Food safety issues in China: a case study of the dairy sector

Xiaoxia Dong and Zhemin Li*

Abstract

BACKGROUND: Over the past 10 years, food safety incidents have occurred frequently in China. Food safety issues in the dairy sector have increasingly gained the attention of the Chinese government and the public. The objective of this research is to explore consumption changes of dairy products of different income groups after these dairy safety incidents.

RESULTS: The research indicates that consumers' response to dairy safety risk is very intense. Dairy consumption has experienced a declining trend in recent years, and the impact of dairy safety incidents has lasted for at least 5 years. Until 2012, dairy consumption had not yet fully recovered from this influence. Using the random effects model, this study examined the relationship between food safety incident and consumption.

CONCLUSIONS: Overall, the results show that consumers in the low-income group are more sensitive to safety risk than those in the high-income group. It can be seen from this paper that the decrease of urban residents' dairy consumption was mainly driven by changes in fresh milk consumption, while the decline of milk powder consumption, which was affected by the melamine incident, was relatively moderate, and milk powder consumption for the high-income group even increased.
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Keywords: food safety; consumer behaviour; different income group; dairy sector

INTRODUCTION

In the last 10 years, dairy has been one of the sectors which has frequently occurred in food safety incidents in China, such as '*Enterobacter sakazakii*' of Enfamil in 2004, the 'melamine incident' in 2008, 'precocious puberty' of Shengyuan in 2010, 'quality gate' of Guangming in 2012,[1] and the imported 'Botulinum toxic' milk powder from New Zealand in 2013.[2−4] Nowadays, China's dairy products industry faces a serious food safety crisis of consumer confidence. Dairy safety incidents have significantly increased consumers' risk perception to dairy products, which results in the decreases in dairy consumption of urban residents. Food safety issues in the dairy sector have increasingly gained the attention of the Chinese government and the general public.

Food safety is a global problem, and public reaction after safety incidents is an important and hot topic in consumer behaviour research. Previous studies have investigated public risk perception to food safety, including characteristics, behavioural attitudes, subjective norm, perception behaviour, and relationships between behaviours of the public in the past and risk perception.[5−10] Among these studies, public characteristics could affect behavioural attitude, subjective norm and perceived behavioural control of the public through affecting behaviour. Having studied food safety risk perception of Spanish consumers, Angulo and Gil[11] discovered that consumers' concern about a food safety situation had a great impact on consumers' psychology and purchasing choice. Fischer *et al.*[12] discovered that public risk perceptions to food safety were different among individuals, which were affected by individual characteristics. Family characteristics, such as gender, age and whether having a child below 12 years old in the family, have important influences on food safety risk perception. Food safety risk perception of women, the elderly, and high-income families with children is much higher than other groups.[13−16]

With the occurrence of food safety incidents in recent years, the study of the relationship between food safety incidents and public perception has become a new hot spot in China. Most researchers find that gender, education, income, cognition of food safety and product features are the major factors that affect food safety risk perception of the public.[17−22] Most previous researches have been analysed based on consumers' willingness to pay for food safety risk and its influencing factors. Empirical studies about consumption risk perception on a specific incident are rather rare. In this study, we focus on the dairy sector (the impact of food safety incidents for dairy consumption of urban residents). Using the Photo & Article database in *China Daily* as data source, the influence of dairy safety incidents can be measured by the number of relevant reports within a year. The melamine incident occurred in 2008 and is the highest with 151 related reports, while the second one, the Fuyang milk powder incident, only has 41 reports. Therefore, the melamine incident which occurred in 2008 is the leading dairy safety incident in recent years that affects the consumption risk perception of Chinese

* Correspondence to: Zhemin Li, Agricultural Information Institute, Chinese Academy of Agricultural Sciences, No.12 Zhongguancun South Street, Haidian District, Beijing 100081, P.R. China. E-mail: lizhemin@caas.cn

Agricultural Information Institute, Chinese Academy of Agricultural Sciences, No.12 Zhongguancun South Street, Haidian District, Beijing 100081, P.R. China

residents for dairy products. Although the melamine incident occurred 6 years ago, its influence on China's dairy consumption still exists. Therefore, this paper considers the melamine incident as a typical case, studying the risk perception of dairy consumption among different income groups.

