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May 2016

Abstract Improving energy efficiency is an unarguable emergent issue in developing economies and an energy efficiency standard and labeling program is an ideal mechanism to achieve this target. However, there is concern regarding whether the consumers will choose the highly energy efficient appliances because of its high price in consequence of the high cost. This paper estimates how the consumer responds to introduction of the energy efficiency standard and labeling program in China. To quantify evaluation by consumers, we estimated their consumer surplus and the benefits of products based on the estimated parameters of demand function. We found the following points. First, evaluation of energy efficiency labeling by the consumer is not monotonically correlated with the number of grades. The highest efficiency label (Label 1) is not evaluated to be no less higher than labels 2 and 3, and is sometimes lower than the least energy efficient label (Label UI). This goes against the design of policy intervention. Second, several governmental policies affects in mixed directions: the subsidies for energy saving policies to the highest degree of the labels contribute to expanding consumer welfare as the program was designed. However, the replacement for new appliances policies decreased the welfare.

Keywords: Consumer surplus, energy efficiency standard and labeling, promotion policies
JEL classification: F15, O14, O30

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1 Introduction

The energy efficiency standard and labeling programs are regarded as an ideal policy to reduce energy consumption via the market mechanism (References (16), (10)). Developing countries are the most desperate to consider its introduction. However, there is concern that the consumers do not choose the most energy efficient appliances because its price is genraly high. This tendency is regarded as a hinderance to the prevalence of energy efficient appliances in developing economies.

To identify whether this concern is true or not, this paper attempts to quantify the impact of the energy efficiency standard and labeling program on the consumer welfare of air conditioner appliances and consumer's decision to purchase. I estimated the consumer welfare of air conditioners based on market audit data for the 30 cities in China, then identify the impact of the standard and labeling program on the consumer side. Here, we found that consumers evaluate the labels negatively: They regarded that it reduces the welfare. At the same time, subsidy from the government did compensate its negative impact. This paper proceeds as follows: Section 2 presents strategy of analysis for this paper. Section 3 presents economic models as an analytical framework, and Section 4 report the estimated results. Section 6 discusses the results and implication for understanding the characteristics of the Chinese markets.

2 Research Strategy

How do the consumer evaluated the energy efficiency standards and labels? They might positively regard them as a good indicator of high quality, or they might dislike the labels and believe them to indicates a high cost and useless features. To address this question, we quantify the consumer welfare and its benefit on different types of products. If a consumer values any particular attributes of products, such as labels, these are positively correlated with consumer welfare. If a consumer them values negatively, the relationship is the opposite.

A theory behind our quantifying exercise is as follows: when a products is traded, the consumer/buyer believes the product is providing a benefit B for them. The value of trade is defined as the difference between a benefit B of product j for consumer i, and its production cost C. As long as $B - C$ is not smaller than zero, the business is viable. The larger the benefit of trade, $B-C$, the larger the contribution provided by the business to the society.

$$\begin{aligned} Value\ of\ trade &= (B-P)+(P-C) \\ &= B-C \end{aligned}$$

Value of trade is divided between the consumer and the producer: consumer/buyer receives a fraction of $B-P$. This is called consumer welfare. The seller receives another fraction of value as much of $P-C$, which is called profit or producer's welfare. Once we obtain the figure of consumer welfare, $B-P$, we can quantitatively compare sizes of the welfare produced by the particular type of sellers or products.

Then, how can we obtain the figures of benefit or consumer welfare? I quantified them from the demand function parameters that are estimated a nested logit type demand function of a particular market (see Section 3). The nested demand function induced from a product choice model based on individual utility will be detailed in Section 3.1.

2.1 Energy Efficiency Standard and Labeling Program in China

In 2005, China first introduced the energy efficiency standard and labeling program for the non-inverter controlling ACs and, then expanded to inverter controlling ACs in 2008. China employs COP as the performance measure and requires the fulfillment of MEPS by every model. The standards and labels are updated regularly, although the frequency is not pre-specified. China employs a multi-grade labeling program for air conditioners that started in 2005. The number of grades is three or five, depending on the type of technology employed[1].

China's regulations are unique in a point that they set double track standards for inverter ACs and non-inverter ACs. It should be noted that (1) MEPS for inverter ACs are set lower than non-inverter ACs so as to induce local manufacturers to shift to inverter ACs. (2) Subsidies were given to the purchasers of inverter ACs at the same time. This policy accelerated the penetration of inverter ACs in China: the ratio of inverter AC in the market shares only 7% in 2008 and drastically increased to 42% in 2011.

