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Study on collaboration of logistics park based on game theory

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ABSTRACT

In recent years, in China, the logistics park has proceeded very far. At the same time, there are also many problems, such as investment and financing structure is irrational, the logistics park vacancy rate is high, profit means single etc. Therefore, it has practical significance to study the operation model of logistics park to solve the above problem.

This paper researched the operation mode of Collaborative Logistics Park, and made specific analysis of the characteristics of logistics park operation mode, Firstly, the paper established the game model of logistics park resource sharing in collaboration mode, and then constructed the cooperative game model of operation cost allocation of logistics park, Finally, based on the collaborative operation mechanism of logistics park, the paper put forward the development strategy of logistics park in operation mode.

KEYWORDS

Logistics park; Operation mode; Collaboration; Game.

INTRODUCTION

Logistics park is an important node of logistics network system, the collaborative and interactive between the park play an important role in the organization of logistics network operation, it can realize the integration of logistics resources and improve the operation efficiency of logistics park. Co-operation between the logistics park is conducive to the promotion of stock resources operation efficiency, and contribute to the orderly, scientific and reasonable development of the planning and construction of Logistics Park. This paper discussed and analyzed the existing problems of logistics park isolated operation, based on game theory, put forward to promote the collaborative operation mode to continue healthy development of logistics park. This operation mode is a kind of innovative exploration on the logistics operation management, has important theoretical value for the research on regional logistics cooperation mechanism[1].

This paper analysed collaborative mode of the logistics park by using the game theory. First, builded a co-operation game model of resource sharing of the logistics park, analyzed the relationship among the logistics park in operation process. On this basis, analyzed the applicable conditions of the model, and useed the examples to verify the feasibility of the model. Secondly, the paper builded a game model of operation cost allocation of the logistics park. Because the enterprises assigned to the park fear to be punished and dare not to take the free riding, therefore, the logistics park can makes cooperation better between different departments[2].

GAME MODEL OF RESOURCE SHARING OF THE LOGISTICS PARK WITH COOPERATIVE MECHANISM

This paper argues that the enterprises of logistics park can form coalitions and collaborative operation to realize the sharing of resources. The game model is shown as the following[3].

Supposed there are n logistics parks.

$p(Q) = a - b(Q)$ ——cost function, $a >, b > 0$

$Q = \sum_{i=1}^{n} q_i$ ——the total output of all logistics park

x_{i0} ——its own special resources of the ith park

Δx_i ——open resources of the ith park

$x_i = x_{i0} + \sum_{j=1, j \neq i}^{n} \Delta x_j \quad i, j = 1,2,..., n$ ——the total amount of available resources of the ith park

$c_i = \theta - x_i$ ——the unit cost function of the ith park

There is $C\left(q_i, x_{i0}, \sum \Delta x_j\right) = c_i q_i = \left(\theta - x_{i0} - \sum_{j=1, j \neq i}^{n} x_j\right) q_i$.

For the kth member of logistics park in the logistics network, its revenue function is the following formula.

$$\max_{q_k} \pi_k(q, \Delta x) = p(Q) q_k - c_k q_k$$
$$= \left(a - b \sum_{i=1, i \neq k}^{n} q_i\right) q_k - c_k q_k \quad (1)$$

Here, $q = \{q_1, q_2, ..., q_n\}^T, \Delta x = \{\Delta x_1, \Delta x_2, ..., \Delta x_n\}^T$

let $\frac{d\pi_k}{dq_k} = a - 2bq_k - b \sum_{i=1, i \neq k}^{n} q_i - c_k = 0$

The production is the following formula when the maximum revenue of the kth park is obtained

$$q_k^* = \frac{1}{(n+1)b}[a-\theta+nx_{k0}-\sum_{i=1,i\neq k}^{n} x_{i0}-(n-1)\Delta x_k+2\sum_{i=1,i\neq k}^{n}\Delta x_i] \quad (2)$$

The maximum revenue of the kth logistics park

$$\prod_k^*(q,\Delta x) = \frac{1}{(n+1)^2 b}[a-\theta+nx_{k0}-\sum_{i=1,i\neq k}^{n} x_{i0}-(n-1)\Delta x_k+2\sum_{i=1,i\neq k}^{n}\Delta x_i]^2 \quad (3)$$

Thus, if one logistics park over open or fully open its own resources, while other parks are less open or not open, then the return value is negative, but it is impossible in reality. That is, there is $\prod_k^* > \prod^{\circ}_{k,q_k^*} > q^{\circ}{}_k$ under normal circumstances.

According to this analysis, if any logistics park established resource sharing in the cooperative relationship, it will get more efficient results than independent operation.

