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# THE INFLUENCES OF AVIAN INFLUENZA, BSE, AND H1N1 INFLUENZA ON ATTITUDINAL CHANGES IN MEAT SAFETY ISSUES

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# The Influences of Avian Influenza, BSE, and H1N1 Influenza on Attitudinal Changes in Meat Safety Issues

## Abstract

Consumption patterns for chicken and eggs have changed since the outbreak of the H5N1 avian influenza (AI) throughout the world, but its potential impact on demand has not been thoroughly unveiled. Our study examines some important factors influencing behavioral changes and estimates their marginal effects by employing the censored regression model to survey data in Taiwan. Results showed that risk perceptions, overall knowledge and some socio-demographic characteristics were profound in determining changes in consumption of chicken and eggs. Public health education programs informing consumers about the AI threat may reduce their negative perceptions; therefore, consumption of chicken and eggs would not be decreased significantly enough to damage related agricultural sectors.

**Keywords:** avian influenza, knowledge, risk perceptions, censored regression model, Taiwan

**JEL codes:** C21; D12; M30.

# The Influences of Avian Influenza, BSE, and H1N1 Influenza on Attitudinal Changes in Meat Safety Issues

## 1. Introduction

Transmission of the highly pathogenic H5N1 strain of avian influenza (AI) by birds migrating from Asian countries to the European and African continents has caused a worldwide alert. Dating back to late 2003, the damage caused from the H5N1 avian influenza has not faded away; on the contrary, major H5N1 infections still occur from time to time in both animal and human cases. According to the World Health Organization (2010), the highly pathogenic H5N1 avian influenza has been confirmed in 493 human cases worldwide and has caused 292 deaths; most of these cases occurred in Asian countries, such as China, Vietnam, Thailand, Cambodia, and Indonesia. In addition, millions of infected poultry were culled including wild, farm-bred, and household-raised birds. As a result, consumers worldwide have been shocked by the effects of this fatal disease and thus have changed their consumption patterns of chicken and eggs.

Declines in the consumption of chicken and eggs caused by this lethal zoonosis also highlight concerns of food safety. Different from food safety issues such as *E. coli* and salmonella, fatalities from the H5N1 were mainly not a result from eating chicken and eggs. Sedyaningsih *et al.* (2007) showed that approximately three fourth of the infected human cases in Indonesia were due to contact with sick and dead poultry while the transmission of the AI virus in the rest of the cases were left unidentified. Even though eating chicken and eggs was not confirmed to be how the epidemic was transmitted, unfortunately, most consumers in European countries reduced or stopped consumption of chicken and eggs altogether as a strategy to avoid contact the disease (Eurobarometer, 2006). Due to basic human self-protection mechanisms, consumers' instinctive reactions to the AI outbreaks have significantly damaged the related agricultural sectors; however, the damage could be alleviated if consumers become more knowledgeable about the AI (Gstraunthaler and Day, 2008).

In the literature, most studies examined general consumers' knowledge levels of H5N1 avian influenza and how the AI information was spread worldwide since the outbreaks. For example, Olsen *et al.* (2005) conducted a study in rural Thailand; Beyhan and Aygoren (2006) researched in Turkey; Gupta *et al.* (2006) tested UK residents living in the London area; Southwell *et al.* (2006) conducted a study in the US; Abbate *et al.* (2006) surveyed poultry workers in Italy; and Leggat *et al.* (2007) examined hostellers' concern about and knowledge of avian influenza in Australia. Additionally, some researchers examined the risk perception and its impact on consumers' preventative behaviors, including Fielding *et al.* (2005), Beyhan and Aygoren (2006), and Gstraunthaler and Day (2008). These studies were all related to the

investigation of knowledge levels and risk perceptions of avian influenza as well as their linkage to prevention strategies for AI in public health and traveling.

Only a few studies analyzed the economic impact of H5N1 avian influenza (e.g., Bloom *et al.*, 2005; Ishida *et al.*, 2006; Beach *et al.*, 2008). Approaches to understanding the economic influence of H5N1 were different among these papers. Bloom *et al.* (2005) used the Oxford Economic Forecasting model to predict a 3.6% drop-off in the GDP growth in Asia in case an AI pandemic would have occurred. Different from this macroeconomic analysis, Ishida *et al.* (2006) utilized a demand system approach to examine the impact of both Bovine Spongiform Encephalopathy (BSE) and AI on Japanese meat demand. With incorporation of a gradual switching model of structure changes, the empirical results from monthly data showed that the impact lengths were estimated to be sixteen months for the BSE and only eight for the AI. As for Beach *et al.* (2008), they examined the effects of the AI news on consumers' behavioral changes in purchasing both fresh and processed (frozen included) poultry. Using weekly data in Italy, Beach *et al.* (2008) constructed the AI information index and concluded that most impact did not last long and began to decline within five weeks.

Nevertheless, consumer survey data were utilized to reveal behavioral changes caused by avian influenza outbreaks or threats in the following studies. Goktolga and Gunduz (2006) employed a multiple bounded Probit model to detect important socio-demographic factors which affected the decrease in chicken consumption in Turkey. Their results showed that age, household size, income, monthly chicken consumption and risk variables were important factors affecting the decrease in consumption of chicken meat after the AI outbreak. Hsu *et al.* (2008) investigated consumers' risk perceptions and knowledge levels of avian influenza and how these factors affected chicken consumption changes of primary household food shoppers in Taiwan. Even though Taiwan has no H5N1 pandemic, their results from using the cluster analysis showed that consumers' behavioral changes were revealed to be different from various knowledge-risk clusters, and moreover, the reduction of chicken consumption under the threat of AI was estimated to range from 3.76 kilograms per month to 11.22 kilograms.

