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Effectiveness of China's Labeling and Incentive Programs for Household Energy Conservation and Policy Implications

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Abstract: With incomplete information about the potential benefits and costs of energy-using durables, households may be unwilling to invest in products that are more energy-efficient but also more expensive in purchase decisions. To deal with this problem, labeling policy has been developed to guide customers' energy consumption decisions by providing understandable information to evaluate the energy efficiency of products. Over the last 20 years, China has implemented a series of mandatory and voluntary energy labeling and incentive policies to reduce energy use and improve the energy efficiency of durable goods in dwellings. This study has employed empirical survey data from the Chinese General Social Survey to study the implementation effectiveness of these policies and explore demographic factors behind consumer investments in energy-saving durables by using the logistic regression model. Statistical results show that energy efficiency labeling, incentive programs, education levels, and regional differences of customers appear to be strong predictors for investing in energy-efficient air conditioners and washing machines. House size is a decisive factor in driving consumers to choose energy-saving air conditioners. In light of the above results, the study suggests improved policy for motivating consumers to purchase energy-efficient appliances in dwellings.



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Keywords: energy conservation; labeling policy; incentive programs; rational inattention; availability of heuristics

1. Introduction

As the world's largest emitter, China emits nearly 10 billion tons of CO₂ each year, accounting for 30% of global emissions [1]. China's households, major contributors to global warming, are responsible for about 12.8% of total energy demand [2]. Moreover, with the constant and rapid economic development and improvement of living standards, the total number of household appliances and other energy-consuming products has increased rapidly in the last 20 years. Accordingly, residential energy consumption and energy-related CO₂ emissions from dwellings have risen dramatically with an average annual growth rate of 7.24% and 5.27%, from 2000 to 2015, respectively [3]. Thus, residential energy saving has become a priority in China. Understanding the energy efficiency policies to reduce residential energy consumption is an essential part of mitigating climate change, such as, most prominently, global warming [4]. Residential energy consumption can be reduced not only with technological advances in durables, but also with behavioral adjustments in the consumption of energy-using durables in buildings [5], as consumer behavior is at the core of many complex environmental problems [6,7]. A growing body of evidence in academic literature has demonstrated that measures targeting consumer behavior offer a cost-effective approach towards energy savings [8–10]. The Energy Efficiency Directive in the European Union provides measures to accelerate energy efficiency improvements by changing societal and individual behaviors, which is very successful with respect to improving energy efficiency [11].

However, a lack of information could lead to consumers' unwillingness to pay for energy-efficient durables. In addition, consumers usually fail to notice the negative exter-

nalities of high energy consumption, such as environmental pollution and related health problems [12], eventually causing more or less welfare loss. The average consumer loss ranges from USD 100 to USD 300 per product when consumers choose energy-using products with limited information about energy efficiency [13].

Such absence of information can be addressed by more salient information regarding these unnoticed welfare losses, which will help to reduce consumers' uncertainties in their consumption decisions. Information intervention is one of the most commonly cited justifications for labeling policies [14]. These policies address problems of incomplete information in markets and inform the previously uninformed consumers to draw full attention to energy costs, therefore helping consumers to overcome cognitive or behavioral biases and make better purchase or investment decisions [15]. In recent years, information-based strategies, such as energy efficiency labels, have been introduced by over 50 countries to guide households to purchase energy-efficient products, including such mandatory programs as the Energy Guide and voluntary Energy Star in the United States, and the Energy Efficiency Grade in the European Union and China. These energy labels aim to drive consumers to buy energy-efficient durables [16]. In order to investigate which demographic factors and whether labeling policies and incentive programs drive consumers to choose high-labeled devices in China, we have employed the data of the majority of Chinese provinces from the Chinese General Social Survey (CGSS), launched jointly by Renmin University of China and the Hong Kong University of Science and Technology in 2018. Based on an analysis of the influencing factors on the purchasing of energy-efficient appliances in the residential sector, we have found that energy efficiency labels, incentive programs, education level, and regional differences of customers are strong predictors of investing in energy-efficient air conditioners and washing machines. Households living in a bigger house are more likely to choose energy-saving air conditioners.

Consumer behavior also leads to different attitudes towards energy-efficient durables. In this study, we have applied behavioral economic theories to clarify the significance of labeling policies and incentive programs. There is a shortage of microdata concerning the actual purchase choices of appliances in dwellings. This study, covering more than 1000 residents in different cities of China, fills the gap by providing the actual data on the possession of energy-efficient appliances in dwellings. Based on these data, we have tried to figure out what factors and policies will eventually contribute to driving consumers to choose high-labeled devices.

2. A General Review of China's Energy Efficiency Labeling and Incentive Programs in the Residential Sector

Over the past 30 years, China has implemented minimum energy performance standards (MEPS) to eliminate highly energy-consuming products and mandatory and voluntary energy labeling to improve the energy efficiency of residential appliances. Either the labeling program is voluntary, and a product is awarded the label for meeting certain criteria, like the China Energy Conservation Program (CECP) and China Environmental Labeling Program (CELP); or a label is mandatory for all products and all those aiming to reduce overall energy demand, regulate product markets, strengthen energy conservation, and steer consumers towards more energy-efficient products, as with the China Energy Label (CEL).

