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How do consumers determine the safety of milk in Beijing, China?

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ABSTRACT

In asymmetric information markets, consumers often rely on certain extrinsic indictors to assess the safety of food products. This study analyzes how consumers in Beijing determined milk safety when they purchased liquid milk using survey data conducted just before the *melamine*-contaminated infant formula event was disclosed. The key finding indicates that milk brand and purchase venue, on average, were ranked as the first two important safety indicators in fluid milk purchases, suggesting that China's milk safety regulators should put more monitoring resources toward supervising the safety of milk produced from branded firms and milk sold in ostensibly trustable stores and not allow exemptions to inspections. Meanwhile, the findings of this study indicate that the existing milk safety certification system in China might be significantly inefficient, suggesting potential waste of regulatory resources.

1. Introduction

The 2008 China melamine milk incident raised important concerns about how to improve food safety in China and how to improve consumer trust in observable factors that indicate safety of food products. Because information on food safety often is imperfect, using traditional intrinsic attributes, such as smelling and tasting, often fail in consumer assessment of safety. Consequently, they have to rely on certain extrinsic indicators such as venue, brand and company names or safety-related certifications to determine the safety of the products they purchase. These indicators are often not integrated into the physical product in nature but attached by producers, processors, retailers, or safety supervisors during food production and supply processes. However, the use of extrinsic indicators depends heavily on the extent to which consumers trust such signals to be indicative of safety, which in turn depends on the credibility behind that indicator.

In the milk safety scandal in China, consumers choosing milk products based on certain safety indicative factors were still largely exposed to milk that was not within China's safety guidelines.[2] Thus, understanding how consumers use these factors to assess safety is important for policymakers to establish policies that match the way consumers shop for food. For example, if consumers are relying on brand names to determine safety, then policies should ensure that brand names, and the claims the brands make to win over consumers, are indeed true. Without such policies, the market can suffer from adverse outcomes due to asymmetric information—producers know the true nature of the product, while consumers rely only on the claims made by

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[2] Some brand names were not implicated in the scandal and are currently enjoying far greater commercial success than their rivals that were implicated, although sales of all milk companies have suffered from the scandal.

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producers. Asymmetric information, when not checked by policies to resolve the information asymmetries, gives producers incentives to invest in brand promotion at the expense of investing in actual processes that ensure safety and quality (McCluskey, 2000).

In this paper, we analyze how consumers determine the safety of milk products and how these determinants vary with economic and demographic variables. The analysis uses a unique data set from a survey conducted in Beijing by the Center for Chinese Agricultural Policy the year before the 2008 milk safety incident. In the survey, respondents were asked to rank the importance of five factors in determining fluid milk safety from the factor they rely on the most to the one they rely on the least. These factors, including purchase venue, certification, milk brand, price, and appearance, were selected by informal focus groups, discussion with professional colleagues, and conducting pretests. More details about factor selection are given in the data description section.

We find that consumers tended to use brand names and purchase venue to determine milk safety and discount the assurances provided by government safety certification programs. Moreover, economic growth, as well as demographic and employment trends, will increase the extent to which consumers use brand and venue to determine milk safety in the future. These findings indicate that policy to insure the integrity of claims made by brands and venues will be more successful at preventing food safety incidents in the future than investments into government certification programs. Although the current study is geographically limited to Beijing, one of the most developed cities in China, our findings from this study will contribute to understanding consumers' preferences for milk safety-related indicators and associated implications on China's food policies because of Beijing's special role as the nation's capital in setting examples for the rest of the country.

2. Dairy economy and food safety

Prior to the 2008 milk safety incident, the consumption of milk and other dairy products in China was booming (Beghin, 2006; Dong, 2006; Fuller, Huang, Ma, & Rozelle, 2006; Bai & Wahl, 2008). Driven by strong income growth, the emergence of a modern dairy sector, and modern retail facilities, particularly in urban areas, per capita milk consumption grew from less than 5 kg to over 20 kg, between 1990 and 2006, and this growth was largely concentrated in urban areas (Bai, Wahl, & McCluskey, 2008). Several national dairy companies emerged to meet the strong demand growth for fluid milk and other dairy products (Wang, Mao, & Gale, 2008). These companies not only developed national brand names, but also imported foreign processing technology and, in some cases, set up joint ventures with international dairy companies. Rising dairy consumption came in tandem with the establishment of supermarkets and other modern food retailers in urban China by both domestic and foreign retailing companies.

Periodic food safety incidents, in dairy and other products, resulted in the government establishing a myriad of safety certification programs over this period as well (Calvin, Gale, Hu, & Lohmar, 2006).[3] To provide greater safety assurances to consumers, the government established safety standards, a number of certification programs, and ramped up inspections and testing. Independent dairy companies also adopted safety programs, particularly the international Hazard Analysis and Critical Control Point (HACCP) practices for domestic milk production (Wang et al., 2008). To reduce the burden and costs of monitoring standards, the government established an "Inspection Exemption" certification program in 2000. Under this policy, any company, including dairy and milk processing companies, could be certified with inspection exemption status if they passed quality and safety inspection three consecutive times, had a large market share, and implemented standards above the national standards. The policy implicitly assumed that the stake large processing companies have in maintaining their reputation provided sufficient incentives for them to establish quality and safety assurances without strict government oversight.