The purpose of this paper is to determine the main factors which would have influenced consumption changes of chicken and eggs in Taiwan under the threat of avian influenza and to quantitatively estimate potential impacts of each identified factor on demand for chicken and eggs. More specifically, we focus on the following three tasks. First, we compare the differences of AI knowledge and risk perceptions between two types of consumers— primary household food shoppers (primary shoppers in short hereafter) and general consumers. Second, on the basis of the types of consumers surveyed as well as AI knowledge and risk perception

levels, we investigate any existing difference in potential changes in the consumption of chicken and eggs if AI outbreaks would have occurred. Last, we construct and estimate a censored regression model to depict important factors among AI knowledge, risk perceptions and socio-economic factors which may play a crucial role in determining consumers' behavioral changes if an outbreak of avian influenza would have occurred in Taiwan.

The contribution of our paper is that, even though several studies analyzed factors affecting decreases in consumption of chicken, e.g., Goktolga and Gunduz (2006) and Hsu *et al.* (2008), our study is one of a few attempts to examine egg consumption changes under the AI threat, which can also be treated as an extension of previous researches; methodologically, our model would be the first attempt to employ the censored regression model to investigate the consumption changes in both chicken and eggs. We will close this gap by quantitatively calculating the marginal effects from an estimation of a censored regression model to determine if the potential impact of the identified factors on chicken and eggs is different. Moreover, this study is unique in that the survey was administered in an area which is free from the H5N1 pandemic. Results from the reactions of consumers in Taiwan may provide evidence of expected behavioral changes in demand for chicken and eggs for the rest of the world.

The remainder of the paper is organized as follows. In the next section, a modified censored regression model is introduced along with the derivatives of marginal effects from the corresponding model. Section 3 describes the data collected in Taiwan and section 4 presents the empirical results. A conclusion is provided in the last section.

## 2. The Modified Censored Regression Model

Even though most eastern and southeastern Asian countries on bird migration routes have reported AI outbreaks in poultry, such as Japan, the Republic of Korea, Cambodia, Lao PDR and Malaysia, Taiwan is one of a few existing countries that remains free from H5N1 infections. The most important question posed in this study is what behavioral changes would occur if a potential AI outbreak should happen in Taiwan. Consumers' responses to this hypothetical question were collected using a face-to-face interview. In our questionnaire design, a respondent would answer a question about his/her behavioral changes by choosing one of three situations: (1) he/she would not eat chicken (or eggs) at all; (2) he/she would remain unchanged; or (3) he/she would reduce a certain proportion of his/her regular amount and by how much. Consumers' responses were recorded between zero and one: zero indicates that the consumer would choose to stop eating chicken (or eggs) and one indicates this respondent would keep the same consumption level of chicken (or eggs) even though an AI outbreak has occurred. As for those consumers who would reduce their consumption of chicken (or eggs), the proportion of

their original consumption levels are recorded and thus the response variable would only vary within a limited range, stimulating the usage of the censored regression model (Tobit model) for analyses.

The conventional Tobit model (Tobin, 1958) is adopted to analyze our hypothetical consumption changes of chicken (or eggs) as though outbreaks of avian influenza would have occurred in Taiwan. Originally, the Tobit model is formulated with one threshold of zero. Following Greene (2003), we modify the Tobit model by incorporating two thresholds (i.e., 0 and 1), since our data consist of a nontrivial proportion of respondents who would stop eating chicken (or eggs) or would remain at the same consumption level (both descriptive statistics will be discussed later). Suppose the demand for chicken (or eggs), proportional to the current consumption level, can be expressed in terms of a latent variable:

$$y_i^* = x_i\beta + u_i, \text{ where } u_i | x_i \sim N(0, \sigma_u^2) \quad (1)$$

where  $y_i^*$  means the latent demand for chicken (or eggs) of consumer  $i$ ,  $x_i$  represents the explanatory variables of consumer  $i$ , and its error term  $u_i$  has an conditional normal distribution with zero mean and variance  $\sigma_u^2$  given  $x_i$ ;  $\beta$  indicates the corresponding parameters to be estimated and also represents the marginal impact of  $x_i$  on the expectation of  $y_i^*$ . The observed dependent variable ( $y_i$ ) can be expressed as:

$$y_i = \begin{cases} 1 & \text{if } y_i^* \geq 1 \\ y_i^* & \text{if } 0 < y_i^* < 1 \\ 0 & \text{if } y_i^* \leq 0 \end{cases} \quad (2)$$

where  $y_i$  contains zeros for no demand for chicken (or eggs), ones for keeping the same demand for chicken (or eggs), or  $y_i^*$ , a proportion of the original demand for chicken (or eggs) if an AI outbreak should occur.

The maximum likelihood estimation (MLE) is utilized to obtain the parameter estimates. The log likelihood function is expressed as:

$$\begin{aligned} \ell(\beta, \sigma_u^2) = \sum_{i=1}^n \{ & I(y_i = 1) \cdot \ln[1 - \Phi((1 - x_i\beta) / \sigma_u)] + I(y_i = 0) \cdot \ln[\Phi(-x_i\beta / \sigma_u)] \\ & + I(0 < y_i < 1) \cdot \ln[\phi((y_i - x_i\beta) / \sigma_u) / \sigma_u] \} \end{aligned} \quad (3)$$

where  $I(\cdot)$  is an indicator function, such that  $I(\cdot) = 1$  if its argument is true and zero otherwise;  $\phi(\cdot)$  and  $\Phi(\cdot)$  are the probability density function (PDF) and the cumulative distribution function (CDF) of a standard normal distribution, respectively.

