The income distribution of construction waste recycling PPP project

Jianbing Liu[1] Yuxin Liu[2]

Abstract. Whether the construction waste recycling PPP project was the success or failure depended on the income distribution being fair and reasonable .It was particularly important for how to work out a income distribution plan which was satisfaction of all parties. Therefore, based on government sector, private enterprise, financial institution for the interests of the related subject, this article considered the cost of inputs, risk sharing, project participation, contribution and how their effects income distribution. With the improved AHP(analytic hierarchy process),entropy weight method and fuzzy mathematics to determine the risk sharing coefficient, improved shapley price income distribution of construction waste recycle based on the PPP model. The income distribution model of construction waste recycling PPP objective and accurate which use of this model, comparing with the traditional method, it was more fair and reasonable, more encouraging, and meet the requirements of the interests of the related subject.

Key words. PPP model, construction waste recycling, income distribution.

1. Introduction

According to the statistics, China's construction waste produced more than 2500m tonnes a year [1].Faced the large number of construction waste, due to lower financial investment in public, lower management efficiency and relevant law policies were not perfect and the level of the construction waste was very low. PPP model not only solved the shortage of government financial funds, but also was a power for sustainable development of construction waste. However, in the process of evaluated, how to distribute the share of the project profit was the focus of the debated, and finally worked out a income distribution plan which was balance the interests of all parties. Therefore, through the state of principle of income distribution, which

[1]School of Economics and Management, Jiangxi University of Science and Technology, Ganzhou Jiangxi, 341000,China
[2]School of Economics and Management, Jiangxi University of Science and Technology, Ganzhou Jiangxi, 341000,China

analyzed the effect factors of income distribution and built out the income distribution model, a good solution of the income distribution of PPP, which made China's construction waste recycling perfect and develop.

Income distribution was one of the key problems in the construction waste recycling PPP project, and it became the focus of some scholar's study. At present, the research of PPP income distribution can be sectioned into cost-benefit analysis and game theory. About cost-benefit analysis, Pekka Leviakangas and others based on cash flow account and cost-benefit analysis, set up a single frame model which include cash flow, cost and income flow, through achieved a win-win situation in economic and financial benefit, he provided reference for successful public-private partnerships policy and investment strategy [2]. Carbonara Nunzia and others used the option model, Monte Carlo simulation and fair structured theory to balance the profitability requirement of private sector and financial management benefit of public authorities [3]. For the game theory, ZhengZhiqiang, thought about the bargained power of all parties, the cost of inputs and risk appetite, through them calculated income distribution model which was optimal [4]. MaQiang was from the cost of inputs, risk factor, innovation and so on, and took into account F-AHP method, the formula used: , set up Nash Bargaining model which was modified[5].HuLi led up AHP and fuzzy mathematics to correct Shapley price, in order to deal with income distribution for all parties was equally [6].

We can saw from the above research on the distribution of PPP model, firstly, they only considered the income distribution of government sector and private sector, which not brought financial institution into the major of the interests of the related subject; secondly, they determined the weight of each influence factor and calculated the coefficient of income distribution, AHP was the primary adopt, which existence was too subjective, more qualitative and quantitative, the index of date was too large and the weight was difficult to determine the problem.

2. The income distribution of construction waste recycling

2.1. The cardinal principle of the income distribution

The cardinal principle of income distribution was cooperation equality, information sharing, share of profit and loss, justice of exchange, tolerance and mutual trust. The cooperation equality was the most cardinal principle in the act of income distribution, by which we reached a consensus on comprehensive cooperative relation. The premise of income distribution was information sharing, which built an information sharing platform based on the cooperation of all parties. The essence of income distribution was share of profit and loss. Justice of exchange was an important means of income distribution.

2.2. The influence factor of the income distribution

In the project, on the basis of the cardinal principle of income distribution, we combined with historical data ,which adopted ISM method and system analysis, and

finally adopted the most compact influence factor to income distribution[7].Firstly, we collected the historical data and then got the initial influence factors. Through the construction waste recycling PPP project and carried through analysis about weight comprehensive and got the initial influence factors, which gave a general described as the proportion of capital, customer satisfaction, risk sharing, innovation ability, project participation, core technology force, contribution degree and so on. Then, we adopted ISM analysis method and combined with the related expect opinion and established the formal influence factors. Finally, established the organizational breakdown structure for the influence factors, then the invariant factors(the cost of input and risk sharing)variant factors(project participation and contribution degree)of the classification on, see Figure 1.
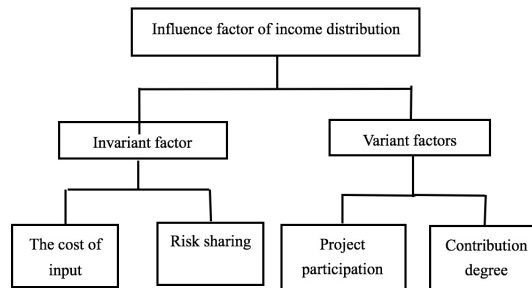

