

# Integrated Facilities Management's Supply Chain Vendor Selection Process

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**Abstract**—Vendor selection for supply chain management is a crucial part of every operation. This paper demonstrated and emphasized how the industrial engineering tools and techniques apply scenario presented in this paper showcased its applications, from failure identification to vendor selection criteria revision. Failure is looked at as an indication of poor performance; however, it is also the best way to discover what went wrong. This capstone paper showed that by using the appropriate mapping tools, identifying the root cause of the problem can be performed with ease. Similarly, comparing AHP and HBWM, the 2 of the commonly used multi-criteria decision-making techniques, this paper was able to identify the most suitable to use for the case. With this, we improved the selection criteria and arrived at a resolution that can prevent similar failure in future for similar high-risk facility such as the bank.

**Keywords**—integrated facilities management, vendor selection, supply chain management, bank, MCDM

## 1. Introduction

Integrated facilities management (IFM) service provision is widespread in the Middle East. In the United Arab Emirates (UAE), the compounded annual growth rate (CAGR) forecast of the industry can go up by 8.72% (2020 baseline) from 2021 to 2026 [1]. It shows how fast the sector is growing in the country. With the UAE, particularly Dubai, becoming a business hub in the Middle East, many companies are coming to the region to build their headquarters and operations then outsource their support functions [2].

Outsourcing is like a version of a “make” or “buy” decision [3]. The majority of the companies are outsourcing their IFM operations as it is not part of their core operations [4]. Banking is one of the industries trying to optimize the balance of their in-house and outsourced operations [5]. Banks have many operational risks being a financial institution [6]. Operational risk is the possibility of loss because of a failed internal process, people, systems, or external events [7].

Much research is done in the vendor selection process, with the information technology (IT) becoming the most reviewed topic. Few studies were about the vendor selection process of the banks for IFM. The typical process of the bank's selection is through four clustered weighted criteria. Operational performance, risk management, reputation and financial [8].

The breach of service level agreement by the facilities service provider in the rectification of the critical equipment in February 2020 exposed the banking operations to operational risk. The incident forced the CRES department to initiate the business continuity plan, which slowed down the business units' functions, thus affecting the customers' transactions and experience.

This paper identified the root cause of the facility management's supply chain failure that compromised the bank's operations. After identifying the cause, we reviewed the vendors selection criteria and decision-making process using the available literature studies and the questionnaire shared with the subject-matter experts (SMEs). We used the analytical hierarchy process (AHP), and the hierarchical best-worst method results, for the criteria selection and decision making. This paper determined which technique addressed better

and could have prevented the operational risk. One of the study’s limitations is that the SMEs approached are only 20. Another limitation is that the reviewed industry is only for one IFM contract for a bank in UAE.

The next sections of the paper discussed the literature reviews made. In chapter 3, we presented the methodology framework that we used. Chapter 4 contains the results and discussions. We presented the discussions about the conclusions made in chapter 5. Finally, Chapter 6 stated the recommendations on how this research can help improve the current vendor criteria selection of the studied organization and how this study can support future research.

## 2. Literature Review

### 2.1. Integrated Facilities Management

Little research discusses the IFM supply chain in different industries despite the fast-growing demand, development, and transformation of its role in the organizations [9]. Abdeen (2018) investigated the nature of FM supply chains, their functions, flows and relationships. They made interviews and observations to support their qualitative approach. They collected their data from professionals engaged in FM function for a company that manufactures apparel. They identified that the FM that the FM supply chain sources and customers are composed of internal and external parties [9]. Based on their findings, they developed the FM supply chain and flow. They also divided it to upstream and downstream, highlighting how multiple parties contribute to customers’ satisfaction. Their study served as a foundation in developing performance evaluation models.

### 2.2. Bank’s Operational Risks

The banking industry is in the top 5, if not the most sensitive, of risks. Unlike other financial risks, the operational risk always pertains to an opportunity of loss [10]. Sune Ferreira’s research article, “A conceptual model of operational risks events in the banking sector,” studied how operational risks can lead to other bank risks and influence the decision and stakeholder’s perceptions [11]. Using statistics, correlation, and testing the data, the behavior of the depositors in South Africa using a survey was tested [10]. Finally, their empirical analysis revealed negative correlation coefficients for all operational risk events and their risk tolerance level.

### 2.3. Suppliers’ Selection Criteria Review

We reviewed various publications and literature related to supplier evaluation. Dickson’s (1996) study was the pioneer as it was the first study on such assessment. He defined 23 criteria where the evaluation of the suppliers can be based. This study is one of the main foundations of the succeeding papers related to suppliers’ selection criteria.

