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# Consumers' Intention and Cognition for Low-Carbon Behavior: A Case Study of Hangzhou in China

Yongliang Yang <sup>1,2</sup> , Yiyang Guo <sup>1,3</sup> and Suqing Luo <sup>4,\*</sup>

<sup>1</sup> School of Economics and Management, Zhejiang Sci-Tech University, Hangzhou 310018, China; royyang@zju.edu.cn (Y.Y.); 2016339901033@mails.zstu.edu.cn (Y.G.)

<sup>2</sup> Ecological Civilization Research Center of Zhejiang Province, Hangzhou 310018, China

<sup>3</sup> University of Chinese Academy of Social Sciences, Beijing 102488, China

<sup>4</sup> Department of Financial Accounting, Zhejiang Normal University, Jinhua 321004, China

\* Correspondence: lsq@zjnu.cn

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**Abstract:** The influencing factors of the low-carbon consumption behavior of urban residents have become popular. This paper explored the factors of consumers' low-carbon behavior through a questionnaire survey. Using Hangzhou as a case study city, which yields 786 valid responses, the results indicated that urban consumers generally had a high perception of low-carbon behavior. At the same time, low-carbon cognition and low-carbon intention had a positive impact on residents' low-carbon behavior. In particular, the level of awareness of global warming adjusted residents' understanding of low-carbon behavior. From a policy point of view, this research contributes to insights into the promotion of guiding residents' low-carbon behavior and improving the response to global warming.

**Keywords:** low-carbon cognition; low-carbon intention; low-carbon behavior

## 1. Introduction

In recent years, with the increase in residents' disposable income, the level of consumers' consumption has been similarly increasing year by year. Meanwhile, "conspicuous consumption," "hedonic consumption," and a series of unreasonable consumption ways of life have been generated [1,2]. The basic problem is consumerism—the belief that the happiness of the people ultimately depends on consumption. Problems caused by high-consumption lifestyles, such as waste of resources, environmental degradation, and global warming, have become prominent [3]. These problems have severely limits on China's high-quality development [4]. It is China's current challenge to reach its carbon neutral target before 2060 [5]. In a speech at the United Nations Biodiversity Summit at the end of September 2020, Xi Jinping advocated that countries adhere to ecological civilization, maintain green development, and promote their sense of responsibility. He emphasized that China is working hard to build a modernization in which man and nature coexist in harmony, and contribute to strengthening biodiversity protection and promoting global environmental governance. Therefore, the "low-carbon economy" has aroused widespread concern in China. The purpose of a low-carbon economy is a better quality of life in which resource utilization efficiency is higher, pollution emissions are less [6,7]. The need for global low-carbon transformation will intensify economic, trade, and technological changes [8]. To build a low-carbon society, China decided to take the path of low-carbon economic development [9].

Low-carbon economic development has become a policy guide and is the common concern of environmental economics and development economics [10]. The implementation of low-carbon consumption requires the government, enterprises and consumers to take joint measures. The environment and brand reputation of low-carbon products are all important factors affecting

low-carbon consumption behavior [11]. From the government's perspective, its investment in low-carbon consumption, fiscal subsidies and taxation will affect the final impact of low-carbon consumption implementation. An important means to promote low-carbon consumption is government subsidies [12,13]. For enterprises, whether to produce low-carbon products will be determined by the research and development degree of enterprises and the profitability of low-carbon products [14]. The market economy remains dominated by consumers, so low-carbon consumption behavior is ultimately realized by the consumers, which effectively connects production consumption with environmental protection. The public's low-carbon cognition and low-carbon intention for low-carbon behavior have an important influence on the practice level [15]. Currently, consumers and stakeholders are paying attention to sustainable consumption [16]. Residents have gradually realized the importance of low-carbon behavior to environmentally sustainable development.

Although the new consumption concept of "green" has obtained a wide range of acceptance, there remains a gap between theory and practice [17]. There are many "free rider" behaviors in the process of implementing low-carbon behavior, namely, residents supporting low-carbon behavior have different preferences. Therefore, the main questions of this paper are as follows: What factors lead to residents' different preferences for low-carbon behaviors? What is the role of residents' knowledge of global warming? The objective of this paper is to contribute to the debate on residents' preferences for low-carbon behaviors. To achieve the objective, a questionnaire was used to elicit responses and the multivariate ordered probit regression model was used to analyze the results of the questionnaire. Actually, it has been shown that scholars have conducted different levels of research on low-carbon consumption. Therefore, the added value of this paper is the use of the entropy weighting method which is used to measure the low-carbon behavior of residents. At the same time, the low-carbon behavior is divided into five aspects, including low-carbon dress behavior, low-carbon food behavior, low-carbon living behavior, low-carbon travel behavior and energy saving behavior, to make the research more specific.

The rest of this paper is arranged as follows: In the first part, a literature review is conducted, and a research hypothesis put forward; the second part provides the questionnaire design, introducing the research design and sample characteristics; the third part explains the empirical analysis. Utilizing baseline regression, low-carbon behaviors are further divided into five aspects: food, clothing, housing, transportation and use. Samples are classified according to gender for subsample regression. We concurrently conducted a regulatory effect analysis and a heterogeneity analysis. The last part consists of the conclusion and suggestion.

## 2. Literature Review

### 2.1. Residents' Low-Carbon Behavior

Behavior is the general term for a series of purposeful activities of people [18,19]. Low-carbon and proenvironmental behaviors specifically refer to the behavior of ensuring the sustainability of the ecosystem while maintaining normal economic development [20]. It is a behavioral method adopted by residents to protect the living environment and rationally use resources based on low-carbon cognition in order to protect the environment and daily life. Low-carbon consumption requires consumers to improve resource utilization efficiency and minimize emissions while meeting basic needs [21]. Low-carbon consumption is a mode of sustainable consumption. Low-carbon consumption behaviors are pronatural and prosocial consumption behaviors. At present, scholars basically study such behaviors of consumers from four perspectives: subjective psychological factors [22,23], demographic factors [24,25], family characteristics [26,27] and external contextual factors [28,29]. Demographic factors such as gender, marriage status, age, education level, and income are considered to be important factors affecting residents' low-carbon behavior [30,31]. Improving education level has a positive effect on residents' perception of low-carbon consumption behavior [32]. Residents with poor economic conditions tend to frugal consumption behavior in daily life [11,26]. Often we think that people living

in our own context are the lowest carbon [11]. Environmental policies and social and cultural customs issued by the government will have a positive impact on low-carbon consumption behavior [33].

