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Research Article

Prioritizing Multi-Interwoven Factors in the Project Management Office Using Delphi and Fuzzy DEMATEL

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This study aims to evaluate the cause-and-effect relationships of potential PMO functions at project-oriented organizations. In this research, the Delphi technique was first employed to identify the potential PMO functions, and DEMATEL technique was conducted to evaluate the cause-and-effect relationships. According to the research findings, structure determination and project organization were the most effective PMO functions, whereas counseling and training through PMO was identified as the most important function. Moreover, participation in project implementation through PMO was the most affected function. To improve the PMO performance, project-oriented organizations can focus on effective functions and causes in order to modify and improve them.

1. Introduction

Improving systems and processes can be considered a reliable strategy for empowering organizations and enhancing their competitiveness. Naturally, project-oriented organizations should select project systems and processes. Most of the project-oriented organizations implement and execute project management systems when necessities arise. Therefore, the usefulness and effectiveness of these systems would require belief in necessity, and senior managers of such organizations should have notional but not compulsory attitudes [1]. The use of project management knowledge is now considered a success factor in project-oriented organizations. In fact, project management plays a key role in the effectiveness of projects. This knowledge provides solutions to the optimal allocation of resources in addition to designing and implementing the necessary management processes for the effective management of projects. A quick look at the numbers and volumes of investments in the current programs of countries would help understand the priority and importance of this strategic topic [2]. Nevertheless, there are no correlations between this strategic goal and the analysis of knowledge and competence for scientific management of projects in countries. Failure, numerous delays, and incompletion of infrastructural projects are among the most important results of failing to establish the scientific principles of project management in the programs and projects of different countries [3]. It is now possible to execute, run, and exploit projects worldwide only by learning and using project management techniques. According to the existing conditions, it is not sufficient to rely on the conventional management method for the optimal execution of programs and projects [4]. Many project managers have focused on the limitation of resources, allocation of resources, and costs of projects [5]. Therefore, projects employ appropriate solutions in order to ensure that resources are used effectively and efficiently in projects. In fact, despite the presence of a department called project planning and control in many organizations, most projects face failure or substantial deviations in time and expenditure, something which is caused by the lack of accurate perception of position and institutionalization of project management in organizations. The lengthy project execution, evident quality decline of projects, and much higher costs of projects than the initial estimates can be considered a few instances in the chain of important problems with projects in different countries [6].

Projects must be altered to include crucial components such as constructability assessment, ongoing work on skills training, and a variety of other tasks. These are accomplished by adhering to a strict commitment to the project improvement process. The findings are critical for increasing process quality throughout the design phase of projects [7].

Generally, it can be stated that not only has the number of projects been on the rise in today's world but also the complexities of projects and the resultant effects of project performance on the final outputs of organizations are increasing on a daily basis. Thus, organizations must look for certain solutions to quicker, less expensive, and better implementation of projects [8]. In this regard, organizations encounter new problems: the conflicts of projects with regard to the priority and preference of using resources, weakness in documentation and sharing of the learned lessons, lack of coordination and communication between projects, inappropriate and different methodologies for project management, lack of alignment between project goals and organizational policies or strategies, parallel processes and duplication of efforts in projects, increased complexity in organizations due to the variety of projects, parallel departments in organizations, and declined agility of organizational structures, difficulty in the integrated management of projects, and many difficulties in striking a balance between current projects and new projects [6]. In such circumstances, it is essential to establish a department that is responsible for project management knowledge in order to institutionalize and help improve project management in organizations. Called the project management office (PMO), this department shoulders the responsibility for the centralized and coordinated management of projects. In fact, a PMO can perform a wide variety of activities such as improving processes and functions of project management in an organization in addition to supporting managers and project management teams [9]. In fact, a PMO can be designed and established to centralize and integrate the project management process of an organization. It can be stated that project-oriented organizations now suffer from the diversity of policies, standards, and procedures in their projects; hence, establishing a PMO can minimize this confusion and develop integrated standards, policies, and procedures in all projects of an organization [10]. Furthermore, project management offices have managed to gain interest of many organizations by achieving considerable results. In addition to scheduling projects and monitoring their progress, these offices are known as a major organizational pillar guaranteeing organizational success in the future. If a PMO is established along with the other organizational departments, it will be possible to ensure the project performance improvement in different areas such as boundaries, quality, duration, and customer satisfaction [11]. These offices try to guarantee organizational interests in terms of both quantitative and qualitative criteria by encouraging projects to use compatible and efficient processes, procedures, and tools [12]. Moreover, a PMO is responsible for providing the necessary infrastructure including tools and specialties required for the effective management of projects. For this purpose, it is necessary to design and employ certain approaches and methods called the "best performance." In other words, inspired by the learned lessons and standardized organizational methodologies, PMOs in project-oriented organizations develop the necessary tools and techniques. These functions are known as the general PMO functions [13]. In an organization, the PMO functions depend on the maturity level of project management and the maturity level of project management office as well as the type of the designated conceptual model [14]. This study aims to evaluate the cause-and-effect relationships of potential PMO functions at project-oriented organizations. In this research, the Delphi technique was first employed to identify the potential PMO functions, and the DEMATEL technique was conducted to evaluate the cause-and-effect relationships. Our study is structured as follows: we have reviewed some studies published in recent year about our study. In the Methodology section, we present our proposed method. After analyzing the proposed method on the used dataset, we have discussed the significance of our study in the Conclusion section, and we have made some suggestions for future research.