Table 1: Dickson’s Supplier Selection Criteria (Dickson 1996)

No.	Criteria	The importance of criterion
1	Quality	Very high importance
2	Delivery	
3	Performance History	
4	Warranties & Claims Policies	
5	Production facilities and capacity	Great importance
6	Price	
7	Technical capability	
8	Financial position	
9	Procedural compliance	
10	Communication system	
11	Reputation and position in the industry	
12	Desire for business	
13	Management and organization	Medium

No.	Criteria	The importance of criterion
14	Operating controls	importance
15	Repair service	
16	Attitude	
17	Impression	Medium Importance
18	Packaging ability	
19	Labir relations record	
20	Geographical location	
21	Amount of past business	Medium Importance
22	Training aids	
23	Reciprocal arrangements	Low importance

Supply chain management has a significant impact on the quality of products and services [12]. Stevic [13] highlighted various publications available for criteria formulations, but their biggest question and aim is to find out how to choose the best solution. They reviewed papers that investigated the criteria selection from 1996 to 2014. Comparing all the studies and tabulating them, they found the standard criteria used by the authors. Financial parameters, quality, and delivery are almost present in all previous studies as criteria for supplier selection [12]. In addition to this, communication systems, reliability, flexibility, logistics capacity, reputation, speed of response to requirements are also essential criteria [13]. Aside from these, it is crucial to continuously collect and process information about suppliers to make the necessary evaluation and methods. Table 2 shows the summary of this study.

### 2.4. Analytical Hierarchy Process (AHP)

The study of Gilleard [14] emphasized that AHP is powerful and flexible in setting priorities on the decision-making process involving benchmarking and effectively handling performance measures data. The results of his study showed the advantage of AHP application to benchmarking facility management.

### 2.5 Hierarchical Best-Worst Method (HBWM)

Razaei [15] showed how many non-linear min-max model could be used to identify the weights. The maximum absolute difference between the weight ratios and their corresponding comparisons is minimized. In another study, Tabatabaei [16] introduced seven steps of the HBWM model, which include calculating the consistency rate of the decisions made based on the pairwise obtained from criteria and sub-criteria. They got the criteria and sub-criteria weight using a novel integrated model. Their study demonstrated how HBWM could effectively determine the criteria weights and sub-criteria.

## 3. Methodology

This research utilized a case study on a previous IFM contract operation. Figure 1 shows the framework of the methodology used. We established a more robust criteria selection by combining different techniques and approaches. The new process shall prioritize the categories addressing the operational risk and actual needs of the stakeholders that the IFM serves.

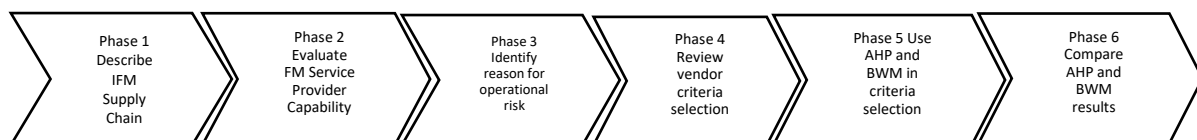


Fig. 1: Research

Table 2: Review of Suppliers' Criteria in Literature by Zejiko Stevic in 2017

Criteria	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Price of material	x		x	x		x	x		x			x	x		x	x	x	x	x	x	x	x	x	x

Financial stability	x	x	x	x	x	x	x		x					x		x			x	x		x		
Method of payment							x	x								x				x				
Price of transport			x				x	x	x	x				x					x					
Volume discounts								x																
Delivery time		x	x	x		x	x	x	x		x	x	x		x	x	x	x	x	x	x	x	x	
Reliability	x	x	x			x		x	x				x		x							x		
Flexibility		x	x					x	x					x								x	x	
Logistics capacity				x	x		x		x	x	x			x	x			x		x		x	x	
The % of correct realization of delivery									x												x	x	x	
Quality of material	x		x	x		x	x		x		x	x	x		x	x	x	x	x		x		x	x
Warranty period				x												x								
Certification of products	x							x	x							x					x	x		
Reputation		x	x	x	x								x	x	x				x				x	
Awards and honors									x															
Communication systems		x	x	x						x					x	x						x		
Speed of response to requirements									x	x						x				x	x	x	x	
Reactions to reclamations																x					x		x	
Information technology									x															
Clean of business									x						x								x	
A-Birgun, 2003; B-Cebi and Bayraktar, 2003; C-Chan and Kumar, 2007; D-Dickson, 1966; E-Ellram, 1990; F-Gencer and Gurpinar, 2007; G-Hruska et. Al., 2004; H-Hudymacova et.al., 2010; I-Jamilet.al., 2013; J-Kahraman et. Al., 2003; K-Kannan and Choon, 2006; L-Kilic, 2013; M-Lee, 2009; N-Lin and Chang, 2008; O-Muralidharan et. Al, 2002; P-Ozbek, 2015; Q-Simpson et. Al., 2002; R-Stevic et. Al., 2015; S-Tam and Tummala, 2001; T-Tung and Cho, 2008; U-Uygun, 2013; V-Wang et. Al, 2004; W-Weber et. Al., 1991; X-Zeydan et.al.,2011.																								

### 3.1. Case Study: Banking Industry IFM Operations – the United Arab Emirates

Bank XYZ’s operations have the IFM function under the Corporate Real Estate Services (CRES) [17], also known as the Property department. Its operations are not limited to the management of building and lands. It includes equipment, machines and processes that support each business unit’s operations, staff welfare, and most importantly, the bank’s customer experience [15]. Figure 2 shows the stakeholder of CRES, the flow of the interactions, the internal and external relations of the department.

As a support function, it is evident that the following are the drivers of the operation of CRES:

- The standard and compliance set by the bank.
- The demands of the business units served.
- The regulations and laws implemented by the country or area where the bank operates.
- The changes in the direction of the organization.

