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Research Article

A Mathematical Model for Optimizing Organizational Learning Capability

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Learning capability is the basis of evolution in every organization. Since the simplification and development of learning level in any organization seems to be necessary, in this paper we represent a mathematical model to maximize organizational learning capability. The proposed mathematical model focuses on required cost, labor, and capital, for implementation of ten effective factors on learning capability in different parts of an organization so that they are effective in learning capability with least cost for organization. To measure the factors in different parts of an organization some metrics are introduced. Computational tests confirm the effectiveness of the model. The model is optimized by epsilon constraint while it is multiobjective one. The validation of the model is also reported to emphasize the validity and applicability of the proposed methodology.

1. Introduction

Since learning is the survival factor of any organization, in this study, we focus on increasing organizational learning capability. An organization requires several capabilities for learning to enable knowledge transfer in the organization. In this environment to integrate the knowledge with the existing knowledge and for creating new knowledge measuring is essential. This capability is called organizational learning capability [1]. Organizational learning capability (OLC) includes many dimensions. Here we will involve ten dimensions of OLC dimensions for better explanation of our aim. We can choose each set of OLC dimensions, in order to obtain maximum level of learning capability and facilitating knowledge sharing process in different segments of an organization, all previous studies in this context measured the learning capability by a limited number of dimensions, and no pattern of decision was presented in this context to increase the organizational learning capability. Also, previous studies did not consider the economic aspects for OLC dimensions. We presented a mathematical model for increasing OLC and determined costs, labor, and capital that each dimension needs to implement. In order to obtain maximum level of learning capability in an organization we should implement each dimension of OLC in a part that has the greatest effect on OLC compared with other parts.

2. Organizational Learning Capability

OLC is defined as the organizational and managerial characteristics or factors that facilitate the organizational learning process or allow an organization to learn [1, 2]. Templeton believes that organizational learning is a collection of organizational functions such as learning knowledge, distribution, and interpretation of information and memory consciously and/or nonconsciously with positive effects on organizational changes [3]. Organizational learning capabilities are a collection of resources and/or tangible and intangible skills for which it is necessary to use competitive advantages as well. An organizational learning capability is a sign of creation capacity and combination of ideas in an effective way in contact with various organizational borders and through special managerial methods and innovations [4]. Ulrich has also considered organizational learning capabilities as a capacity of managers in an organization for further production and combination of important and effective ideas [5, 6]. There are different studies for measuring organizational learning capabilities at industrial and nonindustrial places; among them it is possible to point out to Gómez studies [7]; there is another study made by Bhatnagar at India for measuring of organizational learning capability of managers. According to the results, IT managers and multinational companies had the highest rate of organizational learning capability, and engineering managers had the lowest as well [8]. Ashkenas introduced organizational learning capability in this way: "The ability of an organization to learn from its experiences and taking them through times and borders." They said that an organization incapable of learning tends more to make adjustments to its own solution than to invest and devote time to make changes and improvements [8]. The learning organization or prescriptive literature mainly focuses on the development of normative models for the creation of a learning organization. Goh and Richards [1] and Pedler et al. [9] have reviewed learning literature and introduced the following as the aspects of organizational learning capability: demonstration of mission and goals, management obligation and delegation of power, experimentation, knowledge transfer, teamwork, and group problem-solving. Although most of the OLC measurement proposals and analyses of their dimensions have mainly focused on the learning organization research, the organizational learning literature has also studied the organizational learning facilitating factors. Chiva-Gomez [10] analyzes both literatures in order to determine the facilitating factors of organizational learning. Based on this comprehensive analysis, Chiva et al. [11] developed an OLC measurement instrument that understands OLC as a multidimensional concept, the dimensions of which are experimentation, risk taking, interaction with the external environment, and dialogue and participative decision making. On one hand, these five dimensions are essential enablers of the organizational learning process. On the other hand, they represent the OLC of a particular firm. Jerez-Gómez et al. [12] develop a measurement scale for organizational learning capability, supported by the results of a validation study covering a sample of 111 Spanish firms from the chemical industry. They have extracted four factors of organizational learning which are called organizational learning capability. These four dimensions are managerial commitment, systems perspective, openness and experimentation, and knowledge transfer and integration. Using the literature, we apply ten dimensions of learning capability for increasing organizational learning capability by presented mathematical model.

2.1. Organizational Learning Capability Dimensions

2.1.1. Risk Taking. Risk taking is understood as the tolerance of ambiguity, uncertainty, and errors. Hedberg [13] proposes a range of activities to facilitate organizational learning, amongst which stressed the design of environments is very risky and incur mistakes. Accepting or taking risks involves the possibility of mistakes and failures occurrence. Sitkin [14] goes as far as to state that failure is an essential requirement for effective organizational learning and to this end examines the advantages and disadvantages of success and errors. If the organization aims to promote short-term stability and performance, then success is recommended, since it tends to encourage maintenance of the status quo. According to Sitkin [14] the benefits brought about by error are risk tolerance, prompting of attention to problems and the search for solutions, ease of problem recognition and interpretation, and variety in organizational responses. Since the appearance of this work, many authors have underlined the importance of risk taking and accepting mistakes in order for organizations to learn [15].

