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Abstract: With the rapid development of the information technology and e-commerce, it has become an inevitable trend to promote the application of e-business projects in rural China. Nevertheless, compared with the conventional businesses, the initial cost of an e-business project still remains relatively high in the rural areas. Therefore, it is an urgent issue to explore how to share the cost and benefit among the government and farmers for an e-business project in order to facilitate rural e-business development. By adopting the Shapley Game methodology, this paper has conducted a theoretic analysis of the cost sharing among the central government, local government and farmers, and built an investment cost sharing model (C'_i= P(i)- Vs(i)- V_{ri}, i=1,2,3), which is able to coordinate the benefit of all three stakeholders, and will best encourage the farmers to open family e-businesses in particular. This paper also proposes relevant policy recommendations in an effort to promote the development of e-business in rural China.

Keywords: E-business, investment cost sharing, Shapley game analysis, rural China

1. INTRODUCTION

With the advent of the information age, riding on the rapid development of the Internet, China's e-commerce has been developing at an alarming speed in recent years. At the same time, rural e-commerce is beginning to mushroom in different parts of China. Up to now, China has built over 350,000 rural e-business service points, covering more than half of the country. By the end of June 2016, courier coverage in the rural areas reached 76%, up 20 percentage points higher than the same period last year, the rural express delivery package volume reached 5 billion in China, increasing by 150%.

Rural e-business providers have led to employment in rural areas and poor areas, and increased farmers' income. Up to now, in the demonstration counties, the accumulated e-business training programs have benefited 1.2 million people, creating more than 80 million jobs, which has resulted in an employment of 12 million poor households; and there opened more than 1.18 million e-business shops throughout rural China [1]. According to the statistics of the Ministry of Commerce, in 2015, China's rural online shopping amounted to 353 billion yuan. In the first half of 2016, the rural online retail sales have reached 316.348 billion yuan, which is 4.04 % higher than the national urban online retail growth.

However, China's rural e-business is still at an initial stage, and its development is facing many problems, such as farmers have not yet benefited from the rural e-business providers; most e-business providers have not made any profit; for farmers to open their own family e-businesses, the initial cost is high in addition to the lack of necessary well-trained people.

The existing research on the investment (cost) sharing issue mainly focused on water conservancy and hydropower, construction engineering, logistics and transportation. Zheng Liqun introduced the multi-person cooperative game into the process of cost-sharing of water conservancy projects, and put forward a fair and reasonable proportion allocation for the cost gap [2]. Nasiri F et al proposed a game-theoretic method to model and analyze the process of utilizing biomass for power generation considering three players (distributor, facility

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developer, and participating farmer), and characterized the Nash equilibrium of the sequential game [3]. Chen Yanxiang analyzed the cost-sharing of energy-saving reconstruction of the existing residential buildings with centralized heating supplies, and determined the cost of their respective shares for energy-saving transformation of the existing buildings through analyzing the relationship between revenue, profit and cost [4].

For the issue of investment and profit for energy-saving renovation of the existing buildings, Li Liangliang established a model for the maximum cost allocation by using the multi-person cooperative game theory, and conducted an in-depth analysis of relevant stakeholders [5]. Since then, there have been more studies on the cost sharing issue. Zhou Houzhi et al analyzed the investment-sharing issue of farmland renovation PPP projects through the establishment of an investment game model, and pointed out the important conditions under which the farmland renovation projects can operate efficiently [6]. Wang Xiaoyan et al studied on the profit sharing issue based on the uncertainty of expected income of manufacturing and logistics alliances by the Shapley theorem [7].

Zhang Y J et al made an attempt to help China allocate the carbon emission quotas among regions in the light of collaboration by adopting the Shapley value method [8]. Yu S et al proposed an approach to determine emissions reduction target allocation based on the Particle Swarm Optimization (PSO) algorithm, Fuzzy C-Means (FCM) Clustering Algorithm, and Shapley Decomposition (PSO–FCM–Shapley) [9].

Sun Yanwei et al analyzed the cost of grid-connected PV power generation based on different levels of government subsidies [10]. Ma Shenghong analyzed the feasibility of spillover cost sharing for the entire power grid in terms of wind power generation, biomass power generation and solar PV power generation [11]. Nikoukar J et al assessed the transmission costs based on the tree diagram, and determined a reasonable and effective transmission pricing scheme [12]. Timmer J et al studied on the cost allocation model of stochastic inventory based on the cooperative game theory, and the results showed that the cost allocation based on Shapley decomposition and probability distribution was stable and effective when the participants shared their purchasing costs and beard their shareholding costs [13]. Du J et al. (2010) analyzed the cost and resources allocation using the cross-efficiency DEA model and applied it to the allocation of variable resources [14].