Despite China's seemingly modern dairy sector with well-established brands sold at well-established supermarkets and certified by numerous government safety programs, China's milk supply was not as safe as it appeared. In August, 2008, government officials announced that the industrial chemical melamine had been detected in the milk supply after some illnesses were connected to milk consumption. Eventually the scandal affected an estimated 60,000 people including over 1000 hospitalizations and six infant deaths. The incident was not isolated to a few small milk producers; indeed, most of the 22 milk companies found to have melamine tainted milk were large firms with well-known brands, and almost all of the milk products were certified with one or more quality and safety certifications. Milk safety problem is not unique to China. Across the whole world, there have been countless milk safety incidents involving more than a few famous and well-recognized brand names, including milk brands from developed countries. However, as several milk incidents in recent years often involved severe diseases or even deaths and infant victims, milk safety in China has been at the center of global criticism. As a result, these milk incidents had wide-ranging implications not only in China's domestic dairy industry, but also for China's growing food export industry as multiple export markets established strict inspection regimes for imports from China and other measures that restricted China's food exports.

In the case of melamine tainted milk in China, none of the typical means consumers use to determine the safety of their purchases was valid. However, the policies leading up to the incident tended to emphasize the integrity of government certification programs rather than the integrity of claims made by brand names or modern supermarkets, which implicitly gained a pass under the "Inspection Exemption" program. If consumers were using brand names and purchase venues as factors to determine the safety of their milk, then policies emphasizing government certification misplaced their regulatory investments and did not ensure that the actual factors consumers used to assess safety were indeed conveying accurate information.

[3] Among the more well-known incidents in the dairy industry are the exposure of counterfeit baby formula in Anhui Province in 2004, and the revelation that recycled milk was being sold by one company in 2006.

This paper provides a unique description and analysis of how consumers evaluated the safety of their milk products using data collected before the melamine incident was exposed. We found that not only do milk consumers tend to use brands and venue to determine the safety of their milk purchases, but also that these tendencies are positively correlated with economic and demographic trends that are expected to increase in China. These findings are relevant not only to policymakers charged with developing policies that assure the safety of food purchases, but also to provide consumers means to accurately evaluate the potential safety of their food choices.

3. Literature

Food safety problems often occur when asymmetric information appears in food markets[4] as it can lead to fewer incentives for suppliers to produce high-quality and safe products (Akerlof, 1970), and to various uncertainties about food safety and even to termination of transactions (von Ungern-Sternberg & von Weizsäcker, 1985). In order to reduce food safety risk and uncertainties and protect consumer from food safety incidents, governments and sometimes private sectors are active in regulating markets by using a range of regulatory regimes including input standards, information requirements, and conditions of use requirements (Caswell, 1998). Accordingly, the literature often focuses on measuring the effects of these regulatory regimes and how to maximize social welfares associated. For example, Caswell (1998) investigated how informational labeling of safety could influence food markets. Fulton and Giannakas (2004) analyzed the market and welfare effects of different labeling and regulatory regimes on genetically modified products. Unnevehr and Jensen (1999) and Roberts, Buzby, and Ollinger (1996), in separate studies, examined the economic implications of using Hazard Analysis Critical Control Point (HACCP) as a food safety regulatory standard. Also, many studies have analyzed the effects of the enhancement of food safety standards for developing countries (e.g. Henson & Jaffee, 2008; Unnevehr, Haddad, & Delgado, 2003; Chen, Yang, & Findlay, 2008).

Studies on the demand side have mostly focused on measuring consumers' preferences or willingness-to-pay (WTP) for certain food safety attributes and associated determinants. For example, Shogren, Fox, Hayes, and Roosen (1999) showed that American consumers are willing to pay a price premium for irradiated chicken because the potential public health risks caused by *Salmonella* and *Campylobacter* can be significantly reduced by irradiation. Dickinson and Bailey (2002) studied consumers' preferences and WTP for red meat traceability in the US, concluding with a positive premium that consumers are willing to pay for traceability assurance. Similar results were found in their follow-up studies in Canada, UK, and Japan (Dickinson & Bailey, 2005). McCluskey, Grimsrud, Ouchi, and Wahl (2005) studied factors that affect Japanese consumers' WTP for BSE-tested beef. Their findings showed that consumers in Japan were willing to pay a price premium for BSE-tested beef, but the WTP was not significantly affected by demographic variables such as age and income. Consumers' perception of food safety has also been studied in many other countries such as the UK (Lloyd, McCorriston, Morgan, & Rayner, 2001), Taiwan (Huang, Kan, & Fu, 1999), and France (Latouche, Rainelli, & Vermersch, 1998).