2.2 Promotion Policies

In addition to the energy efficiency standard and labeling program, the Chinese government initiated several policies supporting the improvement of energy efficiency: the Energy Saving

[1]Fixed-speed air conditioners are assigned five grades while inverter air conditioners are assigned three grades. SEER/APF has not yet been employed even though the share of inverter air conditioners in the new sales has risen to approxiately 40 percent.

Table 1: Penetration of Inverter ACs in China

	2008	2009	2010	2011
Market Size (0000 units)	2673	2680	3241	-
Ratio of Inverter ACs	7%	17%	30%	42%

Source: Authors' interviews and reported materials.

Promotion Policy, Replacement Promotion Policy and Promotion of Home Appliances for Rural Area were implemented in the late 2000s in China. These supportive policies also worked to stimulate the economic activity during the period just after the financial crisis occurred in 2008.

Energy Saving Promotion Policy In June, 2009, the Energy Saving product Promotion Policy (節能産品恵民） was initiated. The government provided a subsidy to consumers who purchased higher energy efficient products; ACs in label 1 and label 2. There is a report that the subsidies for air conditioners with labels 1 (the most efficient) and 2 expanded their market shares from 5 per cent to 50 per cent until the end of the year (6, p.1xx).

Table 2: Subsidies of Energy Saving Product Promotion Policy

Label Grade	Cooling Capacity Range (kw) min	max	Subsidy (RMB)	Upper Limit Price for Subsidy (RMB)
1	0	2800	500	4000
1	2800	4500	550	5000
1	4500	7100	650	8500
1	7100	14000	850	12000
2	0	2800	300	3500
2	2800	4500	350	4000
2	4500	7100	450	7500
2	7100	14000	650	11000

Source: State Development and Reform Committee Ministry of Finance.
Note: The subsidy started in June 2009 for selected manufactures.

Replacing the Old with the New Products Policy The Replacing the Old with the New Products（以旧換新）Policy started in 2009 for selected cities and provinces, and then extended to other provines in 2010 as 3. When a consumer purchse a product in exchange for an old one, the consumer can receive a subsidy. Air conditioners were listed in the first policy catalog that came out in January 2009. The amount of subsidy is either smaller, 15 per cent of the retail price or is 350 RMB(6, p.xx).

Table 3: Replacement Policy

City	Provincial-level policy starting year	City-level policy starting year
TIANJIN	2009	
WUXI	2009	
NINGBO	2009	
SUZHOU	2009	
QINGDAO	2009	
HANGZHOU	2009	
BEIJING	2009	
NANJING	2009	
GUANGZHOU	2009	
JINAN	2009	
SHENZHEN	2009	
DONGGUAN	2009	
SHANGHAI	2009	
XIAN	2010	2009
HARBIN	2010	
FUZHOU	2010	
DALIAN	2010	2009
SHIJIAZHUANG	2010	
CHONGQING	2010	
SHENYANG	2010	
NANNING	2010	
HEFEI	2010	2009
XIAMEN	2010	2009
CHENGDU	2010	
CHANGSHA	2010	2009
WUHAN	2010	
ZHENGZHOU	2010	2009
TAIYUAN	2010	
NANCHANG	2010	
KUNMING	2011	

Source: State Development and Reform Committee Ministry of Finance.
Note: The subsidy begun in June 2009 for selected manufactures.

Promotion of Home Appliance to Rural Areas Policy Promotion of Home Appliances for Rural Areas Policy (家電下郷） also began in 2009 to expand sales of home appliances in rural areas in 2009. The government exempted 13 per cent of the value added tax for the designed for rural promotion products. Government accepted applications for the policy target catalogue. The maximum retail price was set for all of the products on the list(6).

3 Model and Estimation

3.1 Estimation model

Here, I describe a model for estimation. Consumer demand is modeled using a discrete-choice formulation. This model describes a process in which the consumer will choose a product according to the size of the utilities. On the supply side, I assume competition between several brands in different geographical markets at different times.