2. Literature Review

According to Bredillet et al. [1], the PMO maturity level is a function of the project management maturity level in an organization. They believed that a PMO would consist of five evolution steps called project control, process control, process development and support, business affairs, and strategies. They also stated that the organizational project management maturity levels would include an initial level, a repeatable level, a defined level, a managed level, and an optimization level [15]. Chen et al. [16] examined the relationship between risk awareness and the development of digital economics. According to the experimental results, the categorization risk level ratio is 18.9%, and the classification error rate of the model is checked. According to Huang et al. [17], achievement objectives, community identification, and online collaborative reflection are interrelated. Their analysis of your work was based on deep learning and Bayesian approaches. The results indicate that the recommended approach is more accurate than the alternative. Chen et al. [18] studied a new model based on a Markov chain position prediction model that uses multidimensional corrections. Haddadian Nekah et al. [19] used genetic algorithm evidence from Iran's khodro vehicle sector to establish the ideal point of purchase intention. The report is often cited by activists working in the automobile sector. Ahmadi [20] investigated how knowledge-based indicators affect economic development and categorised and prioritized them using logarithmic fuzzy preference programming. Meng et al. [21] conducted an analysis on H optimal performance design of an unstable plant with Bode integral constraints. Meng et al. [22] performed a study on nonlinear H^* controls for satellite maneuvers utilizing the sum of squares method. Based on this theory, the PMO maturity levels are functions of the organizational project management maturity levels. In fact, it is first necessary to determine the organizational project management maturity level when a PMO is designed in an

organization. The results of analyses indicate that organizations with PMOs have significantly more mature management capabilities than the organizations without any PMOs [35]. In fact, improving the PMO maturity can enhance the organizational project management maturity level and provide organizations with competitive advantages. Hence, organizations are very interested in improving their PMO maturity levels (Annual Report by [36]). Zheng et al. [25] investigated an improved multi-scale relational network-based image categorization system. The experimental findings demonstrate that when a multi-scale meta-relational network is used, the learnt measurement has a greater capacity for generalization than when another approach is used. Ma et al. [26] investigated the joint embedding of a VQA model using a dynamic word vector. The experimental findings indicate that the N-KBSN created in our study outperforms the alternative technique. Zheng et al. [27] examined the construction of a module for knowledge base graph embedding for the visual question answering model. Taghizadeh et al. [28] categorized a long-run relationship and convergence among a diversity of knowledge variations in the framework of the knowledge-based economy (KBE) in Iran. Liang et al. [29] offer an agent-based model (ABM) for modeling the influence of policy initiatives on inhabitants' decision-making about green space usage. The PMO participation role in managing organizational projects in terms of support, control, and management will determine the type of the PMO conceptual model [6]. Many organizations face the problems of defining the PMO role in their long-term success and determining how to employ the PMO to achieve the strategic goals [30] (Table 1).

Therefore, different conceptual models have been proposed. They can be classified as two general categories, i.e., the conceptual models based on evolution levels and the conceptual models based on organizational roles and position. The following four models were proposed as the conceptual models based on evolution levels. The first three models were proposed by Gartner's consultants, whereas the fourth model was proposed by Kendall and Rollins [31]:

(1) The reservoir model

(2) The reservoir-trainer model

(3) The reservoir-trainer-manager model

(4) The value-added model

It should be mentioned that the fourth model has a highly strategic approach and emphasizes the rapid value-added creation for an organization [31]. Other conceptual PMO models are based on the role and the position considered for a PMO in an organization. This category includes the hierarchical model, managerial support model, and project program portfolio office model. The following table demonstrates differences of the well-known PMO models [32] (Table 2).

In addition to affecting the general performance of an organization, the potential functions of a PMO have cause-and-effect relationships due to the process nature of a project-oriented organization. In other words, the strength or weakness of a function in organizational project management can affect other functions and strengthen or weaken them. As a result, the analysis of cause-and-effect relationships of these functions can include useful information for the better identification of functions. Therefore, the managers of project-oriented organizations can better control these functions and improve the PMO performance by identifying their relationships.

Every project owner's primary responsibility is to complete the project within the parameters established. Much of the time, when the project team has completed the first project plan, it is discovered that there is a need for increased efficiency. The failure to evaluate project risks will diminish the effectiveness of the project in the future. According to the law of diminishing returns, increasing resources after a certain point, known as the saturation point, does not result in a decrease in time and may potentially have negative consequences. Establishing the saturation threshold for each function eliminates excessive resource allocation, which can lead to decreased productivity [33]. Many studies of PMO have neglected the importance and cause-and-effect relationships of potential PMO functions, something which indicates a research gap. Therefore, this study aimed to conduct a systematic review of 60 scientific studies through the Delphi technique, the opinions of 18 scientific industrial experts operating in project management, and a researcher-made questionnaire in order to identify the potential PMO functions. The fuzzy DEMATEL technique was then employed to analyze the importance of these functions and their mutual relationships [34].

Because the globe is confronting a multitude of uncertainties, businesses should be prepared for the unforeseen to occur. Businesses should have traits such as adaptability, proactivity, tenacity, and coping abilities in this respect. As a result, project-based companies must include the resilience notion into their plans. Business resilience is described as an organization's capacity to forecast and adapt to unexpected risks and occurrences in order to keep the business running smoothly [35]. Certainly, the resilience idea may help firms become more resilient to external forces and difficult situations. Organizations must adjust their plans and tactics in response to changes in the environment and the marketplace; otherwise, they risk being eliminated from the survival cycle. They should choose tasks that are currently in line with their goals [36].

