# PORT COMPETITIVENESS EVAULATION BY FUZZY LOGIC OF MAJOR PORT IN ASIA

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**ABSTRACT**

Port competitiveness measurement should be considered of operational efficiency and effectiveness. This paper is to investigate the characteristics of port competitiveness and develop Fuzzy model. This model is primarily for qualitative analysis, but this study invites quantitative indicators. It concurrently takes efficiency and effectiveness indicators into consideration. Fuzzy logic evaluates port competitiveness classification by partial order based on five grades. This paper takes major port in ASEAN's countries such as Myanmar, Cambodia, Malaysia, Singapore, Vietnam, Indonesia, Philippines, Brunei Darussalam and Thailand. It confirms the method is stable and effective in practical applications.

Keywords: port competitiveness, fuzzy, classification model

## 1 .INTRODUCTION

International trade is a key indicator for economic progress in the ASEAN's country. The success of the strategic export in the country to stimulate economic growth, which promotes the growth of commerce to increase the production of containers in the following countries such as Myanmar, Cambodia, Malaysia, Singapore, Vietnam, Indonesia, Philippines, Brunei Darussalam and Thailand.

In maritime transport, the ASEAN port network consists of 47 ports established in nine ASEAN countries, the mainstay of the ASEAN Port Network Developing berths is another important milestone in the physical infrastructure as shipping movements are important to trade. Maritime transport is the most cost-competitive mode of trade compared to highway, rail or air.

Obstacles to achieving effective and low-cost of maritime transport barriers in the region include a variety of port facilities, quality and port efficiency, as well as poor gateway access to land transport. In ASEAN, Singapore and Malaysia, Port Klang has the most potential port. The rest of port gateways are very different in their ability to manage the cargo throughout. The geographical profile of Southeast Asia means that shipping lanes are keys to achieving an effective supply chain network. It has the potential to make it possible for ASEAN to take advantage of and benefit from the shipping industry due to its strategic location in the major shipping lanes around the world. Southeast Asia remains an important hub for shipping because of its outstanding location and modern port infrastructure.

A port's business is a part of maritime transportation. This business is the key factor for promoting economic growth, macroeconomics and giving access to international markets. Containerization is one of the most important factors in ASEAN's economy.

According to Table 1, Singapore and Malaysia are performing far better than the other ports.

Table 1. Top container port in ASEAN in 2015

| Rank | Port | Country | Container Throughput |
|---|---|---|---|
| 1 | Singapore | Singapore | 30,922,300 |
| 2 | Port Klang | Malaysia | 11,890,000 |
| 3 | Laem Chabang | Thailand | 6,780,000 |
| 4 | Tanjung Perak | Indonesia | 3,120,683 |
| 5 | Bangkok | Thailand | 1,559,000 |
| 6 | Penang | Malaysia | 1,265,712 |
| 7 | Hai Phong | Vietnam | 1,003,000 |
| 8 | Cebu | Philippines | 829,146 |
| 9 | Yangon | Myanmar | 721,428 |
| 10 | PAS | Cambodia | 333,904 |
| 11 | Muara | Brunei Darussalam | 106,168 |

The paper of port competitiveness has been an important topic over recent years, and, with the effects that ports are suffering from the recent crisis, it is only gaining importance. This is true in the context of containerized goods.

The purpose of this research is to study the characteristics of port competitiveness and to develop fuzzy logic model. This method is useful for mathematical applications. Therefore, in this paper we

try to address the issue of competitiveness, the criteria that determine it and evaluate the strengths and weaknesses of the ports. In the analysis, the focus will be on selected ports of ASEAN's countries. Mainly the case of containers will be analyzed, as this sector features the strongest worldwide changes.
The structure of this paper is organized as follows: Section 2 reviews the relevant literature; Section 3 presents the research methodology; Section 4 presents the results and gives a discussion of the results; and Section 5 provides some conclusions.

## 2 .LITERATURE REVIEW

This section is devoted to the various Fuzzy logic )Part 1( Port competitiveness )Part 2(.