The first batch of MEPS was introduced in 1989, with subsequent amendments after the Standardization Law of China was adopted. However, the standards were not officially endorsed with legal authority until the Energy Conservation Law (ECL) laid down the regulatory foundation for mandatory energy efficiency standards for energy-using devices in 1997 [17]. In 1998, the China National Institute of Standardization (CNIS) established a voluntary endorsement label. The Medium and Long-Term Plan for Energy Conservation issued in 2004 further laid down more stringent revisions of energy efficiency standards to reinforce the implementation of product standards and energy labels.

CELP was launched by the China Environmental United Certification Centre (CEUCC) as early as 1993 to promote green purchasing and manufacturing, covering energy and water-related products. It joined the Global Eco-Labeling Network (GEN) in 2008. CEL was introduced in 2005, supported by the Product Quality Law and followed by the Regulations for Certification and Accreditation in 2009 [18], which lays a compulsory requirement for manufacturers and importers to attach a CEL label to products informing consumers of the energy consumption and efficiency grades [19], thereby supporting the sales of energy-efficient appliances in China. The newly revised 2008 ECL further highlights the importance of end-use appliance efficiency standards and labeling programs. In 2016, the new administrative measures for energy efficiency labeling were promulgated and implemented, which is one of the most effective ways to protect the natural environment and encourage the development of energy-efficient products.

In short, China's energy efficiency labeling systems have made remarkable progress, covering more than 42 categories of products by now. Figure 1 illustrates the legislative and regulatory history concerning China's MEPS and labeling policies.

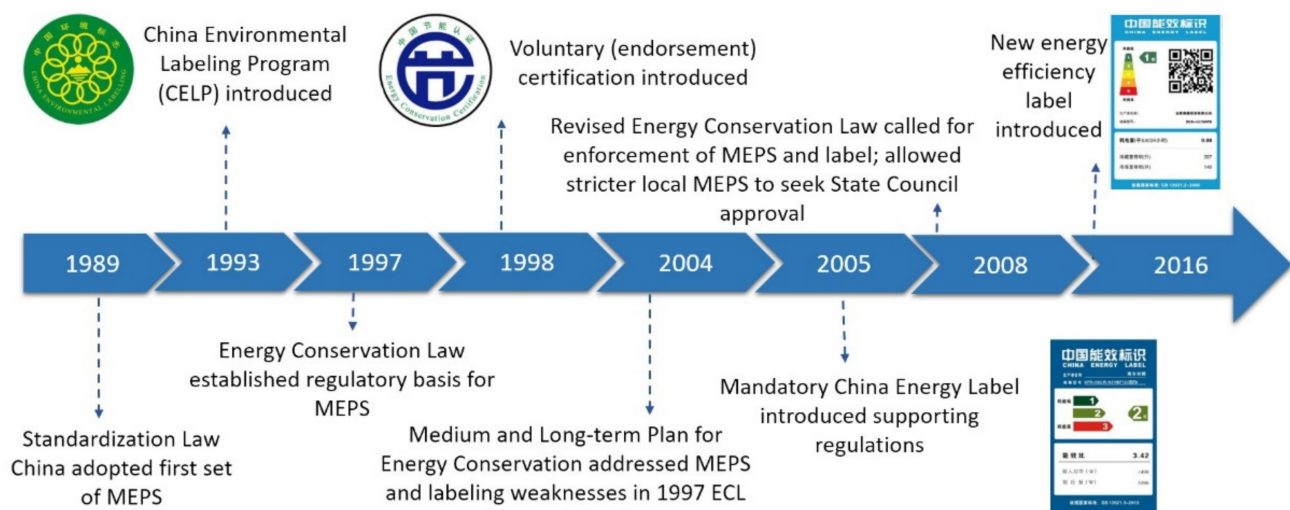


Figure 1. Legislative and regulatory history of China's appliance labeling programs, 1989-present.

The initial purchasing prices of energy-efficient appliances are higher than similar non-efficient appliances. In order to bridge the price gap and prompt the purchasing of efficient durable goods, the Chinese government has also practiced incentive programs, including promoting appliances to rural areas in 2008, subsidizing the purchase of energy-efficient appliances in 2009, and launching appliance trade-ins in 2009 [20], to complement MEPS and CEL programs and to increase the market share of energy-efficient products. All this has resulted in fiscal benefits and cost savings of efficient appliances, thereby guiding the sustainable purchase decision.

The practice of energy efficiency standards and energy labels has witnessed a remarkable reduction in energy consumption. Carbon emissions, nitrogen oxide, sulfur oxide, and atmospheric particulates are expected to decrease by more than 110 million tons, 1.7 million tons, 18.33 million tons, and 10.35 million tons respectively by 2020 [21], which can greatly alleviate environmental problems, such as greenhouse effects, photochemical smog, and acid rain.

China introduced new administrative measures for energy efficiency labeling in 2016, more stringent than ever. Positive effects have been found in the selling of air conditioners. As shown in Figure 2, the sales proportion of energy-saving air conditioners labeled with Grade 1 and Grade 2 energy efficiency has increased gradually, while the percentage of air conditioners labeled with Grade 3 energy efficiency experienced a downward trend, which shows the energy efficiency of air conditioners has greatly increased with the new

administrative measures for energy efficiency labeling. Furthermore, new MEPS for room air conditioners will reduce cumulative CO₂ emissions by 12.8% from 2019 to 2050, saving a cumulative bill of RMB 2620 billion to consumers in China [22].

