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Research article

An Integrated Factor Analysis-Technique for Order Preference by Similarity to Ideal Solution for Location Decision in ASEAN Region: A Case Study of Thai Fabric Manufacturing Plant

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Abstract

In this paper, we propose an integrated model for selecting a suitable location for fabric manufacturing plants in the ASEAN region. In the first phase, Cambodia, Vietnam and Indonesia were determined as candidate locations for evaluation from the screening process. In this regard, key criteria influencing location decisions were derived using factor analysis of responses extracted from questionnaires. In the second phase, criterion weights were calculated using the rank of centroid (ROC) method. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was then used to prioritize three location alternatives, and sensitivity analysis was also employed to verify the stability of the method. Based on TOPSIS method, Vietnam was the preferred location, followed by Indonesia while Cambodia was not recommended. Sensitivity analysis also showed that the proposed model was valid. The findings from this study provided references for enterprises engaged in international location decision making. The results can help them better understand the decision- making process and identify key criteria that can influence location decisions internationally.

Keywords

exploratory factor analysis;

location selection;

TOPSIS;

fabric manufacturing plant;

ROC;

sensitivity analysis

1. Introduction

A supply chain is described as the flow of products, services, currency and information both within and among business entities including suppliers, manufacturers, retailers, and customers. Theoretically, the major objective of supply chain management is to coordinate all activities of each tier, and to facilitate the flow of products to meet market requirements [1]. Thailand is one of a few countries in the global that provide whole supply chains for the entire textile industry within the

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country, from upstream, midstream to downstream. The business of textile products can be divided into apparel, household, and industrial segments.

For over six decades, Thailand has been a world-renowned producer and exporter of several textile products that meet global standards. The industry has accounted for a significant proportion of GDP and export revenue. The export value of textile and apparel products in 2020 was worth US 8,085 billion per year [2]. Presently, there are approximate 4,000 textile and apparel manufacturers in Thailand, most of which are located around Bangkok and the eastern part of Thailand. There are about 1.2 million employees [3]. Not only prominent for textile mills, but Thailand is also famous for creating new kinds of innovative materials. Developments in technology have compelled the textile sectors to preserve and build upon its dynamic character and to further increase its competitiveness and productivity. However, the Thai textile industries have recently faced challenges and struggled to survive from continually increasing competition in the world market, the slowdown of foreign direct investment (FDI), as well as the impact of the COVID-19 pandemic. Problems from labor shortages (both skilled and unskilled) caused rising energy costs, and increases in the minimum rate of wages have made this industry less competitive compared with the industries in other low cost of living countries in the ASEAN region such as Vietnam [4].

Although the Thai government has launched strong strategies and attractive investment incentives for the textile industry, various local challenges still continuous to appear. To survive fierce competition and other obstacles and challenges, the industry is required to upgrade and seek alternatives to obtain cost and market advantages. Further integration with ASEAN, strategies by transfer of production plants, and better access to cheap labor would seem to be ways of increasing competitiveness, especially for fabric producers. These strategies could enable firms to reduce production costs, take advantage of the low cost of foreigner works, and improve proximity to raw materials. Furthermore, they could facilitate textile firms getting improved access to local policies for investment purposes, and expand their market opportunities abroad [5]. Under the umbrella of AEC, ASEAN countries will become a single market, in which all goods and services from other ASEAN members will get a free flow. Therefore, based on the reasons given, the appropriate selection of production plant location within the ASEAN region can enhance the competitiveness and growth of the Thai textile industry in international market.

Location determination is important for the success of the company. If the location is chosen incorrectly, a company can face various challenges, for instance, an unavailability of raw materials, insufficient transportation facilities, and inadequate qualified workforce. Selection of the most appropriate location for investment relates to a set of alternatives, and decision-makers must trade-off between conflicting measurable and unmeasurable factors [6]. Such problems are sometimes solved using Multi-Criteria Decision Making (MCDM) methods. MCDM methods can help decision-makers to evaluate possible locations on multiple related criteria.