3. Methodology

This is a scientific applied causal-descriptive study. According to the research literature and the systematic review of different books and studies, 27 general PMO functions were identified (Table 3).

The Delphi technique was then adopted to identify different Delphi steps and potential PMO functions with the help of 18 expert decision-makers having professional project management degrees. Furthermore, a researcher-made DEMATEL-based questionnaire was utilized for data collection. In fact, this questionnaire was designed through the DEMATEL technique based on pairwise comparisons by extracting 12 potential functions through the Delphi

Table 1: The effects of PMO maturity levels on a project management (based on research findings).

PMO maturity levels	Effects on the PMO status	Organizational project management maturity levels
Level 1—project control	The PMO is involved in temporary processes at this level.	Level 1—the initial level
Level 2—process control	The PMO fixation	Level 2—the repeatable level
Level 3—process development and support	The PMO growth	Level 3—the defined level
Level 4—business affairs	The PMO maturity	Level 4—the managed level
Level 5—strategy	The PMO institutionalization	Level 5—the optimization level

Table 2: Differences of the well-known PMO models [32].

Name of the model		Main functions
Reservoir model		Participation in management and implementation of projects/development of project management methodology
Reservoir-trainer model		Participation in management and implementation of projects/development of project management methodology/project support/consultation and training
Reservoir-trainer-manager model (EPMO)		Development of project management methodology/portfolio management/management of relationships with customers and suppliers/project knowledge management/project governance/determination of organizations and structures of projects/resource management
Hierarchical model	At the project level	Participation in the management and implementation of projects/project support
	At the department level	Participation in the management and implementation of projects/project support/project planning and auditing/portfolio management
	At the organization level (SPMO)	Consultation and training/portfolio management/resource management
Management and support model	Management	Consultation and training/project governance/resource management
	Support	Participation in the management and implementation of projects/development of project management methodology/consultation and training
Model of project, program, and portfolio offices		All functions

EPMO, enterprise project management office; SPMO, strategic project management office.

Table 3: General PMO functions identified through the opinions of different researchers.

No.	Function	Reference
1	Preparing the project charter	De Nadae and De Carvalho [37]; Viglioni et al. [38]
2	Facilitating the management of initial meetings	Xiaoyi Dai and Wells [39]; Sandhu et al. [40]
3	Management project risks	Oliveira et al. [41]; Gonzalez et al. [42]
4	Participating in forming the project control office	Raharjo et al. [4]; Ozguler and Yilmaz [43]
5	Participating in managing project changes	Bredillet et al. [44]; Parchami and Koosha [13]
6	Supporting the establishment of a project library	Lavoie et al. [45]; Szalay et al. [46]
7	Improving the precision and accuracy of work hour registration cards	Ozdemir and Gozlu [47]; Julian [48]
8	Participating in project revision meetings	Duarte et al. [6]; Pemsel and Wiewior [49]
9	Participating in managing project problems	Lacruz and Cunha [50]; Monteiro et al. [32]
10	Participating in project completion	Moura and Cunha [12]; Desouza and Evaristo [51]
11	Project planning	Aubry et al. [52]; Petrovich et al. [53]
12	Project recovery	Abdi and Kaddoura [54]; Arbabi et al. [14]
13	Standardization of reports	Wedekind and Philbin [55]; Amer and Elayoty [56]
14	Preparing patterns	Hamad and Fayoumi [57]; Karayaz and Gungor [5]
15	Supporting the project management tools	Liu and Yetton [58]; Kutsch et al. [59]
16	Determining standards and criteria	Linde and Steyn [8]; Barbalho et al. [60]
17	Determining an excellence level for the portfolio management system	Fernandes et al. [9]; Barbalho et al. [10]
18	Determining the roles in portfolio management	Artto et al. [61]; Hobbs et al. [62]
19	Determining the combination of project portfolios	Richer et al. [2]; Widforss and Rosqvist [11]
20	Optimizing the project portfolios	Paton and Andrew [63]
21	Managing the relationships with customers and suppliers	Misner [64]
22	Managing the knowledge of projects	Silvius [3]
23	Governing the projects	Fernandes et al. [65]
24	Determining the organizations and structures of projects	Unger et al. [66]
25	Managing the resources	Bredillet et al. [1]
26	Planning and auditing the projects	Bredillet et al. [1]
27	Consultation and training	Bredillet et al. [1]

technique (Table 4). Table 5 provides the final list of potential PMO functions.

The face validity of the questionnaire was determined, whereas its reliability was calculated 0.81 through the test-retest method, which indicated the acceptability of the researcher-made questionnaire in terms of reliability. This study was based in Mapna Construction Headquarters. Since it was necessary to use the experts' opinions to identify the potential PMO functions and their cause-and-effect relationships, the statistical population included the project managers of Mapna Construction Headquarters, from whom 18 individuals were selected through the judgmental sampling method (based on the inclusion criteria, availability, and mastery of the research topic). They were then provided with the pairwise comparison DEMATEL questionnaire.