The structure of the remainder of this paper is as follows: the next section presents data sources and research methods, and this is followed by a section that discusses the statistical analysis of different dairy products consumption among different income groups. The empirical results are then presented, and the paper ends with a conclusion.

DATA AND METHODOLOGY
Theoretical issues
As early as the 1960s, scholars confirmed that risk perception for food safety was the basis of consumer decision-making.[23] Many researchers verified some links between risk perception and consumer behaviours, and noted that subjective perception of risk rather than risk itself determined consumer behaviours.[24,25] Generally speaking, after food safety incidents, consumers often take the following four actions: (1) stop buying the products; (2) reduce their purchase of the products; (3) buy alternative products; and (4) continue to purchase the products.[26]

Data
This paper adopts the dairy consumption panel data of China's urban residents among different income households from 2000 to 2012. Dairy consumption data is obtained from the *Chinese Dairy Statistical Yearbook*, including fresh milk, yogurt and milk powder. Disposable income data of different income groups is obtained from the *China Statistical Yearbook*, which is deflated to annual incomes in 2000 using the yearly Consumer Price Index (CPI). Yearly retail price of liquid milk and milk powder comes from the China Price Information Network. According to the *Chinese Dairy Statistical Yearbook* and *China Statistical Yearbook*, income groups are categorised into seven levels: the lowest income group (including families with material difficulties), low-income group, below-average income group, intermediate-income group, above-average income group, high-income group and the highest income group.

Methods
According to the theory of consumer behaviour and data structure, an econometric model as follows is set up to analyse and verify the influence of dairy consumption on different income groups after the dairy safety incidents:

$$C_{it} = \beta_0 + \beta_1 P_t + \beta_2 I_{it} + \beta_3 G_{it} \times D_{it} + \varepsilon$$

The dependent variable C_{it} represents dairy consumption of the i-th income group in the t-th year, $I = 1, 2, \ldots, 7$, in which $1 =$ the lowest income group, $2 =$ low-income group, $3 =$ below-average income group, $4 =$ intermediate-income group, $5 =$ above-average income group, $6 =$ high-income group and $7 =$ the highest income group. t represents the years 2000, 2001, $\ldots$, 2012. The independent variable P_t represents dairy price in the t-th year, which is shown by regular price index of annual liquid milk and dairy consumption (year 2000 as base period); I_{it} represents the income level of the i-th group in the t-th year, taking per capita disposable income level and sample size into account. G_{it} represents income group. In the statistical analysis process, income group includes seven groups, in the model analysis process, income of urban households is further categorised into three groups, low-income households (including the lowest income group and low-income group), middle-income households (including below-average income group, intermediate-income group and above-average income group), high-income households (including high-income group and the highest income group), D_{it} is a yearly dummy variable, with a value of zero before the year 2008 and a value of 1 after the year 2008 (including the year 2008). The $G_{it} \times D_{it}$ in the model represents the cross term of income level multiplied by the dummy variable of dairy safety incidents. Two models, the pooled ordinary least squares (OLS) model and the random effects model, are applied.[1] The Breusch–Pagan test is used to determine the optimal model.