A number of studies on location decision problems were carried out using a range of methods including Analytic Hierarchy Process (AHP), Multi-Objective Optimization by Ratio Analysis (MOORA), Grey Relational Analysis (GRA), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), all of which were examples of MCDM methods [7-10]. Each method had its unique features, logic, benefits, and drawback depending upon the nature of the problem [11]. The choice of selecting MCDM methods for solving multi-criteria decision problems was influenced by aspects such as availability of information relating to the problem, the number of alternatives, and the experience and preferences of decision-makers [12]. As suggested by Miç and Antmen [13], TOPSIS is one of the well-known classical MCDM approaches to identify priorities for facility locations. TOPSIS is a simple and helpful method which is widely used for practical decisions. In this paper, this method was implemented for selecting a suitable textile manufacturing location.

There are several factors affecting location decisions described in the literature. However, these factors varied from time to time depending upon the industry type [14]. As a result, an exploratory study is required in order to investigate those factors for a particular industry. Factor analysis, a multivariate statistical technique, is a powerful technique that can be used to condense a large number of variables or factors into a fewer set, thereby providing the formation and refinement of theory [15]. Accordingly, this study was conducted to demonstrate how hybridization of factor analysis and TOPSIS led to better results in a decision-making process.

2. Materials and Methods

2.1 Identification factors and potential countries

2.1.1 Survey research

At the first step, survey research was conducted to identify factors influencing location decisions internationally. A structured questionnaire was developed to explore key criteria affecting location facilities internationally with a 5-point Likert scale ranging from (1) “Not at all important”, …, to (5) “Extremely important”. The questionnaire consisted of 11 domains, with a total of 30 items relating to location factors, which were identified from the literature survey and interviews with key experts in textile companies. The target population for this study comprised 615 Thai fabric companies [16]. The sample size of this research equaled 234 samples, which were calculated using the Taro Yamane formula [17] with a 95 percent confidence level. A total of 200 companies were approached during this research to identify the relevant factors from a practical perspective and used for further investigation, with a response rate of 82.3 percent. Then factor analysis, a multivariate statistical technique, was employed in this study to reduce and simplify the set of the enormous number of variables to fewer dimensions called factors or criteria that summarized the correlations between those variables [15]. The principal component analysis and varimax rotation method were used to extract factors influencing location decisions internationally [18].

2.1.2 Selection of potential locations

The second step was to identify a possible location set for exploring fabric manufacturing plants in ASEAN region. The preliminary selection of suitable locations required expertise of specific problem to evaluate many different criteria, both qualitative and quantitative factors. Thus, all relevant information about each country, relating to both macro and microeconomic factors, were taken into consideration for comparison and evaluation. Specifically, alternative countries that had more skills in textile and garment products, as well as industries with strongly support from local government, were considered. In the location screening process, ten key professional experts from Thai textile companies were approached. Accordingly, three feasible countries were chosen for further assessment: Vietnam, Indonesia, and Cambodia.

2.2 Multi-Criteria Decision Making (MCDM)

MCDM is a methodological approach in a subfield of Operations Research (OR). It is concerned with reaching optimal solutions and compromise by dealing with numerous and often conflicting criteria in decision-making environments [19]. MCDM involves approaches that are aimed at preference ordering of different decision choices that involve conflicting and interactive multiple criteria simultaneously, with impartial judgment [20]. In a MCDM problem, a set of alternatives with respect to criteria are calculated by decomposing the problem into a hierarchy of sub-problems to satisfy the main goal of the problem. Accordingly, the process is simple to comprehend the problem visibly in a systematic investigation [21]. Bigaret *et al*. [22] mentioned that the process of MCDM can be classified into four stages: problem structuring, problem formulating, method selection and evaluation, and decision recommendation. All MCDM methods are applied in the normalization process of making comparable scales for criteria that typically have different units of measurement [23]. Different MCDM methods use different procedures to normalize those criteria. A number of MCDM methods were applied in various applications in many sectors such as logistics, healthcare, environmental science, and economics [24]. Such popular MCDM methods were TOPSIS [25, 26], SAW [24, 25] or AHP [26]. Yeh [27] suggested that different MCDM methods usually generated several likely outcomes to prioritize a group of decision options.

