Framework for collaborative projects: A partners selection case study

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***Abstract*—In this paper data of a European strategic alliance (KAAT project) is used to demonstrate the application of the proposed partner selection framework. This paper is aimed at (1) illustrating the approach for measuring similarity, complementarity, and coverage of knowledge, (2) illustrating the approach for evaluating the partners' history of collaboration, (3) demonstrating the proposed framework using the actual data, and (4) investigating the position of this framework in the forthcoming research as well as in the selection of partners in complex projects in practice.**

***Index Terms*—Project, strategic alliance, partners selection, knowledge**

I. Introduction

When products, processes, and innovative projects become complex, firms struggle to innovate autonomously. Problems often arise because a firm's own internal knowledge and competence are not enough to produce relevant technological discovery or the new knowledge needed to generate novelty [1]. Moreover, collaboration is increasingly seen as a preferable form of performing complex projects involving many partners, suppliers, and customers [2]. Therefore, firms look to partnerships to manage complex innovative projects [3]–[5]. Partnership in projects permits firms to share different types of knowledge as a means of reaching a set of common objectives while at the same time maintaining the independence of each firm [6], [7]. These strategic alliances share knowledge, collaborate in project activities, and make joint decisions to achieve complex project objectives. This strategic alignment allows partners to not only develop innovation potentials through sharing knowledge and resources but also to jointly manage the project risks. For all the benefits that strategic alliances provide for managing complex innovative projects, it is important to note that the failure rate in these collaborations is very high. More than 60% of New Product Development (NPD) alliances fail due to difficulties of communication between partners, hidden objectives, or missing skills [8]. Based on a practical study Doloi [9] addressed the criticality and importance of different aspects in the partners' selection process. Among them, "communications difficulties" between involved partners were reported to be the most influential aspect in the partner selection process. One of the solutions to overcome these difficulties is to increase the mutual trust between partners. In this paper, we propose a method for selecting partners in complex projects in order to a set of partnerships that can increase the trust between partners and the project success [10]. A case study illustrates the applicability of the proposed method within this research work. We present experimental results related to:

- extracting the total knowledge required to achieve project objectives,
- extracting the knowledge that each partner can bring to the project,
- calculate the knowledge criteria (similarity, complementarity, and coverage) of the partnership in the KAAT project,
- calculate the partnership score for the KAAT project partnership,
- demonstrate the application of the proposed framework in the evaluation phase of alliance formation.

II. Methodology

A. Inputs

One of the key inputs for the partner selection framework is the technological complexity of the project. This data helps to decide about the weights of complementarity and coverage of knowledge in the partner selection framework. This is critical because, in simple terms, the framework is based on the logic that the more complex the project, the more important is the coverage of knowledge in the success of the project.

The second input data that is required for the proposed framework is the collaboration history of partners. This data helps to decide about the weight of similarity and complementarity of knowledge in the partner selection framework. As the framework is based on the logic that if partners are familiar with each other before the current project or if they had a past successful collaboration, they have already built some trust and the weight of similarity of knowledge can be lower in partner selection and more weight can be considered for complementarity of knowledge. On the other hand, if the partners are not familiar with each other or they had a

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past unsuccessful collaboration, the weight of similarity of knowledge must be higher to help them build mutual trust in their collaboration.

The third input concerns the project's required knowledge. For this, we need to take an inventory of all the knowledge that is required to accomplish the project objectives.

The fourth input is the potential partner's knowledge. Afterward, we need to find out what is the set of knowledge that each partner possesses and can bring to the project.

B. Knowledge criteria

A firm's knowledge can be classified into three categories [10], [11]: similarity, complementarity, and coverage. Similarity refers to knowledge known by all partners. Complementarity refers to knowledge that is known by only one or other of the firms and compensates for the deficiency of a partner. Coverage refers to the knowledge required to finish the project which is covered by the partnership.

C. Framework design

According to Figure 1, after the data preparation phase, the partner selection consists of five steps. The logic of these partner selection algorithms is also presented in Algorithm 1. The first step is to make all the possible combinations of the partnerships. The second step is to calculate the knowledge criteria named similarity, complementarity, and coverage for all the combinations of partnerships.

