Coopetitive game fundamentals and concept model representation for LNG transportation industry

Matthew Sumner[1,*], Martina Žuškin[1,*], Srđan Žuškin[1], Mirano Hess[1]

[1] *University of Rijeka, Faculty of Maritime Studies, Croatia*
[*] *Corresponding author:* *matthew.sumner@pfri.uniri.hr*; *martina.zuskin@pfri.uniri.hr* *Tel.*: +385-91-555-1087 (MŽ).

Abstract: Forming strategic alliances, known as coopetition game, offers operational flexibility and collaborative relationships, where usually carriers cooperate to reduce operational costs. This paper presents a mathematical expression of the coopetition strategy in the LNG transportation segment. Furthermore, in this study, the coopetition game represents game-theoretic mathematical framework for LNG shipping structure in order to better understand motivations when forming an alliance; how do participating companies organize their business models, at which level do they cooperate and what is an incentive for competition, and finally to comprehend strategic decision-making processes when participating in an alliance.
The novelty of this paper is a game theory usage in the LNG market industry for profit maximization. In order to set conceptual model, we define mixed-integer nonlinear problem with iterative heuristics approach. Also, the constraints related to LNG transportation industry for conceptual model framework of coopetition game are presented and elaborated.

Keywords: Coopetition, Game theory, LNG shipping

---

1. Introduction

In recent years, we can witness large expansion of the world's LNG fleet, mainly due to the positive forecast of LNG market development. In order to prepare for the market growth, ship owners invested in new LNG tonnage early, making the current market congested with available cargo space. Regardless, many ship owners continue to invest in expansion projects to be ready for the chartering opportunities that lie ahead. Even though we do not witness major formation of alliances in the LNG sector, it is evident that the market is taking similar formation as of the container shipping market; therefore, once the capacity turns into overcapacity, carriers will be forced to reduce cost and to service their customers in a different way. Forming strategic alliances offers operational flexibility and collaborative relationships, where usually carriers cooperate to build scale and reduce operational costs. Furthermore, strategic alliances also compete to optimize their profits. Such a strategic alliance is commonly known as coopetition game. Many authors have extensively researched the topic of coopetition in the last decade, however to the best of our knowledge, there is limited number of work related to coopetition in the LNG sector. Authors recently focused mostly on liner shipping and strategic alliances within the container-shipping sector. In order to analyze a coopetition problem, the fundamentals and concept model representation for LNG transportation industry is presented. Therefore, our intention is to apply, at a conceptual level, the fundamentals and concept model representation in order to better understand motivations when forming an alliance, e.g., how do participating companies organize their business models, at which level do they cooperate and what is an incentive for competition.

