Journal of Korea Port Economic Association
Vol.35, No.3, 2019, pp.01-18.

항만공사와 터미널운영사간 최적임대계약 결정에 관한 모형*

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A Study on the Optimal Concession Contract Decision Model between Port Authority and Terminal Operators

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Abstract

The competition between port authorities (PAs) and terminal operating companies (TOCs) in providing port logistics services has gained importance. The PAs enter into leasing contracts with TOCs in various ways. This study aims to model a contract method that maximizes the joint profit between a PA and a TOC. Particularly, this study aims to model the equilibrium by comparing four types of contract schemes in the non-coordination, cooperation, Cournot, and collusion models.

The results of the analysis show that the two-part tariff scheme generates a higher joint profit than the fixed and fee contracts. It is understood that risk- and profit-sharing between the PAs and TOCs helps the latter to maximize the throughput and the joint profit. These results are expected to provide an important theoretical basis for decision-making about port rent and freight between the PAs and TOCs.

Key words: Port marketing, channel coordination, joint-profit, freight rate decision

▷ 논문접수: 2019. 05. 31.　　▷ 심사완료: 2019. 09. 16.　　▷ 게재확정: 2019. 09. 23.

* 『이 논문은 2018년 한국해양대학교 무역학과 박사학위논문을 보완 및 발전하였음』

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Ⅰ. Introduction

The seaports handle over 80% of global trade by volume and more than 70% of its value to the worldwide (UNCTAD, 2017).In the last years, shipping liners have been defined making huge efforts to overcome the prolonged recession of the global economy and the difficulties in the global shipping market. Their efforts, such as increasing the number of large capacity vessels, merging and venturing to the new alliances, have brought the uncertain impact in the port industry. Further, these updated changes in the shipping industry have brought competition in port activities (Pando et al., 2005).

In the integrating global market, it is hardly surprising that the significant changes are taking space in the port industry. The efficient efforts in the improvements in the cargo handling gave an amount of influence over the container ports on getting the demand on the movement of containers by shipping liners. Thus, the pace of capacity expansion should be sufficient meet the anticipated demand. Shipping companies also forwarded to become alliances with other transportation companies (Yoshida and Kim, 2004), and to enter major ports using joint ventures into TOCs (Lee, 2006), and to develop subsidiaries focused on terminal operations (Parola et al., 2013). The strategic alliances brought the complicated relationship between the merged terminals and the port authorities. From the carrier's view, a closer relationship to the TOC (Parola et al., 2013) and equity partnership to container terminal projects gives effective improvement to carrier's business networks (Parola et al., 2014).

The port management is challenging on sustainable port development, the following aspects: economic, technological, logistical, environmental, and community involvement (Bauk et al., 2015). Currently, the shipping industry has experienced the overcapacity of vessels and large capacity of vessels, and greater logistics services by shipping liners. These current changes have brought PA and TOC into difficulties in capturing the demand from the main customers (Heaver et al., 2000). In same time, they hardly adapt to develop a competitive position in the new market environment (Notteboom, 2017).

World Bank (2001) proposed four main governance models in the port industry. In the most adopted landlord model, PA is responsible for managing port areas with assuring traffic growth, social and economic wealth without directly performing any commercial activities (Meersman et al., 2009). The growth of privatization highlights the advance in two ways. The first way is to achieve more throughput between the origin and the destination areas, and second, to help the appropriate coordination of organizational activities as a commercial port (Pando et al., 2005). Fewer services by giant shipping alliances can lead to high competition among container ports, and among TOCs in the port to make as a port of call within a limited number of continental liner services (Notteboom, 2017).

Among the related studies on governing the port, the authorities use two models for port management. The first type is classic one, where the PA invests in a terminal operating facility, and employs the stevedore and provides the handling services themselves. The second type is modern one, where the PA gives the terminal operation to the third parties in full and part.

Bichou and Gray (2005) suggested that the integration between port and terminal can cover all activities, procedures and monitoring. Terminals in global supply chains are essential and their integration with shipping companies leads to higher performance and competitive advantages for the port (Notteboom and Rodrigue, 2005). In this way, port integration also should satisfy customers with adapting to the requirements of the new market environment. Greater cooperation through inter-ports and intra-ports will help to mitigate the adverse impact on growing cost pressure in container handling (UNCTAD, 2017).

The problem addresses how to coordinate the concession contract optimally between the PA and TOCs. The main aim is to create a favorable cooperation model on port pricing between the PA and TOCs.

The objectivity of the PA and TOCs is quite different from each other. The PA is interested in how to bring more throughput, while the TOCs care about how to get more profit from the handling operations. Without the integration, the players determine their interests for maximizing their private profits. The uncoordinated decisions bring out the double marginalization, which brings to "burden cost" to the customers (Tirole, 1988).

Second, many studies about concession contract between PA and TOC have been studied by different business decisions on pricing depending on welfare (Strandenes and Marlow, 2000), a period of the contract (Notteboom and Verhoven, 2010), and maximizing throughput (Chen and Liu, 2015) and fee revenues (Saeed, 2009; Saeed and Larsson, 2010; Chen and Liu, 2012, 2014; Chen et al., 2017; Liu et al., 2018). However, these studies focused mostly on PA's viewpoints. This study is concerned with the different objectivity on port pricing models for PA and TOC using channel relationship.

Ⅱ. Literature review

The channel coordination participants choose options that maximize the profits. In the other models, the independent strategies may lead to the chain inadequacy. In the view of the importance of joint pricing, most of the previous studies focused on modelling the pricing system in the supply chain.

Petterson-Strandes and Marlow (2000) suggested that port tariffs should be differentiated on the quality of port services related with time, punctuality of handling. Haralambides (2002) mentioned that shipping liners are significantly sensitive to port tariffs in the intense competition among shipping liners. Therefore, transshipment cargoes can be fluctuated easily than O/D cargoes.

