Prioritizing Criteria for Dwell Time Efficiency in Port Logistic Process

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Submission date: 31-Aug-2020 10:16PM (UTC+0700)
Submission ID: 1376982481
File name: Paper_ID_014_-_Oki_Sunardi_-_Rev.pdf (530.84K)
Word count: 4821
Character count: 26802

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ABSTRACT

The efficiency of dwell time at the loading and unloading port is crucial for the overall efficiency of logistics costs. While the Government targets the dwell time to only two days on average, the dwell time average at major Indonesian ports is at 3.5 days. This condition become an obstacle for Indonesia to compete in global port operations. This paper presents how the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) approach may help the decision maker in Port operations to prioritizing criteria which are crucial to streamlining dwell time at the Port Tanjung Priok. Three experts were involved in this study, examining four criteria and 16 sub-criteria. This study found that the Human Resource Management becomes the most dominant criterion to be prioritized, followed by the IT-based Licensing Process, the Loading-unloading process, and the Customer Knowledge Management.

CCS CONCEPTS

Applied computing → Operations research → Industry and manufacturing → Supply chain management

KEYWORDS

Prioritizing criteria, Fuzzy AHP, Dwell time efficiency, Port logistic process.

ACM Reference format:

Oki Sunardi and Yenny Yunita Somakila. 2020. Prioritizing Criteria for Dwell Time Efficiency in Port Logistic Process. In *ACM International Conference Proceeding Series* ……

1 Introduction

The ports play an important role in supply chain efficiency and supervising product handling before entering the broader supply chain network [1]. In practice, according to the Minister of National Development Planning/Head of Bappenas, Indonesia's average logistics costs are still less efficient compared to other countries in Asia. Compared with Vietnam, which reaches 20% of GDP, Thailand (15%), Malaysia (13%), Japan (8%), and Singapore (8%), Indonesia's 24% is less competitive [2].

Indonesia Port Corporation (IPC), the holding company that oversees several major ports in Indonesia, including Port Tanjung Priok, continues to strive to transform these ports into world-class ones, primarily through the implementation of the Digital Port System. The Digital Port System has been implemented since 2016 and has successfully improved cost and resource efficiency [3]. Meanwhile, to emphasize dwell time and save fuel costs, IPC also implemented a buffer area to reduce congestion in the Port Tanjung Priok area.

In line with this, the success of the Port Financing Service at the Port Tanjung Priok was also appreciated by the Indonesian logistics entrepreneurs for being able to shorten entry times, especially during holidays and high season [3]. Also, the Jakarta International Container Terminal has implemented a Transshipment Port at the Port Tanjung Priok, and this allows the Port Tanjung Priok to conduct International Transshipment activities [4]. Port Tanjung Priok Development is also proven to serve ships going to various international trade centers.

Despite numerous efforts initiated by the port authorities, Indonesia's dwell time is still one of the problems in Indonesia's logistics flow. The high logistics costs of air and land transportation modes make sea transportation one of the most feasible solutions. Besides, government planning to make Indonesian ports as the center of Asia and International transshipment port also requires a guaranteed service level.

The problem of dwell time in Indonesia's major ports is also inseparable from the supply chain collaboration amongst the collaborated institutions. To improve the management of Port Tanjung Priok, fluid integration and synchronization between the institutions involved is still a problem. Several steps that need to be focused include simplifying the document clearance process between institutions, having a transparent integrated system, having a shared service center, educating the owners of products and users of port services, and reducing the bureaucracy's complexity at the Port. Moreover, in terms of port management issues, Port Tanjung Priok's inefficient dwelling time is also caused by several things. First, the time of products stays at the Port due to complex requirements and activities—secondly, the existence of illegal activities between service users and port officials. Thirdly, lack of proper supervision, and low human resource efforts to increase productivity [7].

Furthermore, some of the causes of the long dwelling time at Port Tanjung Priok also include the lack of information obtained by

the importers regarding the technical provisions of the Port, so that the process of arranging correspondence and requirements mostly hampered. Several facts also influence inefficient dwell time: agencies that have not yet submitted several modules to the authorities, thus hampering the pre-clearance process. Further, the management office location is far from the Port, followed by a very complex bureaucracy and administration process. In connection with these constraints, several improvement processes were carried out, which intended to reduce dwelling time, namely the provision of preliminary notification facilities, notification of customs, the adoption of the Integrated Customs Service Area, and the establishment of Auto-gate System [8].