Algorithm 1 Algorithm of ranking the set of partnerships based on proposed partner selection framework

Input "Partners knowledge matrix"
Input "Partners history of collaboration matrix"
Input "Project technological complexity degree" ▷ For the KAAT project is "4"

1: **procedure** PARTNER SELECTION ALGORITHM
2: **for** All the partners **do**
3: making all the possible combination of partnership
4: **end for**
5: **for** All the combination of partnership **do**
6: Calculation of knowledge criteria of partnership ▷ Eqn. 1, 2, and 3
7: Calculation of partnership history of collaboration ▷ Eqn. 4
8: Calculation of α, β, and γ ▷ Eqn. 5, 6, and 7
9: Calculation of partnership score ▷ Eqn. 8
10: **end for**
11: Sort the partnerships based on their partnership scores in descending order
12: **end procedure**

Output "Ranking of partnerships"

To calculate the knowledge criteria we have used below equations (Equation 1, Equation 2, and Equation 3). K_{P_N} refers to the set of knowledge of partnership number N.

$$Similarity = K_{P_1} \cap ... \cap K_{P_N} \tag{1}$$

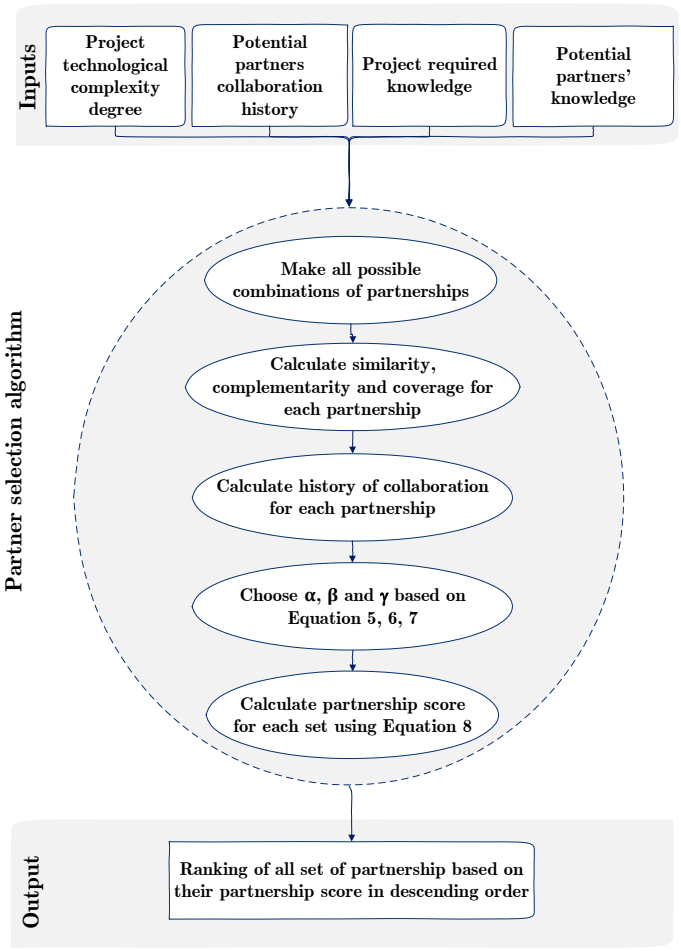

Fig. 1: Inputs, outputs and steps of the partner selection algorithm

$$Complementarity = (K_{P_1} \cup ... \cup K_{P_N}) - (K_{P_1} \cap ... \cap K_{P_N}) \tag{2}$$

$$Coverage = K_{P_1} \cup ... \cup K_{P_N} \tag{3}$$

Then, in the third step, the history of collaboration for all the combinations of partnership needs to be calculated based on the Equation 4. $Sum\ of\ history\ of\ collaboration$ is calculated using the based on the history of collaboration between partners in Table I for each partnership.

$$Partnership\ history\ of\ collaboration = \frac{Sum\ of\ history\ of\ collaboration}{Number\ of\ partners\ in\ the\ partnership} \tag{4}$$

The next step is to choose weights for knowledge criteria (α, β, and γ) based on the technological complexity of the project and the history of collaboration of each set of partnership.

