International Journal of Economic Behavior and Organization
2015; 3(6): 85-88
Published online December 11, 2015 (http://www.sciencepublishinggroup.com/j/ijebo)
doi: 10.11648/j.ijebo.20150306.12
ISSN: 2328-7608 (Print); ISSN: 2328-7616 (Online)

Research on Pricing Strategy of Port Charge Based on Market Regulation

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To cite this article:
Gang Dong. Research on Pricing Strategy of Port Charge Based on Market Regulation. *International Journal of Economic Behavior and Organization.* Vol. 3, No. 6, 2015, pp. 85-88. doi: 10.11648/j.ijebo.20150306.12

Abstract: Under the liberalization of port competitive service charges of China, the paper focuses on the pricing strategy of port charge in order to transform the rates from government guidance or uniform charge into market regulation, comparing the port charge as well as its throughput under the scenarios between Bertrand-competition and price-matching, then conducting the illustration and sensitivity analysis with changing of the major parameter to gain further managerial insights.

Keywords: Port Charge, Competitive Service, Pricing Strategy, Market Regulation

1. Introduction

With the rapidly growing intercontinental container shipping services, China's container throughput has been maintaining the first of world for eleven consecutive years more, which increased up 6.1% to 200.93 million TEUs in 2014, forming five regionalization, scale-up and modernization port clusters involving Southwest Coast, Pearl River Delta, Southeast Coast, Yangtze River Delta and Bohai Sea. Among the world's 10 largest container port throughput rankings, China's container ports including Hong Kong take seven seats on the list of 2014. Especially, Shanghai Port has retained its title as the world's busiest container port for five consecutive years, which increased up 5.0% to 3528.53 ten thousand TEUs in 2014, with the international transit ratio of container throughput reaching 7.1%.

Meanwhile, the port charge in mainland China has been implementing the dual-track system in the past many years. The vast majority of ports refer to the standard rates specified by China's Ministry of Transport, released for the first time on September 1, 1976. After a total 13 times of the rates adjustment, the latest was modified on December 24, 2001.

Fortunately, as one of the concreted measure to deepen the port reform, the liberalization of port competitive service charge was issued by China's Ministry of Transport and National Development and Reform Commission on November 22,2014. Therefore, according to the customizable service, the port can set different lump-sum charges.

2. Related Work

With respect to analyzing price competition between ports, Yap and Lam [1] unveil the competitive dynamics between the major container ports in East Asia by analyzing their extent and intensity, the study suggests that inter-port competition in the region would intensify in the future as the center of gravity of cargo volume shifts to mainland China. Comtois and Dong [2] study competition between the ports of Ningbo and Shanghai by measuring the overlapping hinterland of container distribution for Zhejiang province, analyzing the strategies pursued by international carriers and terminal operators to secure success in this increasingly competitive environment. Acosta et al. [3] analyze the factors that affect port competitiveness from the perspective of the agents and companies that operate in one of the Mediterranean ports most active in container traffic: the Port of Algeciras Bay, in order to apply the necessary judgment when formulating policies to strengthen the competitive position of a port, the model selected to meet the objective outlined is based on the 'extended diamond' of Porter. Yeo et al. [4] identify the components influencing their competitiveness and presents a structure for evaluating them, a regional survey of shipping companies and owners employed factor analysis to reveal that port service, hinterland condition, availability, convenience, logistics cost, regional center and connectivity are the determining factors in these regions.