The fuzzy DEMATEL technique was then employed for data analysis in this study. The decision-making trial and evaluation laboratory (DEMATEL) technique is a structural modeling method adopted to create causal relationships between variables generated by decision-makers (e.g., PMO functions in this case) [67]. Using the premium variables as inputs, the DEMATEL technique helps evaluate their importance and their cause-and-effect relationships by analyzing their direct and indirect relationships and developing a relational model [68]. Due to the importance of this technique, many contemporary studies have used it for analysis in decision-making and planning. For instance, the DEMATEL technique was developed in combination with the fuzzy sorted weight mean to enhance the analysis of risk evaluation [69]. Likewise, given the mutual complicated relationships between the vital success factors in the execution of green supply chain management, the DEMATEL technique was used as a model for exploration in the basic structures of such mutual relationships [70]. In addition, a novel hybrid MCMD model was developed through factor analysis and DEMATEL techniques to evaluate the interwoven effects of electronic learning programs [71]. If decision-makers perceive the system or problem of interest correctly, the DEMATEL technique can be used efficiently in determining structural relationships underlying the system or the problem. Nevertheless, due to the inaccuracy and intrinsic uncertainty of decision-making processes, many researchers have included the fuzzy set theory in the DEMATEL technique. In fact, the fuzzy set theory is a mathematical theory proposed independently by Zadeh [72]. Adopting a verbal scale that enables decision-makers to express their perception of a system or a problem in their natural language, the fuzzy set theory benefits from the inaccuracy and ambiguity of decision-making. Approved by Chang et al. [69] for the first time, the fuzzy DEMATEL (F-DEMATEL) brought about different applications such as the reduction of ambiguity and vagueness in the decision-making process [73]. The fuzzy DEMATEL technique is executed in the following steps:

Step 1. Determining the decision-making goal and creating a group of experts acquainted with the problem for making decisions

Step 2. Determining the criteria (functions) and designing the fuzzy verbal scale: in this step, it is necessary to create a set of necessary criteria for evaluation. After that, the fuzzy verbal scale should be determined to evaluate the direct effect of each factor on the other factors. Due to the ambiguities in expert evaluations of verbal variables, fuzzy sets were employed in this study. In fact, the fuzzy logic can greatly solve the problem of ambiguity in verbal variables. The use of certain and nonfuzzy methods can be criticized for two reasons when verbal variables are dealt with. First, these methods disregard the vagueness of people's judgments and changes in their values when they are converted into numbers. Second, the mental judgments, selections, and priorities of evaluators have great effects on the results of these methods. Therefore, the fuzzy triangular numbers were used in this study (Table 6). A fuzzy triangular number is defined as $\widetilde{n} = (l \cdot m \cdot u)$.

Using the verbal scale presented in Table 6, decision-makers can easily express their judgments in the natural language.

$$\widehat{Z}_K = \left(\widehat{Z}_{ijk}\right)_{n\times n} = \left(l_{ijk} \cdot m_{ijk} \cdot u_{ijk}\right)_{n\times n}, \tag{1}$$

where $\widehat{Z}_{ijk}$ pertains to ranking the k^{th} decision-maker when you are asked about the impact of function i on function j.

Step 3. Collecting the evaluations of decision-makers and creating the direct relation matrix: to evaluate the relationships between criteria $c = \{c_i | i = 1, 2, \ldots, n\}$, a decision-making group of K experts (i.e., the statistical population) will be asked in order to obtain a set of pairwise comparisons based on verbal expressions. Hence, K fuzzy matrices are created by using each expert's opinions. In fact, the K matrices of expert opinions are the matrices of each expert's fuzzy direct relationships. After that, equation (2) is employed to determine the mean of opinions and create the fuzzy direct relationship matrix $\widetilde{Z}$ resulting from matrices $\widetilde{Z_1}, \widetilde{Z_2}, \widetilde{Z_3}, \ldots, \widetilde{Z_k}$.

$$\widetilde{Z} = \left(\widehat{Z}_{ij}\right)_{n\times n} = \left(\frac{\widehat{Z}ij1 + \widehat{Z}ij2 + \widehat{Z}ijK}{K}\right)_{n\times n}. \tag{2}$$

Step 4. Descaling the fuzzy direct relationship matrix: the linear scale transform is used as a descaling relationship to descale and convert criteria into comparable scales. The scaled (normal) fuzzy direct relationship matrix is shown as $\widetilde{x}$ and calculated through the following equation:

$$\widetilde{x}_{ij} = \left(\frac{\widehat{Z}_{ij}}{r} = \frac{l_{ij}}{r} \cdot \frac{m_{ij}}{r} \cdot \frac{u_{ij}}{r}\right),$$
$$r = \max_{1\le i\le n}\left(\sum_{j=1}^{n} u_{ij}\right). \tag{3}$$

Step 5. To continue the analysis, it is necessary to separate the lower, middle, and upper boundaries of the fuzzy triangular matrix $\widetilde{x}_{ij}$, so that appropriate matrix operations can be used:

Table 4: Minimum qualifications required for selecting scientific industrial experts as decision-makers.

Governmental experience	Academic experience	Industrial experience
Having at least 5 years of experience in managing governmental projects	Having at least 5 years of experience in project management training	Having 5 years of industrial work experience
Having a high managerial position	Having at least a master's degree in a management or engineering major	Being a graduate of a management or engineering major
Complete mastery of project management topics	Having reputable scientific papers in project management	Having a high managerial position
Being a graduate of a management or engineering major	Having at least one international invention	Mastery of project management knowledge

Table 5: The final list of potential PMO functions.