3.1.1 Utility and Demand

First, I describe the utility of consumer i that consists of the benefitof the product j. Consumers choose a brand j in a given market (=city and year, here) to maximize their utility. I view a product as a particular brand sold in a city market $m = 1, 2, ...M$.(I delete m hereafter simply for the reader's convenience). The indirect utility U_{ijt} of consumer i from the purchasing brand $j = 1, 2, ...J$ at time $t = 1, 2, ...T$ is,

$$u_{ijt} = -\alpha_i p_{jt} + \beta X_{jt} + \xi_{jt} + \epsilon_{ijt}. \tag{1}$$

p_{jt} denotes the price of brand j at market m in time t. Other factors affect product choice, such as the features of product x_{jt}. ξ_{jt} is a product-market specific unobservable. $\epsilon_{ijt}$is the random unobservable error. The coefficients of price are $\alpha_i = \alpha/Y_i$, Y_i the observed income[2].

The mean utility of product j can be rewritten as,

$$\delta_{jt} = -\alpha_i p_{jt} + \beta X_{jt} + \xi_j + \xi_t. \tag{2}$$

Each consumer i in market m will choose product j to maximize the utility. Therefore, the aggregate market share for product j in market t is the probability that product j yields the highest utility across all products including outside goods. Therefore, the predicted market share of product $j = 1, ...J$, s_j is a function of mean utility δ_{jt} and parameter vector $\theta = (\beta, \alpha, \rho)$. If the unobserved error , ϵ_{ijt} follows iid extreme value, this relationship can be rewritten as a logit choice probability(see Train (2009)).

[2]I used average income of eacy city-year segments in this paper. That means $Y_i = I_{mt} = \frac{\sum Y_i}{I}$ and $\alpha_i = \alpha_{mt} = \alpha/Y_m t$.

$$\begin{aligned} P_{jt} &= s_{jt}(\delta_{jt}, \theta) \\ &= \frac{e^{u_{jt}}}{\sum_k e^{u_{kt}}} \\ &= \frac{e^{-\alpha_i p_{jt} + \beta X_{jt} + \xi_{jt} + \epsilon_{ijt}.}}{1 + \sum_k e^{-\alpha_i p_{kt} + \beta X_{kt} + \xi_{kt} + \epsilon_{ikt}}} \end{aligned} \tag{3}$$

Here, 1 in the denominator represents value of outside option, because $exp(u_0) = exp(0) = 1$. Remaining variable in the denominator is the sum of exponential utilities of all of the choices in every market.

Under this logit assumption, consumer surplus CS_i for consumer i, previously indicated by $B - P$, takes the following closed format.

$$E(CS_i) = \frac{1}{\alpha_i} E[Max(u_{jt})] \tag{4}$$

The expectation is over all possible values of error ϵ_{ijt}. Here, the expected consumer surplus for individual i and product j can be written as follows.

$$E(CS_i) = \frac{1}{\alpha_i} ln(\sum_{j=1}^{J} e^{u_{ijt}}) + C.^3 \tag{5}$$

$$E(CS_j) = \sum_{i=1}^{I} \frac{1}{\alpha_i} ln(e^{u_{ijt}}) + C \tag{6}$$

The absolute value of consumer surplus is meaningless because of the unknown C. However, the difference between several states of consumer surplus is a figure generated from the structure. This paper focused on the difference between two different agents, for example, agent i or ownership type i comparing to agent h or ownership type h, it can be written as follows:

$$\Delta CS_{ih} = \frac{1}{\alpha_i} [ln(\sum_{j=1}^{J} e^{u_{ijt}}) - ln(\sum_{j=1}^{J} e^{u_{hjt}})] \tag{7}$$

In this paper, this relationship is employed to test the impact of the program and policy on consumer welfares.

Once you obtained CS_i from above estimates, I can obtained the value of benefit of product j, B_{jt}.

$$Benefit_j = CS_j + Price_j \tag{8}$$

3.1.2 Nested Logit Model and Identification

The logit-based utility model provides an estimating equation of utility in the following form (see Train(2009) for an explicit explanation.). Based on the model, I estimate the demand parameters following Berry (1994) and Nevo (2000) and other BLP literatures.

Our estimation equation is as follows,

$$ln(\frac{s_j}{s_o}) = -\alpha p_{jt} + \beta X_{jt} + \xi_{jt} + \epsilon_{ijt}. \tag{9}$$

Here, I set the outside option as the difference between the population and total number of air conditioners for the individual market and year.