### 2.1. Fuzzy logic

Fuzzy logic was thought to be a better way for sorting and manipulating data. But it has proven to be a great option for many control systems, from imitation of human control logic. It can be made into a small handheld product to a computerized control system. Use unclear language, but it is more meaningful to manipulate input data than human operators. It is very effective and forgiving in operation and input, and usually works when used initially with little or no customization.
The basic idea of fuzzy logic has been established by L. Zadeh (1965) and J. A. Goguen (1968). The purpose of such logic is to do the "approximate reason" we use in everyday life is by accepting the terms "big", "near", "slow", which is ambiguous. These statements are interpreted by the concept of "Fuzzy subset", which is a generic function with a value in the complete mesh. False logic program is a very promiscuous chapter of ambiguous logic, which aims to create intelligent database systems with "flexible" answers.

### 2.2. Port Competitiveness

Port competitiveness is defined as the ability of a port and its vicinity in the creation of value-added. Port competitiveness evaluation shall take efficiency and effectiveness indices into consideration. The analysis of port competitive advantage can be classified into full order and partial order two types. Some distinguished researches opt to cluster analysis, while others use full order. In fact, full order ranking for comparing the improvement of port competitiveness is not necessarily pertinent to decision makers, if port's ranking varies by marginal difference.
The previous papers of port competitiveness are as follows: Hoffman, P. )1985( and Tongzon, J.L., *(*1995*)* investigated port performance by meaning of ship, berth or terminal indicators, while Miyajima and Kwak )1989( examined container cargo competition among Japanese ports.
Dowd, T.J. and Leschine, T.M.)1990( and Robinson, D., )1999( extended to include production factors or productivity indicators to assess ports productivity.
Murphy, P. R. et al. )1992( developed a framework for classifying existing transportation choice research by using two dimensions: the decision)s( being researched and the respondent's role)s( in the decision process.
Heaver )1995( presented the idea of improving competitiveness, but did not carry it further to include evaluation.
Prescott and Grant )1998( were pioneers by reviewing those competitiveness researches and presenting characteristics of twenty-one evaluation approaches. While, Oral )1993( classified analysis approaches in two categories: )1( descriptive approach, and )2( analytical approach, and applied linear programming on strategies and competitiveness evaluation of glass industry.
Malchow and Kanafani )2001( aims to capitalize on the factors that contribute to their competitiveness in order to extend their captive hinterland. At the same time, they will try to erode those of their competitors.
Yap, W. Y., et al. T. )2006( analyzed a game-theoretic approach was applied by Anderson et al. to competition between Busan and Shanghai. In South Korea, it was emphasized by Yap et al that Busan appeared to face a greater threat from Kwangyang for increasing its transshipment traffic.
Ding, J. F. )2009b( evaluated key capabilities and core competence for port of Keelung for more loyal customers in order to enhance their competitive-ness, and sustain their competitive advantage.
Brooks, M. R., et al. Pallis )2011( examined how users evaluate port effectiveness and identify those constructs relevant to that evaluation. The study concludes that the evaluation criteria influencing users' perceptions of satisfaction, competitiveness, and service delivery effectiveness are different, and so while the determinants of these constructs have considerable overlap, they are different constructs.
Chou, C. C. )2010( attempted to fill this gap in current literature by establishing an integrated quantitative and qualitative fuzzy multiple criteria decision-making model for dealing with both objective crisp data and subjective fuzzy ratings.
Yuen, C. A., et al. )2012(., they explored the relative importance of factors that determine container port competitiveness from the users' perspective. Three groups of port users – shipping liners, forwarders and shippers are considered in them work.
Liang, G. S., et al. (2012), he applied the fuzzy quality function deployment approach to evaluate solutions of the service quality for international port logistics centers in Taiwan, 34 attributes with 11 feasible solutions of the service quality of customer requirements are measured by employing the house-of-quality matrices.
Customer satisfaction must be enhanced in order to gain and retain loyal customers. In order to maintain customer satisfaction, greater customer values must be created and provided to increase favorable behavioral intentions *(*Yang et al., 2013*)*. In order to enhance these behavioral intentions, port competitiveness can be enhanced by providing an efficient service system.

