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# Enhancing the Competitiveness of Container Seaports Through Sustainability: A Case Study of Thailand

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**Abstract**

Sustainability has become a key goal of any supply chain which aims to be more competitive in the long term. And ports are a vital part of maritime transportation and maritime supply chains. Therefore, they need to comply with a global sustainability agenda while developing their competitiveness and performance as well. Their improvement should take economic, environmental and social aspects of sustainability into account simultaneously. Enabling of sustainability in ports is now widely recognised as increasing competitiveness. The sustainability of container seaports has become an increasing focus of attention in developed countries in particular, although emerging economies are the key driver of growth for the global economy. Hence, this paper aims to propose a set of criteria to investigate the port sustainability performance of container ports in an emerging country: Thailand. Thailand port system is one of the busiest of ASEAN. To address this issue, the new MCDM method called Best-Worst is proposed to evaluate the importance of factors. This propose to guide for assessment framework of port sustainability development within the Thailand context in the future.



*Keywords:* Port sustainability; sustainability assessment; sustainability criteria; Best-worst method (BWM), Multi-criteria decision-making

## 1. Introduction and background

### *1.1. Ports and Maritime supply chain*

With the rise in international trade, identifying the possibility of reduced transportation costs plays an important role in increasing competitive advantage [30]. The considerable research attention is paid to maritime transportation because over 80 per cent of the

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global trade volume is transported by sea [27]. The maritime industry is thus the one of the largest industry sectors in the world, and, as mentioned above, more than 80 per cent of world merchandise trade in terms of volume is handled by ports throughout the world. The increasing importance of ports has forced them to adopt new strategies in order to enhance efficiency. Ports handle with a huge demand of goods transported between ports worldwide, and the increasing number of containers exerts pressure on port operations. Therefore, the quality of services and operational improvement will significantly influence the efficiency of maritime supply chain. Ports have to plays a more effective part in improving maritime transportation within maritime supply chain.

### *1.2. Important of sustainable development*

The concept of sustainable development is not new, and has evolved over time. The World Commission for Environment and Development (WCED) defines of sustainable development in its final report 'Our Common Future' that "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[15]. It seems that economic growth alone at the cost of environmental health and social equity does not bring about sustainability[1]. Accordingly, they need to balance economic, social and environmental aspects that will lead to long-lasting prosperity [12] [31]. Regarding the social and economic aspects, it aims to enhance human rights, work conditions and other social issues as well as operational efficiency and cost-effectiveness. On the other hand, the environmental dimension focuses on preventing and reducing environmental pollution. As such, promoting only one particular aspects does not increase a corporation's long-term survival and lead to sustainable development

### *1.3. Port sustainable development*

Sustainability has become a key goal of any supply chain recently which aims to be more competitive. It is increasingly imperative that it be aware of all three aspects of the whole supply chains it belongs to and it proactively manage, monitor and assess those. Maritime transportation is classified as a part of maritime supply chains. Thus ports are a vital part of both maritime transportation and maritime supply chains. As such, sustainable port development can be defined as "business strategies and activities that meet the current and future needs of ports and their stakeholders, while protecting and sustaining human and natural resources"[9] [10]. This in line with Denktas-Sakar and Karatas-Cetin [10] who indicated that the mission to achieve port sustainability should be aimed at within an organization and in collaboration with port partners across crucial supply chain members. They need to acquire technological innovation to comply with a global sustainability agenda while developing their competitiveness as well. The new trend of shipping industries is concerned not only with creating more competition but also about developing sustainability in ports.

### *1.4. Thailand container port: Laem Chabang*

Asia plays a central role in global trade and shipping, in particular container ports, as 80 per cent of the ports featuring in the top 20 are Asian. Moreover, the overall merchandise trade growth in South-East Asia was more positive than other regions [28]. Laem Chabang (LCB) is the largest port of Thailand, the 4th largest in ASEAN, and the 20$^{th}$ in the world (2018). Furthermore, through major investments in infrastructure and the development of the Eastern Economic Corridor (EEC), a strategically located economic zone, and, Thailand is expanding the capacity of LCB to 18 million TEU per year to attract more direct calls in port. Currently, LCB can handle maximum throughput at 11.1 million TEU per year, the new investment phase will increases port connectivity and efficiency.