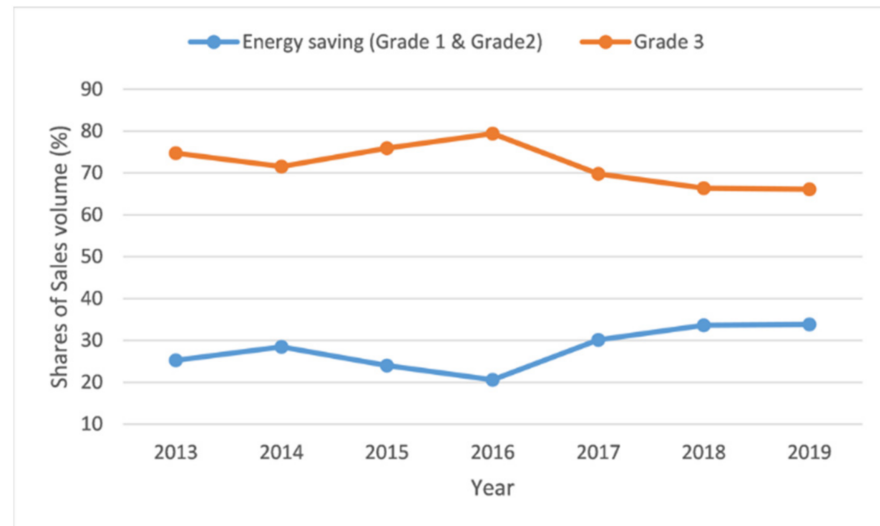


Figure 2. Sales volume of China's air conditioners. Source: <https://data.iimedia.cn/page-category.jsp?nodeid=12839805> (accessed on 18 December 2020).

3. Theoretical Foundation, Hypotheses, and Literature Review

3.1. Theoretical Foundation and Hypotheses

Consumers play an important role in promoting sustainable consumption. The UN Agenda 2030 for Sustainable Development Goals (SDGs) has proposed that consumers also need to assume the responsibility for resource consumption in addition to manufacturers. To meet this end, the UN has been promoting sustainable public procurement practices and increasing awareness for sustainable development through education for consumers [23].

However, consumers may act on incomplete information when the information is costly to acquire, which could cause users to overconsume durable goods, like automobiles or appliances. Almost 50% of the surveyed buyers are reported to have made their decisions without considering energy costs [24]. Greene reviewed 25 studies to find that half of them indicate that the users have undervalued the fuel economy in the market of durable goods [25]. This is due to the fact that the buyers have no way of observing or obtaining information about the durables' operating costs and lifetime costs at the time of purchase.

Labeling policies can lower barriers to information access. Because labels immediately provide information about energy levels and product lifetime costs, consumers are now able to know the energy they use by means of the information on labels [26]. These government-issued labels tend to address any inefficiencies in situations where consumers pay a cost to learn information. A large-scale laboratory experiment has proved the effectiveness of these labels in guiding household decisions [27]. Recent field experiments have demonstrated that consumers are more likely to purchase more efficient lightbulbs when they are provided information about the operating costs of alternative lightbulbs [28].

The uncertainty of information can also result in heavier dependence on heuristics [29]. Much empirical evidence indicates that the discount rate employed by consumers to value the costs and benefits for a period of time is not exponential but hyperbolic [30]. People place a lower discount rate on durable goods whose rewards happen further in the future and a higher discount rate for goods generating benefits that occur at the present time [31]. However, present bias is an important restriction on energy-efficient behav-

ior [15]. People are unwilling to spend more in the present and pay excessive attention to current costs/benefits, which makes people undervalue the benefits of environmentally friendly products. They may misjudge the true difference in utility they would experience from each product. Consumers usually place disproportionate weight on information that is more recent and readily available. Therefore, labeling messages should incorporate energy-saving information that is easily accessible and especially salient in consumers' memories. Research has demonstrated that the consumption of durables of various efficiencies relies heavily on the information provided on energy labels [32]. These labels can both eliminate imperfect information and direct the attention of households towards energy-saving products [28].

Labeling policies aggregate the future energy payments into the present discounted value, which addresses biases in which people underrate the benefits in the future [33], therefore protecting consumers who may be imperfectly informed or may not act in their own best interests. First, individuals potentially react to energy efficiency labels by emphasizing certain attributes of products, such as energy costs. As the information on labeling makes those attributes more salient, they aim at the availability of heuristics by simplifying the rules that give highly accessible energy information a greater impact on choices, while poorly accessible attributes will largely be neglected [34]. By this, labeling policies contribute to reducing costly information acquisition. Moreover, labeling policies aim to correct biased beliefs concerning the value of various energy efficiency measures. When consumers underestimate the energy-saving potential of durables, they may not purchase efficient products according to their own preferences [35]. Labeling policies correcting their beliefs address this internality and even motivate more investment in energy-saving appliances by clearly stating the potential costs/benefits in operating costs and energy costs.

To sum up, a label is a tag that describes information in an intuitive manner [36] by presenting information about the product's attributes or by presenting the most salient information in a graphical way to help consumers evaluate the features of the product. With regard to energy consumption, label policies comprise a selection of information on energy performance ratings of devices, vehicles, and buildings. Economic theories and experimental evidence provide some guidance for labeling policies to address inattention to information about energy efficiency. Labeling policies target building occupants with biased beliefs and those inattentive to future operating costs and energy costs to increase consumer awareness of energy consumption and address the environmental impacts.

