

Subjective Well-being Effects for Electric Power Universal Service Recipients in China from a Culture Poverty Perspective

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Abstract: Lack of cultural knowledge, poor livelihood and inappropriate value orientation of electric power universal service recipient groups basically influence their electricity consumption habit in china. In order to assess the effect of power universal service distribution and measure the welfare of recipient groups, this paper researches individual electricity consumption mentality and behavior through behavioral economics theory, establishes a subjective welfare function tracing recipient individual based on cumulative prospect theory, constructs the recipient groups' subjective welfare function following the traditional social welfare function and researches the influence of the changes of psychological reference points. Through example analysis combined with function feasibility, this paper proves the subjective well-being effect of recipient groups declines when the psychological reference point increases.

Keywords: Electric Power Universal Service, Consumer Psychology, Subjective Well-Being, Cumulative Prospect Theory

1. Introduction

Electric Power Universal Service (EPUS) is a government funded program, aiming to insure people who live in remote areas can consume electric power at affordable prices to improve their welfare level in China. When assessing the effect of EPUS, we take account into the recipient groups' social welfare. Most EPUS receipts live in remote areas with little literal knowledge, poor livelihood habits, backward value orientations and old style customs compared with current leading culture of our society in China. This unique environment can affect consumer psychology and electrical behavior of recipient individual, thus influence the EPUS recipient groups' welfare level. Based a social welfare perspective, the paper will research the EPUS recipient groups' welfare level for Chinese government to assess the effect of EPUS.

In order to measure social welfare level, most international and domestic scholars are focusing their research on assessing the welfare level through analyzing objective factors including income and expenditure based on an individual economic consumer hypothesis. Ref. [1] has explained the designed social welfare functions as a function reflecting the interaction of min income level, average income level and Gini coefficient. Ref. [2] set up a comprehensive evaluation of

the social welfare system tracing economic growth and inequality distribution through change the income-based individual utility function and social welfare function into standard satisfaction function. Ref. [3] established a social welfare maximization condition function through introducing currency measurement into the social welfare function. Ref. [4] created a social welfare evaluation model measuring mix indexes including income, expenditure and health level amid functions and capabilities space. Ref. [5] set up an energy service social welfare function analyzing income and expenditure. Ref. [6] established a social welfare evaluation model using axiomatic system and defining random individual situation based on preference theory. Ref. [7] analyzed unique problems of China's social welfare through summarizing domestic economic and social welfare evolution changed with political and economic development process. Ref. [8] measured income-based social welfare level in short and long term through introducing equal opportunity rule into traditional welfare functions.

Base on social people hypothesis, value orientation, education level and other subjective factors can influence social welfare level through interacting with consumer psychology and behaviors. Ref. [9] researched China's individual consumer behavior and utility level applying

mental accounting theory, prospect theory and consumer behavior analysis. Ref. [10] established a consumer habits-based optimal consumption - saving model through introducing the loss aversion model of consumption habits theory and prospect theory into the consumption and saving situation. Ref. [11] researched the influence of psychological factors on the energy consumption behavior of Chinese urban residents by explaining examples in Shenyang and Dalian City. Ref [12] built the evaluation model from region economy etc. to measure the power universal service economic and non-economic welfares based on the social welfare function theory and prospect theory.

EPUS recipients' welfare can be influenced by subjective factors (e.g. educational level) according to the consumption economics theory. The recipient individuals with different educational level have different cognitive level for electricity, which causes the different individual welfare. The Subjective Well-being (SWB) is defined as the welfare induction, which recipient individual gets from the electricity under the influence of subjective factors (e.g. educational level). SWB embodies the satisfaction for improving their livelihood and beautifying their future life under the psychological effects. This literature from the angle of cultural poverty, focus on the subjective welfare resulting from the educational level differences and assumes that other subjective factors have no difference.

The method we propose consists of three steps. In the first step, one has to explain the characteristics of cultural poverty in the EPUS recipient and to put forward the frugality and herd mentality as their consumer psychological characteristics. In the second step, according to herd consumer behavior and thrifty consumption behavior, one constructs the SWB model to measure the EPUS individual SWB based on the cumulative prospect theory (CPT). The third step involves the SWB measurement of the EPUS recipient groups of different educational level based on the welfare economics.

