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Research Article

Application of Double Hurdle Model on Effects of Demographics for Tea Consumption in China

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The purpose of this study is to investigate the effects of demographic variables on tea consumption in China. A total of 12,745 samples collected from the China Health and Nutrition Survey in 2011 and a double hurdle model were used to analyze the effects of demographic variables on the extent of tea participation and consumption quantity for men and women. The results of this study indicate that the effects of demographic variables differ between genders in terms of tea participation decisions and consumption quantity decisions. For men, education, family size, region, and employment status were found to exert different effects on participation and consumption quantity decisions; for women, age, education, region, employment status, having elderly individuals in the home, and urbanization exerted different effects on their tea participation and consumption decisions. The most obvious difference between variables affecting men and women pertained to age, family size, and having elderly individuals in the home. The perspectives of each gender, coupled with the double hurdle model used in this study, offer important insights.

1. Introduction

Tea is one of the world's oldest plants, first discovered around 2700 BC [1, 2]. It is the second most popular beverage worldwide and boasts several benefits, including reduced incidence of human cancer, improved longevity, and increased likelihood of weight loss [3–7]. In the last few years, global tea consumption has increased sharply from 3.47 million tons in 2006 to 4.84 million tons in 2013 [8]. The main drivers behind this rapid growth include the proliferation of tea consumption and an increase in consumption quantity per capita. China, as the leading tea-producing country in the world, witnessed the fastest progression in tea consumption from 2006 to 2011 [9, 10]. Tea consumption in China has reached 1.61 million tons at a growth rate of 11.68% annually. Moreover, tea consumers in China have expanded from 0.384 billion to 0.424 billion, positioning China as the most important and largest potential tea market in the world [11].

Several factors have been found to influence tea consumption, including tea price, consumer income, and demographics. However, few studies, at least among those publicly available, have focused on demographic variables. A study by Watanabe demonstrated that age and household size significantly affected tea consumption in Japan [12]. Guan and Yang found that tea consumers living in urban areas of China were more likely to drink tea compared with consumers from rural areas [9]. The Food and Agriculture Organization of the United Nations has also emphasized the importance of distinguishing the effects of demographic variables on tea consumption in major tea markets.

Albisu described age, education, gender, income, employment, location, and geographical distribution as some of the demographic variables influencing tea consumption [13]. Individuals with more education may have a better understanding of the benefits of tea consumption to human health compared with less educated individuals, a finding that aligns with a study by Yen [14].

Angulo discovered that income is an important variable related to consumer demand for beverages, such that as family income increases, individuals tend to consume more beverages [15]. Similarly, the variable of employment status reflects economic well-being according to Yen [14]. A dual urban-rural structure also influences tea consumption; urban and rural locations shape the availability of many commodities in China, with people residing in urban areas having more opportunities to drink tea. The variable of region, as a strong proxy for regional price patterns, can reflect different living standards and tea-drinking culture in China. Finally, a clear distinction exists regarding gender-based tea consumption in major countries, providing evidence that the gender should be addressed when analyzing tea intake [12, 16]. Notably, the aforementioned literature came to inconsistent conclusions regarding data collection methodologies and sources, and the results should therefore be interpreted cautiously.

Studies on tea consumption have commonly employed a logistics model using the status of drinking tea (yes or no) as a dependent variable. However, tea consumption involves two-step decisions, namely, a tea participation decision (whether to consume) and a consumption quantity decision (how much to consume). Neglecting this two-step decision process may hamper understanding of true behavioral patterns and lead to erroneous conclusions [17]. Moreover, the determinants behind each of these decisions are often distinct, similar to findings reported about alcohol consumption [18]. To develop and propose policies to promote tea consumption, either by expanding the number of consumers or by increasing consumption per capita, the studies must examine the effects that demographic variables have on tea participation decisions and consumption quantity decisions. As noted earlier, another empirical concern that has often been ignored in literatures is the role of gender. Gender has generally been used as an indicator variable; obvious differences in tea consumption between men and women have been observed, but scholars have yet to determine the specific demographic variables influencing differential consumption between genders. To address this problem, the double hurdle model has been used in this study to account for two-step decision regarding tea consumption.