Literature review reveals that domestic and foreign scholars did a lot of studies on the investment cost sharing (allocation) issue by using different methods to establish investment allocation models for optimization. So far, however, little or none literature have been found on the distribution and sharing of investment cost-benefit for the relevant stakeholders of rural e-business application projects.

2. MODEL BUILDING FOR COST SHARING OF A RUAL E-BUSINESS PROJECT

The major stakeholders of e-business projects include the central government, local governments, farmers and manufacturers. The government can provide subsidies and tax incentives, and will receive social poverty reduction benefits. Farmers provide e-business shop sites and / or self-financing these projects. Manufacturers provide technical support, computer equipment and related installation and training services etc.

Since the current rural e-business is still in its introduction or growing stage, it has the problems of high cost, slow returns and long payback period. Facing such a reality, the Chinese central and local governments have introduced subsidies and supporting policies in order to encourage rural farmers to actively participate and invest in e-business projects. However, the cost sharing issue has not yet been resolved in terms of the cost-benefit allocation and optimization among the central government, local governments and farmers for e-business investment projects in rural China.

Therefore, this paper intends to fill this gap by building a cost sharing model through a theoretical analysis for optimizing the benefits of the central government, local governments and farmers for household e-business projects in rural China. As the main stakeholder of an e-business project, farmers are the direct beneficiaries, while the central and local governments represent the general public for the poverty reduction social benefit generated from the e-business project.

2.1 Theoretical basis

The research methodology of cost allocation often takes the Shapley value and separable and non-separable allocation methods [15]. Shapley value method is based on partners' importance in the process of generating economic benefits to solve the issue of profit distribution or cost-sharing, which does not require homogeneity of the participants. Guo Junxiong analyzed different categories of entities, such as energy service companies, energy-saving enterprises and financial institutions [16], while Hasan K N et al analyzed homogeneous entities' cost sharing of power grid stations [17].

For the analysis of profit distribution based on a multi-person cooperation game, this method allocates the total income of the alliance according to the marginal contribution brought by each and every participant of the cooperation game based on the principle of reciprocity of contribution and benefit, which will reach an equilibrium in both collective and individual rationality. The method is a neutral risk-based income distribution scheme assuming that the members of the allied enterprises bear the same risk.

The limitation of the Shapley value method lies in its difficulty in understanding the profitability of various cooperation scenarios. Chen Yanxiang [4] put forward a new idea to solve the cost sharing problem through the basic formula "cost = revenue－profit", and gave specific details to quantify the external profit, which made the Shapley value method more universal.

Therefore, in this paper we have made an attempt to analyze the cost sharing and profit distribution of the central government, local governments and farmers in the current promotion process of e-business projects in rural China based on the Shapely method.

2.2 Investment cost sharing model

The joint investment in household e-business projects by the central government, local governments and farmers should be based on the following pre-conditions: firstly, the cost-sharing scope is the costs of manufacture, installation and training; secondly, the total cost shared by the farmer, the local government and the central government is no more than an investment project cost with equal effect; thirdly, the total cost shared by the farmer, the local government and the central government is no greater than the total revenue; fourthly, the local government policies and strategies must be in conformity with the central government's macro policies; fifthly, the profit is zero when none of the farmer, local government and central government participate in the game. The basic model of the game diagram is shown in Figure 1.

In addition, since the operation and maintenance cost of an e-business project is very low, the operating costs will remain unchanged whether any of the stakeholders (the farmer, local government or central government) does not participate in the game, and the stakeholder who does not participate in the game also receives a profit.

On the basis of the Shapley value method, we added AHP to modify the external benefit of each participant, and then calculated the cost of each participant by sharing the profits with the following hypotheses:

Hypothesis 1: The farmer, the local government and the central government are a set of N = {1,2,3}, where the farmer = 1, the local government = 2, the central government = 3, S denotes all subsets contained in N, which is the alliance. The total cost of a rural e-business project is denoted by C, and the revenue of each participant is P_i (i=1,2,3).