There are some articles on low-carbon emission reduction from the perspective of the government [34], and this paper is from the perspective of residents. With the development of a low-carbon economy, residents' values gradually turn to green values. The research related to this paper mainly analyzes the influence of low-carbon intention and low-carbon cognition on low-carbon behavior. Low-carbon intention refers to the theory of planned behavior and we define it as the psychological tendency of an individual to engage in low-carbon behavior and make efforts. Low-carbon cognition is defined as people's understanding of environmental knowledge and their feelings about the environment, and is the degree of residents' recognition and acceptance of low-carbon things and low-carbon behaviors.

### 2.2. Low-Carbon Intention and Low-Carbon Behavior

According to Ajzen (1991) [35]'s "Theory of Planned Behavior", individuals' beliefs, attitudes, subjective norms and perceived control all promote the formation of their behavior. Bai and Liu [36] proposed that the higher the residents' awareness of the importance of low-carbon lifestyles, that is, the higher the residents have the correct values, the higher the level of low-carbon behavior. The analysis of environmental behavior of Australian residents by Price et al. [37] also found that individual residents' environmental values and vital interests will significantly affect their environmental protection behavior. Using the theory of planned behavior method and based on the study of Malaysia, it is found that low-carbon behavior of citizens is greatly affected by low-carbon intention [38]. Rodriguez-Barreiro et al. [39] divided environmental attitudes into four aspects: attitude formation, extension activity, nature conservation view and willingness to act. The research results also showed that only the willingness to act could directly affect environmental behavior. Sapci [40] proposed that attitudes about environmental issues are associated with lower energy consumption based on a data set of electricity use by 612 households in Wyoming, USA. Han et al. [41] studied the energy-saving behavior of residents and found that environmental knowledge and behavior motivation play an important role in the energy-saving behavior of residents. The low-carbon behavior intention of urban residents is the most direct reason for their low-carbon behavior. Behavioral intention of the researchee usually directly affects low-carbon consumption behavior [42–44]. Previous studies indicate that the current research results on low-carbon intention and behavior tend to be complete. Current research on the impact of low-carbon intention on low-carbon behavior has not reached a consistent conclusion, some believe that intention has a significant role in promoting behavior [36,42]; another believes that low-carbon intention has no significant effect on behavior [45,46], so further research is needed. Thus, the following hypothesis is proposed in this paper:

**Hypothesis 1.** *The stronger the low-carbon intention, the higher the practice of low-carbon behavior.*

### 2.3. Low-Carbon Cognition and Low-Carbon Behavior

The concept of low-carbon consumption behavior has exerted varying degrees of influence on residents. There is still controversy about the effect of low-carbon cognition on behavior. Some views believe that cognition has a significant role in promoting behavior [47,48]; while another believes that cognition has no significant effect on behavior [49,50]. Self-cognition can significantly promote low-carbon consumption behavior [51–54]. Therefore, compared with external factors, internal knowledge and cognition of residents have a deeper influence on low-carbon behaviors. Low-carbon consciousness is the basis of low-carbon cognition and low-carbon behavior. Abdul-Wahab [55] describes environmental awareness as a multidimensional and highly cited component in the relevant literature. Fielding et al. [56] found that the more extensive an individual's low-carbon environmental protection knowledge was, the easier it was to participate in low-carbon behavior. Huang et al. [57] believes that green consumption behavior is greatly affected by environmental protection consciousness.

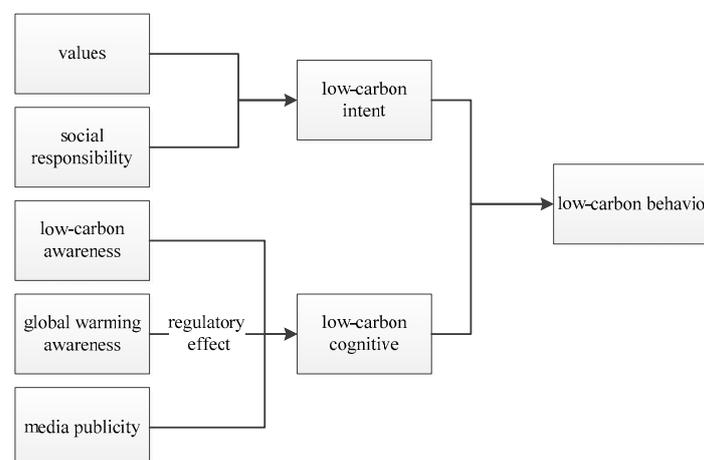
Ding et al. (2018 [11]) found that low-carbon cognition and low-carbon emotion of residents positively influence low-carbon purchasing attitudes and behavior. [58] Xu et al. found that perceived behavioral control has the greatest impact on purchase intention, while environmental consciousness did not show a direct and significant impact on purchase intention. Kaplowitz et al. [59] found that low-carbon behavior is affected by low-carbon knowledge. Only when people understand environmental knowledge, will they make reasonable environmental behaviors. The higher the low-carbon awareness of consumers, the stronger their low-carbon cognition will be, which is good for the practice of low-carbon behavior [60]. However, Kempton et al. [61] founded that environmental knowledge itself is not the basis of environmental behavior by investigated the US environmentalist group and the antienvironmentalist group.

Scholars have studied the relationship between low-carbon cognition and behavior through different research models and dimensions, and the results show that the improvement of residents' environmental awareness is more conducive to their low-carbon behavior. Rational behavior theory (TRA) and planned behavior theory (TPB) both use attitudes as predictors of behavior. Chen [62] also found a strong correlation between green buying attitudes and buying behaviors when studying green buying behaviors. Some scholars even further studied the differences between consumer attitudes and behaviors [63]. Since entering the 21st century, the phenomenon of global warming has attracted peoples' attention. Citizens' understanding of their own climate change knowledge may be uncertain [64]. An active and open mind will have an inhibitory effect on human-caused climate change [65]. The higher people's level of understanding of the causes of climate change, the more they are concerned [66]. Resident carbon emissions are the main source and new growth point of greenhouse gas emissions [67]. The term "low-carbon consumption" for the public is more abstract, but global warming is a specific environmental degradation performance. Residents' understanding of global warming is related to their understanding of the low-carbon economy. Therefore, this paper proposes the following assumptions:

**Hypothesis 2.** *The stronger the low-carbon cognition, the higher the practice of low-carbon behavior.*

**Hypothesis 3.** *Residents' understanding of global warming has a positive moderating effect on the impact of residents' low-carbon cognition on low-carbon behavior.*

Whether residents have correct values and whether they will change their current consumption habits will affect their low-carbon intention; and residents' understanding of the low-carbon economy, global warming, and whether the media has adequately reported on low-carbon consumption will have an impact on low-carbon cognition. Combined with the research results and theoretical analysis, this paper constructs a logical analysis framework, as shown in Figure 1.