Table 1. Laem Chabang port

| No. container terminals | No. of port operators | Capacity (TEUs) | Throughput 2017(TEUs) | Throughput 2016(TEUs) | Percentage change 2016-2017 | Rank 2017 |
|---|---|---|---|---|---|---|
| 11 | 7 | 11.1 m. | 7.7 m. | 7.2 m. | 7.4 | 20 |

The Port Authority of Thailand (PAT) is responsible for the regulations and development of LCB. Recent years, the PAT has started to transform LCB into green ports in accordance with the International Maritime Organization (IMO) standards. In practical, the sustainability movement by the government sector is still vague and invisible as the sustainability is not a part of mission/goal of port operators and the PAT. Moreover, an awareness of sustainability is limit in Thailand. Consequently, the sustainability movement is might fading sometimes; however, ports need to achieve sustainability as it helps enhancing overall port performance. As such, this study aims to propose some form of the best practice with regard to port sustainability development. And, the results of this study could be of benefit to carry out port sustainability in Thailand. To achieve these aims, this paper attempt to address the following objectives:

(1) To identify criteria for sustainability within the context of container terminals in Thailand;
(2) To obtain the final set of criteria that have been evaluated the importance by experts from port industry

The rest of this paper is structured as follows. In section 2, Literature review is described. The research methodology is explained in detail in section 3. Section 4 presents the data collection method and how the proposed methodology is implemented. The results are discussed in section 5. Finally, the conclusion, limitations of this research and suggestions for future research are reported in section 6.

## 2. Review of literature

Since 2006, the increasing interest in sustainability and green ports has gradually attracted attention and growth in the number of academic publications. The majority of these studies focus on global eco-efficiency and greenhouse gas emission reduction trends of ports [13] [7]. Berechman and Tseng [16], Tzannatos [8] and Gibbs et al [5] are relevant examples. Particular interest is extended to sustainability in the environmental aspect. For example, Le et al. [36], Acciaro et al. [24] and Lun et al. [37] highlighted environmental sustainability in seaports. Since then, our increasing awareness of sustainability pressures ports to operate all activities more sustainably.

Accordingly, several researchers have already proposed the frameworks for assessing sustainability that include economic, environmental and social aspects, albeit with a greater emphasis on a framework for transshipment ports in developed and developing countries. The summary of literature review is classified into three groups; Greenhouse emission reduction, environmental sustainability development and sustainability assessment (see table 2). The current study is classified into the third group focusing on criteria and frameworks for sustainability assessment. The literature has been mainly contributed by organisations in America, the UK, China, and, Taiwan [13]. In table 2, these existing frameworks have some differences especially when the frameworks will be implemented for real world problems. Ports worldwide are different in many dimensions such as policy, and port ownership. Furthermore, the role of ports has taken several different forms in terms of the nature of their connectivity. Rodrigue et al. [23] explained the different characteristics of gateway and hub. A gateway typically means a location that have accessibility to transport links in a region. It could be an origin, a destination and a point of transit which will function as an intermodal between different modes. While a hub is a central location for transshipment and distribution in a transport system that deploy many inbound and outbound connections under the same mode [23].

The implementation framework in real world problem should take these issues into consideration because port A and B have different context. It is now mostly agreed that choices are susceptible to contextual influences [29], in this case, we could refers the choices to the set of criteria. There is a need for better understanding of a range of other relevant context effects on the criteria set or framework that selected to evaluate the sustainable development performance. Therefore, an application framework to measure any sustainable port development should be in line with its context to obtain better results. So far, only a few studies have tried to address this issue. For this reason, this paper aims to narrow the literature gap to specifically develop a criteria set for measuring sustainable development performance in container port of an emerging country, Thailand.

