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# Logistic Performance Measurement on a Port in Aceh

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**Abstract**: Indonesia government has established sea toll program through Presidential Regulation No.17 in 2017 to support inter-island distribution. Port X in Aceh is one of the ports included in sea toll program. This paper discusses logistic performance measure, especially in sea transportation. A Logistic Performance Index (LPI) is proposed as a tool to identify challenges and opportunities in Port X performance. Key indicators which affect the value of logistics performance index will also be studied in this paper. There are several logistic performance measurements for port X based on literature study: quality, delivery cost, transportation cost, and information. Eight indicators affect Port X performance: quality of the commodity, the quantity of the commodity, on time delivery, ship call, sea transportation cost, storage cost, electronic availability, and electronic access. Port X average total index, based on Analytical Hierarchy Process, is 2,557. This value can be considered as quite reasonable. The study limits logistic performance for the arrival route of the container vessel leading to Port X. The final result shows that quality performance indicator (quality quantity of commodity index) has the highest index for all originating port. The second highest index is electronic information availability index. Through this finding Port X must improve their service and information because it plays a vital role in their performance.

**Keywords**: Logistic Performance Index, Analytic Hierarchy Process, sea toll program, port.

## Introduction

Indonesia is the biggest archipelagic country in the world with 17,504 islands spanned from Sabang to Merauke. Aceh is one of the provinces in Indonesia. Aceh has an excellent opportunity to be in the global supply chain market since it is located in the Malacca Strait. The Mallacca strait, which runs between Indonesia, Malaysia and Singapore, has long been a major gateway for trade to and from Asia. Aceh government wants to improve port X performance by enabling it to serve container shipping. They expect this will promote economy and logistics performance in Aceh. This study focus on the ship arrived in port X since the number of container departure still very limited.

Port X will need an effective and efficient integrated logistics system. Therefore, a measurement of logistics performance is vital to be developed. Country's effectiveness in running logistics and supply chains is measured by the Logistics Performance Index (Marti, *et al.* [1]). The Logistics Performance Index (LPI) from The World Bank is an interactive benchmarking tool created to help countries to identify challenges and opportunities in trade logistics. The LPI 2016 allows comparisons across 160 countries. It consists of both qualitative and quantitative measures and helps build profiles of logistics friendliness for these countries. Logistics performance index has two outlooks, international and domestic (Arvis *et al.* [2]).

Sea transportation plays a significant role in the distribution of logistics all over the world. International Chamber of Shipping [3] stated sea transports dominate around 90% of the world trade volumes. Therefore, improvement of seaports is required to support logistics in a country or region. They are the central regulators of cargo transport flows and have the essential aspect of improving logistics performance. They function as gateways and hubs of global freight distribution (Rodrigue and Notteboom [4]), Loh and Thai [5]). Container ports play an essential role in facilitating global logistics and supply chains (Ha and Yang [6]). It can be concluded that the seaports are the gateway of inter-island logistics distributors.

LPI has six indicators to rank country performance: customs and border management, quality of trade and transportation infrastructure, ease of international delivery arrangements, logistics services competence and quality, tracking and tracking capabilities, and on time delivery. The LPI 2016 shows that Indonesia is rank 63 out of 160 countries on the list with 2.98 scores. This rank is just above Vietnam but below Rwanda. Indonesia's lowest score comes from infrastructure (2.65) and customs (2.90). Therefore, it is necessary to improve logistics system in Indonesia.

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This paper does not discuss customs performance and ease of international shipping arrangements because currently Port X only serve domestic shipments from Port A, Port B, Port C, and Port D. Four indicators will be considered on logistic performance index according to reference: quality, delivery, cost, and information. This indicator then weighted using Analytic Hierarchy Process (AHP). It is expected to improve logistics performance at Port X.