Thus, this study aims to discover the priority criteria needed to support the dwelling time efficiency in the port logistic process to ensure the competitiveness of Indonesia's logistics. For preliminary, Port Tanjung Priok played as the object of study.

2 Literature Review

2.1 Dwell Time

Dwell time is the total time of cargo or ships spend within a Port. It indicates how efficiently a port is operating, how promptly cargo is streaming through its terminals, and how long a ship is employing in Port [5]. The occurrence of dwell time is mainly caused by delays in the performance of the regulatory agency, and the ineffective customs clearance. Port authorities should be able to improve customs procedures, increase track efficiency, and provide adequate infrastructure [6].

2.2 Criteria and Sub-criteria

2.2.1 IT-based Licensing Process. IT-based digitalization and integration have enabled high-level automation and play a role in the efficiency of the port logistic process [9]. The primary purpose of digitalization at the Port include to increase cargo flows, to accelerate information flow, and to easily monitor ships' position and cargo equipment [10]. Most world-class ports have adopted sophisticated information technology to make every process seamless. Functional data integration will help the Port improve the planning, control, and management of inter-organization operations involved. Digital transformation not only transforms networks and information but also transforms strategy, governance, management, culture, people, and technology. The IT-based Licensing Process is one of the criteria that can accelerate dwelling time because it facilitates and accelerates the flow of information.

2.2.2 Loading-unloading Process. Loading and Unloading Process is one of the factors that play an essential role in a port logistic process. This process determines the speed of other processes, such as shipping the containers using trucks, the process of container inspection, and the container storage process [11]. During loading and unloading, several obstacles usually appear and are considered in the process, such as container size, type and contents of containers, container stability, number of piles, types of material handling and tools used, and inventory strategies [12]. The loading-unloading process was considered as a criterion because of its importance in overall port logistic operations.

2.2.3 Customer Knowledge Management. Customer Knowledge Management (CKM) is an integration of approaches between Knowledge Management (KM) and Customer Relationship Management (CRM). CKM can be defined as a process to capture, share, and disseminate and implement CRM [13, 14]. By implementing CKM properly, a company will get many benefits such as fast feedback, cheaper and easier promotions, sales activities, and customer service, making it easier for companies to evaluate their performance and make improvements. Customer Knowledge Flow is considered to affect CRM, where the better customer knowledge flow, the better CRM significantly.

2.2.4 Human Resource Management. Though Human Resource Management (HRM) is strategic to organizational effectiveness, not all HRM practices were equally effective in building logistics competencies [15]. HRM practices such as training and development, and recruitment and selection are significant in nurturing logistic competencies. Reward and Punishment do not seem to have a significant effect on nurturing motivation [15, 16]. However, for developing countries such as Indonesia, Reward and Punishment are considered crucial variables to motivate performances.

3 Method: Fuzzy Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) provides a variety of frameworks for the selection of appropriate targets of each organization, such as government, business, industry, and the health and education sector [17]. AHP helps to break down complex problems into simple factors with the help of comparative analysis. This technique helps to analyze various decision-making problems. AHP is often used to identify criteria and sub-criteria that may be quantitative or qualitative [18]. The application of AHP is also widely used in many complex decision-making situations. It is good at solving problems, allocating resources, setting priorities, and choosing among alternatives [19].

The Fuzzy Analytic Hierarchy Process (FAHP) method was developed by Chang [20]. The main difference is that FAHP applies the Triangular Fuzzy Number (TFN) ratio. Based on the previous study in many contexts, FAHP has higher accuracy than the classical AHP [21-23]. Fuzzy AHP is an artificial extension of conventional AHP when the uncertainty of the decision maker is considered.

For the purpose of this study, data processing using the FAHP method followed after researchers obtain the data from each respondent/expert through semi-structured interviews. The data then started to be processed in the Pairwise Comparison Matrix. The objective is to assess the weight for each criterion and sub-criterion [24]. Further, fuzzy logic performs a role to decrease the uncertainty, one of which uses a triangular fuzzy number method, an approach used to minimize the uncertainty of conventional AHP.

ICONETSI 2020, September 28-29, 2020, Tangerang, Banten, Indonesia
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ACM ISBN 978-1-4503-8771-2

The fuzzification on the AHP scale generates a new scale entitled the AHP fuzzy scale [25-27].