2.2.1 Weighting method

The rank of centroid (ROC) technique [28] was employed to calculate weights of factors affecting location decisions. According to Morais and Almeida [29], it was found that ROC had performed better than other approximate weights, *e.g.,* Rank sum (RS), Rank reciprocal (RR), and Equal weight (EW) in testing with a simulation study. ROC was simple and easy to follow and practical, but it provided weights that were highly dispersed. The weight, w_j, in the rank of centroid (ROC) method, was calculated using equation (1) [30]:

$$W_j(\mathrm{ROC}) = \frac{1}{n}\sum_{j=1}^{n}\left(\frac{1}{j}\right) \tag{1}$$

whereas w_j was the weight for j^{th} item, $j \in [1,2,..., n]$.

2.2.2 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

In this paper, we applied the TOPSIS method to determine alternative location for fabric manufacturing plants in the ASEAN region. TOPSIS was initially proposed by Erdoğmus *et al.* [31] to rank alternatives over multiple criteria, and developed later by Hwang and Yoon [32]. TOPSIS is a practical method with a simple mathematical model [33]. Moreover, TOPSIS is a rational and logical concept that simultaneously considers both positive ideal and negative ideal solutions [34]. These benefits make TOPSIS the leading MCDM method [35].

The straightforward concept of TOPSIS method is to choose the best option, which is the longest geometric distance from the negative-ideal solution and closest to the positive-ideal solution. The ideal solution consists of all the best criteria values available, and negative-ideal solutions consists of all worst criteria values achievable. The procedure of TOPSIS method is as follows:

1) Step 1: Create the normalized appraisal matrix

Vector normalization is typically employed for computing the normalized value [28] to scale all criteria values on the same scale. A normalized value, r_{ij}, is set up. The procedure depends on the type of criterion.

For beneficial attribute:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{2}$$

For non-beneficial attribute:

$$r_{ij}=\frac{1-x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{3}$$

whereas $i = 1, \ldots, m$; $j = 1, \ldots, n$; m is the number of attribute values in each criterion, n is the number of criteria and x_{ij} is an original score of appraisal matrix.

2) Step 2: Calculate the weighted normalized appraisal matrix

Depending on the different weights of each criterion, the weighted normalized decision matrix is computed using equation (4):

$$v_{ij} = w_j r_{ij} \tag{4}$$

where w_j represents weight of criterion, $j \in [1,\ldots,n]$, given $w_j \in [0,1]$ with $w_1+w_2+..+w_n = 1$. The rank of centroid (ROC) method was used to identify the weight of each criterion in this study.

3) Step 3: Determine the positive ideal and negative ideal solutions

The positive ideal solution (PIS) or A^*_i and the negative ideal solution (NIS) or A'_i for each alternative are calculated using equations (5) and (6):

$$\text{Positive: } A^*_i=\{v^*_1,\ldots,v^*_n\}=\{(\max_i(v_{ij}),j\in J)(\min_i(v_{ij}),j\in J')\}\ i=1,\ldots,m \tag{5}$$

$$\text{Negative: } A'_i=\{v'_1,\ldots,v'_n\}=\{(\min_i(v_{ij}),j\in J)(\max_i(v_{ij}),j\in J')\}\ i=1,\ldots,m \tag{6}$$

whereas v^*_i is the maximum value of i for all the alternatives and v'_i is the minimum value of i for all the alternatives. J and J' represent the PIS and NIS, respectively.

4) Step 4: Calculate the Euclidian distance of each alternative from A^*_i and A'_i

The Euclidean distance approach is used to find the deviations of factor value from positive ideal and negative ideal solution set in the evaluation of each decision point. The deviation values for the decision points obtained are named "positive ideal differentiation measure" (S^*_i) and "negative ideal differentiation measure" (S'_i), and can be calculated using equations (7) and (8):

$$S_i^* = \sqrt{\sum_{j=1}^{n}(v_j^* - v_{ij})^2} \quad i = 1, \ldots, m \tag{7}$$

$$S_i' = \sqrt{\sum_{j=1}^{n}(v_j' - v_{ij})^2} \quad i = 1, \ldots, m \tag{8}$$

5) Step 5: Calculate the relative closeness coefficients of each alternative (R^*_i)

Distinction measurements are used to compute the relative closeness coefficient (R^*_i) to the ideal solution which is shown in the equation (9) [36]:

$$R_i^* = \frac{S_i'}{S_i^*+S_i'} \quad \text{where} \quad 0< R_i^*<1 \tag{9}$$

6) Step 6: Rank alternatives following their closeness coefficients (R^*_i)

At the final step, alternatives are prioritized following their closeness coefficients (R^*_i) and the closer to one, the better the alternative [28, 37].

