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Berth allocation problem under uncertainty: A conceptual model using collaborative approach

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Abstract

Berth as infrastructure in the port have an important role in the operation of container terminals. The performance of terminal to serve the customers is determined by availability of berth and facilities to support of container terminal activities. In the last decade, several research related of these issues had been conducted particularly in the berth allocation problem. Most of the researchers had developed the model base on deterministic assumptions whereas models which are considering variability as uncertainty still rarely. Variability of ship arrival time and handling time are causes the difference between the schedule planned and actual berthing time. These difference reduce berth productivity due loading and unloading time could not predictable. This situation will influence to operational cost for shipping lines and terminal operators. This paper develop a conceptual model of ship-to-berth allocation considering variability of ship arrival and service time. Collaborative strategies is considered as an scenario through asset sharing and joint planning and operation. The objective to develop model are reducing total handling time and improve resources utility such as berth, quay crane, and container yard simultaneously.

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Keywords: *Berth allocation; collaboration; uncertainty*

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1. Introduction

Berth allocation problem (BAP) is the allocation of certain vessels at the berth at a specific time during the time period of planning so that the vessel can carry out loading and unloading activities at the terminal [1]. BAP occur in multi-user terminal, the terminal which is used jointly by several shipping lines [2]. The use of multi-user terminal due to the competition among shipping lines are increasingly stringent, so the shipping lines trying to reduce operating costs by changing the loading and unloading activities of the dedicated terminal to multi-user terminal [2][3]. The challenge facing the terminal is to determine the ship-to-berth allocation in order to provide optimal service to shipping lines.

Based on the arrival of the ship, BAP has two characteristics, namely static and dynamic BAP [4]. Static BAP is ship-to-berth allocation where all ships were already in the terminal when the berth allocation is planned. While dynamic BAP is ship-to-berth allocation where not all vessels to be scheduled for berthing have arrived. Apart by the arrival of the ship, BAP also is based on the spatial conditions of the berth that is discrete, continuous and hybrid [5][6]. Discrete berth allocation problem is done by dividing the berth into several parts, the ship will occupy one section. Continuous ship berth allocation problem can be allocated anywhere along the berth are available. Hybrid models made by combining between discrete and continuous, in one part can be scheduled more than one ship, or one ship can occupy more than one section.

Terminal consists of several berth so that the vessel can be parallel berthing at the same time. Therefore arises the problem of how to allocate the berth and crane simultaneously. Simultaneous discussion between the berth allocation problem and quay crane allocation problem known as berth allocation and quay crane allocation problem (BACAP) [7]. Berth allocation is not only related to the number of cranes, but also with the assignment of the crane. Crane assignment is crucial because the crane cannot move freely. Terminology used is the berth allocation and crane assignment problem (BACASP) [8]. The movement of container depends on the distance between the location of berthing and location of stacking. Differences of distance have consequences on the housekeeping cost [9] [10][11]. Berth allocation problem faced with uncertainty, the uncertainty of the arrival of the ship and the variability of the amount of cargo. Zhen et al [12] and Zhen & Chang [1] proposes two strategies to deal with the uncertainty of the arrival of the ship, which is a proactive strategy and a reactive strategy. Proactive strategy is a strategy that is done by entering the element of uncertainty when preparing scheduling model (baseline schedule), while reactive strategy is strategy is done by making adjustments to the baseline schedule.

Uncertainty arrival of the ship is a factor that is difficult to be avoided and controlled. The uncertainty of the ship arrival cause harm to both parties shipping lines and terminal operators. Terminal operators suffered losses due to berth and other facilities that have been allocated become idle or underutilized. As a result, the port must bear the cost due to the existing facilities cannot be used optimally. Shipping lines suffered a loss of time and cost because the ship had to wait until it gets berthing schedule for discharging and loading.

Based on the observations made in the two largest container terminal in Indonesia, namely JICT and Koja, the arrival of the vessel at both terminals varies when compared with ETA. The uncertainty of the arrival of the vessel was also addressed by several authors such as [12][13][5][14]. The uncertainty of the arrival of the ship caused the idle and shortage, so it is likely to happen at the same time that the terminal has a resource that is not utilized (idle) while at the other terminal there is a shortage of resources. Due to the absence of collaboration, the terminal operator in delivering services to shipping lines only rely on the ability of its resources, without considering the resources of other terminal, and vice versa. In this paper developed a conceptual model on berth allocation problem under uncertainty with collaboration strategy. The goal is to increase the utility of resources, by conducting joint planning and operation.