## 3. Research Methodology

This section focuses on the process for the qualification of key factors of port competitiveness and fuzzy logic.

In order to develop the research to meet the objectives of the study, the research methodology used or each step for conducting the research needs to be built up and clarified. The factors found from previous papers, which have influence on port competitiveness ranking between in ASEAN port.

From the previous papers and the Delphi method, this thesis applies economic factors for port competitiveness in ASEAN port, as follows: Throughput (TEUs)/Berth,Throughput(TEU)/m,Throughput(TEU)/QC, total TEUs, Berth length, Number of Berth, Number of Ship to Shore Gantry Crane and Terminal Area.

Fuzzy sets are mathematical ways to make decisions under ambiguity or ambiguity. It is similar to human thought, invented by Zadeh in 1965, which relies on fuzzy sets to indicate uncertainty, (Zadeh, L. A.,1965(. The fuzzy sets allow the membership level to be determined in the degree of membership is between 0 and 1. Unlike classical sets, there are only two sets of values: 0 means no member in the set, and 1 refers to a set member. The membership level configuration of the interested variables depends on the membership function. Commonly used member functions are many, but here are two types of functions, triangles and trapezoids.

Triangles functions comprised with 3 parameters {a b c} as shown in equation 1 and figure 1:

$$f(x;a,b,c)=\begin{cases}0, & x<a\\ (x-a)/(b-a), & a\le x<b\\ (c-x)/(c-b), & b\le x\le c\\ 0, & x>c\end{cases} \quad )1($$

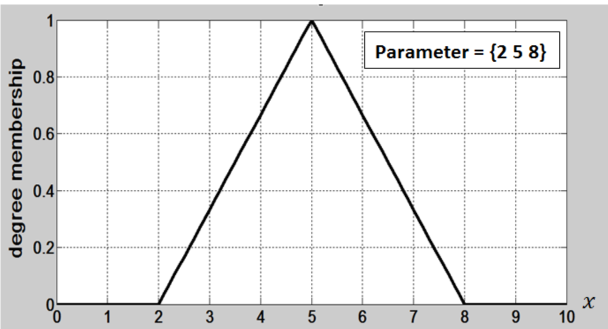


Figure 1. Triangular membership function

Trapezoidal functions comprised with 4 parameters {a b c d} as shown in equation 2 and figure 2:

$$f(x;a,b,c,d)=\begin{cases}0, & x<a\\ (x-a)/(b-a), & a\le x<b\\ 1, & b\le x<c\\ (d-x)/(d-c), & c\le x<d\\ 0, & d\le x\end{cases} \quad )2($$

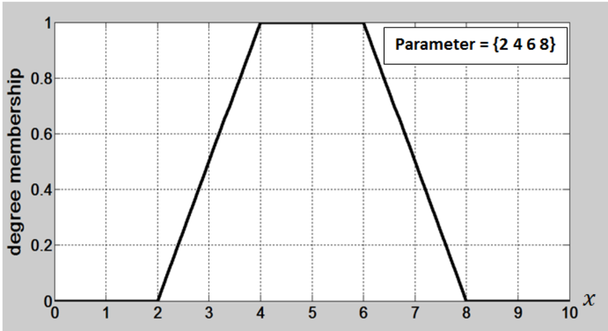


Figure 2. Trapezoidal membership functions

The choice of type of membership function depends on the characteristics of the variables and the needs of the users. In addition, fuzzy sets can be used with language variables to denote quality or quantity, such as' low ',' medium, '' good. The operations in fuzzy set are similar to the general set of union, interactions and complement, $\mu$ are the subsets of the possible members of the set of the universe (universe of discourse). $x$ is the members of the set in $\mu$, $\underset{\sim}{A}$ and $\underset{\sim}{B}$ are the internal members of the set.