Kim (2011) mentioned that when there is unstable supply and demand occurred from the asymmetric transshipment demand and over-supply, it brings the market insecurity, which can later increase the high-sensitivity of shipping companies, strengthening alliances among them.

A number of studies on joint pricing assumed on the cost functions in the different fields. Thomas (1970) created a model on the joint pricing decision in a discrete-time setting. Federgruen and Heching (1999) focused on pricing-production models with the revenue functions. Deng and Yano (2006) developed the model with adding the capacity constraints. Weng (1995) modeled channel coordination with the pricing, the production and the ordering decisions.

The port concession system is divided into three scheme groups: the fixed fee, the unit fee, and the two-part tariffs. Kil and Kim (2016) recorded the ports in the USA, Belgium, Thailand, and Spain work with a two-part tariff scheme; the Netherlands, Vietnam, Japan and Tacoma (USA) applied the fixed fee scheme, and India and Philippines ports adjusted the unit fee scheme. The PAs applied fixed fee scheme with fixed land rent fees (the USA, Spain, Vietnam), with the construction cost to the expected income (Tacoma in USA, the Netherlands, Canada, Belgium, Thailand) or due to the contract period (Japan). Although the PAs applied the unit fee scheme with the profit sharing (Thailand) and per TEU (India). The PAs (Canada, Belgium, Thailand, USA) with two-part tariffs works with fixed land rents with the condition of minimum throughput in TOCs.

There are few studies on domestic port concession system in Korea. The previous studies suggested the changes to the calculation of concession system and managerial implications to adapt for them.

Lim and Lee (1999) studied the construction of the standard cost model to evaluate the appropriateness of the concession system in Busan Port.

Kim (2002) argued that concesion system should be based on the natural, physical and economic characteristics, so that the calculation of concession system for each port should be different, and Kil (2003) proposed a plan to revise the concession calculation system after studying the obstacles of Gwangyang port system and suggested that contracts should be negotiated by taking account with the perspectives of both sides: TOC’ s operating balance maintenance and PA's investment recovery. Kil (2011) also suggested a standardization calculation method in the rental fee system in Busan Port.

Moreover, Kil and Kim (2016) suggested the idevelopment scheme of the rent assessment system (2003-2014) by applying the identical ratio to all rent terminal ports. The suggested contracts covered how TOCs pay for the rented lands and the facilities of the port.

Previous studies on the application of channel coordination in the port industry are few. Anderson et al. (2008) designed a game-theoretic best response model to evaluate the competing ports’ response to the development at the port and adjusted it to Busan and Shanghai, and suggested a pricing game based analysis due to the ports' development policies.

Saeed and Larsen (2010) applied a Bertrand game to analyze Pakistan ports with different concession contracts. Their simulations concluded that the optimal concession contracts should be high in using the unit fees and low in using the annual rents.

Chen and Liu (2014) found the two-part tariff and the unit-fee contract is the best option for a profit maximizing PA, while Chen and Liu (2015) concluded that the fixed-fee contract is ideal for the throughput-maximizing PA.

Moreover, Liu et al. (2018) modeled the optimal concession contract by accounting into the minimum throughput requirements.

III. Model development

In this chapter, the modelling of the integrated profit equilibrium is done for the two-part tariff, fixed fee, unit fee, and mixed fee contract schemes in the different models, such as incoordination, coordination, Cournot and Collision models. Throughout the modelling process, both of PA and TOCs' joint profit maximization are modelled, and compared numerically in the graphics by changing the cost (*c*) and the service differentiation level (*b*).

The players considered in this study are a single PA that earns the profit from berth rents by leasing and two different TOCs that earns their profit by increasing port tariff. While the PA focuses on the how to increase rent fee and to increase the throughput more, the TOCs focus on how to increase the profit from the port tariff with differentiated services.

Here, the market demand functions faced by TOC_1 and TOC_2 are assumed to be,

$$p_1 = 1 - q_1 - bq_2;$$
$$p_2 = 1 - q_2 - bq_1,$$

where p_i is the price per unit cargo (TEU) charged by TOC_i, $i = 1,2$, and q_i is the amount of cargo handled by TOC_i;. Parameter $b \in (0,1)$ represents the service differentiation level, which is the larger *b*, the lower the differentiation degree of the services.

The loading and unloading works bring the service costs for TOCs, such as labor wages and rents of the facilities. Let

$$C_i(q_i) = c_i q_i,\ i = 1,2.$$

$c_i q_i$ is the cost function of TOC *i* in handling the cargo amount q_i, where c_i with $0 < c_i < 1$ is operator *i*' s marginal service cost, $i = 1,2$.

The expansion of the cost function will be:

$$C_1(q_1) = c_1 q_1, 0 < c_1 < 1;$$
$$C_2(q_2) = c_2 q_2, 0 < c_2 < 1.$$

Differently from Chen and Liu (2014), which assumed $c_1 < c_2$ as TOC_1 is more cost-efficient than TOC_2, we assume the both TOCs' cost is same $(c_1 = c_2 = c)$ for formulating easier than previous one.

PA can offer the fixed fee, the unit-fee the two-part tariff and the mixed contracts to TOCs:

a) PA charges a fixed fee $f, f > 0$, which is irrelevant to the handled cargo amount.

b) PA charges a unit fee, r, for per unit cargo handled.

c) PA charges both r, f as two part tariff.

d) PA charges one TOC with fixed, and another TOC unit fee contracts.