The current study first separated all samples into men and women, to test the hypothesis that equal parameters exist in tea consumption for both genders. Next, the sample subgroups were used to investigate and compare the distinct effects of demographic variables on participation and consumption decisions. As the largest tea market in the world with the fastest growth in tea consumption, China was selected as the research setting to explore the effect of demographic variables on tea consumption.

2. Data and Methodology

All data used in this study were obtained from the Chinese Health and Nutrition Survey (CHNS), conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention. The survey was designed to examine changes in the health and nutritional status of Chinese people and to examine how the social and economic transformation of Chinese society has affected residents' health and nutritional status. The first round of CHNS data was collected in 1989. Nine additional datasets were collected in 1991, 1993, 1997, 2000, 2004, 2006, 2009, 2011, and 2015, respectively. The data presented in this study were extracted from the 2011 survey, which included Beijing, Shanghai, Chongqing, Jiangsu, Shandong, Liaoning, Hubei, Hunan, Henan, Heilongjiang, Guizhou, and Guangxi. In 2011, the populations in these 12 provinces and municipal cities accounted for 49.5% of the nation's population and varied substantially in geography, economic development, public resources, and health indicators. Therefore, the survey ensures broad representation and accurately reflects the nutritional and health status of Chinese citizens as a whole.

All information, such as household, individual economic status, and demographics, was collected through the survey. In addition to information on nutrition and health, the CHNS also captured beverage consumption and frequency. We gathered data on tea consumption specifically based on survey responses to items such as "How often did you drink tea during the past 30 days?" And "How many cups did you drink per day?" Because the survey did not address individual consumption, we needed to transform the data for the purpose of this study. Respondents' answers, which included "drink almost every day," "drink 4-5 times weekly," "2-3 times weekly," "no more than 1 time a week," "drink 2-3 times in the past 30 days," "only 1 time in the past 30 days," and "did not drink in the past 30 days" were rated as 30, 20, 12, 4.5, 2.5, 1, and 0.5, respectively. The figure was multiplied by the number of cups of tea consumed after dividing by 30 to obtain the total cups of tea a respondent drank daily. Only 40 respondents answered "did not drink in the past 30 days," most individuals indicated drinking at least one cup of tea during the past month, and the consumption calculations met the sample minimum in all samples; thus, respondents who had not drunk tea within the prior month had little bearing on the overall results.

Data analysis was based on a sample of 5,971 men and 6,774 women and a pooled dataset including all samples. Missing data and respondents younger than 18 years were omitted because of the low proportion of tea consumption in minors. As shown in Table 1, 3,016 of men and 1,892 of women reported drinking tea. The average cups of tea consumed for men was 1.65, and, conditional on tea consumption, the mean number of cups of tea consumed was 3.28 for men. Corresponding figures among women were 0.71 and 2.56. These statistics indicate that men tend to drink tea more frequently than women on average. Detailed definitions and sample statistics for all variables are presented in Table 1.

Upon examining cross-sectional data, we found that a large proportion of respondents (61.5%) reported consuming no tea. Generally, zero observations are based on infrequent purchases, a corner solution (i.e., consumers not buying tea at the current price and income levels), or abstention (consumers being unwilling to buy tea) [19]. If we

were to use an ordinary least squares model with all or only positive observations, results would be biased and some efficiency loss may follow [20]. The Tobit model proposed by Tobin and Goldberger could be applied to the corner solution under the assumption that zero observations were due to economic factors, but this approach would not explain zero observations caused by nonparticipation in consumption [21]. Cragg extended the Tobit model by allowing two-step decision, which in this case would include whether to consume tea as well as how much to consume; hence, zero observations could be caused by either nonparticipation in consumption or lack of demand [22]. Based on Cragg's double hurdle model, the following two hurdles must be overcome before obtaining positive consumption:

$$\begin{aligned} d_i^* &= z_i\alpha + u_i, \\ y_i^* &= x_i\beta + v_i, \end{aligned} \tag{1}$$

where d_i^* denotes latent participation, the value of d_i^* is 0 when consumer decides not to purchase and 1 otherwise, y_i^* denotes latent consumption, z_i is a vector of explanatory variables in the participation equation, x_i is a vector of explanatory variables in the consumption equation, and u_i and v_i are corresponding error terms in two equations distributed as follows:

$$\begin{aligned} u_i &\sim N(0,1), \\ v_i &\sim N\left(0,\sigma^2\right). \end{aligned} \tag{2}$$

Only if d_i^* and y_i^* are both positive, a positive consumption y_i can be observed. The probability of $y_i = 0$ is given by

$$P\left(y_i = 0\right) = \Phi\left(-z_i\alpha\right). \tag{3}$$

Then the density of y_i conditional on being positive is given under the assumption of a mean zero and variance σ^2 as follows:

$$f\left(\frac{y_i}{y_i} > 0\right) = \frac{\left\{1/\sigma\phi\left(\left[y_i - x_i\beta\right]/\sigma\right)\right\}}{\phi\left(\Phi\left(-x_i\beta\right)\right)}. \tag{4}$$

Thus, using the maximum likelihood estimation, a and u can be estimated using the Probit model to regress all samples. β and v can be estimated using a truncated normal estimator with all positive samples.

The motives behind tea participation and consumption quantity are highly complex. It is quite difficult to rationalize why one variable affects participation but not consumption quantity and vice versa. Therefore, we assume that all explanatory variables included in the equations for participation and consumption are identical. We must also extract the income variable from the participation equation, motivated by discrete random preference theory in which sample selection is determined exclusively by noneconomic variables.

3. Results and Discussion

To accomplish the aforementioned empirical results, we must first test the hypothesis that men and women are affected by the same factors. The *lrtest* command in Stata was used to perform a test of the null hypothesis that parameters are equal between men and women. The restricted log likelihood, based on all samples with a gender indicator variable, is −18030.305. The unrestricted log likelihood for men and women is −10357.408 and −7629.843, respectively. These results indicate that, for the samples in this study, the hypothesis that men and women are influenced by the same variables can be rejected. However, gender differences may be obscured if all samples incorporate a gender variable. Thus, we separated samples into men and women and conducted the following analysis based on respective gender results. In addition, the effects of continuous variables and dummy variables were different in the double hurdle model, suggesting that two kinds of variables should be analyzed separately.

According to the empirical results of the double hurdle model, the effect of education and income on tea consumption quantity was identical for men and women. With an increase of education and income, male and female tea consumers exhibited increased daily tea consumption as revealed in prior studies. For nonparticipation consumers, however, education demonstrated no significant effect on tea participation, implying that existing advertisements targeted at educated persons have failed.

Differences between factors affecting tea participation and consumption quantity for men and women are listed in Table 2. The variable of family size showed a negative and significant effect on tea participation, but a positive and significant effect on consumption quantity for men. By contrast, family size did not appear to affect consumption quantity for women, suggesting a lower likelihood of drinking tea for men, although the number of cups of tea consumed daily was found to grow in line with family size. Because the main household earner in Chinese society is traditionally the man, budgetary constraints will naturally increase for families as their household size expands. Relatedly, as the main decision makers for household expenditures, men may reduce their participation in tea consumption by allocating the family budget to other basic necessities. At the same time, however, those who consume tea may drink more cups with a large family. This trend could be explained by the addictive characteristics of tea. Another reason is that tea is consumed in almost every home in China. A large family correlates to a high probability of other family members drinking tea, and men may choose to participate in tea consumption when other family members are drinking tea.

The effect of age also differed between men and women. For men, age demonstrated a significant and positive effect on consumption quantity and tea participation, whereas age exerted a negative effect on tea participation and a positive effect on consumption quantity for women. These results suggest that older men and younger women are ideal target markets for the promotion of tea consumption.