As related to cooperation on port price and service quality, the major literatures include: Song [5] examines the possible competition and co-operation of the adjacent container ports in Hong Kong and South China from a strategic perspective, suggesting that ports have to concentrate on new ways for co-operation in an effort to establish a countervailing power. Wang and Jiang [6] find the multiple port cooperation will lead to increases of all ports' total profits, decreases of the service time and the service price, the higher the level of cooperation between regional multiple ports is, the higher the all ports' total profits will be, the port cooperation can be achieved by designing effective profit allocation mechanism. Li and Oh [7] focus on the study of the competition and cooperation between neighboring ports; several models are developed in the research to analyze the relationship between Shanghai port and Ningbo-Zhoushan port. Saeed and Larsen [8] discuss a two-stage game that involves three container terminals located in Karachi Port in Pakistan, the concepts of "characteristic function" and "core" are used to analyze the stability of these coalitions and this revealed that one combination does not satisfy the superadditivity property of the characteristic function and can therefore be ruled out. Hwang and Chiang [9] explore causal relationships between influence factors, types of port cooperation (i.e. complementary cooperation and coopetition), and port competitiveness, besides, potentially important items for port cooperation are also identified. Ishiia et al. [10] construct a non-cooperative game theoretic model where each port selects port charges strategically in the timing of port capacity investment, deriving the Nash equilibrium and obtain some propositions from the equilibrium, they apply the propositions to the case of inter-port competition between the ports of Busan and Kobe. Mclaughlin and Fearon [11] examine some of the key ways in which seaports have developed from a position of direct competition to increasing collaboration in order to remain competitive in a fast-changing world., strategic port cooperation is considered through a new conceptual cooperation/competition matrix, which can be used to evaluate the response strategies of ports to inter-port rivalry and changing maritime competitive dynamics. Zhuang et al. [12] use alternative duopoly games, namely a Stackelberg game and a simultaneous game, to model port competition, where ports provide differentiated services in the sectors of containerized cargo and dry-bulk cargo. Robinson [13] argues that there is a critical need to rethink the principles and processes of cooperation within the broader framework of the competitive behaviour of firms and business strategy, focusing attention on research into globally significant export coal chains from major east coast Australian ports and in brief case studies finds substantial alignment between concept and practice. Lee and Lam [14] argue that a novel approach is required to evaluate inter-port competition in a comprehensive way to reflect cross-sectional, longitudinal and horizontal aspects of the port evolution. Song et al. [15] conclude that size is not an important factor for the motivations to establish coopetition since ports are mainly aimed at achieving a win–win situation. Other factors, such as similarities in the services offered and competition level, look more influential. Nevertheless, the size difference among the ports seems to have an impact on the choice of the type of coopetition and on the willingness of the ports to adopt this strategy.

3. Pricing Strategy of Port Charge

3.1. Pricing Model

In general terms, besides the charge directly paying to the calling port, the shipper also indirectly undertakes the cargo waiting costs according to practical experience. Therefore, the port demand functions based on the shipper's utility are expressed as:

$$q_1 = -\frac{(\beta s_2+t)s_1}{t(\beta s_1+\beta s_2+t)} f_1 + \frac{\beta s_1 s_2}{t(\beta s_1+\beta s_2+t)} f_2 + \frac{\alpha s_1}{\beta s_1+\beta s_2+t} \quad (1)$$

$$q_2 = -\frac{(\beta s_1+t)s_2}{t(\beta s_1+\beta s_2+t)} f_2 + \frac{\beta s_1 s_2}{t(\beta s_1+\beta s_2+t)} f_1 + \frac{\alpha s_2}{\beta s_1+\beta s_2+t} \quad (2)$$

Where the direct charge of one port and the other port are denoted by f_1 and f_2, the impact of "hardware" to the cargo waiting cost is reflected by the designed capacity of ports s_1 and s_2, while the impact of "software" expressed by the parameter t, α and β are the potential demand and the inverse of price elasticity facing by the port. For simplicity, the ports are assumed to have an identical and constant unit cost.