The game proceeds as follows:

The PA firstly announces a fee scheme to reach its own goal; later each TOC choose freely their own optimal cargo quantities to earn the profits higher. As the model can be different due to the contract types, each TOC's profit function will be:

$$\max \pi_1 = (1-q_1-bq_2)q_1-(c+r)q_1-f = \\ = p_1q_1-(c+r)q_1-f;$$

$$\max \pi_2 = (1-q_2-bq_1)q_2-(c+r)q_2-f = \\ = p_2q_2-(c+r)q_2-f.$$

In this case, the PA can pursue the joint profit maximization of all combination connecting PA, TOC_1 and TOC_2.

$$\max \Pi_j = \pi_p + \pi_1 + \pi_2;$$

$$s.t.\ \pi_p = 2f + r(q_1+q_2).$$

Given the contract scheme, the optimal behaviors and model comparisons between players are described in Appendix.

IV. Numerical analysis results

The multiple results of the joint, coordinated and non-coordinated models in the form of various equilibriums are compared. Each contract scheme is described through the numerical simulation. The simulation software is Graphing Calculator 3D program, which can draw mathematical graphics in a comfort form.

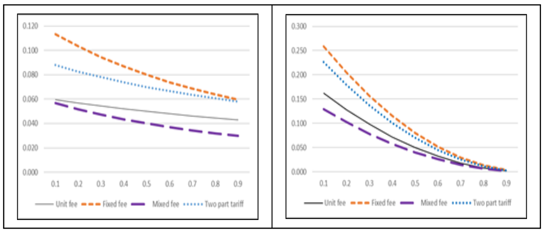
The parameters used for the numerical simulation are:

$$\begin{cases} b=0 & c=0 \\ b=0 & c=1 \\ b=1 & c=0 \\ b=1 & c=1 \\ b\, is\, constant; & 0<c<1 \\ c\, is\, constant; & 0<b<1 \end{cases}$$

The impact of changes in the cost of the total profit is derived.

First, the non-coordination channel model is compared (See Fig. 1). The fixed fee contract scheme are higher for the PA in incoordination, because the PA gets less risk than in other schemes. As the value of cost of the PA decreases, the profit of PA increases to 50% of total profit. The cost parameter c is fixed as c=0.5; the profit of the PA increases to over 10%, as

Figure 1. Comparison schemes in incoordination channel

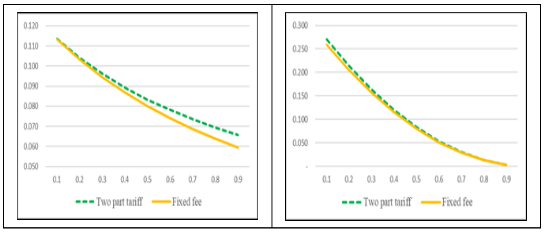


the service increases up. When the service flexibility is fixed (b=0.5) and the cost deceases down, the PA's profit increased over 25% in the fixed contract, over 23% in the two-part tariff contract, over 16% in the unit fee contract and about 13% in the mixed fee contract.

Alternatively, when the cost is fixed and the service flexibility increases, the PA' profit increases over 9% in the two-part tariff contract, about 6% in the unit and mixed contract. It is interesting that the PA's profit coefficient is more elastic to the cost than the service flexibility; that is, the profit increases speedy to the cost changes than the service flexibility changes in all four schemes.

Second, containing both similar and different values in profit coefficients, four contract schemes are compared in the coordination model. The two-part tariff and the unit fee contract schemes are slightly higher in this model, because both PA and TOC make judgement depending on other side' s decisions (See Fig. 2). As the value of PA's cost decreases, the PA's profit boosts till 50% in all bargain schemes. As

Figure 2. Comparison schemes in coordination channel

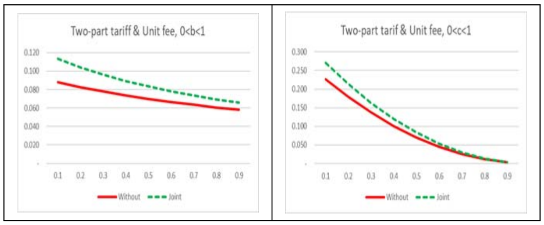


the cost is fixed (c=0.5), the PA's profit in all four contract schemes increases over 11 %. while the service flexibility is fixed (b=0.5), the profit in the unit fee and the two-part tariff scheme expanded over 27% and in the fixed and the mixed contracts expanded to 26% as much as cost decreases. Here, the profit is more tolerant to the cost changes than the service flexibility.

The results of total profit maximization are consecutively compared. As the cost is fixed (c=0.5) and the service flexibility increases, the profit in both two-part tariff and the unit fee contract schemes raised over 11% in the coordination model and 9% in the non-coordination model (See Fig. 3).

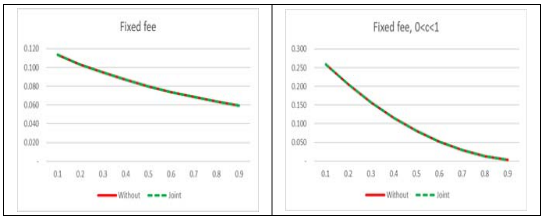
When the service flexibility is fixed (b=0.5), the profit in the unit fee and the two-part tariff scheme increased over 27% in coordination module than 24% in non-coordination one. Therefore, the profit in both models decreases as much as the cost increases. The profit in the fixed fee

Figure 3. The comparison results of the total profit maximization in the two-part and the unit fee schemes



contract scheme are same in both models (See Fig. 4).

