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Influential Criteria for Large-scale Factory and Warehouse Main Contractor Selection Used for End-to-End Procurement Risk Management

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Abstract

Based on prior research, it was found that only a limited number of studies have addressed approaches for enhancing procurement management involving the selection of factory and warehouse construction contractors, along with the control of contractor construction efficiency. Furthermore, the decision-making process in contractor selection was frequently delegated to the procurement department or an individual within the department, potentially introducing personal biases. Consequently, contractors who submitted the lowest bids often secured projects, particularly in fiercely competitive industries. Relying primarily on cost-based decisions may lead to the selection of less qualified and less suitable contractors. This research aims to provide relevant criteria for selecting main contractors for factory and warehouse construction projects with areas greater than 10,000 square meters (sq.m). This is to reduce the risk of low-quality work or construction job abandonment. To not based purely on cost, supplier selection process is a Multi-Criteria Decision Making (MCDM) process. The proposed evaluation criteria are analyzed using Analytic Hierarchy Process (AHP) technique, data were collected from seventeen experienced experts in the field of factory and warehouse construction contractor selection to ensure result reliability. It was found that the decision-makers gave the past and present performance of the construction contractor performance factor as the first priority with a relative weight of 0.32. This is followed by operational technique at 0.19, staff at 0.18, financial at 0.17, and lastly, partner relationship at relative weight of 0.16. The relative importance weights were later used in a large-scale factory and warehouse contractor selection process as a case example. Using Conjunctive method with three inclusion criteria, five alternatives were shortlisted from a total of 40 companies. As a result, Company E received the highest score was chosen as the construction contractor of choice. The study also revealed that certain critical decision-making criteria, such as management expertise and technical proficiency, frequently lack sufficient available data, requiring the acquisition of this information directly from contractors. Therefore, it likely is inadequate for risk assessment and perhaps efficient scoring when selecting alternatives. Consequently, an end-to-end procurement risk management process is also proposed utilizing the top three relatively significant criteria to develop a tool for monitoring contractor performance during operations. Additionally, implementing a vendor checklist for their inclusion in the annual Supplier List is also recommended.

Keywords

Analytic Hierarchy Process, Contractor, Contractor Selection, Supplier Selection, Performance Monitoring and Supplier List.

1. Introduction

Due to Coronavirus Disease 2019 outbreak, lockdown protocols had been enforced to prevent the spread of the COVID-19 virus which permanently affected consumers' lifestyle and shopping behavior. Everyone has become more familiar with technology and convenience of spending through online channels. The sharp increased e-shopping raises motivation both small and large entrepreneurs, including logistics companies who need a warehouse for rental or wants to increase their warehouse space to use as fulfilment center to prepare packages for last mile delivery. Moreover, entrepreneurs in the Eastern Economic Corridor (EEC) in Thailand also need to build factory or more warehouse space to stock products for production, sale, export, and distribution to consumers of various types of products such as the fast-moving consumer goods, electronic products and electrical appliances, automotive parts, high-end fashion and lifestyle, and so on. These groups of products have continued to grow despite facing an economic slowdown. Additionally, demand for new factory or warehouse space also includes from foreign entrepreneurs who have expanded their production base to Thailand and logistics service providers (3PL) for online stores, especially small and medium-sized enterprises that sell products directly to consumers, etc. (Sathapongpakdee 2023). Even though the COVID-19 outbreak situation has begun to subside, the online trading behavior of consumers continues to increase. As a result, it has been a great opportunity for business provides warehouse rental services or increases warehouse space to be used as hub or fulfillment center for distributing products in the country. They would surely build more large-scale warehouse space for rent to capitalize from the upward demand trend which, in turn, causes demand for hiring construction companies to upsurge as well. More often than not in high competition, some contractors offer prices that are lower than what is possible in order to complete for jobs offered by procurement department of production companies or warehouse rental service companies. They, later, might construct low quality buildings or even abandon the contract they won. To control cost, procurement department would likely to prefer low-cost contract. However, the decision making of contractor selection based solely on lowest price criterion may result in not able to get qualified and suitable contractor. Therefore, selecting a contractor should consider many factors as components of decision-making to get the most suitable construction contractor. Research studies focused on contractor selection have primarily offered guidelines for pre-project procurement contractor selection, with limited emphasis on during and post-project analysis. No example cases were provided for analyzing results to identify suitable contractors for factory and warehouse construction projects. Furthermore, according to a study conducted by Thomas T. Macmillan in 1971, the use of expert opinions obtained through the Delphi method or questionnaires from a panel of 17 experts or more is considered highly reliable. This is attributed to the fact that discrepancies tend to diminish significantly and steadily as the number of experts involved in the research exceeds 17. Consequently, this research proposed important factors to be used in Multi-Criteria Decision Making (MCDM) of construction supplier selection for factory or warehouse with area greater than 10,000 square meters (sq.m). The key criteria obtained from 17 experts' opinions which then analyzed using, pair-wise comparison, Analytic Hierarchy Process (AHP) technique. The criteria and their weights were then used to assess and select best choice among five alternative contractor companies. Collected Data was analyzed using Expert choice program. Additionally, the top three criteria and its sub-criteria were used as part of proposed guidelines for practitioner to evaluate contractors in order to maintain consistent quality even after they are selected to work by monitoring supplier performance during operations and the annual assessment of suppliers. The objective is to establish a more streamlined and efficient contractor procurement management process, which in turn can mitigate the risk with selecting subpar contractors during the pre-construction phase and maintaining stringent construction quality control throughout both the construction and post-construction phases. The rest of this paper constructs as follows; next section is literature review. Section 3 and 4 state research methodology and data collection. The results and discussion are in section 5. Lastly, the conclusion is presented in section 6.