3.2. Analyzing Strategy

3.2.1. Subgame 1: Bertrand-Competition

Under the circumstance of Bertrand-competition, both the ports make pricing strategies by maximizing its own profit separately:

$$\max_{f_1} \pi_1(f_1) = f_1\left[-\frac{(\beta s_2+t)s_1}{t(\beta s_1+\beta s_2+t)} f_1 + \frac{\beta s_1 s_2}{t(\beta s_1+\beta s_2+t)} f_2 + \frac{\alpha s_1}{\beta s_1+\beta s_2+t}\right] \quad (3)$$

$$\max_{f_2} \pi_2(f_2) = f_2\left[-\frac{(\beta s_1+t)s_2}{t(\beta s_1+\beta s_2+t)} f_2 + \frac{\beta s_1 s_2}{t(\beta s_1+\beta s_2+t)} f_1 + \frac{\alpha s_2}{\beta s_1+\beta s_2+t}\right] \quad (4)$$

As the second-order conditions are below zero, the profit functions of ports are convex, by taking the first-order condition and setting it equal to zero we get the extreme point, which lead to the following solution:

$$f_1 = \frac{t\alpha(2\beta s_1+2t+\beta s_2)}{3\beta^2 s_1 s_2+4t\beta s_1+4t\beta s_2+4t^2} \quad (5)$$

$$f_2 = \frac{t\alpha(2\beta s_2+2t+\beta s_1)}{3\beta^2 s_1 s_2+4t\beta s_1+4t\beta s_2+4t^2} \quad (6)$$

3.2.2. Subgame 2: Price-Matching Strategy

In this subgame, both the ports adopt price-matching strategy. So the port profits are expressed by:

$$\min\{f_1, f_2\}\begin{bmatrix} -\frac{(\beta s_2+t)s_1}{t(\beta s_1+\beta s_2+t)}\min\{f_1, f_2\} \\ +\frac{\beta s_1 s_2}{t(\beta s_1+\beta s_2+t)}\min\{f_1, f_2\}+\frac{\alpha s_1}{\beta s_1+\beta s_2+t}\end{bmatrix} \quad (7)$$

$$\min\{f_1, f_2\}\begin{bmatrix} -\frac{(\beta s_1+t)s_2}{t(\beta s_1+\beta s_2+t)}\min\{f_1, f_2\} \\ +\frac{\beta s_1 s_2}{t(\beta s_1+\beta s_2+t)}\min\{f_1, f_2\}+\frac{\alpha s_2}{\beta s_1+\beta s_2+t}\end{bmatrix} \quad (8)$$

Which is solved at $f_1 = \alpha/2$. if $f_2 \geq \alpha/2$ and $f_1 = f_2$ otherwise. It can be seen that $f_1 = \alpha/2$ weakly dominates all other strategies.

$$f_1 = \alpha/2 \quad (9)$$

Similarly, $f_2 = \alpha/2$ weakly dominates all other strategies for the port 2.

$$f_2 = \alpha/2 \quad (10)$$

4. Numerical Analysis

4.1. Assumptions About the Parameters

4.1.1. α

The potential demand of the port depends on its geological location, quay depth, operation efficiency and value-added service, such as on-time delivery, shipment frequency, trip tracking, vehicle monitoring, compensation commitment as well as extending financial service. Therefore, according to the related background about Yangshan Deepwater Port, the demand scales of the ports are assumed to be $a = 1770$.

4.1.2. β

Although the port's demand is a derived demand and it is inelastic to its cost, it still could be affected by the generalized price. Such as the price elasticity of demand for Hong Kong container handling services is 0.2055 from empirical studies. As the inverse of price elasticity, we take exchange rate and operational practice into consideration and calculate the value in our model is $\beta = 0.00004$.

4.1.3. t

In perspective of the shipper, the waiting costs in the terminal should include the time cost of containerized cargo and the storage charge. We calculate the value of the parameter $t = 270.25$ RMB/TEU.

4.1.4. s

Combined the background information, the values of designed capacity are $s_1 = 430, s_2 = 500$ (ten thousand TEUs).

4.2. Illustration Analysis

We perform the illustration analysis to gain further managerial insights about adopting different pricing strategies of the ports.