## Literature Review

Pamudji and Achmandi [7] suggested that LPI can be used to measure the logistic index of island communities. It gives information wheater a region logistic distribution system need to be revamped. Their research also shows that shipping route from Surabaya to Makasar has the highest logistic index in this region based on Analytic Hierarchy Process (AHP). Bîzoi and Sipos [8] did comparative research on logistic performance and economic development within European Union. They compared the two world bank indicators LPI and GDP per capita at EU level and confirm Havenga's statement that a good logistics system is a key factor of sustainable economic growth.

d'Aleo [9] also research the mediator role of logistic performance index in Europe from 2007 to 2014 using explanatory linear regression model. Therefore, Logistic Performance Index gives a significant mediator effect for Global Competitiveness Index and Gross Domestic Product. While Martí, *et al.* [1] research about Logistic Performance index using a data envelopment analysis (DEA) to find a synthetic index of overall logistics performance (DEA-LPI) and benchmark countries logistics performance. The proposed method uses DEA as a tool for multiple criteria decision making (MCDM).

Literature study shows that improvement of LPI should be made gradually. Therefore improvement at each of the port in Indonesia is required to increase national logistic performance index. This paper discusses LPI for one of the port in Aceh which is also a member of the Indonesia sea toll program.

# Methods

This research started with the literature review on logistic performance index and important indicators that will be needed in AHP method (Saaty [10]). There were several stages in determining and weighing the indicators before calculation of LPI for ship arrival route.

**Table 1.** Indicators logistic

| No. | Performance | Indicator | Source |
|---|---|---|---|
| 1. | Quality | Quality of commodity | Pamudji and Achmadi [7] |
| | Quantity | Quantity of commodity | |
| 2. | Delivery | Ontime delivery | |
| | | Shipcall | |
| 3. | Cost | Sea Transportation cost | |
| | | Storage cost | |
| 4. | Information | Electronic Access | Elvaretta [12] |
| | | Electronic Availablity | |

## Logistic Performance Indicators

Referring to Arvis *et al.* [2] four logistics indicators will be used in this research: quality, delivery, cost, and information. These port performance indicators were simple but cover different aspects of the port. These indicators will represent every activity regarding the running of port management operations (Nasution [11]).

Quality
Indicator for logistic quality performance measured in this research consist of commodity quality and quantity. Commodity quality is the condition of the product shipped is not damaged from port of origin to port of destination. Commodity quantity is the amount of the product shipped is not reduced. Quality index is calculated with this formula:

$$KK = \frac{TS-Rs}{TS} x\ 100\% \quad (1)$$

$$KW = \frac{TS-Kr}{TS} x\ 100\% \quad (2)$$

where:
$KK$: Quality of commodity (%)
$KW$: Quantity of commodity (%)
$TS$: total supply (ton)
$Rs$: commodity damaged (ton)
$Kr$: lost commodity (ton)

Delivery
Indicator for logistic delivery performance measured in this research consist of on-time delivery and ship call. On-time delivery is the time when the ship carrying the commodity arrives according to the regular schedule. Therefore on-time delivery performance measures percentage number of customer orders which delivered on-time.

$$\text{OTD} = \frac{\text{Number of customer orders delivered on time}}{\text{total number of customer orders}} \text{ x } 100\% \quad (3)$$

where:
OTD: on-time delivery performance (%)

Ship call is the frequency of ship visit to the port. The rate of arrival of the vessel indicates continuous supply and demand for goods and demonstrates that a region has sufficient market potential. The number of trips per year is calculated based on Nasution [11] formula.

$$N = \frac{T}{\frac{J}{v}+C\frac{q}{100/B}2+U} \quad (4)$$

where:
$N$: number of trips per year
$T$: overall active working time (hours per year) (340 days in 1 year)
$J$: the distance between the two ports (nm) (1 nautical mile = 1,852 km)
$v$: sailing speed (knot)
$C$: the capacity of ship transport (tons)
$B$: loading/unloading speed (TEUs/hour)
$U$: sailing time (an hour per year)
$q$: overage load factor

Cost
Indicator for logistic cost performance measured in this research consists of ship transportation cost and storage cost. Transportation cost is the shipping price between two geographic locations and the costs associated with the maintenance of in-transit inventory. A good logistics system can reduce transportation costs. (Bowersox *et al.* [13]). Stopford [14] found that sea transportation costs influenced by the speed of the vessel at sea, voyage cost, and ship charter cost. Therefore, voyage cost will be used to calculate ship transportation cost.

