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"Does Contain" Versus "Does Not Contain": How Do Labeling Strategies for Genetically Modified Foods Impact Consumer Welfare?

Li Zhao[1, a, *], Shumin Liu[1]

[1]College of Economics and Management; Shanghai Maritime University, Pudong District, Shanghai, 201306, China

[a]li_zhao1017@hotmail.com

Abstract

The genetically modified (GM) foods may decrease the usage of fertilizers and pesticides and protect environment. Nevertheless, opponents fear GM crops and foods may have potential environment and public health. Greenpeace and Friends of the Earth both advocate labels on GM foods to give consumers the opportunity to choose whether to consume GM foods. In this circumstance, the current article explores the impact of two labeling strategies including "Does Contain" and "Does not Contain" GM ingredients on consumer welfare using an adjusted Kumaraswamy distribution. Whether "Does not contain" strategy is superior to "Does contain" strategy under the voluntary labeling regime dependes on the inspectoin cost. In the context of lower inspection cost, the increasing inspection cost initially has a positive impact on the superiority of the "Does Contain" strategy, but eventually the advantage of "Does contain" remains unchanged after the label-free products are out of market. Additionally, the "Does not contain" strategy has a stronger advantage under the higher probabilities of GM food in the label-free product and the higher difference of likelihoods of opportunistic behavior.

Keywords

Kumaraswamy distribution; Consumer welfare; Experimental economics; "Does contain" strategy; "Does not contain" strategy.

1. Introduction

The rapid development in the biotechnology has led to considerable public debates about its social, moral, and political implications (Augoustinos, 2010). Policy makers have been faced with the conundrum of how to deal with diverse consumer attitudes toward GM technology in an uncertain environment, and hence different labeling policies have emerged (Zhao et al., 2013; Scatasta et al., 2007). As for the mandatory labeling, in the European Union foods containing 0.9% or more GM ingredients must be labeled as 'Contains GMOs' (Dombey, 2002) and Japan requirs both GMOs and non-GMOs to be labeled (Matsumoto, 2006; Crespi and Marette, 2003). As for the voluntary labeling, in the United States the voluntary 'GMO-free' label are adopted (FDA, 2000; Caswell, 2000) while in Hong Kong GMO producers label their foods voluntarily (http://www.cfs.gov.hk/english/programme/programme_gmf/programme_gmf_gi_label_faq_consumer.html, Centre for Food Safety, Hong Kong, accessed on 7 August 2006).

Using analytical models, the existing literature has derived welfare effects of labeling. Plunkett and Gaisford (2000) studied the welfare effect of introducing GM foods based on the assumption of consumer homogeneity, which was relaxed by Fulton and Giannakas (2004) and Giannakas and Fulton (2002). Giannakas and Fulton (2002) developed a model of heterogeneous consumers and compared consumer welfare between the mandatory labeling (without or with mislabeling) and no labeling. Fulton and Giannakas (2004) extended

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Giannakas and Fulton (2002) to more interest parties and examined the system-wide effects with and without labeling and showed that various parties had different opinions on which labeling policy was the best.

However, previous studies focused on labeling regimes such as mandatory labeling, voluntary labeling and "no labeling", but little research has explored which kind of products, GM or GM-free products, should be labeled. Liaukonyte et al. (2013) and Crespi and Marette (2003) are exceptions. Liaukonyte et al. (2013) investigate the impact of "Contains X" and "Free of X" labels and secondary information on WTP. They concluded that the negative impact of "Contains X" decreases after the secondary information is provided while the "Free of X" label has an impact only after the secondary information is provided. In the context of the mandatory labeling, Crespi and Marette (2003) compared the label "Does Contain" with the label "Does Not Contain" and found that the label "Does Not Contain" will be superior if this ratio of consumers with a strong dislike degree is low while the label "Does Contain" is better if the ratio is high.

This paper investigates voluntary labeling with opportunistic behavior and addresses the issue which products (GM products or GM-free products) should carry the label ("Does contain" label or "Does not contain" label) under voluntary labeling regime in order to maximize consumer welfare. Using experimental data, this paper combines a MATLAB numerical simulation with the maximum likelihood method to estimate the probability density function (PDF) of consumer attitudes towards GM products, in order to calculate the difference in consumer welfare between "Does contain" and "Does not contain" strategies.

The article is organized as follows: Section two sets up the model of consumer welfare, and the third section describes the source of data and the estimation of aversion to GM food, and later analyzes the difference of consumer decision and welfare between the "Does contain" and the "Does not contain" strategy. The final section presents conclusions with policy implications and research in the future.