2.3 Factor analysis

Factor analysis is an inter-dependency technique that is usually used to reduce a large set of variables or items ($X_1, X_2, X_3, \ldots, X_p$) to a smaller set ($F_1, F_2, F_3, \ldots, F_m$) of underlying dimensions that explain relationships between multiple variables or items. It finds the extent to which each variable is explained by each dimension. The key concept of factor analysis is that multiple observed variables have similar patterns of responses as they are all associated with a latent variable, which is not directly measured. The variables in the same group are strongly correlated, whereas poorly correlated variables are placed in different dimensions. Therefore, sometimes this technique is called "dimension reduction". However, the method relies on several assumptions, which are a) a linear relationship between observed variables, b) no multicollinearity, and c) a true correlation between variables and factors [38].

Generally, factor analysis uses three steps: a) extraction of factors, b) rotation of factors to help interpretation, and c) naming and interpretation of each factor based on estimated values for the factor loadings. Similarly, factor analysis can be divided into two major types, *i.e.* exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA is implemented in circumstances in which there are no specific expectations regarding the number of dimensions in a set of variables. On the other hand, CFA is used for testing specific expectations, regarding the structure or the number of dimensions underlying a set of variables, and in which variables reflect given factors. In this research, EFA was used to group factors affecting textile location decisions based on their relationships [38].

2.4 Research framework

A three-phase hybrid model of statistical techniques and MCDM approaches were established for location decision in our study. In phase 1, factors affecting global location decisions were identified using exploratory factor analysis (EFA), and candidate location in the ASEAN region for Thai fabric manufacturing plant expansion was also explored. In the second phase, the rank of centroid method (ROC) was employed to compute the weights of factors acquired from the initial phase. In the final phase, TOPSIS was applied to select the most appropriate country for further investment. Figure 1 shows our research framework.

3. Results and Discussion

3.1 Results

3.1.1 Factors affecting textile location decision

After the questionnaires were returned, exploratory factor analysis (EFA) was employed to identify the criteria according to their relationships. Before analyzing data, Kaiser-Meyer-Olkin (KMO) was performed to measure the sampling adequacy of data that were required to use for EFA whereas Bartlett's Test of Sphericity (χ^2) was performed to test whether the variables in the population correlation matrix were uncorrelated or not [39]. According to the analysis, the KMO test result of the scale was 0.903 which was above the acceptable limit of 0.7. Furthermore, χ^2 test was also significant (*p-value*<0.000). Accordingly, the null hypothesis, H_0, was rejected, which confirmed that the data collected was appropriate. Table 1 illustrates the results of KMO and Bartlett's test.