Table 2. List of literatures on port sustainability

| Literature classification | Authors | Case/research study |
|---|---|---|
| Greenhouse gas emission reduction | Corbett et al. (2009) [17] | Research study |
| | Eide et al. (2009) [25] | Research study |

| | | |
|---|---|---|
| | Tzannatos (2010) [8] | Case study of Greece |
| | Fitzgerald et al. (2011) [35] | Case study of New Zealand |
| | Villalb &Gemechu (2011) [11] | Case study of Barcelona |
| | Gibbs et al. (2014) [5] | Case study of UK |
| Environmental sustainability development | Lun et al. (2011) [37] | Case study of Hutchison Port Holding (HPH) |
| | Lirn et al.(2012) [32] | Research study |
| | Le et al. (2014) [36] | Case study of Vietnam and Cambodia |
| | Acciaro et al. (2014) [24] | Research study |
| Sustainability assessment | Shiau and Chuang [33] | Case study of Singapore |
| | Lu et al. (2012) [3] | Research study |
| | Asgari et al. (2015) [26] | Case study of UK |
| | Xiao and Lam (2017) [38] | Case study of Singapore |
| | Oh et al. (2018) [14] | Case study of South Korea |
| | Wan et al. (2018) [4] | Case study of China |

## 3. Research methodology

In this study, we select the 'best worst method' (BWM), a Multi-Criteria Decision Making Method (MCDM) which has not been used in this area before. We will elaborate the BWM that is used to assess the importance of the criteria in this section.

### 3.1. Best worst method

MCDMs have been widely used across several disciplines. There are many of MCDM methods available to weight multiple decision criteria such as the analytic network process (ANP) and analytic hierarchy process (AHP). The best worst method (BWM) has been developed to solve MCDM problems and that is based on pairwise comparison, similar to ANP and AHP. However the consistency of the comparisons can be influenced by some factors such as respondent debility or a difficult/complex questionnaire. Rezaei introduced a BWM method that can solve such problems with a more structured comparison approach [20]. BWM is able to improve the inconsistency issue, and requires fewer comparison data than other MCDMs [20] [21]. BWM has three key advantages when compares to other MCDMs method: 1) The derived weights from BWM are more reliable, 2) BWM requires less pairwise comparison compared to a full pairwise comparison matrix, and 3) BWM is much simpler because it only uses integers, while a full pairwise comparison matrix, not only deal with integer but also fractional numbers.

The BWM has been already applied to multi-criteria decision-making problems. For example, Rezaei et al. [19] applied the BWM to determine the best freight bundling configuration for transporting freight from outstations to airports. Rezaei et al. [22] have used BWM to select the best suppliers considering environmental and economic criteria. In another study by Ahmad et al. [34], BWM was used to evaluate the external forces affecting the sustainability of oil and gas supply chain. As shown in table 3, a sustainability assessment is a multi-criteria approach, so a MCDM should be used. The goal of BWM is to select the most important criteria. The decision maker select the most important criteria for assessing their sustainability development from a set of criteria. The BWM requires five steps to perform for assigning the weights as follows:

**Step 1.** *Determine a set of decision criteria*

In the first step, define a set of decision-making criteria. The set of criteria $\{c_1, c_2, c_3, \ldots, c_n\}$ is selected for making a decision on the best alternative by the decision maker.

**Step2.** *Determine the best (most important) and worst (least important) criteria*

In this step, the decision-maker determined the best and the worst criteria. There is no a comparison between the criteria made at this stage

**Step 3.** *Determine the preference of the best criterion over all the other criteria*

The preference of the best criterion over all the other criteria will be determined based on a score between 1 and 9. A selecting of 1 means that best criterion and another criterion are equally important. A selecting of 9 means that the criterion is extremely less important than the most important criterion. The result in this step is a vector of Best-to-Others vector that would be:

$$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn}),$$

Where $a_{Bj}$ presents the preference of the best criterion B over the criterion *j*. Generally speaking, in this vector $a_{BB}=1$, indicates the preference of the best criterion over itself