2. Literature Review

2.1 Analytic Hierarchical Process (AHP)

AHP is a pairwise analytical decision process widely used in MCDM partly because it mimics natural human decision-making, making it easy to understand. The elements of the problem are divided as follows: The highest level refers to the goal level, the lower level is the main criteria, the sub-criteria, and the last level represents options or alternatives. This technique is also suitable for making decisions based on both quantitative and qualitative criteria. As considering, alternatives' certain characteristics can be numerically evaluated and certain properties are suitable to be assessed qualitatively; AHP is a way to reduce the bias that exists in the selection process by using a pairwise comparison method for prioritizing data (Chalongsuppunyoo and Payakpate 2014). The appropriate tool for comparing pairs or matching is the matrix shown in Table 1, utilizing scale values for comparing pairwise relationships from scale 1 to 9 explained in Table 2. The resulting largest number is the most important criterion or the best alternative.

Table 1. Pairwise comparisons matrix (Pichaichok and Payakpate 2013)

		Criteria			
		C1	**C2**	**C3**	**Cn**
Criteria	**C1**	1	a_{12}	a_{12}	a_{1n}
	C2	$1/a_{12}$	1	a_{23}	a_{2n}
	C3	$1/a_{1n}$	$1/a_{2n}$	1	a_{3n}
	Cn	$1/a_{1n}$	$1/a_{2n}$	$1/a_{3n}$	1

Table 2. The scale of relative importance (Saaty 1990)

Scale	Interpretation
9	One element is absolutely more important than the other
7	One element is obviously more important than the other
5	One element is highly more important than the other
3	One element is more important than the other
1	Both elements are equally important
8,6,4,2	Values between the two are close

The AHP process includes analysis and checking of Consistency Ratio (C.R.) values to make sure the results are sound. By calculation C.R. from acquired data, resulting C.R. is consistent and reasonable when compares the acceptable compliance ratio values with the following requirements: C.R. ≤ 0.05 for comparison of 3 criteria, C.R. ≤ 0.09 for comparison of 4 criteria, and C.R. ≤ 0.10 for comparison of 5 criteria or more. And if the C.R. value is outside the acceptable range. It shows that the results of the evaluation and analysis are not consistent under the matrix table (Pichaichok and Payakpate 2013; Saaty 2008). Therefore, the assessment should be reviewed or revised until the data are reasonable and finding the Consistency Ratio (C.R) will help the decision maker to be confident in the reliability of the priority from pairwise comparison process by using AHP technique.

2.2 Delphi Technique

Delphi Technique is a systematic process of finding conclusions and the tools are questionnaire-based interviews that are used to collect information from expert's opinions in that field, which will allow experts to express their opinions freely without confrontation between the experts themselves. This technique has been applied by many research studies to increase the accuracy and precision of the data. It was found that when using 17 or more experts, the error was very little and decreased steadily at approximately rate of 0.02 as shown in Table 3. Therefore, using the Delphi technique in research, a data set gained from at least 17 experts should be used (MacMillan 1971; Pengsawat 2000).