Several studies have focused on comparison of consumers' preferences for multiple safety attributes. Baker (1999) used a conjoint analysis approach to evaluate consumer responses to four safety-related attributes, including price, damage, certification program, and pesticide regulations of fresh apples. He found that consumers expressed a broad preference for reduced pesticide usage and that consumer preferences for these attributes differ based on demographic and psychographic characteristics. Davidson, Schroder, and Bower (2003) found that 77% of Scottish consumers considered country-of-origin the most important product attribute, while Loureiro and Umberger (2007) found that American consumers value the certification of the USDA food safety inspection more than country-of-origin labeling, traceability and tenderness in terms of determining food safety.

Research examining Chinese consumer preferences for food safety and food safety attributes, however, is very limited, despite China's food safety incidents in recent years. Wang, Zhang, Mu, Fu, and Zhang (2009). found that consumers in Beijing have little safety knowledge about fish product processing, storage, and the traceability system, but they are willing to pay a 6% premium for safe, traceable fish products over non-traced products. Wang et al. (2008) studied Chinese consumers' preference of manufactured milk products using HACCP management, showing that despite the fact that a majority of respondents were not aware of HACCP, they were willing to pay a modest price premium for milk products certified with HACCP. Although these studies have contributed to understanding food safety issues in China, there is significant need to understand how Chinese consumers search for safe foods and the implications of this behavior for food safety policies and food markets.

4. Data and empirical method

4.1. Data and sampling description

The data used in this study are from a consumer survey that was conducted in Beijing, China in July 2007 primarily designed to collect food consumption and expenditure information from urban households. The sampled households in the survey were randomly selected from among households included in the Urban Household Income and Expenditure (UHIE) survey conducted by China's National Bureau of Statistics. The survey data specifically for this study were collected by interviewing the person most familiar with the food shopping and food consumption in each randomly selected household. The responses were collected by

[4] Asymmetric information often appears in food markets since producers know whether they have used the appropriate methods or ingredients to achieve the desired safety attributes of their products but consumers lack that information (Akerlof, 1970; Nelson, 1970).

enumerators with in-person, in-house interviews. In total, 317 respondents from four out of eight districts of urban Beijing were surveyed. Two observations were excluded from the analysis due to missing problem.

In the survey, respondents were asked to rank the importance of five factors in determining fluid milk safety, from the factor they rely on the most to the one they rely on the least. These five factors were purchase venue, certification, milk brand, price, and appearance. We selected these factors by conducting informal focus groups, discussion with professional colleagues and conducting pretests. At the beginning, nine safety-related factors were selected from the focus groups and discussion with professional colleagues. These factors included expiration date, country-of-origin, package material, processing technology (UHT vs. pasteurized), and the five factors that were used in our final survey. Then, they were reduced from nine to five factors, based on the suggestions from two-pretests. The first pretest was conducted by email and telephone within the researchers' social networks, including relatives, friends, and friends' relatives or friends. A total of 35 individuals were asked to rank these nine factors by importance in determining milk safety. Based on the ranking results, the least two important factors, country-of-origin and processing technology, were eliminated. The second pretest was conducted by face-to-face interview at one convenience store and one residential area in the Haidian district of Beijing by randomly selecting people who entered the area and asking them to rank the importance in determining milk safety for the remaining seven factors. A total of 58 individuals were interviewed. In this pretest, the enumerators were also required to record the time each respondent took to finish the ranking and the point at which the respondent started showing difficulty in making further ranking. Finally, the five factors that earned the most credits were used in our following official survey. The reason for selecting five for the final survey was because we found that most respondents started finding it difficult to differentiate importance for the rest factors after they had ranked the first four or five factors.

Among the five remaining factors, purchase venue, brand and certification can be viewed as extrinsic safety-related attributes of milk that are obtained during milk production and supply processes. Consumers' rankings for these factors largely represent the extent to which they trust the credibility behind these factors, or to what degree that consumers trust the reputations of retailers, producers, and government or authorities in determining milk safety, respectively. Differently, consumers' ranking for appearance reveals the degree to which consumers trust their own organoleptic senses in milk's visible intrinsic attributes such as color, shape, and seals, while the ranking of price represents consumers' perception of the product's invisible intrinsic safety attributes, such as handling and processing techniques as well as source of the milk.

Table 1 presents descriptive statistics for several individual and household demographics. As expected, females accounted for about 80% in the sample because of their dominant role in food shopping for their family. Sixty five percent of respondents received high school or 2–4 years vocation school education, while 20% received junior high education or lower and 14% had a college or advanced degree. Also, per capita monthly disposable income in the survey year was RMB1912 yuan, which has no significant difference from our estimated level (RMB1863 yuan) based on the NBS official data reported in various *China's Statistical Yearbooks*. Seventy seven percent of survey households fell into the middle income group, with monthly per capita income ranging from 1000 yuan to 3000 yuan. Low income households and high income households almost equally split the remaining 23% of the samples. In terms of respondents' age, nearly 60% fell into the middle age group (between 46 and 60 years old), nearly 30% into the young group (45 years old or under), and the remaining 12% were aged over 60. Finally, about a quarter of the respondents were employed in public sectors and about the same number of respondents reported the presence of children in their households.

