A resilient vendor selection approach

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Abstract

Conventionally, decision makers evaluate vendors vis-a-vis traditional criteria (e.g., costs, implementation reliability and quality). However, this approach ignores other important concerns such as resilient implementation and running of a project that is a crucial aspect towards service continuity. This research presents a decision-making approach that helps managers to evaluate vendors profiles based on their submitted tenders to accomplish a proposed radio frequency identification (RFID)-based passport tracking system. First, this evaluation is conducted based on two sets of traditional and resilience criteria presented in a unified framework based on literature and the case company's experts. Second, the weights of identified criteria are quantified by using the decision-making trial and evaluation laboratory (DEMATEL) algorithm. Third, the ELimination Et Choix Traduisant la REalité (ELECTRE) algorithm is applied to evaluate the performance of vendors to recommend the best one. Four employees from the case company participated in evaluating the applicability of the proposed decision-making tool. This includes the selection of one vendor out of 6 submitted their proposals to implement RFID-based passport tracking system.

Keywords
Vendor selection; DEMATEL; ELECTRE; Resilient selection; Decision-making tool.

1. Introduction

The vendor selection is a key factor in implementing a robust business. This is based on the fact that enterprises depend greatly on vendors to contribute to their cost-effective high performance. Furthermore, purchasing activity is one of the main tasks for enterprises, since its costs represent more than 50% of all the internal costs of an enterprise (Mohammed et al., 2018). The vendor selection can be defined as the activity of selecting the best vendor on the basis of their tenders with reference to a number of criteria in order to stabilize the environment of their competition. Generally, it is a major concern and challenge to decision makers since several uncontrollable and unpredictable factors (e.g., unexpected events such as floods and earthquakes) are involved (Bevilacqua et al., 2006). An inappropriate selection may compromise the financial and operational status of the enterprise, most of all when the purchasing is of high value, complex and perhaps critical (Mohammed, 2019).

Generally, vendor or supplier selection is a complex, multi-criteria decision-making process, because different and conflicting criteria must be assessed in order to find suppliers. Kilic (2013) and Mohammed et al. (2019) justify this complexity by the changeable key-factors that may be uncertain and conflict with each other, such as cost, delivery time, service level and product quality. Further supplier selection criteria can be found in Weber et al. (1991); and Govindan et al., 2015. Decision makers normally evaluate vendors on the basis of their performance vis-à-vis traditional criteria such as costs and quality and neglect other aspects such as resilience criteria where agility and flexibility are paramount in sustaining and improving their services. Resilience is the capacity of the system to efficiently cope with expected disruptions and return to its normal process, a vital aspect of any supply chain management (Torabi et al., 2015). If the selection process includes traditional criteria as the only criteria in decision making, it can be described as inefficient and needs further consideration. In addition, resilience criteria can represent supplier's capacity to cope with risk and unexpected events more efficiently and quickly than other suppliers. Purvis et al. (2016) propose a framework for the development and implementation of a resilient supply chain strategy, which illustrates the relevance of various management paradigms. The authors considered four pillars (enablers) as key factors to improved supply chain resilience, namely, redundancy, agility, leanness and flexibility (RALF). In the context of vendor selection, resilience is the ability of a vendor to cope with unexpected requirements from the enterprise that could require slight or some alterations in the specification of products or faster implementation times. In the current study, resilience criteria for vendor selection is presented in terms of are flexibility, robustness and visibility as it will be illustrated in the application section.

Several research papers present research related to the vendor selection problem (Krishankumar et al., 2020; Mohammed et al., 2017; and Sumrit, 2020). However, the literature shows that few if any of the previous studies have presented an integrated approach which considers resilience criteria and traditional criteria simultaneously and in the setting of the RFID-based passport tracking system. This study presents the development of a hybrid decision making tool aiming to select the best tender out of 6 submitted to implement an actual RFID-based passport tracking system. First, a framework was developed for to define the traditional and resilience criteria and sub-criteria (e.g. traditional pillars such as costs and delivery commitment plus resilience criteria such as flexibility and agility). Traditional and resilience criteria were identified according to the literature review and interviews with the institution under study. Then, DEMATEL method was used to determine the relative importance of each traditional and resilience criterion and sub-criterion. In the next stage, ELECTRE method was used to evaluate and rank the vendors with respect to their traditional and resilience performance.