2. Literature review

BAP was initially discussed with first come first service with static berth allocation approach [4]. The study was conducted at the naval port and concluded that the optimal allocation is done by moving the ship is being unloaded to be replaced by another vessel [4]. Commercial port have to serve ships until completion without interruption, so that the approach is not appropriate [4]. Weakness FCFS approach is if the size of the ships that served have different capacities, ships with a small capacity has the time to wait longer. According to Imai et al [15] to find the optimal allocation of ships, must find ways other than FCFS. This approach is also considered less realistic because it is only suitable for very busy port [2][16][17].

Imai et al [4] developed a model dynamic discrete berth allocation problem. Dynamic discrete berth allocation model followed by many other researchers, but differ in the method of solution. Solving methods used included Sub Gradient Lagrangian Relaxation [4], Variable Neighborhood Search [18], Hybrid Meta heuristic [19], the lambda optimal [20], clustering search with a simulated Annealing [21], the Particle Swam Optimization (PSO) [22]. Other researchers have developed a model of multiple depots vehicle routing problem with time windows "unpublished" [23], and the model of heterogeneous vehicle routing problem with time windows [24]. Model heterogeneous vehicle routing problem with time windows is the development model of multiple depots vehicle routing problem with time windows developed by "unpublished" [23]. Some researchers consider the difference in variable water depth [25], variable water depth and tidal condition [26], using a scale of priority [27].

Imai et al [28] and Golias et al [29] using the method of multi-objective. Solving methods used include heuristic genetic algorithm [25], heuristic [26], genetic algorithm [27], Lagrangian Relaxation [28], Genetic Algorithm [29]. Legato et al [30] developed a model that integrates the tactical level and operational level. At the tactical level resolved with mathematical programming, and at the operational level completed by simulation. Multi-purpose models to minimize costs and maximize robust schedule (measured by time buffer) was developed by [1], with completion using heuristic methods. Other terminology used [31] is the coupling problem of berth and quay crane allocation (C-B & CAP), with completion using the inner and outer algorithm. The dynamic continuous berth allocation problem models developed by [32] with the aim to minimize the total weighted flow time. Completion method using Greedy Randomized Adaptive Search Procedure.

Another factor to consider is the uncertainty that is the deviation time of arrival of ships and uncertainties service time [12]. Zhen et al [12] applying two strategies, namely proactive strategy and reactive strategy, where settlement using meta heuristic approach. Golias et al [14] and Ting et al "unpublished" [33] considering the uncertainty of arrival time and handling time. Golias et al [14] completed with a heuristic algorithm method, whereas "unpublished" [33] completed the Simulation Annealing method.

The time taken by ships to load and unload depends on the amount of container quay allocated, the amount and speed of internal vehicle transportation, and the availability of container yard. Therefore, berthing allocation, quay crane allocation, the allocation of container yard and deployment of internal transportation cannot be considered separately, but must be considered simultaneously. Some researchers discuss the completion of BAP and QCAP simultaneously, including [20][2][3][34][35]. The model developed [34] aims to minimize handling time, waiting time and delay time. Liang et al [34] solve this problem by using Hybrid Genetic Algorithm, while [35] completed with a hybrid parallel genetic algorithm method (combination of parallel genetic algorithm and Heuristic Algorithm). BACAP models using two approaches based on the movement QC, i.e. QC who cannot be moved freely [2] [8] and QC that can be moved freely [36] [37]. Imai et al [2] assumes that the QC cannot move freely, because QC just move on the same rail so that cannot cross each other. Imai et al [2] solved this problem by using Genetic Algorithm-based heuristic methods, whereas [8] completing using the cutting plane algorithm method. Han et al [36] and Raa et al [37] using the assumption QC can move freely. Han et al [36] consider the stochastic factor in the arrival of the ship and handling time, the settlement using a Genetic Algorithm, while [37] finish with a mixed integer linear programming. Elwany et al [38] developed model a dynamic continuous berth allocation and crane assignment problems by considering the variable water depth, with completion using heuristic methods. Hendriks et al [39] distinguish the type of container being moved, ie reefer, dangerous goods, empty containers, full containers, with completion using heuristic methods. Lalla-ruiz et al [6] and Jin et al [11] developed a model BACAP specifically for transshipment. Lalla-ruiz et al [6] [6] completed by the method of random genetic bias Encryption, while Jin et al [11] using the method of column generation base approach. Giallombardo et al [9] and Lee and Jin [10] examined the housekeeping cost by integrating between the berth allocation, assignment quay cranes and yard allocation in transshipment terminal. The goal is to maximize total revenue and minimize housekeeping cost. In this model the housekeeping cost distinguished by the displacement distance of container. Differences distance determines the type of transport used