2. EPUS Recipients' Cultural Poverty and Consumer Psychology in China

Culture poverty refers to a group or an individual lives with less literal knowledge, poorer livelihood habits, backward value orientations and older style customs compared with current leading culture of our society, which will hamper their willingness to improve livelihood and spiritual needs. In China, most EPUS recipients are peasant households living in remote areas, with little access to instant information, backward mode of production and the concept of rigid. People aimed culture poverty usually poorly educated and lack of scientific knowledge, poor livelihood conditions lead to outdated value orientations, old-fashioned thinking, low moral standards and weak sense of democracy in China. Influenced by culture poverty, EPUS recipients lead a life of nature, thrifty and emphasis on tribalism, which forms their consuming psychology with features including.

(1) Choosing substantial and low-priced commodities

People living in culture poverty always buy substantial and

cheap commodities to satisfy basic needs at affordable prices in China. In terms of home appliances purchase, recipient individuals tend to choose essential commodities such as CRT television (TV), washing machine and small-sized electric appliances rather than new products including LCD TV, air conditioner and computers.

(2) Extreme frugality

People living in culture poverty always lead an extreme frugal life with thrifty mentality to save money through eating ordinary food, using common daily consumer goods in China. They tend to cut lighting time and reduce the frequency of home appliance to save electricity fees.

(3) Herd mentality

EPUS recipients under culture poverty have limited access to outward information due to outdated public transportation and telecommunications infrastructure in China. Limited local information acquisition and collectivism in big families lead recipient individuals to choose similar products as other people already bought.

3. EPUS Recipient Individual Subjective Well-being Model Based on Cumulative Prospect Theory

3.1. Cumulative Prospect Theory

Cumulative prospect theory (CPT) is resulted from connecting cognitive psychology and behavioral science with rich experimental verification. CPT reflects decision made the procedures in uncertain conditions, which is proper to measure the bounded rationality of EPUS recipients. The recipient individual psychological reference points and value function can reflect individual subjective well-being degree. This paper refers CPT analysis framework to track the subjective well-being model of recipient individual.

Psychological reference point reflects the expectation of electricity while value orientation function tracks the value an individual receives during electricity. Based on cumulative prospect theory, the value loss function is shown as follows:

$$v^-(\Delta x) = -\lambda (aq^* - aq)^\beta, q < q^* \quad (1)$$

And the value profit function is shown as follows:

$$v^+(\Delta x) = (aq - aq^*)^\alpha, q \geq q^* \quad (2)$$

Where α and β represent the risk attitude coefficient; λ represents the avoid coefficient of value loss. According to Tversky and Kahneman's research experience, α and β are equal to 0.88, λ is equal to 2.25.

Base on cumulative prospect theory, the recipient individual undergoes two stages of subjective well-being effect. The first stage is to determine the psychological reference point as T , which the recipient individual expects to receive from electricity. The second stage is to set a recipient individual expected value, which embodies the distance between the individual subjective well-being and the psychological reference point. The

psychological reference point and expected value contribute a recipient individual subjective well-being.

3.2. The Recipient Individual SWB Influenced by Herd Consumer Behavior

Influenced by herd consumer behavior, the EPUS recipient individual subjective well-being will increase with the growth of actual electricity, and be known as the marginal increment for utility. This paper assumes the marginal increment carries linear features. The subjective well-being effect of a recipient individual under herd consumer behavior is shown as follows:

$$U_z = T_z(q^*) + V_z(\Delta x_z) \quad (3)$$

Where q^* represents the reference electricity usage in line with psychological reference point; $T_z(q^*) = aq^*$ represents the psychological reference point utility influenced by herd consumer behavior; $V_z(\Delta x_z)$ represents the expected value function influenced by herd consumer behavior; $\Delta x_z = a(q - q^*)$ represents the cognitive profit and loss from actual electricity; a represents the coordinate coefficient, $a > 0$; q represents the recipient individual actual electricity.