2. Literature review

Several research studies present the vendor selection problem that considers traditional business criteria. Mohammed et al. (2020) & (2019a) developed a multi-criteria decision-making model to select environmental sustainability suppliers. Khaleie et al. (2012) used a ranking process on the two indices of score function and accuracy function, to rank the alternatives. Hague et al. (2015) proposed a TOPSIS-based approach to ranking and selecting the best supplier basing its performance in part on reliability and maintainability.

Over the last decade, interest from researchers and industry in relation to the supply chain resilience has grown rapidly where a successful supply chain management should develop its resilience to cope with unexpected disruptions in relation to supply and demand. Sheffi (2005) defined supply chain resilience as "its inherent ability to maintain or recover its steady state behavior, thereby allowing it to continue normal operations after a disruptive event". Since vendor or supplier selection is one of the main activities in supply chain management, a growing number of academic papers aims to generate a more resilient supply chain by using MCDM algorithms to integrate resilience into selection of vendors or suppliers. Haldar et al. (2014) developed a fuzzy multi-criteria decision making (MCDM) approach to rank suppliers according to their degrees of importance such specific attributes as the linguistic variables formulated by triangular and trapezoidal fuzzy numbers. Torabi et al. (2015) proposed a fuzzy stochastic bi-objective optimization model to improve the supply chain resilience under operational or disruptive risk by solving the SS/OA problem. Rajesh and Ravi (2015) solved a resilience problem in supplier evaluation using a grey relational analysis algorithm that incorporates such resilience criteria as vulnerability, collaboration, risk awareness and supply chain continuity management.

3. Vendor selection approach: Research methodology

Figure It was proposed to implement the RFID technology in a current traditional passport tracking system by the government (i.e., ministry of interior) to improve the information accuracy, security and the issuing and renewing processes of passports for the clients of this institution. Recently, the directorate approved the system design and a project proposal was issued for the vendors to submit their tenders. The institution is interested in seeking the best vender to implement the project because it is a strategic project that handles sensitive data and requires high quality implementation. This research aims to develop a user-friendly decision-making tool to help the decision makers at the institution to select the best tender out from seven submitted. The tender and evaluation process takes account the traditional and resilience criteria. The decision-making tool has been developed using follows steps:

1) A unified traditional and resilience framework is proposed (Figure 1) to meet two main sets of evaluation criteria, the traditional and the resilience. The two main sets of criteria also have their own sub-criteria. The linguistic evaluation of decision makers is used to determine the qualitative relative importance of the criteria and sub-criteria by means of the evaluation scale presented in Table 1.
2) The decision makers' opinions from the previous step are used in the DEMATEL algorithm to determine the quantitative relative importance of the criteria and sub-criteria.
3) The linguistic evaluation of the decision makers is undertaken to determine the qualitative ranking of the vendors vis-à-vis the identified criteria and sub-criteria by means of the evaluation scale presented in Table 2.
4) The ELECTRE algorithm is used to determine the quantitative importance and ranking of vendors according to their traditional and resilience performance.

