RESEARCH ARTICLE

Research on Benefit Distribution of Old Residential Area Renovation Projects under the New PPP Mechanism

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Abstract: The introduction of the new PPP mechanism will bring about huge changes in the implementation methods and revenue sources of old residential area renovation PPP projects implemented in the past in China. In order to cope with the changes brought about by the new PPP mechanism and ensure the smooth implementation of the project, it is necessary to study and explore the scientific and reasonable revenue distribution mechanism for old residential area renovation projects under the new PPP mechanism. Based on the research achievements of predecessors and the characteristics of the project, this paper determines the four indicators of resource input ratio, risk allocation ratio, innovation ability, and community residents' satisfaction as the influencing factors of project revenue distribution, and uses them to revise the initial Shapley value revenue distribution model. The paper then conducts an empirical analysis of the M old residential area renovation project in H City as an example. After the revision, the social capital will receive a higher project revenue allocation than the initial allocation value due to its greater resource input, greater risk allocation proportion, stronger innovation ability, and higher community residents' satisfaction, verifying the fairness and rationality of the revenue distribution model constructed in this paper and its ability to motivate the participation entities to improve both the economic and social benefits of the project and promote the successful completion of the project. The research content of this paper can provide ideas for the revenue distribution scheme research of old residential area renovation projects under the new PPP mechanism, and has certain reference value.

Keywords: PPP new mechanism; Renovation of old residential areas; Income distribution

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1 The proposal of the problem

As an important part of urban renewal, the renewal and construction of old residential areas is a key measure to improve people's livelihood and enhance the happiness of urban residents. With the continuous promotion of the renovation of old residential areas in China, the PPP model of cooperation between government departments and social capital has been widely used in the renovation of old residential areas due to its advantages of easing the pressure of government finance and improving the quality and efficiency of reconstruction. In order to standardize the management of various PPP projects and further reduce the financial pressure on the government, in November 2023, the National Development and Reform Commission and the Ministry of Finance of China issued the Guiding Opinions on Standardizing the Implementation of the New Mechanism for Cooperation between the Government and Social Capital. It requires the new PPP mechanism to focus on user-paid projects, which have certain operational income and can cover construction investment and operating costs. The introduction of the relevant provisions of the new PPP mechanism will bring about great changes in the

implementation methods and sources of return and income of the old residential renovation projects implemented in our country in the past. In order to ensure the smooth implementation of the projects and promote the effective cooperation between the government and social capital, it is necessary to study and explore the scientific and reasonable income distribution mechanism of the old residential renovation projects under the new PPP mechanism. In order to cope with the changes brought about by the new PPP mechanism.

At present, Shapley value method is the main research method on the income distribution of the old residential area renovation PPP project. Shapley value method can determine the income distribution plan based on the marginal income and contribution degree brought by each subject of the project, and avoid the influence of subjective factors on the income distribution structure to a certain extent. However, due to the defect of considering only one factor in the initial Shapley value, other relevant factors affecting the income distribution are ignored. Many scholars have revised the Shapley value. For example, scholar Zhu et al. [1] analyzed the return distribution of the initial Shapley value and added the risk sharing ratio to correct the return distribution of Shapley value. On the basis of the traditional Shapley value, scholar Zhang et al. [2] combined with the research results of existing literatures, identified the project resource input and risk sharing as the influencing factors, and built the income distribution model of the improved Shapley value method. Scholars Li et al. [3] added resource input, risk sharing and contract performance degree as influencing factors to modify the Shapley value income distribution model.

The above scholars' studies on the income distribution of PPP projects for the renovation of old residential areas mainly focus on the economic benefits of the projects, but there are shortcomings such as incomplete consideration of the influential factors of income distribution and neglect of the impact of social benefits on project income. Therefore, based on the previous literature research results and combined with the characteristics of old residential renovation projects under the new PPP mechanism, this paper identifies the factors affecting the income distribution in the project, and is used to revise the Shapley value income distribution model to ensure the fairness and rationality of income distribution, with a view to providing references for the income distribution of old residential renovation projects under the new PPP mechanism.