#	Function	Definition
A	Participation in project implementation	The PMO can identify areas of cooperation in each of the organizational projects requiring help or accepting participation and cooperation, especially in the initial stages of its formation, to fixate its position and prove its usefulness. These areas include preparing the project charter, managing the initial project meetings, participating in project risk management, participating in project change management, and participating in project completion.
B	Project support	This function includes the executive support services that a PMO can provide a project manager and a project team without direct participation in the project. This support can include project planning, project recovery, and standardization of report formats.
C	Development of project management methodology	By definition, methodology means a set of methods, procedures, and regulations that can be used by the individuals working in a specific area. To implement the goals of these standards, the PMO should design certain methodologies for achieving its goals by employing project management standards.
D	Consultation and training	Consultation and training are performed when the project team has appropriate members who lack the necessary competence and qualification for undertaking their tasks. Therefore, the PMO employs one or several well-trained experts for cooperation with the project team members who have some disqualifications.
E	Project planning and auditing	Generally, auditing is a process including certain activities such as observation, identification, evaluation, and detection in which the quality, efficiency, and output values of projects are to be based on the predefined standards and goals. For this purpose, the PMO should provide projects with the auditing capability, guide project auditing, and manage the results of project auditing.
F	Portfolio management	This function empowers the PMO to resolve bottlenecks and concerns of senior managers and project managers in an organization. For this purpose, the PMO can establish the portfolio management, integrate projects in a portfolio, and manage project fractions and interferences.
G	Management of relationships with customers and suppliers	The PMO can manage customer relationships, manage customer contracts, and manage customer satisfaction by identifying the ways of communicating with customers in the project management environment and providing instructions for the business aspects of projects. At the same time, the PMO can create value-added for the organization by identifying and determining the qualifications of suppliers and managing their contracts.
H	Project knowledge management	In project-oriented organizations, a gap is the negligence of or inattention to knowledge management, which imposes heavy costs without even they understand. Therefore, an important PMO function can be used to create and develop knowledge management in order to develop the PMO methodology in an organization.
I	Project governance	This PMO function provides the project stakeholders with the necessary authority and guidance, so that they ensure that the project management goals are fulfilled within the project management environment.
J	Determination of project organizations and structures	The alignment of project managers in an organization is a business goal. For this purpose, the PMO can define the structures of projects, determine roles and responsibilities of project team members, and select the stakeholders in the project management environment.
K	Resource management	A major PMO function is to participate in resource management of projects and make the necessary arrangements for the supply of resources in particular.
L	Project recovery	This function helps an organization take the necessary actions to put the derailed projects back on the PMO-based plan.

Table 6: Fuzzy verbal scales for the opinions of experts.

Verbal variable	Code	Fuzzy triangular number
Without any impacts	NO	(0, 0.1, 0.3)
Very low impact	VLI	(0.2, 0.3, 0.5)
Low impact	LI	(0.3, 0.5, 0.7)
High impact	HI	(0.5, 0.7, 0.9)
Very high impact	VHI	(0.7, 0.9, 1)

$$\hat{X} = \left(\hat{X}_{ij}\right)_{n\times n} = \left(l_{ij}^{*} \cdot m_{ij}^{*} \cdot u_{ij}^{*}\right)_{n\times n} \xrightarrow{So} \begin{cases} x_l = \left(l_{ij}^{*}\right)_{n\times n}, \\ x_m = \left(m_{ij}^{*}\right)_{n\times n}, \\ x_u = \left(u_{ij}^{*}\right)_{n\times n}, \end{cases}$$

$$X_l = \left(\hat{x}_{ij}\right)_{n\times n} = \begin{pmatrix} 0 & l_{12}^{*} & \cdots & l_{1n}^{*} \\ l_{21}^{*} & 0 & \cdots & l_{2n}^{*} \\ \vdots & \vdots & \ddots & \vdots \\ l_{n1}^{*} & l_{n2}^{*} & \cdots & 0 \end{pmatrix},$$

$$X_m = \left(\hat{x}_{ij}\right)_{n\times n} = \begin{pmatrix} 0 & m_{12}^{*} & \cdots & m_{1n}^{*} \\ m_{21}^{*} & 0 & \cdots & m_{2n}^{*} \\ \vdots & \vdots & \ddots & \vdots \\ m_{n1}^{*} & m_{n2}^{*} & \cdots & 0 \end{pmatrix}, \tag{4}$$

$$X_u = \left(\hat{x}_{ij}\right)_{n\times n} = \begin{pmatrix} 0 & u_{12}^{*} & \cdots & u_{1n}^{*} \\ u_{21}^{*} & 0 & \cdots & u_{2n}^{*} \\ \vdots & \vdots & \ddots & \vdots \\ u_{n1}^{*} & u_{n2}^{*} & \cdots & 0 \end{pmatrix}.$$

Step 6. Through the procedures used in the previous steps, the total fuzzy relationship matrix $\widetilde{T}$ can be employed through the following equations.