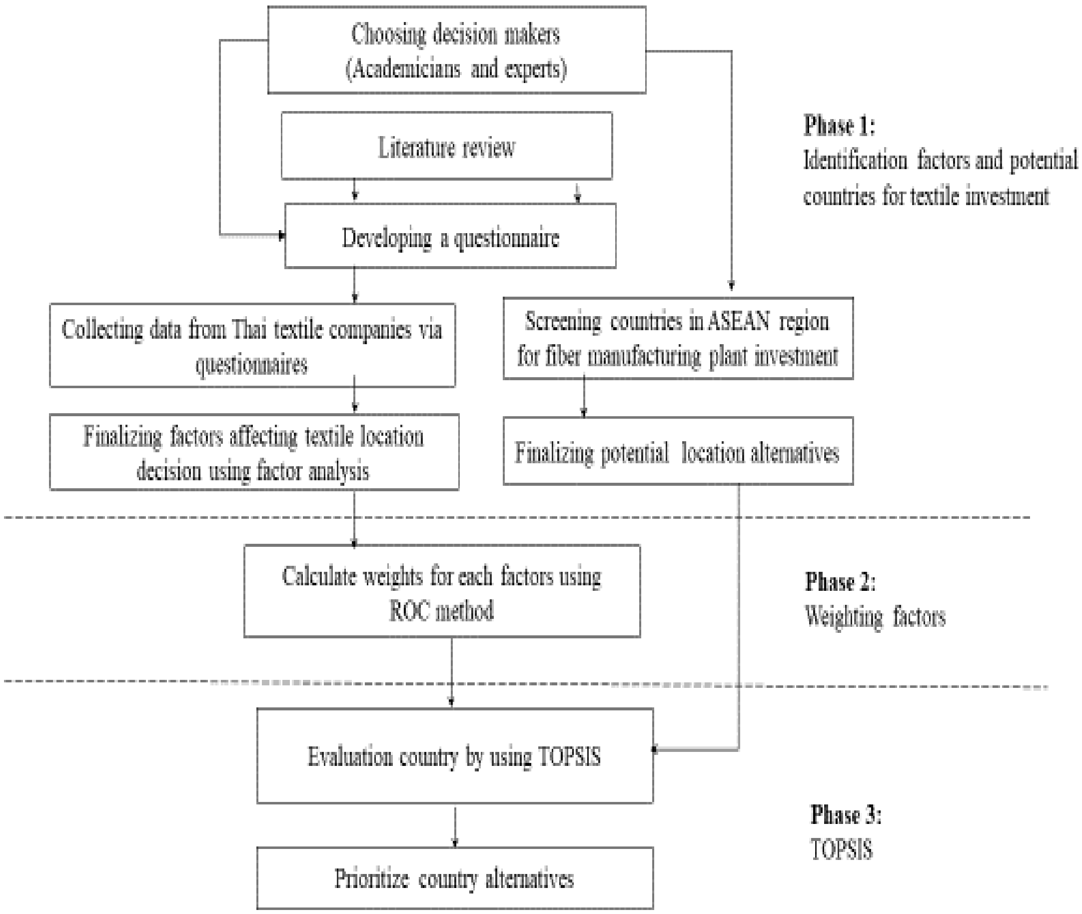

Figure 1. Research framework

Table 1. KMO and Bartlett's test

Test	Result
Bartlett's Test of Sphericity (χ^2)	5,078.901
Kaiser–Meyer–Olkin Measure of Sampling Adequacy	0.903
Df	435
sig.	<0.000

Then factors were extracted through EFA to identify the number of criteria affecting location selection in the textile industry. A varimax rotation of orthogonal axes was chosen. At the 25th cycle of factor extraction, eigenvalues greater than one were selected. This can be seen from Figure 2. Table 2 shows that six factors extracted from the 30 variables could explain about 67 percent of the variance in the study.