Influenced by herd consumption habit, if $q \leq q^*$, the individual psychological demand to follow major groups will be not satisfied, as follows:

$$\Delta x_z = a(q - q^*) \leq 0 \quad (4)$$

If $q \geq q^*$, the psychological demand to follow major groups will be satisfied, as follows:

$$\Delta x_z = a(q - q^*) > 0 \quad (5)$$

Based on CPT, the recipient individual expected value function is calculated as follows:

$$V(\Delta x_z) = \begin{cases} \int_{\Delta x_z^{\min}}^{\Delta x_z} v^-(\Delta x_z) dF(\Delta x_z) & \Delta x_z < 0 \\ \int_{\Delta x_z^{\min}}^{\Delta x_z} v^+(\Delta x_z) dF(\Delta x_z) & \Delta x_z \geq 0 \end{cases} \quad (6)$$

where $F(\Delta x_z)$ represents the recipient individual cognitive profit and loss distribution function influenced by herd consumer behavior, which is uniform distribution or normal distribution, $\Delta x_z^{\min} = -aq^*$.

So the recipient individual subjective well-being function is calculated as follows,

$$U_z = \begin{cases} aq^* - \int_0^q \lambda_z(aq^* - aq)^{\beta_z} dF(q) & q \leq q^* \\ aq^* + \int_0^q (aq - aq^*)^{\alpha_z} dF(q) & q > q^* \end{cases} \quad (7)$$

3.3. The Recipient Individual SWB Influenced by Thrifty Consumer Behavior

Thrifty consumer behavior is also a psychological factor. When the actual electricity and electricity fees increase, the recipient individual subjective well-being utility will decrease, in line with the diminishing marginal utility.

Assuming the diminishing marginal utility function carry linearity, the subjective well-being function influenced by thrifty consumer behaviors is as follows:

$$U_r = T_r(q^*) + V_r(\Delta x_r) \quad (8)$$

Where $T_r(q^*) = b(I^e - pq^*)$ represents the mental reference point utility value of the recipient individual with thrifty consumer behavior; $V_r(\Delta x_r)$ represents the value function influenced by thrifty consumer behavior; $\Delta x_r = b(pq^* - pq)$ represents the cognitive profit and loss from actual electricity; b represents the coordinate coefficient, $b > 0$; I^e represents the maximum electric fee expenditure; p is electric price.

If $q \leq q^*$, the recipient individual frugal consumer psychology and inexpensive consumer psychology will be satisfied, as follows:

$$\Delta x_r = b(pq^* - pq) \geq 0 \quad (9)$$

If $q \geq q^*$, the recipient individual frugal consumer psychology and inexpensive consumer psychology will not be satisfied, he will feel loss, as follows:

$$\Delta x_r = b(pq^* - pq) < 0 \quad (10)$$

Influenced by thrifty consumer behavior, the recipient individual expected value function is as follows:

$$V_r(\Delta x_r) = \begin{cases} \int_{\Delta x_r^{\min}}^{\Delta x_r} v^+(\Delta x_r) dF(\Delta x_r) & \Delta x_r \geq 0 \\ \int_{\Delta x_r^{\min}}^{\Delta x_r} v^-(\Delta x_r) dF(\Delta x_r) & \Delta x_r < 0 \end{cases} \quad (11)$$

Where $F(\Delta x_r)$ represents the cognitive profit and loss influenced by thrifty consumer behavior, which is uniform distribution or normal distribution, $\Delta x_r^{\min} = bpq^* - bpq^{\max}$, q^{\max} is the maximum electricity usage under EPUS.

So the recipient individual subjective well-being function influenced by thrifty consumer behavior is as follows:

$$U_r = \begin{cases} b(I^e - pq^*) + \int_q^{q^{\max}} (bpq^* - bpq)^{\alpha_r} dF(q) & q \leq q^* \\ b(I^e - pq^*) - \int_q^{q^{\max}} \lambda_r(bpq - bpq^*)^{\beta_r} dF(q) & q > q^* \end{cases} \quad (12)$$

3.3. The Recipient Individual SWB Function

After analyzing the welfare effect influenced by herd consumer behavior and thrifty consumer behavior, this paper explains the recipient individual SWB function is as follows:

$$w_i = U_z + U_r \quad (13)$$

Where w_i represents the SWB of recipient individual i .

