
The sales flow information of dairy product	Show	Not show
The dairy product information	Not show	Show
I would choose	□	□

Figure 1. An example of choice-set

We conducted experiments both online and offline in order to enlarge our sample size and to cross validate.

Online experiment: We distributed questionnaires to dairy product consumers on the internet by SOJUMP (http://www.sojump.com/). In order to ensure the quality of responses, each respondents will have a chance to win a gift after the experiment if we believe her answer is consistent (technically we check whether they chose the same service for question 2 and 7).

Offline experiment: In this study, 4 assistants were sent to Carrefour Supermarket (40 West Dazhi Street, Nan Gang District, Harbin) to distribute paper-based questionnaires. They randomly chose consumers who will enter or leave the supermarket to finish the questionnaire. In order to ensure all 10 versions of the questionnaire have about even number of respondents, they disordered the questionnaires and gave a random one to the respondent to fill out. As an incentive, each respondent will receive a bottle of milk as return.

5. EMPIRICAL ANALYSIS

5.1 Data description

Of 230 respondents who participated our offline experiment, 219 (95%) completed the questionnaire. We obtained 137(53%) valid questionnaires from offline. Of 169 respondents who participated our online experiment, 123(72%) completed the questionnaire and passed the consistency check. So we obtain 260(65%) valid questionnaires in all at last. Table 3 shows the demographic information of those 260 respondents.

As in Table 3, 26 respondents' monthly frequency of purchasing dairy product is less than or equal to 1, so we do not consider them as regular dairy products consumers, and their questionnaires are eliminated from our study. Finally, this study had 234 (59%) questionnaires for data processing and analysis.

Table 3. The demographic information table

Gender	male	131	Level of education	College graduated and below	63
	female	129		Bachelor and above	197
Age	≤30	145	Monthly frequency	≤ 1	26
	30-40	79	of purchasing dairy	2-6	165
	≥40	36	product	≥7	69
Whether	One or more child	120	Monthly salary	≤ 3000	126
has child	No child	140		>3000	134

5.2 Results

5.2.1 For all consumers

With the multinomial logit model introduced in Section 3.3, we analyzed the choices of all 234 respondents by SAS 9.3. The parameter estimates are shown in Table 4.

For all 6 coefficients, the p values are less than 0.0001, which indicates a significant difference between the two levels (show, not show) of all information items. Since the estimates of β's are larger than 0, each kind of traceable information item has positive main effect to consumer's perceived utility of a service. This is in accordance with our common sense.

For all respondents, the most valuable traceable information item is the basic information of raw milk, which accounts for 22.78% of consumers' concern. Compared to a service without this information item, a service with this information is more likely being selected by consumers (the probability being selected will be increased by 0.82 times, almost double). The quality information of raw milk and dairy product are also among top concerns to consumers (accounting for 18.24% and 21.66% of consumers' concern). The quality information of raw milk will cause the probability of service being selected increasing by 0.66 times. The quality information of dairy product will increase the probability of service being selected by 0.78 times. Dairy product information, the sales flow information of dairy product and the transport track information of raw milk are also helpful and useful, but not that much comparing to other three items.

Table 4. Analysis results of all respondents table

Attribute name	β	P value	B_i	F_i	Rank
The quality information of raw milk	0.50655	<.0001	0.659556	18.24%	3
The basic information of raw milk	0.60094	<.0001	0.823832	22.78%	1
The transport track information of raw milk	0.30317	<.0001	0.354145	9.79%	6
The quality information of dairy product	0.57856	<.0001	0.783468	21.66%	2
The sales flow information of dairy product	0.36492	<.0001	0.440399	12.18%	5
The dairy product information	0.44156	<.0001	0.555131	15.35%	4

From what has been discussed above, we can draw some conclusions about consumers' preference.

1. For all consumers, the most valuable traceable information is the basic information of raw milk, followed by the quality information of dairy product, the quality information of raw milk, the dairy product information, the sales flow information of dairy product, the transport track information of raw milk.