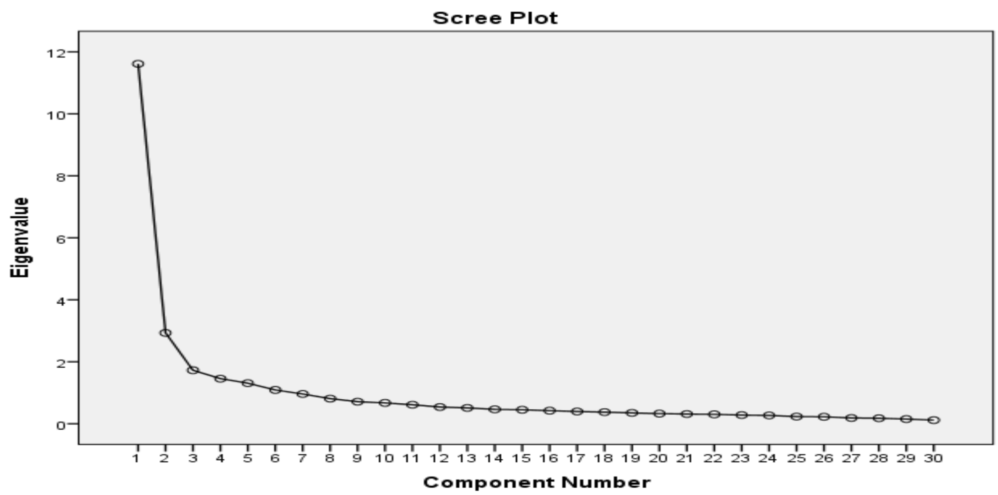

Figure 2. Screen plot diagram

Table 2. Total variance explained

Component	Initial eigenvalues			Rotation Sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	11.614	38.714	38.714	4.813	16.042	16.042
2	2.932	9.773	48.487	3.814	12.712	28.754
3	1.727	5.758	54.245	3.084	10.280	39.034
4	1.455	4.851	59.096	3.083	10.278	49.312
5	1.310	4.368	63.464	2.964	9.880	59.192
6	1.090	3.635	67.098	2.372	7.906	67.098
7	.961	3.202	70.301			
…	…	…	…			
30	.103	.349	100.000			

Six factors extracted from factor analysis were labeled based on common explanatory criteria for the elements that saturated in each of them and to explain their contents. Table 3 explains their names and contributions to the model explanation. These factors were then engaged in our proposed model.

3.1.2 Assigning weights for criteria

The weights of those six criteria for location selection from Table 3, *i.e.* competitiveness (C_1), economic (C_2), utility (C_3), logistics system (C_4), material and production (C_5), and location environment (C_6), were then computed using ROC weighting formulae in equation (1), as illustrated in Table 4.

Table 3. Factors obtained, contribution to the model, and percentage of variance explained

Factor	Name	Component variables	Percentage of variance explained
1	Competitiveness (C1)	High labor skill, Flexibility of wage determination, High labor skill, Low investment in import/export, Funding for technological development and innovation, High quality and reliability of information technology, Connectivity and Higher education.	38.714
2	Economic (C2)	Low labor cost, Growth in employment, Cost of vehicle transport, Exchange rate, Interest rate spread and Government security.	9.773
3	Utility (C3)	Availability of water resource, reliability of water resource, Availability of energy resource, Reliability of energy resource and Accessibility of information technology.	5.758
4	Logistics system (C4)	Availability of 3PLs, Low-cost transport, Ease of transport document, Transport lead time and Transport variabilities.	4.851
5	Material and production (C5)	Material cost, Material availability and Material quality.	4.368
6	Location environment (C6)	Accessibility to suppliers, Positive working environment and Positive working environment climate.	3.635

Table 4. The weight of criteria calculated from ROC method

Criteria	C_1	C_2	C_3	C_4	C_5	C6
w_j	.408	.241	.157	.103	.062	.029

3.1.3 Determining qualified alternative countries for fabric manufacturing plant

The views of a group of ten experts (DM_1, DM_2, …, DM_{10}) from Thai fabric companies, who had planned to expand or relocate their location plant in the ASEAN region, were taken into consideration in the final phase. They were asked to compare those six factors among each alternative country. The weighted normalized decision matrix, as well as PIS and NIS, were computed using equations (5) and (6), as illustrated in Table 5. Normalized Euclidean distance measures defined in equations (7) and (8) were employed to measure positive ideal differentiation (S^*_i) and negative ideal differentiation (S'_i) from the PIS and NIS, and are listed in Table 6. Consequently, with these distances, the relative closeness coefficient to the ideal solution (R^*_i) was calculated by using equation (9). These results are demonstrated in Table 7. According to the values of the closeness coefficient of each alternative, the ranking order from the largest to the smallest of three alternatives was determined. The current results disclosed that the most suitable location was Vietnam, followed by Indonesia and Cambodia, respectively.