DAIRY CONSUMPTION ANALYSIS OF DIFFERENT INCOME GROUPS AFTER GOOD SAFETY INCIDENTS
The trend of dairy consumption in china
Since the mid-1990s, dairy consumption of urban residents has rapidly increased in China. The trend of dairy consumption between 1992 and 2012 is presented in Fig. 1. From 1995 to 2003, per capita dairy consumption of urban residents increased from 8.90 to 25.07 kg, in which fresh milk consumption increased from 5.52 to 18.62 kg, milk powder consumption increased from 0.43 to 0.56 kg, and yogurt consumption increased from 0.37 to 2.53 kg. Since 2004, dairy safety incidents frequently occur in China, especially melamine incident in 2008, residents' risk perception has improved significantly, the effect of food safety incidents on the trust and consumption of dairy products has shown gradually. From 2004 to 2006, per capita dairy consumption of urban residents was a plateau, after in 2007, and dairy consumption of urban residents has declined slightly, especially in 2008, the trend shown a sharp fall. In 2012, dairy consumption of urban residents was 20.91 kg per capita, decreasing by 18.13% compared to 2006. During the same period, consumption of fresh milk and yogurt dropped by 23.85% and 6.99%, respectively.

Effect of dairy safety incidents on overall consumption of dairy products
Dairy safety incidents directly lead to the decrease of China's dairy consumption, and consumption in the low-income group declines slightly faster than that in the high-income group. As shown in Table 1, after the melamine incidents in 2008, there was an obvious decrease in dairy consumption of urban residents. Dairy consumptions of all the seven income groups have experienced a decrease, but the consumptions of the lowest income groups – the low-income group, below-average income group and intermediate-income group – reduced much more than that of other groups. Compared to 2007, the consumptions of the lowest income group, low-income group, below-average income group and intermediate-income group decreased by 22.57%, 19.49%, 16.67% and 16.98%, respectively, in 2012. During the same period, consumptions of above-average income group, high-income group and the highest income group dropped by 12.95%, 13.40% and 13.11%, respectively.
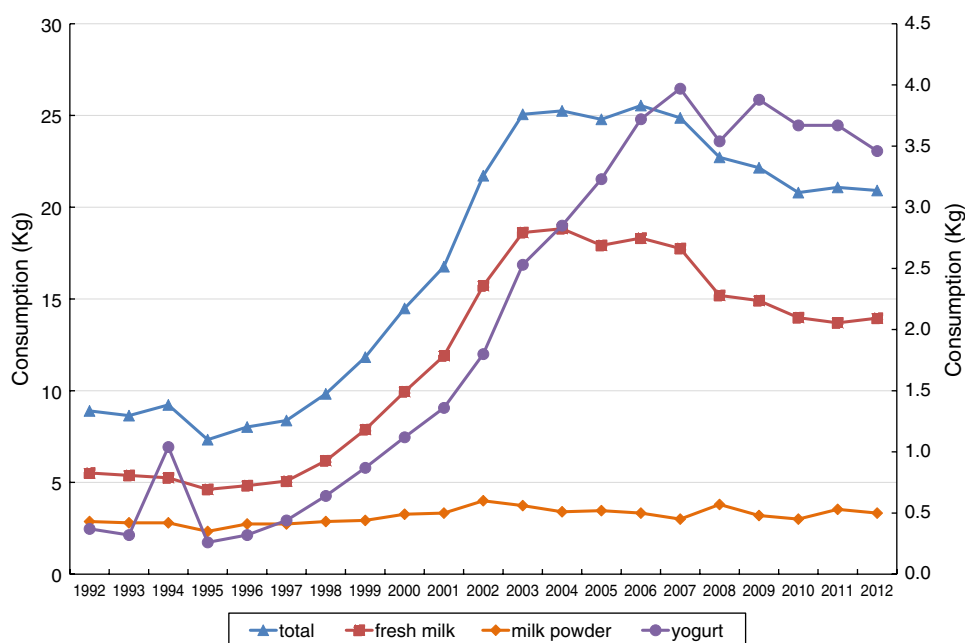
Figure 1. Changes in the consumption of dairy products, 1992–2012. Data source: *China's Dairy Industry Yearbook*. Note: Fresh milk and total consumption is on the left axis; milk powder and yogurt consumption is on the right axis.