The interpretation of the censored regression model is not straightforward. The model combines the regression model for  $E(y_i | 0 < y_i < 1, x_i)$  and probabilities of both  $y_i = 0$  (not eat at all) and  $y_i = 1$  (remain unchanged); therefore, a change in explanatory variables has two effects: one is an effect on the probability of  $y_i$  being observed; the other is an effect on the mean of  $y_i$ , given that it is observed. According to McDonald and Moffitt (1980) and Wooldridge (2002, 2006), marginal effects of  $x_{ij}$ , the associated regressor  $j$  for consumer  $i$ , on both probabilities and expectations can be derived and expressed as:

$$\partial P[y_i = 0 | x_i] / \partial x_{ij} = \partial \Phi[-x_i \beta / \sigma_u] / \partial x_{ij} = -(\beta_j / \sigma_u) \cdot \phi[x_i \beta / \sigma_u] \quad (4)$$

$$\partial P[y_i = 1 | x_i] / \partial x_{ij} = \partial \{1 - \Phi[(1 - x_i \beta) / \sigma_u]\} / \partial x_{ij} = (\beta_j / \sigma_u) \cdot \phi[(1 - x_i \beta) / \sigma_u] \quad (5)$$

$$\partial P[y_i = y_i^* | x_i] / \partial x_{ij} = (\beta_j / \sigma_u) \cdot \{\phi[x_i \beta / \sigma_u] - \phi[(1 - x_i \beta) / \sigma_u]\} \quad (6)$$

$$\begin{aligned} \partial E[y_i | 0 < y_i < 1, x_i] / \partial x_{ij} = & \beta_j \cdot \left\{ 1 - \left[ \frac{\phi[x_i \beta / \sigma_u] - \phi[(1 - x_i \beta) / \sigma_u]}{\Phi[(1 - x_i \beta) / \sigma_u] - \Phi[-x_i \beta / \sigma_u]} \right]^2 \right. \\ & \left. + \frac{[-x_i \beta / \sigma_u] \cdot \phi[x_i \beta / \sigma_u] - [(1 - x_i \beta) / \sigma_u] \cdot \phi[(1 - x_i \beta) / \sigma_u]}{\Phi[(1 - x_i \beta) / \sigma_u] - \Phi[-x_i \beta / \sigma_u]} \right\} \quad (7) \end{aligned}$$

$$\partial E[y_i | x_i] / \partial x_{ij} = \beta_j \cdot \{\Phi[(1 - x_i \beta) / \sigma_u] - \Phi[-x_i \beta / \sigma_u]\} \quad (8)$$

where  $P[\cdot]$  and  $E[\cdot]$  represent probability and expectation functions, respectively. Marginal effects of changes in  $x_{ij}$  on probabilities can be depicted by equations (4) to (6); marginal effects on the expectation levels are captured by equations (7) and (8).

Equations (4) and (5) present the impact of changes in  $x_{ij}$  on the probabilities of no consumption of chicken (or eggs) and of remaining at the same level of chicken (or egg) consumption, respectively. It is obvious that the sign revealed from equation (4) is opposite to the sign of  $\beta_j$  but that from equation (5) is consistent to the sign of  $\beta_j$ . That is to say, the sign of the estimated parameters is coincident to the sign of the marginal effects on the probability of keeping the same consumption level but contrast to the marginal effects on the probability of no eating of chicken (or eggs). However, in equation (6), the impact of  $x_{ij}$  on the probability of reducing consumption levels depends on the difference between the two PDFs. Equation (7) shows the conditional effects of the changing  $x_{ij}$  to the marginal changes of reducing consumption levels; nevertheless, the impact seems quite complicated. As to the marginal effect of the changes in  $x_{ij}$  on the mean of all respondents, equation (8) shows that the marginal effect of the  $x_{ij}$  on the unconditional expectation can be decomposed into two parts:  $\beta_j$  and the

difference of two CDFs. Due to the fact that  $0 \leq \Phi[-x_i\beta/\sigma_u] \leq \Phi[(1-x_i\beta)/\sigma_u] \leq 1$ , marginal effects in equation (8) would always be less than  $\beta_j$ . We will estimate these marginal effects and discuss them later.

### 3. Data

A consumer survey, using face-to-face interviews, was administrated in metropolitan areas in Taipei, Taichung, and Kaohsiung, Taiwan, in early September 2007. Responses were drawn by using a stratified sampling scheme to generate the survey data representing the population distribution of gender and age classes at the end of June 2007. Two types of respondents are included in this study, i.e., primary household food shoppers and general consumers. According to Hsu and Liu (2000) and Hsu and Lin (2006), the sampling scheme of primary shoppers was adjusted to reveal the fact that primary household food shoppers in Taiwan are mainly females (approximately 80%). On the basis of findings in the literature and discussions with professionals and practitioners, each questionnaire was constructed to include three sections. In the first section, knowledge of, risk perception of, and preparedness for the avian influenza were included; food safety, food labeling, and changes in consumers' buying behavior if a potential AI outbreak should occur were asked in the second part; and the final section was composed of demographic and socio-economic information of the respondent.

Personal interviews were conducted at various places, such as parks, train stations, university campuses, hospitals, traditional markets and supermarkets, in three metropolitan areas to ensure the diversity of respondents. Primary shoppers were identified as those who were mainly in charge of buying and preparing food for the family, had purchased fresh poultry products and had heard of avian influenza; whereas general consumers were those who had heard of AI but were not primary shoppers. A gift, worth about one USD, was provided to each participant. It took approximately 25 minutes to answer all of the questions in the questionnaire. In addition, a trained surveyor would assist the respondent by explaining the questions but would not interfere by providing personal judgments, especially in the section about knowledge and risk perception. In total, there were 501 valid samples out of 525 surveyed respondents of primary shoppers and 505 out of 535 of general consumers.