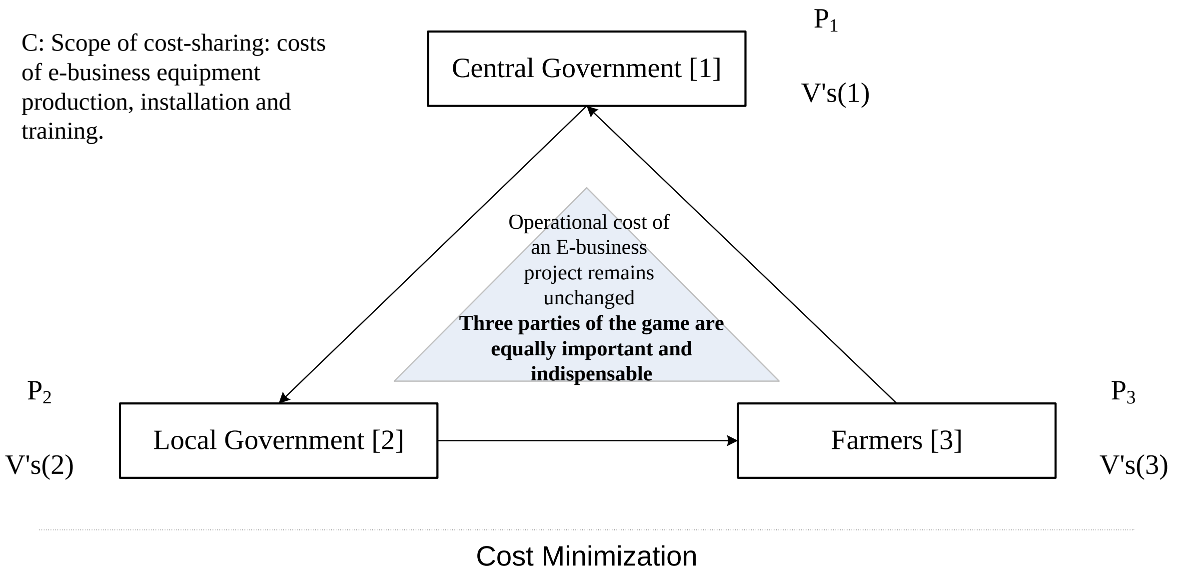

Figure 1 The Basic Tripartite Game Model Diagram

Hypothesis 2: China's rural e-business is at the stage of pilot and demonstration. We assume that the three game players (stakeholders) are equally important. That means if anyone is absent, the alliance will not exist, and the e-business project is unable to implement.

Hypothesis 3: All game players (the farmer, the central government and local governments) have the willingness to participate in the game, and agree to share corresponding costs.

Hypothesis 4: All three game players (stakeholders) pursue cost minimization.

The deduction process of the investment allocation (cost sharing) model is as follows:

(1) The Shapley Value based profit function. We assume that the profit function of the alliance consisting of the farmer, local government and central government is (1).

$$V(s)=Ps-C \tag{1}$$

where, C stands for the total cost of an e-business project, Ps stands for alliance S's revenue.

Next, we did profit allocation based on the Shapley value method, with the following formula:

$$Vs(i)=\sum_{i\in S}\frac{(n-|S|)!(|S|-1)!}{n!}\left[V(S)-V(S-\{i\})\right], i=1,2,3 \tag{2}$$

where, $|S|$ stands for the number of elements in alliance S. Then, we can get the profit vector after allocation:

$$Vs=\{Vs(1),\ Vs(2),\ Vs(3)\} \tag{3}$$

(2) The Shapley value based external profit function. We assume that the external income function is $V'(s) = V_{n-s}$, which is the total sum of income for all members of none alliance when alliance S makes an investment. Then, we did external profit allocation based on the Shapley value method, with the external profit vector after allocation:

$$V's=\{V's(1),\ V's(2),\ V's(3)\} \tag{4}$$

(3) Amendment of external profit. For farmers, the central government and local governments, the amount of external profit should be reallocated among the three. But not all external profit generated by all participants should be reallocated. Suppose δ_i is the expected return rate of the external profit of participant i. δ_i is zero when the distribution value of the external profit amount is smaller than zero. Therefore, it is only necessary to calculate the value of δ_i when the distribution value of the external profit is greater than zero, thereby calculating the distribution value of the negative external profit.