and the fees charged. Giallombardo et al [9] completed with a combination of tabu search method and mathematical programming methods, while Lee and Jin [10] using memetic heuristics.
The studies above using assumptions that arrival time and services time are deterministic. Peng-fei & Hi-gui [3], Zhen et al [12] and Hendriks et al [40] using the assumption that arrival and handling time are stochastic. Peng-fei & Hai-gui [3] completed by Genetic Algorithm. Hendriks et al [40] developed model a robust mixed integer linear programming (MILP).

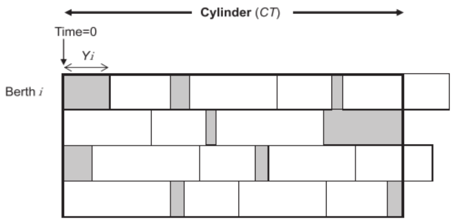

Fig. 1. Cylinder home berth design problem
Source : [16]

Berth allocation is usually made for the long term, in practice the arrival of the vessel (ship call) occurs in fixed period and recurring (usually every week). Because the ship call is repeated with fixed period, then scheduling only need to be made within a period of one week [41]. Moorthy & Teo [41] uses terminology cylinder home berth design problems, while Imai et al [16] uses terminology berth template allocation problem. Schedule is described in the rectangular, where the horizontal side shows the time (arrival time, waiting time, handling time, departure time), while the vertical side shows berth length and the length of the ship. Planning time horizon generally use fixed and repetitive cycle, thus the planning time horizon is analogous to the cylinder. Moorthy & Teo [41] solved using the method of sequence pair based simulated annealing algorithm, while Imai et al [16] solved by using the sub gradient optimization procedure. Fig. 1 shows the template berth allocation problem.

3. Conceptual model and framework

Port operations planning can be broadly classified into three categories, namely strategic, tactical and operational [41][20][39][16]. Cooperation between terminal operators and shipping lines, as well as cooperation between the terminal operator and another operator terminal is a strategic decision. Shipping lines choose cooperation with the operator terminal by considering several factors, such as port efficiency, adequate infrastructure, port charges, and a quick response to port user's needs [42]. Conversely, terminal operators choose shipping lines that can provide maximum throughput [43]. Another strategic decision is cooperation between the terminal operator and another terminal operator associated with the use of resources, planning and operations. Uncertainty arrival of the ship on the one hand lead to resource becomes idle, while on the other hand lead to a shortage of resources.
Decision determines windows or arrange berth allocation is the decision on the tactical level. Terminal operators consider three factors in determining a slot for each shipping lines, which is the estimated number of containers (the amount of cargo), estimated time of arrival and departure, and estimated of handling time. Total container varies in each period, the greater number of the containers the longer time it takes, and or the greater number of container cranes needed. Scheduled arrival and departure of ships interlocking between the previous and next port. Thus the time of arrival and departure times must be adjusted to the time of departure from the previous port and time of arrival at the next port, and voyage time required.

Decisions in determining the location of berthing, the number of quay cranes and stacking location is a decision of an operational nature. At the operational level, problems often arise due to differences between the arrival of the vessel and windows slot, the amount of cargo that is varied, the distance between the location of berthing with the stacking area that is not ideal, as well as limitations to mobilize straddle carriers are needed. Limitations resources owned, restrict terminal operators in providing services to shipping lines, so that services become less flexible. Ships were late arriving at the port (regardless of the amount of delay) should get the service for loading/unloading to completion.

On one side, the ship that came too late causes the resources allocated are planned to be idle. Terminal operators are trying to cope with problems that arise simultaneously by adjusting the berthing schedule and strive to use idle resources. To resolve this problem proposed by the collaborative approach, which is a collaboration between terminal operators. Collaboration is done by the use of resources together, and to develop joint planning and operation. Fig. 2 shows a conceptual model and framework berth allocation problem under uncertainty.

