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A Study on the Consuming Decision of Energy Saving Product in the Cost Perspective

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Abstract

With the development of economy, energy is more and more important around the world, especially in developing countries such as China. How to use limited energy effectively is an important issue not only for consumer and enterprise, but also for government. In academic and practice field, making use of energy saving product is an interesting topic. This paper studies the consuming decision of customers for energy saving product and the impacts of tax and subsidy policy on it. By setting up a series models, the results show that the consuming decision of energy saving product is not only related with its using period of time, consuming cost, but also related with tax and subsidy on it. Moreover, for rational customers, we put forth the conditions that they have the incentive to buy and use energy saving product. Therefore, in order to make use of limited energy and improve its using efficiency, it is necessary for the government to lower the price of energy saving product through policy such as tax and subsidy.

Keywords: energy saving; tax and subsidy; consuming decision making

Introduction

Energy is the development power of economy around the world. On one hand, energy is limited in nature; on the other hand, human beings need more and more energy to improve their living standards. As a result, it is become more and more important of how to use limited energy for consumer, companies, and government. The concept of energy-saving originates from the crisis of Middle-East War in 1973. With the price going up at 21 century, energy shortage is a problem for many governments. From the perspective of economy, it is possible to solve the energy crisis by increasing energy supply and reducing energy demand. But in practice, the quantity of both natural energy and manmade energy is limited. Under this condition, energy-saving is the best measure to deal with the energy shortage. Therefore, energy saving is an open question for the economic groups including developed countries such as Japan and developing countries such as China.

In fact, many countries have taken measure to saving energy such as drawing laws and regulations. In Germany, it issues the Energy Saving Law, sets up telephones to answer questions related with energy saving for citizens in free. In Japan, its government and civil organizations educate people to save energy with websites, presses and lectures. In Paris, the government limits the amount of warm water used each square in buildings. Also in China, it is short of energy, and how to deal with the conflict between energy and economic development is an important issue. According to the Environmental Performance Reviews for China (2006), during the last 15 years, the average rate of economic growth has been 10.1% per year. And even now it is also significant around the world. At the same time, the efficiency of using energy is low in China, and energy intensity is higher than the average in OECD countries. In order to deal with these problems, Chinese departments under the State Council have worked hard to improve the environment quality during the development of economy.

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A range of regulatory and economic instruments (e.g. pollution charges, user charges, emissions trading) and policy approaches that harness markets and public interest in the environment have been developed.

Although energy-saving is important for governments, corporations and consumers, the researches on the energy saving are rare. In the world, although some researchers looking for the solution from the view of energy-saving [1] and new energy [2], many scholars focus on the relationship between the amount of energy and GDP and energy price, and its impacts on economy. For example, in 1978, Kraft finds the cause and effect relation between GDP and the consuming amount of energy in Unite States [3], and there are empirical studies about the other countries such as England, Germany, Italy, France and Japan [4]. In literature, researchers also study the price of energy. For example, there is literature [5] that sets up a theoretical model, and points out that the optimal price is determined if the increase rate is equal to the discount rate. Later, researchers study the impacts of different oil market structures and behaviors on the oil price [6, 7]. Further, researchers discuss the influence of energy price on economy. For instance, literature studies the relationship between the price of energy and employment rate, and there is evidence to support the result that they are negative related [8, 9].

In literature, scholars also find evidence to support the result that the price of energy is negative related with actual wage [10, 11]. Meanwhile, some literatures argue that the relationship between the price of energy and economy development is not related in line [12, 13]. In China, literature study the oversea experience [14] and governments' regulatory [15, 16], but it does not dealing with the problems of how to produce and consume energy saving products. In addition, scholars studies the relationships among average GDP per person, the average amount of energy used, the energy consuming strength, and the average amount of electricity. And the results of it show that the total amount of energy consuming will become larger, and it is likely to reduce the energy consuming strength of GDP in future [17]. And other scholar studies the relationship between oil price and economy increase, and it states that the rising price of oil changes the consuming structure, and energy saving product has more market than non-energy-saving product [18]. To sum up, literature focuses on the energy price and its impacts on economy, but literature about the consuming decisions of energy saving products is rare.

