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Extending strategy of port enterprise value chain based on infra-marginal utility model

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Abstract. Based on the utility theory, this paper constructs the utility function by using industry elements and configuration elements of the port enterprise development as springboard, and it applies the infra-marginal model to study the extension and expansion strategy of the port enterprise value chain. According to the researches, the extension direction of port enterprise value chain includes single-chain and platform, and two extension directions are both closely related to the magnitude of the utility values. Then, on the basis of the infra-marginal utility model, that the utility value of the port enterprise value chain is related to the profit factor, the scale factor and the operation factor. In order to verify the model, we construct the factor evaluation system and collects the basic data of Shanghai port. The results provide a reference for the value chain extension and value network construction of Chinese port enterprises.

Key words. Utility function, infra-marginal analysis, port value chain, port of shanghai.

1. Introduction

Port enterprise value chain, whose core is port, integrates various types of port service providers and demanders, and thusforms a comprehensive integration of enterprise alliances through collaborative mechanisms such as resource sharing and information exchange. In the traditional port enterprise value chain,the creation and transfer of value focus on logistics and basic services, so the attribute of the value chain is single. With the introduction and implementation of national free trade

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zone strategy, One Belt One Road strategy and other open policies, the ecosystem attribute of port enterprise value chain is more and more obvious, and the industry boundary formed around one port enterprise begins to break. Also, the enterprise value chain gradually extends from single-chain to platform [1].

Traditional port enterprises limit their business scope to a specific area, focus on the technology and product development in the industry they involve,then engage in business activities, and thus gather resources to cultivate the core competitiveness of port enterprises, in order to provide corresponding products or services. With the increasing ofport enterprise scaleand profitability, the products and services of port enterprises have gradually entered two and more industries, competing in different fields and gaining diversified returns, this process is called platform [2]. Therefore, in the development process of port enterprises, the extension of value chain is bound to choosesingle-chainor platform. There are no absolute advantages and disadvantages between single-chainand platform [3-4], because they both have casesof success or failure. Then the standard of choosing mainly depends on port enterprises' identification and evaluation of their ability and effectiveness. The extension strategy of port enterprise value chain is an uncertainty plan based on the full measurement of its own factors, and utility theory, as a tool of solving uncertainty problem, provides a new solution for this kind of plan.

2. Methodology

2.1. Basic assumptions

Port enterprises have been deeply integrated with international rules and practices, and their value chain extension decisions are bound by the international shipping market rules and the port industry policies [5]. The external macro elements of the port value chain, which are uncontrollable, include the national and industry policies, the development trend of the shipping market, the international shipping market laws and regulations, etc.[6-7]. From the perspective of port enterprise value division of labor, the internal influencing factors can be transformed into the specific behavior of the enterprise state factor, impacted by the enterprise scale factor, operation factors and profit factors. The development of the three factors determine the quality of the port enterprises, and thus affect the extension of the value chain and the success rate.

Combining the theory of infra-marginal analysis and the characteristics of port enterprise value chain evolution, this paper puts forward the following basic assumptions:

Assumption1: The single-chain or platform that the port enterprise value chain extends is limited to the coopetition relationship within the port industry.

Assumption2: Port enterprises are strictly following the basic principles of single-chain and platform.

Assumption3: As an integral part of the international port and shipping ecosystem, port enterprisesare also a consumption-productionsystem.

2.2. Model construction

Utility evaluation theory is often used in the decision-making program by enterprise managers, and has been widely applied in the staff management.In view of the eco-circle and economic characteristics of the port enterprise value chain system,this paper introducesInfra-marginal Analysisas the analysis method of utility function[8], which was put forward by the economistProfessor Yang Xiaokai. In the new classical economics, infra-marginal analysis mainly solves how market and price system determine the professional level of individual's choice when the scarcity of resources is not fixed [9].