2. Literature Review

Even though forming of alliances was not a common occurrence within the LNG transportation industry, the number of available vessels on the market increased to form significant mass that will warrant change, especially taking in consideration smaller shipping companies that have to find competitive advantages. This chapter will cover literature overview of strategic alliances, competition, cooperation and coopetition, followed by game-theoretic frameworks within the discipline. There is limited work available that considers LNG transportation market; therefore following overview is mainly considering liner shipping. Concluding remarks deliver highlights of the previous research and portray opportunities for further development. Intuitively, many authors consider liner shipping industry to be an oligopolistic market. Even though there was a lack of consensus among some of the authors (see further Peters, 1991; Hoffman, 1998), Sys (2009) used empirical methods to present rational evidence of oligopoly. While LNG shipping market was not within the scope of Sys' research, we can safely consider this market to be oligopolistic, taking in consideration industry's recent concentration levels. Examining the available literature, we can notice that the shipping competition has been thoroughly covered by several authors. Namely, Casaca, Ana, and Marlow (2005) investigated various service parameters within shipping operations that influenced competitiveness. Noteworthy mixed-integer programming approach was developed by Gelareh, Nickel, and Pisinger (2010) who investigated competition between novice line shippers and existing operators. Wang, Meng, and Zhang (2014) observed new container shipping market and proposed three game-theoretical models analyzing competition between couple of carriers. Unlike the LNG transportation industry, recent years deliver a number of studies focused on cooperation among liner shippers, formation of strategic alliances, which factors drive success and how is the strength of strategic alliances measured. More broadly, Slack, Comtois and Robert (2002) studied impact of strategic alliances on the development of container shipping market. Applying cooperative game theory framework to liner shipping alliances was studied by Song and Panayides (2002), which delivered better understanding of functional decision-making. Selecting an alliance partner is challenging task with many non-deterministic factorings for which Ding and Liang (2005) developed fuzzy multiple criteria decision-making model. Chang, Lee, and Tongzon (2008) developed an interesting study about slot exchange allocation where partnering carriers exploit surplus of cargo capacity. We can already see similar behavior in the LNG industry ("Qatargas and Rasgas complete first cooloading", 2017). Agarwal and Ergun (2010) completed extensive study of network design and integration by utilizing mathematical programming and game theory in order to achieve optimal collaboration of carriers in strategic alliances. Panayides and Weidmer (2011) completed overview of large strategic alliances in order to verify stability of alliances. Seashipt Oyster System was the company that coined the term Coopetition for the first time in 1913 representing the idea of cooperative competition (Cherington, 1976). Furthermore, first comprehensive overview of coopetition arguing that real sector consists of collaboration and competition mix is delivered. Most of the recent studies focus on finding optimized coopetitive equilibria in product supply chains, but rarely we can see intermodality or multimodality taken into consideration. Within the recent focus of coopetition, ports take a significant weight, starting with Heaver et al. (2000) who delivered study about cooperation agreements that influenced shipping market structures. Also, Song (2003) focused on coopetition of Chinese seaports. The research is based on coopetition among ports with a complex interconnected relations that include both competition and cooperation. Gurnani et al. (2007) studied incentives for investment of coopetition partners and how did product pricing affect the partnership. Intermodal and multimodal freight transportation is commonly described as coopetitive, because partners often compete on tariffs but cooperate when using available cargo space to forward freights as required. Based on the work listed above, it is apparent that cooperation did get a fair consideration among authors; however, most of the authors focused on port operations, or on liner shipping. Furthermore, coopetitive game theory is strongly influenced by research from De Ngo and Okura (2008), as well as Lin and Huang (2017). Both studies examined mathematics of the coopetition game; however, focus of De Ngo and Okura was on coopetitive relationship between semi-public and a private firm, while Lin and Huang delivered more generic and simplified overview of the coopetition game among private carriers without necessary constraints that would allow for practical use of the model. Liu et al. (2015) considered coopetition in the intermodal segment of the container shipping covering extensive mathematical modeling and game matrix that covered possibilities of cooperating and competing on two levels; investment and price decisions, concluding that cooperating at investment stage and competing at price decision stage is unique Nash equilibrium. In this study we will, therefore, consider scenario of cooperation at investment stage and competition at price decision stage. Also, we will deliver notation, basic assumptions and introduce a mathematical model of a single carrier that will be used to solve iterative heuristic coopetition problem.

3. Coopetitive game fundamentals and concept model representation

With the assumption that total demand on the LNG shipping market depends on the level of cooperation between two shippers (can be extended to higher number of carriers), we design profit-maximizing formulation in the two-stage game. Considering that the game is static, in the first stage both shippers chose their cooperative level to increase total market size, and in the second stage they chose competitive level to increase their market shares. In order to ensure practicality, we introduce constraints formulated down below for the concept model representation. For the set of carriers *A* and *B* with the set of users' Origin Destination - OD pairs, the demand function $\boldsymbol{q_{(A,B)}}$ may be written as:

$$q_{(A,B)} = q_A + q_B + \varepsilon, \tag{1}$$

$$q_s = Q^{s,od}\zeta_{\psi}^{s,od} + Q^{s,new}\zeta^{s,new}\frac{x^s}{x^A+x^B} + \theta^s, \tag{2}$$