$$\widehat{T} = \begin{pmatrix} \hat{t}_{11} & \hat{t}_{12} & \cdots & \hat{t}_{1n} \\ \hat{t}_{21} & \hat{t}_{22} & \cdots & \hat{t}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{t}_{n1} & \hat{t}_{n2} & \cdots & \hat{t}_{nn} \end{pmatrix}, \tag{5}$$

$$\widehat{T} = \begin{pmatrix} \hat{t}_{11} & \hat{t}_{12} & \cdots & \hat{t}_{1n} \\ \hat{t}_{21} & \hat{t}_{22} & \cdots & \hat{t}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{t}_{n1} & \hat{t}_{n2} & \cdots & \hat{t}_{nn} \end{pmatrix}. \tag{6}$$

Step 7. After $\widetilde{T}$ is calculated, it is easy to calculate $\widetilde{D}_i + \widetilde{R}_i$ and $\widetilde{D}_i - \widetilde{R}_i$, for $\widetilde{D}_i$ and $\widetilde{R}_i$ denote the summations of rows and columns of $\widetilde{T}$, respectively. After $\widetilde{D}_i + \widetilde{R}_i$ and $\widetilde{D}_i - \widetilde{R}_i$ are calculated, the following equation is used for the defuzzification of data.

$$T = \left(t_{ij}\right)_{n\times n},$$
$$t_{ij} = \frac{l_{ij}^{**} + m_{ij}^{**} + u_{ij}^{**}}{6}. \tag{7}$$

After defuzzification, the diagram of effectiveness and affectedness is drawn. In fact, the decision-making process is based on this diagram, in which $\widetilde{D}_i + \widetilde{R}_i$ and $\widetilde{D}_i - \widetilde{R}_i$ are placed on the X-axis and the Y-axis, respectively. The values of $\widetilde{D}_i + \widetilde{R}_i$ indicate the importance of each factor. The higher this value for a factor, the more important that factor. Placed on the Y-axis, $\widetilde{D}_i - \widetilde{R}_i$ divides the factors into cause group and effect group. If $\widetilde{D}_i - \widetilde{R}_i$ is positive, the factor belongs to the cause groups; otherwise, it belongs to the effect group.

4. Research Findings

After collection, classification, and summarization of data, the fuzzy matrix of each project management expert was first extracted separately based on the fuzzy DEMATEL steps to determine the cause-and-effect relationships between the potential PMO functions. The fuzzy direct relationship matrix of all experts was then extracted through equation (2) by averaging the opinions of each expert (Tables 7 and 8). The total defuzzied matrix was then created (Tables 9 and 10) after descaling through equation (3) and defuzzification through equation (7). Finally, the results of $\widetilde{D}_i + \widetilde{R}_i$ and $\widetilde{D}_i - \widetilde{R}_i$ were extracted from the total fuzzy relationship matrix.

Given the value of $\widetilde{D}_i - \widetilde{R}_i$ on Table 10, the potential PMO functions can be divided into the cause group and effect group. According to the results of $\widetilde{D}_i - \widetilde{R}_i$, the cause functions affecting the PMO performance were introduced as project support, development of project management

Table 7: Fuzzy verbal scales for the opinions of experts.

	A	B	C	D	E	F	G	H	I	J	K	L
A	NO	VLI	VHI	VLI	LI	VHI	VLI	VHI	VLI	VHI	VHI	VHI
B	HI	NO	VHI	VLI	VHI	VHI	LI	VLI	VLI	LI	VLI	LI
C	LI	VHI	NO	HI	LI	HI	VHI	HI	HI	VHI	HI	LI
D	VLI	LI	VHI	NO	VHI	VLI	LI	VLI	LI	VLI	VLI	HI
E	VHI	HI	LI	LI	NO	VHI	LI	LI	LI	LI	VHI	HI
F	VLI	VHI	VLI	VLI	HI	NO		HI	LI	HI	VLI	VHI
G	VHI	LI	HI	HI	LI	LI	NO	HI	VHI	LI	LI	VHI
H	VLI	VHI	VLI	VLI	HI	VLI	LI	NO	HI	LI	VHI	VHI
I	LI	HI	LI	HI	LI	VHI	LI	HI	NO	VHI	LI	VHI
J	VHI	VLI	VHI	VLI	VLI	VLI	VHI	LI	VHI	NO	HI	VHI
K	VLI	HI	HI	VLI	VHI	LI	VHI	HI	VLI	HI	NO	LI
L	LI	VHI	LI	VHI	NO	HI	LI	HI	LI	VLI	VHI	NO

Table 8: The fuzzy direct relationship matrix $\tilde{Z}$.