2. There is a little difference between the value of the basic information of raw milk and the quality information of dairy product. However, the gap among other traceable information' value is obvious, it is about 3% (measured by the degree of consumers' concern).

5.2.2 Gender matters

We further studied the preference of 112 male respondents and 122 female respondents to investigate the role of gender in determining consumer's preference. Table 5 and 6 show the multinomial logit parameter estimates calculated by SAS 9.3 respectively.

Table 5. Analysis results of male respondents table

Attribute name	β	P value	B_i	F_i	Rank
The quality information of raw milk	0.41456	<.0001	0.513705	13.66%	5
The basic information of raw milk	0.69169	<.0001	0.997088	26.51%	1
The transport track information of raw milk	0.32810	<.0001	0.388328	10.32%	6
The quality information of dairy product	0.54284	<.0001	0.720887	19.17%	2
The sales flow information of dairy product	0.42533	<.0001	0.530095	14.09%	4
The dairy product information	0.47706	<.0001	0.61133	16.25%	3

Table 6. Analysis results of female respondents table

Attribute name	β	P value	B_i	F_i	Rank
The quality information of raw milk	0.59012	<.0001	0.804205	22.62%	2
The basic information of raw milk	0.52362	<.0001	0.688128	19.35%	3
The transport track information of raw milk	0.28409	0.0001	0.328552	9.24%	6
The quality information of dairy product	0.61583	<.0001	0.851192	23.94%	1
The sales flow information of dairy product	0.31621	<.0001	0.371918	10.46%	5
The dairy product information	0.41306	<.0001	0.511436	14.39%	4

For both models, all estimates have p value less than 0.01, suggesting a significant difference between the two levels (show, not show) of all attributes. Since the estimates of β's are larger than 0, each kind of traceable information item has positive effect for both male and female consumer. However, a closer look at the results, we can see there are some subtle difference between genders.

We can draw the conclusions about male and female consumers' preference from table 5 and 6.

1. The male consumers have more clear focus. Specifically, the probability of service being selected can be doubled once the basic information of raw milk is shown to them, which is most valuable, and all other information are only moderately important. While For female consumers, they care about the qualities most, both for raw milk and the diary product.

2. For both male and female consumers, the transport track information and the sales flow information are of their least interest comparing to other information items. But having it in the service is still better than not having it.

6. CONCLUSION

In this study, we used choice-based conjoint analysis method to investigate the preference of consumers for the dairy products traceable information query service, to find out what are the most valuable traceable information for consumers. Firstly, we selected six attributes (each has two levels) through 3 steps. Secondly, we developed the multinomial logit model according to the study of Kenneth Train [21]. Thirdly, we used Sawtooth Software SSI Web to design our experiment, and then we conducted the experiment both online and offline. Finally, we analyzed our experiment data. We find that different consumer groups hold different preference for traceable information. For all consumers, the most valuable traceable information is the basic information of raw milk, followed by the quality information of dairy product, the quality information of raw milk, the dairy product information, the sales flow information of dairy product, the transport track information of raw milk. For male consumers, the most valuable traceable information is the basic information of raw milk, followed by the quality information of dairy product, the dairy product information, the sales flow information of dairy product, the quality information of raw milk, the transport track information of raw milk. For female consumers, the most valuable traceable information is the quality information of dairy product, followed by the quality information of raw milk, the basic information of raw milk, the dairy product information, the sales flow information of dairy product, the transport track information of raw milk. In short, the male consumers have more clear focus. While For female consumers, they care about the qualities most, both for raw milk and the diary product.

Different form the existing studies about the consumers' preference for dairy product, we focus on the traceable information of dairy products rather than the features. And we find different consumer groups hold different preferences. The results of this study can guide the dairy industry to provide dairy products traceable information query service which can greatly promote the consumers' supervision of dairy products industry. That will reduce consumers' information asymmetries [11] and positively change the consumers' trust crisis [14] to dairy industry in China, and promote the development of dairy industry.

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