To prove this, we developed a model based on Gerarden's framework [37]. When consumers choose between two products, "A" and "B", they tend to be inattentive to energy prices and operating costs [38,39]. There are two categories of energy labels: continuous scale labels displaying the monetary units of products, such as the US Energy Guide, and categorical labels presenting the energy classes (EC) of products, like the China Energy Label. The perceived present values of cost (PPVC) for each alternative can be calculated by the following equation:

$$PPVC_j = K_j + \theta(S, N) * O(E_j, P_E) * D(r, T) + \mu(S, N)EC + \varepsilon_{ij}, \quad (1)$$

where K_j stands for the purchasing price of alternative j . $\theta(S, N)$ is an attention parameter that depends on salience S of the present value of operating costs and the number N of components that compete for attention with $0 \leq \theta(S, N) \leq 1$, due to some degree of inattention. $\mu(S, N)$ is the function of the salience of the energy class of salience S and the number of components N with $0 \leq \mu(S, N) \leq 1$, due to some degree of inattention. $O(E_j, P_E)$ represents annual operating costs, based on the energy use E_j and the energy price P_E . $D(r, T)$ denotes a present-value factor, which depends on the buyer's discount rate r and the expected lifetime T of the durables, and ε_{ij} is a random error term.

Consider the case where a product has attributes X_j , which determines the perceived utility of the consumer and is associated with energy consumption. Thinking of energy-saving products as a collection of prices, energy consumption, and other attributes,

consumer i chooses products that maximize utility based on the expected utility they derive from it. The consumer's perceived utility function can be written as the following:

$$U_{ij} = \beta_1 X_j - K_j - \tau(S, N) * \beta_2 O(E_j, P_E) * D(r, T) + \varepsilon_{ij}, \quad (2)$$

where U_{ij} is utility, X_j is a selection of observed attributes, and β_1 and β_2 represent the marginal utility of product price and annual energy consumption cost respectively. K_j is equipment purchase cost. $\tau(S, N)$ represents an attention parameter of operating cost and energy class with $0 \leq \tau(S, N) \leq 1$.

Consumers are supposed to take all these factors into account when purchasing products, especially operating costs and energy costs. However, they will not have such a complete belief system. Experiments show that consumers usually ignore or underestimate the operating costs of products that are not easily visible. Labeling information presents the invisible information, such as energy efficiency and CO₂ emissions, in both comparable energy efficiency classes and absolute energy values, and link labels to fiscal expense or rewards by showing operating costs or lifetime costs to inattentive consumers. As uncertainty about operating costs and energy costs decreases, the utility expected by the consumers rises.

The effectiveness of label policies is largely affected by the way that information is demonstrated and how well the individual can absorb and take action [40]. Mandatory labels provide the government-sanctioned energy-efficiency level ratings of appliances. Evidence has demonstrated the positive influence of presenting information in the form of a simple label on consumer purchase decisions. Changing the labeling of the different energy efficiency ratings of the European energy labels from a mixture of letters and "A-pluses" (the A+++ to D scale) to unique letters only (the A to G scale) makes buyers more likely to purchase the most energy-efficient devices [41].

Loss aversion refers to an individual's tendency to focus more on avoiding losses rather than on acquiring gains [42]. The elements and formats of incentive programs can have the strongest influence on individuals. For example, presenting savings in energy consumption can trigger the loss aversion bias that an individual may have [43]. In addition, incentive programs seem to function well when introduced along with energy efficiency labels in guiding consumers to choose energy-efficient devices [44]. The incentive policies can make the labeling information more visible to consumers at the time of purchase and increase consumer awareness.

Therefore, the following hypotheses were put forward based on the arguments presented above.

Hypothesis 1. *Labeling policies have a positive influence on the possession of efficient appliances.*

Hypothesis 2. *Incentive programs drive consumers to choose high-labeled devices.*

Hypothesis 3. *Demographic variables (region, age, income, education, occupation, residence, quantity of inhabitants, and house size) influence consumers to choose high-labeled devices.*

3.2. Literature Review

Much literature has discussed the effectiveness of labeling policies and related incentive programs on the purchasing of energy-efficient appliances, but has come to a variety of conclusions along with different types of labels. Many researchers found that energy efficiency labels increased the uptake of energy-efficient durables [27]. Bertoldi et al. proved the effectiveness of energy labels in the European Union with the increase of sales of appliances in the highest efficiency class [45]. Zha et al. showed that the energy labels in China are effective, but residents are unwilling to choose the energy-efficient appliances due to an energy efficiency gap [46]. However, some studies found some distrust of the labeling programs due to missed information, such as the amount of en-

ergy required to manufacture the product [47]. Other studies demonstrated that energy labels were only effective for energy-intensive appliances, such as washer dryers, but not for tumble dryers or washing machines [48]. Filippini et al. revealed that the EU energy labels do not have a significant impact on energy efficiency improvements [49]. Egan showed that the U.S. energy labels had little effect on consumers' purchasing of energy-efficient appliances [50].

In terms of incentive programs, the results suggested that rebate policies of energy stars increased the sales share of energy-efficient appliances, ranging from 3.3% to 6.6% [51]. Filippini et al. indicated that financial incentives played a significant role in lowering energy demand [49]. However, Wang et al. found the subsidy program in China was insignificant [52]. Given the variety of reported results, it is essential to identify whether labeling policies and related incentive programs can have a positive impact on sales of energy-efficient appliances in China.

With regard to the demographic variables, Nguyen et al. found that a higher level of education, higher income, and more children positively affect the purchasing of energy-efficient appliances among Vietnamese consumers, while age and gender are weaker predictors of energy-efficient appliances [53]. Abeliotis et al. showed that age, income, and education are the most influential factors that determine sustainable consumption in Greece [54]. Clearly, with the different findings of such studies, more studies are needed to understand the relationship between demographics and purchase patterns of energy-efficient appliances. In light of the previous literature, this paper focuses on the effects of labeling policies, incentive programs, and demographic variables on households' purchases of energy-saving products.