In order to understand the importance of energy saving both in theory and practice, the paper focuses on the impacts of tax and subsidiary policy on consuming decision making of energy saving product. Different from literature, the paper has four contributions to the economics theory and practice of governments. First, we put forth conditions of consumers using energy saving products by setting up models based on the consuming cost, which could be a useful reference for governments to draw policies to improve the efficiency of energy. Second, we analysis the impacts of financial policies on consuming decisions with these models, especially the influence of taxes policy on consuming decision making for non-energy saving products and the influence of subsidiary policy on it. Third, the paper not only analysis the impacts of tax and subsidy on a single consumer's decision making from the micro level, but also studies the influence of tax and subsidy on all consumer's decision making from the macro level. Finally, the results in the paper show that the consuming decision making relates with the prices and consuming costs of energy-saving and non-energy saving products, and also relates with the energy policy of governments such as tax and subsidy. Therefore, in order to improve the efficiency of energy, it is necessary for governments to take all these factors into account, which implies the work of saving energy needs the social society to cooperate with each other.

The rest of the paper is organized as follows. Section II analysis the roles of consumer and government in the energy market. Section III studies the impacts of tax on consuming decision making, and Section IV researches the influence of subsidy on consuming decisions. Section V is the conclusion.

2. The role of the consumer and government in the energy market

Energy is the physical basis and original power for the development of economy and the social improvement. Therefore, both the consumer and government should play roles in energy market. With the limited supply of energy, the behavior of consumer and government would influence the demand of energy indirectly through the goods human beings used in normal life.

From the view of consumer, there are many factors influence the decision making on energy consuming. First, the energy consuming would be influenced by their own characteristics such as income, profession and consuming opinions. Second, it is influenced by social cultures such as social consuming style, living standards, and the responsibility to the descendant and the world. Finally, the characteristics of products such as price, quality, and brand, national policy would also influence the energy consume.

From the point of government, energy is not only a strategy product, but also a special physical product needed every day, which has its own characteristics. First, energy consuming has externality. According to the economics theory, consuming is related with the environments of living, organization and society, and which would also influence other consumers, society and environments, namely, "externality of consuming". Externality of consuming takes the form of positive or negative. Positive externality refers to the consuming would improve the relation between the development of human beings and the environment. For example, consuming green food is likely to benefit not only to the health of consumers, but also to the environment. On the other side, negative externality refers to the consuming behavior would damage the environment and result in pollutions in air, water or soil. As for the energy consuming such as burning coal to warm house or produce electricity, it would also result in environmental pollution, which is likely to increase the social cost to deal with the pollution and lead to negative externality. Thus, government has the obligation to make use of energy to increase its positive externality and to reduce its negative externality.

In order to play a positive role in economy, both of the consumer and government should take the characteristics of energy saving products. In this view, Yuan (2007) points out that energy saving products have the essence of public goods and the function of market is limited. In the process of using energy, market failure always arises in practice. For example, the price of energy does not reflecting the long-term interest, so investors prefer to explore energy rather than to improve the energy-saving technology, and the cost of environment pollution does not included in the price of energy. Upon this opinion, compare to consumers, governments should play more important role in the process of using energy.

According to these characteristics of energy, the price of energy always fluctuates in the world, which results in market failure further. Different from normal goods such as clothes, energy should be controlled by governments to some extent, especially in the process of consuming energy saving product. Actually, there are a few measures for government to solve the energy shortage problem. First, governments could set up energy saving institutions such as United States setting up energy department, environment protection department and energy management department. Second, governments would management energy based on energy saving regulations. For example, some countries such as United States, Japan, Germany and Australia have set up energy efficiency standards to save energy. Third, governments would also use financial policy to save energy and protect environment. For instance, Japan has carried out measures to save energy such as supplying direct subsidies to energy saving program, reducing tax for energy saving instrument, offering preferential loans to energy saving technology. Finally, governments can also improve the energy saving idea of citizens by setting up website; publishing energy saving products, and so on.

In order to measure the influence of government's policy for energy saving, we analysis the impacts of tax and subsidy on decision making of energy saving product bellow.

3. The impacts of taxes on consuming decision making of energy saving product

Suppose a rational consumer has to make a decision of buying an energy saving product A or a non-energy saving product B, which would be replaced with each other in function. The price of energy saving product A is p_1, and the marginal using cost of the energy saving product (i.e., electrical fee per unit) is B_1. The price of non-energy saving product B is P_2, and the marginal using cost is B_2. Given that there is no negative externality for the using energy saving product, but there is negative externality for the using non-energy saving product. Under this condition, for a rational consumer who wants to minimum his (or her) total consuming cost of product, how does he (or she) make the consuming decision?