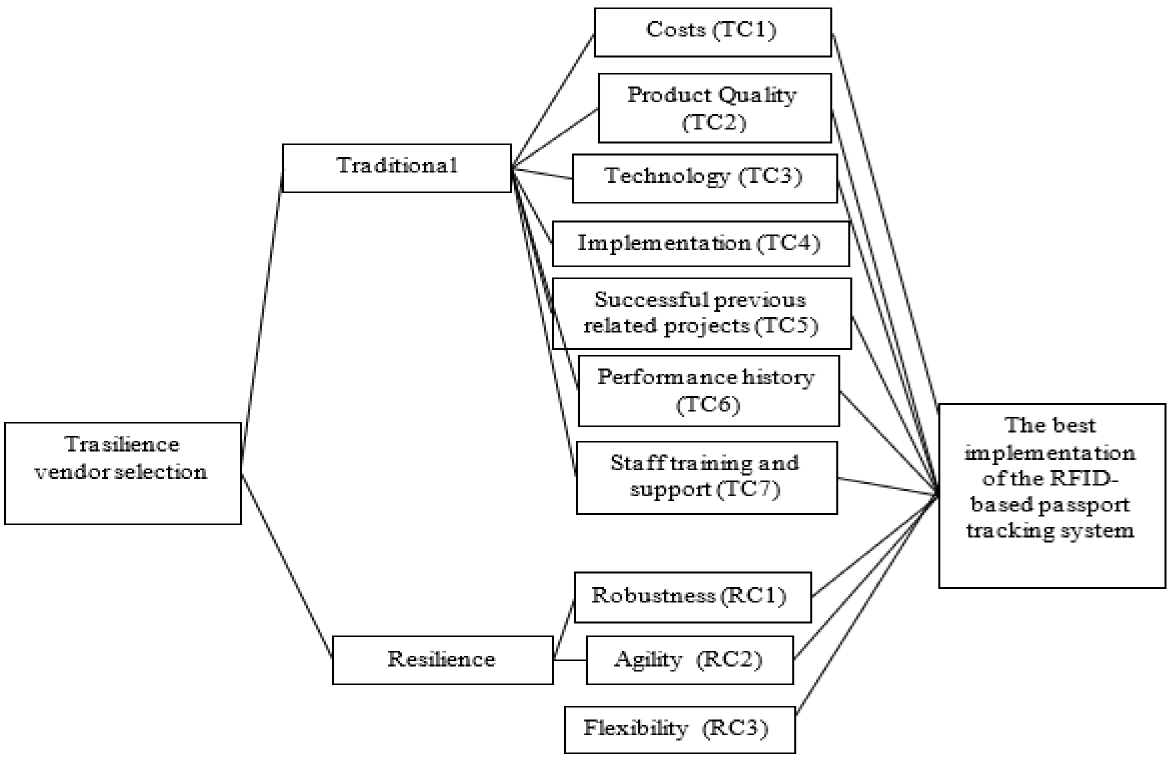

Figure 1. The traditional and resilient vendor selection criteria.

Table 1. Evaluation scale for the traditional and resilience criteria

Linguistic Variable	Scale
No influence (NI)	0
Low influence (LI)	1
Medium influence (MI)	2
High influence (HI)	3
Very high influence (VHI)	4

Table 2. Linguistic variables used for evaluating vendors Hwang and Yoon (1981)

Linguistic Variable	Scale
Very Low (VL)	1
Low (L)	3
Medium (M)	5
High (H)	7
Very High (VH)	9

3.1 Quantifying criteria: DEMATEL

DEMATEL is a multi-attribute decision making algorithm that can be used to determine the weights of attributes and to evaluate the interaction relationship between the variables of a complicated system in order to establish their direct and indirect causal relationships and their relative levels of influence. DEMATEL is implemented in the following steps (Tzeng et al., 2007; Mohammed et al., 2019; and Mohammed, 2020):

Step 1: Generate the linguistic evolution decision matrix based on decision makers' expertise. In this research the linguistic evaluation and its correspondence quantitative scale are shown in Table 1.

Step 2: The linguistic evolution obtained from step 1 is converted to the correspondence scale using the quantitative scale shown in Table 1 to generate a pairwise comparison decision matrix involving the three objectives.

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{1j} \\ a_{21} & a_{22} & a_{2j} \\ . & . & . \\ . & . & . \\ a_{i1} & a_{i2} & a_{ij} \end{bmatrix}$$

where A represents a pairwise decision matrix, in which the element a_{ij} denotes the level to which the ith attribute influences the jth attribute.

Step 3: The aggregated normalized decision matrix N is built based on the decision matrix generated in step 2, using Equation 1.

$$N = A.K \qquad (1)$$

$$N = k \times A, \quad k > 0$$

where

$$0 < k < kup, \quad kup = \frac{1}{\max\limits_{1<i<n}\left(\sum\limits_{j\in n} a_{ij}\right)}; \quad i, j \in \{1, ..., n\} \qquad (2)$$

where n refers to the matrix size.