2. Model Setup

There are three strategies for the voluntary labeling. The first one is GM product producers voluntarily choosing to label their products as GM products, which is "Does contain" strategy. The second is GM-free product producers voluntarily choosing to label their products as GM-free or Non-GM products, which is "Does not contain" strategy. The third strategy is both GM product producers and GM-free product producers voluntarily choosing to label their products as GM products and Non-GM products, respectively (Caswell, 2000). Currently, Hong Kong adopts the "Does contain" strategy while U.S. adopts the "Does not contain" strategy. In this paper we compare the consumer's behavior, market shares and consumer welfare between the "Does contain" strategy and "Does not contain" strategy.

2.1. "Does Not Contain" Strategy

In this study, the "Does not contain" strategy under the voluntary labeling means conventional producers voluntarily send their products for inspection by relevant regulatory bodies, label their products and separate them in the supply chain. The price of the conventional products will rise due to the inspection cost, labeling cost and separate transportation cost and etc., while the substitute and GM products will maintain their original prices. Obviously, products with "Does not contain" label must be conventional ones, while the label-free products could be the conventional or GM products. λ_n denotes the proportion of GM products in the label-free products under the "Does not contain" strategy, μ_n represents the severity of opportunistic behavior of GM products producers. Therefore, consumer utilities are $U_{nt} = U + w - p_t - m - c_1 - c_2$ if one unit of the separated conventional product is consumed,

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$U_{nlf} = U + w - p_{nlf} - \lambda_n\theta = U + w - (1-\lambda_n + \lambda_n\mu_n)p_t - \lambda_n(1-\mu_n)p_{gm} - \lambda_n\theta$ if one unit of label-free product is consumed, and $U_{ns} = U + w - p_s$ if one unit of the substitute product is consumed, where U_{nt} and U_{nlf} represent the utilities from consuming one unit of the conventional product and the label-free product, respectively. U_{ns} is the utility from consuming one unit of the substitute product under the "Does not contain" strategy. w is the consumer's total budget. Parameter θ means the degree of consumer aversion toward GM ingredients. The positive θ implies consumer dislikes GM products and vice versa. When the consumer has a neutral attitude toward GM products, θ is zero. p_{nlf} denotes the price of label-free product under the "Does not contain" labeling regime. GM products (gm) or the substitute ones (s), whose price are p_t , p_{gm} and p_s , respectively. m is the inspection cost, c_1 is labeling cost, c_2 is other separation cost such as separate transportation cost in the supply chain. m, c_1 and c_2 amount to the market separation cost. The market separation cost not only increases the price of the conventional products, but it also affects the market shares of all three kinds of products accordingly. When the market separation cost is high enough, that is, $U + w - p_s > U + w - p_t - c_1 - c_2 - m$, consumers prefer the substitute products and therefore the conventional products would be out of the market.

When the market separation cost is lower, i.e. $p_t + c_1 + c_2 + m < p_s$, the substitute products will not seize market share from conventional products because consumers prefer conventional products to substitute products. The market shares of conventional products and label-free products will depend on U_{nlf} and U_{nt} . Consumers would buy the conventional product if $\theta_n > \frac{p_t + m + c_1 + c_2 - p_{nlf}}{\lambda_n}$, while consumers would prefer label-free products to the conventional ones if $\theta_n < \frac{p_t + m + c_1 + c_2 - p_{nlf}}{\lambda_n}$.

Therefore, the market share of the label-free products is $S_{nl} = \int_{\frac{p_t+m+c_1+c_2-p_{nlf}}{\lambda_n}}^{\theta_{max}} f(\theta)d\theta$, while that of the GM products is $S_{gm} = \int_{\theta_{min}}^{\frac{p_t+m+c_1+c_2-p_{nlf}}{\lambda_n}} f(\theta)d\theta$. By integrating the welfare of each consumer with different attitudes toward GM products, we get the total consumer welfare

$$CS_n^l = \int_{\min\theta}^{\frac{p_t+m+c_1+c_2-p_{nlf}}{\lambda_n}} U_{nlf} f(\theta)d\theta + \int_{\frac{p_t+m+c_1+c_2-p_{nlf}}{\lambda_n}}^{\max\theta} U_{nt} f(\theta)d\theta \tag{1}$$

When the market separation cost is high enough, the conventional products will be out of the market since consumers prefer the substitute products to the conventional ones. The market shares of the substitute products and label-free ones will depend on U_{nlf} and U_{ns} . Consumer prefers the label-free products if $\theta_n < \frac{p_s - p_{nlf}}{\lambda_n}$, while the substitute products are preferred if $\theta_n > \frac{p_s - p_{nlf}}{\lambda_n}$.