In order to study the consuming decision, we make a comparative research on the decisions between two situations of whether taking the externality into account for non-energy saving product.

3.1 The consuming decision condition without taking the externality of non-energy saving product into account

For convince, suppose the life of energy saving and non-energy saving product is T, and consumers need to make a decision of whether consuming an energy saving product or a non-energy saving product. Suppose the total cost of using the product in the period of time T is Y, and then the total cost of consuming energy saving product is

$$Y_1 = P_1 + B_1 T \tag{1}$$

And the total cost of consuming non-energy saving product is

$$Y_2 = P_2 + B_2 T \tag{2}$$

In general, the price of energy saving product is higher than non-energy saving product. Therefore, we have the hypothesis $P_1 \geq P_2$. Moreover, the using cost of energy-saving product is lower than non-energy-saving product, and we have $B_1 \leq B_2$. We analysis the consuming decision making for a single consumer and the total market bellow.

3.1.1 A Single consumer's decision

Based on the hypothesis above, we can compares the cost of a single consumer using an energy saving or a non-energy saving product. For a single consumer, it is rational to require the total cost of using the energy saving product is equal to that of using the non-energy saving product. Therefore, the single consumer will use the energy saving product if and only if the life of the product is bigger than

$$T_0 = \frac{P_1 - P_2}{B_2 - B_1} \tag{3}$$

In other words, it implies that T_0 is the least using time of the energy saving product for consumers. For example, suppose the price of an energy saving product is 9, and the using cost is 0.1 per unit energy; while the price of a non-energy saving product is 2, and the using cost is 0.4 per unit energy. Then, based on the equation (3), we can get the margin life or usable time of a product is 30. Of course, there are two conditions needed for a consumer deciding to use an energy saving product. First, the consumer has the resource to buy or use an energy saving product. Second, he or she is a rational consumer.

3.1.2 Market consuming decision

In the perspective of a market as a whole, we suppose that the total expense of the product which can be used in the period of time T is Z, the market demand for the product is X_1, and the market demand for non-energy saving product is X_2. From the view of the society, it is national to require the total cost of buying and using the product is the same. If all consumers buy and use energy saving product only, or buy and use non-energy saving product only, then we have

$$Z = X_1 Y_1 = X_2 Y_2 \tag{4}$$

We can replace equation (3) as

$$X_1(P_1 + B_1 T) = X_2(P_2 + B_2 T) \tag{5}$$

And finally, we have

$$T = \frac{X_1 P_1 - X_2 P_2}{X_2 B_2 - X_1 B_1} \tag{6}$$

Taking the fact that the T is not negative into account, both the numerator and denominator should be negative or positive, we have the condition of market buying and using energy saving product as follow

$$\frac{P_2}{P_1} < \frac{X_1}{X_2} < \frac{B_2}{B_1} \tag{7}$$

3.2 The consuming decision condition with taking the externality of non-energy saving product into account

According to economics, externality is a concept related with public goods. From the point of energy consuming, using non-energy saving product would result in negative externality. For instance, the using of non-energy saving light instruments would reduce the welfare of society because the social cost of producing them will increase, and therefore, there is negative externality. Meanwhile, using non-energy saving products would cause environment pollution and negative externality. Based on the principle of public economics, the pollution maker should pay the fee to deal with the pollution. Thus, the consume cost resulting from the negative externality should be included both in the cost of producing and using the product. For example, in order to reduce the cost of environment pollution, government should impose taxes on the product in the process of producing to reduce the quantity of non-energy saving product or consuming to protect environment. And the taxes can be imposed on producer, consumer or both of them. Owing to the method of analysis is similar as before in the paper, we just take the government imposing taxes on producer for example.

If the taxes are imposed on producer only, they should be responsible for the social responsibility in total. In other words, they should pay the fee to deal with the negative externality both of the producing and using the product. Suppose government imposes taxes on non-energy saving product C per unit, then the price of a product is $(\mathrm{P}_2 + \mathrm{C})$. Therefore, if the consuming energy saving product, the total cost is

$$Y_1 = P_1 + B_1 T \tag{8}$$

And if he or she uses non-energy-saving product, the total cost is

$$Y_2^{'} = (P_2 + C) + B_2 T \tag{9}$$

Similar with the discussion above, we study the conditions both of a signal consumer's decision and the market decision as a whole below.