2 Analysis of project characteristics

2.1 Project income has uncertainty

Compared with other construction projects, renovation projects of old residential areas are more affected by internal factors and external environment[4]. Due to the lack of operational income, the PPP projects implemented in the past often need to rely on government payments or feasibility gap subsidies[5]. However, in order to reduce the financial burden of the government, the new PPP mechanism clearly requires the reduction of the government's financial expenditure, and can no longer guarantee the project income of social capital by promising to guarantee the bottom rate of return, giving feasibility gap subsidies and other ways. The project itself needs to have certain operational income, and user payment has become the main payment mode. However, due to the lack of mature project practical experience, There is a great uncertainty in the project income. How to solve the problem of "difficult profit" existing in the old residential renovation PPP project is also the key to the success of the old residential renovation project under the new PPP mechanism.

2.2 Project income is greatly affected by residents' satisfaction

Under the new PPP mechanism, the renovation projects of old residential areas carry out diversified business according to the actual needs of the residents in the communities where they are located, and adapt to the requirements of the new PPP mechanism for focusing on user payment. But at the same time, the benefits of the project are also determined by the frequency of residents'

use of services. For community residents, although various user payment services in the project are set up in accordance with actual needs, their satisfaction with the convenience of using various services and service quality is also an important factor influencing their purchase of services. For example, such services as elderly care and childcare and community catering have high requirements on service quality. Only by improving and enhancing the service quality can the potential of user payment be developed to the maximum extent. Therefore, residents' satisfaction with various types of business will directly affect the income of the renovation project of the old residential area under the new PPP mechanism.

3 Income distribution model based on initial Shapley value

The concept of Shapley values is derived from cooperative game theory and was proposed by Lloyd Shapley in 1953 to solve the payoff distribution problem in cooperative games[6]. The Shapley value is able to distribute the benefits of the alliance according to the marginal contribution of the players, thus avoiding unequal distribution, in the following steps:

Assume that I={1, 2,... , n} is a set consisting of n agents participating in the income distribution of the item, any subset of set I S ∈ I, V(S) is its real-valued function, according to cooperative game theory, V(S) must meet the following conditions at the same time:

$$V(\emptyset) = 0 \quad (1)$$

$$V(S_1 \cup S_2) \geq V(S_1) + V(S_2), S_1 \cap S_2 = \phi \quad (2)$$

Formula (1) indicates that if all agents do not participate in the project, then the project income is 0. Formula (2) indicates that the revenue of the cooperative implementation of the project by the entities is not less than the sum of the revenue of the activities carried out by the entities separately. If the above conditions are met, the cooperation is established, and V(S) is the characteristic function defined on I and the cooperation income of the project. Let it be the income that can be obtained by the participant i in the cooperation game, and the Shapley value can be obtained: $\varphi i(V)$

$$\varphi i(V) = \Sigma_{S \in S_i} W(|S|)\{V(S) - V(S-i)\}, i = 1,2,\ldots,n \quad (3)$$

$$W(|S|) = \frac{(|S|-1)!(n-|S|)!}{n!} \quad (4)$$

Therefore, the income distribution of the government sector and the income distribution of social capital can be calculated by the following formula: φP(V)φC(V)

$$\varphi P(V) = V(p)/2 + V(p,c) - V(c)/2 \quad (5)$$

$$\varphi C(V) = V(c)/2 + V(p,c) - V(p)/2 \quad (6)$$

4 Income distribution model based on the modified Shapley value

4.1 Identification of influencing factors of income distribution

Based on the analysis of previous literature and research results on the income distribution of PPP projects for the renovation of old residential areas, most scholars identified three influential factors of income distribution, namely resource input ratio, risk sharing ratio and contract performance degree[7][8], based on the income distribution principle of "input, risk and return equivalence" and the performance degree of franchising contracts.

From the perspective of project characteristics, considering that the new PPP mechanism requires that the project itself has a certain operating income, can cover the construction investment and operating costs, and has a certain return on investment. In order to solve the common problem of "difficult profit" in the old residential renovation PPP projects carried out in our country in the past and reduce the uncertainty of project income, it is necessary to test the ability of social capital to fully explore the project income potential and broaden the scope of operational business through business innovation, and also have higher requirements for the policy innovation ability of government departments. Therefore, the innovation ability is also included in the scope of consideration of the factors affecting income distribution in this paper.