4.2. Empirical method

To investigate whether consumers' characteristics affect their ranking or preferences for factors related to milk safety, we used the rank-ordered logistic regression model (ROLM) to fit the ranking data. The ROLM is a generalization of the conditional logit model for ranked outcomes (Beggs, Cardell, & Hausman, 1981). The key difference between these two models is that the ROLM can

Table 1
Summary statistics.

Variables	Description and coding	Mean	Std. dev.
Respondent's gender	1 = male; 0 = female	0.19	0.40
Respondent's education			
Junior high	1 = junior high or lower; 0 = otherwise	0.20	0.40
High school	1 = high school or equivalent; 0 = otherwise	0.65	0.48
College	1 = junior high or lower; 0 = otherwise	0.14	0.35
Per capita income	RMB1,000 yuan	1.91	1.08
Low income	1 = 1000 yuan or less; 0 = otherwise	0.12	0.30
Middle income	1 = 1000–3000 yuan; 0 = otherwise	0.77	0.41
High income	1 = greater than 3000 yuan; 0 = otherwise	0.11	0.31
Respondent's age	Year	49.07	9.30
Young	1 = under 45 years old; 0 = otherwise	0.29	0.45
Middle age	1 = 45–59 years old; 0 = otherwise	0.59	0.49
Senior	1 = 60 years old or up; 0 = otherwise	0.12	0.32
Public employed	1 = employed in public sectors; 0 = otherwise	0.24	0.43
Children	1 = child aged 16 years old or under present; 0 = otherwise	0.26	0.44

fit dataset recording each individual's rankings for each alternative, while the conditional logit model fit the dataset by simply recording which alternative is most preferred (Long & Freese, 2003). Meanwhile, the ROLM model can also be used when individuals provide tied rankings for some alternatives or when individuals do not rank some of the least-preferred items. For example, people could rank their three most preferred alternatives from a larger set but leave the rest unranked. Below we mainly follow the notations in Allison and Christakis (1994) to present the ROLM method.

The ROLM can be derived from an underlying random utility model (Allison & Christakis, 1994; Beggs et al., 1981). Assume that each respondent, i, assigns a unique integer rank from 1 (least important rank) to J (most important rank) to each factor to determine milk safety. Let U_{ij}, $j=1,\ldots,J$ be the unobserved utility that respondent i derives from the jth factor. The unobserved utilities determine the rankings insofar as i is assumed to rank factor j higher than factor k whenever $U_{ij}>U_{ik}$. Each utility, U_{ij}, is itself conceptualized as the sum of a systematic component, μ_{ij}, which represents the extent to which respondent i prefers factor j to the other $J-1$ factors, and a random component, ε_{ij}. That is

$$U_{ij} = \mu_{ij} + \varepsilon_{ij} \tag{1}$$

where the ε_{ij} are assumed to be independent and identically distributed with an extreme-value distribution $\Pr(\varepsilon_{ij}\le t)=F(t)=e^{-e^{-t}}$, which is the basis of the logit specification.

For any two factors, j and k, the probability of that factor j is ranked higher than factor k can be derived as

$$\Pr(U_{ij} > U_{ik}) = \frac{e^{\mu_{ij}}}{e^{\mu_{ij}} + e^{\mu_{ik}}} \tag{2}$$

Then, the odds that the milk safety factor j will be ranked higher than k can be expressed as $e^{\mu_{ij}-\mu_{ik}}$. Given that a key assumption of IIA holds, that is, the relative preference for any two factors is independent from irrelevant alternatives in the choice set,[5] the probability in Eq. (2) can be extended to the case of an ordered set of factors with $J>2$ (Beggs et al., 1981). Then, for a single respondent i, we have

$$\begin{aligned}
&\Pr\left[U_{i1} > U_{i2} > \ldots > U_{ij}\right] \\
&= \Pr\left[U_{i1} > U_{ij} \text{ for } j = 2,\ldots,J\right]\Pr\left[U_{i2} > U_{ij} \text{ for } j = 3,\ldots,J\right]\ldots\Pr\left[U_{ij-1} > U_{ij}\right] \\
&= \prod_{j=1}^{J}\left[e^{\mu_{ij}} \Big/ \sum_{k=1}^{J}\delta_{ijk}e^{\mu_{ik}}\right]
\end{aligned} \tag{3}$$

where $\delta_{ijk}=1$ if the rank given by the respondent i to factor j is not less than the one given to factor k, and 0 otherwise.[6,7] In practice, the systematic component of utility, μ_{ij}, can be used to introduce the overall differences of ranking factor j over the reference factor and the effects of individual characteristics on preference rankings of factors determining milk safety. We express μ_{ij} as