GAME MODEL OF OPERATION COST ALLOCATION OF LOGISTICS PARK WITH COOPERATIVE MECHANISM

When logistics park form network coalition and reach a cooperative operation pattern, it will necessarily get scale benefit, but not necessarily all individuals can achieve the optimal. Therefore, single individual in the pursuit of profit, how to effectively reduce the cost value becomes the focus of the individual[4-6].

It is easy to establish a coordination mechanism for logistics park under the situation of mutual benefit and win-win situation. It can enhance the enthusiasm of the participants through analysis of operation cost allocation of logistic park based on cooperative game theory. Usually, the overall operating costs will be divided into two parts, that is

$C = \sum_i C_{sp}(i) + C_{nsp}$, here C_{sp} is separable cost that beared directly by each participant, C_{nsp} is inseparable cost that shared cost by each participant. The aim of the paper is to allocate the inseparable cost reasonably[1].

We considered that n logistics Park as the cooperation game player.

S —logistics coalition

$C(S)$ —logistics park network of coalition

$N = \{1,2,...,n\}$ ——universal set

$S \subset N$, N —cost characteristic function

$C(\{i\})$ —independent operation cost of the ith logistics park $x_i (i = 1,2,...,n)$, $x_i \geq 0$ ——cost sharing value of the ith logistics park

U_i —the expected profit value of the ith logistics park

$U(N) = \sum_{i \in N} U_i$ —total expected benefit value of all the logistics park

The basic hypotheses:

(1)The total allocation cost is distributed entirely by all proceed logistics park

(2) For a park, its independent operation cost is less than the cost after allocation

(3)The biggest cost of any coalition is greater than assessed cost

(4)if $C(SU\{i\}) = C(S), \forall S \subset N$, that $x_i = 0$.

Based on the above hypotheses, the constraint equations of cost allocation can be expressed as the followings

$$\begin{cases} \sum_{i \in N} x_i = C(N) \\ x_i \leq C(\{i\}) \quad \forall i \in N \\ \sum_{i \in S} x_i \leq C(S) \quad \forall S \in N \\ x_i \geq 0 \quad \forall i \in N \end{cases}$$

For easy calculation, this paper uses simple sharing coordination model. Before the cost allocation, based on their own benefit expectation the logistics park as the participants consult each other and reach the allocation standard, and then allocate the cost by using above model.

In addition, it can use the optimal equivalent replacement cost ratio as the allocation standard and determine weight value by negotiation. Here $k_r, r \in R$ is weight value and R is sequence set of the above allocation standard.

The model of the operation cost allocation of collaborative logistics park is shown as the following.

$$\min\{k_1 \sum_{i \in N} \left| \frac{x_i}{U_i} - \frac{C(N)}{U(N)} \right| + k_2 \sum_{i,j \in N, i \neq j} \left| \frac{x_i}{U_i} - \frac{x_j}{U_j} \right| + k_3 \sum_{i,j \in N, i \neq j} \left| \frac{x_i}{C(\{i\})} - \frac{x_j}{C(\{j\})} \right| \}$$

$$s.t. \begin{cases} x_i \leq C(\{i\}) \quad \forall i \in N \\ \sum_{i \in N} x_i = C(N) \\ \sum_{i \in S} x_i \leq (1 + W\varepsilon^*) C(S) \quad \forall S \subset N \\ x_i \geq 0 \quad \forall i \in N \\ k_r \in [0,1] \sum_{r \in R} k_r \end{cases}$$

Here ε^* is the minimum relaxation factor, if the constraints are not feasible solution then $W = 1$,otherwise $W = 0$. If determine the weight coefficient $k_r, r \in R$ by advanced consultation the model can be solved, otherwise, then get the interval solution.

In summary, in order to form collaborative operation pattern of logistics park it is important for the logistics park to form the effective resources sharing r and reasonable cost allocation.

It is not necessarily the best allocation based on the cost allocation of cooperative game analysis, but it is the equilibrium solution for participants to negotiate.

CONCLUSIONS

In summary, research on the operation mode of Collaborative Logistics Park involves many factors, the factors influence each other, and in constant flux, therefore, it is very difficult to make a comprehensive analysis of the logistics park operation mode. There are many places worthy of further discussion and research.

First, there are a lot of operation model of logistics park, along with the increase of the social progress, economic development, social capital, the foreign capital enter the logistics park, the mode of operation may be more better. Mode of operation is not good will be eliminated, this paper only studies the existing mode of operation, it will inevitably be inadequate, the investigation about this aspect needs further deepening.

Second, in the process of management of logistics park, it needs to consider the issue not just for the enterprises of the park, and park for its management, the risk management, the external market development management. This paper simply analysis the collaborative operation management between park and price regulation mechanism for enterprises. It is lack of research on how to improve the competitiveness of the park. And these theories still need to further test by practice[7].

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