TABLE I: Partners' history of collaboration

Partners		Country	was familiar with collaboration with	had a past successful collaboration with
P1	Politehnica University of Bucharest	Romania	P2, P3, P4, P5, P8, P9, P11, P13, P16, P17	-
P2	University of Zagreb	Croatia	P1, P10, P14, P15	-
P3	Instituto Superior Tecnico, University of Portugal	Portugal	P1, P6, P7	-
P4	Transport and Telecommunication Institute (TSI)	Latvia	P1	-
P5	University of Strasbourg	France	P1, P16	P16
P6	INOVAMAIS	Portugal	P3	-
P7	Quasar Human Capital	Portugal	P3	-
P8	Deep Blue	Italy	P1	-
P9	University of Žilina	Slovakia	P1	-
P10	Aeronautical Technical Centre	Croatia	P2	-
P11	Menzies Aviation	Romania	P1	-
P12	Aigle Azur	France	P16	-
P13	Avram Iancu International Airport	Romania	P1	-
P14	Croatia Control Ltd	Croatia	P2	-
P15	Croatia Airlines	Croatia	P2	-
P16	IMT Mines Albi	France	P1, P5, P12	P5
P17	Civil Aviation Safety Investigation and Analysis Center	Romania	P1	-

We recommend decision-makers to use the proposed framework to choose weights for knowledge criteria. The proposed framework is based on four assumptions (these assumptions are also shown in Figure 2): (1) If the project is technologically simple and partners knew each other (or their past projects were successful), then complementarity of knowledge is more important (see point A in Figure 2), (2) If the project is technologically simple but it is the first collaboration of partners (or past projects were unsuccessful), then relative to coverage, similarity and complementarity have more weight in partner selection (see point B in Figure 2), (3) If the project is technologically challenging and partners knew each other (or their past projects were successful), then complementarity and coverage are more important (see point C in Figure 2), (4) If the project is technologically challenging and it is the first collaboration between partners (or past projects were unsuccessful), then and similarity, complementarity, and coverage are all important in partner selection (see point D in Figure 2).

In this paper, to satisfy above assumption in partner selection algorithm, we have used Equation 5, Equation 6, and Equation 7 to calculate α, β, and γ for each partnership. These equations are written as a creative method to guarantee that α increases along the axis "Partners' history of collaboration", and γ increases along the axis "Technological complexity degree of the project" (see Figure 2). There might be other equations to calculate α, β, and γ, the most important constraint is to meet the requirements that are indicated in Figure 2.

$$\alpha = \frac{Partnership\ history\ of\ collaboration}{6} \tag{5}$$

$$\gamma = \frac{Project\ technological\ complexity\ degree}{30} \tag{6}$$

$$\beta = 1 - \alpha - \gamma \tag{7}$$

Finally, the last step is to calculate the partnership score for all the sets of partnerships using Equation 8.

$$Partnership\ score = \alpha \times Similarity + \beta \times Complementarity + \gamma \times Coverage \tag{8}$$

Finally, the last step is to calculate the partnership score for all the sets of partnerships using Equation 8.

The output of this partner selection algorithm (Table II) is a ranking of all possible combinations of partnerships based on their partnership scores.

This algorithm is coded in MATLAB software version R2016b.

III. Case study

Knowledge Alliance in Air Transport (KAAT) is a project that is funded by Erasmus+. The main objective of the KAAT project is to fill the educational need that is identified in the aeronautics field. The need that is recognized by the project is to ensure the link between the two aforementioned pathways, since in many situations the lack of schemes for the identification of prior learning and/or gained experience makes the transition from academia to vocational occupations difficult. In many cases, graduates require to participate in new training with an important retake of learning outcomes in order to be ready for their duties in vocational occupations.

The project built up European study programs by application of innovative approaches for teaching and learning based on Information Communication Technology (ICT) tools using the co-creation knowledge of 17 partners from education and business of 7 countries: Croatia, France, Italy, Latvia, Portugal, Romania, and Slovakia. These 17 partners include 7 universities, 3 training providers, and 7 aviation companies (list of partners is available in Table I). This project pursues three main goals: to develop a new viewpoint towards (1) university-business cooperation in aviation, (2) university