The CRES management leads for each of the functions within the department are bank staff. Their team is composed of outsourced members, and they manage and evaluate the department’s budget, operations, and compliance. IFM covers 40% of the CRES deliverables. It combines all the services related to the facility services under a single, unified team [18]. Furthermore, it includes anything within or attached to the building and soft FM like security, cleaning and waste management [19].

1) *Hard Facilities Management (HFM):* Services connected and performed physically to the facilities are included in the HFM category. It means that these are the equipment part of the building that requires preventive maintenance. This requirement is part of company standard, regulations, or law [20].

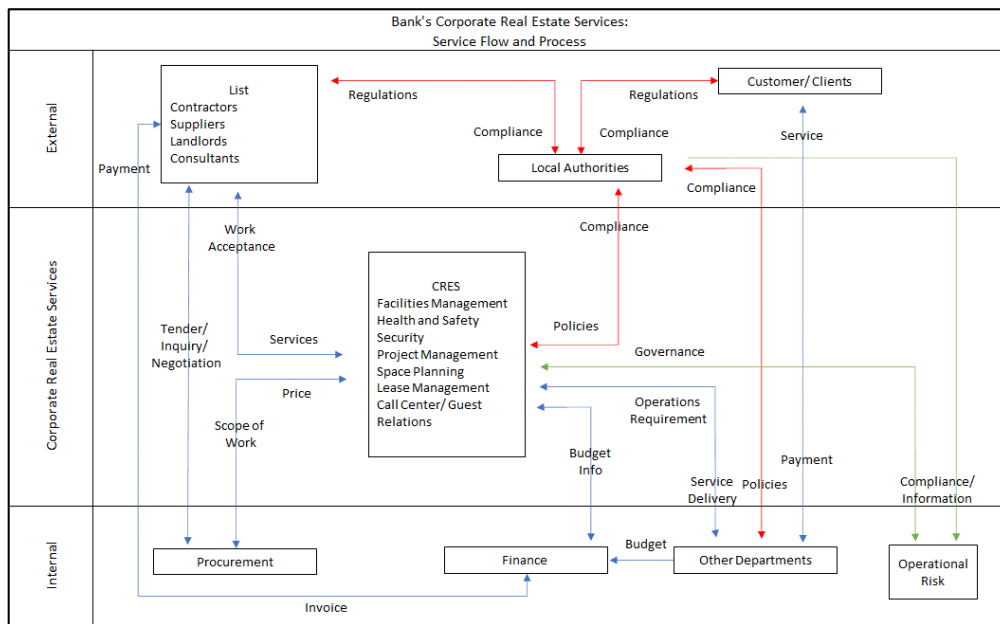


Fig. 2: CRES internal and external interactions

2) *Soft Services Management (SFM)*: These services are the ones that contribute and focus on the welfare of the bank's employees. It also extends to the experience of customers and business partners when using the facility. Not all the services under SFM are mandatory; however, an effective SFM is essential for every business to operate efficiently [21]. Figure 3 shows the structure and composition of the two divisions in the bank's operations.

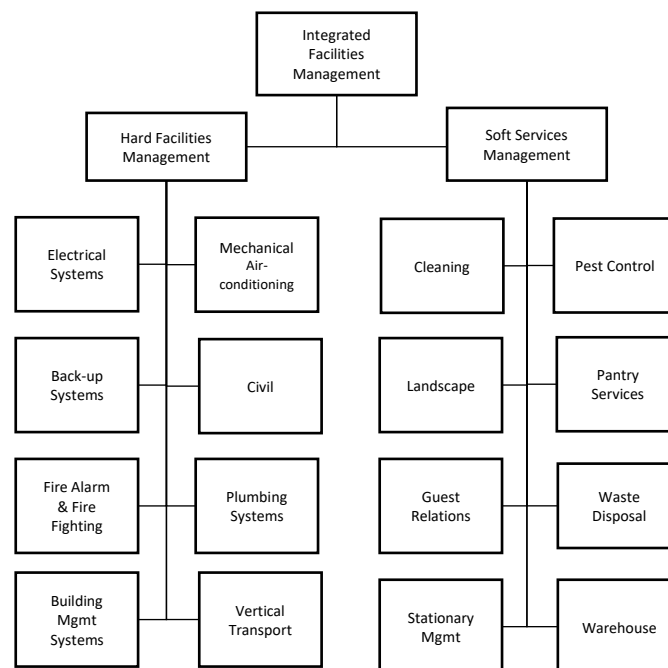


Fig. 3: IFM's Two Main Divisions

3) *Facilities Service Provider*

The evaluation reviewed the 2018 contract tender data and how the bank rated the five shortlisted vendors based on the four criteria and awarded the contract to vendor A. The bank makes four criteria selections where each has a 25% value. The criteria include technical capability, reputation, cost, and experience.

4) *Technical capability*: It is the category that measures how technically equipped the service provider is in providing the required scope of services. Staff technical know-how, the technology used, devices, and the selected subcontractors are all under this category.

a) *Staff qualification and technical know-how*: This criterion evaluates the proposed staff's experience, knowledge, qualifications, personality, applicable. It is through interviews, resume evaluation, and reference checks.

b) *Technology/ communication*: This criterion pertains to the different software used in managing the facilities management operations. Many organizations invest in CAFM software to check, track, monitor, evaluate costs, expenses, and the depreciation value of the equipment. A few examples are Maximo, Concept Evolution, Iviva, and ServiceMax. This sub-criterion will evaluate how the vendor will fit the available CAFM and utilize the system to benefit both parties.

c) *Quality/ response/ service delivery time*: The proposal states the method statements, standard operating procedures, quality, and response times. These are evaluated based on compliance with the proposed service level agreement. It covers how the vendor is planning to deliver the service contract.

d) *Subcontractor management and usage*: This criterion measures how the vendor will manage the other services sub-contracted to other specialists. It also takes the percentage of the services outsourced by the primary vendor. It evaluates the vendor's dependency on their subcontractors and their caliber.