Assuming that there are two extended businesses which are selectable for the port enterprise.They are represented by V_a and V_b, a and b represent the product (or service) each business can provide. Using the utility function form used by Professor Yang Xiaokai in trade choice between two countries, the basic utility function of port value chain is shown in (1)

$$GrindEQ01U = (a_0 + r1\ \widehat{a})^{\alpha}(b_0 + r_2\ \widehat{b})^{\beta} \tag{1}$$

a_0 represents that enterprise generates and utilizes a product volume when choosing Va business, $\widehat{a}$ represents a product volume which absorbed from the outside; b_0 represents that the enterprise generates and utilizes b product volume when choosing Vb business, $\widehat{b}$ represents b product volume absorbed from the outside; $r_i(i = 1,\ 2)$ represents the transaction efficiency of port enterprises within the group; α,β represent the consumption preferences of the two products, and the sum of them is equal to 1

In the actual production activities, corporate capital and technology investment remain unchanged in a period of time, andthe production of the enterprise is a function of the enterprise labor. The materials and human labor, which are required for the output of the port enterprisevalue chain system, change as the input of labor increases. Therefore, the production function of a port enterprise in two business areas is shown in equation (2):

$$GrindEQ02 \begin{cases} a_p = a_0 + a_s = A_a\lambda l_a \\ b_p = b_0 + b_s = A_b\lambda l_b \end{cases} \tag{2}$$

$A_i(i = a, b)$represents labor productivity;$l_i^{\lambda}(i = a, b)$represents the specialized production of a, b products in two different businessVa and Vb, and alsorepresents the efficiency of labor investment; λ is the composite indexof the enterprise internal factor, and represents production efficiency of a certain product in the function. The formula of λ is shown in (3)

$$GrindEQ03\lambda = \sqrt[3]{SF \times OF \times PF} \tag{3}$$

SFrepresents Scale Factor, OF represents Operation Factor, PF represents Profit Factor, and λcan measure the ability of the port enterprise's ability of adapting to the internal system environment. In the basic assumptions, the enterprise's labor input is fixed. We assume that the number is 1.Since the price$p_i(i = a, b)$ of the product or service a, b is certain when port enterprise extends to the businessVa, Vb, then from the perspective of the budget, the enterprise will be restrained no matter what kind of extension,as shown in (4):

$$GrindEQ04 p_a a_s + p_b b_s = p_a \overset{\frown}{a} + p_b \overset{\frown}{b} \tag{4}$$

Based on what we mentioned above, the infra-marginal analysis utility model of port enterprise value chain extension decision can be constructed as shown in (5):

$$GrindEQ05 \quad \begin{array}{l} \max\ U = (a_0 + r1\ \overset{\frown}{a})^{\alpha}(b_0 + r_2\ \overset{\frown}{b})^{\beta} \\ s.t. \begin{cases} a_0 + a_s = A_a \lambda l_a, b_0 + b_s = A_b \lambda l_b \\ l_a + l_b = 1 \\ p_a a_s + p_b b_s = p_a \overset{\frown}{a} + p_b \overset{\frown}{b} \end{cases} \end{array} \tag{5}$$

From the construction of the model, we can see that the essence of the extension of the port enterprise value chain is to seek the maximization of the utility in different directions, which is subject to the enterprise investment and budget.

3. General equilibrium analysis of the model

3.1. Corner solution discussion

In formula(5), they are variables with decision-making capabilities, including a_0, $\overset{\frown}{a}$, a_s, b_0, $\overset{\frown}{b}$ and b_s, and each decision variable can take either 0 or other positive values When a port enterprise makes a decision on the value chain extension, the value of one or more of the six decision variables is zero, then it becomes a corner solution. However, there are 2^6 combinations of 6 decision variables, which cannot be calculated one by one. Therefore, in the case of infra-marginal analysis, we use Wen theorem (Wen, 1996) to analyze the 6 decision variables of the infra-marginal utility model, and exclude a variety of decision-making combinations which are contrary to the theorem, and finally get 4 kinds of combinations, shown in Table 1.

Table 1. Strategic combination of selection

Serial number	Basic enterprise niche	
	V_a	V_b
1	0	0
2	+	0
3	0	+
4	+	+

1. For 2,3, the extension of the port enterprise value chain into Va or Vb, is

a single-chain extension strategy, and the port enterprise value chain obtains the maximum value by selecting a specific link or product. Under these decisions, if we choose Va, the decision variables will be $a_0,\ a_s,\ \widehat{\mathrm{b}},\ l_a > 0,\ \widehat{a} = b_0 = b_s = l_b = 0$.

Under these decisions, the amount of labor invested in the product or service b is 0, and the port enterprise doesn't carry out business in the Vb field. The single-chain decision is changed to (6):

$$GrindEQ06 \quad \begin{array}{l} \max\ U = a_0^{\alpha} \cdot\ r(r_2\ \widehat{b})^{\beta} \\ s.t.\ \begin{cases} a_0 + a_s = A_a \lambda l_a \\ l_a = 1 \\ p_a a_s = p_b\ \widehat{b} \end{cases} \end{array} \tag{6}$$

2. For4, the port enterprise value chain extends as far as possible, and formats a certain scale of the value network.. Under this decision, if we choose Va and Vbsimultaneously, the decision variables will be $a_0,\ b_0, l_a,\ l_b > 0,\ a_s = \widehat{a} = b_s = \widehat{b} = 0$.