The parameters of this demand can be identified as the previous empirical industrial organization literatures claims (see Ackerberg and Crawford (2009)). The identification of price parameters, which is critical for our margin calculations, relies on the fact that the unobserved determinants of demand are uncorrelated with input prices. To account for this potential endogeneity of prices that may be caused by the presence of changes in unobserved attributes, we use the GMM estimator with either type of instruments variables discussed in Section 3.3.

To account for the degree of preference correlation between products of the same group, I impose a further assumption on the error term, ϵ_{ijt}.

$$\epsilon_{ijt} = \rho ln(s_j|g) + \bar{\epsilon_{ijt}} \tag{10}$$

ρ is a "nesting parameter" , $0 \leq \rho \leq 1$ that captures the correlation between preference and product characteristics (1).

Our estimation equation becomes,

$$ln(\frac{s_j}{s_o}) = -\alpha p_{jt} + \beta X_{jt} + \xi_{jt} + \rho ln(s_j|g) + \bar{\epsilon_{ijt}}. \tag{11}$$

Here, I set the outside option as a difference between population and . total number of air conditioner for individual market and year.

Under this nested logit model, consumer surplus will be computed as follows (see Ivaldi and Verboven[2005:677]).

$$E(CS_i) = \frac{1}{\alpha_i} ln(1 + \sum_{j=1}^{J} D_g^{1-\rho}) + C.^4 \tag{12}$$

[4] C is an unknown constant that represents the fact that absolute value level of utility cannot be observed.

$$D_g = \sum_{k=1}^{G_g} exp(\delta_j/(1-\rho)) \tag{13}$$

3.2 Data

I use the market survey data of GfK market services for the air conditioner industries. Sales value and number of units for individual model are available for each top 10 brands and rest of brands for several features of the products for 30 cities [5] for the years from 2000 to 2011 in China. The features of the products are as follows: Air conditioners are divided by (1) horsepower (1 HP, 1 to 2 HP and 2 HP and above) (2) grades of the energy efficiency labels, and (3) types of installment. Regarding the air conditioner data, the data on sales and information related to energy consumption begins with the year 2008 and is obtained from the GfK market auditing data.

Data for power consumption are not available directly from this data base. We supplemented the information from the catalog on e-commerce site, SOHU[6]. Based on the catalog information of air conditioner sold in 2011, I regress cooling capacity and annual power consumption on the available attributes of air conditioner and brands. Predicted values of cooling capacity and annual power consumption were connected to the GfK data.

3.3 Instruments

The estimation of nested logit demand models I employed here is typically done using IV or GMM using instruments for p_{jt}. Instruments z_{jt} that are correlated to p_{jt} but are independent to ϵ_{ijt}. In this case, candidates of instruments here mainly employed from following four sources: (1) cost shifters; fees of electricity etc. (2) price of the same products of the same brand in other city Here, we need to assume difference of prices of the same products across cities only reflects demand factors, the price of other city of the same products are correlated with price via only cost factors. (BLP, 1995 Hausman, 1996. Nevo, 2001). (3) Price of the same type of products by competitor brands in a same city (BLP, 1995) (4) characteristics of products; it is natural to assume that characteristics of products are designed and planned in advance, before the price is fixed. Exploiting this natural assumption, we use the characteristics of products as instruments that predetermined to

[5] Beijing, Changsha, Chengdu, Chongqing, Dalian, Dongguan, Fuzhou, Guangzhou, Hangzhou, Harbin, Hefei, Jinan, Kunming, Nanchang, Nanjing, Nanning, Ningbo, Qingdao, Shanghai, Shenyang, Shenzhen, Shijiazhuang, Suzhou, Taiyuan, Tianjin, Wuhan, Wuxi, Xiamen, Xian, Zhengzhou

[6] URL is $http://product.it.sohu.com/list/subcate_345.html$, We downloaded the data on 12, October 2012.