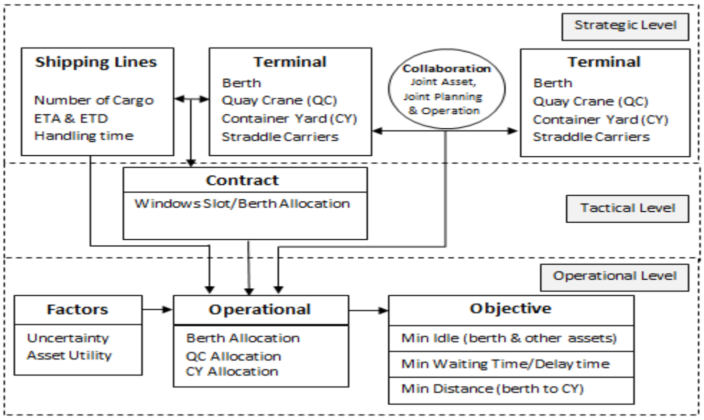

Fig. 2. Berth collaboration framework

The main resource used by the terminal operator to meet the needs of shipping lines is berth, quay cranes, rubber tire gantry, straddle carriers and container yard. Terminal operators allocate its resources to provide optimum service, according to the needs of shipping lines. In windows agreed to allocate the resources to serve the shipping lines. Windows agreements is a guarantee for shipping lines and terminal operators. For shipping lines, windows slot is a certainty to get the time and service facilities, while the operator terminal is certainty to allocate resources optimally. Uncertainty arrival and service vessels cause cannot be utilized resources optimally, and result in low quality service to shipping lines. Companies need a strategy for resource utilization can be in an optimal way, and at the same time can improve the quality of service. One strategy that can be done is through collaboration, as the collaboration does not only rely on its resources, but it can exploit other resources (external resources) [44][45][46]. Based on observations, almost in every port has limited resources, so it is less flexible in the face of uncertainty arrival of the ship. Terminal generally only rely on its resources, working alone and did not do a collaboration.

4. Discussion

Ships that pursue delay arrival of their expected ETA may cause harm to the terminal operator and shipping lines. Terminal operators suffered losses due to resources become idle and cause the disturbed ship schedule (in part or whole), so that the terminal operator must conduct rescheduling. Rescheduling with a high frequency causing declining quality service, in the long term lead to competitiveness decreased. Shipping lines suffered losses due to lost time and incur additional cost. Thus terminal operators need to make innovations and improvements so that the resources used to be optimal and services to shipping lines increased.

Based on the data [47][48][49] showed that more than 80 percent of freight carried out using sea transport, and of these 80 percent are done using a container [48][50]. Based on the value of goods shipped, approximately 70.1% value of goods shipped by sea transportation [48].

Number of containers shipped through the port has increased. Increasing the amount of container led to an increase in the growth of shipping lines, so competition between the shipping line or the shipping industry increased significantly

[48]. Most shipping lines are changing of operating strategy from dedicated terminal to multi-user terminal. Change of strategy becomes a challenge terminal operators to provide optimum service with limited resource [6].
Fig. 3 shows the operating characteristics at the container terminal. The arrival of the ship have been scheduled in accordance with windows slot, but in fact the arrival of the ship is not always appropriate in accordance with a predetermined schedule. Before the ship arrives at the port, shipping lines determined estimated the time of arrival of the vessel (ETA). ETA used by terminal operators as the basis for determining the time when stacking can begin (open stack). Container to be loaded onto the ship (container export), both the amount and timing of delivery not fully be controlled by shipping lines, but it really depends on the shipper. Shipping lines have the time to do the stacking from the time the open stack begins until the ship arrives at the dock. Shipping lines have to make sure that all items listed in the document of bill of lading entirely already in stacking yard. Container import and export is stored / stacked on different yard. The distance between the location of berthing and stacking determine the displacement time and internal vehicle transport are deployed, consequently the greater the distance the movement of container, the greater the cost of movement.