While income has a positive effect on and is significantly correlated with tea consumption in men and women, different results emerge when calculating elasticity of demand. With an increase of 10,000 RMB, men and women would

Table 1: Variable definitions and sample statistics.

Variable	Definition	Men ($n = 5{,}971$)	Women ($n = 6{,}774$)
Dependence variable			
Cups	Number of cups of tea per day	1.65 (2.45)	0.71 (1.86)
	Consumption of cups of tea (3016 men, 1892 women)	3.28 (2.56)	2.56 (2.77)
Explanatory variable			
Age	Age in years	50.79 (15.24)	50.69 (15.48)
Income	Family annual income (10,000 RMB Yuan)	2.12 (3.01)	1.45 (2.17)
Education	Education in years	9.06 (3.88)	7.55 (4.65)
Home size	Family size	—	—
Employed	Is employed (yes = 1, no = 0)	0.67	0.49
East	Resides in eastern China (yes = 1, no = 0)	0.42	0.44
Center	Resides in the center of China (yes = 1, no = 0)	0.32	0.33
West	Resides in western China (reference) (yes = 1, no = 0)	0.26	0.23
City	Resides in city and urban area (yes = 1, no = 0)	0.60	0.59
Rural	Resides in rural area (reference) (yes = 1, no = 0)	0.40	0.41
Old	People above 60 years old living in the home (yes = 1, no = 0)	0.44	0.49

Note: standard deviations are reported in parentheses.

Table 2: Effects of continued demographic variable on tea consumption by different genders.

Variable	Men (log likelihood = −10457.573)				Women (log likelihood = −7713.383)			
	Consumption equation		Participation equation		Consumption equation		Participation equation	
Income	0.093***	4.70	—	—	0.159***	5.09	—	—
Age	0.020***	3.25	0.080***	8.75	0.054***	6.86	−0.070***	−3.71
Education	0.195***	10.38	−0.036	0.18	0.179***	8.55	−0.034	−1.01
Home size	0.168***	2.97	−0.098*	0.09	−0.070	−1.14	0.172	1.07
Constant	−3.243***	−6.36	−0.515	−1.11	−6.853***	−12.42	6.201***	3.75

*Significance at 10%. ***Significance at 1%.

consume 0.093 and 0.159 more cups of tea, respectively. By using mean income for men and women in this survey, the corresponding elasticity of demand is 0.073 and 0.117, respectively, indicating that women are expected to consume more cups of tea daily than men with the same degree of income growth.

The respective effects of all dummy variables were calculated and are presented in Table 3, which also displays different patterns based on gender. For instance, women who live with the elderly at home were found to be less likely to participate in tea drinking, but consume more cups of tea in terms of conditional tea consumption compared with women who did not live with the elderly. However, the *Old* variable had no effect on men. Women in China tend to devote more time to looking after the elderly at home and thus have little opportunity to brew tea; the major type of tea consumed in China is brewed tea, which requires time to make. On the other hand, the elderly are highly likely to drink tea, and women are therefore inclined to join in tea drinking when the elderly drink tea at home.

Being employed appears to contribute to the quantity consumed for women but makes no difference for men. No difference was observed in tea participation between men and women. Living in a rural area exerted a significant effect on daily consumption quantity for men, but not for women, consistent with findings that men in urban areas drink more cups of tea than women. We also found a positive effect of regional distribution on tea consumption. People living in the central or eastern parts of China drank more cups of tea than those living in the western region, presumably because residents of the central and eastern parts of the country earn higher salaries.

In summary, given the results of the continuous and dummy variables on tea consumption, the effects of demographic variables on consumption clearly differ between men and women, highlighting the importance of distinct gender analyses using subgroup samples.