Table 3. Number of experts in panel and the rate of error when using Delphi Technique (Pengsawat 2000)

Panel size	Rate of error	Rate of error reduction
1-5	1.20 – 0.70	0.50
5-9	0.70 – 0.58	0.12
9-13	0.58 – 0.54	0.04
13-17	0.54 – 0.50	0.04
17-21	0.50 – 0.48	0.02
21 - 25	0.48 – 0.46	0.02
25 - 29	0.46 – 0.44	0.02

2.3 Relevant research regarding factors that are commonly used in deciding to select construction contractors

In this research, the authors studied and reviewed literature related to contractor selection for different types of construction. It was found that many studies have grouped and emphasized in different criteria for selecting

contractors. The authors then took all the criteria and regrouped relevant factors. In summary, the top five most popular selection criteria are selected for this research as shown in Table 4. Additionally, the main criteria are in line with previously studied contractor selection concepts.

Table 4. Comparison table between contractor selection concepts and popular factors of selecting construction contractors

Reference **Factors / Criteria**	Contractor Selection Concepts (Chinanuwatwong 2003)	(Pongprasert and Piromyaporn2015)	(Muankunthod 2012)	(Pratummet 2013)	(Sevapop 2020)	(Kaewkanha 2010)	(Tochaiwat and Likitanupak 2012)	Chompookiew and Jaiyong 2020)	(Dechakum and Apiratanapimolchai and Jareonsuk 2017)	(Phiharn and Jantamaneechot 2016)	(Thititantrakool 2014)	(Afolayana, and Ojokoha and Adetunmbi 2020)	(Duartea and Sousa 2020)	(Gholipour and Jandaghi, and Rajaei 2014)	**This Research**
1. Performance															
Quality	•	•	•	•	•		•	•	•		•	•			√
Experience	•	•	•	•	•	•	•	•	•	•		•			√
Work Load	•	•	•	•	•		•	•	•	•		•			√
Budget and construction time		•	•		•		•		•		•	•			
2. Financial															
Registered Capital	•		•	•	•	•	•	•	•		•	•	•	•	√
Current Assets	•		•	•	•	•	•	•	•		•	•	•	•	√
Revenue	•		•	•	•	•	•	•	•		•	•	•	•	√
Profit per year	•		•	•	•	•	•	•	•		•	•	•	•	√
3. Staff															
Skill	•		•	•	•	•	•	•	•	•					√
Capacity (Labor adequacy)	•	•	•	•	•	•	•	•	•	•				•	√
Labor Performance and Training	•	•	•	•	•		•		•	•					√
4. Operational Technique															
Management Skill	•	•	•	•	•		•	•	•	•		•			√
Sufficient tools		•		•	•	•		•	•			•	•	•	
Construction Skill	•	•	•		•	•	•	•	•	•		•		•	√
5. Partners Relationship	•	•	•	•			•	•				•		•	√

From the data in Table 4, the authors summarized the main and the sub-criteria that will be used as selection criteria for this research as follows, Main criterion 1: Performance, consisting of 3 sub-criteria Quality, Experience and Work load. Main criterion 2: Financial consists of 4 sub-criteria Registered capital, Current Assets, Revenue and Profit per year. Main criterion 3: Staff consists of 3 sub-criteria Skill, Capacity and Performance and Training. Main criterion 4: Operational techniques consist of 2 sub-criteria Skill of Management and Skill of Construction. Main criterion 5: Partner Relationship

3. Methods

3.1 Research Methodology

The proposed research methodology consists of ten basic steps as shown in Figure 1.