Table 4: Summary Statistics

Variable	**mean**	**sd**	**min**	**max**
Year	2,007.69	2.72	2,000	2,011
Price (RMB)	4,676.14	2,846.69	350.00	36,400.00
Number of Unit Solds	19,892	57,011	2	1,913,125
Number of Brands	19.68	12.10	1.00	49.00
Attributes of air conditioner				
Capacity				
Horse Power under 1	0.29	0.45	0.00	1.00
Horse Power under 2	0.44	0.50	0.00	1.00
Horse Power over 2	0.26	0.44	0.00	1.00
Cooling capacity (KW)	3,786.47	1,499.91	52.00	12,000
Annual power consumption (KW)	1,287.94	557.24	530.00	5,733.33
Energy label				
Label1 (Most efficient)	0.12	0.33	0.00	1.00
Label2	0.16	0.37	0.00	1.00
Label3	0.20	0.40	0.00	1.00
Label-UI(unidentified)	0.24	0.43	0.00	1.00
Inverter controlled	0.28	0.45	0.00	1.00
Non inverter	0.70	0.46	0.00	1.00
Types of installment				
Stand alone	0.29	0.45	0.00	1.00
Split	0.41	0.49	0.00	1.00
Others	0.29	0.46	0.00	1.00
Policy Interventions				
Subsidy for energy saving target (RMB)	141.12	214.73	0.00	850.00
Replacement policy target	0.40	0.49	0.00	1.00
Demographics data of market				
Average wage (RMB:annual)	35,344.39	12,790.84	9,143.00	71,923.60
Population	7,877,992.60	5,615,040.05	1,249,200	33,034,500
Per capita are of residence (m2)	26.41	6.40	16.32	57.38

Source: GfK market survey. China City Statistical Yearbook.

the price. (i) first type of "quality" dummies are the sum of index of characteristics within the own brand, such as capacity of air conditioners or size of visual panels of color television. (ii) The second type is the sum of the characteristics of other products of rival firms, and (iii) the third one is average index characteristics of other products of own firms (see Grigolon and Verboven (2011) Verboven (1996)). (iv) fourth is the average index of the characteristics of a competitor.

IVs employed in the estimates (3) that used for final computation of consumer welfare in Table 4 is as follows: average of rivals' horse power and own horsepower (Type (3) (iii) and (iv)), sum of own horse power (Type (3) (i)), wage, per capita area of residence and Herfindahl-Hirschman Index of the market.[7].

4 Estimation Results

4.1 Estimated Parameters

Estimated demand parameters are presented in Table 5. Results indicate expected nature for basic capacity of air conditioner (such as cooling capacity, horse powers). However, impact of three policies; energy efficiency standard and labeling program, replacing the old with the new policy and the energy saving subsidies shows mixed and interesting results.

First, the replacing with the old with the new policy do not affect value of first hand air conditioner market. This result is common with both simple logit (2) and nested logit format (3).

Secondly, the Subsidy for energy saving products policy significantly affects value of air condition and the energy efficiency labels. Subsidy variables have a positive coefficients for both format. Coefficients of the energy efficiency labels varies according to the specification. Label 1 has a positive coefficients in specification without no policy variables equation (1) in Table 4, however, it changed into negative in specifications where label and subsidy amount are multiplied (equation (2) and (3)). This implies that consumer values label 1 when it connected with larger subsidies, but they values the label itself negatively. According to the result in equation (3), label 1 is deducted the value of air conditioner is largest. This deduction decreased along with less efficient products (Coefficients of Label 1 is -4.0 whereas Label 2 is -3.8 RMB, label 3 is -3.3 and unidentified group is -2.3).

[7] GMM c-statistics of demand estimates results in Figures 5 show that the IV were confirmed as exogenous to our demand systems. However, there remains a possibility of weak IV's problem as Shea's partial R square are as much as low as 0.06 and 0.004 for price and nested parameter variables. Details of HHI indices showed in Appendix A.1 and A.2. They indicated the market we focused a highly competitive.

This result shows that consumer values the energy efficiency labels just against the design of the labeling program. The program is designed to resolve the information asymmetry problem between manufacturers and consumers on the energy efficiency with an assumption that consumer will prefer to buy the more energy efficient appliances when they got informed. However, the results here showed that consumer preferred less efficient appliances more when they got informed on the energy efficiency of the products[8].

This result document a phenomenon that is consistent with a concern by the practice side: Consumer may not prefer the energy due to higher prices. We must consider the factor that causes this negative preference phenomenon. In order to explore the reason, we conducted several tests in the following subsection.

4.2 Comparison of Consumer Surplus and Benefit

Consumer theory assumes that consumer will choose to purchase a product when the consumer welfare of a product is larger than others. Our estimation also relies on this assumption.

In order to trace the consumer's response to the labels more clearly, we compare the consumer welfare and benefit among the different labels consistently exist. Estimated demand parameters allow us to compute the benefit and consumer surplus of each product. Then, I tested whether mean of consumer surplus or benefit across the grades of energy efficiency label air conditioner is systematically different (Table 6 summarize the results.).