The cost of sea transportation is calculated by the formula (Stopford ([14]):

$$VC = FC + PD + CHC + CC \quad (5)$$

where:
$VC$: voyage costs
$FD$: fuel costs for main engines and auxiliaries
$PC$: port and light dues
$CHC$: cargo handling cost
$CC$: charter cost

Storage cost is affected by time spent in the container yard. The more extended container stays in the yard storage cost becomes higher.

$$SC = Ws\ x\ M\ x\ Ts \quad (6)$$

where:
$SC$: storage cost
$Ws$: waste storage
$M$: number of containers
$Ts$: the cost of storage

Information
Bowersox *et al.* [13] suggest that supply chain information system can initiate activities and track information regarding processes, facilitate informa

**Table 2.** The fundamental scale

| Intensity of Important | Definition | Description |
|---|---|---|
| 1 | Equally important (S) | Two activities contribute equally to the objective |
| 3 | Somewhat more important (AP) | Experience and judgment slightly favor one activity over another |
| 5 | More important (LP) | Experience and judgment strongly favor one activity over another |
| 7 | Very important (SP) | An activity is favored very strongly over another; its dominance demonstrated in practice |
| 9 | Absolute more important (MP) | The evidence favoring one activity over another is of the highest possible order of affirmation |
| 2,4,6,8 | Values between two adjacent considerations | Values between two values of adjacent considerations |

tion sharing both within the firm and between supply chain partners. It also assists in management decision making. Data to measure indicator for logistic information performance collected through port expert interview.

## Analytic Hierarchy Process

### *Questionnaire Design and Survey*

This research collected data through Analytical Hierarchy Process questionnaire which designed based on the port survey, expert interview and literature studies on logistic performance indicators. There are 28 questions which associated with each performance indicators: delivery, quality, cost, and information. According to Saaty [10], criteria and alternative assessment are assessed through pairwise comparisons and the scale 1 to 9 is the best in expressing opinions (see Table 2 and Table 3).

### Data Collection

AHP requires respondent who answers the questionnaire to be an expert related to the research conducted with the minimum of two. There are nine respondents in this research: Three from Port X, three from the shipping company, and three from users.

**Table 3.** One of the AHP questionnaire charts determining the logistics performance index

| | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q1 | MP | | SP | | LP | | AP | | S | | AP | | LP | | SP | | MP | Q2 |

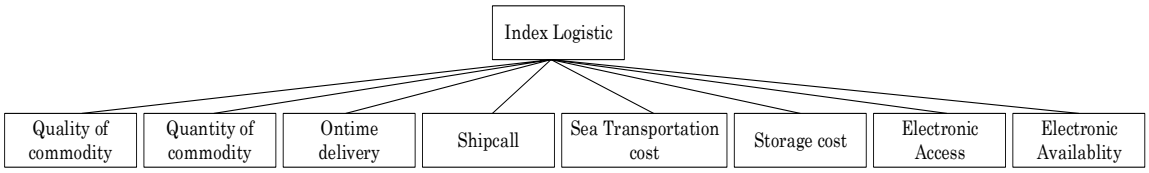


**Figure 1.** Hierarchy of problems

## AHP Method

AHP method develops a hierarchical structure of problems through decomposition, perform a pairwise comparison between variables, analyze and determine the best alternative. These are the steps in AHP:

Develop a hierarchical structure of Logistic performance index. (see Figure 1)

The geometric mean calculation is done to aggregate the individual preference objectively. It is required to optimize the decision outcomes of AHP. In this research, the geometric mean is done on each of the respective groups of respondents (see Table 4).

$$GM = \sqrt[n]{R_1 \; x \; R_2 \; x \; R_3 x \; R_n} \qquad (7)$$

Priority Determination
Since this research have three different group of respondents, each group geometric means will be compared to know their priority. Logistic performance index will be calculated based on the weight from the group that has the consistency index closest to zero.