Demographic and socio-economic characteristics of respondents are listed in Table 1. As for primary shoppers, since gender was controlled to reflect the population, our sample shows that about 80% of the respondents were females. In addition, approximately 75% of the respondents were married and almost one third were housewives. On the other hand, gender was almost evenly distributed in the group of general consumers; less than 60% were married

and only 12.4% were housewives. The mean age of respondents for both groups was close to 39 years old, with an average of 3.8 persons per household. As to education level of the participants, more than half of the respondents in both groups had a college education. Our data shows that a relatively large portion of the population in these three metropolitan areas possesses a relatively high education level in general and those with higher educational levels were the ones who were willing to participate in the consumer survey. Nevertheless, the distribution of occupations in both groups is similar, except primary shoppers were more likely to be housewives whereas more students interviewed were general consumers. The average monthly household income was 64,990 NTD (about 1,970 USD) for primary shoppers and 77,108 NTD (about 2,335 USD) for general consumers.

**Table 1. Demographic and socio-economic characteristics of respondents**

Characteristic	Primary shoppers (n=501)	General consumers (n=505)
Gender (%)		
Male	19.96	47.92
Female	80.04	52.08
Marriage (% , married)	74.25	58.81
Average age (in years)	39.35	38.35
Educational level (%)		
Junior high school or less	7.03	7.95
Senior high school	30.72	22.47
College	52.41	54.27
Graduate school	9.84	15.31
Occupation (%)		
Public sector <sup>a</sup>	11.29	15.00
Industrial sector	8.07	11.60
Business sector	25.40	24.80
Housewives	32.86	12.40
Students	5.85	15.80
Others <sup>b</sup>	16.53	20.40
Average monthly household income (NTD <sup>c</sup> )	64,989.82	77,108.43
Average household size (in persons)	3.76	3.87

Note: n= sample size.

<sup>a</sup>. Public sector includes military, government, or educational institutions.

<sup>b</sup>. agricultural sector is included.

<sup>c</sup>. Household income is measured by New Taiwan Dollars.

#### 4. Empirical Results

Our empirical results are discussed as follows. First, we make a comparison of knowledge levels and risk perceptions between the primary shoppers and general consumers. Next, we compare the changes in purchasing behavior for chicken and eggs by both high and low knowledge levels and risk perceptions, respectively. Finally, parameter estimation from the

modified censored regression model is presented followed by a discussion of their marginal effects.

#### 4.1 Comparison of knowledge levels and risk perceptions

Table 2 presents the percentage of correct answers about AI knowledge for both primary shoppers and general consumers, respectively. Similar to the Eurobarometer study (2006), both groups of consumers in Taiwan answered the statement ‘if a chicken is contaminated by avian influenza on a farm, all the poultry on that farm must be destroyed immediately’ with the highest percentage of correct answers, with the accuracy rate of 92.22% for primary shoppers and 91.02% for general consumers. However, the highest inaccurate rate in answering the knowledge questions came from the question ‘it is not dangerous to eat the meat of a chicken vaccinated against avian influenza,’ with only a 36.13% and 37.62% accuracy rate for primary shoppers and general consumers, respectively. Among these seven statements, the accuracy rates for both groups were not statistically different except for two questions related to transmission of the H5N1 virus between humans and the elimination of the virus via thorough cooking, namely, the correctness of answers of the primary shoppers is statistically lower than that of the general consumers in these two questions. Our conjecture is that primary shoppers are mostly housewives who are more likely to be risk-averse and more conservative and thus, compared with general consumers, primary shoppers may not fully trust the information released in the news resulting in a lower percentage answering both statements correctly.

**Table 2. Percentage of correct answers to each statement of AI knowledge**

Statement <sup>a</sup>	Primary shoppers (n=501)	General consumers (n=505)	t-statistic
The avian influenza virus cannot be easily transmitted between humans.	54.49	61.19	-2.15**
Even when it is contaminated, poultry is not a health risk if it is thoroughly cooked.	55.29	62.38	-2.29**
Humans can catch avian influenza by touching contaminated birds.	87.82	86.73	0.52
The vaccination against seasonal influenza is not effective against avian influenza.	61.48	64.36	-0.94
The avian influenza virus contained in an egg or present on its shell can be eliminated by prolonged cooking.	46.91	50.10	-1.01
If a chicken is contaminated by avian influenza on a farm, all the poultry on that farm must be destroyed immediately.	92.22	91.09	0.65
It is not dangerous to eat the meat of a chicken vaccinated against avian influenza.	36.13	37.62	-0.49

Note: \*\* indicates p-value < 0.05; n= sample size.

<sup>a</sup> Questions are adopted from Eurobarometer (2006).

Table 3 shows six scores for each of the AI risk perception questions asked in the questionnaire.<sup>1</sup> The average scores of both primary shoppers and general consumers are calculated separately and compared using a *t*-statistic. Generally, the results show that primary shoppers are more conservative than general consumers since most scores are higher for primary shoppers, especially concerning the four risk items: (1) risk of AI infection from traveling to areas with AI outbreaks, (2) risk of AI infection from purchasing wild or smuggled live birds, (3) risk of AI infection from eating poultry that is not thoroughly cooked, and (4) risk of AI infection from eating eggs that are not thoroughly cooked.