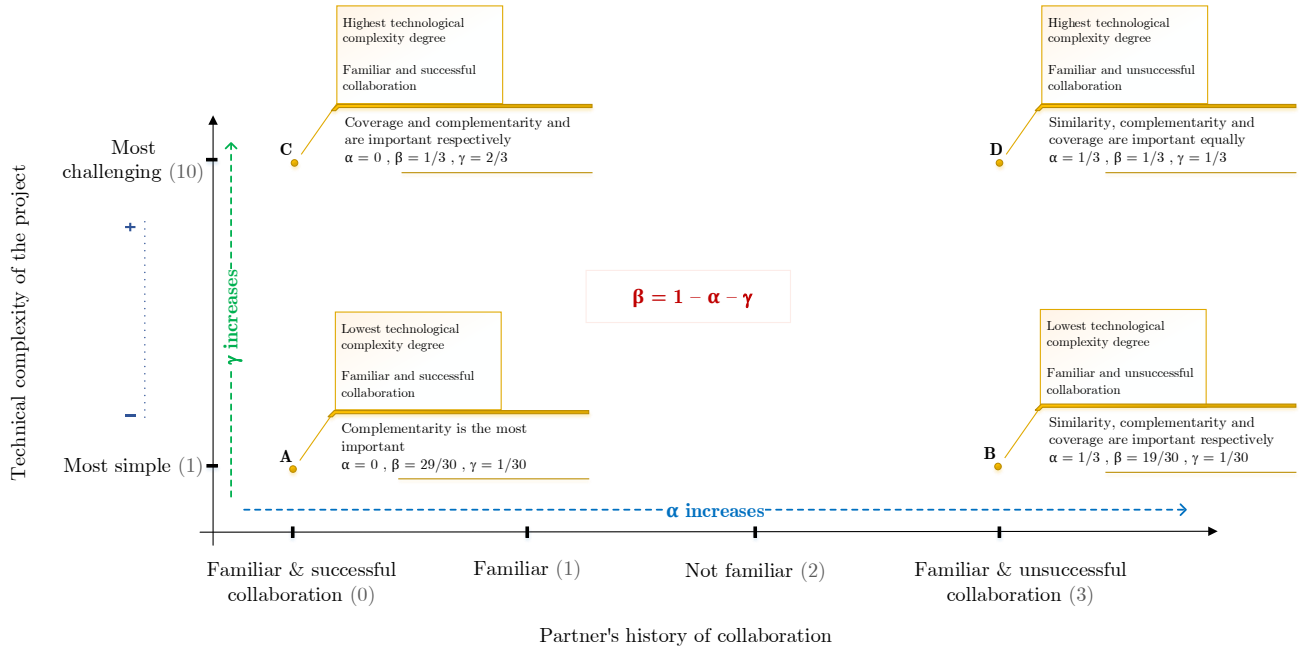

Fig. 2: Plot of partnership scores for all the possible partnerships

study programs, and (3) anticipating the future demand of the aviation labor market in terms of skills and competencies.

A. KAAT project inputs

For evaluating the technological complexity degree of the KAAT project, we asked two expert project managers involved in the KAAT project to rank this project in terms of complexity degree on a 10 points Likert scale. Given the number of resources or domains involved in the project, variety of resources and technological skills needed, inter-dependency between the components of the project or technological process, and demand for creativity and scope of development. The average ranking of the experts' opinions was to consider the degree of complexity of this project as 4 out of 10.

In this study, we can consider four different degrees of history of collaboration: (1) partners are familiar with each other and had a successful collaboration = 0, (2) partners are familiar with each other = 1, (3) partners are not familiar with each other = 2, and (4) partners are familiar with each other but had an unsuccessful collaboration in the past = 3 (based on the information in Table I). Accordingly, based on this information, a partners' history of collaboration matrix can be generated and used as the input of the partner selection algorithm in the following section.

Based on KAAT project objectives and other complementarity information that we could find in the description of the project we have classified the required knowledge of this project as follows:

- Soft skills: leadership, coordination, teamwork, relational/technical problem solving, etc.
- Hard skills: teaching, research, financial reporting, project management, etc.
- Resources: having different networks such as industrial networks, academic networks, political networks, etc.
- Services: based on the educational nature of KAAT project in the aviation industry, there was a need of having partners who give services in different aviation sectors such as handling, maintenance, flight, etc.
- Organizational culture: being multi-cultural, open-minded, aware of innovation, having internal/external communication ability, etc.
- Language: in KAAT project we have considered 7 languages. English as a common necessary language for having effective communication in the KAAT project, and also a category called multi-language for the partners who are able to communicate with more than two of the mentioned languages.

The above classification can be modified and used based on various aspects of other projects. Afterward, we need to find out what is the set of knowledge that each partner possesses and can bring to the project. This information is helpful in calculating the amount of similarity, complementarity, and coverage of knowledge of the partnership. To do so, we studied the presentation of each partner in the description file of the KAAT project as well as the website of each partner. For the sake of brevity, the result of this study on the knowledge in possession of each partner is not detailed in this paper.