Measure of Consistency
Numeric values in AHP process derived from subjective preferences of respondents, there will be some inconsistencies in the final matrix of judgments. First, the eigenvectors of each pairwise matrix are calculated, then the Consistency Index. Consistency Ratio (CR) is calculated by comparing Consistency Index (CI) to Random Index (RI). If the consistency ratio is ≤ 0.1, AHP analysis can be continued. The data is consistent and valid when CR is closer to zero. This research will determine the weigh based on the group with lowest CR.

**Table 4.** Summary of geometric mean of respondents

| Comparative between factors | Geometric mean Port X | Shipping | User |
|---|---|---|---|
| Q1 with the Q2 | 1.442 | 0.843 | 0.585 |
| Q1 with the Q3 | 0.523 | 0.280 | 0.280 |
| Q1 with the Q4 | 0.523 | 1.000 | 0.548 |
| Q1 with the Q5 | 0.362 | 0.435 | 0.435 |
| Q1 with the Q6 | 0.189 | 0.519 | 0.888 |
| Q1 with the Q7 | 3.979 | 2.080 | 1.442 |
| Q1 with the Q8 | 1.379 | 1.040 | 0.410 |
| Q2 with the Q3 | 1.000 | 1.817 | 1.260 |
| Q2 with the Q4 | 0.329 | 0.630 | 0.909 |
| Q2 with the Q5 | 0.329 | 0.909 | 0.531 |
| Q2 with the Q6 | 0.271 | 0.519 | 0.360 |
| Q2 with the Q7 | 1.913 | 1.442 | 2.080 |
| Q2 with the Q8 | 0.956 | 0.721 | 0.721 |
| Q3 with the Q4 | 2.260 | 0.691 | 0.404 |
| Q3 with the Q5 | 1.182 | 0.997 | 0.997 |
| Q3 with the Q6 | 2.759 | 4.217 | 3.557 |
| Q3 with the Q7 | 1.913 | 2.080 | 2.466 |
| Q3 with the Q8 | 2.596 | 0.794 | 1.357 |
| Q4 with the Q5 | 0.693 | 1.710 | 1.710 |
| Q4 with the Q6 | 2.105 | 3.915 | 1.882 |
| Q4 with the Q7 | 1.913 | 2.080 | 3.557 |
| Q4 with the Q8 | 1.913 | 2.080 | 3.557 |
| Q5 with the Q6 | 3.979 | 2.080 | 1.442 |
| Q5 with the Q7 | 5.278 | 1.442 | 2.466 |
| Q5 with the Q8 | 2.529 | 0.997 | 1.182 |
| Q6 with the Q7 | 1.913 | 1.000 | 1.442 |
| Q6 with the Q8 | 1.322 | 0.479 | 0.997 |
| Q7 with the Q8 | 0.794 | 0.794 | 0.794 |

Note:
Q1 = Quality of commodity
Q2 = Quantity of commodity
Q3 = Ontime delivery
Q4 = Shipcall
Q5 = Sea Transportation cost
Q6 = Storage cost
Q7 = Electronic access
Q8 = Electronic availablity

## Results and Discussions

The result from AHP with respondent from port X shows that transportation cost (23%) gives the highest weight, while respondent chooses ship call (frequency of ship visit) from the shipping company (20%) and users (23%). Therefore ship call is the most critical weight in determining the logistics performance index in port X. Based on CR value, the respondent from the user has the lowest CR of 0.061, while shipping company CR is 0.076 and port X respondent CR is the highest with 0.096. Therefore

**Table 5**. Weight each indicator

| No. | Indicator | Weight |
|---|---|---|
| 1. | Quality of commodity | 7% |
| 2. | Quantity of commodity | 11% |
| 3. | On time delivery | 16% |
| 4. | Shipcall | 23% |
| 5. | Sea Transportation cost | 15% |
| 6. | Storage cost | 11% |
| 7. | Electronic Access | 6% |
| 8. | Electronic Availablity | 11% |

the weight from the user will be used in Logistic Performance Index calculation.

