

Research on Profit Distribution Mechanism for the Alliance of Industrial Park Wastes

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Abstract. This paper mainly consider company's implementation capacity, alliance profit and other factors with the certainty equivalence revenue maximization as the goal of the game, under the condition of meeting the cooperative game rationality to construct the cooperative profit distribution model of wastes disposal alliance and get profit distribution mechanism. Finally, industrial park wastes disposal in Chongqing as an example to verify scientific validation and the applicability of the proposed model and method.

Introduction

Industrial park wastes disposal is the most important work in urban pollution control and environmental protection. Park wastes disposal can enhance the competitiveness of enterprises, and achieve integration of resources and effective management. Wastes disposal alliance development of the key is to establish a reasonable profit distribution mechanism. The scholars mainly adopted Shapley value method, core method, and game model to solve it. Researchers used Shapley value method more and improved continuously [1-4]. Core method mainly used for the empirical analysis to build the alliance profit distribution model [5-6]. The dynamic game model is used to solve alliance profit allocation mechanism [7] and to conclude alliance optimal profit distribution coefficient and optimal effort level [8-9].

Project group conducted special investigations to Chongqing characteristic industrial park wastes disposal between May 2012 and March 2013. This paper based on the actual investigation data to analysis the wastes disposal alliance's feature and build alliance profit distribution model, used cooperative game and non-cooperative game to reverse calculate, obtained scientific and reasonable profit distribution mechanism, provided practical theory basis for park wastes management.

The construction of profit distribution model for the alliance of industrial park wastes

Industrial Park wastes disposal alliance composes mainly of providing wastes disposal services for a number of business license enterprises, it has the general characteristics of strategic alliance.

Assuming that the Industrial Park wastes disposal alliance is made up of N enterprises ($i=1,2,\dots, n$), i represents the i -th enterprises, 1 refers to the leader; other $N-1$ enterprises are leagues.

Hypothesis 1: Alliance and enterprise profit and the level of effort are linear relationship. R represents alliance profit, D_i represents earnings that the independent enterprise engaged in wastes disposal to obtain under the non-aligned situation, the enterprise pay the same level of effort: $R \geq \sum_{i=1}^n D_i$.

According to Holmstrom and Milgrom parametric expansion model [10], D_i and

the level of effort are linear relationship: $D_i = v_i a_i + e_i$ (e_i means normal distribution random variables with mean of 0, and reflects output affected by changes in the market, with uncertainty.

a_i represents enterprises level of effort, it is equal to the ratio of the enterprise actual effort and ideal

hard indicators, $0 < a_i \leq 1$. Enterprises can choose the level of effort indicators including the total input, total output or the total recycling capacity etc; Acute effort index is the real data obtained by enterprises in business, and the ideal index is data the enterprises can realize under the full ability worked. n_i represents output coefficient of the i -th independent enterprise, it is the enterprise unit of effort outputs, and can be used to measure corporate profitability. If n_i is measured by currency, n_i is the level of effort's profit coefficient. n_i reflects the enterprise wastes management implementation ability; The bigger the n_i is, the greater the enterprise implement ability is. The enterprise alliance profit

R and enterprise alliance effort are linear relationship: $R = \sum_{i=1}^n (v_i a_i) + R^0 + e$. it is the normal distribution of random variable with mean of 0 and variance S^2 , R^0 represents alliance profit increment, $R^0 > 0$ represents the overall revenues increase. Alliance expects earnings or average earnings: $E(R) = \sum_{i=1}^n (v_i a_i) + R^0$.

Hypothesis 2: Enterprise's cost and the level of effort are quadratic function relation. Wastes disposal cost is composed of sunk cost and the cost of innovation, sunk costs are a relatively fixed cost, it has nothing to do with the degree of effort; the cost of innovation increase along with the increase of the degree of effort. f_i is the i -th enterprise innovation cost coefficient, $f_i > 0$; f_i depends on the enterprise implementation capacity, the greater the value shows, the more enterprises cost is and the weaker the enterprises implement ability is on the same level of effort. Enterprise innovation cost can be expressed as a quadratic function of the effort level of the enterprise, $0.5f_i a_i^2$. if C_i is the total cost of the i -th enterprise, I_i is sunk cost, then, $C_i = I_i + 0.5f_i a_i^2$, ($i = 1, 2, \dots, N$).