Therefore, the paper puts the values of related parameters into model. By comparison of the scenarios of Betrand-competition and price-matching strategies in detail, the outcomes are solved and some interesting results are shown as following:

Table 1. The outcomes of port 1 between Bertrand-competition and price-matching strategies.

Lump-sum charge (RMB/TEU)	Throughput (thousand TEUs)
650.60	7579.57
885.13	5926.13

Table 2. The outcomes of port 2 between Bertrand-competition and price-matching strategies.

Lump-sum charge (RMB/TEU)	Throughput (thousand TEUs)
667.40	8502.66
885.13	6890.85

4.3. Sensitivity Analysis

First up, if both ports adopt the Bertrand-competition strategy, that is the case of subgame 1, the port charge is related with the change of inverse of price elasticity, the higher inverse of price elasticity causes a lower port charge. When both ports adopt the price-matching strategy, that is the case of subgame 2, the port charge has nothing to do with the change of inverse of price elasticity.

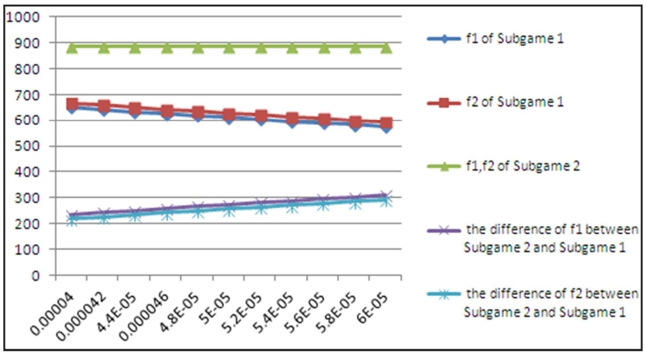

Figure 1. The trend of port charge with the changing of β.

Secondly, under the circumstance of subgame 1 and subgame 2, going along with the increase of inverse of price elasticity, the throughput is in the process of reducing.

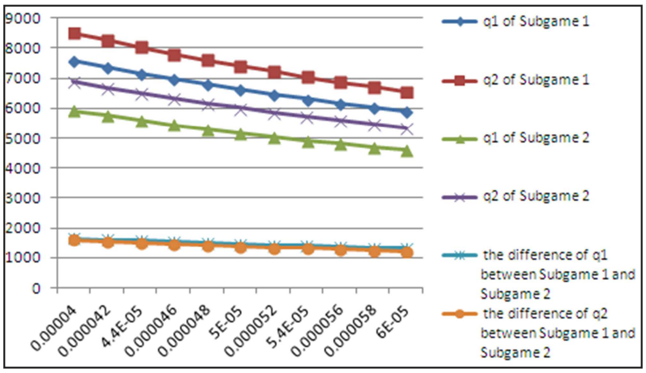

Figure 2. The trend of port throughput with the changing of β.

5. Conclusion

The paper researches the pricing strategy of port charge under the circumstance of transforming the rates from government guidance or uniform charge into market regulation. Through the illustration and sensitivity analysis, some interesting results are finding. Firstly, the port charge is related with the change of inverse of price elasticity under scenario of adopting the Bertrand-competition strategy, especially the higher inverse of price elasticity causes a lower port charge. But the port charge has nothing to do with the change of inverse of price elasticity under scenario of adopting the price-matching strategy. Secondly, the throughput is in the process of reducing with the increase of inverse of price elasticity regardless of adopting Bertrand-competition or price-matching strategy. Finally, the differences of port charges between adopting the price-matching strategy and not have been maintaining positive, the higher inverse of price elasticity, the larger difference of port charge. While the differences of ports' throughputs between adopting the price-matching strategy and not have been maintaining negative, especially the higher inverse of price elasticity, the slight larger difference of port throughput.

Acknowledgements

This research was financially supported by the Decision-making Consulting Foundation of Shanghai Municipal People's Government (2015-GR-10), Shanghai Municipal Education Commission (14YS050) and Shanghai Maritime University Foundation (20130424).

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