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Research Article

Modeling Framework of Hybrid Method for Site Selection of Dry Port: A Case Study in Southern Region of Thailand

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Abstract
International trade is considered as one of the most important areas to drive the economy of Thailand. With goods moved and stored on a regular basis, the nation's logistics cost per GDP is quite high on account of relying mainly on the road mode, where freight transport is heavily linked to fuel price. The solution to reduce costs may be by using intermodal transport, where a dry port is regarded as a crucial part. The southern region is selected as a case study because of particular reasons of the peninsula (particularly, seaports along both coasts) and the possible rise of cross-border and global trade with Malaysia and other territories. In this study, the modeling framework for site selection of a dry port, including the systematic SEM-MACBETH-PROMETHEE approach is proposed. Different sample sizes were compared as a sensitivity analysis. Results show that Hatyai railway station is the most attractive location as a dry port in southern Thailand.

Keywords: Intermodal transport, Dry port, SEM, MACBETH, PROMETHEE

1 Introduction

Trade, the transfer of goods (or services) in exchange for cash, is viewed as one of the most important sources to generate income for each country. Thailand has continuously driven its economy through the export sector: over half the value of GDP [1]. Based on price, goods, however, are likely to be competitive in every market owing to numerous factors. One of them is logistics cost, which is basically composed of transport, warehousing along with inventory and administration costs. Thailand's National Economic and Social Development Board [2] reports that logistics cost per GDP in 2013 of public and private sectors approximately stands at 14.2% (transport: 7.4%; warehousing along with inventory: 5.5%; administration: 1.3%), which is higher compared to such developed nation as USA, Japan and European countries [3]. The country now uses domestic freight transport of airways, railways and waterways with 0.02, 2.2, and 17.78% (comprising inland and coastal waterway of 9 and 8.4%, respectively) of all modes, respectively while the highest ratio for goods movement of 80% is on road [2]. This proves that the conveyance on road causes a huge effect on transport costs. Its cost of 2.12 baht per ton-kilometer [4] is just over two and three times as much as rail and water transport (0.95 and 0.65 baht per ton-kilometer, respectively), while the highest cost (10.00 baht per ton-kilometer) is for air cargo.

By reducing the transport costs on road mode, rail may be an alternative because rail networks are greater than inland waterways. However, a single mode cannot minimize costs for the entire route, if long distances are

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involved. Therefore, a combined solution is preferable, particularly using intermodal transport, described as at least two modes are utilized to convey container(s) without opening from the starting to destination point. In other words, freight is moved by combined transport of truck and freight train. To link between rail and road on purpose of transshipment, a dry port is required as a terminal for those modes. At present, there is one dry port in Thailand: an inland Container Depot (ICD) at Ladkrabang, to support Laemchabang seaport activities. However, if the volume of exports and imports rise in the future, a new dry port in other locations should be taken into account. Among many sites for dry port establishment, the southern zone seems to be the most attractive one owing to situating in an excellent geography. As the railway line is the backbone from north to south in the southern region, the potential dry port should be founded at any railway station for connecting to gateways, in particular seaports. Commonly, dry ports are located inland from seaports but are linked directly to the seaport(s) [5]. Similarly, Jeevan, *et al*. [6] make clear that many countries have developed dry ports to facilitate trade and cargo flows between seaports and final destinations.

In this study, two essential problems are eventually expressed. The first is that development guidelines of a dry port in Thailand based on multiple policies for being a dry port establishment policy has never existed; and location determinants of a dry port in the context of southern Thailand has not yet determined. The second is concerned with the lack of a systematic approach to locate a dry port in that region. The objective of this study is to originate the modeling framework of a dry port establishment and initiate the systematic approach in that framework. The modeling framework associated with a dry port is constructed for collecting related variables of establishment policy and location determination, including criteria and alternatives for dry port location. The systematic SEM-MACBETH-PROMETHEE approach is used for evaluation of pre-determined dry port sites. The aim of this is to rank those sites from best to worst.