Table 1. Changes in dairy consumption (kg) among different income urban residents before and after the melamine incidents

Year	Total	Lowest income group	Low-income group	Below-average income group	Intermediate-income group	Above-average income group	High-income group	Highest income group
2000	14.63	6.93	9.25	12.37	14.56	17.29	20.29	26.58
2001	17.46	8.21	11.03	14.01	16.72	20.40	23.51	27.12
2002	21.35	7.72	12.31	17.33	21.61	26.42	31.13	34.53
2003	25.07	9.56	15.42	21.51	25.78	30.88	35.08	37.03
2004	25.25	10.66	17.17	22.35	25.95	30.73	34.34	37.46
2005	24.79	10.76	16.73	21.42	25.98	30.66	34.86	36.64
2006	25.54	12.15	17.91	22.68	26.88	30.79	34.08	36.70
2007	24.87	13.38	18.37	21.84	26.74	29.20	32.31	34.47
2008	22.72	11.75	15.88	19.79	23.85	27.68	30.60	32.83
2009	22.15	11.65	15.88	19.05	23.75	26.94	29.51	32.26
2010	20.80	10.95	14.89	17.80	21.96	25.32	28.42	30.45
2011	21.08	11.71	14.66	18.36	22.17	25.67	28.67	29.68
2012	20.91	10.36	14.79	18.20	22.20	25.42	27.98	29.95

Data source: *China's Dairy Industry Yearbook* (2001–2013).
Dairy products include fresh milk, yogurt and milk powder (milk powder is converted from fresh milk; the conversion index is 1:7).

Effects of dairy safety incidents on the consumption of different varieties of dairy products

Risk perception of urban residents to different dairy products is different. Fresh milk consumption decreased rapidly, while milk powder consumption dropped slightly. According to Table 2, Table 3 and Table 4, the melamine incidents had a greater influence on fresh milk and yogurt consumption than on milk powder consumption. As shown in Table 2, in recent years fresh milk consumption of urban residents in China has significantly declined year by year. Consumption of fresh milk in 2012 was only 13.95 kg per capita, decreasing by 21.41% compared to 2007. Consumption by the low-income group declined more than that of high-income group, which was in line with the trend above. Consumption by the lowest income groups – the low-income group, below-average

income group and intermediate-income group – decreased by 25.39%, 21.47%, 21.69% and 21.76%, respectively, which was much higher than that of the above-average income group, high-income group and the highest income group.

Yogurt consumption by different income households decreased differently. In accordance with the downtrend of consumption, consumption by low-income households dropped a little more than that of high-income households. It can be seen from Table 3 that the melamine incident resulted in a huge decrease in yogurt consumption in 2008 (10.83%). Decreases in the lowest income group, low-income group, below-average income group and intermediate-income group surpassed 11.37%. Although yogurt consumption of all income groups rose again in 2009, it was still lower than that in 2007. Per capita yogurt consumption in 2012

Table 2. Changes in fresh milk consumption (kg) among different income urban residents before and after the melamine incidents

Year	Total	Lowest income group	Low-income group	Below-average income group	Intermediate-income group	Above-average incomegroup	High-income group	Highest income group
2000	9.94	4.60	6.04	8.27	9.83	11.95	14.08	17.52
2001	11.90	5.63	7.73	9.69	11.78	14.79	17.00	19.60
2002	15.68	4.83	8.39	11.78	15.79	19.99	23.63	26.46
2003	18.62	6.71	10.85	15.51	18.94	23.43	26.82	28.29
2004	18.83	7.79	12.70	16.49	18.93	23.18	26.18	28.30
2005	17.92	7.80	11.70	15.30	18.69	22.56	25.74	26.05
2006	18.32	8.80	12.91	16.26	19.16	22.29	24.52	25.91
2007	17.75	9.57	12.53	15.35	19.16	21.02	23.23	24.89
2008	15.19	7.56	10.30	13.17	15.84	18.81	20.80	22.37
2009	14.91	8.01	10.47	12.80	15.98	18.20	20.08	21.35
2010	13.98	7.39	9.76	11.96	14.98	17.02	19.13	20.19
2011	13.70	7.56	9.71	11.71	14.60	16.73	18.84	18.98
2012	13.95	7.14	9.84	12.02	14.99	16.94	18.64	19.86

Data source: *China's Dairy Industry Yearbook* (2001–2013).