where $\boldsymbol{Q^{s,od}}$ represents the market demand for carrier $\boldsymbol{s} \in \boldsymbol{S}$ and OD pair $\boldsymbol{od} \in \boldsymbol{OD}$ with $\boldsymbol{S}$ representing a set of carriers (in this example, carrier *A* and carrier *B*); $\boldsymbol{\zeta_{\psi}^{s,od}}$ is a factor that denotes if the selected path $\boldsymbol{\psi} \in \boldsymbol{\Psi^s}$ connects $\boldsymbol{od}$ for carrier $\boldsymbol{s}$. $\boldsymbol{\zeta_{\psi}^{s,od} = 1}$ when the selected path is connecting $\boldsymbol{od}$, while $\boldsymbol{\zeta_{\psi}^{s,od} = 0}$ otherwise; $\boldsymbol{Q^{s,new}}$ represents induced market demand that is a result from cooperation of carriers $\boldsymbol{s}$, and is dependent on various market factors, and cooperation levels; $\boldsymbol{\zeta^{s,new}}$ is a factor that denotes if the virtual path (as a result of induced demand) is used. $\boldsymbol{\zeta^{s,new} = 1}$ when used, $\boldsymbol{\zeta^{s,new} = 0}$ otherwise; $\boldsymbol{x^s}$ is the competitive effort level of carriers $\boldsymbol{s}$ (in this example, it is $\boldsymbol{x^A}$ and $\boldsymbol{x^B}$) and it represents investments in competitiveness, such is marketing. Increasing $\boldsymbol{x^s}$ leads to increased profits for a carrier $\boldsymbol{s} \in \boldsymbol{S}$. The ratio $\boldsymbol{x^s/(x^A + x^B)}$ is concave in $\boldsymbol{x^s}$ while the overall market demand function is linear in $\boldsymbol{y^s}$ which stands for cooperative effort level for carrier ***s***. Thus, in order to guarantee the existence of the optimal $\boldsymbol{x^s}$ and $\boldsymbol{y^s}$, we assume that the cost functions of $\boldsymbol{x^s}$ and of $\boldsymbol{y^s}$ are, respectively, linear and quadratic (De Ngo and Okura, 2008); $\boldsymbol{\varepsilon}$ represents error on demand. $\boldsymbol{\theta^s}$ is an administrative surplus that contains political, social, and technological components, which can have significant impact on competitiveness of an LNG shipping company. If a carrier does not have any administrative competitive advantage, the value of $\boldsymbol{\theta^s}$ will be set to 0. Generally, the carrier ***s*** profit function can be defined as:

$$R_s = (P^s - C^s)Q - k_x^s x^s - k_y^s (y^s)^2, \tag{3}$$

where $\boldsymbol{R_s}$ stands for carriers $\boldsymbol{s}$ profit function; $\boldsymbol{P^s}$ is the transport price and $\boldsymbol{C^s}$ is the variable cost for carrier $\boldsymbol{s}$. Furthermore, $\boldsymbol{Q}$ is a total market demand; $\boldsymbol{k_x^s}$ is the competitive level unit cost and $\boldsymbol{k_y^s}$ is the cooperative level unit cost for carrier ***s***. As stated before, $\boldsymbol{y^s}$ stands for cooperative effort level and $\boldsymbol{x^s}$ stands for competitive effort level for carrier ***s***. As noted in De Ngo and Okura (2008), Lin and Huang (2013) and Lin et al. (2017), $\boldsymbol{y^s}$ measures relative efforts carrier made to cooperate with other carriers and can, for example, represent all the additional costs incurred by employing staff to communicate with other carriers in order to establish cooperation. Increase in $\boldsymbol{y^s}$ leads to decrease of average cost and increase of the total market size. Considering carriers $\boldsymbol{s} \in \boldsymbol{S}$; we have following expression for their respective profit functions:

$$R^s = Q^{s,od}\left(P_{\psi}^s - C_{\psi}^s\right) + Q^{s,new}(P^{s,new} - C^{s,new}) - k_x^s x^s - k_y^s (y^s)^2. \tag{4}$$