$$\mu_{ij} = \alpha_j + \sum_{l=1}^{L}\beta_{jl}x_{il} \tag{4}$$

where α_j is used to catch the differences in log odds of ranking factor j ahead of the reference factor, x_{il}, $l=1,\ldots,L$ are the individual's lth characteristics that vary across respondents but are fixed across factors. Notice that one of the five factors must be dropped out for achieving identification in the model estimation, indicating that all estimates for α_j and β_{jl} contrast with the reference factor. Therefore, each of the remaining α_j can be interpreted as factor differences in log odds that factor j is ranked as more important than the reference factor; and each of the remaining β_{jl} can be interpreted as the effect of a one-unit change in the lth explanatory variable on the log odds. By taking exponentiation for β_{jl} estimate, we can yield the effect of the lth characteristic variable on the relative preference for factor j over the reference factor; and exponentiation for differences between β_{jl} and β_{kl} generates the effect of the explanatory variable on the relative preference for factor j and any non-reference factor k, for $k\neq j$. Similarly, if we exponentiate the coefficients of α_j, we can obtain the odds ratio of preferring factor j to the reference factor. The percent change in odds ratio of ranking factor j ahead of the reference factor can be obtained by computing $100(e^{\alpha_j}-1)$ or $100(e^{\beta_j}-1)$.

[5] Allison and Christakis (1994) believe that this invariance assumption (or IIA) is a reasonable approximation of a more complex situation.

[6] In many studies such as Allison and Christakis (1994), "1" is often assigned to the most important factor while "5" is often assigned to the least important one. In that case, $\delta_{ijk}=1$ is defined if the respondent i ranks a greater number to factor k than the one to factor j. Correspondingly, the mean ranks based on this type of assignment indicate that the higher mean rank the less important the factor (Allison and Christakis, 1994, pp. 209 and 211).

[7] In the data used in current study, three individual respondents provided tied ranks for the 4th and the 5th factors. This is why we used the "not less than" definition for $\delta_{ijk}=1$ rather than the "greater than" definition. However, since only three tied ranks are presented in the dataset, either definition for $\delta_{ijk}=1$ actually does not matter much for model estimation and the resulting explanation in current study.

Table 2
Ranking outcomes for factors in determining fluid milk safety.

	Least important (%)	Not very important (%)	Important (%)	Somewhat important (%)	Most important (%)	Total (%)	Mean Rank
Venue	1	6	12	25	57	100	4.34
Brand	4	12	17	37	31	100	3.82
Price	16	30	35	18	0	100	2.53
Certification	38	19	19	13	11	100	2.40
Appearance	35	39	18	7	1	100	2.00

Based on the probability in Eq. (3), we can derive a log-likelihood function for a sample of n independent respondents as

$$log\ L = \sum_{i=1}^{n}\sum_{j=1}^{J} \mu_{ij} - \sum_{i=1}^{n}\sum_{j=1}^{J} log[\sum_{k=1}^{J} \delta_{ijk} exp(\mu_{ik})] \quad (5)$$

According to Beggs et al. (1981), the log-likelihood function in Eq. (5) is globally concave, guaranteeing a global maximum, if any. In practice, μ in Eq. (5) is replaced with Eq. (4). Meanwhile, the data set was organized to include a separate record for the five factors for each respondent. Each record includes a unique identification number for the respondent, the rank assigned by the respondent to the factor, a set of four dummies corresponding to four of the five safety determining factors (one of five factors must be dropped out for identification), and the products of each of the dummies and each of the explanatory variables.

5. Empirical results

5.1. Descriptive analysis

Table 2 presents the ranked results for five factors determining the safety of fluid milk. Over 80% of the respondents ranked purchase venue as most important or somewhat important in determining milk safety. Brand was also ranked at a relatively high level, with 31% choosing it as the most important category and 37% choosing it as somewhat important. On the contrary, appearance was ranked at the two lowest levels of importance by over 70% of respondents, while fewer than 20% ranked appearance as somewhat important and only 1% ranked it as most important. For product price, while 35% and 30% of respondents ranked it as important and not very important, respectively, none ranked it at top level. As for certification, although 13% and 11% of respondents ranked it as somewhat important and most important, respectively, nearly 40% put it at the least important category.

Assume we have an ordinal index for importance levels, with 1 to be assigned to the least important and 5 to be assigned to the most important, then, we can calculate a mean rank for each factor (the last column in Table 2), which reveals the degree to which consumers rely on the factor for gathering milk safety information. Clearly, the bigger the mean rank the more important the factor is in determining the safety of milk products. Apparently, in search of safer milk, Beijing consumers' trust in a retailer's or store's reputation matters the most, which is reflected by the highest ranked purchase venue (mean rank is 4.34). In addition, a milk firm's reputation as represented by its brand is also heavily relied upon in searching for safer milk (mean rank is 3.82).

It is interesting to note that although the Chinese government or related authorities have used large social, economic, and political resources to issue safety-related certifications for fluid milk, such as "green food," "HACCP," "and "quality safe (QS)," these efforts seem to be having trouble in winning consumers' trust in determining milk safety (mean rank for certification is 2.40), suggesting the existence of the potential inefficiency of certification. The mean rank for price was 2.53, which is relatively lower than the ranks for purchase venue and brand, suggesting that Chinese consumers do not strongly and positively link price with milk safety.