DM1	A	B	C	D	E	F	G	H	I	J	K	L
A	(0, 0, 0)	(0, 0.1, 0.3)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.2, 0.3, 0.5)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.2, 0.3, 0.5)	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)
B	(0, 0.1, 0.3)	(0, 0, 0)	(0.3, 0.5, 0.7)	(0.2, 0.3, 0.5)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)	(0.7, 0.9, 1)	(0.7, 0.9, 1)
C	(0.5, 0.7, 0.9)	(0.3, 0.5, 0.7)	(0, 0, 0)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)	(0.2, 0.3, 0.5)	(0.2, 0.3, 0.5)	(0.7, 0.9, 1)	(0.2, 0.3, 0.5)	(0.2, 0.3, 0.5)	(0.3, 0.5, 0.7)
D	(0.7 ,0.9, 1)	(0.2, 0.3, 0.5)	(0.3, 0.5, 0.7)	(0, 0, 0)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0, 0.1, 0.3)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.7, 0.9, 1)
E	(0.5, 0.7, 0.9)	(0, 0.1, 0.3)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0, 0, 0)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.2, 0.3, 0.5)	(0.2, 0.3, 0.5)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.7, 0.9, 1)
F	(0, 0.1, 0.3)	(0.3, 0.5, 0.7)	(0.2, 0.3, 0.5)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0, 0, 0)	(0.2, 0.3, 0.5)	(0.3, 0.5, 0.7)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.2, 0.3, 0.5)	(0.5, 0.7, 0.9)
G	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0, 0.1, 0.3)	(0, 0, 0)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0, 0.1, 0.3)	(0.2, 0.3, 0.5)	(0.5, 0.7, 0.9)
H	(0, 0.1, 0.3)	(0.3, 0.5, 0.7)	(0.2, 0.3, 0.5)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.2, 0.3, 0.5)	(0, 0.1, 0.3)	(0, 0, 0)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.2, 0.3, 0.5)
I	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)	(0, 0.1, 0.3)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0, 0.1, 0.3)	(0, 0, 0)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)
J	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.2, 0.3, 0.5)	(0.5, 0.7, 0.9)	(0.2, 0.3, 0.5)	(0.2, 0.3, 0.5)	(0.7, 0.9, 1)	(0.2, 0.3, 0.5)	(0.2, 0.3, 0.5)	(0, 0, 0)	(0.7, 0.9, 1)	(0.7, 0.9, 1)
K	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)	(0.7, 0.9, 1)	(0, 0.1, 0.3)	(0.5, 0.7, 0.9)	(0.2, 0.3, 0.5)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.2, 0.3, 0.5)	(0.7, 0.9, 1)	(0, 0, 0)	(0.2, 0.3, 0.5)
L	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0, 0.1, 0.3)	(0.7, 0.9, 1)	(0.2, 0.3, 0.5)	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0, 0, 0)

Table 9: The total defuzzy matrix.

DF	A	B	C	D	E	F	G	H	I	J	K	L
A	0.18	0.19	0.27	0.23	0.23	0.30	0.22	0.28	0.22	0.17	0.26	0.23
B	0.36	0.24	0.29	0.35	0.35	0.36	0.28	0.31	0.29	0.24	0.30	0.30
C	0.33	0.28	0.24	0.29	0.40	0.36	0.36	0.34	0.32	0.26	0.31	0.33
D	0.34	0.33	0.35	0.27	0.36	0.42	0.34	0.34	0.30	0.23	0.30	0.34
E	0.36	0.34	0.27	0.27	0.26	0.37	0.29	0.29	0.31	0.20	0.27	0.30
F	0.27	0.27	0.29	0.32	0.30	0.25	0.29	0.27	0.25	0.24	0.26	0.28
G	0.27	0.27	0.27	0.27	0.30	0.27	0.20	0.21	0.24	0.22	0.19	0.29
H	0.31	0.36	0.28	0.35	0.38	0.38	0.33	0.25	0.30	0.30	0.32	0.28
I	0.35	0.32	0.30	0.38	0.36	0.34	0.37	0.36	0.24	0.30	0.27	0.32
J	0.32	0.32	0.29	0.27	0.34	0.34	0.31	0.31	0.27	0.20	0.23	0.35
K	0.33	0.29	0.32	0.35	0.35	0.38	0.30	0.35	0.32	0.26	0.23	0.28
L	0.37	0.35	0.31	0.36	0.36	0.36	0.35	0.32	0.31	0.28	0.25	0.26

Table 10: Classification of potential PMO functions.

Classification	No.	Function	D	R	D−R	D + R
Effect	1	A	2.76977	3.79845	−1.0287	6.56822
Cause	2	B	3.65062	3.54978	0.10084	7.20039
Cause	3	C	3.79723	3.49152	0.30571	7.28876
Cause	4	D	3.9287	3.72238	0.20632	7.65108
Effect	5	E	3.5255	3.99893	−0.4734	7.52442
Effect	6	F	3.31353	4.1161	−0.8026	7.42963
Effect	7	G	3.00984	3.65303	−0.6432	6.66288
Cause	8	H	3.83839	3.63627	0.20212	7.47466
Cause	9	I	3.9347	3.35789	0.57681	7.29259
Cause	10	J	3.55361	2.89666	0.65696	6.45027
Cause	11	K	3.76517	3.19314	0.57203	6.95831
Cause	12	L	3.88408	3.55699	0.32709	7.44108

methodology, consultation and training, project knowledge management, project governance, determination of project organizations and structures, resource management, and project recovery due to their positive values. However, the effect functions or affected functions were then introduced as participation in project implementation, project planning and auditing, portfolio management, and management of relationships with customers and suppliers due to the negative values of $\widetilde{D}_i - \widetilde{R}_i$. Based on the values of $\widetilde{D}_i + \widetilde{R}_i$, the most important functions were listed as consultation and training, project planning and auditing, project management knowledge, project recovery, portfolio management, project governance, development of project management methodology, project support, resource management, management of relationships with customers and suppliers, participation in project implementation, and determination of project organizations and structures. The causal diagram was then drawn as shown in Figure 1 based on $\widetilde{D}_i + \widetilde{R}_i$ and $\widetilde{D}_i - \widetilde{R}_i$.