On the other hand, the project income depends to a certain extent on the residents' satisfaction with the reconstruction effect of the old residential area and the

various businesses carried out by the project. Considering this feature, the residents' satisfaction should also be included in the correction process of Shapley value as one of the influencing factors of income distribution, so as to supplement the shortcomings of the existing research. Reflect the role of social benefits in the income distribution model of old residential area renovation projects under the new PPP mechanism, so that the influential factors of project income distribution are more comprehensive.

To sum up, this paper takes 5 indicators, such as resource input ratio, risk sharing ratio, contract performance degree, innovation ability and residents' satisfaction degree, as the influencing factors of income distribution, and revises the initial Shapley value income distribution model.

4.2 Identification of influencing factors of income distribution

Before adding the influential factors of income distribution into Shapley for correction, the weights of each influential factor should be determined. In this paper, C-OWA operator is used to measure the weights. This method combines the weight assigned by experts with the combination number, which can reduce the influence of expert decision information preference on the target weights, and realize the scientific weighting of evaluation indicators. The specific methods are as follows:

First, n experts are invited to score the importance of each influencing factor to the income distribution of the old residential area renovation project under the new PPP mechanism according to the 10-point scale, and the original set of values assigned by n experts to each indicator is obtained $T=\{t_1, t_2,\dots, t_m\}$, the original data are arranged in the order from largest to smallest, and numbered from 0 to obtain a new data set, namely $U=\{u_0, u_2,\dots, u_{m-1}\}$.

Calculate the weight of u_i using the combined number C^i_{m-1}, denoted by β_{i+1} :

$$\beta_{i+1}=\frac{C^i_{m-1}}{\sum_{i=0}^{m-1} C^i_{m-1}}=\frac{C^i_{m-1}}{2^{m-1}}; i=0,1,2\dots,m-1 \qquad (7)$$

The data set Q is weighted β_{i+1} by the above data weight ψ to obtain the absolute weight of risk sharing influencing factors $\bar{\theta}_j$:

$$\bar{\theta}_j=\sum_{i=1}^{m}\beta_i u_i\ ;\ \ j=1,2,\dots,z \qquad (8)$$

Calculate the relative weights of risk sharing influencing factors θ_j :

$$\theta_j=\frac{\bar{\theta}_j}{\sum_{i=1}^{z}\bar{\theta}_j};\ \ j=1,2,\dots,z \qquad (9)$$

4.3 Measurement of the influencing factors of income sharing

(1) Resource input ratio

Based on the principle of "investment, risk and return equivalence" of income distribution, resource investment and income distribution should be proportional, that is, the greater the proportion of resource investment of government departments and social capital in the renovation project of old residential areas under the new PPP mechanism, the greater the proportion of income distribution. Under the new PPP mechanism, the resource input of the old residential area renovation project includes tangible resource input and intangible resource input, but the input of intangible resources such as professional technology, land acquisition, policies and tax incentives is difficult to quantify. This paper refers to scholar Kou's idea of measuring the investment factor of PPP projects. The distribution result of the initial Shapley value model without considering other influence factors represents the resource input of each subject[9]. The proportion of resource input of government departments and social capital is expressed by C_1 and C_2 respectively, and the initial Shapley value calculates the income distribution of government departments and social capital as g_1 and g_2 respectively, then:

$$C_1=\frac{g_1}{g_1+g_2} \qquad (10)$$

$$C_2=\frac{g_2}{g_1+g_2} \qquad (11)$$

(2) risk sharing ratio

Based on the principle of "investment, risk and return equivalence" of income distribution, the greater the

proportion of risk sharing between government departments and social capital in the renovation project of old residential areas under the new PPP mechanism, the greater the proportion of income sharing. By referring to the previous research results on risk sharing of PPP projects, combined with the characteristics of old residential renovation projects under the new PPP mechanism, six types of risk factors that need to be shared in the project are identified, which are: policy and legal risk, economic risk, construction risk, operational risk and management coordination risk. For the above risk factors, this paper uses a bargaining game model to simulate the process of risk negotiation between government departments and social capital. Assuming that the negotiation loss coefficient$_1$ of the government side is δ, the social capital side$_2$ is δ, and the risk proportion of the government department is k (0≤k≤1), then the risk proportion of the social capital is 1-k, and the government department can transfer the risk transfer share γ to the social capital with the risk transfer probability p by virtue of its negotiating position advantage. According to Shaked and Sutton's idea of solving the infinite round bargaining model[10], taking the third round negotiation as the inverse derivation point, the equilibrium solution of the model is calculated as follows:

$$k = \frac{\delta_2 - 1}{\delta_1\delta_2 - 1} + p\gamma \qquad (12)$$

$$1 - k = \frac{\delta_1\delta_2 - \delta_2}{\delta_1\delta_2 - 1} - p\gamma \qquad (13)$$

Considering the large randomness of the model parameters, this paper solves the parameters through Monte Carlo simulation, assuming that variable X_1 is the negotiation loss coefficient$_1$ δ of government departments, X_2 is the negotiation loss coefficient$_2$ δ of social capital, X_3 is the risk transfer probability p, X_4 is the risk transfer share γ, and the output variable Y is the risk sharing ratio k of government departments, according to equation (9), we can obtain:

$$Y = \frac{X_1 - 1}{X_1X_2 - 1} + X_3X_4 \qquad (14)$$

Then, the probability distribution of input variable X is determined to be F(X), the number of simulation times n is determined, and the sample values of n groups of variable X_i are obtained through random simulation, which are substituted into equation (9) to obtain n simulated values of output variable Y. The average value of n output variables Y is calculated, so as to determine the specific share ratio of government departments and social capital to each risk factor. Finally, the C-OWA operator is used to assign weight to each risk factor, and the comprehensive risk sharing ratio D_{21} and D between government departments and social capital in the renovation project of the old residential area under the new PPP mechanism is obtained.

(3) Degree of contract performance

The higher the degree of contract performance of the participant in the project, the greater the proportion of income distribution. Since the degree of contract performance can only be assessed after the completion of the project or the expiration of the franchise, it can be assumed that the public and private parties have the same degree of contract performance, that is, the degree of contract performance of government departments and social capital R_1= R_2=0.5, when the income distribution plan is made before or in the middle of the PPP project.

(4) Innovation capability

The stronger the innovation ability of government departments and social capital, the greater the proportion of income distribution. The innovation ability parameters of government departments can be measured by expert scoring method to evaluate their policy and system innovation ability, which is denoted as Z_1. The innovation ability parameter of social capital can invite experts to score its business development ability and mark it as Z_2.

(5) Residents' satisfaction

The higher the satisfaction degree of residents in government departments and social capital, the greater the proportion of income distribution. Residents' satisfaction can be collected in the form of questionnaire survey, and the collected questionnaire information can be sorted out and the parameters E_1 and E_2 of residents' satisfaction between government departments and social capital can be calculated.

4.4 Modified Shapley value income distribution model

Since the initial Shapley value model assumes that the resource input ratio, risk sharing ratio, innovation ability and resident satisfaction of each income distribution entity are all equal, the above influential factor of income distribution is default to 1/n (n is the number of income distribution entities). Under the new PPP mechanism, the renovation project of old residential areas is a cooperative game between government departments and social capital. If n=2, the initial Shapley value income distribution model defaults each influencing factor to 1/2. Therefore, the incremental proportion of resource input generated by the distribution benefits formed by different resource inputs is $\Delta C_i = C_i - \frac{1}{2}$, assuming that the resource inputs are equal. Similarly, the increment of risk sharing ratio is $\Delta D_i = D_i - \frac{1}{2}$, the increment of contract performance is $\Delta R_i = R_i - \frac{1}{2}$, the increment of innovation capability is $\Delta Z_i = Z_i - \frac{1}{2}$, and the increment of resident satisfaction is $\Delta E_i = E_i - \frac{1}{2}$. The income distribution value of income distribution subject i after adjusting Shapley value is:

$$\varphi_i'(V) = \varphi_i(V) + V(S)(\theta_c \cdot \Delta C_i + \theta_d \cdot \Delta D_i + \theta_r \cdot \Delta R_i + \theta_z \cdot \Delta Z_i + \theta_e \cdot \Delta E_i) \quad (15)$$