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Therefore, the market share of the substitute products is $S_s = \int_{\frac{p_s - p_{nlf}}{\lambda_n}}^{\max\theta} f(\theta)d\theta$, while the market share of GM products is $S_{gm} = \int_{\min\theta}^{\frac{p_s - p_{nlf}}{\lambda_n}} f(\theta)d\theta$. The consumer welfare CS_n^h is

$$CS_n^h = \int_{\min\theta}^{\frac{p_s - p_{nlf}}{\lambda_n}} U_{nlf} f(\theta)d\theta + \int_{\frac{p_s - p_{nlf}}{\lambda_n}}^{\max\theta} U_{ns} f(\theta)d\theta \tag{2}$$

Combining two situations above, we have

$$CS_n = \begin{cases} \int_{\min\theta}^{\frac{p_t + m + c_1 + c_2 - p_{nlf}}{\lambda_n}} U_{nlf} f(\theta)d\theta + \int_{\frac{p_t + m + c_1 + c_2 - p_{nlf}}{\lambda_n}}^{\max\theta} U_{nt} f(\theta)d\theta, \ if \ m + c_1 + c_2 < p_s - p_t \\ \int_{\min\theta}^{\frac{p_s - p_{nlf}}{\lambda_n}} U_{nlf} f(\theta)d\theta + \int_{\frac{p_s - p_{nlf}}{\lambda_n}}^{\max\theta} U_{ns} f(\theta)d\theta, \ if \ m + c_1 + c_2 \geq p_s - p_t \end{cases} \tag{3}$$

2.2. “Does Contain” Strategy

Hong Kong has adopted voluntary labeling and allows GM product producers to voluntarily label their products as GM products since in practice, it is difficult to guarantee a product is free of GM ingredients and unintentional and technically unavoidable GM materials in seed, products, or feed can get into products. Under “Does contain” strategy, the labeled product is GM food while the label-free product is the conventional or GM food. In this situation it is almost impossible to ensure that all GM products producers do not undertake opportunistic behavior due to the asymmetric information. In fact, a considerable part of producers would not label their GM products in order to obtain higher returns, so unlabeled products are not necessarily conventional ones, but may contains some GM ingredients. λ_p denotes the proportion of GM products in the label-free products, μ_p still represents the severity of opportunistic behavior of GM products producers. . Consumers make a decision in the label-free, GM and substitute products and the corresponding utilities are $U_{plf} = U + w - p_{plf} - \lambda_p\theta = U + w - (1 - \lambda_p + \lambda_p\mu_p)p_t - \lambda_p(1 - \mu_p)p_{gm} - \lambda_p\theta$ if one unit of label-free product is consumed, $U_{pgm} = U + w - p_{gm} - \theta - c_1$ if one unit of GM product is consumed, and $U_{ps} = U + w - p_s$ if one unit of substitute product is consumed, where subscript “p” means “Does contain” strategy and variables have the similar meaning with the previous ones.

Obviously consumer with characteristic $\theta = \frac{p_s - p_{plf}}{\lambda_p}$ is indifferent between consuming the substitute and label-free products. Similarly, consumer has the same preference for the substitute and GM products if $\theta = p_s - p_{gm} - c_1$, and consumer has the same preference for the label-free and GM products if $\theta = \frac{p_{plf} - p_{gm} - c_1}{1 - \lambda_p}$.

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If $p_s - p_{gm} - c_1 < \frac{p_s - p_{plf}}{\lambda_p} < \max\theta$, there exists GM food, label-free products and the substitute products. If $\frac{p_s - p_{plf}}{\lambda_p} \le p_s - p_{gm} - c_1$, label-free products will be out of market. If $p_s - p_{gm} - c_1 \le \max\theta \le \frac{p_s - p_{plf}}{\lambda_p}$, the substitute products will be out of market. Therefore consumer welfare CS_p under the “Does contain” strategy is