Table 5. The weighted normalized decision matrix

Criteria	Vietnam	Indonesia	Cambodia	A^*	A'
C_1	.2622	.2336	.1954	.2622	.1954
C_2	.2102	.1983	.1666	.2102	.1666
C_3	.0359	.0396	.0301	.0396	.0301
C_4	.1487	.1487	.1423	.1487	.1423
C_5	.1049	.1120	.1144	.1144	.1049
C_6	.0760	.0792	.0633	.0792	.0633

Table 6. Positive ideal differentiation (S^*_i) and negative ideal differentiation (S'_i) measures

	S^*_i	S'_i
Vietnam	.0107	.0812
Indonesia	.0311	.0538
Cambodia	.0821	.0095

Table 7. Country ranking

Alternatives	R^*_i	Rank
Vietnam	.8836	First
Indonesia	.6340	Second
Cambodia	.1040	Third

3.1.4 Sensitivity analysis

As suggested by Simanaviciene and Ustinovichius [40], sensitivity analysis is an effective final step to verify the stability of the optimal solution and to validate the model before implementing quantitative decisions. Due to the priorities of alternatives being remarkably reliant on subjective judgments of the decision-makers, the stability of the final evaluation under different inputs or the initial conditions should be carried out [41]. Therefore, in this paper, sensitivity analysis was conducted to determine whether the final solution was sensitive or stable when possible modifications in the weight of the most influential criteria had occurred in the starting conditions.

Eight scenarios were devised to test the sensitivity to variation of each weight using TOPSIS for R^*_i values, as follows:

Scenario 1-4: Weights of the top three criteria from Table 4 were assumed to change separately (competitiveness factors-C_1, economic factors-C_2, and logistics system factors-C_4).
Scenario 5: Set the weight of C_1 =.408 and other criteria =.118 remained constant.
Scenario 6: Set the weight of C_2 =.408 and other criteria =.118 remained constant.
Scenario 7: Set the weight of C_4 =.408 and other criteria =.118 remained constant.
Scenario 8: The weight of each criterion was assumed to be equal to each other =.167.

The results of sensitivity analysis are demonstrated in Table 8.

Table 8. Results of sensitivity analysis

Scenario	Experimental conditions	R^*_i values		
		Vietnam	Indonesia	Cambodia
1	C_1=.408, C_2=.103, C_3=.157, C_4=.241, C_5=.062, C_6=.029	.8785	.6264	.1086
2	C_1=.241, C_2=.408, C_3=.157, C_4=.103, C_5=.062, C_6=.029	.8793	.6588	.1079
3	C_1=.103, C_2=.241, C_3=.157, C_4=.408, C_5=.062, C_6=.029	.8642	.6429	.1212
4	C_1=.103, C_2=.408, C3=.157, C4=.241, C_5=.062, C_6=.029	.8589	.6701	.1258
5	C_1=.408, C_2=.118, C_3=.118, C_4=.118, C_5=.118, C_6=.118	.8276	.6641	.1044
6	C_1=.118, C_2=.408, C_3=.118, C_4=.118, C_5=.118, C_6=.118	.8094	.7417	.1147
7	C_1=.118, C_2=.118, C_3=.118, C_4=.408, C_5=.118, C_6=.143	.7619	.7518	.1402
8	C_1=.167, C_2=.167, C_3=.167, C_4=.167, C_5=.167, C_6=.167	.7595	.7491	.1414

The sensitivity results from Table 7 indicated that the ranking of the location-based on R^*_i values remained unchanged for all the eight scenarios regarding change weights of criteria. It was observed that Scenario 7 (when the weight of C_4 was the most important and other criteria remained constant) and Scenario 8 (the weight of each criterion was equally important) were considered, both Vietnam and Indonesia were approved and were the preferred countries. Moreover, the R^*_i values were quite closed to each other. However, Vietnam was still ranked as the first priority when decision-makers considered investing in fabric manufacturing plants. Consequently, it was implied that this proposed model had been reliable and robust.

3.2 Discussion

The results of the study from the first phase found that the top three factors that had a major impact on plant selection for textile were competitiveness, economic and logistics system factors. According to Aiginger *et al.* [42], competitiveness should be measured through productivity, which was also mentioned in the study of Porter [43]. There are many competitiveness factors of the textile industry that can enhance a company's competitiveness, such as labor force, access to inputs, physical infrastructure and innovation efforts [44]. These factors can influence strategies to bring and promote countries' economic growth and development sustainability for maximizing the profit of the investment.