The next step is designing the questionnaires to be reviewed by the experts. Experts consist of three persons, including Port Tanjung Priok official, which plays a role in loading and unloading containers, an academician whose researcher in the field of logistics, and a business actor who plays the role of a user of port services. The questionnaire uses five valuation scales: Equal Importance (EI), Moderate Importance (MI), Strong Importance (SI), Very Strong Importance (VSI), and Extremely More Importance (EMI). Each of the fuzzy rating scales filled by the experts in the questionnaire has different membership functions, such as EMI (8,9,10), VSI (6,7,8), SI (4,5,6), MI (2,3,4), and EI (1,1,2). These membership functions involved in the calculation of the weight of each criterion. The following table represents the fuzzy importance rating scale used in the questionnaire. Table 1 represents the priority assessment scale for this study.

Table 1: Scale Priority

Priority scale	Notes	Membership function
9	Extremely more importance (EMI)	(8,9,10)
7	Extreme importance (VSI)	(6,7,8)
5	Strong importance (SI)	(4,5,6)
3	Moderate importance (MI)	(2,3,4)
1	Equal importance (EI)	(1,1,2)

At this stage, a consistency test is carried out for the Comparative Judgment results to determine whether the data to be processed meets the consistency requirements. Saaty has successfully proven that the following equation can obtain the consistency index of the matrix:

$$CI = (\lambda maks-n) / (n-1) \quad (1)$$

Where, CI = Consistency deviation ratio (consistency index); λmax = the largest eigenvalue of the "n" order matrix; and n = order matrix. After getting the value of CI, the next step is to calculate the CR value to know the consistency of the data. The formula of calculating CR is as followed:

$$CR = CI / RI \quad (2)$$

Where Random Index (RI) value is based on "n" value, table 2 described several RI values based on n (1 to 10).

Table 2: Random Index (RI) Value

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

After conducting the above consistency test, if the CR value is > 0.1 (10%), the results of the assessment cannot be accepted and need to be reassessed. Fuzzification and defuzzification stages in this study were as follows:

1. Make a Pairwise Comparison Matrix based on the Comparative Judgment values for consistency test by converting each valuation value into a Triangular Fuzzy Number.
2. Combine the three results of each respondent's assessment in the form of a Pairwise Comparison Matrix into one Pairwise Comparison Matrix. This merger is done using the Mean Geometric method as in the following equation:

$$A_g(l,u) = \sqrt[3]{(l_1 * l_2 * l_3),(u_1 * u_2 * u_3)} \quad (3)$$

Where, A1= (l_1,u_1); A_2= (l_2,u_2); A_3= (l_3,u_3).

3. The defuzzification role was to convert the fuzzy values into a "crisp" value. The calculation of crisp value was at $\alpha = 0.5$ was based on formula 4.

$$\text{Crisp Value} = 0{,}5*l+(1-0{,}5)*u \quad (4)$$

After conducting the fuzzy stage, which consists of several stages, in the end, a crisp value is obtained for the criteria and sub-criteria. This crisp value is the beginning of calculating the weight of each criterion or sub-criterion. The Crisp Value normalization produced the AHP weights. After Normalization, the consistency check is performed for the crisp value obtained from the merging of the three expert assessment results. If it is consistent, it will continue with AHP weighting.

Data was then analyzed together by the researchers and experts through separate discussions. Mathematical results were discussed thoroughly and comments were gathered from the experts.

4 Results and Discussion

This research involves four criteria: IT-based Licensing Process (ITBLP), Loading and Unloading (LAUL), Customer Knowledge Management (CKM), and Human Resources Management (HR). Besides, this study also involved 16 sub-criteria: Data Tracking (DT), Data Integration Between Organizations (DIBO), Web-Based Knowledge Management Platform (WBKMP), Digital Payment (DP), Online Licensing (OL), Ship Schedule (SS), Cargo Handling Equipment (CHE), Cargo Transportation (CT), Cargo Quantity (CQ), Queueing Method (QM), Storage (S), Multiple Knowledge Network (MKN), Customer Relationship Management (CRM), Training (T), Punishment (P), Reward (R).