Fig. 1. Influence factor of the income distribution

2.2.1. The cost of input

Different interests related subject as investors, who had very different investment way in the project. Public authorities used financial fund, land source, developed preferential policy as the cost of input in the project. Private enterprise had specific technique and management ability. For financing institution used loans ,industry funds, equity bond and other financing.

2.2.2. Risk sharing

Risk sharing is the key element of PPP income distribution. This paper analysis the whole process from make policy research of project to operating management, combined with the recognition theory of PPP project risk of life cycle, we let risk fell into four categories: decision making, financing, construction, operation and others, in the meantime, each kind of risk can include all kinds of risks, we established the target system of risk factor about the project [8].See table1.

2.2.3. Project participation

In the project implementation of the process, the participation of the interest of the related subject directly affects the distribution of benefits.

2.2.4. Contribution degree In the cooperative process of all parties, due to the external environment of project changes more complex, the internal components were complex, that is must be emerge much unpredictable question. This made certain concessions in one side. In order to encouraged the behavior, the contribution degree of all parties should be taken into the income distribution.

Table 1. Risk factor index system of construction waste recycling PPP

Target layer	First class indicator	Second class indicator
Risk factor index system of construction waste recycling PPP project	Decision risk	Improper selection of PPP mode
		Changes in law
		Public opposition
		Approval delay
	Financing risk	Bidding failure
		Unreasonable financing structure
		High cost of financing
		Poor credit of financial institutions
		Contract management not in place
		Item company set up unreasonable
	Construction risk	Design change
		Construction delay
		Cost overrun
		Quality defect
		Safety accident
	Operational risk	Project revenue lower than expected
		Item company management inefficiency
		Operation and maintenance cost overrun
		Item is not unique
		Government to withdraw or levy in advance to nationalization

3. The improved Shapley price income distribution model

3.1. Shapley price income distribution model

Shapley price method [9]: Hypothesis N is stakeholder collection, $S \in N$ is a coalition of N. $V(S)$ was characteristic function defined on the union set, represents

the proceeds of the union S,the following conditions were established, $V(\varphi) = 0$, $V(S) > \sum_{i \in S} V(i)$, Set φ_i for the bureau of the income of the people i, which was got according to Shapley price theorem:

$$\phi = \frac{(|S| - 1)!(N - |S|)!}{N!}[V(S) - V(S - i)], \qquad (1)$$

In the formula: S represents the number of league member, $V(S - i)$ of the value of the coalition in the S of the members of the removal of the income of i after the $[V(S) - V(S - i)]$, can be seen as the number of i of the $[V(S) - V(S - i)]$ marginal contribution to the union.

Assume $i = 1, 2, 3$, which expressed government sector, private enterprise and financial institution : $N = \{i\}$, N is a collection of participants in the i, then $n = 3$; $\varphi_1, \varphi_2, \varphi_3$ respect before the improvement of government sector, private enterprise and financial institution related to the distribution of the benefits of income.

3.2. The improved Shapley price income distribution model

The paper based on the Shapley price, the four factors of the cost of input, risk sharing, project participation and contribution degree were applied to the improved model, and set up a set of factors for the improvement of income distribution $J = \{j\}, j = 1, 2, 3, 4$. The improvement coefficient of the first participants in the collection N is about α_{ij} for j, look at the table2 below.

Table 2. Matrix table improvement factor

	1 (The cost of input)	2 (Risk sharing)	3 (Project participation)	4 (Contribution degree)
1 (Government sector)	α_{11}	α_{12}	α_{13}	α_{14}
2 (Private enterprise)	α_{21}	α_{22}	α_{23}	α_{14}
3 (Financial Institution)	α_{31}	α_{32}	α_{33}	α_{34}

According to table2, An improved matrix A that can affect the income distribution.

$$A = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} \end{bmatrix}.$$

The performance of improved AHP [10], the influence weight of each factor on income distribution is calculated: $aa = \alpha = |\alpha_1 \ \alpha_2 \ \alpha_3 \ \alpha_4|$, from $A \times \alpha = |\beta_1 \ \beta_2 \ beta_3|$ get β. Let $\beta = |\beta_1 \ \beta_2 \ beta_3|$. β is the final improvement for each party. The actual

value of the actual income distribution:

$$V_1 = \varphi_1 + (\beta_1 - \frac{1}{n}) \times V(S),$$

$$V_2 = \varphi_2 + (\beta_2 - \frac{1}{n}) \times V(S), \qquad (2)$$

$$V_3 = \varphi_3 + (\beta_3 - \frac{1}{n}) \times V(S).$$

In this: V_1 is the improvement of the impact of various factors on the income distribution of government sector, V_2 is the income distribution value of each factor in the private enterprise after the improvement, V_3 was the value of the income distribution of financial institution after the improvement; $V(S)$ was the total revenue value of the parties after the improvement.