5 Case study

5.1 Project Overview

This project is a comprehensive renovation project for the old residential area of M community in H City, covering 4 old residential areas under the jurisdiction of M community, with a total of 76 residential buildings and more than 3,000 permanent residents. The community covers an area of about 24 hm2 and the construction area is about 33 hm^2. According to the franchise agreement, the renovation project of M old community will be implemented in a build-operate-transfer (BOT) mode, with a construction period of 2 years and a tentative operating period of 20 years. The total investment of the project is 118.389 million yuan, of which K Company has invested 79.082 million yuan, which mainly includes the construction cost of various buildings and facilities of the project, the operating cost of operational business and the property management cost. H City Housing and Urban-Rural Development Bureau invested 39.307 million yuan, mainly for the user pay project construction costs, the first three years of operation of the project's operating subsidies. The expected total revenue of the 20-year operation period of the project is 127.367 million yuan (after tax), of which, the rental income of parking space and charging pile is 34.363 million yuan, the rental income of advertising column is 39.522 million yuan, the business income of supermarkets, restaurants, barber shops and other businesses carried out by the comprehensive service center is 29.921 million yuan, and the property management income is 23.561 million yuan.

5.2 Project benefit allocation based on initial Shapley value

If the project is not implemented in PPP mode and is implemented by H City Housing and Urban-Rural Development Bureau independently, it can be estimated that the total after-tax income of H City Housing and Urban-Rural Development Bureau independently invested in the implementation of the project is about 25.79 million yuan; If K company invests and implements the project separately, it is estimated that the total after-tax income of K company investing and implementing the project separately is about 59.07 million yuan. Therefore, the main parameters of the Shapely value model can be obtained: The total revenue of project cooperation V(P, C)= 127.367 million yuan, the revenue of the project implemented by the Housing and Urban-Rural Development Bureau of H city V(P) = 25.79 million yuan, the revenue of the project implemented by K company V(C) = 59.07million yuan, Substituting equations (5) and (6) yields the income distribution amount of H City Housing and Urban Rural Development Bureau, denoted as $\varphi P(V)$, and the income distribution amount of K Company, denoted as $\varphi C(V)$

$$\varphi P(V) = \frac{25.79}{2} + \frac{127.367 - 59.07}{2} = 47.0435 \text{ million yuan}$$

$$\varphi C(V) = \frac{59.07}{2} + \frac{127.367 - 25.79}{2} = 80.3235 \text{ million yuan}$$

5.3 Empowerment of income distribution influencing factors

In this paper, C-OWA operator is used to measure the weight of each influential factor of income distribution in M old residential projects. Ten experts in the field of renovation of old residential areas and staff involved in the project were invited to score the importance of five influential factors in the renovation project of old residential areas, such as resource investment ratio, risk sharing ratio, contract performance degree, innovation ability and residents' satisfaction degree according to the 10-point system. After 10 experts score the 4 income distribution factors, C-OWA operator is used to determine the index weight, and the weight of 5 influential factors such as resource investment ratio, risk sharing ratio, contract performance degree, innovation ability and residents' satisfaction is obtained=$[0.1900, 0.2162, 0.2048, 0.1899, 0.1990]^T$

5.4 Measurement of the relevant influencing factors of income distribution

(1) Resource input ratio

According to the correlation analysis of the measurement of resource investment ratio in 5.5.2 of this paper, the initial Shapely value income distribution value without considering other influencing factors is the return obtained by each income distribution subject by investing resources. According to equations (10) and (11), The resource input ratio C_1 of H City Housing and Urban-Rural Development Bureau in the project and the resource input ratio C_2 of K company in the project can be calculated:

$$C_1 = \frac{4704.35}{4604.35 + 8032.35} = 0.3694$$

$$C_2 = \frac{8032.35}{4704.35 + 8032.35} = 0.6306$$

(2) risk sharing ratio

In order to determine the specific sharing ratio of various risk factors, this paper adopts Monte Carlo method to simulate the bargaining game process. Variable X_1 is set as the negotiation loss coefficient of Housing and Urban-Rural Development Bureau of H city, X_2 is the negotiation loss coefficient of Company K, X_3 is the risk transfer probability, X_4 is the risk transfer share, and output variable Y is the risk sharing ratio of government departments, and $1 < X_1 < X_2$. With reference to scholar Li's[11]relevant research results on risk sharing bargaining game, the distribution and value range of the four variables are determined, as shown in Table 1.