**Table 3. AI risk perception scores by consumer types**

Item <sup>a</sup>	Primary shoppers (n=501)	General consumers (n=505)	<i>t</i> -statistic
Risk of AI infection from visiting slaughter houses and live bird markets	11.38	11.18	0.97
Risk of AI infection from touching live birds and their droppings with bare hands	12.34	11.96	1.86*
Risk of AI infection from purchasing wild or smuggled live birds	12.24	11.74	2.37**
Risk of AI infection from traveling to areas with AI outbreaks	12.29	11.76	2.52**
Risk of AI infection from eating not thoroughly cooked eggs	11.34	10.73	2.91***
Risk of AI infection from eating not thoroughly cooked poultry meat	11.74	11.09	3.20***

Note: \* indicates p-value < 0.10; \*\* indicates p-value < 0.05; \*\*\* indicates p-value < 0.01. n= sample size.

<sup>a</sup> Score of risk measure was calculated using product of possibility of happening and severity if happened for each observation.

## 4.2 Comparison of buying behavioral changes

From the comparisons of knowledge and risk perception levels, it is obvious that general consumers seem to have a better understanding of AI knowledge, whereas primary shoppers are more risk-perceptive. In order to examine how consumers' behavior would change, we make a brief comparison by using a chi-square test. Under potential AI outbreak threats, the behavior changes between primary shoppers and general consumers are different. Table 4 presents the proportion of buying behavior of both chicken and eggs. In the upper panel, 43% of primary

<sup>1</sup> Following Hsu *et al.* (2008), risk perception is measured by two sets of four-point Likert scales, including the possibility of happening and severity if AI happened. Each set of the Likert scale is measured from one to four, and then the score for each risk statement is measured by a multiplication of the two scales, ranging from 1 to 16. The variable *Risk\_perception* is measured by a sum of the scores from six risk statements, and therefore, it varies between 6 and 96.

shoppers would not eat chicken at all compared to 28.23% of general consumers. The chi-square test statistics also show the same results, which indicates that the behavioral changes between primary shoppers and general consumers are statistically different. As to eggs, results in the lower panel show that more primary shoppers than general consumers would still not consume eggs at all, with the chi-square test statistic indicating a significant difference.

**Table 4. Proportion of buying chicken and eggs under potential AI outbreak threats**

Changing situation	Primary shoppers	General consumers	$\chi^2$
Chicken (n=987)			28.63***
Not eat at all	42.97	28.23	
Reduce	39.31	43.14	
Remain unchanged	17.72	28.63	
Eggs (n=986)			6.74**
Not eat at all	24.29	18.70	
Reduce	43.93	42.89	
Remain unchanged	31.78	38.41	

Note: \*\* indicates p-value < 0.05; \*\*\* indicates p-value < 0.01; n= sample size.

Additionally, we attempt to examine differences in behavioral changes by knowledge levels and risk perceptions. Data were classified by high and low levels of knowledge and risk perceptions.<sup>2</sup> The results are presented in Tables 5-6. In Table 5, using chi-square tests, comparisons among the two types of consumers by knowledge levels show that there seems to be no difference in proportion of buying behaviors between low and high knowledge levels, except for primary shoppers of chicken. However, Table 6 reveals that consumers' purchasing behaviors are statistically different between low and high risk perceptions. Regardless of the products chosen (either chicken or eggs) between primary shoppers and general consumers, risk perceptions seem to play a critical role in behavioral changes since more risk-perceptive consumers would react stronger to lethal diseases in order to keep from becoming infected. Later, the modified censored regression model is used to evaluate again the impacts of knowledge and risk perceptions on changing purchasing behavior.

<sup>2</sup> According to the medians of the knowledge levels of the two consumer types, primary shoppers and general consumers, data were classified into high and low groups.

**Table 5. Proportion of buying chicken and eggs under potential AI outbreak threats by types of consumers and knowledge levels**

Chicken:	Primary shoppers (n= 491)		General consumers (n= 496)	
	Low knowledge	High knowledge	Low knowledge	High knowledge
Changing situation				
Not eat at all	45.58	40.75	30.05	26.96
Reduce	32.74	44.91	38.42	46.42
Remain unchanged	21.68	14.34	31.53	26.62
$\chi^2$ test statistic	8.96**		3.19	

  

Eggs:	Primary shoppers (n= 494)		General consumers (n= 492)	
	Low knowledge	High knowledge	Low knowledge	High knowledge
Changing situation				
Not eat at all	24.67	23.97	19.40	19.21
Reduce	42.73	44.94	39.80	45.02
Remain unchanged	32.60	31.09	40.80	36.77
$\chi^2$ test statistic	0.25		1.35	

Note: \*\* indicates p-value < 0.05; n= sample size.

**Table 6. Proportion of buying chicken and eggs under potential AI outbreak threats by types of consumers and risk perceptions**

Chicken:	Primary shoppers (n= 491)		General consumers (n= 496)	
	Low risk perception	High risk perception	Low risk perception	High risk perception
Changing situation				
Not eat at all	37.78	47.37	27.00	29.61
Reduce	40.00	38.72	35.74	51.50
Remain unchanged	22.22	13.91	37.26	18.89
Test statistic: $\chi^2$	7.41**		21.99***	

  

Eggs:	Primary shoppers (n= 494)		General consumers (n= 492)	
	Low risk perception	High risk perception	Low risk perception	High risk perception
Changing situation				
Not eat at all	22.12	26.12	16.86	20.78
Reduce	40.71	46.64	35.63	51.08
Remain unchanged	37.17	27.24	47.51	28.14
Test statistic: $\chi^2$	5.59*		19.80***	

Note: \* indicates p-value < 0.10; \*\* indicates p-value < 0.05; \*\*\* indicates p-value < 0.01.  
n= sample size.