3.2.1. The cost of input

In this paper, we did not discuss the factors that influenced the time value of funds when we constructed the income distribution model, according to the contracted and the related agreement, through the combination of quantitative and qualitative methods, government sector, private enterprise and financial institution, the proportion of capital investment accounted for the total cost of investment, namely is $\alpha_{11}, \alpha_{21}, \alpha_{31}$.

3.2.2. Risk sharing

In order to determined the size of each of the interest of the related subject of risk in the project, they used the improved AHP, entropy weight and fuzzy mathematics risk sharing.

2.2.2.1. Improved AHP

AHP always needed consistency judgment, if inconsistent, it was necessary to reconstruct the judgment matrix, very troublesome. So we used the improved AHP, consistency testing became history, if A and B are equally important represented by the symbol 1, if A is more important than B represented by the symbol 2, if A was not important than B represented by the symbol 0.

1) Used this method to construct the judgment matrix of the target layer

2) Calculated weigh

$$\omega_i = \frac{\bar{\omega}_i}{\sum_{i=1}^{n} \bar{\omega}_i}, \qquad (3)$$

Include :

$$\bar{\omega}_i = ^n \sqrt{\Pi_{j=1}^{n} \alpha_{ij}}.$$

2.2.2.2. Entropy weigh

Entropy weight can improved the subjective weight, the basic idea determined the objective weight based on the size of the index variability. The judgment matrix of the improved AHP was normalized. Then calculated the information e_j, finally,

we used entropy weight to improved the weight of AHP. Namely was

$$\lambda_j = \frac{u_j \omega_j}{\sum_{j=1}^n u_j \omega_j}. \tag{4}$$

2.2.2.3 Project risk sharing model based on fuzzy comprehensive evaluation method
Fuzzy evaluation method established expert group, they comprehensive evaluated the risk of program and got the fuzzy synthetic judgment matrix R. At the same time,we used the entropy weight method to obtain the weight of each project risk evaluation W'. Then we got the result of fuzzy comprehensive evaluation B. Namely is

$$B = W' * R, \tag{5}$$

After normalized the B, We got the $B' = (b'_1, b'_2, \ldots, b'_n)$.
The risk sharing coefficient of government sector was α_{12}, risk factor for private enterprise and financial institution were α_{22}, α_{23}. Project risk had many species, the share of each risk in government sector, private enterprise and financial institution are $\bar{x}_i, \bar{y}_i, \bar{z}_i$; $\bar{x}_i + \bar{y}_i + \bar{z}_i = 1$, So

$$\begin{aligned}
\alpha_{12} &= b'_1 \bar{x}_1 + b'_2 \bar{x}_2 + \cdots + b'_n \bar{x}_n, \\
\alpha_{22} &= b'_1 \bar{y}_1 + b'_2 \bar{y}_2 + \cdots + b'_n \bar{y}_n, \\
\alpha_{32} &= b'_1 \bar{z}_1 + b'_2 \bar{z}_2 + \cdots + b'_n \bar{z}_n,
\end{aligned} \tag{6}$$

Among set up $x_i, y_i, z_i = B_i v^T$ to evaluate the single risk of the project, and carried on the normalization, got all kinds of single factor risk sharing coefficient. Is $\bar{x}_i, \bar{y}_i, \bar{z}_i$.

3.2.3. Project participation

Project participation was difficult to determined with specific values, we hired consult firms from all aspects of analysis. Thus the project participation factor $\alpha_{12}, \alpha_{23}, \alpha_{33}$.

3.2.4. Contribution degree

The degree of contribution was the action of the parties to deal with unexpected events, so as to made the sacrifice and contribution. According to the parties to the investment,we calculated the contribution of the parties $\alpha_{14}, \alpha_{24}, \alpha_{34}$.