Ships docked at a particular berth where they have windows slots, as well as the use of yard and other equipment. Mismatches between the arrival of ships with ETA resulted in the possibility at one terminal on the one hand there are idle resources, and on the other side of the terminal there is a shortage of resources. Since each terminal is managed separately and there is no cooperation, then the idle resources cannot be used by another terminal. Vice versa, terminal operators rely on the resources that they have, even though they are deficient, they do not take advantage of the resources owned by another terminal, although these resources are idle.
The uncertainty of the arrival of the ship, the limited resources, the amount of cargo, the number of quay cranes, berthing location, location of stacking, as well as the internal transport vehicle that is allocated will affect the time of service of the vessel. These factors cause idle and shortage at the same time. Idle resources and lack of resources also occurs in another terminal. On one side of the terminal operators cannot utilize the idle resources, on the other hand the operator terminal shortage of resources. Only idle resources that could be used by another terminal, and vice versa terminal operator can utilize the idle resources are owned by the other terminal.

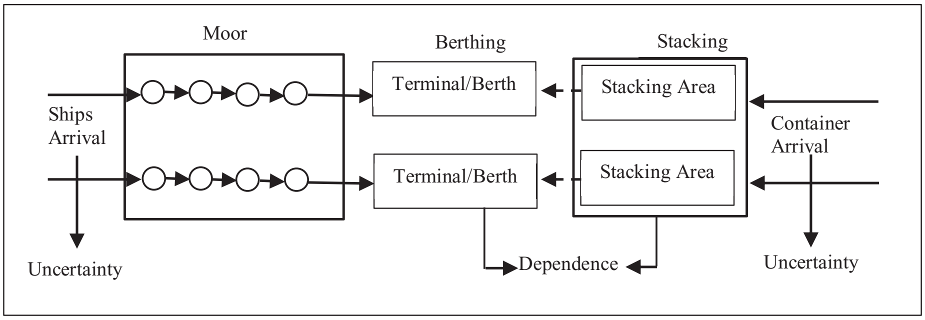

Fig. 3. Port operation characteristic

Competition today is not only between companies with the company, but between supply chain [51]. Competition is not enough to simply rely on its resources, but should be able to utilize external resources [44][45][46]. Therefore, to be able to utilize external resources, one of the strategies that can be done is to build collaboration.
According to Wang et al [52] factors are driving companies to collaborate because of the high cost of the investment required for expansion. The port is one of the companies that require huge investments [40]. Another constraint is the unavailability of land in ports which allow for expansion [37].

Collaboration can improve the quality and flexibility of service and allows the use of resources in economies of scale [53][54], increasing the use of asset utilization [49][55], increase the speed of distribution and customer services [55], lowering logistics costs [56][57]. According to Cousin & Menguc [58], a collaboration can be done by improving the sharing of resources. According to Lorentz [59], there are factors that allow collaborative relationships which are involved in the planning, control of operations together, and share the profits and risks. Collaboration is done to improve the response to the customer by identifying ways to reduce or eliminate excessive costs, improve quality and reliability, as well as increasing the speed and flexibility of service [60]. The ability to provide services by the terminal is determined by the availability of key resources such as berth, quay crane, internal vehicle transportation, and container yard.

According to Hall et al [61] collaboration among port stakeholders is one innovative strategies in an effort to provide services to shipping lines, especially related to the flow of goods in the supply chain. Ports and shipping lines have an interest to facilitate the flow of goods, so the port seeks to provide a more competitive, effective, efficient and flexible. The ability to provide services in accordance with customer needs become an attraction shipping lines. Services effectively, efficiently can improve the competitiveness of the port, while the ability to provide a flexible service that can be used as a competitive advantage [60].

5. Conclusion and future research

In this study we proposed collaboration framework among port terminal operators. This framework is built to cope with berth allocation under uncertainty. As arrival of vessels in port is highly uncertain, collaboration is believed to improve both service level and facility utilization. Our preliminary results suggest that the success of collaboration is determined not only by the willingness of the port operators to collaborate, but also the setting of the port infrastructure. Sharing resources for loading and unloading, for example, would be possible if the two or more collaborating parties manage facilities which are physically adjacent so that vessels could have an easy alternative for berthing. This study will be extended to include more in depth case analysis to map the current state of horizontal collaboration.

References

[1] L. Zhen and D. Chang, "A bi-objective model for robust berth allocation scheduling q," *Comput. Ind. Eng.*, vol. 63, no. 1, pp. 262–273, 2012.

[2] A. Imai, E. Nishimura, and S. Papadimitriou, "Berthing ships at a multi-user container terminal with a limited quay capacity," *Transp. Res. Part E*, vol. 44, pp. 136–151, 2008.