Economic factor, which consists of policies, wages, governmental activities, legislative factors, and so on, can affect and influence the operation of businesses. These sub-factors are generally controlled by local governments [14]. The logistics system factor was ranked as the third in terms of importance. Logistics factor plays a significant role in today's economy and affects location decisions in all types of businesses. Logistics controls the effective forward and backward flow of products and services from origin to end-users, which can improve a firm's competitiveness [45, 46]. According to Banomyong *et al.* [47], a significant element in doing business is logistics performance.

Our results revealed that Vietnam is the best location for relocation of fabric mills into the ASEAN region. Vietnam has been emerging gigantic in the global textile and apparel industry over the past years. The industry has played a key role in the economic development of the country. In

2021, Vietnam's GDP growth reached 4.8% [48]. The population of Vietnam in 2021 was declared to be ~98.5 million. More than 96 percent of Vietnam's population who are age 15 years and older are literate. It can be implied that Vietnam has the advantages of an abundant and skilled workforce, as well as high domestic consumption. The country has also received high scores for political stability at 4.5 [49]. In 2019, Vietnam attracted FDI capital of around 19.3 billion USD, which implies that Vietnam is one of the interesting countries in the ASEAN region and has fascinated foreign investors [49]. Moreover, in recent years, transportation and infrastructure systems within the country have been increasingly expanded and upgraded [50]. Compared to Thailand, Vietnam has lower labor costs. These points seem to make Vietnam an attractive option for Thai investments to expand or relocate their fabric mills into this country.

Before the COVID-19 outbreak, Indonesia was the sixth-ranked textile and garment-producing country in the world [51]. Export values of textiles and garments in 2018 were ~US$16 billion [52]. Nevertheless, the industry has faced several serious drawbacks such as the US-China trade war, the shutdown of global economy, as well as ongoing complications due to the COVID-19 outbreak, which have resulted in declining in export demand [53]. Currently, internal constraints, such as old production technology, and higher electricity and energy costs compared to other textile manufacturing countries have forced Indonesia to lose its competitive edge in the international market [54]. Hermawan [55] argued that by doing business in Indonesia, which consisted of thousands of islands nation, new initiatives would obviously encounter numerous supply chain challenges, especially infrastructure and logistics issues, which could affect longer product movement and increase total expenses. Additionally, the minimum wages in Indonesia increased by 8.5 percent in 2020, and have since risen each year. These challenges make Indonesia less attractive than Vietnam.

Presently, the textile industry is the largest sector in Cambodia, and plays a vital role in contributing to economic development as it creates jobs, and increases the population, and assist country's income. Textile and leather industry exports accounted for 40 percent of Cambodia's GDP in 2017 and generated more than 60 percent of total export earnings [56]. There are about 800,000 employees in garment factories across the country. However, compared to Sri Lanka, Bangladesh and Myanmar, the competitiveness of this sector has declined due to increases in the minimum wages [48]. Compared to other countries in Southeast Asia, Cambodia has the highest electricity rates [57]. Furthermore, the logistics systems and infrastructure are still poor and unreliable, factors which interrupt export and import procedures, resulting in a longer lead time in the whole supply chains [58]. As such, these challenges make Cambodia least preferred option.

4. Conclusions

Location determination is vital for the achievement of a company and has a direct effect on an operation's cost. When firms decide to make the final decision to locate their manufacturing plants in a certain region, the image of the place should match the image of the company. As a result, choosing the right location is one of the most important priorities. In this work, we explored factors affecting location decisions for the textile industry and proposed a model for choosing an appropriate country in a given region. The paper contributes a hybrid model by integrating both the statistical approach and MCDM method to determine key criteria, and it creates a new model for country selection. Ranking these measures based on experts' opinions, we synthesized a novel location selection framework that is specific for the textile industry. This research concentrated on one industry in a particular region; however, the framework was generic and could be applied to other industries in other counties. In this paper, only TOPSIS was implemented to choose the suitable location for the fabric company. However, the method developed can be extended by utilizing other MCDM methods in a fuzzy environment, and it can also be applied in other industries.

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