Beijing consumers apparently do not rely on their sensory senses in searching for safe milk, reflected by the mean rank of 2.00. On the one hand, this might indicate that consumers do not trust themselves very much in investigating milk safety. On the other hand, this might reflect that safety-related problems of fluid milk resulting from inappropriate packaging and delivery (such as inappropriate packaging materials, out of shape, and leaking) are no longer major concerns due to the rapid development of milk packing and delivery techniques. Moreover, milk is often packaged in a non-transparent carton in China and cannot be observed directly.

5.2. Results from ROLM regression

Table 3 presents the maximum likelihood estimates from the rank-ordered logistic model with appearance as a base category. The estimated coefficients for factor effects indicate that there are significant differences between the reference factor and other factors. On average, Beijing consumers significantly rank purchase venue, brand, and milk price ahead of appearance in terms of importance in determining milk safety, but rank certification at a significantly lower position than the reference (Table 3). These results are largely consistent with what the mean ranks show in Table 2, except the comparison between certification and appearance is reversed from the ROLM regression.

Table 3
ML estimates from ROLM regression[a].

	Venue	Price	Brand	Certification	*p*-value from Wald test[b]
Factor effects	2.44***	0.75*	2.17***	−1.02**	(0.00)**
	(0.53)[c]	(0.46)	(0.55)	(0.47)	
Explanatory effects					
Gender	0.15	−0.32	−0.03	−0.13	(0.55)
	(0.30)	(0.27)	(0.30)	(0.28)	
Junior high	0.37	−0.31	0.02	0.42	(0.36)
	(0.44)	(0.40)	(0.44)	(0.41)	
High school	0.07	−0.17	0.00	0.33	(0.69)
	(0.36)	(0.33)	(0.37)	(0.35)	
Middle income	0.13	0.09	0.79**	0.84**	(0.04)**
	(0.39)	(0.35)	(0.39)	(0.36)	
High income	0.20	0.28	0.94**	0.79**	(0.05)*
	(0.38)	(0.35)	(0.41)	(0.36)	
Young	−0.87*	0.05	−1.12**	1.19***	(0.00)***
	(0.48)	(0.39)	(0.48)	(0.42)	
Middle age	−1.06**	−0.07	−0.91**	0.66*	(0.01)***
	(0.44)	(0.35)	(0.44)	(0.37)	
Public employed	0.01	−0.03	0.39	0.53*	(0.09)*
	(0.27)	(0.25)	(0.28)	(0.27)	
Children	0.24	0.17	0.65	0.07	(0.25)
	(0.32)	(0.28)	(0.31)	(0.30)	
Model statistics					
No. of obs.	1575				
No. of groups	315				
Obs. per group	5				
Log likelihood	−1272.6				
LR chi2(24)	501.44				
Prob. > chi2	0.000				

[a] Appearance is the reference category.
[b] The null hypothesis of Wald test is that coefficients for all factor differences or for all products between factors and each explanatory variable are zero.
[c] Standard errors in parentheses.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.

The estimated factor coefficients can be interpreted in a way of exponentiating the factor differences. Table 4 reports the calculated exponentiations for factor differences and differences between groups for selected variables. Consider purchase venue, which has a coefficient of 2.44. Exponentiating, we get $\exp(2.44)=11.44$, which means that the odds of preferring to use purchase venue as a milk safety indicator by consumers are 11.44 times the odds of preferring to use appearance. Similarly, taking exponentiation of coefficient of price, we get $\exp(2.17)=8.75$, meaning the odds of preferring brand is 8.75 times the odds of preferring appearance. Notice that certification is ranked as the least important position in overall in determining milk safety, although there are some significant ranking differences between respondent groups as we can see below. This result may indicate that the government sectors or authorities in charge of regulating milk safety and issuing safety certifications did not earn much trust from consumers, reflecting potential waste of regulatory resources.

To capture the effects of respondents' individual and household characteristics on their preferences for milk safety indicators, the products of each of the four factor dummies and each of these characteristic variables are included in the ROLM regression. These characteristic variables include the respondent's gender, age, income, employment status, and existence of children in the household. A Wald test statistic was used to test the significance of each explanatory variable. The null hypothesis is that all

Table 4
Exponentiations of factor differences and differences between groups.

	Venue	Price	Brand	Certification
Factor effects	11.44	2.12	8.75	0.36
Explanatory effects				
Middle income	1.13	1.09	2.20	2.32
High income	1.22	1.32	2.56	2.19
Young	0.42	1.05	0.33	3.27
Middle age	0.35	0.93	0.40	1.93
Publicly employed	1.00	0.98	1.47	1.70
Children	1.27	1.19	1.91	1.07

Notes: Exponentiations are calculated only for variables which have significant effects on consumers' rankings.

Table 5
Probabilities of ranking *j* over all other alternatives.