Union or OR operation is shown as in equation 3

$$\mu_{\underset{\sim}{A}\cup\underset{\sim}{B}}(x)=\{x: x\in\underset{\sim}{A} \text{ Or } x\in\underset{\sim}{B}\}, \quad \max(\mu_{\underset{\sim}{A}}(x), \mu_{\underset{\sim}{\mathbf{B}}}(x)) \quad )3($$

Intersection or AND operation is shown as in equation 4

$$\mu_{\underset{\sim}{A}\cap\underset{\sim}{B}}(x)=\{x: x\in\underset{\sim}{A} \text{ And } x\in\underset{\sim}{B}\}, \quad \min(\mu_{\underset{\sim}{A}}(x), \mu_{\underset{\sim}{\mathbf{B}}}(x)) \quad (4)$$

Complement is shown as in equation 5

$$\mu_{\bar{\underset{\sim}{A}}}(x)=1-\mu_{\underset{\sim}{A}}(x) \quad (5)$$

## 4 .THE RESULTS AND DISCUSSION

This section presents the results of fuzzy logic to evaluate port competitiveness in ASEAN's.

Countries and finally, gives the discussion of the results.

## 4.1 Fuzzy set grading

The fuzzy set will look similar to the baseline method. But to be different, fuzzy sets use the principle of infinite or vague sets to evaluate. The method of class performance in this way starts with the evaluator having to determine the type of membership function. To calculate the weight membership function, the membership weight in the set is based on scores in Table 2. In this research, each members are detail the following grades.

X = raw score
F = the evaluation result (fail)
D = the evaluation result (very poor)
$D^+$ = the evaluation result (poor)
C = the evaluation result (fair)
$C^+$ = the evaluation result (fairly good)
B = the evaluation result (good)
$B^+$ = the evaluation result (very good)
A = the evaluation result (excellence)

Table 2. Criteria for Score Factor Grading

| **level of assessment** | **grade level** | |
|---|---|---|
| | **grade** | **score** |
| Excellence | A | 80.00 – 100.00 |
| very good | B+ | 75.00 – 79.99 |
| Good | B | 70.00 – 74.99 |
| fairly good | C+ | 65.00 – 69.99 |
| Fair | C | 60.00 – 64.99 |
| Poor | D+ | 55.00 – 59.99 |
| very poor | D | 50.00 – 54.99 |
| Fail | F | 0.00 – 49.99 |

The details of some grades are shown as follows.

*Evaluation of Grade* F, Use the trapezoidal member function as Equation 6, following as,

$$\text{function } F\,(x;0,0,45,50) = \begin{cases} \text{If } 0 \le x \le 45 \text{ Then } 1\ (True) \\ \text{If } 45 < x < 50 \text{ Then } (50 - x)/(50 - 45) \\ \text{If } 50 \le x \text{ Then } 0\ (False) \end{cases} \quad (6)$$

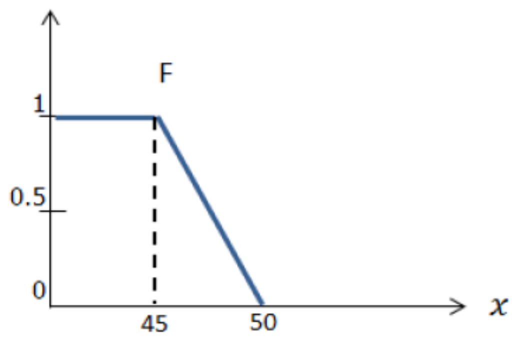

Figure 3. Membership function of function F

Figure 3 shows the membership function of function F.