4. Experiment Design

We adopted a discrete choice experiment with the data from the Chinese General Social Survey (CGSS), conducted by the National Survey Research Center of China, which was a continuous large-scale nationwide survey covering 28 provinces in both urban and rural China in 2015. This CGSS survey consists of different modules, including Core, Work and Economy, East Asian Social Survey (EASS), International Social Survey Program (ISSP), and Energy and Law. Each module uses a different sample size to systematically investigate the changing relationship between social structures and the quality of life. In this study, we employed the Core Module (a sample size of 10,968) and the Energy Module (a sample size of 3557) to discuss the influencing factors of consumers' possessions and use of energy-efficient appliances in the residential sector. The final sample size was 1143 after removing the observations with missing values.

4.1. Demographic and Policy Variables

The primary variables from the survey are the demographic and policy variables of the respondents in the final samples listed below. Income, education, region of residence, occupation, registered residence (rural and urban), quantity of inhabitants, and house size are indicated as socio-economic variables to study which factors affect the purchasing of energy-saving air conditioners and washing machines. Air conditioners and washing machines, as the most common household appliances, were among the earliest batches of products implemented by the mandatory energy information label.

In addition, the purchasing date and incentive programs were used as the policy index of appliances to investigate whether the labeling policies and incentive programs have a positive effect on energy-efficient appliances. The incentive programs include promoting appliances to rural areas, subsidizing the purchase of energy-efficient appliances, and launching appliance trade-ins. The program "subsidizing the purchase of energy-efficient appliances" promotes the application of energy-efficient appliances labeled as Grade 1 and Grade 2 through financial subsidies to consumers. "Promoting appliances to rural areas" offers rural households subsidies at their local township government finance agencies. "Launching appliance trade-ins" boosts the upgrade of household appliances

by returning old items for new ones for energy saving. In participant responses, the questionnaire consisted of four questions, including no subsidies, promoting appliances to rural areas, subsidizing the purchase of energy-efficient appliances, and launching appliance trade-ins.

Table 1 summarizes the demographic and policy variables in the survey and their features. Moreover, we were interested in whether the energy labeling policies and incentive programs of appliances actually function. The survey asked each interviewee to state the energy labels of the air conditioner and washing machine he or she owns, in which year he or she purchased them, and whether he or she benefited from the incentive programs. The remainder of this paper puts emphasis on identifying which of the explanatory variables make consumers invest in energy-efficient appliances. We first display the basic descriptive statistics for the household sample in the survey and then compare them with the national statistics from the National Bureau of Statistics (NBS).

Table 1. Main structure of the survey.

Variables	Questions	Description
Region	What city do you live in?	3 options: east, middle, or west
Gender	What is your gender?	2 options: female or male
Age	What is your age?	5 options: 18–29, 30–39, 40–49, 50–59, 60 or over
Income	What was your household income in 2014 (in RMB)?	Continuous: gross household income, in $[0, +\infty]$
Education	What is your education background?	5 options: primary school, junior school, senior and professional school, college and university, graduate school
Occupation	What is your occupation?	6 options: full-time employed, self-employed, part-time, retired, student, unemployed
Residence	What is your current registered residence?	2 options: urban residents, rural residents
Qty. of inhabitants	How many people are there in your family?	Continuous: number of inhabitants, from 1 to ≥ 8
House size	What is the gross living area of the house you are living in?	The size of house, in $[0, +\infty]$
Purchasing date	Which year did you purchase this product?	6 options: <1990, 1990–1995, 1995–2000, 2000–2005, 2005–2010, 2010–2015
Incentive program	Was there a buyer subsidy at the moment of purchase?	2 options: 1 = with incentive program, 0 = otherwise

4.2. Dataset Validation

To verify that our statistics in the sample provided a sound representation of China, the distribution of the demographic factors in our sample survey was compared against the 2015 statistics from the National Bureau of Statistics [55].

The education levels of respondents are presented in Figure 3a and the overall trend is similar to that of NBS. Figure 3b displays the age distributions of the modeling sample and NBS. Typically, the household head answered the survey, so there were some differences in the “Age 1” category. The remaining categories were similar to those of NBS. Table 2 shows that the distributions of registered residence and gender in the survey sample closely match those of the NBS. The comparison of other variables was not possible due to the fact that the classes recorded in this sample were different from those used in the NBS, or those explanatory variables were not included in the NBS.