Figure 4. The comparison results of the total profit maximization in the fixed fee schemes



Next, the total profit in the mixed fee scheme

Figure 5. The comparison results of the total profit maximization in the mixed fee schemes

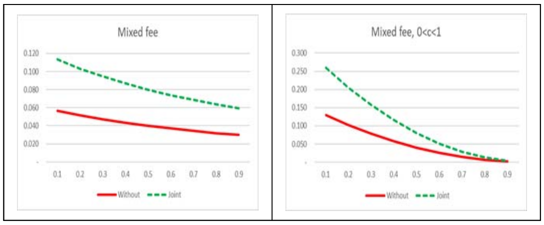
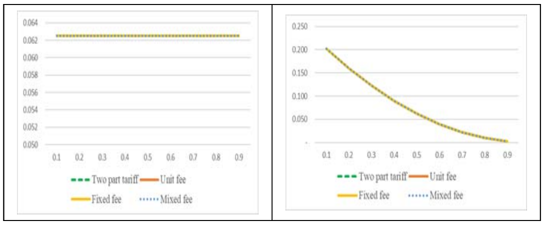


Figure 6. The comparison results of total profit maximization in the joint coordination



between non-coordination and coordination models is given. As the cost is fixed (c=0.5) and the service flexibility increases up, the profit in the mixed fee schemes increases over 11% in the coordination model twice more than in the non-coordination model (5.5%) (See Fig.5).

When the service flexibility is fixed (b=0.5), the profit in the unit fee and the two-part tariff scheme increases over 26% in the coordination model twice more than in the non-coordination (13%); the difference between two models declines as much as the cost increases.

The joint profit model is compared in four schemes, respectively. The joint profits of all four contract schemes are identical. The joint profit increases as the PA and TOCs decrease their cost (See Fig.6). Despite of the service flexibility changes, the joint profit is absolute in all contract schemes.

Finally, the four contract schemes in Cournot and Collusion models are compared. As the cost is fixed, the profit in the two-part tariff and the unit fee contract schemes equals to 6% in both models, in spite of the changes of service flexibility (See Fig. 7). When the service flexibility is fixed (b=0.5) and the cost increases, the profit in the unit fee and the two-part tariff schemes increases over 20% in both models. The profit in the two-part tariff and the unit fee contract schemes are identical in both models.

Figure 7. Comparison results two-part and unit fee models in Cournot and Collusion

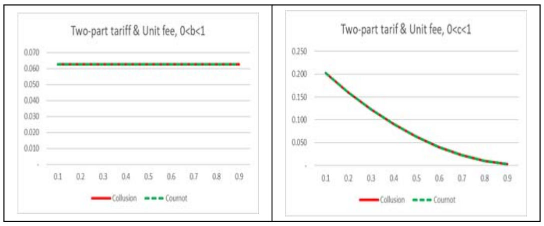
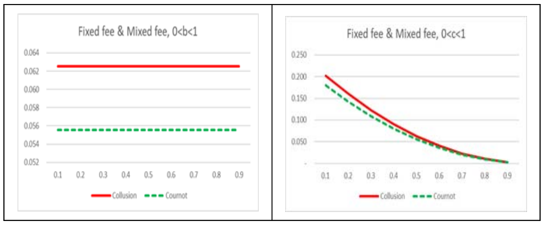


Figure 8. Comparison results fixed and mixed models in Cournot and Collusion



However, the profit in the fixed and the mixed fee contract schemes in the Collusion model is higher than the Cournot model. As the cost is fixed and the service flexibility increases, the profit in the fixed and the mixed fee schemes reaches to 6% in the Collusion model; while it reaches to 5.6% in the Cournot model (See Fig. 8).

Alternatively, when the service flexibility is fixed (b=0.5) and the cost increases, the profit in the fixed and the mixed fee schemes increases to over 20% in the Collusion model, and to over 16% in Cournot model.

V. Conclusion

When the PA attempts to maximize its profit in same time increasing the cargo throughput, the fixed fee contract is a favorable choice, which is identical with Chen and Liu (2015). Regularly, the PA maximizes its profit by increasing rent fee to the TOC, while the TOC maximizes its profit through increasing the port tariff. When the PA attempts to maximize the profit by sharing the market risk with the TOCs, then the two-part tariff and the unit fee contracts are favorable preferences. This result proves the model assumed by Chen and Liu (2014) and Liu et al. (2018).

The study results show that the PA can increase its profit when it offers a coordinated contract. Moreover, the PA can increase the profit not only from the fixed fee contract but also sharing the market risk with increasing the throughput. The total joint profit supports the fixed profits to both sides. When the PA and both TOCs converge to the joint profit, both parties can achieve higher profit in any condition.

The main limitation in the study is the data accessibility. As the lack access of the real data, the model is calculated with the numerical analysis. Second, the model parameters, such as the service flexibility and the cost on service are limited to find the optimal profit, that is the model does not include enough factors and conditions. Furthermore, the cost and the service flexibility scale and degree can be various in the practice and the reality.

The study model can be enlarged with the detailed variables and parameters in the further studies. The accessible data, various players, and different conditions in the model can bring the study more challengeable.

References

Anderson, C.M., Y.A. Park, Y.T. Chang, C.H. Yang, T.W. Lee, and M. Luo(2008), A game theoretic analysis of competition among container port hubs: The case of Busan and Shanghai, *Maritime Policy and Management,* 35, 5-26.

Bauk, S., S. Seklarac-Ivosevic, and N. Jolic(2015), Seaport positioning supported by the combination of some quantitative and qualitative approaches, *Transport,* 30(4), 385-396.

Bichou, K. and R. Gray(2005), A critical review of conventional terminology for classifying seaports, *Transportation Research Part A: Policy and Practice,* 39(1), 75-92

Chen, H.C. and S.M. Liu(2014), Optimal concession contracts for landlord port authorities to maximize fee revenues, *International Journal of Shipping Transportation and Logistics*, 6(1), 26-45.

Chen, H.C. and S.M. Liu(2015), Optimal concession contracts for landlord port authorities to maximize traffic volumes, *Maritime Policy and Management*, 42(1), 11-25.

Chen, H.C., Y.H. Lin, and S.M. Liu(2017),. Optimal concession contracts for landlord port authorities under price competition of terminal operators, *International Journal of Shipping Transportation and Logistics*, 9(2), 131-165.

Deng, Sh. and C.A. Yano(2006), Joint production and pricing decisions with setup costs and capacity constraints, *Management Science*, 52(5), 741-756.