**Figure 1.** Logic diagram 1.

### 3. Methods and Data

#### 3.1. Questionnaire Design

This survey took residents of nine municipal districts of Hangzhou city as the survey objects and conducted multistage random sampling. Although Hangzhou is one of the cities with the highest per capita income, the low-carbon behavior of Hangzhou residents is not very green-friendly [68,69]. The questionnaire was issued from December 2018 to 20 May 2019. Communities were selected as the questionnaire distribution location, and multistage sampling was used to design a reasonable survey process. Under the 95% confidence interval, the maximum allowable error of 3.5%, and the maximum value of  $p$  equal to 0.5, our solution sample size should be no less than 786 copies. In total, 810 questionnaires were distributed (See Appendix A). Incomplete questionnaires were removed from this study through the screening process, and 786 valid questionnaires remained. The questionnaire included 23 questions over four parts: low-carbon cognition, low-carbon intention, low-carbon behavior and basic personal information. A five-point Likert scale was used to lower statistical deviation in which the scale ranged from 1 to 5, as shown in Table 1.

**Table 1.** Questionnaire contents.

Category	The Variable Name	A Brief Description of Relevant Topics
Low-carbon behavior	Low-carbon dress behavior	Recycle old clothes
	Low-carbon food behavior	Use of disposable cutlery
	Low-carbon living behavior	Optimum temperature for air conditioning in summer
	Low-carbon travel behavior	Take public transport
	Energy saving behavior	Power off
Low-carbon intention	Values	Low-carbon consumption improve the quality of life
	Social responsibility	Be willing to change current spending behavior
	Priority to buy low-carbon products	Green products are preferred
Low-carbon cognition	Global warming awareness	Focus on global warming
	Low-carbon product labels	Focus on low-carbon labeling of goods
	Low-carbon awareness	Understanding of the low-carbon economy
	Media publicity efforts	Whether the media coverage is adequate
Personal information	Gender	Male or female
	Age	Age range
	Education	Record of formal schooling
	Family	Education level of family members
	Income	Average monthly household income
	Work	Profession
	Register	Household registration and residence status
	Baby	Is there a baby in the house

Although we tried our best to make the sample represent the overall situation of Hangzhou in the design of sampling scheme, there are still some deviations from the results. This is mainly reflected in the high proportion of educated young people. On the one hand, it is because young people are more willing to answer the questionnaire. On the other hand, they are more likely to meet young people in the process of questionnaire interview. In the last three years, Hangzhou has been the city with the largest inflow of skilled individuals in China. We must admit that this affects the generalizability of the conclusion to some extent. So we need to consider the extent to which conclusions may deviate.

#### 3.2. Data Processing Methods

A preliminary statistical analysis of the demographic indicators of the survey samples was conducted to obtain the results shown in Table 2. It can be clearly seen that the proportion of male respondents is higher than that of female respondents; the age distribution is generally between 20 and 40 years old; the average monthly income is more than 5000 yuan; the education level of 63.3% is college or above; and the distribution of occupation and household registration is relatively average.

In general, the distribution of demographic indicators of the survey samples is wide, so further data processing and analysis can be conducted.

To improve the normalization and reliability of the data, each variable in the questionnaire was assigned before data entry. For the gender variable, male = 1 and, female = 0. When assigning values to variables such as low-carbon behavior, low-carbon cognition and low-carbon intention, 1 = strongly disagree, 2 = disagree, 3 = uncertainty, 4 = agree, and 5 = strongly agree; dummy variables were used for factors such as income, education level and, with values ranging from low to high ranging from 1 to 5, as shown in Table 1. As for the assignment of occupation and registration, we assign 1–5 and 1–4 respectively according to their degree of influence on low-carbon behavior.

**Table 2.** General descriptive statistics.

Project	Indicators	Number of Samples	The Percentage
Gender	Male	476	60.6%
	Female	310	39.4%
Age	20–29	495	62.9%
	30–39	185	23.5%
	40–49	80	10.2%
	50 to 59	16	2.1%
	More than 60 years of age	10	1.3%
Average monthly household income	3500 or below	23	3.0%
	3500–5000.	110	14.0%
	5000–6500.	211	26.8%
	More than 6500	442	56.2%
Record of formal schooling	Primary school and below	12	1.5%
	Junior high school	65	8.7%
	High school	204	25.9%
	University or above	498	63.3%
Profession	An administrative organ	17	2.2%
	Business unit	104	13.2%
	enterprise	321	40.8%
	freelance	162	20.6%
Household registration and residence status	students	182	23.2%
	Registered resident of Hangzhou	221	28.1%
	Permanent resident of Hangzhou	185	23.5%
	Registered residents of Zhejiang	174	22.2%
Is there a baby in the house	Other	206	26.2%
	Yes	217	27.6%
	No	569	72.4%

### 3.3. Model Selection and Regression Method Selection

Based on the analysis of the samples and the logical framework, and referring to the existing research methods of de-Magistris et al. Zhao et al. [16,70], this paper selects the multiple linear regression model as follows:

$$Lcb_i = \beta_0 + \beta_1qua_i + \beta_2hab_i + \beta_3warm_i + \beta_4awa_i + \beta_5med_i + \beta_6control_i + \varepsilon_i \tag{1}$$

$$Lcb_i = \beta_0 + \beta_1qua_i + \beta_2hab_i + \beta_3warm_i + \beta_4awa_i + \beta_5med_i + \beta_6warm_i * cog_i + \beta_7control_i + \varepsilon_i \tag{2}$$

Equation (1) represents the basic model, the increase in residents’ understanding of global warming is conducive to residents’ understanding of the low-carbon economy, so Equation (2) represents the model with interaction terms added.  $Lcb_i$  refers to the low-carbon behavior of the  $i$ -th resident,  $qua_i$  and  $hab_i$  respectively refer to the values and social responsibility of the  $i$ -th resident,  $warm_i$  refers to the degree of the  $i$ -residents understanding of global warming,  $awa_i$  refers to the  $i$ -th resident’s understanding of the low-carbon economy,  $med_i$  refers to the  $i$ -th residents attitude to media reports

about low-carbon. Among them, for the low-carbon behavior of the residents of the explained variable, this paper adopts the average weight method and the entropy method to measure the five data categories of clothing, food, shelter, transportation and essentials. The average weighting method means that the weight of each factor is the same, while the entropy weighting method gives different weights to different factors. Because the five factors we studied will have differences in the proportions of low-carbon consumption, entropy weighting is adopted. Explanatory variables include residents' values (quality), social responsibility (habit), global warming awareness (warm), low-carbon awareness (awareness), and media reporting (media). The control variables include gender, age, income, education, residence status, and the highest education level of family members.  $\beta$  and  $\varepsilon$  are the regression coefficient and random disturbance term, respectively, and  $i$  represents the serial number of respondents.