Step 4: Generate the total-relation matrix T using Equation 3, in which I denotes the identity matrix. The matrix T reveals the entire relationship between each pair of decision attributes.

$$T = N\left(I - N\right)^{-1} \qquad (3)$$

Step 5: Sum the rows and columns of matrix T using Equations 4 and 5. These two summations are presented by the D and R vectors.

$$D_i = \left[\sum_{j\in n} t_{ij}\right]_{nx1}; \quad i = 1, 2, ..., n \qquad (4)$$

$$R_j = \left[\sum_{i \in n} t_{ij} \right]_{1xn}; \quad j = 1, 2, ..., n \tag{5}$$

Step 6: Define a threshold value *a*. Matrix *T* shows how one attribute influences another. It thus becomes necessary for the decision makers to define a threshold value *a* for elucidating the structural relations between attributes while simultaneously keeping the intricacy of the entire system to a convenient level. An relationship of influence between two attributes is excluded from the evaluation if their correlation value in matrix *T* is smaller than *a;* in this case only the effects greater than the set *a* value are chosen and shown in the digraph. In this work, the threshold value *a* is determined from the average of the values in matrix *T* using Equation (6), where *N* is the total number of values in matrix *T*.

$$a = \frac{\sum_{i \in n} \sum_{j \in n} t_{ij}}{N} \tag{6}$$

Step 7: Build the relationship table by summing *D* and *R* and subtracting *D* from *R* in which the *D+R* vector reveals how important the criterion is. The *D-R* vector divides the attribute into causal and effect groups. Generally, a positive value of *D-R* refers to the attributes which belong to the causal group, while if the *a* value *D-R* is negative it refers to the attributes that belong to the effect group.

Step 8: Use Equation (7) to determine the weight of each attribute by normalizing the *D+R* vector in which the sum of normalized weights equals 1.

$$w_i = \frac{D_i + R_i}{\left(\sum_{i \in n} (D_i + R_i) \right)}; \quad i = 1, 2, ..., n \tag{7}$$

3.2 Evaluating vendors : ELECTRE

Bernard Roy developed the ELECTRE algorithm, which ranks possible choices while working at the SEMA Consultancy Company. It is a Multi Criteria Decision Making (MCDM) algorithm used to evaluate and rank a number of options from the best to worst. ELECTRE applies a pairwise comparison of options with respect to the weights of the required criteria,' aiming to calculate a concordance set and a discordant set. In this algorithm, different types of matrix are constructed on the basis of the concordance and discordance sets and then the threshold values are used to filter out the less favourable options and select the better ones (Figueira et al., 2005). So far, ELECTRE seems to be one of the most important evaluation MCDM algorithms employed for applications in MCDM problems in practice, since it is based on the construction and exploitation of a valued "outranking relation" (Hwang and Yoon, 1981). Table 2 presents the linguistic variables and the correspondent numbers that were used to evaluate the vendors' performance vis-à-vis each criterion. This evaluation is based on the decision makers' expertise when they judge the performance of each supplier with respect to the traditional and resilience criteria.

The main steps in applying ELECTRE for the evaluation and ranking of vendors can be described as follows:

1. Construct the basic decision matrix *R* s that the numbers of matrix rows (i) and matrix columns (j) refer to the options and the criteria respectively.

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{1j} \\ r_{21} & r_{22} & r_{2j} \\ . & . & . \\ . & . & . \\ r_{i1} & r_{i2} & r_{ij} \end{bmatrix}$$

2. Normalize the decision matrix as follows:

$$v_{ij} = \frac{r_{ij}}{\left(\sqrt{\sum_i r_{ij}^2}\right)} \tag{8}$$

where the normalized decision matrix V is presented as follows:

$$V = \begin{bmatrix} v_{11} & v_{12} & v_{1j} \\ v_{21} & v_{22} & v_{2j} \\ . & . & . \\ . & . & . \\ v_{i1} & v_{i2} & v_{ij} \end{bmatrix}$$

3. Construct the normalized weighted decision matrix W by multiplying the normalized decision matrix by the weight of the various criteria (w_i) as revealed via DEMATEL.

$$W_{ij} = v_{ij}\ w_i \tag{9}$$

4. Apply Equations 10 and 11 to determine the concordance and discordance sets, respectively. The concordance matrix is constructed by adding the values of the weights of the elements in the concordance set. The discordance matrix is constructed by dividing the values of the members of the discordance set to the total value of the whole set.

$$C_{ab} = \sum_{j^*} w_{j^*}; \forall j^*_a \geq j^*_b \tag{10}$$

Where *a* and *b* refer to alternatives.

$$D_{ab} = \frac{\left(\sum \left|W_{aj^*} - W_{bj^*}\right|\right)}{\left(\sum \left|W_{aj} - W_{bj}\right|\right)} \tag{11}$$

where $C(a,b) = \{ j,\ W_{aj} \geq W_{bj} \}$ and $D(a,b) = \{ j,\ W_{aj} < W_{bj} \}$.