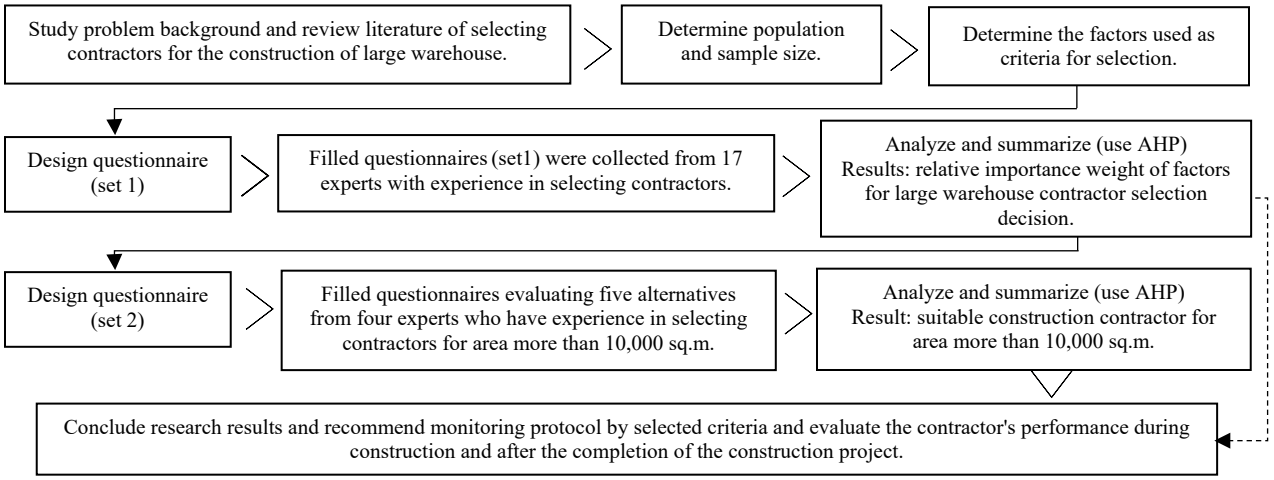


Figure 1. Research flow chart

3.2 Decomposition of evaluation criteria

Determination of factors used as criteria for selecting main construction contractors, it was done from comparing concepts of selecting contractors and articles related to contractor selection and only matching factors are selected to use in this research. The hierarchical decision structure of the AHP method of proposed criteria is shown in Figure 2.

The definition of criteria:

1) Performance – This criterion is considered past and current works by selecting the main contractor for the performance, all 3 sub-components must be considered including:
   - Sub-criteria 1, Quality (Q1) - the good quality and controlling work is in standards.
   - Sub-criteria 2, Experience (Q2) - the amount of past work and reputation for construction of similar projects.
   - Sub-criteria 3, Work load (Q3) - the amount of work currently responsible for the production capacity and the amount of work inconsistently. This may cause work to be abandoned, submitted late and poor quality.

2) Financial – This can be found from websites such as the Department of Business Development website (https://datawarehouse.dbd.go.th) where the selector can check the contractor's financial status. There are five sub-components as follows:
   - Sub-criteria 1, Registered Capital (F1) represents the value of shareholders' liabilities that may be held liable if creditors or project owners sue to hold the company liable for the debts incurred.
   - Sub-criteria 2, Current Assets (F2) represents how often the company can use all its available assets to generate sales.
   - Sub-criteria 3, Revenue (F3) refers to money earned from business operations.
   - Sub-criteria 4, Profit per year (F4) represents annual gross profit if it is too much, it can be seen that the project bid price may have a higher rate than others or the company may have good management of protecting the company's interests. Otherwise, if it is negative, the company is making a loss or has financial problems. This may cause the risk of the contractor abandoning the job.

3) Staff – Personnel and labor are considered as an important force in measuring how much work can be driven forward. Especially work that requires labor, skills, ideas and decision-making. The staff factor has 3 components, including:
   - Sub-criteria 1, Skill (S1) - the owner of the company as well as the foreman who supervises the work with experience caring for construction control and has a history of education in the field.
   - Sub-criteria 2, Capacity of labor (S2) - the amount of labor involved in dealing with and work. The team should be diverse and each team has the expertise and is suitable for the job.

- Sub-criteria 3, Performance and Training (S3) means whether training or certification is provided to workers.

4) Operational Technique – The organization's operations should be well managed to complete a construction project. Construction contractors should have management knowledge and construction knowledge regarding factory and warehouse construction projects.
   - Sub-criteria 1, Management Skill (O1) means being responsible for the management of a clear schedule and completing according to plan. Including project management to ensure success.
   - Sub-criteria 2, Construction Skill (O2) means using knowledge, skills, and abilities in construction that meet construction requirements.

5) Partners Relation - Construction contractors should have a good relationship with construction material dealers as well as machinery sales or rental service providers. It will help the construction work go smoothly, and cost controlling as well.