What is interesting here is that consumer surplus of label 1 between label 2 and label 3 in 2008, and label 1 and label 2 and 2009 are evaluated as more less the same. There is no systematic difference at mean. At the same time, benefit of label 1 is evaluated systematically higher than label 2 and other grades. This implies that prices of label 1 product is high enough to cancel out the difference of benefits of label 1. Consumer do not strongly prefer label 1 because of the price factors. This is consistent with the concern of practitioners.

In the middle of 2009 and 2010, subsidy to energy saving products were started. Since then, label 1's consumer surplus get systematically higher than the other grades of labels.

4.3 Drawing Price Benefit Indifferent Curves

Tests in Subsection 4.2 on point at mean. In this section, we observe whole distribution. In order to visualize the distribution, we drew the price benefit curve for the each label

[8]This is against the a result of Japanese case that the authors are simultaneously conducting analysis. In Japan , consumer values more efficient appliances more with positive and larger coefficients.

Table 5: Demand Estimates:Air Conditioner

	$ln(s_j) - ln(s_o)$		
	(1)	(2)	(3)
price/wage: α	-6.878***	-2.986***	-2.859***
	(0.448)	(0.489)	(0.790)
ln mkt share within hp index: ρ			0.368***
			(0.089)
replacement_policy target		-0.126	-0.170
		(0.211)	(0.138)
replace_period		-0.053	0.010
		(0.210)	(0.138)
label period X label1	4.901***		
	(0.127)		
label period X label2	-1.781***		
	(0.057)		
label period X label3	-1.034***		
	(0.048)		
label period X labelUI	-0.497***		
	(0.041)		
subsidy for energy saving		0.003***	0.003***
		(0.001)	(0.001)
label1 X subsidy_es		-0.002***	-0.002***
		(0.000)	(0.000)
label1		-6.375***	-4.032***
		(0.342)	(0.699)
label2		-6.034***	-3.827***
		(0.337)	(0.673)
label3		-5.343***	-3.393***
		(0.342)	(0.617)
labelUI		-3.719***	-2.314***
		(0.333)	(0.489)
cooling capacity	0.000***	-0.000	
	(0.000)	(0.000)	
power consumption	-0.000***	-0.000***	
	(0.000)	(0.000)	
HP=under 1	0.417***	0.244	1.285***
	(0.125)	(0.154)	(0.180)
HP=under 2	0.369***	0.302***	1.035***
	(0.091)	(0.111)	(0.132)
inverter controlled	-0.927***	-1.286***	-0.727***
	(0.041)	(0.053)	(0.126)
installment type: Stand alone	-0.034	0.178**	0.342***
	(0.059)	(0.076)	(0.071)
installment type: Split type	-3.194***	-2.984***	-1.635***
	(0.126)	(0.157)	(0.285)
Constant	-5.043***	0.257	-1.656***
	(0.249)	(0.351)	(0.277)
City dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Brand dummies	Yes	Yes	Yes
Observations	17956	11896	11896
R^2	0.499	0.253	0.812
Exogeneity test of IV $GMCt - statistics$	3.231	2.383	4.059
p-value	0.0722	0.1226	0.1314
Over identified test $Hansen's J$	265.4	2.815	455.0
p-value	0.00	0.5891	0.00

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Difference in mean among the energy label grade: Air Conditioner

year	unit: RMB	Consumer Surplus	Benefit	Price
2008	(Label 1) - (Label 2)	-280	670***	950***
	(Label 1) - (Label 3)	264	1437***	1173***
	(Label 1) - (Label UI)	1994***	4020***	2026***
2009	(Label 1) - (Label 2)	76	1703***	1627***
	(Label 1) - (Label 3)	372 ***	2434***	2062***
	(Label 1) - (Label UI)	775***	3041***	2266***
2010	(Label 1) - (Label 2)	688***	2029**	1341***
	(Label 1) - (Label 3)	895***	2903***	2007***
	(Label 1) - (Label UI)	1381***	3474***	2093***

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

groups[9]. This exercise facilitated us to visually capture a relative relationship between products configuration the two different groups, though it is not a rigorous statistical test.