Table 5 shows that respondent believes that ship call is the most important in port X. It has an impact on the productivity of a port. Based on the survey and interviews with each expert, port X performance has not increased significantly due to very few container ship visits. Transportation and storage cost also considered as an essential factor for port X. Therefore, customer will choose an efficient seaport to minimize the cost.

### Index Calculation

Logistic performance index for port X is measured by multiplying the first index from each indicator to the weight from previous part. The initial index is derived from the relevant data from each route to Port X. The following table is the result of the calculation of each indicator multiplied by the weight of each indicator.

Table 6 shows that quality performance indicator (quality quantity of commodity index) has the highest index for all originating port. Therefore, Port X should give priority to improve their service in maintaining the quality and quantity if commodity which arrives there. The second highest index is electronic information availability index. Since seaport is a service business, their customer needs to have accurate information about their products. Information availability and accuracy play an essential role in seaport performance. It also affects the cost occurs in the port. Through this finding port X must improve their service and information because it plays a vital role in their performance.

**Table 7.** Total index

| Route | Indeks |
|---|---|
| Port A- Port X | 2,897 |
| Port B- Port X | 2,741 |
| Port C- Port X | 2,364 |
| Port D- Port X | 2,226 |
| Average | 2,557 |

Index description (Arvis *et al.* [2]):
≤1: very bad ≤4: good
≤2: bad ≤5: very good
≤3: quite good

Table 7 shows that average total index for container arrival for port X is 2.557, and according to (Arvis *et al.* [2]) this is quite a good result. The index for each route also in the range between 2.226 (from port D) to 2.897 (from port A), so all originate port also give a good result. There is a possibility that port A is more advanced than other port, so container coming from there has better quality, delivery, cost and information. While port D cannot give this result, it is shown in their delivery index which is very poor. It is suggested that port X work together with the less developed port to improve their quality so the overall index can be better.

## Conclusion

Logistic performance index measurement is vital for every country because it reflects the effectiveness of a logistic system. Indonesia as an archipelagic country, need to improve its logistics performance to achieve inter-island and inter-state connectivity. There are four logistic performance indicators measured in this

**Table 6.** Result index total individual indicators

| Indicator | *Quality* | | *Delivery* | | *Cost* | | *Information* | | TI |
|---|---|---|---|---|---|---|---|---|---|
| Rute | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $X_8$ | |
| Port A- Port X | 0.354 | 0.565 | 0.172 | 0.386 | 0.377 | 0.354 | 0.246 | 0.444 | 2.897 |
| Port B- Port X | 0.354 | 0.565 | 0.165 | 0.338 | 0.354 | 0.293 | 0.240 | 0.433 | 2.741 |
| Port C- Port X | 0.354 | 0.565 | 0.144 | 0.200 | 0.344 | 0.252 | 0.180 | 0.325 | 2.364 |
| Port D- Port X | 0.354 | 0.565 | 0.154 | 0.100 | 0.323 | 0.224 | 0.180 | 0.325 | 2.226 |

Table Description:
$X_1$: Quality of commodity index
$X_2$: Quantity of commodity index
$X_3$: On time delivery index
$X_4$: Ship call index
$X_5$: Index of sea transportation cost
$X_6$: Index of Storage cost
$X_7$: electronic access index
$X_8$: electronic availability index
TI: Total index

research for a container port in Aceh: quality, delivery, transportation cost, and information. AHP method is used to measure the weight for LPI index of Port X. Then LPI index is calculated for four different routes to Port X. The results also show which indicator play essential roles in Port X improvement.

The final result shows that quality performance indicator (quality quantity of commodity index) has the highest index for all originating port. The second highest index is electronic information availability index. Through this finding Port X must improve their service and information because it plays a vital role in their performance.

Average total index for container arrival for port X is 2.557. The index for each route also in the range between 2.226 (from port D) to 2.897 (from port A). It is suggested that port X work together with the less developed port to improve their service quality so the overall logistic performance index can be better. Currently, port X has tried to increase their productivity by working 24 hours per day and has increased loading/unloading speed by using adequate infrastructure.

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