5. Construct the binary concordance and discordance matrices according to the sets obtained in step 5.
6. Rank each option by constructing the aggregated binary concordance and discordance matrices by the binary multiplication of the concordance and discordance matrices together.

4. Application and evaluation

To validate the applicability and effectiveness of the developed vendor selection decision making tool, it was applied to a directorate ('directorate A', henceforth) that belongs to the Ministry of Interior in one of the West Asia Countries. Directorate A is responsible for issuing and/or renewing passports for the citizens of the country. An RFID-based passport tracking system design was proposed as a replacement for a traditional passport tracking system, which aims to provide a user-friendly decision making tool for selecting the best vendor from a group which submitted their tenders for implementing a proposed RFID-based passport tracking system (Dukyil et al., 2018; and Dukyil et al., 2017). Recently, directorate A approved the design of an RFID-based passport tracking system and invited 6 vendors to submit their tenders for implementing it. The seven vendors consist of four international companies (three vendors from Asia and one vendor from Europe) and three local companies. However, companies' names are not revealed in this study upon the request of the evaluation panel. At the same time, the institution was interested in acquiring a suitable selection tool that would help to thoroughly evaluate the submitted tenders and find the best since the project, which handles sensitive data, is strategic and needs high quality implementation. Therefore, the developed decision-making tool was applied in this case study.

Four employees (E1, E2, E3 and E4) with an average work experience of 12 years were involved in the evaluation and selection panel as was suggested by the head of the Technical Department at directorate A. The four employees' evaluation panel includes three employees who worked at the Technical Affairs Division and an employee work at the Planning Department. These employees are normally involved in the evaluation and selection of vendors for such a technical project. It included an evaluation of 6 tenders and then recommendation related to the most suitable vendor for the project. Two interviews in depth (each about 3 hours in length) with the selection panel were held to clarify, discuss and evaluate the traditional and resilience criteria, sub criteria and the performance of the 6 vendors (V).

4.1 The weight of criteria: DEMATEL

First, the DEMATEL algorithm was applied to determine the relative importance of the criteria and sub-criteria (see Figure 1) based on the qualitative evaluation of criteria performed by the four employees. The pairwise comparison of the criteria was generated on a scale of 0, 1, 2, 3 and 4, as illustrated in Table 1. Tables 3 and 4 show the equivalent quantitative evaluation for the traditional and resilience criteria, respectively, based on the decision makers' expertise. The aggregated normalized decision matrix for the traditional and resilience criteria was then built on the basis of the decision matrix using Equation 2. The total-influence matrix (T) for the traditional and resilience criteria was generated by using Equation 3. The sums of rows and columns as represented by vectors D and R respectively were computed. These values show the levels of total influence and net influence respectively, where the positive values indicate that the criterion will influence other objectives more than any other objective influences it. The traditional criterion of cost was revealed to have the greatest net influence compared to the criteria of previous related projects that had succeeded, which were revealed to have less net level. In addition, the resilience criterion of agility was revealed to have more net influence level than the criterion of flexibility, which was revealed to have the least net influence.

Table. 4. Decision matrix as regards resilience criteria

Criteria	RC1	RC2	RC3
		E1	
RC1	0	2	1
RC2	2	0	1
RC3	0	1	0
		E2	
RC1	0	3	1
RC2	3	0	3
RC3	0	3	0
		E3	
RC1	0	4	2
RC2	4	0	1
RC3	0	1	0
		E4	
RC1	0	3	3
RC2	3	0	2
RC3	0	2	0

Table. 3. Decision matrix as regards traditional criteria

Criteria	TC1	TC2	TC3	TC4	TC5	TC6	TC7
	E1						
TC1	0	4	3	1	0	0	4
TC2	4	0	9	0	0	3	0
TC3	0	9	0	2	0	0	0
TC4	9	0	2	0	1	3	0
TC5	0	2	0	1	0	3	0
TC6	2	0	1	0	3	0	0
TC7	0	1	0	3	0	0	0
	E2						
TC1	0	4	4	3	0	3	4
TC2	4	0	3	2	1	3	0
TC3	0	3	0	1	1	1	0
TC4	3	0	1	0	1	4	0
TC5	0	1	0	1	0	3	1
TC6	1	0	1	0	3	0	1
TC7	0	1	0	3	0	1	0
	E3						
TC1	0	4	4	2	3	2	3
TC2	4	0	3	3	0	3	0
TC3	0	3	0	3	0	2	1
TC4	3	0	3	0	1	3	0
TC5	0	3	0	1	0	0	2
TC6	3	0	1	0	0	0	1
TC7	0	1	0	0	0	1	0
	E4						
TC1	0	4	4	2	0	3	3
TC2	4	0	3	1	0	3	4
TC3	0	3	0	2	2	1	0
TC4	3	0	2	0	1	2	0
TC5	0	2	0	1	0	3	2
TC6	2	0	1	0	3	0	3
TC7	0	1	0	3	0	3	0