3.2.1 A Single consumer's consuming decision from the perspective of tax

As analysis before, based on the equation (8) and (9), we can compare the cost of a single buying and using an energy saving or a non-energy saving product. For a single consumer, it is rational to require the total cost of using the energy saving product is equal to that of using the non-energy saving product. Therefore, the consumer will use energy saving product if and only if the using period of product is bigger than

$$T^* = \frac{P_1 - P_2 - C}{B_2 - B_1} \tag{10}$$

As the discussion before, there are two conditions for the result. On one side, a consumer has the capacity to buy and use energy saving product with high price, and on the other side, he or she is a rational consumer. It is easy to getting the relation of $T^* < T_0$ based on the equation (2), (8) and (9). The equation (10) implies that if the taxes imposed on producer C is not less than the difference between the price of energy saving and non-energy-saving product $(P_1 - P_2)$, consumers will buy or use energy-saving product in sure.

3.2.2 **The market consuming decision from the perspective of tax**

Similar with the discussion before, we suppose the government imposes taxes on non-energy saving product C per unit, then the price of a product is $(P_2 + C)$, and the other assumption are the same. If all consumers use energy saving product only, or use non-energy saving product only, for the national market, the total cost of buying and using energy saving and non-energy saving product should be same as below

$$Z = X_1 Y_1 = X_2 Y_2^{'} \tag{11}$$

Or $$X_1(P_1 + B_1 T) = X_2(P_2 + C + B_2 T) \tag{12}$$

So we have the demand for the using period of time for the product is

$$T = \frac{X_1 P_1 - X_2(P_2 + C)}{X_2 B_2 - X_1 B_1} \tag{13}$$

Taking the fact that the T is not negative into account, both the numerator and denominator should be negative or positive, we have the condition of market consuming energy saving products as below

$$\frac{P_2 + C}{P_1} < \frac{X_1}{X_2} < \frac{B_2}{B_1} \tag{14}$$

Or $$\frac{B_2}{B_1} < \frac{X_1}{X_2} < \frac{P_2 + C}{P_1} \tag{15}$$

The equation of (14) or (15) implies that given the amount of expense of the market for the product, the relationship between the amount of energy saving and non-energy saving product is not only related with the relation between their prices, but also related with their consuming cost. Therefore, in order to enlarge the consuming of energy saving product, it is necessary to adjust the consuming cost. Moreover, it will benefit the society if the government adjusts the price of energy saving product such as energy saving light tubes. But how does a government could adjust the price of energy saving product?

In order to answer the question, we change the condition (14) as follows

$$C < \frac{X_1}{X_2} P_1 - P_2 \tag{16}$$

The condition (16) shows that given the price and consuming amount of energy saving and non-energy saving product, governments can adjust taxes to make the condition (14) or (16) correct, which means governments could incentive consumers to use energy saving product by impose taxes on non-energy saving product.

Also, we can change the form of condition (15) as follows

$$C > \frac{X_1}{X_2} P_1 - P_2 \tag{17}$$

The condition (17) shows that given the price and consuming amount of energy saving and non-energy saving product, governments can adjust taxes to make the condition (15) or (17) correct, which implies that governments could incentive consumers to use energy saving product by impose taxes on non-energy saving product.

Combing the condition (16) and (17) together, it shows that government could influence the energy demand by impose taxes on non-energy saving product indeed, which implies governments could raise the efficiency of limited energy as a whole. As the opposite of impose taxes on no-energy saving products, government can also incentive producers and consumers to produce or to use energy saving product, and we discuss it below.

4. The impacts of subsidy on energy saving product

In order to incentive the produce and consume of energy saving product, governments could supply subsidy to the producer or consumer of energy saving product. Given the total subsidy S to energy saving product is fixed. And the subsidy would be supply to producer once in the process of production to reduce its cost and finally reduce the sale price, or offer to consumers in the process of consuming energy saving product to reduce their buying or using cost (for example, governments can give this subsidy to consumers in the process of using energy saving light tubes, such as subsidy to using electricity). For convenient, we also suppose governments offer subsidy to producer to reduce their sale price. In this view, the total cost of consumer to buy and use energy saving product is

$$Y_1^{'} = (P_1 - S) + B_1 T \tag{18}$$

While the total cost of buying and using non-energy saving product below is showed in equation (2) as before.

$$Y_2 = P_2 + B_2 T \tag{19}$$

Similar with the analysis above, we study the conditions of a single consumer and the total market using energy-saving product.