Table 3. Changes in yogurt consumption (kg) among different income urban residents before and after the melamine incidents

Year	Total	Lowest income group	Low-income group	Below-average income group	Intermediate-income group	Above-average income group	High-income group	Highest income group
2000	1.12	0.51	0.62	0.88	1.09	1.42	1.52	2.06
2001	1.36	0.55	0.78	1.10	1.30	1.69	2.17	2.27
2002	1.82	0.51	0.98	1.35	1.76	2.30	2.74	3.31
2003	2.53	0.68	1.35	2.01	2.57	3.11	3.92	4.33
2004	2.85	1.05	1.60	2.36	2.96	3.56	3.96	4.82
2005	3.23	1.00	2.09	2.55	3.51	3.97	4.71	5.62
2006	3.72	1.39	2.27	3.13	3.87	4.58	5.22	6.31
2007	3.97	1.85	2.83	3.41	4.22	4.61	5.51	5.94
2008	3.54	1.60	2.43	2.98	3.74	4.32	5.04	5.49
2009	3.88	1.89	2.75	3.38	4.20	4.68	5.23	5.73
2010	3.67	1.81	2.61	3.11	3.83	4.59	4.95	5.57
2011	3.67	1.84	2.50	3.15	3.79	4.53	5.14	5.52
2012	3.46	1.47	2.29	3.10	3.64	4.21	4.65	5.12

Data source: *China's Dairy Industry Yearbook* (2001–2013).

decreased by 12.85%, from 3.97 kg in 2007 to 3.46 kg in 2012. For all income groups, decreases in consumption surpassed 8.68%. In particular, in the lowest income households and low-income households, the decreases even exceeded 19.08%.

Milk powder was expected to be responsible for the melamine incidents. However, compared with liquid milk (fresh milk and yogurt), dairy products safety incidents in 2008 had less impact on milk powder. As shown in Table 4, although milk powder consumption in recent years fluctuated slightly, it shows a rising trend as a whole, especially in intermediate-income group, high-income group and the highest income group. In 2012, the increases in intermediate income group, above-average income group, high-income group and the highest income group were 6.25%, 19.61%, 31.37% and 36.54% compared to that in 2007. The results do not imply that residents' risk perception of milk powder consumption is high. There may be two reasons. On the one hand, in China the major consumers of milk powder are the elderly and babies (especially babies, whose milk powder consumption has a feature of relative rigid demand); on the other hand, infant milk powder market share of foreign brands has risen in recent

years, and the increase counteracts the decline in consumption of domestic milk powder.

MODEL ESTIMATION RESULTS AND ANALYSIS

Results of the pooled OLS model are shown in Table 5 and results of random effects model are shown in Table 6. Models I, II, III and IV present the results of total dairy products, fresh milk, yogurt, and milk powder respectively. As shown in Table 5 and Table 6, most coefficients achieve a high significant level and signs of coefficients are consistent with theoretical assumption, which implies that the regression results are stable and better reflect the affecting factor on changes of various dairy consumption. In accordance with the Breusch–Pagan test in Table 6, the following discussion is based on the random effects model.