In order to adapt profit functions to a game theoretic model, we deliver profit maximization formulation for a single LNG shipping carrier with a list of applicable constraints for the model:

$$\begin{aligned} MaxR^s = {} & Q^{s,od}\zeta_{\psi}^{s,od}\left(P_{\psi}^s - C_{\psi}^s\right) + Q^{s,new}\zeta^{s,new}(P^{s,new} - C^{s,new})\frac{x^s}{x^A + x^B} + \theta^S \\ & + \varepsilon - k_x^s x^s - k_y^s (y^s)^2, \end{aligned} \tag{5}$$

$$P^s \geq C^s \geq 0, \tag{6}$$

$$x^s \geq 0, y^s \geq 0 \quad \forall\, s \in S, \tag{7}$$

$$\textstyle\sum_{\psi \in \Psi^s} \zeta_{\psi}^{s,od} V^{s,od} = Q^{s,od} \qquad \forall\, od \in OD, \tag{8}$$

where $\boldsymbol{V^{s,od}}$ represents the volume for carrier $\boldsymbol{s} \in \boldsymbol{S}$ between OD pair $\boldsymbol{od} \in \boldsymbol{OD}$. Furthermore,

$$\frac{\sum_{n \in S} y^n}{\mu_s} = Q^{s,new} \qquad \forall\, s \in S, \tag{9}$$

where $\boldsymbol{\mu_s}$ is a factor used to convert cooperation/competition level into induced demand for company $\boldsymbol{s}$. Also,

$$\sum_{\psi\in\Psi^s}\sum_{od\in OD}\zeta_{\psi}^{s,od}\delta_{\psi,ij}^{s,od}V^{s,od} \leq \hat{U}_{ij}^{s} \qquad \forall ij \in I, \tag{10}$$

where $\boldsymbol{\delta_{\psi,ij}^{s,od} = 1}$ if arc $\boldsymbol{ij} \in \boldsymbol{I}$ is part of the selected path $\boldsymbol{\psi} \in \boldsymbol{\Psi^s}$ that connects $\boldsymbol{od} \in \boldsymbol{OD}$ for LNG shipping carrier $\boldsymbol{s}$, otherwise $\boldsymbol{\delta_{\psi,ij}^{s,od} = 0}$; $\hat{U}_{ij}^{s}$ represents upper volume bound for LNG shipper on related arc $\boldsymbol{ij} \in \boldsymbol{I}$. The last set of constraints for the model are:

$$\zeta^{s,new} \geq Q^{s,new} > 0, \tag{11}$$

$$\zeta_{\psi}^{s,od} \in \{0,1\} \qquad \forall s \in S, od \in OD, \psi \in \Psi^s, \tag{12}$$

$$\zeta^{s,new} \in \{0,1\} \qquad \forall\, s \in S, \tag{13}$$

$$k_y^s = f(y^s) \qquad \forall\, s \in S, \tag{14}$$

$$P_{\psi}^{s} = f_1\big(q_{(A,B)}\big) \qquad \forall\, \psi \in \Psi^s, s \in S, \tag{15}$$

$$P^{s,new} = f_2\big(q_{(A,B)}\big) \qquad \forall\, s \in S, \tag{16}$$

$$C_{\psi}^{s} = f_3\big(q_{(A,B)}\big) \qquad \forall\, \psi \in \Psi^s, s \in S, \tag{17}$$