### 4.3 Estimates of the modified censored regression model

Excluding those who do not consume chicken (or eggs) regularly, observations of the two types (primary shoppers and general consumers) are pooled to increase the representativeness of

the analysis. Several factors, such as knowledge levels about AI, risk perception scores, and socio-economic characteristics, were included in the modified censored regression models of chicken and eggs, respectively. In this study, our model specification for equations of chicken and eggs is constructed as:

$$\begin{aligned}
 x_i\beta = & \beta_0 + \beta_1 \cdot Risk\_perception + \beta_2 \cdot Knowledge + \beta_3 \cdot Male + \beta_4 \cdot Married \\
 & + \beta_5 \cdot Age + \beta_6 \cdot Senior + \beta_7 \cdot College + \beta_8 \cdot Graduate + \beta_9 \cdot Public \\
 & + \beta_{10} \cdot Business + \beta_{11} \cdot Housewife + \beta_{12} \cdot Income + \beta_{13} \cdot HS + \beta_{14} \cdot Shopper \quad (9)
 \end{aligned}$$

Definition of the explanatory variables and their expected signs are presented in Table 7. As indicated earlier, consumers who are more risk perceptive would stop eating chicken (or eggs) or reduce consumption levels; therefore, the variable *Risk\_perception* would expect to negatively affect the demand for chicken (or eggs), should AI outbreaks occur in Taiwan. In contrast, people with more correct knowledge about AI would understand how to correctly cook chicken (or eggs) and thus would not choose to reduce or stop eating them; hence, the expected sign is positive. In addition, female, elderly, and married consumers would expect to behave conservatively; therefore, the dummy variable of gender (*Male*) would positively impact the demand for chicken or eggs but the dummy variable of married people (denoted by *Married*) and the continuous variable *Age* would negatively influence the demand for chicken (or eggs). Since chicken and eggs are normal goods, income is presumed to positively affect the demand for chicken and eggs. As to the dummy variable of primary household food shoppers, since they play a crucial role of taking care of the nutritional needs of all family members, it is expected that they would be more conservative and thus the expected sign should be negative. As to dummy variables for education levels and vocations of the respondents, we use the education level less than or equal to junior high school as a reference group; as to occupation, only three dummy variables are used and thus those occupations not in the public or business sectors nor housewives are treated as a reference group. Their impacts on demand for chicken and eggs are not presumed to be positive or negative.

**Table 7. Definition of the explanatory variables**

Variable	Definition	Expected sign
Risk_perception	Scores of risk perception, ranging from 6 to 96.	–
Knowledge	Knowledge level, ranging from 0 to 7.	+
Male	Male=1; Female=0	+
Married	Married=1; else=0	–
Age	Ages in years	–
-----		
Education level <sup>a</sup>		
Senior	Highest education level is senior =1; else=0	?
College	Highest education level is college =1; else=0	?
Graduate	Highest education level is graduate =1; else=0	?
-----		
Vocations <sup>b</sup>		
Public	Occupation in public sector =1; else=0	?
Business	Occupation in business sector =1; else=0	?
Housewife	Housewife=1; else=0	?
-----		
Income	Monthly income of a family in NTD	+
HS	Household size in persons	+
Shopper	Primary shopper=1; general consumer=0	–

Note: <sup>a</sup>. Reference group: education level less than or equal to junior high school.

<sup>b</sup>. Reference group: other vocations which are not specified as public, business, and housewife.

The parameters are estimated using the MLE; the estimates of the censored regression models for chicken and eggs are revealed in Table 8. There were totally 968 valid observations for chicken included in the estimation (and 967 observations for eggs). If Taiwan happened to have AI outbreaks, among 968 respondents, 344 of them would choose “not to eat chicken at all,” i.e.,  $y_i = 0$ ; whereas 225 observations would remain unchanged in their chicken consumption ( $y_i = 1$ ). However, as to changes in egg consumption, only 205 out of 967 consumers would choose not to eat eggs if AI outbreaks occurred in Taiwan; 341 respondents would remain the same. As to the goodness of fit of the models, the pseudo R-squared statistics of chicken and eggs are 0.0659 and 0.0537, respectively; it is reasonably low when large-scale cross-sectional data are used. The likelihood ratio (LR) test statistics are 135.21 for the chicken equation and 107.89 for the egg equation, respectively, indicating that model specifications are statistically significant.

**Table 8. Parameter estimates of the censored regression model**

Variable	Chicken		Eggs	
	Coef.	S.E.	Coef.	S.E.
Risk_perception	-0.007***	0.002	-0.006***	0.002
Knowledge	0.022	0.026	0.050**	0.025
Male	0.148**	0.068	0.091	0.064
Married	-0.248***	0.084	-0.115	0.079
Age	-0.016***	0.004	-0.018***	0.003
Senior	-0.114	0.118	0.005	0.110
College	-0.223*	0.121	-0.149	0.113
Graduate	-0.219	0.146	-0.077	0.138
Public	-0.098	0.096	-0.179**	0.090
Business	-0.108	0.075	-0.096	0.071
Housewife	-0.149*	0.090	-0.116	0.084
Income	0.009	0.007	0.010	0.007
HS	0.018	0.021	0.022	0.020
Shopper	-0.155**	0.061	-0.024	0.057
Constant ( $\beta_0$ )	1.687***	0.248	1.792***	0.232
Scale ( $\sigma_u$ )	0.799***	0.034	0.755***	0.031
Pseudo R <sup>2</sup>		0.0659		0.0537
LR test statistic		135.21***		107.89***
Total observations		968		967
Observations of $y = 0$		344		205
Observations of $y = 1$		225		341

Note: \* indicates p-value < 0.10; \*\* indicates p-value < 0.05; \*\*\* indicates p-value < 0.01.