[3] Z. Peng-fei and K. Hai-gui, "Study on Berth and Quay-crane Allocation under Stochastic Environments in Container Terminal," *Syst. Eng. - Theory Pract.*, vol. 28, no. 1, pp. 161–169, 2008.

[4] A. Imai, E. Nishimura, and S. Papadimitriou, "The dynamic berth allocation problem for a container port," *Transp. Res. Part B*, vol. 35, pp. 401–417, 2001.

[5] A. Imai, X. Sun, E. Nishimura, and S. Papadimitriou, "Berth allocation in a container port : using a continuous location space approach," *Transp. Res. Part B*, vol. 39, pp. 199–221, 2005.

[6] E. Lalla-ruiz, J. L. González-velarde, B. Melián-batista, and J. M. Moreno-vega, "Biased random key genetic algorithm for the Tactical Berth Allocation Problem," *Appl. Soft Comput. J.*, vol. 22, pp. 60–76, 2014.

[7] F. Meisel and C. Bierwirth, "Heuristics for the integration of crane productivity in the berth allocation problem," *Transp. Res. Part E*, vol. 45, no. 1, pp. 196–209, 2009.

[8] Y. B. Türkogulları, Z. C. Taskın, N. Aras, and I. K. A. B, "Optimal berth allocation and time-invariant quay crane assignment in container terminals," *Eur. J. Oper. Res.*, vol. 235, pp. 88–101, 2014.

[9] G. Giallombardo, L. Moccia, M. Salani, and I. Vacca, "Modeling and solving the Tactical Berth Allocation Problem," *Transp. Res. Part B*, vol. 44, no. 2, pp. 232–245, 2010.

[10] D. Lee and J. G. Jin, "Feeder vessel management at container transshipment terminals," *Transp. Res. Part E*, vol. 49, no. 1, pp. 201–216, 2013.

[11] J. G. Jin, D.-H. Lee, and H. Hua, "Tactical berth and yard template design at container transshipment terminals : A column generation based approach," *Transp. Res. Part E*, vol. 73, pp. 168–184, 2015.

[12] L. Zhen, L. Hay, and E. Peng, "A decision model for berth allocation under uncertainty," *Eur. J. Oper. Res.*, vol. 212, no. 1, pp. 54–68, 2011.

[13] P. Legato, R. M. Mazza, and R. Trunfio, "Simulation-Base Optimization For The quay Crane Scheduling Problem," in *Proceedings of the 2008 Winter Simulation Conference*, 2008.

[14] M. Golias, I. Portal, D. Konur, E. Kaisar, and G. Kolomvos, "Robust berth scheduling at marine container terminals via hierarchical optimization," *Comput. Oper. Res.*, vol. 41, pp. 412–422, 2014.

[15] A. Imai, K. Nagaiwa, and W. T. Chan, "Efficient planning of berth allocation for container terminals in Asia," *J. Adv. Transp.*, vol. 31, no. 1, pp. 75–94, 1997.