*Evaluation of Grade* D, Use the triangle member function as Equation 7, following as,

$$\text{function } D\,(x;45,50,55) = \begin{cases} \text{If } x \le 45 \text{ Then } 0\ (False) \\ \text{If } 45 < x < 50 \text{ Then } (x - 45)/(50 - 45) \\ \text{If } 50 \le x < 55 \text{ Then } (55 - x)/(55 - 50) \\ \text{If } 55 \le x \text{ Then } 0\ (False) \end{cases} \quad (7)$$

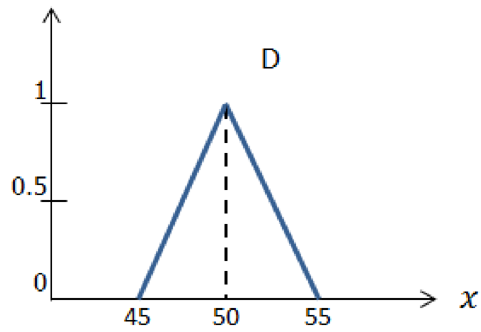

Figure 4. Membership function of function D

Figure 4 shows the membership function of function D.

*Evaluation of Grade* $B^+$ Use the triangle member function as Equation 8, following as,

$$\text{function } B+\,(x;70,75,80) = \begin{cases} \text{if } x \le 70 \text{ Then } 0\ (False) \\ \text{if } 70 < x < 75 \text{ Then } (x - 70)/(75 - 70) \\ \text{if } 75 \le x < 80 \text{ Then } (80 - x)/(80 - 75) \\ \text{if } 80 \le x \text{ Then } 0\ (False) \end{cases} \quad (8)$$

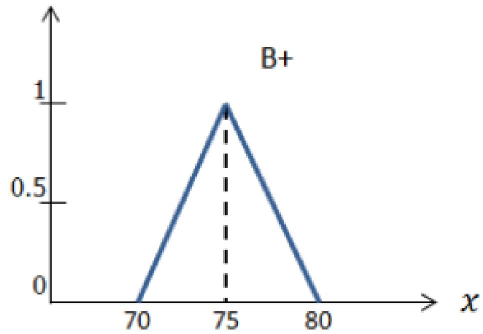

Figure 5. Membership function of function $B^+$

Figure 5 shows the membership function of function $B^+$

Evaluation of Grade **A**. Use the trapezoidal member function as Equation 15, following as,

$$\text{Function A}\,(x;75,80,100,100) = \begin{cases} \text{if } 80 \le x \le 100 \text{ Then } 1\ (True) \\ \text{if } 75 < x < 80 \text{ Then } (80 - x)/(80 - 75) \\ \text{if } x \le 75 \text{ Then } 0\ (False) \end{cases} \quad (9)$$

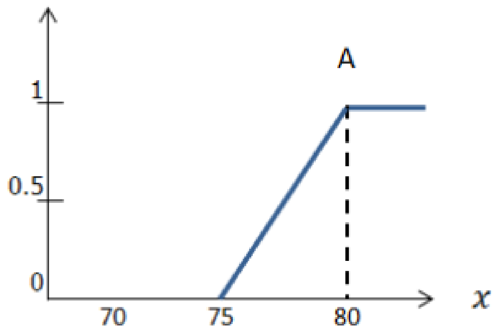

Figure 6. Membership function of function A

Figure 6 shows the membership function of function A.

When the membership function of all 8 grades is written together under the same axis, the graph is shown in Figure 7.

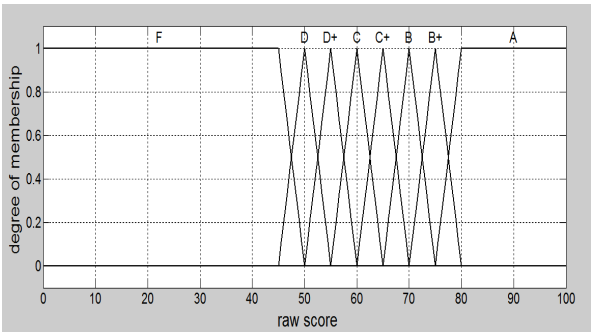

Figure 7. Condition check on all criteria.

**4.2 Result**

Based on the results of the study, the raw scores and data from 11 ports in ASEAN's Countries were evaluated by fuzzy sets. The factors are both of port performance and port facilities. The detail of port performance are number of container throughput per birth, number of container per berth length, number of container throughput per number of Ship to Shore Gantry Crane and number of container throughput, while port facilities are berth length, number of berth, number of Ship to Shore Gantry Crane and terminal area. The grade-based assessment results for each method can be shown in Table 3.