5) *Reputation*: This component reviews the factors related to the service provider's image in the market and industry. Bank, being a financial organization, they cannot be associated with companies that can harm their reputation.

a) *Clients*: Reference checks based on the current and previous clients. Who, what, scale, and the reputation of their previous and present clients or customers.

b) *Financial stability*: The financial stability of the vendor. It measures how well the company manages its business in terms of cash flow. It extends to insurance policies, debts, loans, and assets.

c) *Service flexibility*: The design of the service delivery plan proposed to adapt and accommodate the business operations and changes that might happen to the bank's business units.

d) *Brand/ name in the market*: The bank cannot deal with a company involved or has a record of transactions that were considered illegal. This criterion will review the reputation and ensure that the vendor only transacts legally and complies with the authorities' regulations.

6) *Cost*: All operations have a budgeted cost. This component evaluates the price of the different cost line items. The pricing comparison is benchmarked against the current market cost and compared against each tender participant. Data was gathered based on the previous contract operations, expenditures, asset condition assessment, subcontracting percentage, and spare utilization.

a) *Cost of service*: It evaluates the price and value offered in exchange for the annual maintenance contract. It includes all the maintenance activities within the agreed scope and the price of the staffing based on the category and role that they will perform.

b) *Payment methods/ terms*: The vendor's payment terms and credit capability. How well they fit in the bank's cash flow cycle. Will delayed monthly payments impact their operations? Do they need advance before initiating variation works? Ease of transactions and billing process.

c) *Cost flexibility*: This criterion evaluates how the vendor proposes its adaptability to the bank's operations and needs for money transactions. For example, will they process transactions based on written approvals due to urgency, or will they have to stick with their SOPs?

d) *Value-added service*: Aside from complying with the scope, this criterion measures the vendor's proposed added value as part of the service contract period. It can be through environmental initiatives, optimization of operations, and other proposals that are in line with the mission and vision of the bank.

7) *Experience*: This criterion is one of the most important categories when selecting a service provider. Many of the clients wanted a company that already operated a similar facility, business, and operations. It can go to obtaining feedback from other client of the shortlisted company.

a) *Experience in the same industry*: This sub-category reviews the vendor's previous clients with a similar industry to the bank. It is one of the main drivers when it comes to the assessment of the vendor's capabilities and references.

b) *Experience in the same system*: This criterion evaluates the vendor’s familiarity with the equipment, assets and systems available in the bank. It also extends to monitoring software, building management system, and other specialized equipment/ system that is only present in a similar institution.

c) *Certification particular to the industry/ equipment*: This sub-category verifies the vendor’s credentials in delivering the services and managing their assets. It also explores the company’s certifications that should comply with the standard that the bank operates (i.e., ISO, Health and Safety, Data Centre Operations Certification)

d) *Risk Management and Business Continuity*: This section reviews how the vendor plans to mitigate the risks. It presents the readiness of the vendor based on their knowledge and experience in protecting the bank from risks, particularly the ones related to the FM operations.

### 3.2. Root-Cause Analysis

The failure in the IFM supply chain operations was analyzed using the Ishikawa diagram as the mapping tool summarized by the 5 why – diagram. It helped evaluate the causes and the sub-causes of the problem, which uncovered the issues in the supply chain [22].

A critical equipment breakdown took ten working days to be resolved. It is more than the agreed resolution time, and the risk management department highlighted this during an audit. There were no financial losses; however, the failure compromised the bank’s electrical power redundancy [23]. The situation exposed the bank to a possible significant financial loss. This incident raised questions on the credibility of the IFM operations, particularly on the vendor’s subcontracted services.

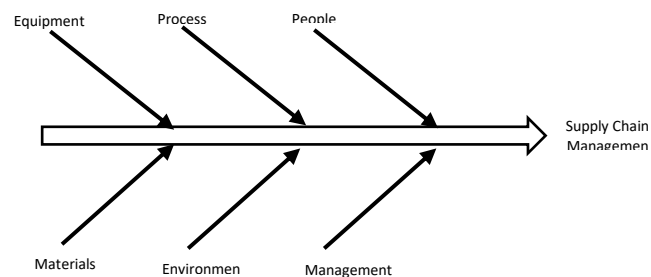


Fig. 4: Fishbone Diagram, International Journal of Managing Value and Supply Chains (IJMVSC) Vol.3, No. 2 June 2012

### 3.3. Qualitative Survey Analysis

We combined the available literature reviews and the survey shared with the subject matter experts involved in managing and selecting IFM contracts. We intend to obtain the best criteria selection and priority to eliminate or reduce the operational risks. Zejicko Stevis’s table in 2017, which reviewed the supplier’s criteria, was the primary reference used to prepare the questions in the survey.