Table 1 Value range of related variables in bargaining game

Name of variable	Distribution	Range of values
H City Housing and Urban-Rural Development Bureau negotiating loss coefficient X_1	Uniform distribution	[1.00 1.25]
K company's negotiating loss factor X_2	Even distribution	[1.00 1.25]
Risk transfer probability X_3	Normal distribution	[1.00 1.25]
Risk transfer share X_4	Normal distribution	[1.00 1.25]

Input the value range, distribution and other conditions of the above variables into the risk management software Oracle Crystal Ball, and define the calculation relationship of the output variable Y according to equation (14), and set the simulation times to 1500 times. The simulation results of 6 risk factors including policy and legal risk, economic risk, construction risk, operation risk and management coordination risk are obtained, as shown in Table 2.

Table 2 shows the result of sharing the risk of the renovation project of M old residential area

Risk Factors	Nominal risk sharing ratio of H City Housing and Urban-Rural Development Bureau	Nominal risk sharing ratio of Company K	Transfer share	H City Housing and Urban-Rural development bureau actual risk sharing ratio	Actual risk sharing ratio of Company K
Policy and legal risk	79.6%	20.4%	12.8%	66.8%	33.2%
Economic Risk	52.4%	47.6%	13.9%	39.5%	60.5%
Construction risk	62.9%	37.1%	16.8%	45.1%	54.9%
Operational risk	46.5%	53.5%	9.6%	36.9%	63.1%
Management coordination risk	53.9%	46.1%	7.1%	46.8%	53.2%

After determining the actual risk sharing ratio, C-OWA operator is used to calculate the weight to calculate the weight of each risk factor in the project. Combining the

preliminary risk sharing result and the shared risk sharing result, the comprehensive risk sharing ratio D_1=0.4483 of H City Housing and Urban-Rural Development Bureau can be calculated. The comprehensive risk sharing ratio D_2=0.5517 for Company K.

(3) Contract performance degree

Since the contract performance can only be assessed after the completion of the project or the expiration of the franchise, the M old residential renovation project is still in the early stage of operation. Therefore, assume that the contract performance degree of H City Housing and Urban-Rural Development Bureau and K company R_1= R_2=0.5.

(4) Innovation ability

In order to evaluate the innovation ability of H City Housing and Urban-Rural Development Bureau and K Company in the renovation project of M old residential district, 10 experts in the field of renovation of old residential district and the staff involved in the project were invited to evaluate the innovation ability of H City Housing and Urban-Rural development Bureau and K company's business development ability respectively. In this project, Company K adapts to the actual needs of the community residents, and on the basis of earning profits from convenient services such as supermarkets, restaurants, barbershops, logistics express stations, door-to-door housekeeping, and activity rooms for the elderly, it also develops two business businesses, namely parking space and charging pile rental and advertising column rental, to improve the overall income of the project. Therefore, it got a high score from experts, with an average score of 8.1, while the average score of H City's Housing and Urban-Rural Development Bureau for innovation ability was 7.3. According to the average scores of innovation capability of H Housing and Urban Rural Development Bureau and K Company, the innovation capability parameter Z_1 of H Housing and Urban Rural Development Bureau and the innovation capability parameter Z_2 of K Company can be obtained:

$$Z_1 = \frac{7.3}{7.3 + 8.1} = 0.4706$$

$$Z_2 = \frac{8.1}{7.3 + 8.1} = 0.5294$$

(5) Residents' satisfaction

In order to measure the satisfaction of residents of H City Housing and Urban-Rural Development Bureau and K Company in the renovation project of M old residential area, this paper collects data through questionnaire survey. The specific implementation method is as follows: After the questionnaire was designed and completed, the staff of M community was commissioned to distribute online questionnaire links among the four owner groups of the old residential areas under the jurisdiction of the community to participate in the renovation, and the satisfaction of residents of H City Housing and Urban-Rural Development Bureau was evaluated from four aspects: policy publicity, public opinion collection, information disclosure and project supervision. The satisfaction of residents of K company was scored from six aspects: construction progress, property management, infrastructure transformation, operation of comprehensive service center, operation of parking Spaces and charging piles, and advertisement delivery. In the end, a total of 205 questionnaires were collected. After excluding invalid data, 193 valid questionnaires remained, with an effective rate of 94.1%. According to the questionnaire survey, the satisfaction score of H City Housing and Urban-Rural Development Bureau is 3.2274, and that of K company is 3.3108. The satisfaction parameters E_1 and E_2 of H City Housing and Urban-Rural Development Bureau and K company in the renovation project of M old residential area can be obtained:

$$E_1 = \frac{3.2274}{3.2274 + 3.3670} = 0.4895$$

$$E_2 = \frac{3.3108}{3.2274 + 3.3670} = 0.5105$$

5.5 Modified Shapley value income distribution model

By substituting the calculated parameters of the influencing factors of income distribution and their weights into equation (15), the revised project income of the θHousing

and Urban-Rural Development Bureau of H City and the project income of Company K can be obtained: $\varphi_P^{'}(V)$ $\varphi_C^{'}(v)$

$\varphi_P^{'}(V) = 47.0435 + 127.367[0.1900 \cdot - (0.1306) + 0.2162 \cdot - (0.0517) + 0.2048 \cdot 0 + 0.1899 \cdot - (0.0294) + 0.1990 \cdot - (0.0105)] = 47.0435 - 5.5366 =$ 41.5069 million yuan

$\varphi_C^{'}(V) = 80.3235 + 127.367(0.1900 \cdot 0.1306 + 0.2162 \cdot 0.0517 + 0.2048 \cdot 0 + 0.1899 \cdot 0.0294 + 0.1990 \cdot 0.0105) = 80.3235 + 55366 = 85.8601$ million yuan

According to the modified Shapley value income distribution model, it is calculated that the income of H City Housing and Urban-Rural Development Bureau in the renovation project of M old residential area is 41.5069 million yuan, and the project income of K company is 85.8601 million yuan. After the revision, the income distribution value of K company's project increased by 5.5366 million yuan compared with the initial Shapley value, while the income distribution value of H City's Housing and Urban-Rural development Bureau decreased by 5.5366 million yuan. In addition to the same degree of contract performance, the proportion of resource input and other four parameters of K company are large. When the income distribution plan is adjusted according to the revised Shapley value income distribution model, K Company is compensated to a certain extent, while H City Housing and Urban-Rural Development Bureau reduces part of the income distribution quota, and the overall project income is still conserved. In line with the requirement of fair and reasonable income distribution.

6 Conclusions

In this paper, based on the previous studies on the income distribution of PPP projects for the renovation of old residential areas, combined with the characteristics of PPP projects under the new mechanism, the resource input ratio, risk sharing ratio, contract performance degree, innovation ability and community residents' satisfaction are identified as the influencing factors of the project income distribution, and are used to revise the initial Shapley value income distribution model. Finally, taking the renovation project of M old residential area in H city as an example, the modified Shapley value income distribution model constructed in this paper is empirically analyzed. After the revision, social capital invested more resources in the project, assumed a larger proportion of risks, showed stronger innovation ability and higher residents' satisfaction, and its project income distribution value increased compared with the initial Shapley value, which verified the feasibility, fairness and rationality of the income distribution model. In addition, the revised income distribution model can also encourage government departments and social capital to pay more attention to the above influencing factors in the implementation process of the project, and actively assume their own responsibilities, while improving the economic and social benefits of the project, and promoting the smooth completion of the project. Therefore, the research content of this paper can provide ideas for the study of the income distribution scheme of the renovation project of the old residential area under the new PPP mechanism, and has certain reference significance.

However, due to the complexity of the old residential renovation project under the new PPP mechanism and the immature practical experience, in the actual implementation process of the project, in addition to the 5 influencing factors identified in this paper, the income distribution may also be affected by other factors. Therefore, when determining the final benefit distribution plan of the project, the subsequent relevant research should be fully considered in the specific practice of the project, flexibly set the influence factors of income distribution, and constantly revise the income distribution plan, in order to achieve the fair and reasonable results of income distribution.

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