$$C^{s,new} = f_4\big(q_{(A,B)}\big) \qquad \forall\, s \in S. \tag{18}$$

The constraint (6) infers that price is higher than cost and that it must have a positive value, which is logical. In order for our model to be feasible, cooperation and competition levels should be positive, which is described with the constraint (7). The constraint (8) is designed to ensure that demand between each OD pair can be serviced with the available capacity. Unlike the general and container shipping, where custom is to ensure volume is related to one shipment (carrier cannot split shippers' volume), in bulk and LNG transport cargo can be split into several shipping volumes. There is also possibility to leave part of the available volume empty. Good example is recent shipment made by Qatargas and Rasgas where one vessel was used for two different buyers and ports (Qatargas and Rasgas complete first cooloading, 2017). Constraint (9) states that the induced demand is a result of cooperation level. In other words, we can estimate how much one dollar spent on the cooperation level increases induced demand. Constraint (10) is related to the flow network of the graph theory and stipulates that the amount of flow on each arc cannot exceed its capacity. Constraint (11) is related to induced demand and states that virtual path exists only when the induced demand is positive. With constraints (12) – (13) we specify that selected path and new market demand path are binary variables. Constraint (14) specifies that the cost of cooperation is the extent of cooperation itself. In other words, higher cooperation level requires higher cooperation cost. Finally, constraints (15 – 18) assume that initial and induced prices and costs are functions of the market demand. In our example, we have LNG shipper *A* and LNG shipper *B* with already existing customers they serve. The approach to solution is through iterative heuristics. For example, the company *A* solves equations (5) – (18) and gets profit maximizing cooperation and competition levels. This will result in new market price and cost that can induce new demand, after which LNG shipping companies of the market service new demand and share profits depending on the competition efforts invested. Based on the information from the company *A*, company *B* solves for equations (5) – (18) and gets its own best cooperation and competition levels. Considering the additional change at the market, the company *A* again solves equations (5) – (18) in order to take in consideration results from the company *B* adjusting its cooperative and competitive strategies. This process continues until no company can benefit from changing its' strategy.

In order to prove that our coopetition game contains unique solution and that both carriers will use same strategy when reaching equilibrium; therefore, we are searching for unique pure strategy Nash equilibrium where all players have incentive to choose cooperation at the first stage and then competition at the second stage, given all the constraints of the model and perfect information. To derive this coopetition game, we use backward induction method adapted from McCain's (2010) work on analysis of strategy. Backward induction is commonly used in game theoretic models, and it requires us to think forward and reason backward. In this case, backward induction requires deriving equilibrium in the second stage on the basis of the first stage even though the first stage was not yet played. After completing this step, we proceed with deriving the first stage with the data resulting from the second stage derivation. We continue with the second-stage derivations below. Given the appropriate $\boldsymbol{x^s}, \boldsymbol{s} \in \boldsymbol{S}$, we have first order conditions:

$$\frac{\partial R^A}{\partial x^A} = Q^{A,new}\zeta^{A,new}(P^{A,new} - C^{A,new})\frac{x^B}{(x^A+x^B)^2} - k_x^A = 0, \tag{19}$$

$$\frac{\partial R^B}{\partial x^B} = Q^{B,new}\zeta^{B,new}(P^{B,new} - C^{B,new})\frac{x^A}{(x^A+x^B)^2} - k_x^B = 0. \tag{20}$$

We can, therefore, define the cost of increasing the competitive efforts for each of the carriers:

$$k_x^A x^A = k_x^B x^B = \frac{Q^{s,new}\zeta^{s,new}(P^{s,new} - C^{s,new})}{4}. \tag{21}$$

Considering the above, we can deliver the equilibrium competitive effort levels as:

$$x^A = x^B = \frac{Q^{s,new}\zeta^{s,new}(P^{s,new} - C^{s,new})}{4k_x^s}. \tag{22}$$