[16] A. Imai, Y. Yamakawa, and K. Huang, "The strategic berth template problem," *Transp. Res. Part D*, vol. 72, pp. 77–100, 2014.
[17] S. Wang, Z. Liu, and X. Qu, "Advanced Engineering Informatics Collaborative mechanisms for berth allocation q," *Adv. Eng. INFORMATICS*, pp. 8–14, 2015.
[18] P. Hansen, C. Og, and N. Mladenovic, "Variable neighborhood search for minimum cost berth allocation," *Eur. J. Oper. Res.*, vol. 191, pp. 636–649, 2008.
[19] E. Lalla-Ruiz, B. Melian-Batista, and J. M. Moreno-Vega, "Artificial intelligence hybrid heuristic based on tabu search for the dynamic berth allocation problem," *Eng. Appl. Artif. Intell.*, vol. 25, pp. 1132–1141, 2012.
[20] M. M. Golias, M. Boile, and S. Theofanis, "A lamda-optimal based heuristic for the berth scheduling problem," *Transp. Res. Part C*, vol. 18, no. 5, pp. 794–806, 2010.
[21] R. M. de Oliveira, G. R. Mauri, and L. A. N. Lorena, "Clustering Search for the Berth Allocation Problem," *Expert Syst. Appl.*, vol. 39, no. 5, pp. 5499–5505, 2012.
[22] Q. Yang, T. Lu, T. Yao, and B. Zhang, "ScienceDirect The impact of uncertainty and ambiguity related to iteration and overlapping on schedule of product development projects," *JPMA*, vol. 32, no. 5, pp. 827–837, 2014.
[23] J.-F. Cordeau, G. Laporte, P. Legato, and L. Moccia, "Models and Tabu Search Heuristics for the Berth Allocation Problem," pp. 1–24, 2005.
[24] K. Buhrkal, S. Zuglian, S. Ropke, J. Larsen, and R. Lusby, "Models for the discrete berth allocation problem : A computational comparison," *Transp. Res. Part E*, vol. 47, no. 4, pp. 461–473, 2011.
[25] E. Nishimura, A. Imai, and S. Papadimitriou, "Berth allocation planning in the public berth system by genetic algorithms," *Eur. J. Oper. Res.*, vol. 131, pp. 282–292, 2001.
[26] D. Xu, C. Li, and J. Y. Leung, "Berth allocation with time-dependent physical limitations on vessels," *Eur. J. Oper. Res.*, vol. 216, no. 1, pp. 47–56, 2012.
[27] A. Imai, E. Nishimura, and S. Papadimitriou, "Berth allocation with service priority," *Transp. Res. Part B*, vol. 37, pp. 437–457, 2003.
[28] A. Imai, J.-T. ZHANG, E. NISHIMURA, and S. PAPADIMITRIOU, "The Berth Allocation Problem with Service Time and Delay Time Objectives," *Marit. Econ. Logist.*, pp. 269–290, 2007.
[29] M. M. Golias, M. Boile, and S. Theofanis, "Berth scheduling by customer service differentiation : A multi-objective approach," *Transp. Res. Part E*, vol. 45, no. 6, pp. 878–892, 2009.
[30] P. Legato, R. M. Mazza, and D. Gullì, "Integrating tactical and operational berth allocation decisions via Simulation – Optimization q," *Comput. Ind. Eng.*, vol. 78, pp. 84–94, 2014.
[31] C. Yang, X. Wang, and Z. Li, "An optimization approach for coupling problem of berth allocation and quay crane assignment in container terminal," *Comput. Ind. Eng.*, vol. 63, no. 1, pp. 243–253, 2012.
[32] D. Lee, J. H. Chen, and J. X. Cao, "The continuous Berth Allocation Problem : A Greedy Randomized Adaptive Search Solution," *Transp. Res. Part E*, vol. 46, no. 6, pp. 1017–1029, 2010.
[33] C. Ting, S. Lin, and K. Wu, "The Continuous Berth Allocation Problem by Simulated Annealing," *Asia Pacific Ind. Eng. Manag. Syst.*
[34] C. Liang, Y. Huang, and Y. Yang, "A quay crane dynamic scheduling problem by hybrid evolutionary algorithm for berth allocation planning," *Comput. Ind. Eng.*, vol. 56, no. 3, pp. 1021–1028, 2009.
[35] D. Chang, Z. Jiang, W. Yan, and J. He, "Integrating berth allocation and quay crane assignments," *Transp. Res. Part E*, vol. 46, no. 6, pp. 975–990, 2010.
[36] X. Han, Z. Lu, and L. Xi, "A proactive approach for simultaneous berth and quay crane scheduling problem with stochastic arrival and handling time," *Eur. J. Oper. Res.*, vol. 207, no. 3, pp. 1327–1340, 2010.
[37] B. Raa, W. Dullaert, and R. Van Schaeren, "An enriched model for the integrated berth allocation and quay crane assignment problem," *Expert Syst. Appl.*, vol. 38, no. 11, pp. 14136–14147, 2011.
[38] M. H. Elwany, I. Ali, and Y. Abouelseoud, "A heuristics-based solution to the continuous berth allocation and crane assignment problem," *Alexandria Eng. J.*, vol. 52, no. 4, pp. 671–677, 2013.
[39] M. P. M. Hendriks, E. Lefeber, and J. T. Udding, "Simultaneous berth allocation and yard planning at tactical level," *OR Spectr.*, pp. 441–456, 2013.
[40] M. Hendriks, M. Laumanns, E. Lefeber, and J. Tijmen, "Robust cyclic berth planning of container vessels," *OR Spectr.*, pp. 501–517, 2010.
[41] R. Moorthy and C.-P. Teo, "Berth management in container terminal : the template design problem," *OR Spectr.*, 2006.
[42] J. L. Tongzon, "Port choice and freight forwarders," *Transp. Res. Part E*, vol. 45, no. 1, pp. 186–195, 2009.
[43] W. K. Talley and M. Ng, "Maritime transport chain choice by carriers , ports and shippers," *Intern. J. Prod. Econ.*, vol. 142, no. 2, pp. 311–316, 2013.
[44] J. P. Sheppard, "Resources Dependence Approach to Organizational Failure," *Soc. Sci. Res.*, vol. 24, pp. 28–62, 1995.
[45] B. S. Fugate, B. Davis-sramek, and T. J. Goldsby, "Operational collaboration between shippers and carriers in the transportation industry," vol. 20, no. 3, pp. 425–447, 2009.
[46] K. A. Assi, "Integrating Resource Dependence Theory and Theory of ConstraintWeak Ties To Understand Organizational Behavior," in *Public Management Research Conference*, 2013, pp. 1–26.