According to formula (7) and (13), the recipient individual subjective well-being can be calculated.

4. EPUS Recipient Groups SWB Model

In order to the recipient groups' subjective well-being

model in China, this paper analyzes the psychological reference point, sets up individual well-being model based on traditional social welfare function on the premise of individual welfare comparability and calculates the welfare effects when the psychological reference point changes.

4.1. The Recipients' Psychological Reference Point

According to the psychological reference point, under current cognitive level of EPUS recipients in china, the recipient individual should obtain the enough utility T after consuming the reference electricity usage q^* . The psychological reference point T and the recipient individual subjective well-being w_i depend on the reference electricity usage q^* .

Under culture poverty, different recipient individual has different judgments on the reference electricity usage. This paper assumes that the judgment about the reference electricity usage is only affected by their educational level. The better education an individual gets, he will be more

$$\delta_j = \begin{cases} \theta_1 & j = 1, \text{ recipient individual of primary education} \\ \theta_2 & j = 2, \text{ recipient individual of junior middle school education} \\ 1 & j = 3, \text{ recipient individual of high school education} \end{cases}$$

Where θ_1 represents the electricity usage coordinate coefficient of recipient individual of primary education; θ_2 represents the electricity usage coordinate coefficient of recipient individual of junior middle school education; $\theta_1 < \theta_2 < 1$.

The psychological reference point for recipient individual is shown as follows:

$$T_j = T_{zj}(q^*) + T_{rj}(q^*) \quad (15)$$

Where T_j represents the psychological reference point utility of the j education level recipient individual; $T_{zj}(q^*)$ represents the psychological reference point utility influenced by herd consumer behavior; $T_{rj}(q^*)$ represents the psychological reference point utility influenced by thrifty consumer behavior. Then the Equation (15) can be shown:

$$T_j = aq_j^* + b(I^e - pq_j^*) \quad (16)$$

4.2. The SWB Function for EPUS Recipient Groups

According to the theory of traditional social welfare, social welfare is the sum of all individual well-being when an individual well-being is countable. As for EPUS, based on cumulative prospect theory, this paper establishes a model to make individual well-being countable. Meanwhile, assuming all personal information except education level are the same, so individual well-being effect is comparable. On this basis, this paper sets up the social welfare function W for EPUS through applying of traditional social welfare function.

Supposing there are M individuals in an EPUS region, then social welfare function W can be expressed as:

willing to use more home appliances to improve his living conditions, then his reference electricity usage is larger, otherwise the reference electricity usage is small if an individual receives little education.

The recipients' educational level can be divided into three levels in Chinese EPUS region, namely the level of primary education, junior middle school and high school level. So the reference electricity usage is shown as follows:

$$q_j^* = \delta_j \times q_0^* \quad (14)$$

Where q_j^* represents the recipient individual reference electricity usage of the j education level; q_0^* represents the benchmark reference electricity usage; δ_j represents the coordinate coefficient of electricity usage of the j education level.

Set $q_0^* = q_3^*$, so

$$W = \sum_{i=1}^M w_i \quad (17)$$

Where w_i represents the SWB function for individual i .

4.3. Effect of the Reference Point Changes on SWB

The difference between reference electricity usage and actual electricity usage influences individual subjective well-being effect. The subjective well-being effect changes along with the reference electricity usage changes.