As for the estimation method, the ordinary least square (OLS) is the most frequently used method for classical linear regression models. For ordered data, if we use multinomial logit, the inherent order of the data will be ignored, and OLS treats sorting as a cardinal number. Therefore, if the disturbance item  $\varepsilon$  obeys a normal distribution, an ordered probit model is obtained, and oprobit regression is generally used for regression; if the disturbance item  $\varepsilon$  obeys a logistic distribution, an ordered logit model is obtained, and ologit regression is used for regression. Oprobit model is a sorting selection model in which the error distribution obeys the standard normal distribution. Ologit model refers to a logit regression model in which dependent variables are classified and ordered. Ologit model is used when the dependent variable is more evenly distributed, and Oprobit model is used when the dependent variable is close to the normal distribution. There is usually not much difference between the two models when the sample size is large enough. Since the explained variable takes values from the range [1,5], this paper uses the ordered probit regression method. At the same time, we use OLS regression and ordered logit regression for comparative analysis, showing the robustness of the results to a certain extent. We divide low-carbon behavior into five aspects to facilitate the continuation of the research. But what we have to admit is that there is a certain deviation between low-carbon behavior and actual life after weighting it into a value.

## 4. Empirical Analysis

### 4.1. Variable Definition and Descriptive Analysis

As can be seen from Table 3, the average value of the low-carbon consumption behavior data obtained by either mean weighting or entropy weighting is approximately 3.7, indicating that the low-carbon behavior of Hangzhou residents is efficiently practiced. The mean values of the core explanatory variables were all above 3, and all consumers indicated willingness to change their current living habits for low-carbon consumption behavior. Residents' attitudes towards the improvement of their quality of life by low-carbon consumption even reached 4.2, indicating that all urban residents had a strong desire for low-carbon consumption behavior. In the sample data investigated, men accounted for 60.6%, and 27.6% of the surveyed families had infants. Therefore, family members who have infants have stronger low-carbon intention and cognition. The age group is generally distributed between 20 and 35 years old, and the average monthly income is approximately 6000 yuan. Consistent with the research results of Yin and Shi [71], we found that family scales, incomes, and housing sizes have significant influences on low-carbon household behaviors.

As can be seen from the sample structure, more than 60% respondents are well-educated childless respondents. Therefore, the Heckman sample selection model is used for testing. The Heckman test on the sample shows that the inverse Mills ratio coefficient is significant, indicating that the selection bias is there. After considering the sample selection problem, we don't think the results have changed significantly. As a comparison, we provide the coefficients of the main variables in Appendix B. In the later results, we continue to focus on the results of ordered logit and ordered probit.

Measuring qualitative variables such as work and register in this quantitative way can be controversial. Some researchers believe that this approach may mask the real results. In order to reduce this kind of doubt, we have done the relevant test, replacing work and register with three dummy variables respectively. The results show that the setting in this paper does not cause very large deviation whether in economic significance or statistical significance, and the relevant results are shown in Appendix C.

**Table 3.** Descriptive statistics of variables.

Category	Variable	Variable Definitions	Min	Max	Average	Standard Error
Explained variable	Weight	Average-weighted low-carbon behavior	1.8	4.8	3.619	0.473
	Entropy	Entropy-weighted low-carbon behavior	1.799	5	3.736	0.529
Core explanatory variable	Quality	Values	2	5	4.216	0.746
	Habit	Sense of responsibility	1	5	3.636	0.679
	Warm	Global warming awareness	1	5	3.518	0.819
	Awareness	Low-carbon awareness	1	5	3.458	0.841
	Media	Media publicity	1	5	3.342	0.905
Control variables	Gender	Gender	0	1	0.606	0.489
	Age	Age	1	5	1.551	0.852
	Income	Average monthly income	1	4	3.364	0.829
	Education	The degree of education	1	4	3.519	0.718
	Family	Highest degree for family	1	4	3.663	0.642
	Work	profession	1	5	3.494	1.053
	Register	Household registration and residence status	1	4	2.532	1.156
	Baby	Is there a baby	0	1	0.276	0.447
Sample size: N = 786						

#### 4.2. Basic Empirical Results

For Model (1), Stata15.0 software was used to conduct OLS regression, multivariate ordered logit regression and multivariate-ordered probit regression, and the regression results are shown in Table 4. Columns (1), (3) and (5) selected the average-weighted low-carbon behavior as the explained variable, while columns (2), (4) and (6) selected the entropy-weighted behavior as the explained variable.

The regression coefficients and levels of significance shown in Table 4 show that four factors, including quality, habit, global warming and media, significantly affect consumers' intentions and cognitions. That is, low-carbon intention (values, social responsibility) and low-carbon behavior are significantly positively correlated, and low-carbon cognition (media, global warming) has a significant positive correlation with low-carbon behavior. This result is consistent with the result of Bai et al. and Latif et al. [36,47]. This result also supports the theoretical assumption of this paper. When residents' low-carbon willingness and low-carbon cognition increase, their low-carbon behavior implementation degree will also increase greatly. At the same time, the OLS regression results were taken as the robustness test, and the conclusion was still drawn that the coefficients of quality, habit, global warming and media are significantly positive, which was consistent with the results of ologit regression and oprobit regression, again supporting the theoretical assumption of this paper. Consistent with the conclusions of Yang et al. [25], women's low-carbon behaviors perform better overall. And our research found that income is negatively correlated with low-carbon behavior, which is consistent with the findings of Ramos et al. and Poruschi and Ambrey [24,26]. The higher the level of education, the better the performance of low-carbon behavior, this conclusion is consistent with Ye et al. [32].