Hypothesis 3: All alliance profit is allocated to enterprises. s_i represents the coefficient of the i -th enterprise profit distribution, $\sum_{i=1}^n s_i = 1, 0 < s_i \leq 1$ ($i=1, 2, \dots, N$). $E(R) = \sum_{i=1}^N R_i$, $R_i = s_i E(R)$, R_i represents the i -th enterprise profit in the alliance. Leader according to the linear relationship paid to members $T / (N - 1) + s_i R$ ($i \neq 1$), T is a fixed payment, associates with sunk costs, has nothing to do with the level of effort, it is both leader cost and members benefits. $s_1 R$ represents leader profit, $T / (N - 1) + s_i R$ represents members earning.

The alliance of profit allocation decisions are two-stage decision-making process, including the cooperative game and non-cooperative game. Optimal benefit allocation decisions should meet three conditions of rationality: • Individual rationality conditions, players benefit can't less than nonparticipants in the alliance ; , The overall rationality condition, the alliance benefit allocated to all participants; \mathcal{f} Alliance rationality conditions, the alliance's overall profit is more than non- alliance's.

Enterprises are generally risk-averse, their utility function u has absolute risk aversion characteristics: $u(w) = -e^{-rw}$, $r = -u''(w) / u'(w) \geq 0$, r is the arrow - para absolute risk aversion coefficient, indicates the extent to which enterprises are afraid of the risk; w is the actual monetary profit. Alliance profit: $R_i = s_i R$, the variance: $s_i^2 S^2$. According to Arrow-Prat theory, enterprise risk cost = $0.5 \times$ the absolute risk aversion \times the variance of profit, the i -th enterprise risk cost: $0.5 r_i s_i^2 S^2$,

r_i represents the i -th enterprise absolute risk aversion coefficient. Enterprise risk cost and the profit coefficient is proportional, the greater the profit's share is, the bigger the risk is, reflecting the "profit sharing and risk-sharing" principles of alliance cooperation.

Alliance profit of cooperative game decision-making: $R = \sum_{i=1}^N (v_i a_i) + R^0 + e$, the actual alliance monetary profit: $\sum_{i=1}^N (v_i a_i) + R^0 + e - \sum_{i=1}^N C_i$, expected monetary profit: $\sum_{i=1}^N (v_i a_i) + R^0 - \sum_{i=1}^N C_i$, so the union of certainty equivalent profit: $\sum_{i=1}^N (v_i a_i) + R^0 - \sum_{i=1}^N C_i - 0.5 \sum_{i=1}^N p_i s_i^2 \mathbf{s}^2$. Non-cooperative game enterprise alliance based on their own interests determined the degree of effort, the leader enterprise actual monetary profit and deterministic equivalent profit: $s_1 E(R) - T - C_1$, $s_1 E(R) - T - C_1 - 0.5 r_1 s_1^2 \mathbf{s}^2$. Similarly, alliance members actual monetary profit: $T/(N-1) + s_i E(R) - C_i$ and its deterministic equivalent profit: $T/(N-1) + s_i E(R) - C_i - 0.5 r_i s_i^2 \mathbf{s}^2$.

According to the principle of cooperation game and alliance revenue allocation mechanism, CE and CE_i ($i = 1$ represents the leader) mean wastes disposal alliance and members determine the revenue equivalence respectively. Bring the enterprise cost function and expected benefit of the league into the alliance and enterprise certainty equivalence revenue calculation formula, obtain:

$$CE = \sum_{i=1}^N (v_i a_i) + R^0 - \sum_{i=1}^N (I_i + 0.5 f_i a_i^2) - 0.5 \sum_{i=1}^N r_i s_i^2 \mathbf{s}^2 \quad (1)$$

$$CE_1 = s_1 \left[\sum_{i=1}^N (v_i a_i) + R^0 \right] - T - I_1 - 0.5 f_1 a_1^2 - 0.5 r_1 s_1^2 \mathbf{s}^2 \quad (2)$$

$$CE_i = T/(N-1) + s_i \left[\sum_{i=1}^N (v_i a_i) + R^0 \right] - I_i - 0.5 f_i a_i^2 - 0.5 r_i s_i^2 \mathbf{s}^2 \quad (3)$$

Eq. (1), (2), (3) ($R^0 > 0$, $\sum_{i=1}^N s_i = 1$) meet the alliance rationality condition and the overall rationality condition, but lack the individual rationality condition $R_i > E(D_i)$. Bring $R_i = s_i E(R)$ and $E(D_i) = v_i a_i$ into individual rationality conditions can obtain:

$$s_i \left[\sum_{i=1}^N (v_i a_i) + R^0 \right] \geq v_i a_i \quad (4)$$

Eq. (1), (2), (3), (4) constitute alliance profit allocation model.