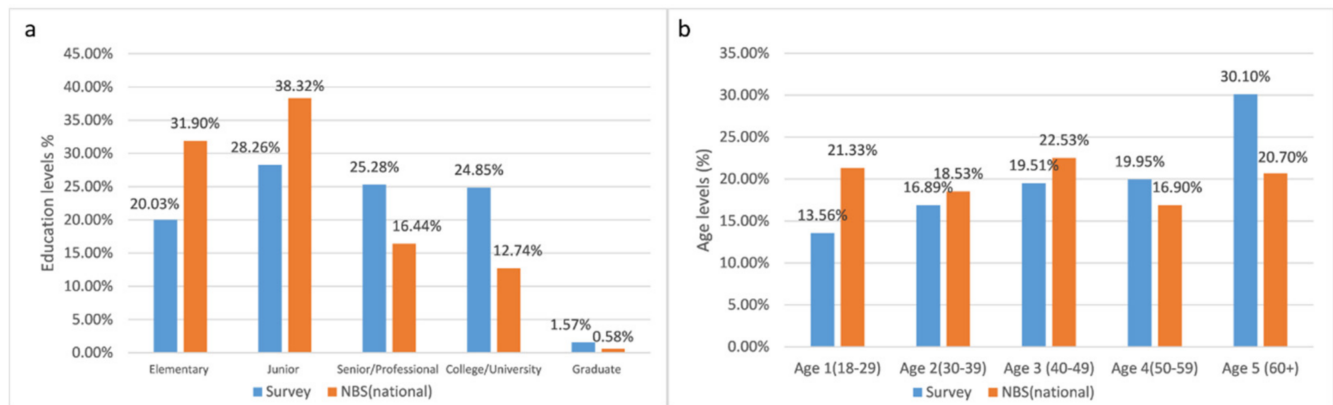


Figure 3. Education levels and age levels: survey sample and national distribution. (a) Education levels, (b) age levels.

Table 2. Registered residences and gender: survey sample and national distribution.

Registered Residence	Residence Sample	Residence NBS	Gender	Gender Sample	Gender NBS
Urban residence	57.31%	56.10%	Female	53.28%	48.78%
Rural residence	42.69%	49.30%	Male	46.72%	51.22%

4.3. Economic Model

We conducted the discrete choice experiment to evaluate consumers' willingness to purchase the energy-efficient appliances, which can be useful for those involved in policy decisions [56]. Specifically, the logistic regression model that we use is constructed as follows:

$$P_j = F(\beta_0 + \sum_{i=1}^m \beta_i x_{ij}) + \mu = \frac{1}{\{1 + \exp[-(\beta_0 + \sum_{i=1}^m \beta_i x_{ij})]\}} + \mu, \quad (3)$$

$$\ln \frac{P_j}{1 - P_j} = \beta_0 + \sum_{i=1}^m \beta_i x_{ij}, \quad (4)$$

where P_j represents the probability of possession of energy-efficient appliances. x_{ij} represents the j -th explanatory variables of the i -th sample, and β_i represents the coefficient of the explanatory variables. m represents the number of explanatory variables. β_0 is the intercept value and μ is the random error term.

In this study, the dependent variable y represents the possession of energy-efficient appliances with energy levels of Grade 1 and Grade 2 among air conditioners and washing machines. (1 = possession of energy-efficient appliances, 0 = otherwise). Only independent variable x_j , with clear intention in the survey, was selected for the study according to the purpose of the study, including region, income, education, house size, registered residence, occupation, income, quantity of inhabitants, purchasing date, and subsidy.

$$y = F(x_1, x_2, x_3, \dots, x_j). \quad (5)$$

5. Results

Table 3 presents the results of the multivariate regression logit model by using SPASS. Regarding the air conditioners, the regression coefficients of education and purchasing date are statistically significant at 0.01, indicating that education and energy labels have a significant positive effect on purchasing energy-efficient air conditioners. Furthermore, the coefficient values of incentive programs and house size are significant at 0.05, showing that incentive programs and house size have a significant positive effect on the investment in energy-efficient air conditioners. In addition, the odds ratio (since $\exp(0.455)$) of the incentive program is 1.576, which means the probability of investing in energy-efficient

air conditioners will be 1.576 times larger by increasing the subsidy of one unit. As the east, middle, and west regions are set 1, 2, and 3, respectively, the coefficient of the region is -0.349 and is significant at 0.05, showing that respondents in the east are more willing to purchase energy-efficient air conditioners than those in the middle and west. Other explanatory variables of the sample with p -values higher than 0.05 show that income, occupation, registered residence, and quantity of inhabitants seem to be irrelevant to the possession of air conditioners.

Table 3. Consumer investment model of air conditioner estimates.

Explanatory Variables	Coeff.	Std. Error	p -Value	Significance Level
Intercept	-2.668	0.647	0.000	**
Education	0.187	0.063	0.003	**
Purchasing Date	0.394	0.071	0.000	**
Subsidy	0.455	0.220	0.038	*
House size	0.284	0.128	0.026	*
Region	-0.349	0.148	0.018	*

Significance codes for p -values: '***', '**' represents significance at 0.01 and 0.05, respectively.

Table 4 presents the results of the multivariate logit regression model of the washing machines, the regression coefficient of education is statistically significant at 0.01 (coefficient = 0.213, $p = 0.005 < 0.01$), indicating that education will have a significant positive effect on purchasing energy-efficient washing machines. Additionally, the odds ratio (since $\exp(0.231)$) is 1.237, which means the expected odds of purchasing washing machines will be 1.237 times larger with increasing education by one unit. Furthermore, both the coefficient value of the purchasing date and incentive programs are also significant at 0.01, showing that both energy labels and incentive programs have a significant positive effect on investments in energy-efficient appliances. The coefficient of the region is -0.438 and is significant at 0.05, indicating that the respondents in the east are more willing to purchase energy-efficient washing machines.

Table 4. Consumer investment model of washing machine estimates.

Explanatory Variables	Coeff.	Std. Error	p -Value	Significance Level
Intercept	-2.735	0.525	0.000	**
Education	0.213	0.075	0.005	**
Purchasing date	0.353	0.071	0.000	**
Subsidy	0.642	0.212	0.002	**
Region	-0.438	0.171	0.010	*

Significance codes for p -Values: '***', '**' represents significance at the 0.01 and 0.05, respectively.