We approached twenty subject matter experts to provide insights on the criteria selection priority. We rephrased the criteria to be more related to service delivery than materials suppliers and disregarded those unrelated.

### 3.4. Determine Weighting Criteria

The respondents provided the following inputs about their role and criteria preference ranked based on how important they see the criteria:

- Role function
- Intention for entering IFM contracts
- Main category priorities
- Sub-criteria ranking

8) *Analytical Hierarchy Process (AHP)*: The main category was divided into four classifications that the SMEs ranked. They compared each possible pair of criteria, and the main categories were composed of 4 sub-criteria. We used the 1-9 scale [24], numerical values. The SMEs assigned the values that denote the criteri’s importance, as shown in Table 3.

We used a pairwise comparison to identify the priority. This study has a total of 16 criteria under four main categories. We produced a 4 x 4 matrix under each category by tallying the SME’s survey results.

We used the following steps to normalize the matrix produced:

- Summing the weight of each column
- Divide the value of each column by the total column value
- Calculate the relative priority vector of each criterion by averaging the normalized weight

Table 3: The Saaty Rating Scale [27]

No.	Criteria	The importance of criterion
1	Equal importance	Two factors contribute equally to objective
3	Somewhat important	Experience and judgment slightly favor one over the other
5	Much more important	Experience and judgment strongly favor one over the other
7	Very much more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice
9	Absolutely more important	The evidence favoring one over the other is of the highest possible validity

The eigenvector was obtained by dividing the number of criteria, 4. The results of the priority weight calculation was a decimal number below one, and the absolute priorities in one group will also be equal to 1. After determining the weights, we calculated the matrix’s consistency. We did it by summing all the values in every column inside the matrix. We divided every value of the column by the corresponding overall columns to reach the normalization of the matrix – the summation values of every row and dividing the factors to obtain the average [25].

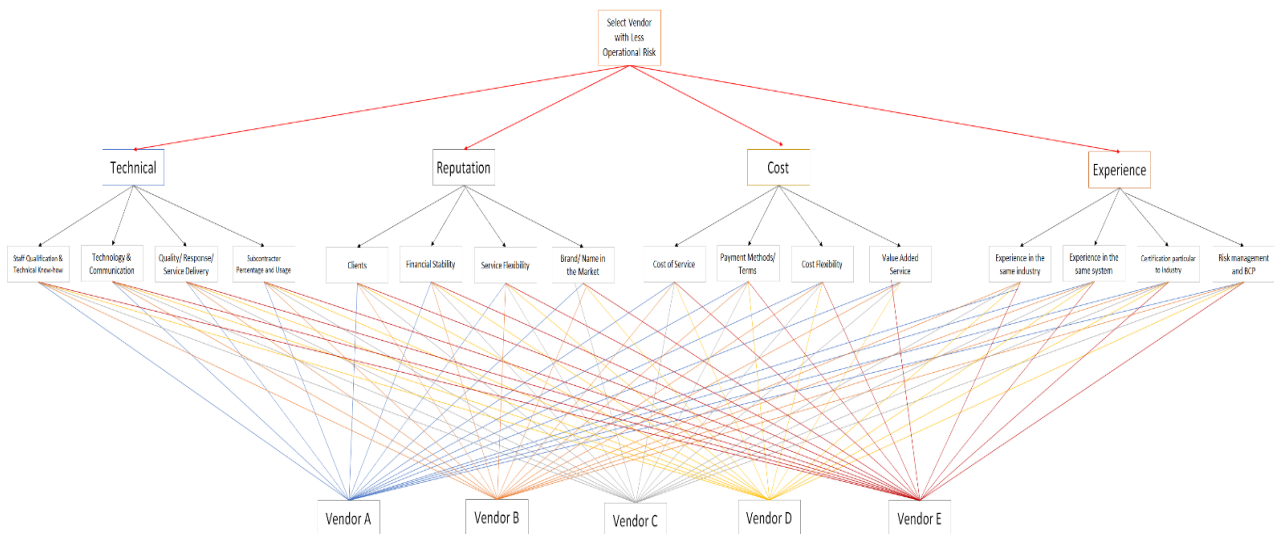


Fig. 5: Analytical Hierarchy Process Diagram

We used the results to calculate the consistency ratio (CR). It showed us the consistency of the judgments made to the sample of random judgments [26]. The AHP calculator by Goepel K.D. (2018) was used to solve the ratios [28]. Upon obtaining the results, we noted that if we got a value of CR, which is more than 0.1, the judgments are unreliable as they were too close for comfort to randomness. Since we have the 2<sup>nd</sup> level of the hierarchy, we performed a separate calculation of CR for them.

9) *Hierarchical Best-Worst Method (HBWM)*: The bank’s selection process comprises primary and sub-criteria; therefore, we decided to use the HBWM model. HBWM allowed the calculation of the consistency rate of the decisions made on the pairwise comparison performed on both criteria [16,25].

We used M.H. Tabatabaei’s model, that was consists of the following steps:

- We identified the decision criteria and sub-criteria. We defined them as  $\{c_1, c_2, \dots, c_n\}$  and  $\{c_{1k}, c_{2k}, \dots, c_{nk}\}$  respectively.
- We identified the most and least important from the qualitative survey results from SMEs.