**Step 4.** *Determine the preference of all the other criteria over the worst criterion*

The preference of all the other criteria over the worst criterion will be based on a score between 1 and 9. . A selecting of 1 means that worst criterion and another criterion are equally important. A selecting of 9 means that the criterion is extremely more important than the least important criterion. The result of this step is an Others-to-Worst vector that would be:

$$A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})^T,$$

Where $a_{jW}$ presents the preference of the criterion over the worst criterion W. Generally speaking, in this vector $a_{WW}=1$, indicates the preference of the worst criterion over itself

**Step 5.** Calculate the optimal weights

The optimal weight $(w_1 *, w_2 *, w_3 *, \ldots, w_n *)$ is identified in the last step. The optimal weight for the criteria is the one where $w_B/w_j = a_{Bj}$ and $w_j/w_W = a_{jW}$ for each pair of $w_B/w_j$ and $w_j/w_W$. To obtain the optimal weight, it is required to satisfy these condition for all j by minimising the maximum absolute differences $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_W} - a_{jW}\right|$ for all *j*. There is no negative of the weights and the sum of it must equal to 1, the following problem can be formulated as:

$$\min \max_j \{|w_B - a_{Bj} w_j|, |w_j - a_{jW} w_W|\}$$

Subject to

$$\sum_j w_j = 1 \quad (1)$$

$$w_j \geq 0, for\ all\ j$$

The Eq. (1) can be transferred to a linear programming problem to be solve as follows:

$$\min \xi^L$$

Subject to

$$|w_B - a_{Bj} w_j| \leq \xi^L, for\ all\ j$$

$$\left|w_j^* - q_{jw} w_w^*\right| \geq \xi^L, for\ all\ j$$
$$\sum_j w_j = 1 \quad (2)$$
$$w_j \geq 0, for\ all\ j$$

After solving this linear programming problem Eq. (2), the optimal weights ($w_1^*, w_2^*, \ldots, w_n^*$) and $\xi^L$ are obtained.

## 4. Implementation

### *4.1 Determining the set of decision criteria*

According to the first step of BWM, the decision makers have to identify a set of criteria. The set of criteria are identified through a literature review and classified them into three pillars of sustainability. Initially, the 16 criteria were identified. In the filtering process, all criteria were verified by academic and practitioners within this field from Thailand who are familiar with the Thailand context. Finally, the 14 criteria are selected as shown in Table 3.

- Academics: Experts in port and maritime studies with over 10 years experience.
- Practitioners: Port directors and managers in container terminals who have worked in the field for more than 10 year.

Table 3. Sustainability criteria selected for sustainability assessment

| Aspects | Criteria | References |
|---|---|---|
| Economic | 1. Investing in port infrastructure (ECO1) | [3], [14], [26], [33] |
| | 2. Attracting shipping liners (ECO2) | |
| | 3. Cost-efficiency (ECO3) | |
| | 4. High quality of services (ECO4) | |
| Environmental | 5. Establish environmental policies (EN1) | [3], [4], [14], [18], [26], [33] |
| | 6. Environmental impacts in port area (EN2) | |
| | 7. Identify categories of environmental pollution (EN3) | |
| | 8. Waste management (EN4) | |
| | 9. Energy consumption (EN5) | |
| | 10. Commitment Identification (EN6) | |
| Social | 11. Occupational health and safety management system enforcement (SOC1) | [3], [4], [12], [14], [26], [33] |
| | 12. Recognising requirements of the neighbouring community (SOC2) | |
| | 13. The interests and rights of employees (SOC3) | |
| | 14. Providing support for employees' training and education (SOC4) | |

### *4.2 Questionnaire survey*

The structure of questionnaire was separated into 2 sections. First section is the personal information. Second section, it aims to evaluate the importance of sustainability criteria by using 1 to 9 scale to represent the preference of criterion *i* over criterion *j*. The designed questionnaire based on step 2 to step 4 in BWM five steps approach. The questionnaire was developed in English and translated to Thai in order to ensure that all participants would have full understanding of answering questionnaire. And to prevent lost in translation, the translated questionnaire was proofread by language specialist

### *4.3 Participations*

To collect data, structured interviews were performed by using questionnaires based on an identical set of questions. Target participants are supervisor, managers and directors who work at container terminal within LCB port. There is 17 participants from 10 terminals (6 operators) as shown in Table 4. Participants currently involved in operational activities in these terminals. In addition,

all of them have been worked in ports/terminals more than 5 years. Therefore they are definitely competent to answer the questions that reflect the whole picture of sustainability in terminals/ports.