In this decision, the enterprise input for both products or services are greater than 0, the platform decision is changed to equation (7):

$$GrindEQ07 \quad \begin{array}{l} \max\ U = a_0^{\alpha} \cdot b_0^{\beta} \\ s.t.\ \begin{cases} a_0 = A_a \lambda l_a,\ b_0 = A_b \lambda l_b \\ l_a + l_b = 1 \end{cases} \end{array} \tag{7}$$

3. For 1, port enterprise value chain will maintain status quo.

3.2. Optimal solution discussion

Through the discussion of the corner solution, there are three basic decisions for utility model of the port enterprise value chain extension: the single-chain, the platform and the original type. Then the study mainly discusses the utility optimizationin single-chain and platform.

1. For single-chain, it is assumed that the utility of Va is Ua, the utility of Vb is Ub, the formula (6) can be transformed into (8):

$$GrindEQ08Ua = (r_2 p_b)^{\beta} \cdot a_0^{\alpha} \cdot (A_a \lambda - a_0)\beta \tag{8}$$

The maximum utility of Va is (9), and$l_a = 1,\ l_b = 0$.

$$GrindEQ09Ua = (r_2 \frac{p_b}{p_a} \beta)^{\beta} \cdot \alpha^{\alpha} \cdot A_a \lambda \tag{9}$$

2. For platform, it is assumed that the utility of Va and Vb isUab. Substituting the constraint condition into the utility function, the formula (7) can be transformed into (10):

$$GrindEQ10Uab = (A_a \lambda l_a)^{\alpha} \cdot [A_b \lambda (1 - l_a)]\, \beta \tag{10}$$

we can obtain the partial derivation of utility function, and the maximum utility for Va and $Vb$is shown in (11),and $l_a = 0.5,\ l_b = 0.5$.

$$GrindEQ11Uab = (\alpha A_a)^{\alpha} \cdot (\beta A_b)^{\beta} \cdot \frac{\lambda}{2} \tag{11}$$

In general, through calculating the maximum utility of different extension decisions, the overall optimal solution is obtained by comparing three utility values Ua, Ub and Uab, and the corresponding decision-making scheme is selected.it can be seen that the final solution of the extension decision of port enterprise value chain is influenced by four factors: customer preference (α, β), production efficiencyA_i, relative pricep_i and internal factor composite index λ.

4. Analysis of Typical Case

This paper selects Shanghai International Port (CROUP) CO.,LTD. as a case, evaluates the internal factor index of Shanghai port in recent 10 years, and analyzes the evolution process and basic characteristics of enterprise value chain from single-chain to platform type. At present, the value chain extension of Shanghai Port Group is mainly platform type, and its businesses include container terminal Terminal for Bulk & General Cargo port logistics shipping land transportation agent finance sports and so on.

According to the analysis of the optimal solution of the super marginal utility model, we can know that the enterprise's state factor consists of the scale factor, structure factor and operating profit factor, and this state factor is one of the key indexes determining the utility of the extended direction of the port value chain. This paper constructs the evaluation index system of the 3 factors: Operation factor(Efficiency of labor,Total assets turnover, Berth efficiency,Container throughput growth rate),Scale factor(Total assets,Total income,Number of port berths,Cargo throughput,Container throughput),andProfit factor(Cost profit margin,profit ratio of sales,Total assets profit,Total assets profit margins,net assets income rate).

Through data collection and collation, we can get the index data as shown in Table 2.

Data source: China ports yearbook, annual report of port

Therefore, we can calculate the internal factors and comprehensive index of Shanghai port group in 2009-2016, and shown in Table 3.