Federgruen, A. and A. Heching(1999), Combined pricing and inventory control under uncertainty, *Operations Research*, 47(3), 454-475.

Haralambides, H.E.(2002), Competition, excess capacity and he pricing of port infrastructure, *International Journal of Maritime Economics*, 4, 323-347.

Heaver, T., H., Meersman, F. Moglia, and E. Van de Voorde(2000), Do mergers and alliances influence European shipping and port competition? *Maritime Policy and Management*, 27(4), 363-373.

Kil, K.S.(2003), Gwangyang port container terminal tariff reorganization plan, *Korea Maritime Institute*, 5-30.

Kil, K.S.(2011), Standardization of the lease fee assessment system of Busan port container terminals, *Journal of Korea Port Economic Association*, 27(3), 65-90.

Kil, K.S. and E.S. Kim(2016), Improvement scheme of lease rate assessment system for terminal operating company' s wharf, *Journal of Korea Port Economic Association*, 32(4), 127-147.

Kim, H.T.(2002), A study on the variable to affect the leasing rate of the TOC terminals, *Journal of Korea Shipping*, 109-133.

Kim, K.S.(2011), A study on market stabilization schemes of Busan container stevedore market, *Journal of Korea Port Economic Association*, 27(2), 169-191.

Lee, S.W.(2006), Urgent strategy for port alliance between Korea and China, *Maritime Fishery Trends*, Vol. 1229, Korea Maritime Institute.

Lim, J.K. and T.W. Lee(1999). Developing a standard costing model for a container terminal: A case study for PECT and GCT, *Journal of Korea Port Research*, 13(2), 279-287.

Liu, Sh.M., H.Ch. Chen, W. Han, and Y.H. Lin(2018), Optimal concession contracts for landlord port authorities to maximize fee revenues with minimal throughput requirements, *Transportation Research Part E*, 109, 239-260.

Meersman, H., E. Van de Voorde, and T. Vanelslander(2009), Future challenges for Port and Shipping Sector, London: Informa.

Notteboom, T.E.(2017), The relationship between port choice and terminal involvement of alliance members in container shipping, IAME 2017 Conference, Kyoto, Japan.

Notteboom, T.E. and J. Rodrigue(2005), Port regionalization: towards a new phase in port development, *Maritime Policy and Management*, 32(3), 297-313.

Notteboom, T.E. and P. Verhoven(2010), The awarding of seaport terminals to private operators: European practices and policy implications, *European Transportation*, 45, 83-101.

Pando, J., A. Araujo, and F.J. Maqueda(2005), Marketing management at the world' s major ports, *Maritime Policy and Management*, 32(2), 67-87.

Parola, F., T.E. Notteboom, G. Satta, and J.P. Rodrigue(2013), Analysis of factors underlying foreign entry strategies of terminal operators in container ports, *Journal of Transport Geography*, 33, 72-84.

Parola, F., G. Satta, and S. Caschili(2014), Unveiling co-operative networks and "hidden families" in the container port industry, *Maritime Policy and Management*, 41(4), 384-404.

Saeed, N.(2009). Competition and cooperation among container terminals in Pakistan: with emphasis on game theoretical analysis, PhD thesis,

Molde University College.
Saeed, N. and O.I. Larsen(2010), An application of co-operative game among container terminals of one port, *European Journal of Operational Research*, 203, 393-403.
Strandenes, S.P. and P.B. Marlow(2000), Port pricing and competitiveness in short sea shipping, *International Journal of Transportation Economics*, 27, 315-334.
Thomas, L.J.(1970), Price-production decisions with deterministic demand, *Management Science*, 16(11), 747-750.
UNCTAD(2017), Review of maritime transport, Geneva: United Nations Publication.
Weng, Z.K.(1995), Channel coordination and quantity discounts, *Management Science*, 41(9), 1509-1521.
World Bank(2001), Port reform toolkit, Washington, DC: World Bank.
Yoshida, Sh. and K.H. Kim(2004). Structural changes of container route network in East Asia after alliance formation, *Journal of Korea Trade*, 8(1), 5-24.

Appendix

There are four types of contract schemes, so the equilibriums for each of them are modeled:

1. TOC's optimal behaviors under schemes

1) Under the two-part tariff scheme

When the two-part tariff scheme (r, f) is adopted, the PA will collect an unit-fee $(r>0)$ per container for the amounts handled by TOCs, and the fixed-fee $(f>0)$, where TOCs choose the optimal quantities (q_1^*, q_2^*) to solve the following equations. Here, both TOC' s maximum profit function is:

$$\max \pi_1 = (1-q_1-bq_2)q_1-(c+r)q_1-f = \\ = p_1q_1-(c+r)q_1-f.$$

$$\max \pi_2 = (1-q_2-bq_1)q_2-(c+r)q_2-f = \\ = p_2q_2-(c+r)q_2-f.$$

The first-order conditions (FOC) for (q_1^*, q_2^*) are

$$\frac{\partial \pi_1}{\partial q_1} = 1-2q_1-bq_2-(c+r)=0.$$

$$\frac{\partial \pi_2}{\partial q_2} = 1-2q_2-bq_1-(c+r)=0.$$

By solving the equation, the optimal quantities, and the profit are obtained in the following ways:

$$q_1^* = \frac{1-(c+r)}{2+b};\ q_2^* = \frac{1-(c+r)}{2+b};\\ q_1^* = q_2^* = q^*.$$

$$p_1^* = \frac{1+(1+b)(c+r)}{2+b};\\ p_2^* = \frac{1+(1+b)(c+r)}{2+b};\\ p_1^* = p_2^* = p^*.$$