Table 4. Participants

| No. | Terminal operators | Participant(s) | Experienced | Berth | Berth length | Throughput 2017 (TEUs,) |
|---|---|---|---|---|---|---|
| 1 | LCMT CO., Ltd | 4 | 9-22 years | A0 | 150 m. | 731,460 |
| | | | | B1 | 300 m. | 883,843 |
| 2 | Hutchison Laem Chabang Terminal | 4 | 15-18 years | A3, | 350 m. | 109,852 |
| | | | | C1-C2 | 1,200 m. | 2,047,135 |
| 3 | Evergreen Container Terminal | 4 | 5-35 years | B2 | 300 m. | 756,699 |
| 4 | Eastern Sea Leam Chabang Terminal | 1 | 17 years | B3 | 300 m. | 530,451 |
| 5 | TIPS CO., Ltd | 3 | 8-25 years | B4 | 300 m. | 886,341 |
| 6 | Laem Chabang International Terminal | 1 | 20 years | B5, | 400 m. | 694,041 |
| | | | | C3 | 500 m. | 734,684 |
| Total | | 17 | 5-35 years | 10 | | 7,374,506 |

## 5. Results and discussion

The final results of the study are presented in table 5. We found the weights of all the criteria together with the consistency ratio to measurement the reliability of the output. The consistency ratio (CR) was calculated of the all comparison are considerably close to zero which means a very good consistency in comparison of each aspect.

In the economic aspect, ‘cost-efficiency (ECO3)’ take the highest importance among all the criteria with weight of 0.383. This followed by ‘high quality of service (ECO4)’ and ‘investment in infrastructure (ECO1)’ with average weight of 0.254 and 0.210 respectively while the ‘attracting shipping lines’ (ECO2) is the least important. Not surprisingly, ECO3 and ECO4 are in the first and second rank respectively. One more reason is that LCB port is the gateway port. It mainly handles the cargoes which are import or export to/from Thailand. Hence, LCB need to improve their cost-efficiency together with quality of service to attract more direct port call from customers. Greater attention from port directors and manager were paid into these criteria so they can move ahead with efficiency in costs and services. The efficiency in port could enhance environment efficiency. Port with better efficiency tends to achieved environment efficiency. Therefore, terminals/ports possibly carry out the sustainability in both aspect by firstly improving their economic practice. ECO1 is not considered highly important. Traditionally, port are the area for infrastructure and super structure to accommodate ships and handle the cargoes [6]. However, port are expended their function to create value-added to cover the logistic concept. This might draw some interests toward the investment in infrastructure. Furthermore, LCB is a public-private port where the PAT is the regulator and landlord of LCB, while the private sector will handle the cargo and operate activities between sea and land. All terminal operators in LCB are concession holder. The concession contracts of terminals in the first phase of LCB is about to expire recently.

Table 5. The BWM results: The importance of criteria to port sustainability development

| Aspects | Criteria | Average weight | S.D. | Rank | CR |
|---|---|---|---|---|---|
| Economic | ECO1 | 0.210 | 0.195 | 3 | 0.059 |
| | ECO2 | 0.163 | 0.145 | 4 | |
| | ECO3 | 0.383 | 0.212 | 1 | |
| | ECO4 | 0.254 | 0.153 | 2 | |
| Environmental | EN1 | 0.287 | 0.132 | 1 | 0.031 |
| | EN2 | 0.244 | 0.155 | 2 | |
| | EN3 | 0.097 | 0.065 | 5 | |
| | EN4 | 0.143 | 0.082 | 3 | |
| | EN5 | 0.116 | 0.078 | 4 | |

| | | | | | |
|---|---|---|---|---|---|
| | EN6 | 0.114 | 0.087 | 6 | |
| Social | SOC1 | 0.295 | 0.222 | 1 | 0.058 |
| | SOC2 | 0.168 | 0.177 | 4 | |
| | SOC3 | 0.258 | 0.205 | 3 | |
| | SOC4 | 0.279 | 0.217 | 2 | |