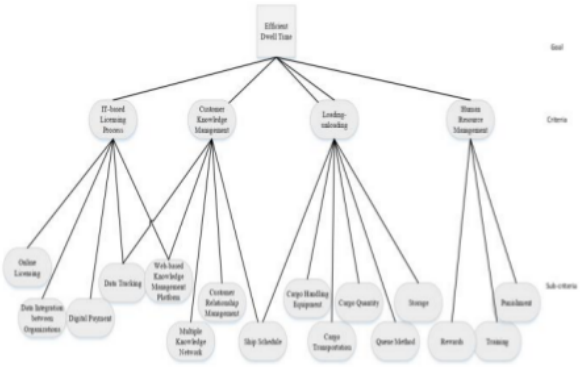

Figure 1: Goal, Criteria, and Sub-criteria

There are five fuzzy weighing scales used in the assessment of the importance of each criterion, including EI (equally important), MI (more important), SI (important), VSI (very important), EMI (very more important). Each weighing scale has different membership functions: EI (1,1,2), MI (2,3,4), SI (4,5,6), VSI (6,7,8), EMI (8,9,10). Figure 1 represents a hierarchical structure for the criteria and sub-criteria developed in this study:

The data obtained is then processed into a Pairwise Comparison Matrix. The list of criteria and sub-criteria were compiled in the form of a questionnaire which contains a comparison between each criterion or sub-criterion. The next step is to form a joint Pairwise Comparison Matrix, which is a combination of the three respondents. The mean geometric method calculated the data merger from the three experts, using equation (3). Table 3 summarizes the pairwise comparison of criteria combinations from three experts.

Table 3: Pairwise Comparison of Criteria Combination

CRITE-RIA	ITBLP			LAUL			CKM			HR		
ITBLP	1.00	1.00	1.00	1.00	1.00	2.00	2.00	3.00	4.00	0.15	0.17	0.22
LAUL	0.50	1.00	1.00	1.00	1.00	1.00	1.59	2.08	3.17	0.23	0.25	0.35
CKM	0.25	0.33	0.50	0.31	0.48	0.63	1.00	1.00	1.00	0.11	0.12	0.14
HR	4.58	5.74	6.84	2.88	3.98	4.31	2.00	2.26	2.55	1.00	1.00	1.00

The next step was the defuzzification stage as a process to transform fuzzy values. The Centroid method is used as a solution to find the crisp value by finding the center point of the desired fuzzy area. In this study, a confidence level of 5% was applied (0.5). Table 4 shows the defuzzification output for this study.

Table 4: Defuzzification Output

CRITERIA	ITBLP	LAUL	CKM	HR
ITBLP	1.00	1.25	3.00	0.18
LAUL	0.88	1.00	2.23	0.27
CKM	0.35	0.48	1.00	0.12
HR	5.72	3.79	2.27	1.00
TOTAL	7.95	6.51	8.50	1.57

Further, the consistency limit (CR) was calculated. CR < 0.1 would be the standard. If CR > 0.1, then the reviews by experts should be re-evaluated. CR calculation showed that all criteria were consistent. Table 5 summarizes the CR calculation.

Table 5: CR Calculation

Consistency	λ MAX	CI	RI	CR
CRITERIA	4.23	0.08	0.90	0.084
ITBLP	5.15	0.04	1.12	0.035
LAUL	6.29	0.06	1.24	0.046
CKM	5.21	0.05	1.12	0.046
HR	3.03	0.01	0.58	0.023

The final step is to assign a weight to each criterion and sub-criterion. In this study, the preparation of criteria and sub-criteria was conducted by grouping criteria and sub-criteria within the process group. It started with the handling of the various equipment needed that were categorized in the IT-Based Licensing Process. Next are the loading and unloading process, followed by the relationship between customers and ports, which both categorized in Customers Knowledge Management. Finally, Human Resources as the main actors in each process at the Port. Based on the FAHP calculation results (Table 6), the criterion that has the highest weight was Human Resources at 0.55. The second highest weight was IT-based Licensing Process (0.20), followed by Loading-unloading (0.17), and Customer Knowledge Management (0.08).

Table 6: FAHP Calculation on Criteria

CRITERIA	ITBLP	LAUL	CKM	HR	WEIGHT	RANK
ITBLP	0.13	0.19	0.35	0.11	0.20	2
LAUL	0.11	0.15	0.26	0.17	0.17	3
CKM	0.04	0.07	0.12	0.08	0.08	4
HR	0.72	0.58	0.27	0.64	0.55	1

Human resources have an essential role in the sustainability of a company. According to the Head of the Loading and Unloading Section at the Port Tanjung Priok, to create and run a smooth system, the employees need a healthy organization with clear direction, planning, implementation, and control. The three experts have relatively similar opinions that the criterion with the highest priority was Human Resource Management. Therefore, the Port must be able to guarantee that its human resources are sufficient and capable of creating a sound system and work environment. Three sub-criteria which considered to support the Human Resources criteria include Training, Reward, and Punishment. From the three sub-criteria, the highest AHP weighting result was training with a weight of 0.803. This result showed that all experts agreed that in order to guarantee good quality of human resources at the Port, the Port must always provide decent training for employees. Meanwhile, Reward (0.1) and Punishment (0.096) can be said to have the same level of importance as the effects of the good or bad performance of workers. Table 7 summarizes the following discussions on sub-criteria.