Table 5 and Figure 2 show the relative weight of all the criteria that were determined by normalizing the total influence vector (D+R). As shown in Table 5, the traditional criterion of cost has the highest weight (0.302215) followed by product quality, implementation, successful previous related projects, technology, staff training and support and performance history and that revealed the lowest weight (0.086012). Traditionally, it is expected to have the criteria of cost and quality to get the highest weight among others in industry. Also, it is noticed that the evaluation panel gives a high attention for the criteria of the implementation plan and successful previous related projects. This is understandable for such an important project to have a robust implementation schedule supported by a successful related project previously implemented by the vendor. Moreover, the resilience criterion of robustness was revealed to have the greatest weight (0.658428) followed by agility and flexibility that revealed the lowest weight (0.088675). All the weights were then used to evaluate the performance of the vendors by applying ELECTRE, as illustrated in the next sub-section.

Table 5. Weights of the criteria

Criteria	Sub-criteria	IW	Ranking
Traditional	TC1	0.302215	1
	TC2	0.206216	2
	TC3	0.095256	5
	TC4	0.155072	3
	TC5	0.100813	4
	TC6	0.054416	7
	TC7	0.086012	6
Resilience	RC1	0.658428	1
	RC2	0.252898	2
	RC3	0.088675	3

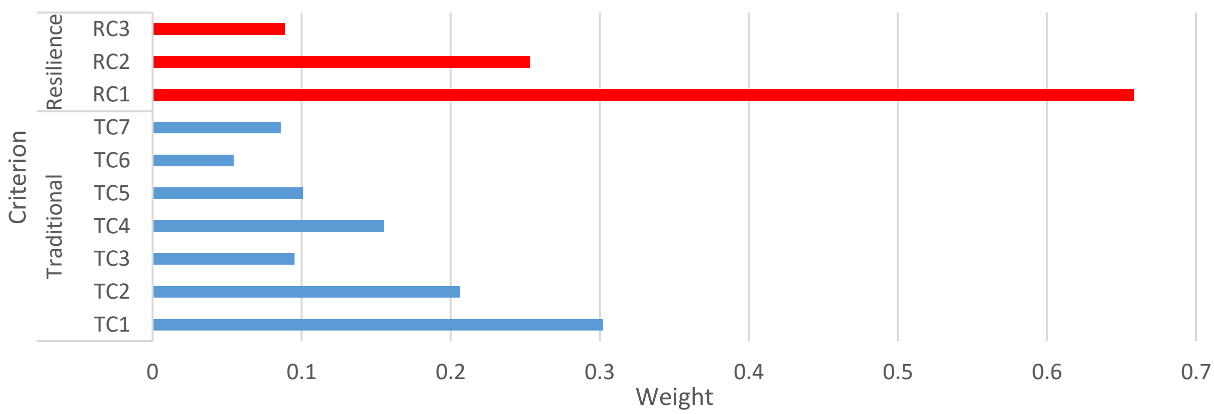

Figure 2. A graphical illustration of criteria weights.

4.2 Ranking vendors: ELECTRE

After revealing the relative weight of each traditional and resilience criterion via DEMATEL, ELECTRE was implemented to reveal the ranking of the vendors on the basis of their traditional and resilience performance. The four employees were invited individually to evaluate the performance of the 6 vendors with respect to each sub-criterion using the evaluation scale presented in Table 2. It was intended to have the evaluation of the four employees individually to avoid the conflict of interest. Table 6 shows the aggregated performance evaluation decision matrix. It was noted roughly that the four employees given almost different evaluations for the 6 vendors vis-à-vis the traditional and resilience criteria. This makes the direct accurate selection of the best vendor aggregating the opinions of the four employees impossible. Thus, following this, ELECTRE was applied as follows.