2 Literature Review

2.1 *Development of dry port*

Nowadays, many companies have swiftly responded and adapted themselves for surviving in competitive markets and in turn making profits. A popular tool to sustain business is logistics management, directly resulting in cost reductions and customer satisfaction. Islam, *et al*. [7] indicate that there are five key elements of logistics (e.g. transport, warehousing, inventory, packaging and information processing). Among them, transport is the most important one of logistics. Clearly, this causes the largest effect on the cost structure of logistics. Thailand's transport cost was the greatest proportion in 2013 at 51.9%, followed by inventory holding and logistics administration with 39 and 9.1%, respectively, in logistics cost [2]. There are many solutions in the micro scale to decrease logistics costs of those companies, such as changing route for selecting the shortest path, rescheduling of vehicles to adjust for traffic congestion, consolidating orders, utilizing vehicles with backhaul applications, implementing alternative energy by using natural gas instead, and outsourcing from professional logistics service providers. Still, those solutions have not been sustainable for long-term logistics operations. Thus, the mode combination for movement of freight from the origin to destinations could be an alternative choice in macro scale of the country. The association of two or more modes of transport in a transport chain is a well-established and regular practice in the freight transport business [8]. Hence, intermodal transport is visible as the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes [9]. In accordance with Hanaoka and Regmi [10], the development of intermodal carriages requires the consideration of three attributes: encompassing transport nodes (e.g. seaport, airport, truck terminal); transport links (e.g. highway, railway, waterway); and transport services (e.g. trade, transport and service quality). As part of an intermodal transport system, most seaports have encountered congestion of containers owing to the large amount of freight. This barrier is the reason behind the long operation times in supply chain networks. The main problems seaports face today, as a result of growing containerized transport, are lack of space at seaport terminals, and growing congestion on the access routes serving their terminals [11]. Alternatively, the inland node has become more attractive for freight transport. In response, a dry port, serving as the transshipment terminal between transport modes, has emerged to reduce above-mentioned problem and also support seaport operations. Rodrigue, *et al*. [12] mention that dry ports as the part of logistics centers have become the basic elements of local, national and international transport systems in regions with a high volume of trade. With the advent of a dry port, some activities initially carried out within seaports were shifted to dry ports, complementing international and domestic transport services through providing intermodal connectivity, together with a wide range of services related to cargo processing, storage, consolidation, distribution and customs brokerage [13].

Based on policy on dry port development, it is clear that the government initiates its development with multiple policies. Hanaoka and Regmi [10] point out that the policies have a strong influence on dry port development. They state that a lack of clear policies can pose severe threats to the selection of locations for inland dry ports [10]. Or else, the unclear policies will definitely affect site selection of a dry port. Additionally, some criteria must be considered when deciding on the location of a dry port [10], for example industrial and agriculture centers; major intersections of railways, highways and waterways; intersections along trunk railway lines, major highways, inland waterways and at airports. Also, the level of import and export activities handled by the inland port is originated from the populous area [14].

2.2 *Site selection by multi-criteria decision method*

Decision making is regarded as a key factor to achieve success in any discipline, especially in a field which requires handling large amounts of information and knowledge [15]. Over the years, Multi-Criteria Decision Making (MCDM) methods seem to be one of the most important tools to solve complex problems in the number of issues. MCDM application is even wider as it can be used to solve any problem where a significant decision needs to be made [16]. Thus, the MCDM method is employed to investigate a number of alternatives in the light of multiple criteria and conflicting objectives [17]. Site selection is viewed as one of the MCDM problems because it is basically associated with several locations for consideration. For the last two decades, many MCDM methods concerned with site selection have appeared in academic papers. For example, Özcan, *et al*. [18] proposed three different MCDM methods, but compared TOPSIS, ELECTRE and GST. They used those methods for solutions in retail business about a case study of the problem of warehouse location selection. By opting for an appropriate borough in the region of greater London to construct a large casino, Ishizaka, *et al*. [19] presented the comparison among WSM, PROMETHEE and TOPSIS. They indicated that the first two methods were more suitable than TOPSIS, because of compliance with decisions of the Casino Advisory Panel in the United Kingdom. With the limitations of each single method, however, the trend of combined methods, between MCDM ones or MCDM one(s) and other(s), has become more widely recognized. For instance, Sayareh and Alizmini [20] carried out a study to weigh the most dominant decision-making criteria using TOPSIS and selected an optimized container seaport in the Persian Gulf by AHP with decisive port selection factors. Yildirim and Önder [21] demonstrated the freight village analysis model by combining AHP and PROMETHEE. While many subjective and objective opinions of the logistics managers or experts were turned into a quantitative form with AHP, PROMETHEE was employed to calculate the freight villages' ratings. Komchornrit [22] extended the decision tool by combining statistics and MCDM techniques (CFA, MACBETH and PROMETHEE) to locate the most appropriate dry port in Thailand. Onut, *et al*. [23] used the fuzzy ANP-based approach to select a container port in Turkey. With the conflicting qualitative and quantitative criteria existing in order to evaluate the alternative ports, this combined approach could solve ambiguities and vagueness. Awasthi, *et al*. [24] utilized the fuzzy theory to quantify criteria values under uncertainty and application of fuzzy TOPSIS to evaluate and then selected a suitable location for implementing an urban distribution center. In the task of Kabir and Sumi [25], a simple, systematic and logical scientific methodology was structured to evaluate a power substation location in Bangladesh by integrating fuzzy AHP and PROMETHEE. The proposed integrated method provided more realistic and reliable results, and enabled a decision maker to handle multiple contradictory decision perspectives by eliminating the limitations of both methods. Roig-Tierno, *et al*. [26] tackled the development of a methodology for the process of selecting the retail location in the Spanish city of

Murcia by integrating GIS and AHP. As a result, the MCDM method will be selected as a part of the decision procedure on the site of the dry port.

3 Methodology

3.1 *The proposed modeling framework*

To respond to research problems, the modeling framework for site selection of a dry port is proposed. As depicted in Figure 1, it comprises phases of establishment and location analysis. In terms of approach, SEM (Structural Equation Modeling) is employed in the first phase to examine the causal relationship of variables. Also, the hypothesis testing is applied between establishment policy and location determination. In the second phase, the hybrid SEM-MACBETH-PROMETHEE approach is used to evaluate pre-determined dry port locations, which criteria, transformed from variables, are derived from the first phase. Ultimately, the aim is to rank from the most to least appropriate sites of a dry port.