ICONETSI 2020, September 28-29, 2020, Tangerang, Banten, Indonesia

ACM ISBN 978-1-4503-8771-2

Table 7: FAHP Calculation on Sub-criteria

Criteria	Sub-criteria	Weight	Rank
Human Resource Management (0.55)	Training	0.803	1
	Reward	0.100	2
	Punishment	0.096	3
IT-based Licencing Process (0.20)	Data Integration between Organizations	0.521	1
	Web-based Knowledge Management Platform	0.191	2
	Online Licensing	0.137	3
	Data Tracking	0.092	4
	Online Payment	0.058	5
Loading-unloading Process (0.17)	Cargo Handling Equipments	0.309	1
	Ship Schedule	0.198	2
	Cargo Transportation	0.178	3
	Storage	0.128	4
	Queueing Method	0.097	5
	Cargo Quantity	0.090	6
Customer Knowledge Management (0.08)	Customer Relationship Management	0.353	1
	Data Tracking	0.220	2
	Web-based Knowledge Management Platform	0.220	3
	Ship Schedule	0.188	4
	Multiple Knowledge Network	0.089	5

IT-based Licensing Process was the second criterion that should be prioritized with a weight of 0.20. According to the expert from PT. Purigiri as a port service user, the licensing process had already employed an excellent system, making it easier for consumers to make licensing arrangements. In this study, five sub-criteria had a role in the IT-based Licensing Process. The five criteria include Data Integration Between Organizations with a weight of 0.521, followed by Web Based KM Platform (0.191), Online Licensing (0.137), Data Tracking (0.092), and Digital Payment (0.058). Data Integration Between Organizations was considered the most prioritized to be considered by the three experts.

The process of Loading and Unloading showed a weight of 0.17. The loading and unloading criteria had a 'considerable' influence. According to the Head of the Loading and Unloading Section at the Port Tanjung Priok, the loading and unloading activities at the Port of Tanjung Priok were already sufficient. Starting from the availability of tools for loading and unloading purposes, transportation facilities, and people skill. However, the expert mentioned that the average of dwelling time at Port Tanjung Priok was still around 3.5 days. In this study, the researcher arranged six sub-criteria that to support the loading-unloading process at the Port. Based on the experts' evaluation, the sub-criteria with the highest weight (0.309) was cargo handling equipment. The second sub-criteria were Ship schedule (0.198), followed by Cargo Transportation (0.178), Storage (0.128), Queueing method (0.097), and Cargo Quantity (0.090). Cargo Handling Equipment is a sub-criterion that becomes the priority in the loading-unloading process. It was because the activities of lifting the containers were very closely related to the availability of tools used in the process of loading and unloading. The queue at the Port was based on the schedule and window given to the Port. The Cargo Quantity sub-criterion, despite being ranked last priority, also has quite a several roles. The more cargo quantity information quickly acknowledged, the faster the loading and unloading process would be. The cargo quantity information helped determine the exact number of tools to use, and which type of equipment to choose.

Customer Knowledge Management was at the fourth priority level, with a weight of 0.08. Customer Knowledge Management was an approach on how a company can adequately manage its customer-based information to ensure excellent customer relations. Excellent customer relations can be achieved if the three previous criteria, namely Human Resources, IT-based Licensing Process, and Loading-unloading process, have been going well. In this study, five sub-criterion formed the CKM, such as Customer Relationship Management (0.353), Data Tracking (0.220), Web-based KM Platform (0.220), Ship Schedule (0.188), and Multiple Knowledge Network (0.089).

5 Conclusion

This study shows that Human Resource Management was considered as the essential criterion to support adequate dwell time in Port Logistic Process. The next crucial criteria were the IT-based Licensing Process, followed by Loading-unloading Process and Customer Knowledge Management.

Proper training should take place regularly to support good Human Resource Management practices. In similar, Data Integration between Port Management, Government, and Corporate Users would help the effectiveness of the IT-based Licensing Process. To make the Loading-unloading process more fluid, Port Management should provide the various operations activity with complete cargo handling equipment. Finally, to support effective Customer Knowledge Management, the Port Authorities should focus on maintaining customer relationships, data tracking, and improving web-based knowledge management platform.

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