Analysis on the profit distribution mechanism

Considering profit distribution game decision inverse process. Suppose the leader and members know both sides of the profit distribution coefficient. According to (2) and (3) partial derivative of a_i , let $\partial CE_1 / \partial a_1 = 0$, $\partial CE_i / \partial a_i = 0$ can obtain: $\partial CE_1 / \partial a_1 = s_1 v_1 - f_1 a_1 = 0$, $\partial CE_i / \partial a_i = s_i v_i - f_i a_i = 0$. By solving the equation, the degree of enterprise effort in game equilibrium:

$$a_i = s_i v_i / f_i \quad (i = 1, 2, \dots, N) \quad (5)$$

The degree of effort is proportional to the output coefficient and the profit distribution coefficient, and is inversely proportional to the cost of innovation. Eq. (5) shows that the implementation of strong ability and high profit distribution of enterprises are willing to increase investment to improve the level of output.

According to the ep.(1) and $\sum_{i=1}^N s_i = 1$ to set a new function $CEF(s_i)$ in order to solve the optimal value problem with the condition:

$$CEF = \sum_{i=1}^N (v_i a_i) + R^0 - \sum_{i=1}^N (I_i + 0.5 f_i a_i^2) - 0.5 \sum_{i=1}^N r_i s_i^2 \mathbf{s}^2 + I \left(1 - \sum_{i=1}^N s_i \right). \quad (6)$$

Bring eq.(5) into eq.(6), let $\partial CEF / \partial s_i = 0$, $\partial CEF / \partial I = 0$, then calculate:

$$v_i^2 s_i + r_i f_i s^2 s_i = v_i^2 - f_i I \quad (7)$$

$$\sum_{i=1}^N s_i = 1 \quad (8)$$

Solving by the formula (7), (8) consisting of simultaneous equations to obtain:

$$I = \left\{ \sum_{i=1}^N \left[\frac{v_i^2}{(v_i^2 + r_i f_i s^2)} \right] - 1 \right\} / \sum_{i=1}^N \left[\frac{f_i}{(v_i^2 + r_i f_i s^2)} \right] \quad (9)$$

$$s_i^* = (v_i^2 - f_i I) / (v_i^2 + r_i f_i s^2) \quad (i = 1, 2, \dots, N) \quad (10)$$

The above equations indicate that the I coefficient depends on the various parameters of the alliance enterprise, but for specific alliance, it is a constant. s_i^* is seeking the optimal distribution coefficient, which shows that the enterprise profit distribution coefficient decided enterprise output coefficient v_i , innovation cost coefficient f_i and risk aversion coefficient r_i . The stronger the ability of enterprises implement is (the bigger v_i is, the smaller f_i is), the larger enterprise profit distribution coefficient is; the more conservative enterprises are (the bigger r_i is), the higher the risk cost is, the smaller enterprises profit distribution coefficient is.

Bring eq.(10) into (5) to get the optimal the level of effort:

$$a_i^* = (v_i^3 - v_i f_i I) / (f_i v_i^2 + r_i f_i^2 s^2) \quad (i = 1, 2, \dots, N) \quad (11)$$

Eq. (10) and eq.(11) institute a combination of decision-making (s_i^* , a_i^*) show that coalition optimal allocation mechanism and v_i , f_i , r_i and s^2 are related, has nothing to do with T , I_i and R^0 ; the stronger enterprises implementation and risk awareness are (the greater v_i is, the smaller f_i and r_i are), the bigger enterprises pay the effort and the share of profit distribution are.