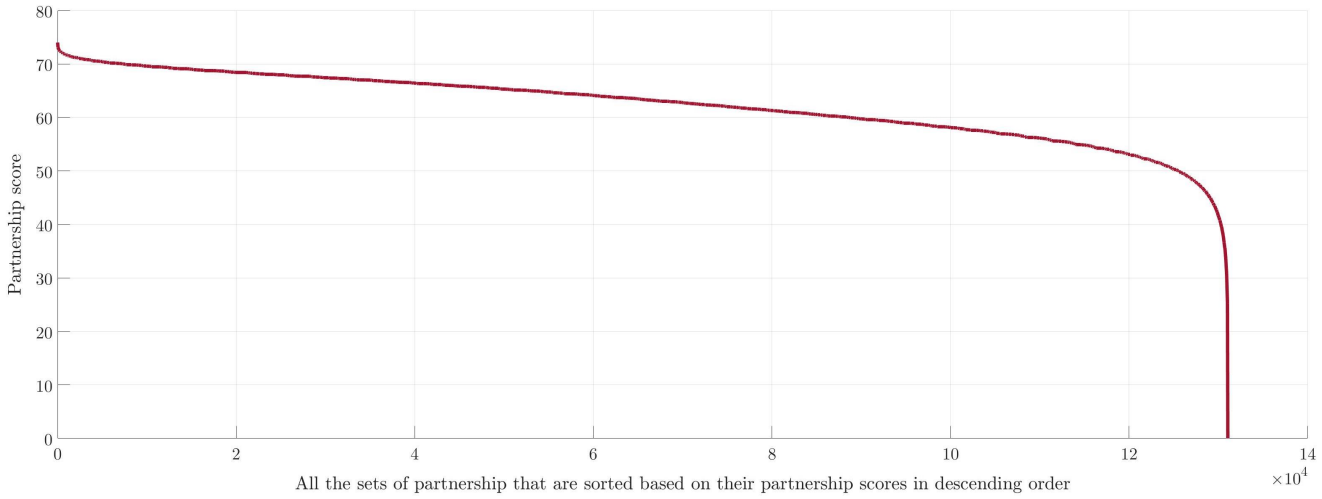

Fig. 3: Plot of partnership scores for all the possible partnerships

IV. Results

The algorithm sorts all the sets of partnerships based on their partnership scores in descending order. In this subsection, we discuss the results in two steps, first the actual state of the KAAT project, second, assuming that we are choosing partners among 17 potential partners to participate in the KAAT project.

A. Evaluating the KAAT projects actual partnership score

Since the KAAT project is not in the partner selection phase, all the partners that we have in this chapter, have been chosen to participate in this project. As we have the actual state of the KAAT project, we know that shortly after the start of the project, Partner 12 refused to continue participating in the project, and the project proceeded with 16 partners. Hence, we calculated the partnership score of partnership for two different scenarios:

- Scenario 1 (initial situation): all the 17 partners are involved in the KAAT project.
- Scenario 2 (actual situation): 16 partners are involved in the KAAT project (all the partners except the partner 12 (who quit the project)).

Table II shows the result of calculation of partnership score, similarity weight (α)complementarity weight (β), and coverage weight (γ) for the two scenarios.

Table III – The partnership score, and the weight of similarity, complementarity and coverage of the actual state of the KAAT project

This result shows that the partnership score for conducting the KAAT project with all the partners except partner 12 is higher than conducting it with all 17 partners. Looking at the knowledge weights (α, β, γ) gives us the reasons behind these findings. The weight of similarity in knowledge is higher and the weight of complementarity is lower in the first scenario. Moreover, we know that partner 12 only has familiarity with one other partner (see Table I). Hence, the algorithm calculated the weight of similarity higher in the first scenario to compensate for the lack of familiarity between partners. However, the results show that the amount of knowledge that partner 12 could bring to the project was almost accessible with other partners.

B. Assuming that we are choosing partners among 17 potential partners for the KAAT project

In this scenario, we ask the algorithm to plot the ranking of all the possible partnerships based on their partnership scores in descending order and also to print the 10 partnerships with the highest partnership score with details. The result of this calculation is shown in Figure 3 and Table III.

Moreover, the result in Table III shows that based on the proposed algorithm the best set of partners is P1, P2, P3, P4, P5, P6, P7, P8, P9, -, P11, -, P13, -, -, P16, P17.