In addition, different criteria have been used to diagnose the reliability of the model:

1. The model likelihood ratio test was used to analyze the effectiveness of the models of air conditioners and washing machines. A p -value less than 0.05 shows that the model is effective. Otherwise, the model is invalid. The results of both the air conditioner test and the washing machine test are a p -value of 0.000, indicating that this model is effective.

2. The Hosmer–Lemeshow’s Goodness of Fit test was employed in the logistic regression model to demonstrate the fit between the model and the dataset obtained from a simple random survey [57]. It determines whether the null hypothesis H_0 of the observed rates of energy-efficient appliance possession matches the predicted rates, and then returns a p -value. If the p -value is less than 0.05, the predicted rate of energy-efficient appliances possession deviates from the observed ones in a way that the binomial distribution does not predict accurately and should be rejected. The p -values of the air conditioner test and washing machine test are 0.911 and 0.955, respectively, indicating that there is no evidence to reject the model.

6. Discussion of the Results

This study investigated whether the labeling policies and incentive programs promote the purchasing of energy-efficient durable goods, and which demographic characteristics influence the possession of energy-efficient appliances. For each type of appliance, labeling policy has a positive effect on the possession of energy-efficient appliances. A large-scale laboratory experiment by Newell and Siikamaki proves the effectiveness of the labeling policies, including Energy Guidelines, Energy Stars, and Energy Efficiency Grades [27]. The study also shows that energy labels have had a significant effect on the high tendency of consumers in China to invest in energy-efficient durable goods [58].

Regarding the incentive programs, the respondents prefer to invest in energy-efficient appliances with the incentive programs. Other studies demonstrate that incentive programs, as a predictor, encourage consumers to purchase energy-efficient appliances. Long surveyed 6346 households in the United States and demonstrated that people were more likely to pay for energy conservation devices with the incentive programs [59]. Cho et al. analyzed the influence of incentive measures on electricity consumption when consumers buy energy-saving TVs in South Korea. This shows that incentive measures can effectively promote consumers' purchases of energy-saving TVs [60].

On the side of education, the model estimates verify the positive correlation: the probability of purchasing energy-efficient appliances increases with education. This conclusion applies to several other studies. Harris believes that education is a more effective tool that the government can provide, that is, changing people's environmental awareness through education [61]. Steg believes that education can increase residents' energy knowledge, cognition, and norms, so as to realize residents' energy-saving behaviors [62]. Mills and Schleich have demonstrated that a higher level of education increases the likelihood of purchasing appliances with energy efficiency labels [63]. Also, Velasco-Martínez et al. have found that education is positively linked to environmentally sustainable products [64].

The region variables result in positive parameter estimates of both air conditioners and washing machines. The respondents in the eastern region were more likely to choose energy-efficient appliances during the purchasing process than those in the central and western regions.

House size was one of the strongest predictors for energy-efficient air conditioners, but not for washing machines. Moreover, consumers in larger rooms, in general, were more willing to choose energy-efficiency air conditioners, because the air conditioners in larger houses cause higher expenses for electricity, and thus consumers have a greater incentive to purchase energy-efficient air conditioners. However, house size was not one of the strongest predictors to energy-efficient washing machine purchases, because the energy consumption of washing machines has little to do with house size, as also confirmed by the results.

7. Conclusions and Policy Implications

Globally, in order to stimulate energy savings in the residential sector, a series of policies have been proposed [65]. Labeling programs have become a commonly used policy for addressing the problems of asymmetric information and promoting the adoption of more efficient devices. Studies have proven their effectiveness in promoting the investments of consumers in energy-efficient appliances. The Chinese energy policies are successful in directing consumers toward the purchasing of energy-efficient durables, but there is still some room for improvement. This paper has studied the effects of energy labels and incentive programs on the choice of air conditioners and washing machines by conducting a discrete choice experiment. Based on the results, we suggest improving energy label policies by targeting key demographical factors to enhance consumer awareness of energy efficiency labels.

7.1. Improved Regulatory Framework for Energy Efficiency Programs

An appropriate legal framework is fundamental to the success of any labeling program. Policy implementation is determined, to a large extent, by legislation and regulations that directly set a timetable for energy performance standard-setting, improvement of appliances, product coverage, and a legal penalty for non-compliance. The newly revised 2008 Energy Conservation Law in China provides the legislative basis for the implementation of efficiency standards and labeling programs. However, weak regulatory authority on energy labels directly affects the effect of the implementation of the energy label programs. Some enterprises take advantage of the self-declaration process to put false information on energy labels, which seriously harms the interests of consumers [58]. It is necessary to articulate labeling-specific legal systems to empower competent agencies to enforce and supervise the programs and introduce complementary energy label policies, such as energy performance standards, to eliminate highly energy-guzzling products. It is also imperative to upgrade incentive programs linked to energy efficiency alongside the labeling programs to improve the effectiveness of energy efficiency labeling policies [14].

The incentive programs motivate consumers to purchase energy-efficient appliances. By reducing the initial cost of energy-saving durables, we can guide households to adopt environmental protection consumption. Monthly sales of energy-saving appliances increased from more than 1.6 million units to 7 million units with the introduction of incentive programs from 2012 to 2013 [66]. However, there are also some problems in the implementation of programs, such as subsidizing energy-efficient appliances and launching appliance trade-ins. They either cover fewer product varieties with complicated procedures or encounter various subsidy cheating with little effective formative and follow-up supervision from the government. As the subsidy programs make energy efficiency labels and standards more effective [67], it is necessary to develop mechanisms to ensure the supervision of incentive programs and empower agencies for enforcement and inspection to encourage compliance with subsidy programs. Furthermore, periodic assessments should be scheduled to monitor and report on incentive outcomes to increase the effectiveness of incentive programs. The program for promoting appliances to rural areas is not limited to energy-saving appliances and there is a great potential for rural areas to develop efficient appliances, so we suggest that in the future, only appliances labeled with Grade 1 (the most efficient) would be subsidized, and subsidy size should be raised in order to satisfy the expectations of buyers in rural areas to ensure the enforcement of label policies [68].