4.1 A Single consumer's consuming decision from the point of subsidy

We compare the cost of a single consumer using energy-saving or non-energy-saving product. Upon the equation (18) and (19), it is easy to understand that the single consumer will use energy-saving product if and only if the usage period of time of a product is larger than

$$T^{**} = \frac{P - S_1 - P_2}{B_2 - B_1} \tag{20}$$

As the discussion before, there are two conditions for the result. First, a consumer has the capacity to buy or use energy-saving product with high price. Second, he or she is a rational consumer.

4.2 The market consuming decision from the point of subsidy

We have the assumptions as before. Suppose that the total expense of the product which can be used in the period of time T is Z, the market demand for the product is X_1, but the market demand for non-energy-saving product is X_2. And the total subsidy to an energy-saving product is S. If all consumers can use energy saving product only, or use non-energy saving product only, the market rational demand is that the total cost of buying and using both of the two products is the same. So we have the equation below

$$Z = X_1 Y_1 = X_2 Y_2^{'} \tag{21}$$

Or $$X_1(P_1 - S + B_1 T) = X_2(P_2 + B_2 T) \tag{22}$$

Thus, we have $$T = \frac{X_1(P_1 - S) - X_2 P_2}{X_2 B_2 - X_1 B_1} \tag{23}$$

Taking the fact that the T is not negative into account, both the numerator and denominator should be negative or positive, and we have the conditions of the market consuming energy saving product as below

$$\frac{P_2}{P_1 - S} < \frac{X_1}{X_2} < \frac{B_2}{B_1} \tag{24}$$

Or $$\frac{B_2}{B_1} < \frac{X_1}{X_2} < \frac{P_2}{P_1 - S_1} \tag{25}$$

The formula above implies that given the amount of expense in the market for the product, the relationship between the amount of energy saving and non-energy saving product is not only related with their prices, consuming cost, but also related with the subsidy from the government.

If changing the form of the condition (24) and (25), we can get some results further. First, consider the fact that the total subsidy to an energy saving product S should be no more than its price P_1, we change the form of (24) and get the relation below.

$$S < P_1 - \frac{X_2}{X_1} P_2 \tag{26}$$

It shows that the government can change its subsidy policy to satisfy the condition of (24) or (26), implying the government could adjust the subsidy to reach its goals of saving energy if the amount and price of energy-saving and non-energy saving product are given.

We can also change the condition (25) and have the relation as follow

$$S > P_1 - \frac{X_2}{X_1} P_2 \tag{27}$$

The condition of (26) also indicted that given the price and consuming amount of energy saving and non-energy saving product, governments can adjust subsidy to make the condition (25) or (27) satisfied, which implies that governments could incentive consumers to use energy saving product by offering subsides to consumers who use energy saving products..

Combing the discussion above together, they show that governments could influence the energy demand by offering subsidy to the corporations who produce energy saving product or consumers who buy and use it, and imposing taxes on enterprise who produce non-energy saving products. These energy policies would improve the efficiency of limited energy not only for the corporations, but also for the sustainability development of economy around the world.

5. Summary

With the development of economy, the problem of energy shortage is more and more important not only for corporations and consumers, but also for different countries around the world. How to use energy efficiency is an open question for scholars, institutions and governments.

The paper analysis the decision-making conditions of consumer using energy saving products from the perspective of consuming cost and government's policy. It shows that for a rational consumer, given the price of product and its consuming cost, consumers would like to use energy saving product if and only if the usage period of time of energy saving product is no less than non energy products with the same function. This implies that there are three reasons to explain why consumers do not use energy saving products. First, consumers can not afford the cost of buying energy saving product. Second, the quality of energy saving product has not reach the least level of consumers required. Third, consumers do not know the advantages of energy saving products. Further, the paper indicts that the relation between the consuming amount of energy saving product and non-energy saving product is related with their price, consuming cost per unit, taxes on non-energy saving product and subsidy for energy saving product. In addition, the models in the paper reflect that governments could influence the demands and supply of energy-saving products in two ways. On one hand, governments should supply subsidy to the producers and consumers in the process of producing or consuming energy saving products. On the other side, governments should impose taxes on non-energy saving products in the process both of producing and consuming. Upon the actions of governments, corporation and consumers, the efficiency of energy is likely to be improved and the environment we lived will be better.

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