Because the consumer surplus is defined by benefit minus price, position at right lower segments on the price benefit curve indicates higher consumer surplus, and left higher segments implies lower consumer surplus. In the Figures, the price benefit indifferent curve label 1 goes located in left and higher position than other grades labels. This implies label 1 is inferior to other label grades' products in terms of consumer surplus.

Although, consumer surplus of label 1 at mean is higher than other grade in 2009 and 2010, a whole distribution of price-benefit configurations shows that inferiority of label 1. [10]

5 Discussion: Standard and Labeling and Consumer's Choice in China

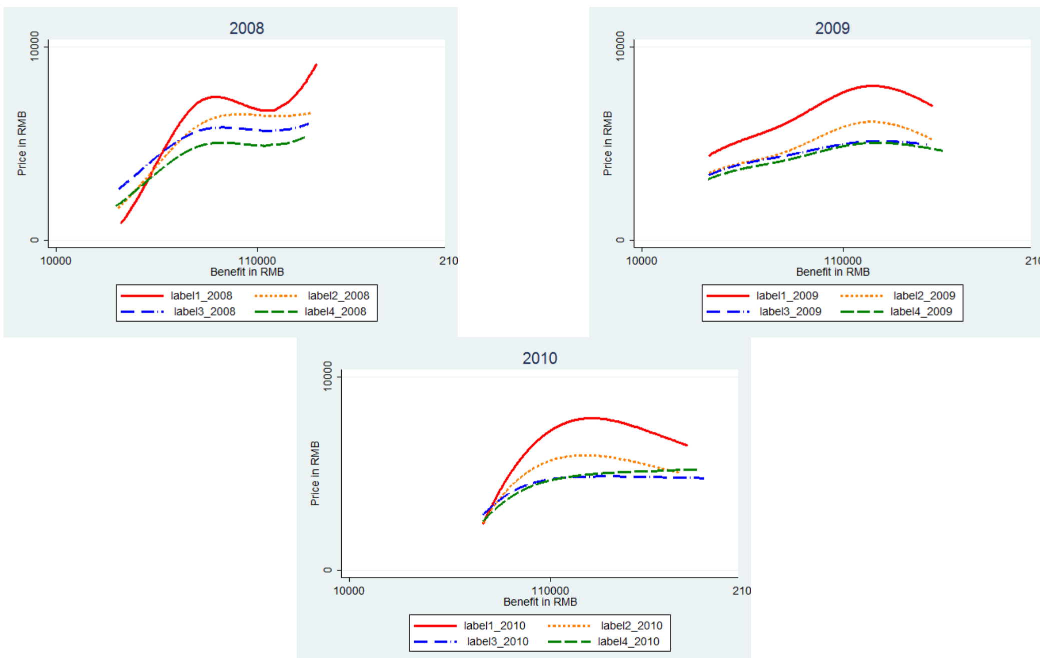
In China, the energy efficiency standard and labeling program were introduced in 2005 for non-inverter type and in 2008 for inverter type[11]. The program expected to expand

[9] The procedures are as follows: First, utilizing the demand function estimates obtained above, I obtain the predicted value of the benefit of individual products in equation (8). Secondly, draw a spline within the group, such as ownership or brand. I employ a linear spline with equally spaced knots based on the prices and benefits of all units sold in each year.

[10] Table B.1 shows result of regression on consumer surplus and benefits. It shows that price and subsidies does not affect consumer surplus, although benefit is a function of prices, but not of subsidies.

[11] Our data set has label information only since 2008.

Figure 1: Price Benefit Indifferent Curve by Energy Label Grade: with Policies



(Source): Author's estimation

purchase of energy efficient products in order to reduce power consumption. Attachment of energy saving labels will reduce information asymmetry between products and consumers, and is expected to increase consumer' welfare.

However, the results here shows that the label fails to let consumer behave ideally. Parameters of the labels are negative and its magnitude increased for the more energy efficient categories.

This result needs further investigation what cause this phenomenon. We have closely observed and found that subsidy for energy saving products alleviated the problem and the consumer surplus improved since the subsidy policy introduced. Benefit of label 1 products are systematically higher than the other grades, consumers rationally evaluated function of label 1 products.

However, there still remains a possibility that following factors affect the current results: First, our estimation does not include the impact of the third policy of promotion, that is, Promotion of Home Appliances to Rural Areas. In case of the products list of the policy that were exempted 13 per cent of value added tax are not neutral or less supportive to energy efficient products, consumer's choice was distorted by the rural promotion policy in terms of energy efficiency. Secondly, our data does not have information of labels and inverter between 2005 to 2007, when the label programs implemented only for non-inverter air conditioner. We need supplement information on this to improve accuracy of the estimation.