$$CS_p = \begin{cases} \int_{\min\theta}^{p_s - p_{gm} - c_1} U_{pgm} f(\theta)d\theta + \int_{p_s - p_{gm} - c_1}^{\max\theta} U_{ps} f(\theta)d\theta, if\ \frac{p_s - p_{plf}}{\lambda_p} \le p_s - p_{gm} - c_1; \\ \int_{\min\theta}^{\frac{p_{plf} - p_{gm} - c_1}{1-\lambda_p}} U_{pgm} f(\theta)d\theta + \int_{\frac{p_{plf} - p_{gm} - c_1}{1-\lambda_p}}^{\frac{p_s - p_{plf}}{\lambda_p}} U_{plf} f(\theta)d\theta + \int_{\frac{p_s - p_{plf}}{\lambda_p}}^{\max\theta} U_{ps} f(\theta)d\theta, \\ if\ p_s - p_{gm} - c_1 < \frac{p_s - p_{plf}}{\lambda_p} < \max\theta; \\ \int_{\min\theta}^{\frac{p_{plf} - p_{gm} - c_1}{1-\lambda_p}} U_{pgm} f(\theta)d\theta + \int_{\frac{p_{plf} - p_{gm} - c_1}{1-\lambda_p}}^{\max\theta} U_{plf} f(\theta)d\theta, if\ p_s - p_{gm} - c_1 < \max\theta \le \frac{p_s - p_{plf}}{\lambda_p} \end{cases} \quad (4)$$

3. Numerical Sinulation

3.1. Experimental Design

In 2012, a total of 216 randomly recruited participants across China completed experimental auctions. The products in the auction were 0.5 kilograms of conventional and GM apples. All apples had similar appearances including color, shape and size. Experiments were conducted in Shanghai, Pingdingshan and Shihezi which stand for the eastern, central and western areas in China, respectively with seventy-two participants in each city. To further enhance the representativeness of our sample, we recruited local residents for the study rather than university students. In the experiment, each participant got 50RMB (about \$8) in compensation. Three rounds were run for each auction and the top three bidders got the object.

3.2. The Estimate of Aversion to GM Food

It is critical to select the appropriate distribution function before the estimation. The density function of the β distribution has various shapes but β distribution does not have a closed cumulative distribution function, so based on Zhao et al. (2013) we choose an adjusted Kumaraswamy distribution whose density function is

$$f(\theta) = \frac{ab}{\max(\theta) + |\min(\theta)| + 2} \left(\frac{\theta + |\min(\theta)| + 1}{\max(\theta) + |\min(\theta)| + 2}\right)^{a-1} \left[1 - \left(\frac{\theta + |\min(\theta)| + 1}{\max(\theta) + |\min(\theta)| + 2}\right)^{a}\right]^{b-1} \quad (5)$$

To estimate the standardized GM aversion $\tilde{\theta}$ first using the maximum likelihood method before obtaining the original GM aversion θ. The likelihood function of $\tilde{\theta}$ is $L = \max_{a,b>0} \left\{ \prod_{i=1}^{n} ab\tilde{\theta}^{a-1}(1-\tilde{\theta}^{a})^{b-1} \right\}$, where n is the number of valid observations. Using *Matlab*, the

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optimal solution is $a = 5.14, b = 9.83$ under the voluntary labeling regime. From (5), we have the PDF of GM aversion is $f(\theta) = 5.14 \times 9.83 \times \frac{1}{14} \times (\frac{\theta + 8}{14})^{4.14} \times [1 - (\frac{\theta + 8}{14})^{5.14}]^{8.83}$.

3.3. Simulation Result of the Consumer Welfare Difference

The impact of market separation cost and the likelihood of opportunistic behavior on consumer welfare are explored. Suppose the inspection cost is between 0 and 0.7 and the difference of likelihoods of opportunistic behavior between the "Does contain" strategy and the "Does not contain" strategy changes from 0 to 0.3. The proportion of GM food in the label-free food under "Does contain" strategy is 0.716 while that under "Does not contain" strategy is 0.828. The prices of the conventional, GM and the substitute food remain 3.5, 3 and 4.2, respectively. The simulation results are shown in Figure 1.