7.2. Program Recognition and Awareness Enhancement among Consumers

Many consumers are not aware of the programs or lack in-depth knowledge of the programs. A survey showed that more than half of the respondents said that they have heard of or have seen the subsidy program, but only 10% of interviewees were able to identify all categories of durable goods covered by the program, and some consumers did not even know the subsidy amounts at all [68].

In addition, the China Sustainable Consumption Report shows that 55.35% of the respondents have heard of the China Energy Label. Only 36.64% of the respondents knew China's environmental label and 32.53% of the interviewees recognized China's Energy Conservation Certification [69]. This highlights the importance of outreach of energy-efficiency labels to the broader public, because consumers are unlikely to consider energy efficiency information from labels if they are unfamiliar with the labels. In general, the popularity of sustainable energy labels and incentive programs still needs to be improved [58]. For the purpose of consumer outreach, a user-friendly labeling website could be established to provide useful messages in addition to the fixed information on the labels. The website should include energy efficiency information and incentive program information in promotional materials through other major media, especially online sources, to increase public awareness of the labeling programs and incentive programs. Two-way communication channels should be established to address the comments and respond to feedback from consumers by using social media to increase public participation.

In addition, it would be effective for labeling programs to cover all categories of appliances, including both new and used appliances, to maximize the influence of labeling programs. Up to now, 15 batches of mandatory energy efficiency labels with 42 products have been enforced. Comprehensive market research could be conducted to survey consumer expectations of energy-efficient appliances regularly. Real-world consumption performance data could be collected to ensure the information shown on the energy labels matches the real-world performance to gain the consumers' trust.

With regard to these trends and the region outcomes of our finding, it is necessary for the Chinese policymakers to improve the promotion of energy label programs and incentive programs in central and western regions, creating an energy conservation culture over the long run. Energy conservation awareness campaigns could be developed for consumers, for example, by developing energy label promotion programs to enable these households in these regions to understand the benefits of energy-efficient appliances for the total household energy consumption and the contribution energy-saving products would make in the short and long terms. The underlying assumptions are that consumers are unwilling to invest in energy-efficient durable goods partly because of a lack of knowledge concerning the rewards of saving energy. Therefore, education policies should thus be aimed at increasing the awareness of energy-saving durables with an emphasis on end-use behaviors of consumers. This could result in more conscious energy saving and use in daily life, which, in turn, as demonstrated in our findings, is linked to a greater uptake of efficient durable goods in dwellings [70].

7.3. Upgraded Label Designs and Information Disclosure

Labeling policy can lower the cost of attention and improve welfare. The cost-effective way of lowering attention costs is to steer more efforts towards the appropriate presentation of information on the energy labels, where there is a need for continuous improvement. For example, research has demonstrated clearly that the willingness to pay for efficient appliances increases by shifting the EU energy labels from a mixture of letters to unique letters only [41].

Furthermore, it is also necessary to provide information for efficient appliances comparable to conventional appliances in terms of operating cost, energy efficiency, CO₂ emissions, and incentive programs. The additional information for alternative appliances allows customers to make comparisons among all relevant durable goods [46].

In 2016, a two-dimensional barcode (abbr. QR code) system was attached to the new version of energy efficiency labels in China, providing all-round product information online, and thus facilitating consumer comparison and market supervision. However, physical units rather than monetary units are displayed on the energy labels and no label provides information on the running costs and energy costs in China. Since energy information in physical units typically makes consumers overestimate the cost savings and steers consumers towards choosing appliances with low energy efficiency [71], the monetary information, particularly lifetime cost, ought to be disclosed. Therefore, it is necessary to present economy efficiency in both absolute value and comparable energy efficiency classes, and associate labels with fiscal expense or rewards by showing lifetime energy costs or operating costs. Furthermore, since China has implemented a series of energy efficiency-oriented incentive programs, it would be more effective to present fiscal policy on energy labels or websites so as to further increase the awareness of the public to conserve energy in the dwellings.

In this study, behavioral economic theories have been applied to clarify the significance of labeling policies and incentive programs. We have proposed some practical policy recommendations for future implementation based on our findings. These findings provide some practical guidelines for policymakers when they provide the legislative basis for energy efficiency labels and related incentive programs. The findings also guide the manufacturers and retailers to improve designs for energy efficiency labels. In addi-

tion, the results of the study can help consumers make better choices in the purchasing of appliances.

The major limitations of the present study are as follows:

We have simply focused on air conditioners and washing machines to study the effects of policies and demographic variables on the purchasing of energy-efficient appliances. In future studies, other commonly used electrical appliances (like refrigerators, televisions, etc.) should be covered, and the findings could be compared with the results of this study. Moreover, the subsidy programs, including promoting appliances to rural areas in 2008, subsidizing the purchase of energy-efficient appliances in 2009, and launching appliances trade-ins in 2009, have been considered as one variable to study the effectiveness of incentive programs. In the future, separate studies could be conducted with each being an independent variable to investigate the effect of each program on the purchasing of energy-efficient appliances.

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