	Venue	Price	Brand	Certification	Appearance
Unconditional probabilities					
$\Pr(U_j > U_k \forall k \in J, k \neq j)$	0.38	0.11	0.36	0.08	0.06
Conditional probabilities					
By per capita income					
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid low\ income)$	0.38	0.11	0.36	0.08	0.06
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid middle\ income)$	0.28	0.08	0.48	0.12	0.04
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid high\ income)$	0.27	0.08	0.50	0.10	0.04
By respondent's age					
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid young)$	0.28	0.15	0.22	0.27	0.08
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid middle\ age)$	0.32	0.14	0.32	0.14	0.08
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid senior)$	0.38	0.11	0.36	0.08	0.06
By respondent's employment sector					
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid public\ sectors)$	0.33	0.09	0.42	0.11	0.05
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid non\text{-}public)$	0.40	0.12	0.34	0.08	0.07
By presence of children					
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid children)$	0.35	0.10	0.44	0.07	0.05
$\Pr(U_j > U_k \forall k \in J, k \neq j \mid no\ child)$	0.39	0.12	0.33	0.09	0.07

Notes: Probabilities are calculated only for variables which have significant effects on consumers' rankings.

products between the four factor dummies and the explanatory variable have zero coefficients. Test results are reported in the last column of Table 3.

Apparently, consumers' preferences for factors in determining milk safety are significantly related to household income. Consumers with middle and high household income are more likely to rank brand and certification ahead of appearance in determining milk safety than the low income group, with differences between middle and low income groups and between high and low income groups of 0.79 and 0.94 for brand, respectively, and 0.84 and 0.79 for certification, respectively (Table 3). The coefficients of the products between factor dummies and income dummies can be interpreted in an exponentiation way. Considering the coefficient of middle income for brand, we take exponentiation to get $\exp(0.79) = 2.20$. Then, we may say that the odds of middle income consumers preferring brand to appearance are about 2.20 times the odds for people in the low income group (Table 4). Similarly, $\exp(0.94) = 2.32$ for the coefficient of certification of middle income tells us that the odds of preferring certification to appearance is about 2.32 times greater for people with middle income than the odds for the low income group.

Consumers' preferences for milk safety-related factors are also significantly affected by respondents' age. Table 3 shows that both young (under 45 years old) and middle aged (45–59 years old) respondents are more likely to rank certification ahead of appearance but rank purchase venue and brand behind appearance compared with seniors (60 years old or up) (Table 3). The numerical values for the products of age-by-factor have an odds interpretation too. Taking the products of young-by-factor as an example, the estimated coefficient for venue, brand, and certification is −0.87, −1.12, and 1.19, respectively. Take exponentiation to get 0.42, 0.33, and 3.27, respectively, which means that the odds of preferring purchase venue and brand to appearance are below half as great for young respondents as for seniors, but the odds of preferring certification to appearance for young consumers are over three times greater than the odds for seniors (Table 4).

In addition, people working in government or other public sectors are more likely to prefer certification to appearance in determining milk safety than those working in other sectors or unemployed (Table 3). The associated exponentiation of the difference between the groups is 1.70, meaning that the odds of ranking certification ahead of appearance for people employed in public sectors are about 1.70 times as great as the odds for others (Table 4). The respondent's employment status, however, has no significant effects on their rankings among purchase venue, price, brand, and appearance (Table 3).

Although the Wald test did not show that respondents' preferences are significantly related to whether the household has children, apparently respondents who have children in the household are more likely to rank brand of milk ahead of appearance than those without children. The result indicates that for households with children the reputation of milk producers has relatively higher importance in determining milk safety than households without children. Associated odds of difference are 1.91.

Final, the empirical results indicate that respondents' education level has no significant effects on their decisions for factor choice. This can be easily seen from the Wald test statistics for two educational dummies in Table 3. Although this result is beyond our expectation, it is not that surprising given that similar results have been found in many studies such as Baker and Crosbie (1993), Jussaume and Judson (1992), and Jussaume and Higgins (1998). There were also no significant differences found between genders for consumers' preferences.

To further understand the effects of individual and household characteristics on consumers' preferences, we predict both unconditional and conditional probabilities of a factor to be ranked at the most important level for several explanatory variables which have significant effects on respondents' ranking of factors (Table 5). The unconditional probabilities are predicted by assuming all exogenous variables being constant; the conditional probabilities are obtained by assuming all exogenous variables except the specified one being constant. Clearly, given all else being equal, purchase venue, which mainly represents the store's reputation, as we mentioned earlier, is most likely to be ranked as the most important category, with a probability of 0.38. The probability for brand to be

Table 6
Significance of estimated factor differences from ROLM regressions.