The outcome of environmental aspect shows that an EN1 criterion, 'establish environmental policies', have the highest weigh of 0.287. This follow by 'environmental impacts in port area (EN2)' with weight of 0.244. Some of previous studies with regard to green port criteria/indicators proposed set of criteria/indicators without EN1 and EN2 criteria. For example, Lirn et al. [32] and Shiau and Chuang [33], their criteria are mainly about greenhouse gas emission and pollution by ports. On the other hand, Asgari et al. [26] included this criteria to measure port sustainability of the major UK ports. Similar to this study, we would like to capture the whole picture of environmental issues into policy to cover all environment problems. The environmental policy could reflect the awareness of sustainability of ports. From a practical perspective, establishment of policies help them to work comfortably. Policy could frame their awareness and behaviour to the right direction of environmental sustainability. Base on the weight given to EN2, this could imply that they do not only focus on pollution or greenhouse gas emission in port and leave the others related issues behind. They concern all environment impact surrounding their terminals especially traffic congestion problem which is a key issue in LCB. The weights of EN3, EN4, En5, and EN6 are hardly different. This could imply that they are almost equally least important for environmental sustainability.

In the last aspects of sustainability, our finding indicates that 'occupational health and safety management system enforcement (SOC1) ' and 'Providing support for employees' training and education (SOC4) ' are the first and second rank for social aspect, with the criterion weight of 0.295 and 0.279 respectively. The results is consistent with Azadnia et al. (2010) [2]. They studied the sustainable supplier selection and SOC1 take the highest rank in their study. Even though an operation within terminals is not similar to manufacturer, the safety and wellbeing of employees cannot be overlooked. SOC2 is seen importantly, this probably because of high turnover rate of employee among terminals within LCB. Ahmadi et al. [12] assess the social sustainability of supply chains. The results of their study support this research as SOC3 was also ranked the third. The interests and rights of employees (SOC3) is considered less importance, with the weight of 0.258. It probably because some practices that related to SOC3 are fairly similar among terminals in LCB such as working condition, wages and working hours. Recognising requirements of the neighbouring community (SOC2) is the least important criteria in this study, with weight of 0.168. To summarise, Ports much more concern with internal parties than external parties. This could be foreseen because internal parties are a vital asset to their terminals.

## 6. Conclusion

Port sustainability development are studied regarding to the criteria that influenced their sustainability performance. BWM is applied to evaluate the importance of each criteria from three sustainability aspects. We find that cost-efficiency, establish environmental policies and occupational health and safety management system enforcement are the most vital criteria that could affect the sustainability of terminals/ports in Thailand. The results could guide port/terminal manager to prioritise criteria that they need to be focused. In addition, port operators should promote and integrate sustainability issues in decision-making process not only on an operational level but also strategic level.

However, we also have some limitations in this study. Firstly, the number of potential participant within LCB port is limited by nature. More participants involved would have wider perspectives and provide the results more precisely. Secondly, the derived criteria for port sustainability assessment was developed in specific country settings, the finding are not generalised. Hence, external factor such as port ownership, port regulations and laws need to take into account. These external factors are also the important dominant for evaluated criteria. However, the qualification and uniformity of participants, we are fairly certain that related concerns and activities in achieving port sustainability within container ports and Thailand port in general. Thirdly, our findings are encompass a single period of study so the importance of these criteria would change over time. For better understanding in the future, the empirical research is required to be tested these results, together with identification of further indicators or sub-criteria of sustainability development. This should be take into account to deliver the results of sustainability assessment more elaborately and precisely. In addition, future researchers might use other MCDMs to compare the results with our BWM.

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