To have the non-negative equilibrium cargo quantities from both TOCs, the TOC' s marginal cost and PA's unit-fee are assumed be not higher, so that both operators will handle the non-negative cargo quantities. If the PA charges the unit-fee higher, then one of the TOC may go out from the market. Here, TOCs' profit is identical:

$$\pi_1^* = (q_1^*)^2 - f;\ \pi_2^* = (q_2^*)^2 - f.$$

2) Under unit fee scheme

Given unit fee (r), TOCs select the optimal quantities (q_1^u, q_2^u) to solve the following equilibriums. By letting $f=0$ at (r, f), a unit fee scheme is given, and TOC$_i$'s profit function becomes π_i with $f=0$,

$$\max \pi_1 = (1-q_1-bq_2)q_1-(c+r)q_1 = \\ = p_1q_1-(c+r)q_1;$$

$$\max \pi_2 = (1-q_2-bq_1)q_2-(c+r)q_2 = \\ = p_2q_2-(c+r)q_2.$$

By solving the equation, the optimal quantities, and the profit are obtained in the following ways:

$$q_1^u = \frac{1-(c+r)}{2+b};\ q_2^u = \frac{1-(c+r)}{2+b};\\ q_1^u = q_2^u = q^u.$$

$$p_1^u = \frac{1+(1+b)(c+r)}{2+b};$$
$$p_2^u = \frac{1+(1+b)(c+r)}{2+b};$$
$$p_1^u = p_2^u = p^u.$$

Both TOCs' profit will be equal to:

$$\pi_1^u = (q_1^u)^2; \ \ \pi_2^u = (q_2^u)^2.$$

As a result, two-part tariff and unit fee schemes get equal products:

$$q_1^* = q_2^* = q_1^u = q_2^u;$$
$$p_1^* = p_2^* = p_1^u = p_2^u.$$

3) Under fixed fee scheme

Given fixed fee (f), TOCs select the optimal throughput quantities (q_1^f, q_2^f) to solve the following equations. By letting $r=0$ at (r, f), a unit fee scheme and each TOC$_i$'s maximum profit function becomes π_i with $r=0$,

$$\max \pi_1 = (1-q_1-bq_2)q_1 - cq_1 - f = \\ = p_1 q_1 - cq_1 - f;$$

$$\max \pi_2 = (1-q_2-bq_1)q_2 - cq_2 - f = \\ = p_2 q_2 - cq_2 - f.$$

By solving the equation, the quantities and the profit are obtained as follows:

$$q_1^f = \frac{1-c}{2+b}; \ \ q_2^f = \frac{1-c}{2+b}; \ \ q_1^f = q_2^f = q^f.$$

$$p_1^f = \frac{1+(1+b)c}{2+b};$$
$$p_2^f = \frac{1+(1+b)c}{2+b};$$
$$p_1^f = p_2^f = p^f.$$

Both TOCs' profit becomes:

$$\pi_1^f = (q_1^f)^2 - f; \ \ \pi_2^f = (q_2^f)^2 - f.$$

4) Under mixed fee scheme

Given mixed fee (f and r), TOC$_1$ chooses optimal quantities (q_1^m) and TOC$_2$ chooses optimal quantities (q_2^m) to solve the following problems:

$$\max \pi_1 = (1-q_1-bq_2)q_1 - cq_1 - f,$$
$$\max \pi_2 = (1-q_2-bq_1)q_2 - (c+r)q_2.$$

By solving the simultaneous equation, the quantities and the profit are obtained as follows:

$$q_1^m = \frac{1-c}{2+b} - \frac{2r}{4-b^2}r;$$
$$q_2^m = \frac{1-c}{2+b} + \frac{br}{4-b^2}.$$

$$p_1^m = \frac{1+(1+b)c}{2+b} + \frac{2-b^2}{4-b^2};$$
$$p_2^m = \frac{1+(1+b)c}{2+b} + \frac{br}{4-b^2}.$$

Both TOCs' profit is equal to:

$$\pi_1^m = (q_1^m)^2 - f; \ \ \pi_2^m = (q_2^m)^2.$$

2-1. PA's optimal behaviors under four schemes: non-cooperation case

1) Under two-part tariff scheme

PA's fee revenue equals:

$$\pi_p = 2f + r(q_1 + q_2).$$

Main equilibrium becomes:

$$\max \pi_p = 2f + r(q_1{}^* + q_2{}^*).$$

Condition should be satisfied:

$$\pi_i = (q_i^*)^2 - f \geq 0.$$

The maximization profit for fixed and unit fee equal to:

$$r^* = \frac{1-c}{2};\ f^* = \frac{1}{4}(\frac{1-c}{2+b})^2.$$

So, the profit function in this scheme becomes:

$$\pi_p^* = 2q^*(r^* + q^*).$$

2) Under unit fee scheme

Main equilibrium equals to:

$$\max \pi_p = r(q_1^u + q_2^u).$$

As the maximization profit for fixed and unit fee become:

$$r^u = \frac{1-c}{2};\ f^u = 0.$$

So, the profit function in this scheme becomes:

$$\pi_p^u = 2q^u r^u = \frac{2+b}{2}(\frac{1-c}{2+b})^2.$$

3) Under fixed fee scheme

Main equilibrium equals to:

$$\max \pi_p = 2f.$$

As the maximization profit for fixed and unit fee becomes

$$r^f = 0;\ f^f = (q^f)^2 = (\frac{1-c}{2+b})^2.$$

So, the profit function in this scheme becomes:

$$\pi_p^f = 2q^f = 2(\frac{1-c}{2+b})^2.$$

4) Under mixed fee scheme

Main equilibrium equals to:

$$\max \pi_p = f + rq_i^m.$$

The maximization profit for fixed and unit fee becomes:

$$r^m = 0;\ f^m = (q^m)^2 = (\frac{1-c}{2+b})^2.$$

So, the profit function in this scheme becomes:

$$\pi_p^m = (q_i^m)^2 + r^m q^m = (\frac{1-c}{2+b})^2.$$

2-2. PA's optimal behaviors under four schemes-cooperation case

1) Under two-part tariff scheme

Main equilibrium equals to:

$$\max \Pi_j = \pi_p + \pi_1 + \pi_2 = 2(rq_1^* + (q_2^*)^2).$$

Condition should be satisfied:

$$\pi_i = (q_i^*)^2 - f \geq 0.$$

The maximization profit for fixed and unit fee becomes:

$$r^* = \frac{b}{2}(\frac{1-c}{1+b});\ f^* = \frac{1}{4}(\frac{1-c}{1+b})^2.$$

So, the profit function in this scheme equals to:

$$\Pi_p^* = 2q^*(r^* + q^*) = \frac{1}{2}(\frac{1-c}{1+b})(1-c) = \\ = (1-c)q^*.$$