The main factors affecting δ_i include: the degree of scarcity of the participants, denoted as A_1; the willingness of the parties to join the alliance A_2; the attention of the participants to the benefits of the alliance A_3. A matrix is constructed with δ as the target layer, and A_1, A_2 and A_3 as the criteria layer. The weights α_1, α_2 and α_3 corresponding to A_1, A_2 and A_3 can be obtained by a correlation test. Then, give scores to A_1, A_2, A_3, using this scoring standard: the more irreplaceable of the participant, the closer to 1; when the participant has a strong willingness to participate in the alliance, the score is close to 1; when the participant is pretty much concerned with the profit of the alliance, the score is close to 1. δ_i can be obtained based on the scores of A_{i1}、A_{i2}、A_{i3} and corresponding weights α_1、α_2、α_3 of each participant i.

For the participant whose external income is greater than 1 after income allocation, the modified value of its external income is the product of the sum of external income allocation and expected return rate, i.e., $V_{ri}=V's*\delta_i$. V_{r+} is the sum of the modified value of the total external income of all participants, whose external incomes are greater than 1 after income allocation. Considering that the positive and negative external income is due to the shift of external income among different participants, then, $V_{r+}= V_{r-}$, of which V_{r-} indicates the sum of the modified values of the external income of all participants, whose external incomes are smaller than zero.

For participant i whose external profit is smaller than zero after income allocation, then:

$$V_{ri}=\frac{V's*V_{r^-}}{V's^-} \tag{5}$$

where, $V's^-$ signifies the sum of the external profit of the participant whose external income is smaller than zero. Then, we can get the vector of the modified external income:

$$V_b =\{ Vs(1)+ V_{r1}, Vs(2)+ V_{r2}, Vs(3)+ V_{r3}\} \tag{6}$$

(4) Cost sharing of modified fixed costs. We can get the modified cost allocation vector based on the basic formula "cost = revenue — profit", where, $P(i)$ is also $Ps,s=\{i\}$,which refers to the revenue when there is only one participant in the alliance:

$$C'=\{ C'_1,C'_2,C'_3\}=\{P(1)- Vs(1)- V_{r1}, P(2)- Vs(2)- V_{r2}, P(3)- Vs(3)- V_{r3}\} \tag{7}$$

This is the final cost sharing model for a joint investment project for e-business in rural China.

3. COST SHARING ESTIMATION OF A RURAL E-BUSINESS PROJECT

3.1 Estimating the externality of a rural e-business project

For the implementation of a rural e-business project, the farmers are the most direct beneficiaries, who can enjoy both economic and social benefits. The social benefit, which is regarded as the government profit on behalf of the public in this study, is the externality of an e-business project. In order to quantify its externalities, we take the profit recovery rate as the target layer, and criteria layer consists of three factors: (1) the value of contribution to rural poverty reduction; (2) rural poverty reduction efficiency; (3) the attention paid to the social benefits in Hubei Province.

In this paper, we adopted the Delphi scoring methodology to determine the weights between Hubei Provincial Government and the central government in terms of contribution to rural poverty reduction. We invited 20 experts in the related fields in each round of the Delphi survey. We did statistical analyses of the survey results after each round of the survey and improved the survey questions based on experts' responses. After three rounds of Delphi survey, the final weights have been determined as such: Hubei Provincial Government 0.36, and the Central Government 0.64.

We set the benefiting period of this project as 25 years, shared by the farmer, the local government of Hubei Province, and the central government. Therefore, the annual investment return rate was selected as 2.6% (the one-year state bond interest rate). Thus, we calculated the profits of e-business project stakeholders (farmers, local governments and central government) as shown in Table 1.

Table 1 Profit Distribution of All Stakeholders for an E-business Project

Stakeholders (Beneficiaries)	Annual Value of Profit (10,000 yuan)	Annuity Present Value Coefficient （2.6%, 25）	Present Value (10,000 yuan)
(1)Farmer	0.573*0.216+0.478*（0.4-0.216）=0.212	18.26	3.871
(2) Hubei government	(0.1164+0.1052+0.0147+0.0014+0.0011+0.0078+0.0012)*0.36=0.0892		1.629
(3) Central government	(0.1164+0.1052+0.0147+0.0014+0.0011+0.0078+0.0012)*0.64=0.1586		2.896
Total	—	—	8.396

Source: calculated by the authors.

3.2 Cost sharing estimation

(1) The profit function after allocation using Shapley value method:

We define the profit function of the alliance as:

$$V(s)=Ps-C \tag{8}$$

where, C refers to the total cost of a family e-business project, Ps is the revenue of the corresponding alliance.