**Table 4.** Logistic regression analysis on residents' low-carbon behavior.

		OLS		Ologit		Oprobit	
		(1)	(2)	(3)	(4)	(5)	(6)
		Weight	Entropy	Weight	Entropy	Weight	Entropy
Intention	Quality	0.079 *** (3.44)	0.071 *** (2.82)	0.311 *** (3.39)	0.216 *** (2.36)	0.173 *** (3.45)	0.138 *** (2.76)
	Habit	0.067 *** (2.77)	0.071 *** (2.60)	0.266 *** (2.71)	0.257 ** (2.41)	0.150 *** (2.71)	0.134 ** (2.38)
Cognition	Warm	0.093 *** (4.35)	0.108 *** (4.55)	0.385 *** (4.49)	0.381 *** (4.51)	0.209 *** (4.40)	0.216 *** (4.58)
	Awareness	0.016 (0.76)	0.016 (0.69)	0.041 (0.48)	0.049 (0.60)	0.030 (0.64)	0.029 (0.65)
	Media	0.055 *** (2.86)	0.039 * (1.84)	0.234 *** (2.98)	0.128 (1.59)	0.126 *** (2.88)	0.073 * (1.68)
Controls	Family	0.035 (−1.42)	0.043 (−1.57)	0.125 (−1.26)	0.151 (−1.38)	0.071 (−1.26)	0.079 (−1.37)
	Gender	−0.113 *** (−3.44)	−0.169 *** (−4.47)	−0.455 *** (−3.40)	−0.616 *** (−4.44)	−0.266 *** (−3.52)	−0.365 *** (−4.72)
	Age	−0.024 (−1.15)	−0.027 (−1.18)	−0.054 (−0.64)	−0.065 (−0.81)	−0.047 (−1.01)	−0.046 (−1.02)
	Income	−0.045 ** (−2.18)	−0.073 *** (−3.26)	−0.173 ** (−1.99)	−0.288 *** (−3.56)	−0.111 ** (−2.36)	−0.167 *** (−3.66)
	Education	0.080 *** (3.36)	0.087 *** (3.22)	0.320 *** (3.34)	0.301 *** (3.14)	0.182 *** (3.37)	0.173 *** (3.19)
	Work	0.026 * (1.72)	0.049 *** (2.87)	0.058 (0.89)	0.114 * (1.81)	0.0546 (1.57)	0.089 *** (2.60)
	Register	0.021 (1.51)	−0.001 (−0.09)	0.085 (1.49)	−0.006 (−0.11)	0.052 * (1.66)	−0.002 (−0.07)
	Baby	0.089 ** (2.40)	0.058 (1.37)	0.260 * (1.75)	0.108 (0.69)	0.207 ** (2.43)	0.095 (1.10)
	_cons	2.414 *** (11.59)	2.672 *** (11.32)				
F	8.02 ***	8.02 ***					
R2	0.131	0.132					
Pseudo R2			0.029	0.016	0.030	0.017	
Wald			89.87 ***	89.37 ***	99.67 ***	106.2 ***	

Note: \*\*\*, \*\* and \* mean passing the significance test at 1%, 5% and 10%, respectively.

To study the low-carbon behavior of urban residents at different levels, the low-carbon behavior of residents was divided into five aspects (clothing, food, housing, transportation and essentials), and the results of the approach of multiple ordered logit regression are shown in Table 5.

Residents' low-carbon behavior is not completely the same across the five aspects. Residents' sense of responsibility and their concern about global warming are significantly positively correlated with low-carbon clothing behavior. Residents' values, attention to global warming, and the intensity of media reports show a significant positive correlation with residents' low-carbon living behaviors. Residents' values, sense of responsibility, and concern about global warming are positively correlated with low-carbon travel behavior. Residents' social responsibility, attention to global warming, and adequate media coverage are significantly related to residents' energy conservation behaviors. Residents' values and media reports are positively correlated with their low-carbon behavior in food consumption. Different influencing factors not only reflect the public's preference for low-carbon behavior but also show the emphasis of the media in publicity. Generally, the residents have a more obvious behavioral tendency towards low-carbon travel and low-carbon housing.

It can be seen from Table 4 that women are more active than men, which is consistent with Ding et al. [11]. Furthermore, Table 6 can be obtained by further analysis of subsamples according to the gender of residents' low-carbon consumption behaviors.

For male residents, low-carbon intention (values, sense of responsibility) and low-carbon cognition (media reports) have a significant positive correlation with low-carbon behavior. However, for female residents, only low-carbon intention (sense of responsibility) has a significant positive correlation with low-carbon behaviors. Our results show that men's low-carbon intention and low-carbon cognition have a more obvious impact on low-carbon behavior than women. Among them, residents' values and media coverage were positively correlated with men but not with women. Taking media reports as an example, compared with women, men usually pay more attention to political and economic news, so media publicity is significant for men but not for women. The research on each gender's differential preferences for low-carbon behaviors is beneficial to the formulation of government policies and the design of media communications strategies.

**Table 5.** Regression analysis on low-carbon behaviors at different levels.

		(1)	(2)	(3)	(4)	(5)
		Dress	Reside	Travel	Life	Food
Intention	Quality	0.073 (0.73)	0.182 * (1.73)	0.192 * (1.89)	−0.035 (−0.36)	0.278 *** (3.00)
	Habit	0.224 ** (2.12)	0.061 (0.54)	0.210 * (1.73)	0.204 * (1.89)	0.170 (1.59)
Cognition	Warm	0.184 ** (2.11)	0.230 ** (2.25)	0.325 *** (3.49)	0.343 *** (3.37)	0.146 (1.61)
	Awareness	−0.014 (−0.16)	0.075 (0.80)	0.051 (0.57)	−0.050 (−0.52)	0.096 (1.20)
	Media	−0.020 (−0.24)	0.207 ** (2.34)	0.113 (1.27)	0.143 * (1.66)	0.275 *** (3.47)
Controls	Family	−0.029 (−0.24)	−0.173 (−1.48)	−0.127 (−1.14)	−0.015 (−0.16)	−0.036 (−0.30)
	Gender	−0.613*** (−4.17)	−0.421 *** (−2.91)	−0.435 *** (−2.82)	−0.031 (−0.20)	0.207 (1.47)
	Age	−0.241 ** (−2.55)	0.124 (1.39)	−0.132 (−1.38)	0.021 (0.26)	−0.045 (−0.58)
	Income	−0.009 (−0.09)	−0.259 *** (−3.15)	−0.290 *** (−3.30)	−0.033 (−0.39)	0.077 (0.83)
	Education	0.167 * (1.70)	0.291 *** (2.73)	0.210 ** (2.01)	0.202 * (1.90)	0.108 (1.02)
	Work	−0.068 (−0.93)	−0.104 (−1.36)	0.326 *** (4.56)	0.180 ** (2.46)	0.019 (0.31)
	Register	0.079 (1.30)	0.055 (0.87)	−0.130 ** (−2.06)	0.170 *** (2.68)	0.158 *** (2.63)
	Baby	0.466 *** (2.97)	0.544 *** (3.18)	−0.164 (−0.91)	0.023 (0.13)	0.139 (0.87)
Pseudo R2		0.028	0.035	0.051	0.024	0.029
Wald		57.98	58.73	97.12	37.54	55.65

Note: \*\*\*, \*\* and \* mean passing the significance test at 1%, 5% and 10%, respectively.