Following the competitive efforts equilibrium levels, we further investigate competitive and cooperative efforts relationship. Using equation (22) we calculate following derivatives:

$$\frac{\partial x^A}{\partial y^A} = \frac{\partial x^B}{\partial y^A} = \frac{\zeta^{A,new}\left(P^{A,new}\left(1+\frac{1}{m^A}\right) - C^{A,new}\left(1+\frac{1}{m^B}\right)\right)}{4k_x^S}, \tag{23}$$

$$\frac{\partial x^B}{\partial y^B} = \frac{\partial x^A}{\partial y^B} = \frac{\zeta^{B,new}\left(P^{B,new}\left(1+\frac{1}{m^A}\right) - C^{B,new}\left(1+\frac{1}{m^B}\right)\right)}{4k_x^S}, \tag{24}$$

where $\boldsymbol{m^s}$ represents the market share of carrier $\boldsymbol{s} \in \boldsymbol{S}$. This value is determined by each carrier's competitive level. It is calculated by the ratio $\boldsymbol{x^s}/(\boldsymbol{x^A} + \boldsymbol{x^B})$. When numerator of the equations (23) or (24) is < 0, the competitive level will decrease as the cooperative level increases, so we can assume that $\boldsymbol{x^s}$ and $\boldsymbol{y^s}$ are substitutes. However, when numerator of the equations (23) or (24) is > 0, the competitive level will increase with the increase of the cooperative level. This denotes that $\boldsymbol{x^s}$ and $\boldsymbol{y^s}$ are complements. We can now use backward induction and analyze first stage with the results from the second stage. Using equilibrium competitive effort levels $\boldsymbol{x^A}$ and $\boldsymbol{x^B}$, we calculate updated profit functions for $\forall\, \boldsymbol{s} \in \boldsymbol{S}$:

$$R_s = Q^{s,od}\zeta_\psi^{s,od}\left(P_\psi^s - C_\psi^s\right) + \frac{Q^{s,new}\zeta^{s,new}(P^{s,new} - C^{s,new})}{4} + \theta^s + \varepsilon - k_y^s(y^s)^2. \tag{25}$$

Finally, applying conditions of $\frac{\partial \boldsymbol{R_s}}{\partial \boldsymbol{y^s}} = \boldsymbol{0}, \forall\, \boldsymbol{s} \in \boldsymbol{S}$, the equilibrium cooperative effort levels are:

$$y^A = y^B = \frac{\zeta_\psi^{s,od}\left(P_\psi^S\left(1+\frac{1}{m^A}\right) - C_\psi^S\left(1+\frac{1}{m^B}\right)\right) + \zeta^{s,new}\left(P^{s,new}\left(1+\frac{1}{m^A}\right) - C^{s,new}\left(1+\frac{1}{m^B}\right)\right)}{8k_y^S}. \tag{26}$$

We can now observe that competition and cooperation equilibrium levels are identical for both companies, which implies that both LNG shipping carriers will use the same strategies when reaching coopetition equilibrium and will achieve similar resulting profits. We can conclude that there is a unique solution to the game of coopetition.

4. Conclusion

Even though we do not yet see LNG shipping companies forming strategic alliances in the same way as it is the case in shippers focusing on container transportation, the increasing number of emerging LNG transportation companies and general expansion of the market leads to the higher number of cooperative maneuvers in the near future. An investment is complementary element and companies have strong incentive to cooperate at investment stage. In this paper we set the framework for coopetitive game fundamentals and concept model representation for LNG transportation industry. In order to develop feasible model that will assist maritime practitioners and researchers, we used profit maximization approach of a single carrier in order to resolve coopetition model. With profit maximization problem defined as mixed-integer and nonlinear problem, we approach to solution with iterative heuristics. In this approach, the coopetition game is elaborated from the static perspective; therefore, dynamic direction with asymmetric information is also a feasible methodology that could be considered for future research. Finally, we considered formation of strategic alliances based on competition and cooperation level, but coopetition can be function of other factors, such are various agreements among carriers, special deliveries to multiple customers, or even generation of specific projects that generate new demand. A model that incorporates these factors would produce insightful solutions.

References

[1] Agarwal, R., and Ergun, O. 2010. Network Design and Allocation Mechanisms for Carrier Alliances in Liner Shipping. Operations Research 58 (6): 1726–1742.