- The preference of the best criterion over all other criteria was also identified. We made the comparison easier by using the same scale of 1-9. The result gave the best-to-others vector:

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

$a_{Bj}$  showed the preference of the best criterion B over criterion j-th, where  $a_{BB}$  is 1.

- Like step 3 but this time, we determined the others-to-worst vector. Below is the formula:

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})$$

$A_{jW}$  showed the preference of the criterion j-th over the worst criterion W where  $a_{jW}$  is 1.

- In this step, the priority of each sub-criterion from the most important criteria was determined for each as a number between 1 and 9. We expressed it as  $A_B = (a_{B1}^j, a_{B2}^j, \dots, a_{Bk}^j)$  where  $a_{Bk}^j$  is the priority of the best sub-criterion over the k-th sub-criterion in j-th criterion and  $a_{BB}^j = 1$ .
- Like step 5 but this time, the least important sub-criterion. We expressed it as  $A_B = (a_{1W}^j, a_{2W}^j, \dots, a_{kW}^j)$ , where  $a_{kW}^j$  is the priority of the k-th sub-criterion over the least important sub-criterion for j-th criterion  $a_{WW}^j = 1$ .
- Finally, we calculated the weights of the criteria  $(w_1^*, w_2^*, \dots, w_n^*)$ , and sub-criteria  $(w_1^{j*}, w_2^{j*}, \dots, w_k^{j*})$ .

Summarizing the HBWM model, the equations are used [15].

$$\text{Min} \xi^L + \sum_j \xi_j^L \tag{1}$$

$$|w_B - a_{Bj} w_j| \leq \xi_j^L, \forall j \tag{2}$$

$$|w_j - a_{jW} w_W| \leq \xi_j^L, \forall j \tag{3}$$

$$|w_B^j - a_{Bk}^j w_k^j| \leq \xi_j^L, \forall j \ \& \ \forall k \tag{4}$$

$$|w_k^j - a_{kW}^j w_W^j| \leq \xi_j^L, \forall j \ \& \ \forall k \tag{5}$$

$$Gw_k^j = w_j w_k^j, \forall k \tag{6}$$

$$\sum_j w_j = 1, w_j \geq 0 \tag{7}$$

$$\sum_j w_k^j = 1, w_k^j \geq 0 \tag{8}$$

Figure 6 shows the primary and sub-criteria illustration made for this capstone paper.

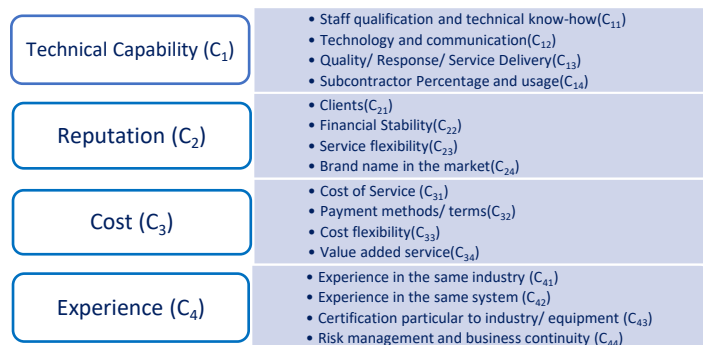


Fig. 6: Main Criteria and Sub-Criteria

We applied the same procedure to calculate the normal BWM method [15]. Table 4 shows the consistency index for the basic BWM.

Table 4: Onsistency Index in BWM

$a_{Bi}, a_{BW}^j$	1	2	3	4	5	6	7	8	9
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<i>Consistency Index</i> (Maxξ)	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23
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These results from the minimum deviations for the criteria ( $\xi^*$ ) and the sub-criteria for each criterion ( $\xi_j^*$ ) can be used along with the index in Table 4 for the equations 9 and 10 to calculate the consistency rate [15].

$$\text{Consistency rate} = \frac{\xi^*}{\text{Consistency Index}} \quad (9)$$

$$\text{Consistency rate} = \frac{\xi_j^*}{\text{Consistency Index}} \quad (10)$$

### 3.5. Comparison and Ranking

We compared the consistency rates from both method against each other. The method with a closer CR value to zero is used against the results of the most recent criteria selection process. The 2018 bank vendor's data on the tender is the primary reference to test the new vendor criteria selection. The outcome was reviewed to determine if the new process addressed the identified root cause of the problem.

## 4. Results and Discussions

### 4.1. Results

1) *Root-cause analysis:* Figure 7 shows the summary of the root-cause analysis after using the Ishikawa diagram. The delay in the rectification pointed out the non-availability of the spare. The spares were not available because the selected subcontractor of the IFM vendor was not the original equipment manufacturer of the asset that failed. These factors resulted in the service level agreement breach that placed the bank's operations at risk.