Shown as mutual enhancement, the integrated SEM-MACBETH-PROMETHEE method is chosen for the following reasons. PROMETHEE is used because of its simplicity, clearness and stability [27]. Furthermore, it is a logical and rational method with its preference functions, allowing an analyst to consider the type of data available [28]. However, the constraint is that there has been no certain procedure to construct the weight of each criterion. As stated by Velasquez and Hester [29], PROMETHEE does not provide a clear methodology by which to assign weights. By removing this limitation, MACBETH is applied to determine weights. Bana e Costa and Chagas [30] note that it is a method designed to build a quantitative model of values, developed in a way that enables facilitators to avoid forcing the decision makers to produce direct numerical representations of their preferences. In addition, its advantage is that there is no inconsistency on weights of criteria. If the matrix of MACBETH is consistent, the attractiveness will only be calculated; otherwise the user is obliged to revise judgments [16]. Nevertheless, MACBETH cannot fulfill to sort criteria in order of their importance, from most to least. Accordingly, SEM is conducted to define the importance of those criteria based on factor loading of each, which variables (criteria) are expressed as being interrelated.

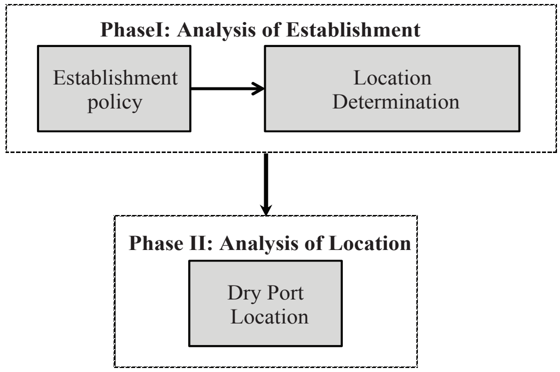


Figure 1: The modeling framework.

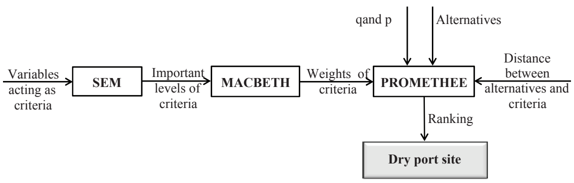


Figure 2: The systematic approach.

In accordance with Figure 2 of the systematic approach, overall, alternatives of a dry port site are first determined. Afterward, the criteria (observed variables of location determination of dry port) are sorted from the most to least important by factor loadings of SEM, based on regression analysis. Apart from these criteria, SEM is conducted to investigate the relationship between latent variables (dry port establishment policy and location determination of dry port) with observed ones. Later, weights of criteria are obtained from MACBETH, which pairwise comparison and linear programming are manipulated. Eventually, weight of criteria, q (indifferent threshold) and p (preference threshold) values of criteria, pre-determined alternatives and distance (km) between each pair of alternative and criterion are brought to compute by pairwise comparison and preference function (linear one used) of PROMETHEE for ranking the most to least attractive sites of dry port.

3.2 *Scope of the study*

The southern region of Thailand is likely to be an outstanding choice for the establishment of a dry port, especially for trade tendencies. Apparently, the cross-border trade with Malaysia is viewed as the highest value compared to that with Myanmar, Laos and Cambodia. The ratios of import and export cross-border values with Malaysia compared to total cross-border ones with other neighboring countries were roughly 57 and 43% in 2015, respectively [31]. In addition, the economic development corridor for the cooperation of trade among three nations, comprising Indonesia, Malaysia and Thailand, will demand a freight transshipment terminal, where the southern Thailand seems more attractive. In terms of geography, the southern part is a long distance from north to south and is narrow from east to west, bounded by the Gulf of Thailand and the Andaman Sea. While its railway is in a vertical line – approximately 1,140 km from Bangkok, one of the railway stations will be chosen as a potential dry port by expanding its area by way of land acquisition. It can link to gateways, production bases and consumption points through existing/potential roads or railways. Evidently, this conforms to intermodal transport that the Thai government has strongly promoted as the national strategy.

3.3 *Survey design*

To obtain relevant data for phase I of a dry port establishment in the southern area of Thailand, a questionnaire (part I) shown in Appendix A, the instrument of this study, were initially created. All answers were from respondents, who assessed scales ranging from one (strongly disagree) to five (strongly agree). The purpose is to collect all data of observed variables bound to latent ones at once. Regarding policies of dry port, development guidelines [10], [32] comprise agriculture, transport projects, railway transport, airports and seaports, distribution centers, human resources, logistics law, information technology, national single window system, cross-border logistics, cross-border rules, economic corridor, economic zones and gas emission. Location determination of the dry port [10], [33], based on the context of southern Thailand, was developed from seaports, airports, highways, industrial areas, local markets, regional markets and cross-border markets.