[2] Casaca, P., Ana, C., and Marlow, P. B. 2005. The Competitiveness of Short Sea Shipping in Multimodal Logistics Supply Chains: Service Attributes. Maritime Policy Management 32 (4): 363–382.

[3] Chang, Y. T., Lee, S. Y., and Tongzon, J. L. 2008. Port Selection Factors by Shipping Lines: Different Perspectives between Trunk Liners and Feeder Service Providers. Marine Policy 32 (6): 877–885.

[4] Cherington, P. T. 1976. Advertising as a Business Force: A Compilation of Experiences, Ayer Company Publishers, Manchester, NH, USA.

[5] De Ngo, D., and Okura, M. 2008. Coopetition in a Mixed Duopoly Market. Economics Bulletin 12 (20): 1–9.

[6] Ding, J. F., and Liang, G. S. 2005. Using Fuzzy MCDM to Select Partners of Strategic Alliances for Liner Shipping. Information Sciences 173 (1–3): 197–225.

[7] Gelareh, S., Nickel, S. and Pisinger, D. 2010. Liner Shipping Hub Network Design in a Competitive Environment. Transportation Research Part E-Logistics and Transportation Review 46 (6): 991–1004.

[8] Gurnani, H., Erkoc, M., and Luo, Y. 2007. Impact of product pricing and timing of investment decisions on supply chain coopetition. European Journal of Operational Research, vol. 180, no. 1, pp. 228–248.

[9] Heaver, T., Meersman, H., Moglia, F., and Eddy, V. D. V. 2000. Do Mergers and Alliances Influence European Shipping and Port Competition? Maritime Policy & Management 27 (4): 363–373.

[10] Hoffman, J. 1998. Concentration in Liner Shipping-Its Causes and Impacts for Ports and Shipping Services in Developing Regions. ECLAC, Santiago.

[11] Lin, D. Y., and Huang, C. C. 2013. Coopetition in International Maritime Shipping. Polish Maritime Research 20: 5–12.

[12] Lin, D. Y., Huang, C. C., and Ng, M. 2017. The coopetition game in international liner shipping. Maritime Policy & Management 44: 474-495.

[13] Liu, J., Li, Y., and Li, J. 2015. Coopetition in Intermodal Freight Transport Services. Discrete Dynamics in Nature and Society, vol. 2015, Article ID 680685, 1-11.

[14] McCain, R. A. 2010. Game Theory, A Nontechnical Introduction to the Analysis of Strategy, World Scientific

[15] Panayides, P. M., and Wiedmer, R. 2011. Strategic Alliances in Container Liner Shipping. Research in Transportation Economics 32 (1): 25–38.

[16] Peters, H.J. 1991. The commercial aspects of freight transport-ocean transport: freight rates and tariffs. Infrastructure Notes Transportation, Water and Urban Development Department, The World Bank, Transport no. PS-3.

[17] Qatargas and Rasgas complete first cooloading of LNG. (October 2017). Retrieved from http://www.amemaritime.com/news/view,qatargas-and-rasgas-complete-first-coloading-of-lng_48851.htm

[18] Slack, B., Comtois, C., and Robert, M. 2002. Strategic Alliances in the Container Shipping Industry: A Global Perspective. Maritime Policy & Management 29 (1): 65–76.

[19] Song, D.-W. 2003. Port Coopetition in Concept and Practice. Maritime Policy & Management 30 (1): 29–44.

[20] Song, D.-W., and Panayides, P. M. 2002. A Conceptual Application of Cooperative Game Theory to Liner Shipping Strategic Alliances. Maritime Policy & Management, no. 3: 285–301.

[21] Sys, C., 2009. Is the container liner shipping industry an oligopoly? Transport policy, 16, 259-270.

[22] Wang, H., Meng, Q., and Zhang, X. N. 2014. Game-Theoretical Models for Competition Analysis in a New Emerging Liner Container Shipping Market. Transportation Research Part B-Methodological 70: 201–227.