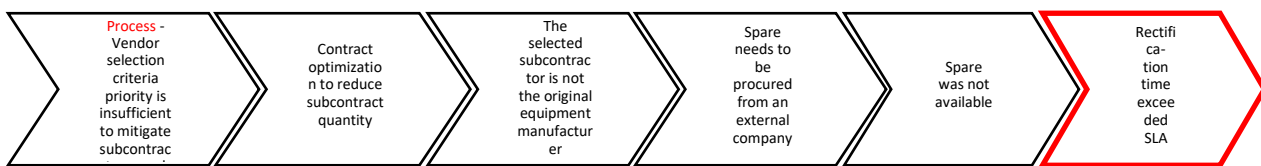


Fig. 7. Root-Cause Analysis – 5 Why Diagram

Table 5: AHP Results

Main Criteria			
Category	Criterion	Priority	Rank
Main	Technical Capability	64.8%	1
	Reputation	11.0%	4
	Cost	12.7%	2
	Experience in the same Industry	11.4%	3
	Consistency Ratio		0.012
Sub-Criteria			
Category	Criterion	Priority	Rank
Technical Capability	Staff Qualification	9.0%	3
	Technology and Communication	4.2%	4
	Service Delivery	65.2%	1
	Sub-contractor Management	21.6%	2
	Consistency Ratio		0.075
Reputation	Clients	18.2%	2
	Financial Stability	65.6%	1
	Service Flexibility	10.1%	3
	Brand/ Market Image	6.1%	4
	Consistency Ratio		0.09
Cost	Cost of Service	60.7%	1
	Payment Method	8.6%	3

	Cost Flexibility	25.1%	4
	Value Added Service	5.6%	2
	Consistency Ratio		0.024
Experience	Same Industry	9.3%	3
	Same System	5.4%	4
	Certification	43.8%	1
	Risk Management & Business Continuity	41.5%	2
	Consistency Ratio		0.066

1) *Analytical hierarchy process results:* Using AHP, we identified the most important criterion for each sub and the main category. Table V is the summary of the importance ranking. Technical capability got the highest priority while the remaining three categories were very close to each other. Service delivery and sub-contractor management ranked 1<sup>st</sup> and 2<sup>nd</sup> for technical capability for the sub-criteria. In reputation, financial stability followed by clients obtained the highest importance. In the cost category, the cost of the service and the cost flexibility were labeled as the two most important. Certification and risk management became the top picks for the experience category.

2) *Hierarchical Best-Worst Method Results:* Using the formula and solver created by Rezaei (2016) [29], we obtained Table VI. In the main category, technical capability led the ranking with almost a gap of 44% to the second-best criterion, reputation.

Table 6: HBWM Results

<b>Main Criteria</b>			
Category	Criterion	Priority	Rank
Main	Technical Capability	61.9%	1
	Reputation	17.4%	2
	Cost	6.1%	4
	Experience in the same Industry	14.5%	3
	Reliability Score		0.25
<b>Sub-Criteria</b>			
Category	Criterion	Priority	Rank
Technical Capability	Staff Qualification	16.0%	3
	Technology and Communication	5.3%	4
	Service Delivery	58.7%	1
	Sub-contractor Management	20.0%	2
	Reliability Score		0.21
Reputation	Clients	56.7%	1
	Financial Stability	18.9%	3
	Service Flexibility	5.4%	4
	Brand/ Market Image	18.9%	2
	Reliability Score		0.19
Cost	Cost of Service	66.6%	1
	Payment Method	6.7%	4
	Cost Flexibility	14.3%	2
	Value Added Service	12.3%	3
	Reliability Score		0.19
Experience	Same Industry	5.9%	4
	Same System	16.9%	3
	Certification	16.9%	2
	Risk Management & Business Continuity	60.2%	1
	Consistency Ratio		0.25

For the sub-criteria category, quality, responses, and service delivery came as the best criterion in the technical capability category, followed by the sub-contractor management. In the reputation section, the client became the best criterion while the company's brand/image was the second-best. Clients and cost flexibility

came first and second for the cost-sub-category, respectively. In the experience, risk management became the best criterion with a considerable gap from certification as the second category prioritized.

1) *Comparison and Ranking*

a) *Comparing AHP and HBWM results:* The results from the two-method showed hoq close these processes are but different. Most of the top priorities or best criteria were similar for both methods apart from the reputation sub-criterion, where priorities differed. Based on the consistency ratio and the reliability score, AHP showed a better result with its value closer to 0. It justified why AHP is a better decision-making tool for the problem in this paper.

Comparing Results: We used the 2018 tender criteria weightage to compare our results. Table VII shows how the weightage is compared to side to side. The hierarchy of the rankings was the same for the main and sub-criteria. The weightage of the importance and percentage are the ones that show a significant difference.

Table 7: HBWM Results

Cat	Main Criteria				
	Table column subhead	Capstone (AHP)		Existing Criteria	
Main	Technical Capability	64.8%	1	50%	1
	Reputation	11.0%	4	15%	3
	Cost	12.7%	2	20%	2
	Experience	11.4%	3	15%	3
Cat	Sub-Criteria				
	Criterion	Capstone (AHP)		Existing Criteria	
Technical Capability	Staff Qualification	9.0%	3	25%	2
	Technology & Communication	4.2%	4	20%	3
	Service Delivery	65.2%	1	40%	1
	Sub-contractor Management	21.6%	2	15%	4
Reputation	Clients	18.2%	2	25%	1
	Financial Stability	65.6%	1	25%	1
	Service Flexibility	10.1%	3	25%	1
	Brand/ Market Image	6.1%	4	25%	1
Cost	Cost of Service	60.7%	1	50%	1
	Payment Method	8.6 %	3	15 %	3
	Cost Flexibility	25.1 %	2	20 %	2
	Value Added Service	5.6 %	4	15 %	3
Experience	Same Industry	9.3 %	3	20 %	3
	Same System	5.4 %	4	20 %	3
	Certification	43.8 %	1	25 %	2
	Risk Management & Business Continuity	41.5 %	2	35 %	1

To meet the objectives of this paper, we applied the new criteria and ran them to the scorecards of the 2018 shortlisted vendors. It is a straightforward replacement to the 2018 results by changing the percentage of the scoring outcome. Table VIII shows the previous result. It gave a better reference to understand how the percentage distribution made vendor A win the contract.