After all data of the questionnaire of part I were processed, a second questionnaire directly linked to phase II was generated from responses of the first (Appendix B). Location determination's variables, transformed as criteria, were sorted from the most to least important based on values of factor loading. Subsequently, experts were asked to compare each pair of those criteria from scales of difference in attractiveness, ranging from indifference (0) to extremely attractive over another (6). Also, sub-criteria were applied by the same method of pairwise comparison. Finally, those experts gave their opinions for the distance of q and p thresholds between those criteria and a dry port (Appendix C).

3.4 *Data collection*

The population of this study is employers/employees, experiencing in working at or using services of Thailand's ICD at Ladkrabang. Random sample size is drawn from three groups (government agents, private-sector concessionaires and brokers/freight forwarders). To identify a number of people in the sample size, the software of G*Power 3, designed as a general stand-alone power analysis program for statistical tests [34], was conducted by means of Chi-square test, where SEM is involved in goodness-of-fit tests. By determining the sample size, the following inputs are then required. Firstly, the effect size is an impact of the independent variable(s) on dependent one. Cohen [35] justifies the levels of effect sizes of the Chi-square test, classified as three types – small (0.1), medium (0.3) and large (0.5). On account of the default value, the medium effect size of 0.3 is undertaken. Secondly, the significance level of 0.05 is generally used. Thirdly, the power $(1 - \beta)$ of the statistical test is the complement of β, which denotes the Type II or beta error probability of falsely retaining an incorrect H_0 [34]. Then, the power of test is 0.80, commonly utilized [36]. Lastly, the degree of freedom is calculated by the formula of $[NI \times (NI+1)]/2$, where NI is the number of observed variables. As the number of observed ones was 21, the degree of freedom was 231. Hence, the consequence of total sample size, calculated by G*Power 3, was 655. However, the actual sample size of 889 was collected.

With reference to the number of experts, who define weights of each criterion, however, there is no certain rule to assign a specific number of them, but depending on availability of those experts. For example, Sayareh and Alizmini [20] invited 25 experts in their work of selecting a container seaport using a hybrid MCDM model while Portugal, *et al*. [37] conducted 30 specialists with an AHP approach related to locations of truck cargo terminal in Brazil. In the research of Kabir and Sumi [25], they requested 14 experts to participate in a Delphi based decision group. In this study, 11 experts in logistics disciplines were invited to use their experience for making decisions on comparisons of criteria and distance between a dry port and criteria.

4 Results

4.1 *Results of SEM*

Based on the structural model in Figure A1 of Appendix A, standardized factor loading, Standard Error (S.E.) and Critical Ratio (C.R.) are shown in Table 1. It is noted that values of S.E. and C.R. at EP1 and LD1 are not applicable because of the parameter fixed at 1.00. A factor loading is defined as the weight of an observed variable on a latent one. Regarding standardized factor loading of EP, EP9 is the highest one of 0.86, whereas EP12 is the lowest one of –0.04. Based on LD standardized factor loading, LD1 reaches a high loading at 0.93. In contrast LD2 hit a trough at 0.13 of loading. In terms of S.E., values of observed variables are rather low, ranging from 0.03 to 0.08. With regard to C.R. (t-value), a t-value greater than 1.96 or smaller than –1.96 implies a statistical significance at a level of 0.05 [38]. Results show that C.R. of EP11, EP12 and EP14 are between –1.96 and 1.96, indicating that they are not significant on EP.

With respect to the hypothesis, the effect of EP on LD is examined. As demonstrated in Table 2, the impact of dry port establishment policy on location determination of the dry port is significant at 0.05, where C.R. is 2.03 (higher than 1.96), whereas the standardized factor loading and S.E. are 8% and 0.07, respectively. In terms of fitness demonstrated by the goodness-of-fit indices, χ^2 and df are 312.91 and 147, respectively, so χ^2/df is at 2.13, being an acceptable criterion (between 2 and 3). RMR and RMSEA are 0.03 and 0.04, respectively, holding between 0 and 0.05 of criterion. NFI is 0.94, falling within the acceptable criterion ($0.90 \leq$ NFI ≤ 0.95), while CFI is 0.97 (within 0.97 and 1.00), viewed as a good shape of criterion. Finally, GFI and AGFI are 0.97 and 0.95, respectively, staying in a good range of criteria ($0.95 \leq$ GFI ≤ 1.00 and $0.90 \leq$ AGFI ≤ 1.00). Consequently, those indices were proved to support fitness of the structural model.