[47] M. Feng, J. Mangan, and C. Lalwani, "Comparing port performance : Western European versus Eastern Asian ports," *Int. J. Phys. Distrib. Logist. Manag.*, vol. 42, pp. 490–512, 2011.

[48] N. Asgari, R. Zanjirani, and M. Goh, "Network design approach for hub ports-shipping companies competition and cooperation," *Transp. Res. Part A*, vol. 48, pp. 1–18, 2013.

[49] R. Mason and R. Nair, "Supply-side strategic flexibility capabilities in container liner shipping," *Int. J. Logist. Manag.*, vol. 24, pp. 22–48, 2013.

[50] W.-K. K. Hsu, "Improving the service operations of container terminals," *Int. J. Logist. Manag.*, vol. 24, no. 1, pp. 101–116, 2013.

[51] J. Li, W. Li, and Y. Lin, "Port Supply Chain Simulation Model under Interactive Analysis," *Procedia Eng.*, pp. 1–5, 2011.

[52] X. Wang, H. Kopfer, and M. Gendreau, "Operational transportation planning of freight forwarding companies in horizontal coalitions," *Eur. J. Oper. Res.*, vol. 237, no. 3, pp. 1133–1141, 2014.

[53] R. Leitner, F. Meizer, M. Prochazka, and W. Sihn, "CIRP Journal of Manufacturing Science and Technology Structural concepts for horizontal cooperation to increase efficiency in logistics," *CIRP J. Manuf. Sci. Technol.*, vol. 4, no. 3, pp. 332–337, 2011.

[54] B. Adenso-Diaz, S. Lozano, S. Garcia-Carbajal, and K. Smith-Miles, "Assessing partnership savings in horizontal cooperation by planning linked deliveries," *Transp. Res. Part A*, vol. 66, pp. 268–279, 2014.

[55] A. A. Juan, J. Faulin, E. Perez-Bernabeu, and N. Jozefowiez, "Horizontal Cooperation in Vehicle Routing Problem with Backhouling and Environmental Criteria," *Procedia - Soc. Behav. Sci.*, vol. 111, pp. 1133–1141, 2014.

[56] O. Yilmaz and S. Savasaneril, "Collaboration among small shippers in a transportation market," *Eur. J. Oper. Res.*, vol. 218, no. 2, pp. 408–415, 2012.

[57] S. Lozano, P. Moreno, B. Adenso-díaz, and E. Algaba, "Cooperative game theory approach to allocating benefits of horizontal cooperation," *Eur. J. Oper. Res.*, vol. 229, no. 2, pp. 444–452, 2013.

[58] P. D. Cousins and B. Menguc, "The implications of socialization and integration in supply chain management," *J. Oper. Manag.*, vol. 24, no. 2006, pp. 604–620, 2013.

[59] H. Lorentz, "Collaboration in Finnish-Russian supply chains of experience," *Balt. J. Manag.*, vol. 3, pp. 246–265, 2008.

[60] J. Tongzon, Y. Chang, and S. Lee, "How supply chain oriented is the port sector ?," *Intern. J. Prod. Econ.*, vol. 122, no. 1, pp. 21–34, 2009.

[61] P. V Hall, T. O. Brien, and C. Woudsma, "Environmental innovation and the role of stakeholder collaboration in West Coast port gateways," *Res. Transp. Econ.*, vol. 42, no. 1, pp. 87–96, 2013.