Table 8: Vendor Selection Score Card

<b>Main Criteria</b>
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<i>Cat</i>	<i>Crit</i>	<i>Capst one %</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
Main	Technical Capability	50%	43.63	43.38	42.88	43.25	43.75
	Reputation	15%	13.50	13.13	13.13	12.56	12.56
	Cost	20%	18.45	17.65	17.15	17.95	17.80
	Experience	15%	12.75	12.38	12.98	12.11	12.34
<b>Total</b>			<b>88.33</b>	<b>86.54</b>	<b>86.14</b>	<b>85.87</b>	<b>86.45</b>

Using the new criteria weightage and priority results, we summarized the scorecard in Table IX. This table showed how different the result changed. For calculation purposes, we rounded off to whole number the weight percentages.

Table 9: Applying the Capstone (New Criteria Weightage)

<b>Main Criteria</b>							
<i>Cat</i>	<i>Crit</i>	<i>Cap-stone %</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
Main	Technical Capability	65%	56.78	57.20	55.97	55.71	58.66
	Reputation	11%	9.92	9.44	9.70	9.30	11.35
	Cost	13%	11.99	11.36	10.97	11.60	11.56
	Experience	11%	9.35	9.21	9.34	8.98	9.09
<b>Total</b>			<b>88.04</b>	<b>87.21</b>	<b>85.98</b>	<b>85.59</b>	<b>90.66</b>
<b>Sub-Criteria</b>							
<i>Cat</i>	<i>Crit</i>	<i>Cap-stone %</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
Tech Capabi-lity	Staff Qualification	9%	85	80	85	95	85
	Tech & Comm	4%	90	90	85	80	80
	Service Delivery	65%	90	90	85	85	90
	Sub-con Management	22%	80	85	90	85	95
<i>Cat</i>	<i>Crit</i>	<i>Cap-stone %</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
Reputa-tion	Clients	18 %	90	85	80	85	80
	Financial Stability	66 %	90	85	90	85	90
	Service Flexibility	10 %	95	90	90	80	85
	Brand/ Market Image	6 %	85	90	90	85	80
Cost	Cost of Service	61 %	95	85	80	90	90
	Payment Method	9 %	95	95	95	95	95
	Cost Flexibility	25 %	85	90	90	85	85
	Value Added Service	5 %	90	90	90	90	85
Exper-ience	Same Industry	9 %	85	75	80	75	85
	Same System	5 %	85	80	95	80	80
	Certification	44 %	85	80	80	80	85
	Risk Mngmt & Business Continuity	42 %	85	90	90	85	80

## 4.2. Discussions

The results between AHP and HBWM priorities and criterion ranking were close but, the sensitivity and risks that the bank carries were addressed better through a hierarchy ranking. HBWM offers lesser pairwise comparison and an immediate min and max criterion. It will be a more straightforward process; however, the obtained reliability score is not close to zero. It made the results unreliable compared to the AHP, where the

consistency ratio is much closer to zero. One of the capstone's objectives is to address the failure; thus, using the AHP gave more attention to the need of the operations.

After the changes in the weightage of the criteria when using the AHP and HBWM was expected. The existing criteria are from standards and best practices in the market. The new priorities were based on the subject matter experts' point of view and importance as scored. These professionals understood the depth of each criterion because they are directly involved with the IFM function.

Applying the new criteria percentage changed the tender results. Instead of Vendor A, Vendor E became the recommended service provider. The data shows that Vendor A has the lowest sub-contractor management score while Vendor E has the highest. The results support how we believe that this change will address the problem in the capstone. The criteria selection now reflects the importance of the other sub-contracted services in the supply chain. It is also pre-screening how the primary vendor will manage the other part of their service chain. The new criteria weightage provides an extra layer of assurance to the bank.

Another factor highlighted by this study is the distribution of the weight percentage per criterion. It is common to provide an exact number (i.e., 5%, 10%, 25%); these percentages need not be in such "perfect" figures; instead, it should be allocated based on its importance and relation, in comparison to the other criteria.

## 5. Conclusion

Integrated facilities management service provider for banks involves a lot of operational risks. With the organization outsourcing, the function significantly increases the risks' probability. Developing a proper process when creating the vendor selection criteria is essential to prevent, if not, eliminate the potential risks.

This paper highlighted that by involving the stakeholders in the process who have in-depth knowledge of the requirement and using the appropriate tool, the selection process could be improved and be weighed based on the actual operational needs and data. AHP and HBWM both showed excellent results in reflecting the desired weight percentage of each criterion compared to the currently used one. With the sensitive operations of the bank, HBWM, having a lesser pairwise comparison, showed that it is not the best tool to be considered. These outcomes justify how important it is to develop the correct customized vendor selection process, particularly for service industries.

Predicting the perfect outcome with many human factors involved in a service provision supply chain might be more complex. A structured and concrete vendor selection process provides a better evaluation and prevents and reduces the probability of operational risk failures.

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