Coefficient estimates, including their standard error, are reported in Table 8. In addition, parameter estimates of the standard deviation  $\sigma_u$  of the normal distribution for chicken and eggs (in equation 1) are expressed under the variable *Scale*. Most of the coefficients have the expected signs and some of them are statistically significant. Parameter estimates for chicken and egg equations are almost of the same signs except for the dummy variable of respondents with a diploma of senior high school; however, both coefficients are insignificant. Among all explanatory variables, risk perception and age are the important factors because both are statistically significant in each equation; moreover, they are negative, as expected. The estimated coefficients represent the marginal effect of changing the explanatory variable to the expected value of the latent variable  $y_i^*$  ( $\partial E(y_i^* | 0 < y_i^* < 1, x_i) / \partial x_j$ ). However, since the latent

variable is not observable, the meaning of this marginal effect should not be overstated. Meaningful impact can be calculated by using the equations (4)–(8) as indicated in the previous section.

Risk perception has a negative impact on the demand for chicken and eggs, as expected, indicating that consumers are more likely to be risk-averse. As to knowledge, a positive sign of the coefficient estimates indicates that the more knowledge a consumer has about AI, the more likely he/she is to continue purchasing and eating chicken and eggs in case an AI outbreak would have occurred; however, this effect is statistically significant in the egg equation but not in the chicken equation. Another important factor is age, which also has a negative influence on demand for chicken and eggs, meaning that the older the consumers, the less the demand for chicken and eggs. Male respondents are usually more tolerant to severe epidemic outbreaks like AI; hence, the coefficients are positive and statistically significant in the chicken equation. In addition, parameter estimates of married respondents, housewives, and primary food shoppers are all statistically negative, revealing that these characteristics would reduce chicken demand in case an AI outbreak would have occurred. As to eggs, the impacts of the former factors are insignificant. Some of the dummy variables of education or vocation such as *College* and *Public* are statistically significant but not all of them; hence, we used an F-test to examine whether education and vocational dummies are important factors in the censored regression models. Unfortunately, the F-test statistics of education and vocation for the chicken equation are 1.42 and 1.21, respectively, and 1.83 and 1.62 for the egg equation; all of them are not statistically significant.

#### **4.4 Marginal effects for chicken and eggs**

Marginal effects cannot be adequately explained from the estimated coefficients of the censored regression models as explained earlier. The effects of changes in explanatory variables on probabilities of the three situations and the expected values of the demand for chicken and eggs can be calculated according to equations (4)–(8). The estimated marginal effects for chicken and eggs are presented in Tables 9 and 10, respectively. Standard errors of the estimated marginal effects are calculated at the mean values of the explanatory variables by using the delta method; they are not explained exclusively for simplicity. However, we use conventional p-values to indicate their statistical evaluation.

**Table 9. Marginal effects for chicken**

Variable	Probability of			Expectation of	
	Not eat at all	Reduce	Remain unchanged	Conditional	Unconditional
Risk_perception	0.003***	-0.001***	-0.002***	-0.001***	-0.003***
Knowledge	-0.010	0.002	0.008	0.003	0.010
Male	-0.066**	0.011**	0.055**	0.018**	0.068**
Married	0.109***	-0.016***	-0.093***	-0.031***	-0.115***
Age	0.007***	-0.001	-0.006***	-0.002***	-0.007***
Senior	0.052	-0.012*	-0.040	-0.014	-0.052
College	0.100*	-0.019	-0.081*	-0.028*	-0.103*
Graduate	0.103	-0.030	-0.073*	-0.027	-0.099
Public	0.045	-0.011	-0.034	-0.012	-0.045
Business	0.050	-0.012	-0.038	-0.013	-0.050
Housewife	0.069	-0.017	-0.052*	-0.018*	-0.068*
Income	-0.004	0.001	0.003	0.001	0.004
H-size	-0.008	0.002	0.007	0.002	0.008
Shopper	0.070**	-0.014**	-0.056**	-0.019**	-0.071**

Note: \* indicates p-value < 0.10; \*\* indicates p-value < 0.05; \*\*\* indicates p-value < 0.01.

**Table 10. Marginal effects for eggs**

Variable	Probability of			Expectation of	
	Not eat at all	Reduce	Remain unchanged	Conditional	Unconditional
Risk_perception	0.002***	0.001***	-0.003***	-0.001***	-0.003***
Knowledge	-0.018**	-0.007*	0.025**	0.007**	0.024**
Male	-0.031	-0.014	0.044	0.012	0.043
Married	0.039	0.018	-0.057	-0.016	-0.055
Age	0.006***	0.003***	-0.009***	-0.002***	-0.009***
Senior	-0.002	-0.001	0.002	0.001	0.002
College	0.051	0.021	-0.072	-0.020	-0.071
Graduate	0.028	0.009	-0.037	-0.011	-0.037
Public	0.067*	0.016***	-0.084**	-0.025**	-0.087**
Business	0.034	0.012	-0.046	-0.013	-0.046
Housewife	0.042	0.014*	-0.055	-0.016	-0.056
Income	-0.002	-0.001	0.002	0.001	0.002
H-size	-0.007	-0.003	0.010	0.003	0.010
Shopper	0.008	0.003	-0.012	-0.003	-0.012

Note: \* indicates p-value < 0.10; \*\* indicates p-value < 0.05; \*\*\* indicates p-value < 0.01.