Table 1: Results of factor loading, S.E. and C.R. on SEM

Latent Variable	Observed Variable	Standardized Factor Loading	S.E.	C.R.
EP	EP1	0.68	-	-
	EP2	0.49	0.05	15.53
	EP3	0.63	0.06	17.75
	EP4	0.48	0.06	12.90
	EP5	0.56	0.05	15.68
	EP6	0.67	0.05	17.97
	EP7	0.77	0.06	20.05
	EP8	0.78	0.06	21.39
	EP9	0.86	0.06	22.13
	EP10	0.43	0.07	12.27
	EP11	–0.03	0.07	–0.96
	EP12	–0.04	0.07	–1.20
	EP13	0.17	0.08	4.80
	EP14	–0.01	0.08	–.31
LD	LD1	0.93	-	-
	LD2	0.13	0.03	3.52
	LD3	0.51	0.07	7.92
	LD4	0.28	0.05	6.20
	LD5	0.20	0.05	5.11
	LD6	0.16	0.04	4.18
	LD7	0.21	0.05	5.14

Remark: EP1: agriculture, EP2: transport projects, EP3: railway transport, EP4: airports and seaports, EP5: distribution center, EP6: human resources, EP7: logistics law, EP8: IT, EP9: NSW system, EP10: cross-border logistics, EP11: cross-border rules, EP12: economic corridor, EP13: economic zones, EP14: gas emission, LD1: seaports, LD2: airports, LD3: highways, LD4: industrial areas, LD5: local markets, LD6: regional markets, LD7: cross-border markets

Table 2: Results of hypothesis testing and fitness on SEM

Variable	Standardized Factor Loading	S.E.	C.R.
EP → LD (H1)	0.08	0.07	2.03
Fit indices: χ^2 = 312.91 (df = 147), χ2/df = 2.13, RMR = 0.03, RMSEA = 0.04, NFI = 0.94, CFI = 0.97, GFI = 0.97, AGFI = 0.95			

4.2 *Weights of criteria*

Table 1 at LD, it implies that LD1–LD7 can be sorted out in order from the most to least important based on factor loading. At this point, those observed ones, designated as criteria, are ranked and tabulated in Table 3. Then, 11 experts in the field of logistics were invited to make their decision by comparing each pair of criteria by means of how attractive of one over another, concerned directly with the distance from a dry port. Later, the weight computation of MACBETH was executed using M-MACBETH software. Weights of criteria are calculated based on the linear optimization, which is used to minimize the score of the most attractive criterion [16]. Hence, weights of seaport, highway, industrial area, cross-border market, local market, regional market and airport were 22.45, 20.41, 18.36, 16.33, 14.28, 7.49, and 0.68%, respectively.

Table 3: Rank of criteria

Rank	Criterion	Factor Loading
1	Seaport	0.93
2	Highway	0.51
3	Industrial area	0.28
4	Cross-border market	0.21
5	Local market	0.20
6	Regional market	0.16
7	Airport	0.13

However, those seven criteria were composed of sub-criteria, so weights were allocated into sub-criteria based on judgment of experts. Therefore, all weights of sub-criteria in this study were as follows:

- Seaport was composed of two sub-criteria of Port of Songkhla and Phuket with weight of 19.24 and 3.21%, respectively.
- Highway consisted of a sub-criterion of Highway 4 (or 41) with weight of 20.41%.
- Industrial area had only one sub-criterion of Southern region industrial estate with weight of 18.36%.
- Cross-border market had two sub-criteria of Sadao and Padang Besar with weight of 13.06 and 3.27%, respectively.
- Local market had three sub-criteria of City municipality of Hatyai, Surat Thani and Nakhon Si Thammarat with weight of 8.79, 4.39, and 1.10%, respectively.
- Regional market had a sub-criterion of Bangkok with weight of 7.49%.
- Airport consisted of Phuket and Hatyai international airport with weight of 0.58 and 0.10%, respectively.

4.3 *Rank of alternatives*

The ranking problem of dry port sites in this study is performed by PROMETHEE, based on pairwise comparison and preference function of linear, through software of Visual PROMETHEE. The pre-determined alternatives of dry port locations were railway stations (Mapammarit, Banthungpho, Surat Thani, Thungsong, Hatyai, Chumphon, Bansong, Nakhon Si Thammarat, Trang and Phatthalung). The first five stations are also acted as rail freight terminals. The rest are first-class stations where their districts have carried population densities higher than the average of southern ones, which is 131.38 people per square km. Also, q and p values used as preference functions were obtained from 11 experts. Eventually, results, as presented in Table 4, exhibit that Hatyai railway station is the most attractive location of a dry port with the highest Phi value of 0.52. In this case, the higher values of Phi are the more attractive sites of dry ports in southern Thailand.

Table 4: Rank of rail-based dry port site

Dry port location	Phi	Rank
Hatyai	0.52	1
Phatthalung	0.45	2
Trang	0.31	3
Thungsong	0.23	4
Bansong	0.04	5
Nakhon Si Thammarat	-0.07	6
Banthungpho	–0.13	7
Surat Thani	–0.14	8
Chumphon	–0.42	9
Mapammarit	–0.78	10

4.4 *Sensitivity analysis*

The rank of criteria, explicitly regarded as the sensitivity analysis, seem to have a significant influence on the final outcome because it is the cause of weights allocated to criteria. In the questionnaire in part I, dry port establishment policy and location determination of dry port were manipulated by SEM in order to confirming the consistency of policy having an impact on location determination. Results demonstrated the relationship between observed and latent variables through such statistics as t-value and factor loading. Particularly, different factor loadings of observed variables, later transformed as criteria, on location determination are used to rank those criteria. Afterward, a sample size is defined. While a number of 889 had been applied, other sizes were taken into account for comparison. In this case, 655 were used as a required value (referred in Section 3.3). A sample size of 236 was chosen because it was the minimum number of requirements with 0.5 effect size. Accordingly, values of factor loading with ranks of criteria on three different sample sizes are shown in Table 5.