2) Under unit fee scheme

Main equilibrium equals to:

$$\max \Pi_j = 2q^u(r+q^u).$$

The maximization profit for fixed and unit fee becomes:

$$r^u = \frac{b}{2}(\frac{1-c}{2+b});\ f^u = 0.$$

So, the profit function in this scheme equals to:

$$\Pi_j^u = \frac{1}{2}(\frac{1-c}{2+b})(1-c).$$

3) Under fixed fee scheme

Main equilibrium equals to:

$$\max \Pi_j^f = 2(q^f)^2.$$

As the maximization profit for fixed and unit fee becomes:

$$0 \le f^f \le (\frac{1-c}{2+b})^2;\ r^u = 0.$$

So, the profit function in this scheme becomes:

$$\Pi_j^f = 2(\frac{1-c}{2+b})^2.$$

4) Under mixed fee scheme

Main equilibrium equals to:

$$\max \Pi_j = (q_1^m)^2 + q_2^m(r+q_2^m).$$

As the maximization profit for fixed and unit fee becomes:

$$r^m = 0;\ f^m = (q^m)^2 = (\frac{1-c}{2+b})^2.$$

So, the profit function in this scheme becomes:

$$\Pi_j^m = 2(\frac{1-c}{2+b})^2.$$

2-3. PA's optimal behaviors under four schemes-Cournot cooperation

1) Under two-part tariff scheme

Main equilibrium equals to:

$$\max \Pi_j = \pi_p + \pi_1 + \pi_2 = (p_1 - c)q_1 + (p_2 - c)q_2$$

As the maximization profit for fixed and unit fee in quantity becomes:

$$q_1^* = q_2^* = \frac{1-c}{4}; p_1^* = p_2^* = \frac{1+c}{2}.$$

So, the profit function in this scheme becomes:

$$\Pi_j^* = (\frac{1-c}{2})^2;\ \pi_p^* = 2f^* + \frac{1-c}{2}r^*;$$
$$\pi_1^* = \pi_2^* = \frac{1}{2}(\frac{1-c}{2})^2 - \frac{1-c}{2}r^* - f^*.$$

2) Under unit fee scheme

Main equilibrium equals to:

$$\Pi_j^u = 2rq^u + 2(q^u)^2 = 2q^u(r+q^u)$$

As the maximization profit for fixed and unit fee will become:

$$r^u = \frac{b}{2}(\frac{1-c}{1+b});\ f^u = 0.$$

So, the profit function in this scheme becomes:

$$\Pi_j^u = \frac{1}{2}(\frac{1-c}{1+b})(1-c).$$

3) Under fixed fee scheme

Main equilibrium equals to:

$$\max \Pi_j^f = 2(q^f)^2$$

As the maximization profit for fixed and unit fee becomes:

$$f = (q^f)^2.$$

So, the profit function in this scheme is:

$$\Pi_j^f = 2(\frac{1-c}{2+b})^2.$$

4) Under mixed fee scheme

Main equilibrium equals to:

$$\max \Pi_j = (q_1^m)^2 + q_2^m(r + q_2^m).$$

As the maximization profit for fixed and unit fee becomes

$$r^m = 0;\ f^m = (q^m)^2 = (\frac{1-c}{2+b})^2.$$

So, the profit function in this scheme is

$$\Pi_j^m = 2(\frac{1-c}{2+b})^2.$$

2-4. PA's optimal behaviors under four schemes-Collusion cooperation

1) Under two-part tariff scheme

Main equilibrium equals to:

$$\max \Pi_j = \pi_p + \pi_1 + \pi_2 = 2f + rq + pq - \\ -(c+r)q - 2f = (p-c)q$$

As the maximization profit for fixed and unit fee in quantity will become:

$$q_1^* = q_2^* = \frac{1-c}{4};\ p_1^* = p_2^* = \frac{1+c}{2}.$$

So, the profit function in this scheme is

$$\Pi_j^* = (\frac{1-c}{2})^2;\ \ \pi_p^* = 2f^* + \frac{1-c}{2}r^*;$$
$$\pi_1^* = \pi_2^* = \frac{1}{2}(\frac{1-c}{2})^2 - \frac{1-c}{2}r^* - f^*.$$

2) Under unit fee scheme

Main equilibrium equals to:

$$\Pi_j^u = rq^u + pq^u - (c+r)q = (p-c)q.$$

As the maximization profit for fixed and unit fee will become:

$$q_1^* = q_2^* = \frac{1-c}{4};\ \ p_1^* = p_2^* = \frac{1+c}{2}.$$

So, the profit function in this scheme is

$$\Pi_j^u = (\frac{1-c}{2})^2;\ \ \pi_p^u = \frac{1-c}{2}r^u;$$
$$\pi_1^u = \pi_2^u = \frac{1}{2}(\frac{1-c}{2})^2 - \frac{1-c}{4}r^u.$$