**Table 6.** Regression analysis on low-carbon behaviors based on gender.

		Male		Female	
		(1)	(2)	(1)	(2)
		Weight	Entropy	Weight	Entropy
Intention	Quality	0.187 *** (2.88)	0.150 ** (2.37)	0.109 (1.26)	0.060 (0.69)
	Habit	0.161 ** (2.06)	0.181 ** (2.37)	0.166 ** (2.19)	0.123 (1.53)
Cognition	Warm	0.140 ** (2.30)	0.151 ** (2.57)	0.300 *** (3.97)	0.301 *** (3.89)
	Awareness	−0.0001 (−0.001)	−0.006 (−0.10)	0.087 (1.21)	0.100 (1.35)
	Media	0.144 *** (2.65)	0.085 (1.59)	0.100 (1.34)	0.063 (0.85)
Controls	Family	−0.122 * (−1.69)	−0.145 ** (−1.96)	0.079 (0.83)	0.094 (0.95)
	Age	−0.014 (−0.21)	−0.031 (−0.48)	−0.048 (−0.69)	−0.052 (−0.81)
	Income	−0.160 *** (−2.60)	−0.244 *** (−3.83)	−0.040 (−0.50)	−0.059 (−0.85)
	Education	0.188 ** (2.40)	0.162 ** (1.99)	0.157 ** (2.01)	0.159 ** (2.25)
	Work	−0.021 (−0.47)	0.030 (0.67)	0.162 *** (2.83)	0.163 *** (2.95)
	Register	0.100** (2.48)	0.056 (1.44)	−0.059 (−1.11)	−0.107 * (−1.85)
	Baby	0.142 (1.30)	0.151 (1.33)	0.314 *** (2.35)	0.057 (0.42)
	Pseudo R2	0.028	0.014	0.040	0.022
	Wald	59.32	51.10	54.57	59.59

Note: \*\*\*, \*\* and \* mean passing the significance test at 1%, 5% and 10%, respectively.

#### 4.3. Moderation Effect and Heterogeneity Effect

The variable of residents' understanding degree of global warming was taken as the moderating variable between residents' low-carbon understanding degree and low-carbon behavior. Warm \* awareness is a cross-product to measure the adjustment effect of global warming awareness. Warm \* awareness was added to Model (1) to obtain Model (2), and regression analysis was conducted, as shown in Table 7.

After the addition of the interaction terms, residents' understanding of global warming increased significantly, residents' understanding of the low-carbon economy became significantly positively correlated with low-carbon behavior, and the overall joint significance of the equation increased. Among them, residents' awareness of global warming on low-carbon behavior increased significantly, and the influence of growth increased from 0.093 to 0.231. For each additional unit of global warming awareness, the probability of low-carbon consumption behavior will increase by 51.5%, which reflects the importance of the influence of individual attitudes on behavior.

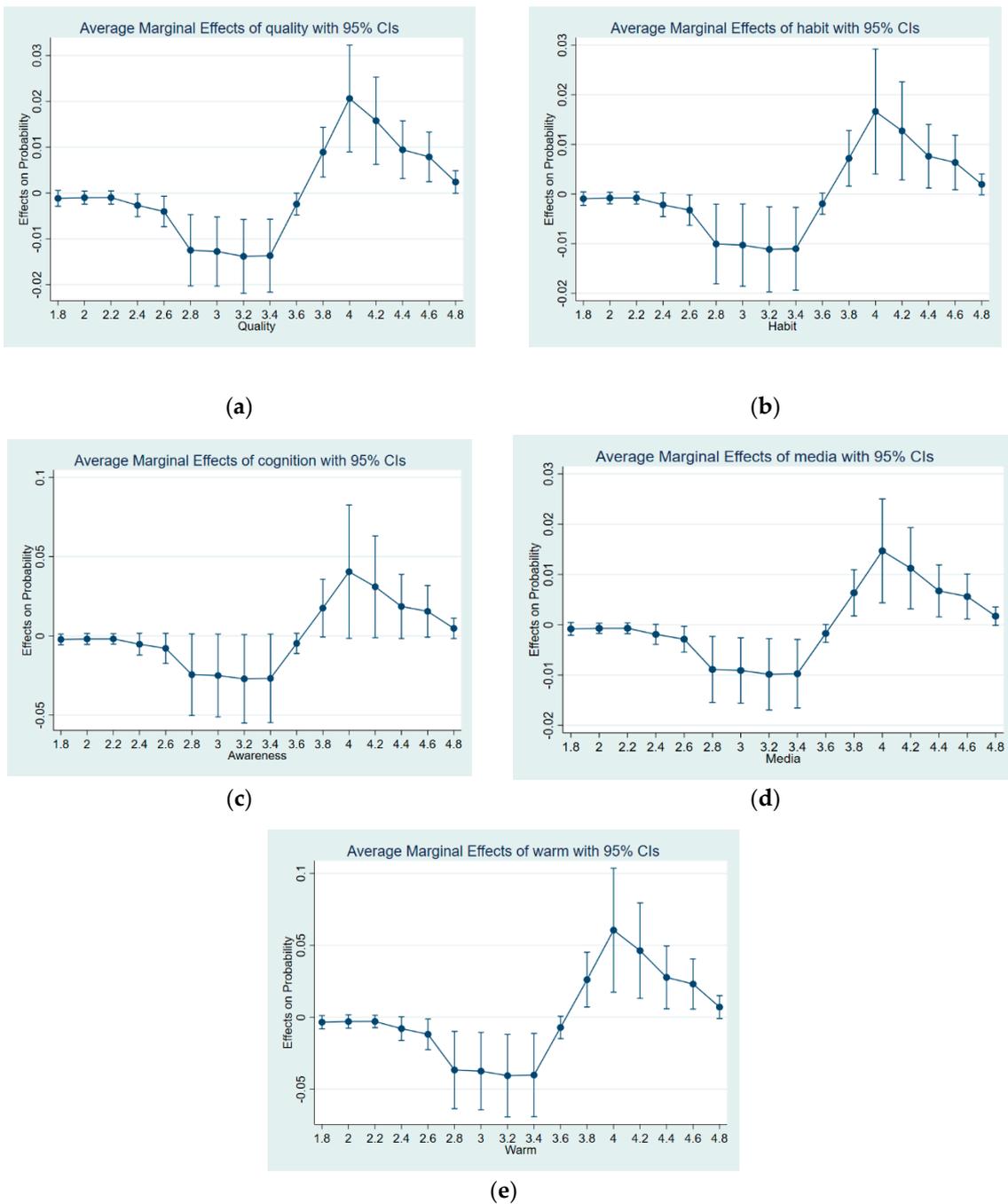
Table 7. Regression results of the interaction terms.