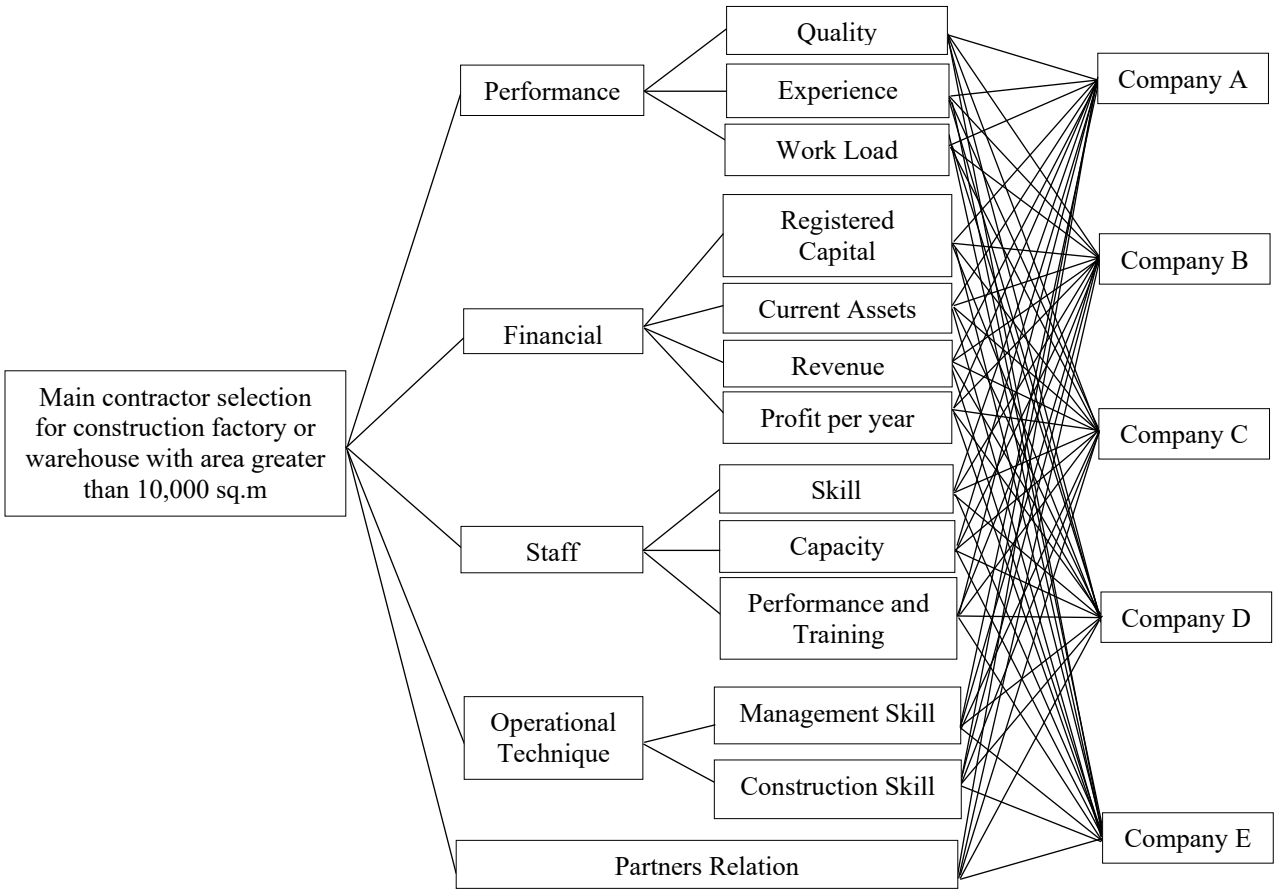


Figure 2. Hierarchical decision structure of the research

4. Data Collection

4.1 General information of respondents

The respondents were 17 experts with experience in selecting contractors for factory and warehouse construction projects. Two aspects of their experience information are presented here as follows: firstly, experience in selecting/ controlling/ managing factory and warehouse construction projects, and, secondly, the number of projects in which they involved in. The data is displayed as frequency and number of respondents, as shown in Table 5.

Table 5. Summarized general experience information of expert respondents

General experience information of respondents	Information	Number of experts
Experience information in selecting/ controlling/ managing factory and warehouse construction projects	Less than 5 years	8
	5-10 years	4
	11-15 years	2
	More Than 15 years	3
Number of projects in which they involved in selecting/ controlling/managing factory and warehouse construction projects.	Less than 10 projects	14
	11-30 projects	2
	31-50 projects	0
	More than 50 projects	1

4.2 Configuration weight values of main criteria and sub-criteria

Data collected from 17 experts via questionnaire, they answered the questionnaire based on their opinions on the comparison of the main criteria and sub-criteria in pairs. The results from the questionnaire were analyzed accordance to the analytical hierarchical process using the Expert Choice program. The resulting weight of each main criterion and sub-criteria has values as shown in Table 6.