With the deep implementation of EPUS, recipients under culture poverty change their cognitive level, consumer psychology and consumer behavior, then reference electricity usage and psychological reference point change. According to Bell's theory about spending habits, it presumes that EPUS recipients' psychological reference point and reference electricity usage will increase along the growth of actual electricity usage. Therefore, based on the theory of consumer habits, the reference electricity usage of a recipient individual i during $t+1$ period is as follows:

$$q_{i(t+1)}^* = \begin{cases} (1-\phi)q_{it}^* + \phi q_{it} & q_{it} \geq q_{it}^* \\ q_{it}^* & q_{it} < q_{it}^* \end{cases} \quad (18)$$

where q_{it}^* represents reference electricity usage of recipient individual i during t period, q_{it} represents individual i actual electricity usage during t period; ϕ represents the continued strength of consumer habit. If $\phi=0$, the reference electricity usage during $t+1$ period is equal to the reference electricity usage during t period; If $\phi=1$, the reference electricity usage

during $t+1$ period is equal to the actual electricity usage during t period.

The psychological reference point T_{it} of a recipient individual i during t period is as follows:

$$T_{it} = aq_{it}^* + b(I^e - pq_{it}^*) \quad (19)$$

Then the psychological reference point $T_{i(t+1)}$ of a recipient individual i during $t+1$ period is as follows:

$$W_t = \sum_{i=1}^M \{ \rho [aq_{it}^* - \int_0^q \lambda_z (aq_{it}^* - aq_i)^{\beta_z} dF(q_i) + b(I^e - pq_{it}^*) + \int_q^{q_{\max}} (bpq_{it}^* - bpq_i)^{\alpha_r} dF(q_i)] + (1-\rho) [aq_{it}^* + \int_0^q (aq - aq_{it}^*)^{\alpha_z} dF(q_i) + b(I^e - pq_{it}^*) - \int_q^{q_{\max}} \lambda_r (bpq - bpq_{it}^*)^{\beta_r} dF(q_i)] \} \quad (21)$$

To research the influence of psychological reference point changes on subjective well-being effect, this paper assumes that all individual actual electricity usages and maximum electric fee expenditures are fixed. When compare the individual subjective well-being effect during t and $t+1$ period, we can get the subjective well-being change function as follows:

$$\Delta w_i = w_{i(t+1)} - w_{it} \quad (22)$$

If $q_i \geq q_{it}^*$, the recipient individual tends to improve electricity usage in next time period following consumers habit, so $q_i \geq q_{i(t+1)}^* \geq q_{it}^*$, the recipient individual subjective well-being change function is as follows:

$$\Delta w_i = a\varphi(q_i - q_{it}^*) + \int_0^q (1 - (1-\varphi)^{1+\alpha_z}) a^{\alpha_z} (q_i - q_{it}^*)^{\alpha_z} dF(q_i) + b\varphi p(q_{it}^* - q_i) - \int_q^{q_{\max}} \lambda_r (1 - (1-\varphi)^{1+\beta_r}) b^{\beta_r} p^{\beta_r} (q_{it}^* - q_i)^{\beta_r} dF(q_i) \quad (23)$$

If $q_i < q_{it}^*$, the recipient individual remains electricity usage in next time period. so $q_i < q_{i(t+1)}^* = q_{it}^*$, there is no apparent change in individual subjective well-being.

Based on the above, M individual SWB effect changes

depend on the SWB effect changes of N individual whose actual electricity usage during t period is higher than the reference usage ($M > N$). The influence effect of psychological reference point changes is calculated as follows:

$$\Delta W = \sum_{i=1}^N \{ a\varphi(q_i - q_{it}^*) + \int_0^q [1 - (1-\varphi)^{1+\alpha_z}] a^{\alpha_z} (q_i - q_{it}^*)^{\alpha_z} dF(q_i) + b\varphi p(q_{it}^* - q_i) - \int_q^{q_{\max}} \lambda_r [1 - (1-\varphi)^{1+\beta_r}] b^{\beta_r} p^{\beta_r} (q_{it}^* - q_i)^{\beta_r} dF(q_i) \} \quad (24)$$

5. Example Analysis

This paper takes a certain EPUS region in China as the example to focus on research of EPUS subjective well-being and analyze the influence of psychological reference point changes on social welfare.

The EPUS region is remote with poor economics and livelihood, insufficient power grid infrastructures and culture poverty. There are 30 peasant households with difference income, education and power consumption level (Chart 1). Electric fee is set at 0.5 RMB/kWh.