		OLS		Ologit		Oprobit	
		(1)	(2)	(3)	(4)	(5)	(6)
		Weight	Entropy	Weight	Entropy	Weight	Entropy
Intention	Quality	0.079 *** (3.50)	0.072 *** (2.84)	0.314 *** (3.44)	0.216 ** (2.37)	0.176 *** (3.50)	0.139 *** (2.78)
	Habit	0.063 *** (2.68)	0.069 ** (2.55)	0.257 *** (2.68)	0.252 ** (2.38)	0.142 *** (2.62)	0.131 ** (2.35)
Cognition	Warm	0.231 *** (2.88)	0.186 ** (2.06)	1.016 *** (3.18)	0.691 ** (2.12)	0.515 *** (2.85)	0.320 * (1.76)
	Awareness	0.158 ** (1.97)	0.096 (1.07)	0.684 ** (2.16)	0.364 (1.14)	0.345 * (1.92)	0.137 (0.76)
	Media	0.054 *** (2.83)	0.039 * (1.82)	0.235 *** (2.99)	0.127 (1.58)	0.125 *** (2.85)	0.072 * (1.67)
	Warm * awareness	-0.041 * (-1.80)	-0.023 (-0.91)	-0.187 ** (-2.04)	-0.092 (-0.99)	-0.091 * (-1.76)	-0.031 (-0.60)
Controls	Family	-0.034 (-1.40)	-0.042 (-1.55)	-0.125 (-1.25)	-0.152 (-1.40)	-0.069 (-1.23)	-0.078 (-1.37)
	Gender	-0.112 *** (-3.41)	-0.169 *** (-4.46)	-0.457 *** (-3.42)	-0.616 *** (-4.44)	-0.263 *** (-3.49)	-0.364 *** (-4.71)
	Age	-0.021 (-1.00)	-0.025 (-1.11)	-0.041 (-0.48)	-0.060 (-0.75)	-0.040 (-0.87)	-0.044 (-0.97)
	Income	-0.046 ** (-2.25)	-0.073 *** (-3.29)	-0.177 ** (-2.04)	-0.291 *** (-3.59)	-0.114 ** (-2.42)	-0.167 *** (-3.68)
	Education	0.079 *** (3.35)	0.086 *** (3.21)	0.320 *** (3.31)	0.302 *** (3.14)	0.181 *** (3.36)	0.172 *** (3.19)
	Work	0.025 (1.65)	0.048 *** (2.83)	0.053 (0.82)	0.111 * (1.76)	0.052 (1.51)	0.088 ** (2.57)
	Register	0.022 (1.55)	-0.001 (-0.06)	0.089 (1.56)	-0.004 (-0.08)	0.054 * (1.70)	-0.002 (-0.05)
	Baby	0.085 ** (2.29)	0.056 (1.32)	0.244 * (1.65)	0.103 (0.66)	0.198 ** (2.33)	0.092 (1.07)
	_cons	1.953 *** (5.93)	2.411 *** (6.51)				
	F	7.65 ***	7.50 ***				
	R2	0.135	0.133				
	Pseudo R2			0.029	0.016	0.031	0.017
	Wald			93.30	90.61	101.62	106.54

Note: \*\*\*, \*\* and \* mean passing the significance test at 1%, 5% and 10%, respectively.

It is worth noting that the regression coefficients of the interaction terms are negative. The interaction term coefficient is negative, but the total effect of residents' understanding of global warming and low-carbon is positive. Under the multivariate ordered logit regression, the total effect of these two variables is  $1.016 + 0.684 - 0.187 = 1.513$ . Therefore, residents' understanding of global warming has a positive moderating effect on residents' understanding of the low-carbon economy, which verifies the theoretical assumption of this paper.

Further heterogeneity analysis of explanatory variables was performed, as shown in Figure 2.



**Figure 2.** Marginal effects of the five explanatory variables. (a) Average marginal effects of quality; (b) average marginal effects of habit; (c) average marginal effects of awareness; (d) average marginal effects of media; (e) average marginal effects of warm.

Under multiple-ordered probit regression, the marginal effect of each explanatory variable on low-carbon consumption behavior is first negative and then positive. With the boundaries of 2.6 and 3.6, the residents surveyed can be divided into three categories. Residents in the 0–2.6 category do not have a strong awareness of low-carbon behavior and do not practice it, so publicity of knowledge should be the preliminary focus. For residents in the 2.6–3.6 category, most of them are “free riders”, which means they have a strong awareness of low-carbon behavior but a low practice degree of low-carbon behavior. Therefore, certain measures should be taken to motivate their low-carbon behavior. Residents in the 3.6–5 category have a strong awareness of low-carbon behavior, and their

practice degree of low-carbon behavior is very high. The heterogeneity of public low-carbon behavior provides space for market segmentation and further development. Through the heterogeneity analysis of residents, the government and media should adopt different strategies and policies for different groups of residents when guiding public low-carbon behavior to ensure the effectiveness of policies and publicity.

## 5. Conclusions and Discussion

Low-carbon development has become an inevitable trend of social and economic development to respond to climate change. Based on the investigation and analysis of the low-carbon consumption behavior of 786 residents in Hangzhou city, this paper constructs a logical analysis framework and conducts an empirical test on the basis of literature review and theory to explore the factors that influence consumers' low-carbon behavior through a questionnaire survey, and draws the following conclusions and inspirations.

First, Hangzhou residents do well in practicing low-carbon behavior. Through a statistical description analysis of the survey data, it is found that 71.4% of residents will recycle used clothes, 67.1% will adjust to the appropriate temperature when using air conditioning, and 78.5% will turn off all the power in their homes when going out for a short time. In terms of travel, 70.6% of residents will take public transportation when they go out. For respondents who choose other tools of transportation, the main reasons are the inconvenience of public transportation and their weak physical condition. In general, residents in Hangzhou have a high degree of implementation of environmental protection behaviors and are more inclined to implement low-carbon travel behaviors.

Second, the stronger the low-carbon intention, the higher the practice of low-carbon behavior, confirming H1. Thus, to further strengthen the low-carbon behavior of residents, one should actively create conditions for the transformation of residents' low-carbon intention to low-carbon behavior. Priefer et al. [72] pointed out that stricter laws, economic incentives and more modest measures tend to be more effective. The government should issue relevant regulations and policies to support the low-carbon behavior of residents, such as subsidies to people who buy low-carbon products. At the same time, it is also necessary to expand the choice space for residents to buy low-carbon products and strengthen the education and cultivation of residents' low-carbon consciousness.