From models I, II III and IV in Table 6, coefficients for dummy variables of middle income group and high-income group are both positive. But only in models I and II, coefficients for dummy variable of income × year are negative and significant statistically. In model III, although all the three income coefficients are negative,

Table 4. Changes in milk powder consumption (kg) among different income urban residents before and after the melamine incidents

Year	Total	Lowest income group	Low-income group	Below-average income group	Intermediate-income group	Above-average income group	High-income group	Highest income group
2000	0.51	0.26	0.37	0.46	0.52	0.56	0.67	1.00
2001	0.60	0.29	0.36	0.46	0.52	0.56	0.62	0.75
2002	0.55	0.34	0.42	0.60	0.58	0.59	0.68	0.68
2003	0.56	0.31	0.46	0.57	0.61	0.62	0.62	0.63
2004	0.51	0.26	0.41	0.50	0.58	0.57	0.60	0.62
2005	0.52	0.28	0.42	0.51	0.54	0.59	0.63	0.71
2006	0.50	0.28	0.39	0.47	0.55	0.56	0.62	0.64
2007	0.45	0.28	0.43	0.44	0.48	0.51	0.51	0.52
2008	0.57	0.37	0.45	0.52	0.61	0.65	0.68	0.71
2009	0.48	0.25	0.38	0.41	0.51	0.58	0.60	0.74
2010	0.45	0.25	0.36	0.39	0.45	0.53	0.62	0.67
2011	0.53	0.33	0.35	0.50	0.54	0.63	0.67	0.74
2012	0.50	0.25	0.38	0.44	0.51	0.61	0.67	0.71

Data source: *China's Dairy Industry Yearbook* (2001–2013).

Table 5. Estimated results of the pooled ordinary least squares (OLS) model

	Dairy product consumption			
Variable	Model I	Model II	Model III	Model IV
Dairy products price index	0.3295 (0.77)	0.2932 (0.67)	1.1703 (2.60**)	−0.4340 (−0.82)
Income level group (control group is low-income group)				
Middle-income group	0.542 (6.11***)	0.5493 (6.12***)	0.3894 (4.22***)	0.6673 (6.11***)
High-income group	0.8144 (8.36***)	0.8236 (8.37***)	0.5200 (5.14***)	0.6673 (6.11***)
The difference before and after 2008				
Dummy variable of low income group × the year after 2008	−0.1515 (−1.75*)	−0.2239 (−2.55**)	−0.0617 (−0.68)	0.0800 (0.75)
Dummy variable of middle income group × the year after 2008	−0.1679 (−2.36**)	−0.2365 (−3.26***)	−0.0148 (−0.20)	0.0094 (−0.11)
Dummy variable of high income group × the year after 2008	−0.1414 (−1.64)	−0.2116 (−2.42**)	0.1210 (1.35)	2.7076 (1.10)
Constant term	1.1999 (0.60)	1.0244 (0.51)	−6.4938 (−3.12***)	2.7076 (1.10)
R^2	0.8685	0.8748	0.7953	0.8508
Adjusted R^2	0.8461	0.8534	0.7602	0.8253

*, **, *** represent the significance levels of 10%, 5% and 1%.

only the coefficient of the low-income group is statistically significant. In model IV, the coefficient of the high-income group is positive. It shows that the income elasticity of urban residents' dairy consumption is still significant, and the dairy safety incident has not changed the trend of dairy products consumptions of high-income group and middle income group. But the dairy safety incident brings about that the dairy product consumptions drop among the high-income group, middle income group and low-income group, in which the majority is the decrease of fresh milk. There are two reasons leading to this phenomenon. First, major consumers of milk powder are the elderly and children, who have a rigid demand for dairy products. Second, because of the existence of milk substitutes of foreign brands, consumers could purchase foreign brands as substitutes for domestic brands, especially for high-income consumers. Furthermore, as it can be seen from the results of models I, II and III, consumption levels of different income groups went down substantially after the dairy safety incident. In model I, coefficients for dummy variable of low-income group × 2008, middle income group × 2008 and high-income group × 2008 are, respectively, −0.1509, −0.1676

and −0.1418, which indicates that in the case of other conditions unchanged, compared with the average consumption from 2006 to 2007, the dairy consumptions of low-income group, middle income group and high-income group respectively dropped by 15.09%, 16.76% and 14.18% due to the melamine incidents. One possible reason is that after food safety incidents, relatively low-income residents, with lower education and limited information receptivity, are more likely to be guided by public opinion, and they are less likely to buy high-quality foreign brands, thus boycott of consumption is the main option that can be used to deal with food safety incidents.