Chart 1. Example details

Index		Number of peasant households	Ration (%)
Average annual income	RMB 1,500~2,000	3	10.0
	RMB 2,000~2,500	9	30.0
	RMB 2,500~3,000	13	43.3
	More than RMB 3,000	5	16.7
Education degree	primary school	2	6.7
	Junior middle school	22	73.3
	high school	6	20.0
Annual power usage	300~400kWh	3	10.0
	400~500kWh	12	40.0
	500~600kWh	13	43.3
	more than 600kWh	2	6.6

The recipient peasant households are influenced by frugal and herd behaviors when using electricity, the cognitive profit and loss from actual electricity are shown as:

$$\begin{cases} \Delta x_z = q - q^* \\ \Delta x_r = 0.5(q^* - q) \end{cases} \quad (25)$$

$$q^* = \begin{cases} 400 & \text{recipient peasant household of primary education} \\ 500 & \text{recipient peasant households of junior middle school education} \\ 550 & \text{recipient peasant households of high school education} \end{cases}$$

Assuming that the provided maximum power volume for the recipients is 1,000 kWh/year and the peasant cognitive profit and loss follows uniform distribution, as follows:

$$F_z(q) = F_r(q) = \frac{q}{1000} \quad (26)$$

So the SWB level for the recipient group during t period is calculated to be 54,684 units as Chart 2.

Chart 2. Subjective well-being for the EPUS region

NO.	Education degree	Reference power usage (kWh)	SWB during t (unit)	SWB during t+1 (unit)
1	primary	400	339	339
2	primary	500	490	490
3	Junior high	400	411	411
4	Junior high	500	409	409
5	Junior high	500	561	561
6	Junior high	500	585	585
7	Junior high	500	409	409
8	Junior high	500	355	355
9	Junior high	500	618	618
10	Junior high	500	561	561
11	Junior high	500	637	637
12	Junior high	500	661	661
13	Junior high	500	774	774
14	Junior high	500	436	436
15	Junior high	500	673	673
16	Junior high	500	3003	3003
17	Junior high	500	3042	3042
18	Junior high	500	3111	3111
19	Junior high	500	3001	3001
20	Junior high	500	3014	3014
21	Junior high	500	3030	3030
22	Junior high	500	3726	3726
23	Junior high	500	3625	3625
24	Junior high	500	3923	3923
25	High school	550	487	487
26	High school	550	781	781
27	High school	550	3051	3051
28	High school	550	3060	3060
29	High school	550	3647	3647
30	High school	550	3884	3884
total			54684	52304

The recipient peasant households choose reference electricity usage concerned with education degree only. Peasants with difference education degrees choose difference references, as follows:

The recipient peasant household tends to change reference electricity usage according to the theory of consumption habit. Assuming the actual electricity usage and the maximum electric fee expenditure are fixed during t+1 period, the continued strength of consumer habit ϕ is set at 0.5, then recipient group subjective well-being utility is changed to 52,304 units, falling 2,380 units from t period. The calculations are as Chart 2.

If the actual electricity usage and electric fee expenditure are fixed during the next period, the recipients' SWB effect will fall when the reference electricity usage increases in EPUS regions.

6. Conclusion

EPUS recipients usually carry the characteristic of culture poverty in China. From culture poverty perspective, EPUS recipient individuals act herd consumer behavior and thrifty consumer behavior. Based on the two kinds of behaviors, this literature introduces the psychological reference point and value function from CPT to establish the individual SWB function. It described a psychological reference point based on the differences of educational degree and established the groups' SWB function on the premise of countable individual welfare indexes, and analyzes the influence of psychological reference point changes on individual SWB effect. With empirical analysis to verify the feasibility of the function, this paper at last proved that the recipient SWB effect declined when the psychological reference point increases. Thus, Chinese government authorities should pay attention to emphasizing equipment maintenance and improving power service standards for enjoying the electricity and enhancing the SWB at proper time.

This paper not only provides a quantification method to measure SWB effect, but also introduces a theoretical basis to assess EPUS implementation effect comprehensively, including subjective factors.

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