3) Under fixed fee scheme

Main equilibrium equals to:

$$\Pi_j^f = 2f^f + pq^f + cq^f - 2f^f = (p-c)q\ .$$

As the maximization profit for fixed and unit fee becomes

$$q_1^f = q_2^f = \frac{1-c}{4}; p_1^f = p_2^f = \frac{1+c}{2}.$$

So, the profit function in this scheme is

$$\Pi_j^f = (\frac{1-c}{2})^2;\ \pi_p^f = 2f^f;$$
$$\pi_1^f = \pi_2^f = \frac{1}{2}(\frac{1-c}{2})^2 - f^f.$$

4) Under mixed fee scheme

Main equilibrium equals to:

$$\max \Pi_j = f + rq_2^m + pq_1^m - cq_1 - (c+r)q_2^m - f.$$

As the maximization profit for fixed and unit fee becomes:

$$q_1^m = q_2^m = \frac{1-c}{4};\ p_1^m = p_1^m = \frac{1+c}{2}.$$

So, the profit function in this scheme is

$$\Pi_j^m = (\frac{1-c}{2})^2;$$
$$\pi_p^m = f^m + \frac{1-c}{2}r^m;$$
$$\pi_1^m = \frac{1}{2}(\frac{1-c}{2})^2 - f^m;$$
$$\pi_2^u = \frac{1}{2}(\frac{1-c}{2})^2 - \frac{1-c}{4}r^m.$$

3. Comparison between assumed models

1) Comparisons between schemes in incoordination

The non-coordinated profit maximization equation results show that the PA's profit is higher than the TOC's profit in all contract schemes:

$$\pi_T < \pi_P$$

when b=c=0 → $\pi_p^f > \pi_p^* > \pi_p^u = \pi_p^m$;

when 0<b<1 → $\pi_p^f > \pi_p^* > \pi_p^u > \pi_p^m$;

when b=1 → $\pi_p^f = \pi_p^* > \pi_p^u > \pi_p^m$;

Totally, $\pi_p^f \geq \pi_p^* > \pi_p^u \geq \pi_p^m$.

2) Comparisons between schemes in coordination

The PA and TOC profit maximization equations summarized in the coordinated contract schemes as follows:

when b=c=0 → $\pi_p^* = \pi_p^u = \pi_p^f = \pi_p^m$;

when 0<b<1 → $\pi_p^u = \pi_p^* > \pi_p^f = \pi_p^m$;

when c=1 → $\pi_p^f = \pi_p^* = \pi_p^u = \pi_p^m = 0$;

Totally, $\pi_p^u = \pi_p^* \geq \pi_p^f = \pi_p^m$.

3) Comparisons between schemes in Cournot model

Although the PA and TOCs attempt to maximize the joint profit, the profit equation results are complicated to the TOCs and the PA. The unit fee and the mixed fee schemes are favorable for the TOCs, while the fixed and the mixed contract schemes are a significantly favorable choice to the PA.

when b=c=0 → $\Pi_j^f = \Pi_j^* = \Pi_j^u = \Pi_j^m$;

when 0<b<1 → $\Pi_j^u = \Pi_j^* \geq \Pi_j^f = \Pi_j^m$;

when c=1 → $\Pi_j^f = \Pi_j^* = \Pi_j^u = \Pi_j^m$;

when *0<c<1* → $\Pi_j^u = \Pi_j^* < \Pi_j^f = \Pi_j^m$;

Totally, $\Pi_j^u = \Pi_j^* \geq \Pi_j^f = \Pi_j^m$.

4) Comparisons between schemes in Collusion model

The analyse result showed this model achieves the model of joint profit maximization model which generates profit equally for both PA and TOCs in any contract scheme.

$$\Pi_j^f = \Pi_j^* = \Pi_j^u = \Pi_j^m.$$

항만공사와 터미널운영사간 최적임대계약 결정에 관한 모형

아슈로프 압둘라지즈 · 김재봉

국문요약

오늘날 선사 간 제휴 및 기술진보 등 세계 해운환경의 급격한 변화로 항만 간 경쟁이 더욱 치열해지고 있으며, 이에 따라 항만물류서비스를 제공하는 항만공사와 터미널 운영사 간의 협력이 매우 중요하다 하겠다. 항만들은 터미널운영사와 다양한 방식으로 임대 계약을 체결하고 있으며, 터미널 운영사는 산정된 임대료 하에서 최적 운임을 결정하여 수익을 창출하고 있다.

이와 같은 상황에서 본 연구는 항만공사와 터미널운영사의 상호 이익을 극대화하는 계약 방식 도출을 목적으로 하고 있다. 즉, 본 연구는 항만공사의 이익 극대화에 초점을 맞춘 기존 연구들과 달리, 항만공사와 터미널 운영사 간의 공유이익 극대화 측면에서 최적화 계약방식을 도출하고자 한다. 이러한 맥락에서 본 연구는 항만공사와 터미널 운영사 간의 네 가지 유형의 계약방식들을 과점시장 모형인 Non-cooperation, Cooperation , Cournot 및 Collusion 모델을 상호 비교하여 각 모형의 균형을 도출하고자 한다.

본 연구의 결과 two-part tariff 계약방식이 fixed contract 및 unit contract 계약방식에 비해 항만공사와 터미널운영사간의 공유이익이 많이 창출되는 것으로 분석되고 있다. 이는 two-part tariff 계약방식의 경우 항만공사와 터미널운영사가 수익과 위험을 상호 공유하므로 터미널 운영사는 보다 많은 물동량 확보를 위해 노력을 하게 됨에 따라 공유 이익이 극대화되는 것으로 사료된다.

본 연구는 향후 항만공사와 터미널운영자 간의 항만임대료 및 운임 결정을 위한 의사결정과정에서 중요한 이론적 토대를 제공할 수 있을 것으로 기대된다.

주제어: 항만 마케팅, 채널 코디네이션, 공유이익, 운임 결정