Table 6. The Weight Value of Each Sub-Criteria and Criteria

Rank	Criteria	Weight	Sub-Criteria	Weight
1	Performance	0.32	Q1	0.40
			Q2	0.37
			Q3	0.23
4	Financial	0.17	F1	0.38
			F2	0.24
			F3	0.21
			F4	0.17
3	Staff	0.18	S1	0.37
			S2	0.44
			S3	0.19
2	Operational Technique	0.19	O1	0.75
			O2	0.25
5	Partner Relationship	0.16		

From Table 6, the results of the weight analysis of the importance of each sub-criteria can be summarized in order from the criterion with the most importance weight to the least importance weight as follows; 1) Weigh the importance of past performance and the current level of contractors' construction workload is equal to 0.32. The sub-criteria can be sorted as follows; Q1: Factors related to the performance of past construction projects. The importance weight value is 0.40, Q2: Experience factor in working on similar projects. The importance weight value is 0.37, and Q3: The factor in the workload that is currently responsible. The importance weight value is equal to 0.23. 2) Weigh the importance of operation technique criterion is equal to 0.19. The sub-criteria can be ordered as follows, O1: Factor in expertise in management. The importance weight value is 0.75, and O2: The factor of expertise in construction techniques. The importance weight value is equal to 0.25. 3) The importance weight of the staff criterion is equal to 0.18. The sub-criteria can be ordered as follows, S2: Capacity of labor factor. The importance weight value is 0.44, S1: is the skill or experience factor of personnel in key positions. The importance weight value is 0.37, and S3: The labor efficiency factor. Develop the skills of staff. The importance weight value is equal to 0.19. 4) Weight the importance of the financial criterion is equal to 0.17. The sub-criteria can be sorted as follows, F1: Factor in registered capital. The importance weight value is 0.38, F2: Current assets factor per year. The importance weight value is 0.24, F3: Factor in revenue from professional work. The importance weight value is 0.21, and F4: Profit per year factors. The importance weight value is 0.17. Finally, 5) the weight of the criterion for the partner relationship between contractors and construction material dealers is equal to 0.16.

Later, the consistency of the questionnaire results from all 17 respondents were calculated. The Consistency Ratio (C.R) value of the criterion score is shown in Table 7. The resulting ratios are all less than 0.10 and are considered reasonable for comparison of 5 criteria or more.

Table 7. Consistency Ratio of the main criteria weight value and sub-criteria from opinions of 17 respondents.

Expert	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
C.R. of Main Criteria																	
C.R.	0.07	0.09	0.07	0.08	0.05	0.03	0.08	0.05	0.06	0.09	0.08	0.03	0.07	0.08	0.09	0.06	0.09
C.R. of Sub Criteria																	
C.R.(P)	0.03	0.02	0.03	0.02	0.01	0.01	0.01	0.03	0.00	0.01	0.03	0.02	0.03	0.01	0.04	0.01	0.02
C.R.(F)	0.05	0.07	0.09	0.09	0.06	0.08	0.08	0.07	0.00	0.08	0.07	0.07	0.02	0.08	0.04	0.06	0.33
C.R.(S)	0.05	0.01	0.00	0.05	0.05	0.01	0.05	0.02	0.05	0.01	0.01	0.01	0.00	0.05	0.02	0.00	0.00
C.R.(O)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5. Results and Discussion

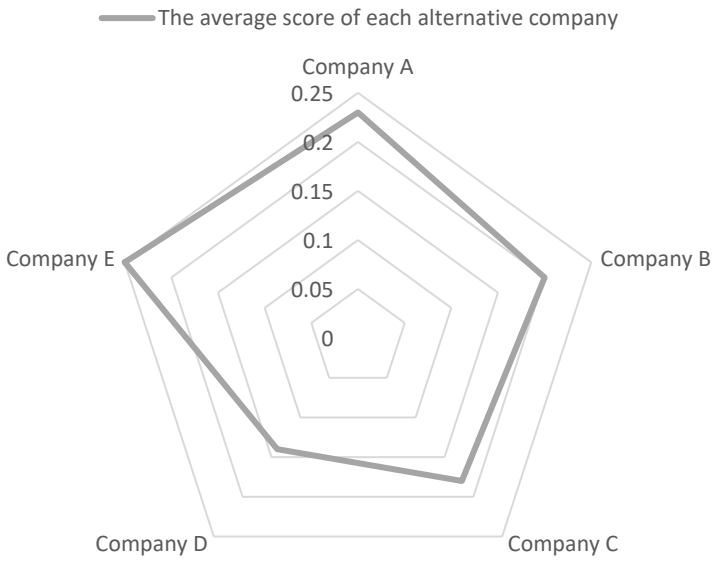
5.1 Numerical Results from case example on applying relative weights on supplier selection