This modified censored regression model can provide us two marginal effects of the impact of explanatory variables: probabilities and expected values. Table 9 presents the marginal effects for chicken. Risk perception, gender, marriage status, age, education, housewife, and primary shoppers have a significant effect on probabilities and the expected

values of demand for chicken. To be more specific, if AI outbreaks occur in Taiwan, married consumers would increase about 10.9% in probability not to eat chicken at all over not-married consumers; college-graduated and above consumers are more likely not to eat chicken at all than consumers possessing a lower education level. A male consumer would have a 5.5% probability more than a female consumer to maintain the same consumption patterns, and a primary household food shopper would have 7% more probability not to eat chicken than general consumers.

As to the impact on the changes of demand for chicken, the conditional expectations are relatively small, ranging from -3% to 2% of its original consumption. However, the impact of the selected explanatory variables on the unconditional expectations of demand for chicken reveals several interesting findings. First, among all those significant factors, married consumers would reduce, on average, 11.5% of their current consumption level compared to non-married consumers; consumers with college degrees would decrease 10.3% compared with consumers with educational levels of junior high school or less. In addition, primary food shoppers would reduce their current consumption of chicken, on average, by 7% less than general consumers. Housewives and female consumers would reduce their consumption of chicken by about 6.8% compared to consumers in other occupations and to male consumers. Finally, every increase in the risk perception score would reduce the demand for chicken, on average, 0.3%; but as the knowledge level increases, the demand for chicken increases by 2.4%, on average, even though it is not statistically significant.

Similarly, the same explanatory variables were used to fit the egg equation; the empirical results turn out to be slightly different. In Table 10, *Risk\_perception* and *Age* are still the variables, which are statistically significant, along with *Knowledge* and *Public*. As to the marginal effect on probability, people working in the public sector would increase their probability of no consumption of eggs by 6.7% compared with consumers in other occupations. Housewives, compared to other types of occupations, would increase the probability of reducing their egg consumption by 1.4%. In addition, the unconditional marginal effects of knowledge show that, with an increment of consumers' scores on knowledge, their egg consumption would increase 2.4% from their original consumption level; however, an increment of age, on the contrary, would drop about one percent of their current egg consumption. Finally, different from the results of the chicken equation, types of respondents (whether they were primary shoppers or general consumers) are not critical; their coefficients and marginal effects are not statistically significant.

## 5. Conclusions

The zoonosis of the H5N1 avian influenza has raised concerns of food safety and most consumers worldwide would choose not to remain at their usual consumption level of chicken and eggs, thus shrinking the market size for the poultry industry. Unfortunately, the potential impact of the avian influenza threat on the behavioral changes in consuming chicken and eggs has not been thoroughly discovered. Our study attempted to close this gap by providing a better understanding from a consumers' perspective, i.e., we constructed a modified censored regression model to identify the most profound factors and thus to estimate their marginal effects. Utilizing the large-scale cross-sectional data in Taiwan, our empirical results show that risk perceptions about AI, knowledge of AI and some socio-demographic characteristics are important factors, revealing valuable information for policy makers in several aspects.

First, risk perceptions would play a key role in determining consumers' behavioral changes, in our case, for chicken and eggs; in other words, consumers' potential reactions to the AI outbreak threats are heavily influenced by their risk perceptions, which is in substantial agreement with the BSE study in Schroeder *et al.* (2007). Similar to the results revealed from the student survey in Gstraunthaler and Day (2008) and household survey in Goktolga and Gunduz (2008) and Hsu *et al.* (2008), our findings reinforce that the higher the risk perceptions, the more likely consumers would choose not to consume chicken and eggs and the more quantity reduction. Therefore, policy makers should take proactive actions to reduce consumers' concerns of risk and strengthen consumers' confidence towards the food safety issue. This can be achieved with well-established public health education programs; however, policy makers may have to choose effective channels to release related information.

Second, it was anticipated that consumers' knowledge of avian influenza would have played a crucial role in reducing the adverse impact on the chicken and egg industry. Different from a significant negative effect of the AI information on poultry sales in Italy (Beach *et al.*, 2008), our empirical results confirmed that, *ceteris paribus*, consumers would reduce less of their original consumption levels of chicken and eggs if they possessed more correct knowledge of avian influenza; however, the potential impacts of consumers' AI knowledge on their behavioral changes in chicken seem to be not statistically significant. Our speculation about this insignificant finding is that, even though consumers with a better understanding of avian influenza would tend to be unafraid of purchasing chicken and eggs, the influence of knowledge on consumption changes could be diluted since the configuration of all AI information into practicable knowledge would take time to process and the related scientific research findings are sometimes mixed and complicated to interpret. Our findings still provide evidence to

support the importance of education programs about AI to strengthen consumers' knowledge which may find it helpful to reduce the damage in both the chicken and egg industries if a potential AI outbreak should happen; but how successful these education programs would be in order to enhance consumers' knowledge is beyond the scope of this study and may require more research.

Finally, some socio-economic factors, such as gender, age and consumer types (i.e., consumers belong to the group of primary household food shoppers or not), are influential in determining consumption changes if AI outbreaks would have happened. Compared with Goktolga and Gunduz (2006), our finding reinforces that age is one of the most important factors to explain consumption changes in chicken. They concluded that the percentage drop in chicken consumption would reduce as the age of consumers increased; however, our findings suggest that the likelihood of not eating chicken at all would increase and the quantity consumed in chicken would decrease as age increases, revealing slightly different results in both studies. Additionally, our findings reveal behavioral differences among heterogeneous consumer types. Therefore, these differences suggest that strategies should be developed with special focus on target consumers who are female, elderly and primary household food shoppers, in order to enhance consumer concerns on food safety and to reduce the damage to the poultry industry.

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