Table 3. Membership weight in each grade for Container throughput per Shore Side Gantry Crane

| Port | Score | weight Membership Function | | | | | | | | Fuzzy Set Grading |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | D | D+ | C | C+ | B | B+ | A | |
| Singapore | 88.73 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | A |
| Port Klang | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | A |
| Laem Chabang | 85.61 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | A |
| Tanjung Priok | 64.09 | 0 | 0 | 0 | 0.2 | 0.8 | 0 | 0 | 0 | C+ |
| Bangkok | 59.89 | 0 | 0.1 | 0.9 | 0 | 0 | 0 | 0 | 0 | C |
| Penang | 52.01 | 0 | 0.4 | 0.6 | 0 | 0 | 0 | 0 | 0 | D+ |
| Haipong | 32.81 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | F |
| Yangon | 32.61 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | F |
| Cebu | 58.61 | 0 | 0 | 0.2 | 0.8 | 0 | 0 | 0 | 0 | C |
| PAS | 75.32 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | B+ |
| Muara | 29.66 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | F |

Table 3 evaluates only Container throughput per Shore Side Gantry Crane, not only the evaluated this factor and the other factors also evaluated. The result are presented in table 4.

Table 4. Ranking of Port Competitiveness in ASEAN's Countries

| Rank | Port | Country | Container | Port C |
|---|---|---|---|---|
| 1 | Singapore | Singapore | 30,922,300 | 1 |
| 2 | Port Klang | Malaysia | 11,890,000 | 2 |
| 3 | Laem Chabang | Thailand | 6,780,000 | 3 |
| 4 | Tanjung Perak | Indonesia | 3,120,683 | 4 |
| 5 | Bangkok | Thailand | 1,559,000 | 5 |
| 6 | Penang | Malaysia | 1,265,712 | 6 |
| 7 | Hai Phong | Vietnam | 1,003,000 | 7 |
| 8 | Yangon | Myanmar | 721,428 | 8 |
| 9 | Cebu | Philippines | 829,146 | 9 |
| 10 | PAS | Cambodia | 333,904 | 10 |
| 11 | Muara | Brunei Darussalam | 106,168 | 11 |

**5. CONCLUSIONS**

This article states that the competitiveness of ports and its drivers has been greatly affected by significant changes in the maritime industry. So the original explores the nature of "Port Competitiveness" by conducting a systematic literature review of international journals. Port performance and port infrastructure are used in this article. The results are shown that Port of Singapore is the most competitiveness in ASEAN's Countries, Port Klang and Laem Chabang are respectively.

In Southeast Asia, the Singapore Port will continue to be a leading port in the region due to its existence and excellent service. However, by establishing other regional hubs, their dominance will continue to decline.

Singapore ports are facing increasing competition from Tanjung Pelepas Port, but also to other ports in the region, such as the Port Klang, Laem Chabang Port and Tanjung Priok Port.

A review of previous studies focusing on key container ports in ASEAN, port competition is expected to increase with the development of new ports and the upgrading of existing facilities. In a competitive environment, most of these ports ASEAN are needed to develop and expand facilities in response to the increase in container cargo.

The evaluation methods used by the researcher were the fuzzy set. Based on the results of the research, it can be seen that when comparing a fuzzy set with the others method, it is found that the fuzzy set evaluation allows for flexibility at the level of the range.

Therefore, the result is more accuracy, which will benefit for port officers to develop as a tool for measuring and evaluating the factors for port competitiveness that can help reduce the ambiguity of evaluators in decision making and is also easy to apply.

However, the fuzzy set also has limitations in determining the appropriate membership function for adoption. It may be necessary to use retrospective data that have been evaluated and assist in determining the membership function in the set.

The others factor such as Key economic growth drivers, quality and cost are adopted in the future research.

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