Table 6. The aggregated decision matrix

	TC1	TC2	TC3	TC4	TC5	TC6	TC7	RC1	RC2	RC3
V1	3	5	5.5	4	7	6.5	7	3.5	2	3.5
V2	6.5	6	6.5	5	3	6.5	3	5	7	5
V3	7	5.5	6	6	4.5	4.5	4	4	4.5	5
V4	3.5	3	5	6.5	6.5	4	4	2	4	4.5
V5	6	5	4.5	6.5	4.5	5	6	5.5	5	4.5
V6	4	5	5.5	6	2.5	4	2.5	3.5	3.5	3.5

Based on the aggregated matrix presented in Table 6, the ELECTRE algorithm was applied as follows:

Step 1: The normalized decision matrix and the weighted normalized decision matrix were obtained by multiplying the sub-criteria weights obtained by DEMATEL (see Table 5).

Step 2: The concordance set was built using Equation 10.

Step 3: The discordance set was built using Equation 11.

Step 4: The aggregated concordance and discordance binary matrix was built via a binary multiplication between the concordance and discordance sets, as shown in Table 7.

Table 7. The aggregated concordance and discordance binary matrix

	V1	V2	V3	V4	V5	V6
V1	0	0	0	1	0	0
V2	0	0	1	0	0	0
V3	0	0	0	0	0	0
V4	0	1	0	0	0	0
V5	1	0	0	0	0	0
V6	0	0	0	0	1	0
V1> V4, V3 and V2 V2>V3 V4>V2 and V3 v5> V1, V2, V3 and V4 V6> V1, V2, V3, V4 and V5						

According to the results obtained via ELECTRE, the performance of all the vendors was rated very close to the others, which would have made it very difficult for the evaluation panel to have chosen the best one without the decision-making tool developed in this study. The results revealed by using ELECTRE show the ranking of the vendors as V6>V5>V1>V4>V2>V3. Thus, it is recommended to award the tender to implement the RFID-based passport tracking system to vendor 6. It was argued with the four employees that this evaluation would not be able to be accomplished efficiently, considering all criteria and experts ‘opinions. Mainly, they mentioned that they would normally study submitted proposals individually and then have a meeting (s) to discuss advantages/disadvantages and capabilities of submitted vendors. Then, this meeting would lead to a consensus normally. However, they mentioned that debate due to a conflict of opinions is possible. Furthermore, two of the employees mentioned that such an exact evaluation would further support the team towards the recommended vendor. Finally, the experts mentioned that this tool would be used for evaluating upcoming similar decision-making problems.

5. Conclusion

This study solves a serious vendor selection problem in industry using the MCDM algorithm because it accommodates traditional and resilience criteria and sub-criteria. The main traditional and resilience sub-criteria were identified in a unified hierarchical framework. The DEMATEL algorithm was used to determine the weight of the traditional and resilience criteria and sub-criteria based on the opinions of four employees who were nominated as a panel to select the best vendor out of the group of 6. The results show that the traditional criterion of cost and the resilience criteria of agility have the highest importance. Next, the performance of each vendor vis-à-vis the defined criteria and sub-criteria with a view to ranking them from 1 to 6 were determined by using the ELECTRE and TOPSIS algorithms and incorporating the weights of the criteria and sub-criteria obtained via DEMATEL. The two algorithms performed well in revealing almost the same ranking for the vendors. Furthermore, the reliability of the two algorithms was validated by applying the Spearman rank correlation coefficient, which revealed a high absolute association between TOPSIS and ELECTRE. However, the evaluation panel preferred to keep the EXCEL sheet that takes TOPSIS implementation for the upcoming evaluation of similar projects. This was a justified decision because TOPSIS does not require difficult changes when solving another similar evaluation problems. Based on the obtained results via ELECTRE and

TOPSIS, it was recommended to let vendor 6 implement the project as its performance was closest to an ideal performance and furthest from the worst performance.
The decision-making tool was made available so that the panel could easily use it to solve upcoming similar vendor selection problems. However, it was recommended to re-evaluate the evaluation of the criteria, since different problems, for instance, may confer greater importance to quality rather than cost. It is worthy to mention that we have delivered the decision-making tool that is based on TOPSIS due to its simplicity for similar evaluation tasks in the future.

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