The relative weight results shown in Table 6 are used in large-scale contractor selection as a case example. The alternatives were screened and selected based on various qualifications. Defining qualifications used to filter the selection of main construction companies for factories and warehouses of sizes more than 10,000 sq.m by Conjunctive method with 3 criteria for inclusion in the case are as follows; 1) Performance in contracting construction for factories and warehouses within the past 5 years. 2) Experience in the construction of factories and warehouses with areas from 10,000 sq.m or more within the past 5 years, and 3) Registered capital of more than the reference cost of construction project that will incur, according to the principle of shareholder liability that affects the creditors of the limited company. The reference price is based on the estimated building construction costs for the years 2020-2023 determined by the Realtors Appraisal Foundation of Thailand and the reference price is 8,600 baht per square meter. Therefore, the total construction cost estimate of the upcoming project is at least 86 million baht. The three aforementioned criteria are used to screen the shortlisted group construction companies. The authors gathered information through the company profile obtained from the company's website, requesting from construction companies, or business information through the Department of Business Development's website. From shortlisted 40 companies, there were only five companies that passed the inclusion criteria, as shown in Table 8.

Table 8. Information on alternative main construction companies

Company	Experience in constructing factories and warehouses of 10,000 sq m.	Performance on the construction of factories and warehouses (past 5 years)	Registered capital of more than 86 million baht
Company A	Yes	3 Projects	550,000,000 Baht
Company B	Yes	37 Projects	1,102,904,144 Baht
Company C	Yes	8 Projects	100,000,000 Baht
Company D	Yes	6 Projects	12,650,632,144 Baht
Company E	Yes	20 Projects	100,000,000 Baht

From the summary in Table 8, there are a total of five factories and warehouses construction companies that have passed the preliminary screening. They are referred to as Company A, Company B, Company C, Company D, and Company E. They are considered as the main construction contracting companies of choice for the construction of factories and warehouses by applying the results of the relative important weight of factors. With extensive related background information provided, the alternatives were rated based on the proposed criteria by using the second set of questionnaires as a tool for collecting opinions on each alternative from four respondents who have experience in selecting contractors for construction of factories and warehouses with area sizes more than 10,000 sq.m. The collected data were then analyzed using the Expert Choice program. The rankings of each company, determined by the scores assessed using the previously mentioned factors, are displayed in Figure 3. As a result, Company E received the highest score would be chosen as construction contractor of choice.



Ranking of companies with the average scores from highest to the least as follows:
Company E > Company A > Company B > Company C > Company D

Figure 3. The average score of each alternative company under the factors used as criteria for selection

5.2 Proposed Procurement Management Improvements

From previous literature, the authors found weaknesses in applying weight important factors in selection process of contractors. In literature and practice, the weighted criteria would only be used in the supplier selection decision-making in bidding process before the construction starts. From the study and collection of data in case example, it was found that some crucial and popular factors used as criteria for decision making often have limitations in data

collection or the information could only gain from contractors. It is often insufficient for risk assessment and even efficiently scoring.

For example, in this research, the authors found that the data on expertise in management and expertise in technique are information that each construction company will not reveal previous project errors in bidding process. This information is also hard to find from other sources as secondary data. They hesitate to provide information relating to project errors or lateness because it will decrease their score on reliability and expertise and might lose bidding for the project. As a result, the decision maker will likely not receive sufficient information to properly score and assess risks in operation technique factors. The results also illustrate in this research, in the case example experts felt they did not have enough information to allow them to give over-under scores in pairwise comparisons between alternatives on the sub-criteria in operational technique. The experts rated alternatives as equal on operational technique and its sub-criteria. Therefore, the authors presented guidelines for evaluating contractor performance and procurement management, divided into three phases as shown in Figure 4, in order to continue to monitor and evaluate the five important factors during construction bidding and after the construction starts to ensure efficient project risk management. The evaluating results of selected supplier list are to be considered for selection in the next construction project and beneficial to the procurement process.