Table 5: Comparison of factor loadings (F.L.) of criteria with rank (R.) on different sample sizes (S.S.)

Criterion	S.S. of 236		S.S. of 655		S.S. of 889	
	R.	F.L.	R.	F.L.	R.	F.L.
Seaport	1	0.74	1	0.91	1	0.93
Airport	3	0.32	7	0.13	7	0.13
Highway	2	0.71	2	0.52	2	0.51
Industrial Area	4	0.15	3	0.28	3	0.28
Local Market	7	0.02	5	0.20	5	0.20
Regional Market	6	0.06	6	0.17	6	0.16
Cross-border Market	5	0.10	4	0.21	4	0.21

In Table 5, ranks from different sample sizes have an effect on making the questionnaire in part II. For example, airport has a higher rank than local market in 236 samples, but a lower rank than local market in sample sizes of 655 and 889. This leads to the pairwise comparison between criteria, for which experts gave opinions on the scale of difference in attractiveness. Later, their weights were calculated using MACBETH on different sample sizes, as shown in Table 6. Apparently, those weights conform to factor loading values. If factor loading is higher, weight will be increased.

Table 6: Comparison of weights (W. in %) of criteria with rank (R.) on different sample sizes (S.S.)

Criterion	S.S. of 236		S.S. of 655		S.S. of 889	
	R.	W.	R.	W.	R.	W.
Seaport	1	21.66	1	25.22	1	22.45
Airport	3	18.33	7	0.91	7	0.68
Highway	2	20.00	2	21.62	2	20.41
Industrial Area	4	16.67	3	18.92	3	18.36
Local Market	7	0.56	5	13.51	5	14.28
Regional Market	6	7.78	6	3.61	6	7.49
Cross-border Market	5	15.00	4	16.21	4	16.33

After that, the authors extended seven criteria to 12 sub-criteria, with which specific places are identified. In regard to criteria with more than two sub-criteria, for instance, the Ports of Songkhla and Phuket are major deep seaports in southern Thailand. On the basis of freight volumes, the Port of Songkhla was more than Phuket; thus Port of Songkhla was more considerable. The amount of freight was also applied to airports and cross-border markets, while local markets depended upon population numbers. Experts were asked to conduct pairwise comparison for those sub-criteria. MACBETH was then used to compute weights. All weights (%) of sub-criteria on different sample sizes are displayed in Table 7.

Table 7: Comparison of weights (W. in %) of criteria on different sample sizes (S.S.)

Criterion	Sub-criterion	W.		
		S.S. of 236	S.S. of 655	S.S. of 889
Seaport	S1	18.56	21.44	19.24
	S2	3.10	3.78	3.21
Airport	A1	15.71	0.78	0.58
	A2	2.62	0.13	0.10
Highway	H1	20.00	21.62	20.41
Industrial Area	I1	16.67	18.92	18.36
Local Market	L1	0.34	8.31	8.79
	L2	0.17	4.16	4.39
	L3	0.05	1.04	1.10
Regional Market	R1	7.78	3.61	7.49
Cross-border Market	C1	12.00	12.97	13.06
	C2	3.00	3.24	3.27

Remark: S1: Port of Songkhla, S2: Port of Phuket, A1: Phuket international airport, A2: Hatyai international airport, H1: Highway 4 or 41, I1: Southern regional industry estate, L1: City municipality of Hatyai, L2: City municipality of Surat Thani, L3: City municipality of Nakhon Si Thammarat, R1: Bangkok, C1: Sadao, C2: Padang Besar

Based on preference functions, q and p values of criteria were evaluated by experts. Those values, along with weights of 12 sub-criteria from Table 7, were input data for PROMETHEE to compute Phi values of alternatives. Their ranks are exhibited in Table 8.

Table 8: Comparison of Phi values of alternatives with rank (R.) on different sample sizes (S.S.)

Alternative	S.S. of 236		S.S. of 655		S.S. of 889	
	R.	Phi	R.	Phi	R.	Phi
Mapammarit	10	–0.77	10	–0.86	10	–0.78
Banthungpho	6	–0.02	7	–0.15	7	–0.13
Surat Thani	7	–0.03	8	–0.16	8	–0.14
Thungsong	4	0.23	4	0.25	4	0.23
Hatyai	2	0.32	1	0.57	1	0.52
Chumphon	9	–0.41	9	–0.47	9	–0.42
Bansong	5	0.17	5	0.05	5	0.04
Nakhon Si Thammarat	8	–0.13	6	–0.07	6	–0.07
Trang	3	0.29	3	0.35	3	0.31
Phatthalung	1	0.34	2	0.49	2	0.45

As shown in Table 8, the top three alternatives of 236 samples are Phatthalung, Hatyai and Trang with Phi values of 0.34, 0.32, and 0.29, respectively, while those of 655 samples are Hatyai, Phatthalung and Trang with Phi values of 0.57, 0.49, and 0.35, respectively. Those of 889 samples are Hatyai, Phatthalung and Trang with Phi values of 0.52, 0.45, and 0.31, respectively. It can be concluded that larger sample size was not related to the higher Phi values, as expressed by 655 and 889. In comparison to 236, when sample size became larger (655 and 889 in this study), the evidence is likely to indicate that the same results were obtained.