4. Case analysis

In this paper we took Haian urban franchise project of construction waste disposal and recycling resources as an example, the Haian county government, Haiantianpeng limited company of renewable resources and technology, Haian rural commercial bank were the interests of the related subject. The project used the PPP model, in a 35million yuan, Haiantianpeng invested 7million yuan, the rest of 25million yuan lent by Haian rural commercial bank. According to calculations, the overall revenue from the overall project was 164.242 million yuan. Firstly, got the income distribution

value of all parties, namely the government got 23.269 million yuan, Haiantianpeng got 60.221million yuan, Haian rural commercial bank got 80.752million yuan.

Through analysis the influence factors of income distribution of all parties, concluded the proportion of cost is $\alpha_{11}, \alpha_{21}, \alpha_{31} = (0.25, 0.35, 0.4)$, risk sharing coefficient is $\alpha_{12}, \alpha_{22}, \alpha_{32} = (0.36640.34480.2848)$,project participation coefficient is $\alpha_{13}, \alpha_{23}, \alpha_{33} = (0.46670.35830.175)$,contribution degree coefficient is $\alpha_{14}, \alpha_{24}, \alpha_{34} = (0.23080.38460.3846)$. Through calculated a series of the influence factors of income distribution, we got the improved matrix A.

We used the improved AHP to evaluate the coefficient α of income distribution, the weight of the judgment matrix and the influence factors obtained ,we got $\alpha_1 = 0.2634, \alpha_2 = 0.5638, \alpha_3 = 0.1178, \alpha_4 = 0.0550$, which was $\alpha = (0.2634, 0.5638, 0.1178, 0.0550)^T$.

According to the above calculation, we obtained improved matrix A and income distribution coefficient α, calculated the weight of each factor in the income distribution $\beta == (0.3401, 0.3522, 0.3077)$,together to get income distribution precept on which account of improved Shapley price.

Government: $V_1 = 2326.9 + (0.3401 - 1/3) \times 1642.2 = 24.38$ million yuan

Haiantianpeng: $V_2 = 6022.1 + (0.3522 - 1/3) \times 1642.2 = 63.32$ million yuan

Haian rural commercial bank: $V_3 = 8075.2 + (0.3077 - 1/3) \times 1642.2 = 76.542$ million yuan

Compare improved Shapley price to not consider the influence factors of Shapley value, we gave full the role and contribution to all parties in the project, thus to satisfy the earning appeal to beat the overall target of the project, which was the best income distribution project.

5. Conclusion

In this paper, we searched a lot of literature and practical projects, combined theoretical research with case analysis, government sector, private enterprise and financial institution were selected as the interests of the related subject, and the objective and comprehensive analysis of the role played in income distribution, the basic principles of income distribution was described in detail, systematic analysis of the factors affected income distribution, used the improved AHP, entropy weight and fuzzy mathematics, construct a profit allocation model based on the improved Shapley price of construction waste recycling PPP mode.

References

[1] J.Y.Sun: *Study on the policy of construction waste recycling. M.* Beijing: China Architecture and building press (2015), *100.*

[2] P. Leviakangas, T. Kinnunen: *Aki Aapaoja Infrastructure public-private partnership project ecosystem-financial and economic Lpositioning of stakeholders.J.* The European Journal of Finance *22* (2016), 221–236.

[3] C.Nunzial,C.Nicola, P.Roberta: *Revenue guarantee in public-private partner-*

ships: a fair risk allocation model.J. The Construction Management and Economics *32* (2014), 403–415.

[4] Z.Q.Zheng, C.Q.Tao,Y.Leng: *Cooperative Game Analysis on PPP model of large sports facilities supply. J.* Sports science *05* (2011), 27–32.

[5] Q.Ma,D.Liu: *Design of income distribution mechanism of non operating PPP project. J.* Business times *09* (2011), 97–98.

[6] L.Hu, W.G.Zhang, X.S.Ye: *Research on PPP project benefit allocation model based on Shapely revision. J.* Journal of management engineering *02* (2011),149–154.

[7] X.B.Zhang,X.F.Zhang: *Analysis of the interaction between risk factors of international PPP project based on ISM...J.* Building economy *02* (2013), 38–41.

[8] L.Li, W.Feng,Y,Zhong, S.Xue: *Risk identification of PPP project from the perspective of life cycle. J.* Journal of Engineering Management *01* (2016), 54–59.

[9] R.W.Ma,Z.F.Wang: *Research on the ownership structure of the Shapley model of public-private infrastructure project based on. J.* Contemporary economic science *04* (2015), 118–123+128.

[10] X.J.Zhang, J.H.Li,K.Ding: *Based on the combination weighting model of the minimum deviation of the use of water emergency management capability. J.* Hydropower and energy science *06* (2016),22–26.