Figure 1 shows the effectiveness and affectedness of potential PMO functions. In this figure, $\widetilde{D}_i + \widetilde{R}_i$ and $\widetilde{D}_i - \widetilde{R}_i$ are placed on the X-axis and the Y-axis, respectively. The values of $\widetilde{D}_i + \widetilde{R}_i$ indicate the importance of each function. The greater this value of a function, the more important that function. Placed on the X-axis, $\widetilde{D}_i - \widetilde{R}_i$ divides the functions into the cause group and effect group. In other words, if $\widetilde{D}_i - \widetilde{R}_i$ is positive, the function of interest belongs to the cause group; it belongs to the effect group, if the value is negative. Therefore, the functions above the X-axis belong to the cause group and are effective, whereas the functions below the X-axis belong to the effect group and are affected. According to Figure 1, determination of project organizations and structures was placed above the diagram in the group of cause functions, something which indicates that this function is the most effective one. However, it is the least important function of all based on the value of $\widetilde{D}_i + \widetilde{R}_i$, something which is clearly evident in the figure. The positions of other functions in the causal diagram can be analyzed with respect to the values of $\widetilde{D}_i + \widetilde{R}_i$ and $\widetilde{D}_i - \widetilde{R}_i$. It can also be inferred from Figure 1 that determination of project organizations and structures (J) was the most effective function based on the positions of functions on the diagram, whereas participation in project execution (A) was the most affected function. The other functions had intermediary roles in terms of effectiveness, affectedness, and importance.

5. Discussion

The research results demonstrated that participation in project implementation, project planning and auditing, portfolio management, and management of relationships with customers and suppliers were classified as the affected functions. The most affected function was introduced as participation in project implementation. There is no sufficient empirical evidence in the research literature with regard to the affectedness of management of relationships with customers and suppliers. However, the continuous improvement in management of relationships with customers and suppliers can be considered an effect of project management methodology development that is represented by adopting efficiently codified policies and plans. Each of the researchers believed that management of relationships with customers and suppliers was a cause of different functions, out of which project governance and determination of project organizations and structures were mentioned. Finally, the research findings indicated that participation in project implementation, portfolio management, and management of relationships with customers and suppliers were identified as the three most affected functions, out of which participation in project implementation was the most affected one. According to the previously reported empirical evidence, these three functions were introduced in the bulk of studies on the analysis of PMO functions as the potential functions. The effects of other variables on these functions were also measured.

Although this study employed the specialists and experts of project management in a project-oriented organization as a case study, the research findings can be used by managers in different industries in order to improve their actions in PMO implementation and development. In this regard, the managers of different industries can focus on the effective cause functions to enhance the PMO performance by improving and correcting those functions. Evidently, modification and improvement of causes can improve the effect functions and will generally reform and enhance the project management system.

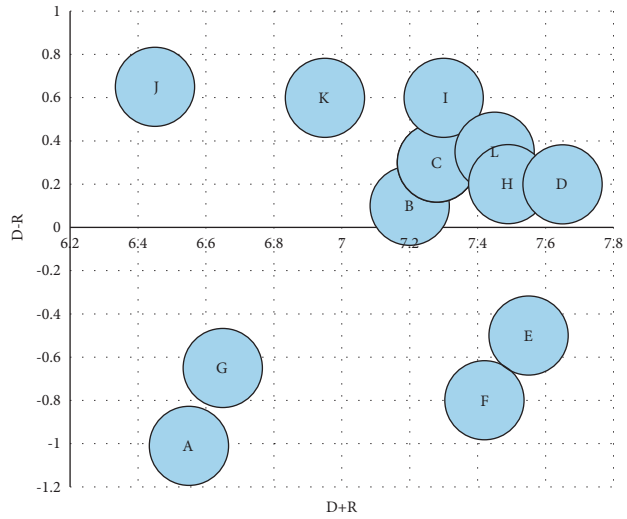

Figure 1: The causal diagram of potential PMO functions.

6. Conclusion

This study evaluated the cause-and-effect relationships of the potential PMO functions. The research results indicated that project support, development of project management methodology, consultation and training, management of project knowledge, project governance, determination of project organizations and structures, resource management, and project recovery were classified as cause functions affecting the PMO performance due to their positive values. According to the research findings, determination of project organizations and functions was introduced as the most effective function of all. Moreover, Barbalho et al. and Atashafrouz et al. deemed it necessary to determine the structures and organizations of projects for the alignment of project managers in an organization. In this regard, the results regarding participation in project implementation confirm the consistency between results and previously reported theoretical and empirical evidence. Participation in project implementation was classified as effect and affected functions. In other words, determination of project organizations and structures by the PMO would lead to the extensive determination of organizational authorities and responsibilities for project managements and would enable them to have active and effective participation in the management and implementation of organizational projects. The other cause functions were identified as project support, development of project management methodology, and consultation and training. In this class, consultation and training is among the important functions. Unlike its high importance, it had the lowest value of effectiveness in the class of cause functions, something which indicates its intermediary role. Moreover, resource management was ranked third in terms of importance among the cause functions. For future work, the prioritizing process can be implemented with other methods based on pairwise matrixes and fuzzy preference methods.

6.1. Future Work. In future empirical studies, project governance should be examined at several recommended organizational levels. Researchers able to develop and explain the context-specific hypotheses as well as the actions and practices associated with certain organizational levels can benefit from level-specific research. In other words, project governance research should be considered an extension of corporate governance theories, drawing from a growing body of theories to develop project-specific theories of governance and questioning fundamental research assumptions. The machine learning method can also be used in future work to assign the sensitivity analysis.

Data Availability

The data used to support this study are available from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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