	Venue	Brand	Price	Certification	Appearance
Model 1 [a]	*** (+) [b]	*** (+)	* (+)	** (−)	Reference
Model 2	*** (+)	*** (+)	*** (+)	Reference	** (+)
Model 3	*** (+)	*** (+)	Reference	*** (−)	* (−)
Model 4	(+)	Reference	*** (−)	*** (−)	*** (−)
Model 5	Reference	(−)	*** (−)	*** (−)	*** (−)

[a] Model 1 is mainly discussed in this study in which appearance is used as the reference factor; Models 2 through 5 used certification, price, brand, and venue as the reference in each, respectively.
[b] "+" and "−" in parentheses following asterisks indicate that the factor is ranked relatively ahead or behind of the reference factor, respectively.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.

ranked at top position is slightly lower, being 0.36, but significantly higher than the ones for price (0.11), certification (0.08), and appearance (0.06).

The probability of ranking a factor first varies between consumer groups. First, as income grows, consumers have a relatively higher probability to rank brand at top position over other factors in determining milk safety, with the conditional probabilities being 0.50 for the high income group, 0.48 for the middle income group, and 0.36 for the low income group (Table 5). Second, the respondent's age is positively related to the probability of ranking purchase venue and brand first, but negatively related to the likelihood of ranking certification at the top. Third, consumers employed in public sectors have about a 7% lower probability to rank purchase venue first, while they have a 6% higher probability for brand compared to their counterpart. Finally, the presence of children in a household increases the probability of ranking brand as the most important category, but decreases the probability for purchase venue. It is especially noticed that for households with children brand of milk has the highest probability to be ranked at the top position in determining milk safety, which is the reverse of what we see from the unconditional probabilities where purchase venue has the highest probability to be top-ranked.

Remember that all of the coefficients in Table 3 are contrasted with the reference factor, appearance. In order to show whether there are significant factor differences between other pairs of factors, we also estimated four extra models with each of the remaining factors as the reference, respectively. The significance for factor differences from these model estimations are presented in Table 6. For the sake of simplicity, all results for products between factors and explanatory variables are omitted in the table. Several interesting aspects in Table 6 are worthy of discussion. First, purchase venue and brand are ranked ahead of other factors overall. Second, consumers' preferences are significantly different between each pair of factors except between purchase venue and brand, suggesting that the reputations of retailers and producers of milk are playing equally important roles for consumers in determining milk safety. Finally, it is interesting to notice that certification is ranked by Beijing consumers behind all other factors. This confirms what we have found from the mean ranks in Table 2, suggesting potential inefficiency of the existing certification programs in China and possible waste of political resources in regulating milk safety.

6. Concluding remarks and discussion

This paper analyzes how Beijing consumers determined milk safety before the *melamine*-contaminated baby formula event. Our findings show that purchase venue and brand of milk were the first two important indicators for consumers to determine milk safety, while milk price and appearance of products and certification were put at relatively lower positions. Consumers' factor preferences, however, varied with regard to individual and household characteristics such as income, respondent's age, employment status, and family composition. For example, high income respondents were more likely to rank brand and certification ahead of appearance than low income respondents; people working in public sectors preferred certification to appearance more than did others; young and middle aged respondents had higher probability to rank certification over appearance but lower probability to rank purchase venue and brand ahead of appearance than seniors; and the presence of children under 16 years old in the family also made the respondents more likely to use brand rather than their organoleptic senses as an indicator to determine milk safety. Despite its relatively lower ranking position of certification, economic and demographic trends in China will strengthen the preferences for certification as well as brand as an important means to determine milk safety. Both rising income and aging population in China could contribute to this dynamic change.

Several interesting aspects of our findings are worthy of discussion. First, the findings of this study provide a possible explanation for why so many milk companies with branded names were involved in the event of *melamine*-contaminated infant formula. The inspection exemption policy and consumers' trust in milk brand together might take most of the responsibility. By checking some visible indicators such as brand when consumers purchase milk, they could have reduced the uncertainty of food safety. Unfortunately, as for the absence of an efficient safety monitoring system in assuring the credibility of branded names, consumers' self-protecting behavior did not reduce their exposure to unsafe products. This suggests that China's government or associated authorities should put more regulatory resources into supervision of branded firms and products rather than less and increase the consequences to large companies of food safety violations.

Second, our findings suggest that the existing milk safety-related certification system in China might lack effectiveness in conveying safety information to consumers and reducing uncertainty (this is at least true in Beijing), indicating that social, economic and political resources being employed to build and maintain the system might be more effectively allocated elsewhere.

Third, the finding that Beijing consumers rank purchase venue at a significantly important level provides an explanation for why more than 80% of milk product shopping occurred in supermarkets or hypermarkets in urban China (Bai et al., 2008). As incomes increase and more and more consumers become sensitive to milk safety, modern retail chains such as supermarkets and hypermarkets will likely increase their share of milk sales relative to traditional outlets such as outdoor markets and community vendors. Regulators in China could potentially take advantage of supermarkets' dominant role in milk retail sales and include them in the deliberations on developing a viable milk traceability system.

Finally, the study has a geographical limitation. Given China's great regional differences, using data only from Beijing, one of the most developed cities, limits our ability to make generalizations from the study results. To have an understanding of the situation across the entire nation, more evidence from studying consumer preferences in other regions is needed.

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