6 Conclusion

The energy efficiency standard and labeling programs expect the consumer to purchase the more efficient products. However, the practitioners concerns uncertainty of consumer decision: Consumer may prefer less energy efficient products because of high prices.

This paper quantified consumer surplus products by the energy efficiency label in order to capture actual decision by the consumers in air conditioner market in China. We found that the coefficient of the labels in a demand function is negative and decreasing along with the efficiency of the label improves. We also found that consumer surplus of label 1 products were no better than label 2 or label 3 products when the label were introduced. Socially optimal consumer's decision was hindered by income constraint. Subsidy for the Energy Saving products contributed to correct the market failure. Policies to encourage the manufactures to list the lower price and energy efficient products, a disruptive innovation, is also necessary to work the energy efficiency standard and labeling program work ideally.

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A HHI for Instrument Variables

In our estimation of demand, we use Herfindahl-Hirschman Index for 30 cities and 2000 to 2010 market.

Table A.1: **Herfindahl-Hirschman Index: Yearly development**

year	mean	median	sd
2000	0.074	0.068	0.027
2001	0.073	0.068	0.028
2002	0.074	0.064	0.036
2003	0.066	0.059	0.022
2004	0.062	0.059	0.018
2005	0.064	0.062	0.018
2006	0.067	0.067	0.022
2007	0.074	0.073	0.025
2008	0.057	0.053	0.016
2009	0.033	0.032	0.008
2010	0.024	0.023	0.007
Total	0.045	0.041	0.024

Source: GfK data

B Consumer Surplus, Benefit functions

Table A.2: **Herfindahl-Hirschman Index: Geographical distribution**

city	**mean**
BEIJING	0.038
CHANGSHA	0.049
CHENGDU	0.029
CHONGQING	0.036
DALIAN	0.044
DONGGUAN	0.045
FUZHOU	0.047
GUANGZHOU	0.051
HANGZHOU	0.040
HARBIN	0.051
HEFEI	0.055
JINAN	0.029
KUNMING	0.085
NANCHANG	0.038
NANJING	0.041
NANNING	0.057
NINGBO	0.040
QINGDAO	0.060
SHANGHAI	0.043
SHENYANG	0.043
SHENZHEN	0.058
SHIJIAZHUANG	0.042
SUZHOU	0.045
TAIYUAN	0.037
TIANJIN	0.037
WUHAN	0.049
WUXI	0.056
XIAMEN	0.050
XIAN	0.035
ZHENGZHOU	0.040
Total	0.045

Source: GfK data

Table B.1: Consumer Surplus, Benefit functions

	(1)	(2)	(3)	(4)
	cs	cs	benefit	benefit
price	-0.03*		0.97***	
	(0.02)		(0.02)	
subsidy_energy saving	1.82		1.82	
	(1.28)		(1.28)	
ln_price		0.00		0.06***
		(0.00)		(0.00)
ln_subsidy		-0.01		-0.00
		(0.01)		(0.01)
replace_period==1	6644.55***	0.13***	6644.55***	0.12***
	(768.34)	(0.01)	(768.34)	(0.01)
replacement_policy	3798.31***	-0.02*	3798.31***	-0.02*
	(770.23)	(0.01)	(770.23)	(0.01)
label_period	33089.46***	0.00	33089.46***	0.00
	(345.36)	(.)	(345.36)	(.)
intro_label2	182.05	0.00	182.05	0.00
	(251.40)	(0.00)	(251.40)	(0.00)
intro_label3	305.55	0.00	305.55	0.00
	(253.05)	(.)	(253.05)	(.)
intro_labelUI	54.18	0.00	54.18	0.00
	(241.31)	(.)	(241.31)	(.)
Constant	52715.55***	11.83***	52715.55***	11.38***
	(433.97)	(0.04)	(433.97)	(0.04)
Year dummies	Yes	Yes	Yes	
City dummies	Yes	Yes	Yes	
Brand dummies	Yes	Yes	Yes	
Observations	17349	5639	17349	5639
R^2	0.957	0.927	0.959	0.928

Standard errors in parentheses. City, Brand dummies are not displayed here.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$