Table 2. Index data of Shanghai Port in recent 10 years

	2009	2010	2011	2012	2013	2014	2015	2016
Number of employees(People)	23489	22322	21530	20748	19842	19044	18338	18183
Total operating income (Billion yuan)	16.5	19.1	21.7	28.3	28.1	28.7	29.5	31.3
Total assets(Billion yuan)(Early year)	59.1	63.3	65.8	83.2	87.1	88.6	94.2	98.5
Total assets(Billion yuan)(Year end)	633.4	658.9	832.5	871.0	886.1	942.7	985.1	1167.8
The total profit (Billion yuan)	5.3	7.9	7.2	7.2	7.8	9.8	9.8	9.9
Total cost(Billion yuan)	12.0	12.7	15.0	22.5	21.9	21.5	23.1	25.6
Profit after tax (Billion yuan)	4.7	6.6	5.7	5.9	6.2	7.8	7.8	8.0
Owners' equity (Billion yuan)	38.1	41.4	51.3	53.5	55.8	60.2	67.1	68.2
Container volume (Ten thousand boxes)	2500.2	2906.9	3173.9	3252.9	3377.3	3528.5	3653.7	3713.3
Cargo throughput (Ten thousand tons)	36501.5	42835.1	48442.3	50237.5	54302.4	53862.4	51332.6	51406.6
Number of port berths	1145	1160	1164	1183	1191	1220	1300	1335

Table 3. Comprehensive index statistics about internal state factor of Shanghai Port

	OF	SF	PF	λ
2009	0.0483	0.0799	0.0953	0.0717
2010	0.1168	0.0884	0.1177	0.1067
2011	0.1054	0.0993	0.0998	0.1015
2012	0.0902	0.1072	0.0832	0.0930
2013	0.1000	0.1101	0.0891	0.0994
2014	0.1052	0.1133	0.1049	0.1077
2015	0.0991	0.1160	0.103	0.1059
2016	0.0850	0.1230	0.0960	0.1001

Combining the total capital, the total income, the state factor composite index and other indicatorsof Shanghai Port Group, the value chain extension process of Shanghai Port Group can be divided into three stages.

(1). Utility analysis in phase I (Approximate single-chain, $\overline{\lambda} \leq 0.085$,2007-2009)

In the first stage, Shanghai Port Group was in the rising period of the development of the company. From 2006 to 2009, the shipping industry in China developed a lot, and the situation of domestic economy, international trade and international shipping market offered a best chance for the shipping industry.

(2). Strategic utility analysis in phase II(Platform, $0.085 < \overline{\lambda} \leq 0.1$,2010-2014)

The II stage is the most important period for Shanghai Port Group. The world's financial crisis in 2008 led to the recession of shipping industry, bringing opportunities for the transformation of port value chain, and then the value chain transformed to the platform. At this stage, Shanghai Port Group made fully use of resources and industry advantages, shared hinterland, technology, customer and channels. Therefore, it extended the value chain to other areas of the business and obtained excess profits from the other industries.

(3). Strategic utility analysis in phase III(Super platform, $\overline{\lambda} > 0.1$,2014-2016)

In the stage III, the enterprise continued to optimize the platform value chain, and formed a value network with overall advantages. Before 2014, the world shipping industry was not prosperous, which affected the development of port shipping enterprises to a great extent. But later, China launched a number of policies and measures to promote the development of shipping industry, such as "Belt and Road Initiative" strategy, Shanghai FTA test area etc, which provide an opportunity for Shanghai Port to optimize its value chain.

5. Conclusion

In order to study the value chain extension decision of Port Enterprises, we introduce utility theory and super marginal analysis model. This can provide a new perspective for the port enterprises, and help them cope with the unfavorable situation of international shipping market downturn and the malignant competition in domestic market as well as enhance the value of enterprises. The extension of the value chain of port enterprises is affected by the internal and external environment, so enterprises should occupy the resource space and profit space, then find the extension scheme from the perspective of improving the overall utility of the value chain.

Super marginal utility model provides feasibility for quantitative study of port enterprise value chain extension decision making. The value of three maximum utility U_a U_b U_{ab} of the extension decision determine the overall optimal solution and countermeasures. The extension decision of port value chain is finally influenced by customers' preference α β production efficiency A_i relative priceP_i and the composite index of internal state factor λ. This paper chooses Shanghai Port as a case, constructs the internal factor index system, compares the utility of single-chain with the utility of platform, then analyzes the evolution process and basic characteristics of value chain on the basis of time background, and finally verifies the theory and application value of this model.

In this paper, the direction of value chain extension is assumed to be two fields . However, in the actual port value chain system, there must be more than two directions of extension, so we need to do further researches about it. In addition, for the evaluation of the enterprise internal factors, the enterprise development stage and the current targets should also be considered. So we can form a more objective and systematic evaluation index system, and make it more reasonable and to simulate and describe the quality of the enterprise.

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