Then, the profit of the farmer is:

$V（1）=3.871-6.5 = -2.629$

Likewise, the profits of Hubei local government and the central government are:

$V（2）=1.629-6.5=-4.871$

$V（3）= 2.896-6.5 = -3.604$

The profit for the alliance of the farmer and Hubei local government is:

$V（1，2）=3.871+1.629-6.5 = -1$

Likewise, the profit for the alliance of the farmer and the central government is:

$V（1，3）=3.871+2.896-6.5=0.267$

The profit for the alliance of Hubei local government and the central government is:

$V（2，3）=1.629+2.896-6.5 = -1.975$

The profit for the alliance of all three participants is:

$V（1，2，3）=8.396-6.5 = 1.896$

By calculation based on Shapley formula, we get the profits of all three participants:

The farmer: $Vs(1) = 1.704$

Hubei local government: $Vs(2) = -0.538$

The central government: $Vs(3) = 0.729$

(2) The external profit function after allocation using Shapley value method:

We define the external profit function as:

$$V'(s)= V_{n-s} \tag{9}$$

i.e., the total sum of profit for all members of none alliance when the alliance S makes an investment.

Then, the profit of the farmer is:

$V'（1）= 4.525$

Likewise, we can get:

$V'（2）= 6.767$，$V'（3）= 5.5$;

$V'（1,2）= 2.896$

V'（1,3）= 1.629

V'（2,3）= 3.871

V'（1,2,3）= 0

By calculation based on Shapley formula, we get the profits of all three participants:

The farmer: $V's(1)$= -1.072

Hubei local government: $V's(2)$ = 1.170

The central government: $V's(3)$ = -0.097

(3) The amendment of the external profit:

For farmers, local governments and the central government, the amount of external profit should be reallocated among the three. In so doing, we need to determine the expected return rate δ_i. The factors influencing δ_i include: the degree of scarcity of the participants, denoted as A_1; the willingness of the parties to join the alliance A_2; the attention of the participants to the benefits of the alliance A_3. By expert judgment scoring, we built a corresponding matrix:

$$\begin{pmatrix} 1 & 3 & 5 \\ 1/3 & 1 & 3 \\ 1/5 & 1/3 & 1 \end{pmatrix}$$

This matrix has passed the consistency test, and we obtained the following through further calculation:

α_1=0.64，α_2=0.24，α_3=0.1

For the second step, only one participant's external income is greater than zero, which is Hubei local government. Then, we further evaluated this participant by scoring in the three factors A_1, A_2, A_3, with the scoring range of [0,1]. That means that the more irreplaceable the participant is, the closer to 1; when the participant has a strong willingness to participate in the alliance, the score is close to 1; when the participant is pretty much concerned with the profit of the alliance, the score is close to 1.

Then, we get A_{21}=0.2, A_{22}=0.2, A_{23}=0.2, and further,

δ_2=0.196

The amendment value of external profit of Hubei local government is:

V_{r2}=0.196*1.170=0.229

That means that the positive external income that needs to be recovered is 0.229. Considering that the positive and negative external income is due to the shift of external income among different participants, then, $V_{r1}+V_{r3}$=0.229 (see the following calculation).

$$V_{r1}=\frac{-1.072*(-0.229)}{-1.169} = -0.210$$

$$V_{r3}=\frac{-0.097*(-0.229)}{-1.169} = -0.019$$

V_b ={1.704-0.210，-0.538+0.229，0.729-0.019} = {1.494，-0.309，0.71}

Therefore, we can get the amended vector values of the external profit as:

V_b ={1.704-0.210，-0.538+0.229，0.729-0.019} = {1.494，-0.309，0.71}

4. CONCLUSION

This paper draws the following conclusion:

(1) The cost of a rural e-business project should be shared based on the following model:

$C'_i = P(i) - Vs(i) - V_{ri}$，$i$=1,2,3

where, $P(i)$ refers to the revenue of the alliance when i is the only participant, $Vs(i)$ denotes the initial income allocation value and V_{ri} refers to the corrected additional profit.

Therefore, we make the following recommendations based on the above conclusions:

(1) Coordinating the relationship among different stakeholders of an e-business project in rural China, in an effort to promote the rapid development and widespread application of family businesses based on Internet. In rural China, especially in the poverty stricken areas, family e-business projects will help farmers quickly build the bridge between agricultural products and the markets both in China and throughout the world. Once the farmers' incentives are mobilized and open their own online shops, it will contribute greatly to both the farmers themselves in a way of poverty reduction and the society as a measure of creating green GDP and welfare of the people.

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