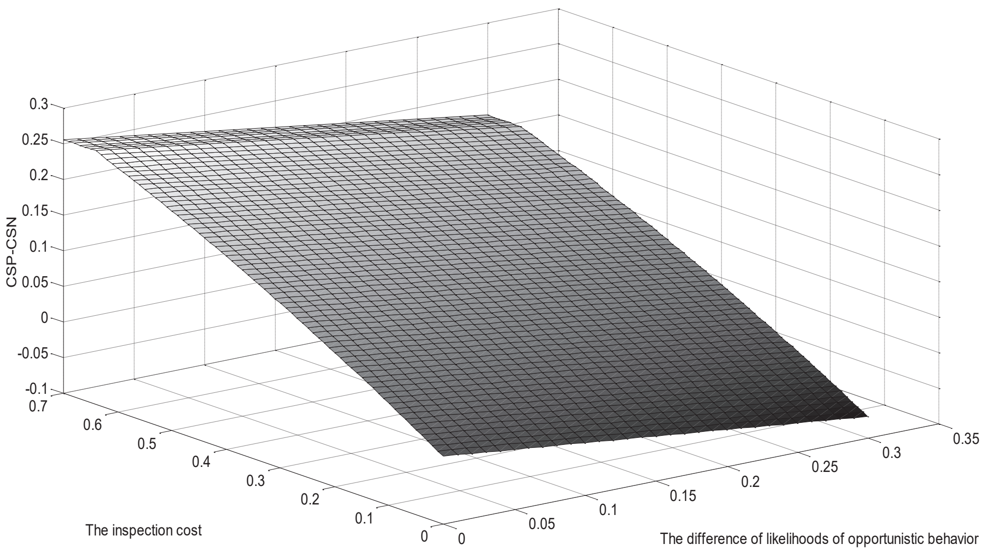

Figure 1. The difference of consumer welfare using adjusted Kumaraswamy distribution

Figure 1 shows the advantage of "Does not contain" strategy increases as the difference of likelihoods of opportunistic behavior between the "Does contain" strategy and the "Does not contain" strategy goes up. Suppose the inspect cost is taken as given and equal to 0.1, the difference of consumer welfare deceases from 0.0429 to -0.0252 as the difference of the likelihoods of opportunistic behavior increases from 0 to 0.3 and this result shows that the "Does not contain" strategy surpasses the "Does contain" strategy finally. Additionally, the "Does contain" strategy is superior to the "Does not contain" strategy if the inspect cost is high enough, but the advantage of the "Does not contain" strategy gradually appears as the inspect cost goes down. Suppose the difference of the likelihoods of opportunistic behavior remains 0.1, the difference of consumer welfare increases from -0.0264 to 0.2279 and the "Does contain" strategy surpasses the "Does not contain" strategy as the inspect cost increases goes up from 0 to 0.7. The advantage of "Does contain" strategy increases as the inspection cost goes up since there are both inspection cost and labeling cost with the "Does not contain" strategy but only labeling cost exists in the "Does contain" strategy. However, eventually the impact of separation costs on the difference of consumer welfare between the "Does contain" and "Does not contain" strategy remains the same level since label-free products are out of market with the higher separation costs. That is why Figure 1 shows significant difference between the lower separation costs and the higher separation costs.

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4. Conclusions

This paper was motivated by the considerable controversies over GMO labeling regulations around the world. In the US, the labeling is voluntary and "Does not contain GMOs" are labeled voluntarily by the conventional foods producers while in Hong Kong the voluntary labeling is adopted and GMO producers label their foods voluntarily. However, in Europe, there is mandatory testing and labeling policy with the requirement that GM products must be labeled. In terms of current situations, there is no clear international consensus regarding GMO labeling regimes and strategies. Considering there is abundant literature on mandatory labeling regime, this paper focuses on voluntary labeling and compares the difference of consumer welfare between "Does contain" and "Does not contain" strategies.

In this study of consumer welfare and preferences for GM food, the simulation results showed under the condition that voluntary labeling is adopted, "Does contain" is superior to "Does not contain" strategy in the context of the higher inspection cost while "Does not contain" is better than "Does contain" strategy in the context of the lower inspection cost. Additionally, the rising inspection cost helps increase the advantage of the "Does contain" strategy at first, but later there is no effect. Finally, the advantage of the "Does not contain" strategy goes up as the difference of the likelihood of opportunistic behavior between the "Does contain" strategy and the "Does not contain" strategy rises. Moreover, the "Does not contain" strategy has a more advantage under the higher probabilities of GM food in the label-free product.

The study also has some limitations. All separation costs are assumed to pass on to consumers in our paper since we assume the elasticity of demand is zero. In addition, the auction subjects were recruited from in and around the urban areas of China so our results may not stand for consumers in the rural areas. Furthermore, our results could be more applicable to those countries with the similar market characteristic and consumer preference to those of China. Future research could consider how elasticity of demand affect the estimation results and examine the effects of the different types of information under various labeling strategies on consumer welfare in more countries or areas.

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