Regarding demographic variables influencing tea consumption for men and women, the factors of age, family size, and having elderly people in the home affected each gender differently. As age increased, the potential to drink tea was higher for men but lower for women; the family size variable had a negative effect on tea participation and consumption decisions for men, but no effect on women. When living with the elderly at home, the probability of drinking tea decreased significantly for women, whereas consumption quantity in terms of conditional tea consumption increased. However, this variable had no effect on tea consumption for men. On the basis of different phases of tea consumption, the factors of education, family size, and employment status exerted different effects on tea participation and consumption decisions for men. The factors of age, education, region, employment status, living with elderly people in the home, and urbanization demonstrated different effects on tea participation and consumption decisions for women.

These results offer preliminary insights into how demographic variables influence tea consumption in two

Table 3: Effects of binary explanatory variables on tea consumption by different genders.

Variable	Men (log likelihood = −10457.573)				Women (log likelihood = −7713.838)			
	Consumption equation		Participation equation		Consumption equation		Participation equation	
Central	0.925***	2.93	−5.054	−0.05	1.651**	2.38	−13.977	−0.09
East	2.304***	9.63	−4.832	−0.05	2.741***	4.75	−14.010	−0.09
Job	0.076	0.42	−0.210*	−1.75	0.468*	1.82	−0.421***	−3.01
Old	0.143	0.90	−0.111	−1.14	0.507***	2.03	−0.336***	−2.80
Rural	0.547***	3.28	0.570***	4.97	0.083	0.29	0.993***	3.12
Constant	−0.428	−2.03	−1.477***	0.05	−3.751	−11.09	14.936	0.10

*Significance at 5%. ***Significance at 1%.

phases (i.e., tea participation and consumption). With the rapid development of the tea market, the market in China is expected to become increasingly segmented by gender and other demographic variables, underlining the need to develop appropriate marketing strategies by targeting custom markets rather than the tea market overall. The expansion of tea consumers and increase in consumption per capita should also be considered as two different avenues to expand tea consumption, and correspondingly distinct policies should be formulated.

4. Conclusions

In the present study, a double hurdle model was employed based on 12,745 responses gathered from the 2011 CHNS to investigate the different effects of demographic variables on tea consumption in China. The double hurdle model presented in this paper is a novel approach that, to the best of our knowledge, has not been utilized in extant literature regarding tea consumption. Estimates indicate that nearly 38.5% of consumers in this survey drank tea, with men being highly likely to drink tea and consume more cups of tea than women. The unique effects of demographic variables on tea consumption in China were therefore observed in men and women, in terms of their tea participation decisions and consumption quantity decisions. This study is not without limitations. For example, we used the cups of tea consumed as an explanatory variable, but we could not differentiate tea quality across different consumers even when they consumed equal quantities of tea. With an increase in income, consumers may choose to purchase and consume higher-quality tea that is more expensive, resulting in increased expenditures for tea consumption with no change in quantity.

Although the double hurdle model provides many useful findings and information in this study, other traditional mathematical models such as AIDS (Almost Ideal Demand System), ELES (Extended Linear Expenditure System), LES (Linear Expenditure System), and logistic models should be thoroughly considered and compared in the future. In addition, some other variables including tea consumption and their related tea healthy effects (antidiabetic, antiobesity, and anticancer) as well as the correlation between tea consumption and the incidence of diabetes, obesity, and cancer should be also considered for better understanding of the overall effects of demographics on tea consumption in China. To date, our current study shows that the tea-drinking habit has significantly negative correlation (−0.769) with BMI index for Chinese obese adults, and the tea-drinking amount has also negative effect (−0.02) on BMI for Chinese overweight adults. Some analyses are proceeding and are expected to complete in the future. Briefly, as elucidated in this research, the double hurdle model is a readily available and suitable approach for demographics.

Data Availability

The data generated and analyzed in this paper are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors' Contributions

All authors have contributed to the intellectual content of this paper. Lingwen Chen, Xi Guan, and Tzu-Hsing Ko conceived and designed the research. Jingying Zhuo, Munishi Gasper, Batoai Doan, and Hau Han collected data and performed the model analysis. Lingwen Chen and Tzu-Hsing Ko wrote the manuscript. Jiangfan Yang and Tzu-Hsing Ko provided many suggestions and revised this paper. All authors have read and approved the final manuscript.

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