V. Conclusion and perspectives

The proposed framework could serve as a tool for a decision-maker in the partner selection phase of an alliance formation. Although there are several determinant factors in selecting the partner in a complex project which is not considered in the proposed framework, it provides a credible vision of the ranking of different sets of partnerships. In case that the input data for the algorithm written based on the proposed framework is correctly extracted, the results of this algorithm can provide an efficient illustration of the partnerships that provide the required knowledge of the project and at the same time, its partners have the basis for building mutual trust. Moreover, the framework is also practical when some of the partners are chosen but there is hesitation among other potential partners to ally.

In this paper, data of a European strategic alliance (KAAT) is used to demonstrate the application of the proposed partner

TABLE II: The partnership score, and the weight of similarity, complementarity and coverage of the actual state of the KAAT project

Set of partners	partnership score	$alpha(\alpha)$	$beta(\beta)$	$gamma(\gamma)$
All the partners (P1, P2, ..., P17)	73.2054	0.3113	0.5554	0.1333
All the partners without P12	73.3653	0.3097	0.5569	0.1333

TABLE III: The result of algorithm for the 10 last set of partnership with highest partnership score

Rank	Set of partners	partnership score	$alpha(\alpha)$	$beta(\beta)$	$gamma(\gamma)$
1	(P1, P2, P3, P4, P5, P6, P7, P8, P9, -, P11, -, P13, -, -, P16, P17)	74.0145	0.3034	0.5632	0.1333
2	(P1, P2, -, P4, P5, P6, P7, P8, P9, -, P11, -, P13, -, -, P16, P17)	73.7944	0.3056	0.5611	0.1333
3	(P1, P2, P3, P4, P5, P6, P7, P8, P9, -, P11, -, P13, -, P15, P16, P17)	73.7630	0.3059	0.5608	0.1333
4	(P1, P2, P3, P4, P5, P6, P7, P8, P9, -, P11, -, P13, P14, -, P16, P17)	73.7630	0.3059	0.5608	0.1333
5	(P1, P2, P3, P4, P5, P6, P7, P8, P9, -, P11, P12, P13, -, -, P16, P17)	73.7630	0.3059	0.5608	0.1333
6	(P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, -, P13, -, -, P16, P17)	73.7630	0.3059	0.5608	0.1333
7	(P1, P2, -, P4, P5, -, P7, P8, P9, -, P11, -, P13, -, -, P16, P17)	73.6667	0.3000	0.5667	0.1333
8	(P1, P2, P3, P4, P5, -, P7, P8, P9, -, P11, -, P13, -, -, P16, P17)	73.6152	0.3005	0.5662	0.1333
9	(P1, P2, -, P4, P5, P6, P7, P8, P9, -, P11, -, P13, -, P15, P16, P17)	73.5744	0.3077	0.5590	0.1333
10	(P1, P2, -, P4, P5, P6, P7, P8, P9, -, P11, -, P13, P14, -, P16, P17)	73.5744	0.3077	0.5590	0.1333

selection framework. This chapter is aimed at (1) illustrating the approach for measuring similarity, complementarity, and coverage of knowledge, (2) illustrating the approach for evaluating the partners' history of collaboration, (3) demonstrating the proposed framework using the actual data, and (4) investigating the position of this framework in the forthcoming research as well as in the selection of partners in complex projects in practice. This partner selection framework can be a beneficial tool for decision-makers in the strategic alliance formation phase to choose partners who can build mutual trust and collaborate well to finish the project successfully.

To do so, firstly, the theoretical aspects has been introduced in terms of a summary of the main features and output of the project, aims and objectives, and a brief description of the partners involved. Secondly, the steps of performing the framework on the project data are clarified. Thirdly, all the required input data is represented as well as the steps to extract them from the project information. The required inputs are the project complexity degree, partners' history of collaboration, project required knowledge, and the knowledge that each partner has to bring to the project. Then, the steps of the partner selection algorithm are discussed and applied to KAAT project in the case study section. In addition, programming the algorithm in MATLAB software is illustrated. Afterward, the results of the partner selection algorithm are discussed as well as its limitations and shortcomings.

The outcomes of this paper highlight the potential of future research. This research strongly encourages scholars to study the following suggestions: first, in order to examine the effectiveness of the proposed framework, we recommend calculating the partnership score for several finished projects and comparing their partnership score with their success level. This comparison gives an overall view of how efficient the proposed framework is. Second, we suggest comparing the result of other partner selection approach with this framework. Third, we assume the proposed framework of this research work provides the basis for designing a more comprehensive partner selection approach by supplementing complementarity constraints such as communications, branding, networking, and partner financial situation and etc, so we recommend that researchers use this research work as one of the possible potential start points for their contributions.

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