5 Conclusions and Discussion

The indication was therefore that the final result depended upon the rank of criteria. Accordingly, the principle of putting the criteria in order, based on importance, is crucial in this study. In general, sorting the importance of criteria in order can be done by two modes through questionnaires, in which experts' opinions are used. The first uses the average values from all criteria based on the Likert scale. Sorting criteria by means of importance, then changing to average values, is the second. Nonetheless, the proposed method was SEM because its factor loadings are clearly concerned with relationships between variables. Also, three different sample sizes (236, 655, and 889) were applied with the purpose to compare the ranks of criteria. Results showed that the same rank came from 655 and 889 samples. Therefore, it may be inferred that large sample sizes have a tendency to go in the same direction. Based on the questionnaire in part I, opinions should come from operators rather than experts. The operators deal with actual operations and have clear perspectives to rank criteria (seaports, airports, highways, industrial areas, local markets, regional markets and cross-border markets). That ranking was further used for pairwise comparison in the questionnaire in part II. Moreover, some sub-criteria stuck to statistics data were also brought for pairwise comparison. Experts, who understand the significance of those data, were asked for their judgments. As a result, outcomes based on statistics data seem to have an impact on weights of those sub-criteria. With different sample sizes of 236, 655, and 889, data from operators in the questionnaire in part I for ranking criteria have an influence on the final outcomes rather than the ones in the questionnaire in part II because those outcomes rely greatly in weights of criteria. Hence, it can be concluded that data, obtained from questionnaire of part I, are vital to determine ranks of criteria. In a case of insufficient data, for example a sample size of 236, final results are different from those with 655 and 889 samples.

In this study, however, distance is picked as the measurement between 10 alternatives with 12 criteria for each pair. The reason is that distance has an effect on daily operation costs of transport, which concerned directly with logistics costs.

With regard to foreseeability, Hatyai railway station is located on the route of the southern land bridge between Pakbara and Songkhla II port, including on-going establishment of a special economic zone at Sadao. In addition, regional cooperation of the Indonesia – Malaysia – Thailand growth triangle (IMT-GT) could sustain cross-border trade on the trade facilitation of non-tariff barriers, single declaration form, single inspection and computerized customs procedures. Therefore, it seems preferable to consider a potential dry port at Hatyai.

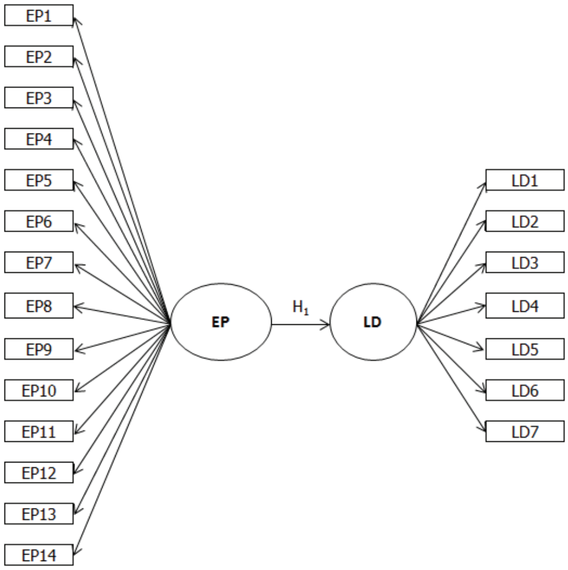
The limitations of this study are that only 10 alternatives for dry port sites are determined at existing railway stations. Other conditions should be defined as alternative, such as some positions in province, some points within the radius of seaport, some places adjacent to production base, or some areas close to consumption point. Alternatively, other methods, e.g. GIS (geographical information system) with specific criteria can identify any point for a dry port location. Those locations may be filtered out by land acquisition for example.

Acknowledgments

We are grateful to all respondents and experts in logistics/transport industry and relevant areas, who were the samples in this study.

Appendix A. Input data of SEM

Overall, the structural model with relationship of variables is demonstrated in Figure A1. In the questionnaire (part I), there are 14 questions with respect to development guidelines, based on policies from dry port development, presented by ESCAP



Remark: EP: dry port establishment policy, EP1: agriculture, EP2: transport projects, EP3: railway transport, EP4: airports and seaports, EP5: distribution center, EP6: human resources, EP7: logistics law, EP8: IT, EP9: NSW system, EP10: cross-border logistics, EP11: cross-border rules, EP12: economic corridor, EP13: economic zones, EP14: gas emission, LD: location determination of the dry port, LD1: seaports, LD2: airports, LD3: highways, LD4: industrial areas, LD5: local markets, LD6: regional markets, LD7: cross-border markets

Figure A1: The structural model of dry port establishment.

and Thailand's 11th NESD plan. Respondents were asked to rate scales ranging from "strongly disagree" to "strongly agree" in reference to establishment policy of dry ports. An example is shown in Table A1. Meanwhile, seven questions for location determination of dry ports are involved. Similarly, the rating scale ranges from "strongly disagree" to "strongly agree" of importance for each strategic place as shown by an example in Table A2.