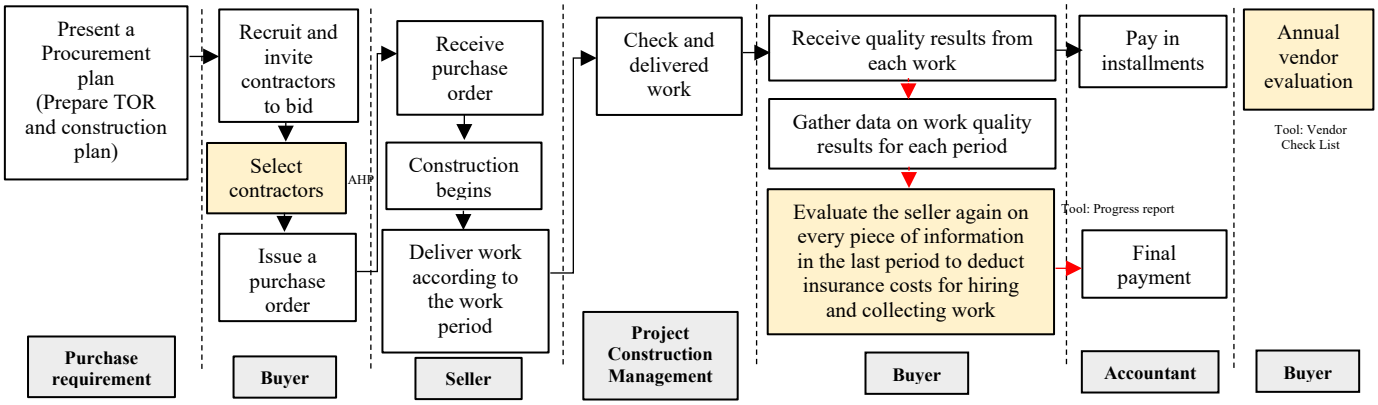


Figure 4. Example of steps and tools used to evaluate construction contractor performance to develop the procurement process.

From Figure 4, phase 1: Contractor selection criteria using the AHP tool from this research, the results of the priority evaluation of selection criteria were obtained, the ranked as follows; 1) Performance, 2) Operational technique, 3) Staff, 4) Financial, and 5) Partner relationship.

Secondly, phase 2: Procedure for monitoring contractor performance during operations should be done by using the results of each work period for evaluation. Suggested data is the monthly progress report showing results that measure the effectiveness of the top three decision criteria as follows; first, performance for past work and present of the construction contractor, it could be measured from the current workload the contractor is responsible for as of the start of construction compared to during construction. If the contractor has high and increased workload while number of workers remains the same, it may be a risk to work quality and project time management. Second, operational techniques that are measured in terms of the quality of past projects. It could be evaluated and monitored from the results of work progress and photos of the progress each month, and how well they adhere to project plan is used to evaluate the work efficiency of the operating contractor companies. Lastly, staff criterion can be observed in the results from the personnel work assignment table to assess staff capacity for the job. If there is any one of indicators showing sign of problems that could cause delay or quality problem, the project owner or buyer (procurement department) will be able to take initiative step for corrections or prevention plan with contractor immediately.

Finally, Phase 3 is the process of annual suppliers evaluating after implementation. It should be done in order to select them into the Supplier List which will be considered for selection in the next construction project. in evaluating and rating contractors who have completed the project. It could be done according to the proposed key measurable indicators which can also be gathered from the monthly progress report data.

6. Conclusion

The analysis of gathered research data from 17 experts using AHP approach results in the relative weight of importance of proposed five criteria and their sub-criteria for MCDM of large-scale factory or warehouse construction contractor selection to ensure that procurement department does not selects contractor focusing merely on cost. The authors apply proposed criteria in a case example on select the suitable main contractor for construction projects of factories and warehouses, and alternative that meets the requirements the most gained the highest score is Company E. Company E is efficient in terms of past and present performance of the construction contractor which is an important criterion that is first and foremost used as a major decision criterion. Moreover, the company does lack in other criteria as well, it makes Company E appear to be reliable to win the project and expected to be able to complete the project as planned.

Furthermore, this research identified certain vital factors for contractor selection that face challenges in data collection, specifically in terms of information related to project management expertise and construction technical proficiency. Since this information is pivotal for gauging reliability and efficient management expertise, its absence from each bidding company's presentation can obscure potential project shortcomings. This, in turn, hinders decision-makers from obtaining adequate information to assess risks and score operational technical aspects. Subsequently, an end-to-end procurement risk management process is also proposed using top three relative important criteria, with "performance" and "current contractor construction workload" being the first and foremost. The second and third ranked criteria, "operational technique" and "staff," are essential components as well. This approach is aimed at developing tools for ongoing contractor performance monitoring during operations, as well as establishing a vendor checklist for their inclusion in the annual Supplier List.

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