(s_i^* , a_i^*) must satisfy (4), bring eq.(5) into eq.(4): $\sum_{i=1}^N (v_i a_i) + R^0 \geq v_i^2 / f_i$. The left is alliance expected return $E(R)$, the alliance expected profit must satisfy the equation: $E(R) \geq v_i^2 / f_i$ ($i=1, 2, \dots, N$). Bring the optimal coefficients s_i^* into the relationship formula:

$$R^0 \geq \frac{v_i^2}{f_i} - \sum_{i=1}^N \left(\frac{v_i^4 - v_i^2 f_i I}{v_i^2 f_i + r_i f_i^2 s^2} \right) \quad (12)$$

Eq. (12) shows that the enterprise alliance additional revenue must achieve a certain level, the league member enterprises of individual rationality conditions can be met. This level is decided by eq.(12). (s_i^* , a_i^*) became the alliance optimal profit distribution mechanism.

Case analysis

An industrial park is located in Chongqing urban area, has the large-scale automobile and motorcycle and car accessories industry group, industrial output value is more than 50 billion Yuan in 2014. Take Chongqing characteristic industrial park A, B, C three licensing enterprises as an example, A enterprise can recycle disposal 1200 tons of oil, B and C enterprises process 800 tons respectively, they can satisfy the main 2-3 zone of waste oil disposal requirements. Suppose A enterprise as the leader ($i = 1$), B and C as leagues ($i = 2, 3$), It is expected to alliance additional revenue R^0 will add RMB 120000 every year, alliance benefit variance is RMB 1.4391 million every year.

The leader paid to members fixed payment is $T=40000$ yuan every year, each member was 20000 yuan. The level of effort: $0 < a_i \leq 100$. According to the enterprise data to calculate V_i , f_i and I_i . r_i references to American finance and investment industry convention, the value is limited to 2-6, and the specific value of each enterprise is determined by the expert experience. The alliance profit distribution model parameters and data are shown in Table 1.

Alliance enterprise ($N = 3$)	A	B	C
n_i	0.05	0.034	0.034
f_i	0.0007	0.0003	0.0003
r_i	0.04	0.06	0.06
I_i	0.55	0.45	0.48

Table 1 Parameters of oil disposal alliance (unit: million Yuan)

Take the above data into formula (1) to (11), by calculating and analyzing to obtain the park disposal alliance profit distribution model and decisions: [(s_i^*, a_i^*)] = [(0.3829, 27.3843) , (0.3086, 34.9704) , (0.3086, 34.9704)]. Take enterprise alliance data into the formula (12), get a vector [-17.3970, 10.7934, 10.7934], due to union added revenue $R^0 = 12 > [-0.173970, 0.107934, 0.107934]$ (million Yuan), the union operation satisfy individual rationality condition, so the decision (s_i^*, a_i^*) is the league's optimal allocation mechanism.

Analysis of the operation of the Alliance

According to the allocation model, the coalition expected benefit = $5a_1 + 3.4a_2 + 3.4a_3 + 12$, total cost = $148 + 0.035a_1^2 + 0.015a_2^2 + 0.015a_3^2$, risk cost = $287.82s_1^2 + 431.73s_2^2 + 431.73s_3^2$, take formula (s_i^*, a_i^*) data into the calculation equation, league expected revenue and total cost and risk cost respectively are 3.865, 2.109, 1.244 million Yuan every year and its deterministic equivalent profit $3.865 - 2.109 - 1.244 = 0.512$ million Yuan every year.

Calculation results show that leader enterprise have large output coefficient, small risk aversion coefficient, big recycling disposal capacity, the implementation ability occupies a larger share of the proceeds 38.29% under the alliance operation optimal allocation mechanism; all profit deduct annual fixed payment to league enterprises 0.04 million Yuan and obtain the equivalent maximum benefit 0.206 million Yuan every year, it is higher than B and C. Leader's optimal level of effort is 328.6 tons every year, the other two enterprises are 279.8 tons every year, Alliance disposal wastes oil 888.2 tons, obtain the expected revenue and deterministic equivalent profit respectively 3.865 and 0.512 million Yuan every year.

Conclusions

Industrial Park wastes disposal alliance revenue allocation mechanism only is related with enterprise output coefficient, coefficient of innovation cost, risk aversion coefficient and the union of the variance of return, has nothing to do with a fixed payment, fixed costs. Strong implementation capability, innovation spirit and large recovery processing enterprises occupy a larger share of the profit distribution in the league.

Alliance additional profit must reach a certain level to establish the optimal allocation mechanism, and additional revenue mainly comes from alliance enterprises learning. In this paper, the research is weak on the alliance learning and the benefits problems, so they need further study.

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