Table A1: An example of questionnaire (part I) for dry port establishment policy

Development Guidelines	Opinion Level				
	1	2	3	4	5
Do you agree that logistics management in agricultural sector should be promoted in order to reduce product decay and inadequate transport, and provide temperature controls, tracking and traceability, considering as a development guideline to establishment a dry port?					

Remark: 1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree

Table A2: An example of questionnaire (part I) for location determination of dry port

Determinant of Dry Port Establishment	Opinion Level				
	1	2	3	4	5
Do you agree that distance between dry port and seaport has an impact on establishment of Thailand's southern dry port?					

Remark: 1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree

Appendix B. Input data of MACBETH

In the questionnaire (part II), an expert was asked to compare 27 pairs of criteria in aspects of the difference in attractiveness between those criteria, in which their importance levels were in order. The scales from the decisions of experts are ranged from no (zero) to extreme (six) difference [39] as follows:

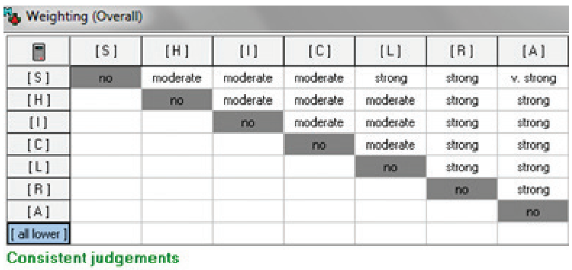
0= indifference between alternatives.
1= an alternative is very weakly attractive over another.
2= an alternative is weakly attractive over another.
3= an alternative is moderately attractive over another.
4= an alternative is strongly attractive over another.
5= an alternative is very strongly attractive over another.
6= an alternative is extremely attractive over another.

An example of scale of difference in attractiveness is displayed in Table B1.

Table B1: An example of opinion on scale of difference in attractiveness

Criterion	Scale of Difference in Attractiveness							Criterion
Distance from seaport	6	5	4	3	2	1	0	Distance from airport

The average input data from 11 experts in order to build weight further are exhibited in Figure B1.


Weighting (Overall)

	[S]	[H]	[I]	[C]	[L]	[R]	[A]
[S]	no	moderate	moderate	moderate	strong	strong	v. strong
[H]		no	moderate	moderate	moderate	strong	strong
[I]			no	moderate	moderate	strong	strong
[C]				no	moderate	strong	strong
[L]					no	strong	strong
[R]						no	strong
[A]							no
[all lower]							

Consistent judgements

Remark: [S]: seaport, [H]: highway, [I]: industrial area, [C]: cross-border market, [L]: local market, [R]: regional market, [A]: airport

Figure B1: Average judgments of criteria from experts

Likewise, those sub-criteria of seaport, cross-border market, local market and airport are used the same procedure.

Appendix C. Input data of PROMETHEE

Each expert gave his/her 14 opinions for the distance of indifferent (q) and preference (p) threshold between those criteria and a dry port, as seen in the example in Table C1.

Table C1: An example of q and p

Criterion	q and p	Distance (km.)
Seaport	Indifferent threshold of alternatives of dry port (q)	
	Preference threshold of alternatives of dry port (p)	

The ranking problem of dry port sites in this study is performed by PROMETHEE through Visual PROMETHEE. The main window with some input data, as illustrated in Figure C1.

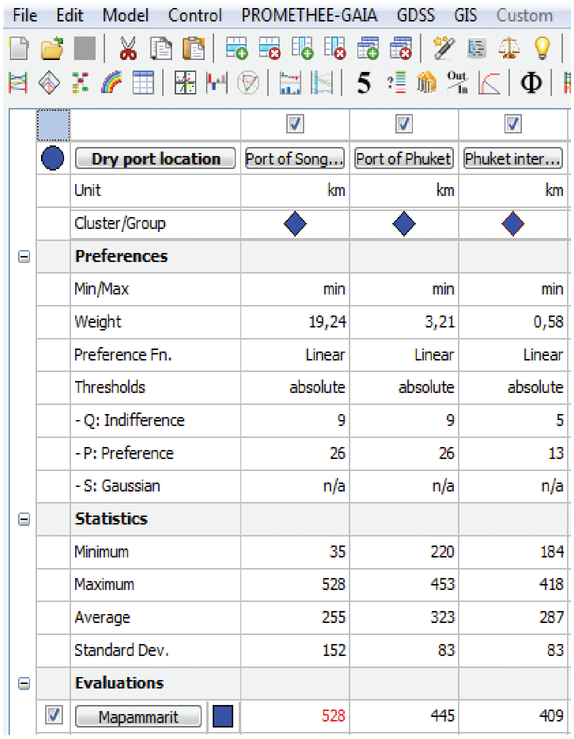


Figure C1: Input data for PROMETHEE.

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