In model II, the coefficients for dummy variable of low-income group × 2008, middle income group × 2008 and high-income group × 2008 are respectively −0.2233, −0.2359 and −0.2118, which implies that in the case of other conditions unchanged, compared with the average consumption from 2006 to 2007, the dairy consumptions from 2008 to 2012 of the low-income group, middle income group and high-income group dropped by 22.33%, 23.59% and 21.18%, respectively. This also verifies the conclusion above that the fresh milk consumption drops mostly.

Table 6. Estimated results of the random effect model

Variable	Dairy product consumption			
	Model I	Model II	Model III	Model IV
Dairy products price index	0.3199 (2.79***)	0.2798 (2.05**)	−0.4473 (−2.36**)	1.1805 (4.12***)
Income level group (control group is low-income group)				
Middle-income group	0.5423 (3.65***)	0.5493 (3.70***)	0.6673 (3.74***)	0.3894 (2.88***)
High-income group	0.8150 (5.01***)	0.8236 (5.06***)	1.0446 (5.34***)	0.5200 (3.51***)
The difference before and after 2008				
Dummy variable of low income group × the year after 2008	−0.1509 (−6.08***)	−0.2233 (−8.20***)	−0.0806 (−2.14**)	−0.0621 (−1.09)
Dummy variable of middle income group × the year after 2008	−0.1676 (−8.87***)	−0.2359 (−10.46***)	−0.0088 (−0.28)	−0.0153 (−0.32)
Dummy variable of high income group × the year after 2008	−0.1418 (−6.20***)	−0.2118 (−7.78***)	−0.0517 (−1.37)	0.1170 (2.05**)
Constant term	1.2435 (2.30**)	1.0861 (1.69*)	2.7691 (3.13***)	−6.5409 (−4.92***)
Wald statistics	Chi2(6) = 175.50	Chi2(6) = 257.48	Chi2(6) = 38.66	Chi2(6) = 49.70
	Prob > chi2 = 0.0000	Prob > chi2 = 0.0000	Prob > chi2 = 0.0000	Prob > chi2 = 0.0000
Breusch–Pagan tests	Chi2(1) = 90.15	Chi2(1) = 84.60	Chi2(1) =78.89	Chi2(1) = 34.54
	Prob > chi2 = 0.0000	Prob > chi2 = 0.0000	Prob > chi2 = 0.0000	Prob > chi2 = 0.0000

*, **, *** represent the significance levels of 10%, 5% and 1%.

In model III, only the coefficient of low-income group is statistically significant, and in model IV, the coefficient of high-income group is positive significantly, which are consistent with the analysis above.

CONCLUSION

The results of this paper verify that dairy safety incidents (especially the melamine incidents) increase risk perception of urban residents, which results in rapid decrease of dairy consumption. The impact of dairy safety incidents has lasted at least 5 years, and dairy consumption has not fully recovered yet.

Although milk powder is the protagonist of melamine incident, which still has a great influence on the consumption of fresh milk and yogurt for domestic milk source. The results also verify the burst effect of food safety incident in dairy industry, which means that if one product in an industry has safety problems, consumers will perceive risks and have less confidence in all related products, thus the demand for the whole industry would be damped.[27]

Meanwhile, the paper discovers that the reflection on dairy safety incident of relatively low-income groups is more intense than the high-income groups, and the decrease in consumption of low-income groups is more obvious after the dairy safety incidents.

ACKNOWLEDGEMENTS

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