Third, the stronger the low-carbon cognition, the higher the practice of low-carbon behavior, which verifies H2. Residents' understanding of global warming has a positive moderating effect on the impact of residents' low-carbon cognition on low-carbon behavior, which verifies H3. Therefore, the priority of the government and media is to attract people's attention to the low-carbon economy. The government's guidance to citizens to practice low-carbon behavior has irreplaceable influence, so it should build green, harmonious consumption values to realize the socialization of a low-carbon economy, improve the relevant policy framework, and issue legal documents. The media should use the right advertising strategy to reduce reports of conspicuous consumption and increase publicity guidance for low-carbon economies. Through more vivid pictures and diversified means, residents will take the initiative to understand the low-carbon economy.

Although our hypotheses have been verified, our research still has certain limitations. An important flaw of this article is the representativeness of the research sample. Although we set up multilevel sampling, the response rate of young people is much higher than that of older people. Hangzhou is a famous city with a well-developed digital economy, and basically does not have much industry. The new Hangzhou people are mainly people with high education. From the research content, on the one hand, although both low-carbon intention and low-carbon cognition have a positive impact on low-carbon behavior, we have not discussed in depth which of the two influences is dominant and the relationship between the two. On the other hand, this paper analyzes low-carbon behavior from the perspective of consumers, but does not conduct a more comprehensive study from the perspective of companies or products, such as the impact of low-carbon product brands and prices on low-carbon behavior. In future research, we should improve the method of sampling and questionnaire distribution

to improve the representativeness of the questionnaire. We will analyze the influencing factors of low-carbon consumption behavior in more detail.

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## Appendix A

**Table A1.** Comparative analysis of sample and total population.

Population Characteristics of Hangzhou in 2018				Sample			
Project	Indicators	Numbers	Percentage	Project	Indicators	Number of Samples	Percentage
Household registered population by sex	Male		49.6%	Gender	Male	476	60.6%
	Female		50.4%		Female	310	39.4%
Age structure of household registered population	0–17		17.2%	Age	20–29	495	62.9%
	18–34		22.0%		30–39	185	23.5%
	35–59		38.3%		40–49	80	10.2%
	Over 60 years old		22.5%		50–59	16	2.1%
						More than 60 years old	10
Per capita income and expenditure of households	Disposable income	54,348 yuan		Average monthly household income	3500 or below	23	3.0%
	Expenditure	37369 yuan			3500–5000	110	14.0%
					5000–6500	211	26.8%
					More than 6500	442	56.2%
Number of students	Primary school	590,491		Record of formal schooling	Primary and below	12	1.5%
	Junior	235,003			Junior	65	8.7%
	Senior	114,324			High school	204	25.9%
	Higher Education	496,383			University	498	63.3%
Number of employed persons by three industrial sectors	Primary		8.6%	Profession	Administrative body	17	2.2%
	Secondary		35.1%		Business	104	13.2%
	Tertiary		56.3%		Enterprise	321	40.8%
					Freelance	162	20.6%
					Students	182	23.2%
Natural changes of household registered population	Birth		12.4‰	Is there a baby in the house?	Yes	217	27.6%
	Natural		6.31‰		No	569	72.4%

Note: We compare the individual characteristics in the sample with some relevant indicators published of Hangzhou to measure the representativeness of the sample.

## Appendix B

Table A2. Coefficient under sample selection model.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Weight	Entropy	Dress	Reside	Travel	Life	Food
Intention	Quality	0.079 *** (3.55)	0.071 *** (2.87)	0.044 (0.98)	0.118 *** (2.80)	0.101 ** (2.45)	−0.009 (−0.23)	0.138 *** (3.19)
	Habit	0.067 *** (2.72)	0.071 ** (2.56)	0.085 * (1.67)	0.035 (0.73)	0.081 * (1.76)	0.074 * (1.70)	0.062 (1.29)
Cognition	Warm	0.093 *** (4.63)	0.108 *** (4.82)	0.058 (1.42)	0.078 ** (2.06)	0.131 *** (3.52)	0.141 *** (4.01)	0.055 (1.40)
	Awareness	0.016 (0.81)	0.016 (0.72)	−0.007 (−0.19)	0.041 (1.11)	0.030 (0.83)	−0.015 (−0.45)	0.030 (0.80)
	Media	0.055 *** (3.12)	0.039 ** (1.99)	−0.017 (−0.47)	0.085 ** (2.53)	0.042 (1.27)	0.046 (1.48)	0.120 *** (3.48)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	_cons	2.414 *** (12.61)	2.672 *** (12.47)	3.134 *** (7.98)	2.615 *** (7.17)	2.512 *** (7.04)	2.586 *** (7.70)	1.221 *** (3.26)
	Insigma	−0.820 *** (−32.53)	−0.708 *** (−28.06)	−0.102 *** (−4.02)	−0.176 *** (−6.97)	−0.198 *** (−7.86)	−0.259 *** (−10.25)	−0.148 *** (−5.87)
	Wald	118.52 ***	119.53 ***	49.06 ***	73.88 ***	93.38 ***	40.02 ***	50.86 ***

Note: \*\*\*, \*\* and \* mean passing the significance test at 1%, 5% and 10%, respectively. The Z statistic is in brackets below. For a more concise comparison, we ignore the control variables and so on, and only report the most important parameters. Maximum likelihood estimation is used to estimate the sample selection model.

## Appendix C

Table A3. Regression results when work and register are set as dummy variables.

		OLS		Ologit		Oprobit	
		(1)	(2)	(3)	(4)	(5)	(6)
		Weight	Entropy	Weight	Entropy	Weight	Entropy
Intention	Quality	0.0800 *** (3.50)	0.0708 ** (2.81)	0.315 *** (3.43)	0.209 * (2.30)	0.177 *** (3.51)	0.138 ** (2.76)
	Habit	0.0660 ** (2.72)	0.0705 ** (2.59)	0.263 ** (2.68)	0.255 * (2.38)	0.147 ** (2.67)	0.134 * (2.39)
Cognition	Warm	0.0919 *** (4.28)	0.107 *** (4.49)	0.380 *** (4.41)	0.379 *** (4.46)	0.208 *** (4.36)	0.215 *** (4.55)
	Awareness	0.0174 (0.84)	0.0193 (0.85)	0.0510 (0.59)	0.0595 (0.72)	0.0341 (0.73)	0.0368 (0.81)
	Media	0.0544 ** (2.83)	0.0375 (1.77)	0.237 ** (3.02)	0.125 (1.57)	0.125 ** (2.85)	0.0695 (1.61)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	F	6.47 ***	6.80 ***				
	R2	0.1338	0.1385				
	Pseudo R2			0.0295	0.0165	0.0310	0.0176
	Wald			95.70 ***	104.73 ***	105.39 ***	118.07 ***

Note: \*\*\*, \*\* and \* mean passing the significance test at 1%, 5% and 10%, respectively. The t or Z statistic is in brackets below.

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