2.1.2. Interaction with the External Environment. We define this dimension as the scope of relationships with the external environment. The external environment of an organization is defined as factors that are beyond the organization's direct control of influence among others. It consists of industrial agents such as competitors and the economic, social, monetary, and political/legal systems. Environmental characteristics play an important role in learning, and their influence on organizational learning has been studied by a number of researchers [16]. Relations and connections with the environment are very important, since the organization attempts to evolve simultaneously with its changing environment. Hedberg [13] considers the environment as the prime mover behind organizational learning. More turbulent environments generate organizations with greater needs and desires to learn [15].

2.1.3. Dialogue. In particular, authors from the social perspective [17] highlight the importance of dialogue and communication for organizational learning. Dialogue is defined as a sustained collective inquiry into the processes, assumptions, and certainties that make up everyday experience [18]. Schein [19] considers dialogue as a basic process for building common understanding, in that it allows one to see the hidden meanings of words, first by revealing these hidden meanings in our own communication. The vision of organizational learning as a social construction implies the development of a common understanding, starting from a social base and relationships between individuals [17]. Goh and Richards [1] advocate teamwork and problem solving in groups, with particular emphasis on multifunctional teams. By working in a team, knowledge can be shared and developed amongst its members [20]. Easterby-Smith et al. [21] hold that the recent literature is moving away from a vision of an integrating dialogue in which consensus is sought towards one that seeks pluralism and even conflict. Oswick et al. [22] claim that authentic dialogue fosters organizational learning because it creates, rather than suppresses, plural perceptions. Individuals or groups with different visions who meet to solve a problem or work together create a dialogic community.

2.1.4. Participative Decision Making. Participative decision making refers to the level of influence on employees in the decision-making process [23]. Organizations implement participative decision making to benefit from the motivational effects of increased employee involvement, job satisfaction, and organizational commitment [24]. Scott-Ladd and Chan

[24] provide evidence to suggest that participative decision making gives better access to information and improves the quality and ownership of decision outcomes. Parnell and Crandall [25] also maintain that divulging information is a requirement for participative decision making. Subordinates are assumed to be informed in order to participate efficiently. This literature [1, 9, 16, 24] considers participative decision making as one of the aspects that can facilitate learning.

2.1.5. Managerial Commitment. Management should recognize the relevance of learning, thus developing a culture that promotes the acquisition, creation, and transfer of knowledge as fundamental values [26–29]. Management should articulate a strategic view of learning, making it a central visible element and a valuable tool with an influence on obtaining long-term results [2, 5, 30]. Likewise, management should ensure that the firm's employees understand the importance of learning and become involved in its achievement, considering it an active part in the firm's success [20, 31–33]. Finally, management should drive the process of change, taking the responsibility for creating an organization that is able to regenerate itself and face up to new challenges [33]. Management should eliminate old beliefs and mental models that may have helped to interpret reality in the past but may now be seen as obstacles inasmuch as they help to perpetuate assumptions that do not correspond to the current situation [27, 29, 34–36].

2.1.6. Systems Perspective. Systems perspective entails bringing the organization's members together around a common identity [20, 37]. The various individuals, departments, and areas of the firm should have a clear view of the organization's objectives and understand how they can help in their development [2, 34]. The organization should be considered as a system that is made up of different parts, each with its own function, but act in a coordinated manner [26, 38, 39]. Viewing the firm as a system implicitly involves recognizing the importance of relationships based on the exchange of information and services [5] and infers the development of shared mental models [20, 40, 41]. Inasmuch as organizational learning implies shared knowledge, perceptions, and beliefs, it will be enhanced by the existence of a common language and joint action by all the individuals involved in the process. Thus, the presence of a common language favors knowledge integration—a crucial aspect in the development of organizational learning [42]. In this way, organizational learning goes beyond the employees' individual learning and takes on a collective nature [43].

2.1.7. Openness and Experimentation. Our unit of analysis is generative or double-loop learning, which requires a climate of openness that welcomes the arrival of new ideas and points of view, both internal and external, allowing individual knowledge to be constantly renewed, widened, and improved [20, 30, 37, 38]. To create a climate of openness, there needs to be a previous commitment to cultural and functional diversity, as well as a readiness to accept all types of opinions and experiences and to learn from them, avoiding the egocentric attitude of considering one's own values, beliefs, and experiences to be better than the rest [27, 43]. Openness to new ideas, coming from within the organization or from outside, favors experimentation—an essential aspect for generative learning, inasmuch as it implies the search for innovative flexible solutions to current and future problems, based on the possible use of different methods and procedures [28, 38]. Experimentation requires a culture that promotes creativity, an enterprising ability, and the readiness to take controlled risks, supporting the idea that one can learn from one's mistakes [30, 31, 44].

2.1.8. Knowledge Transfer and Integration. This fourth dimension refers to two closely linked processes, which occur simultaneously rather than successively: internal transfer and integration of knowledge. The efficacy of these two processes rests on the previous existence of absorptive capacity [45], implying the lack of internal barriers that impede the transfer of best practices within the firm [46]. Transfer implies the internal spreading of knowledge acquired at an individual level, mainly through conversations and interaction among individuals [17, 39, 47]. Fluid communication relies mainly on the existence of agile information systems that guarantee the accuracy and availability of the information [27]. With regard to dialogue and debate, work teams and personnel meetings can be ideal forums in which employees can openly share ideas [26, 28, 31, 34, 36]. The main role of work teams in developing organizational learning is frequently underlined in the literature [48], with particular emphasis placed on multidiscipline and multifunction teams [5, 28, 29, 36]. Team learning places the group above the individual, allowing the transfer, interpretation, and integration of the knowledge acquired individually [2, 20]. This integration leads to the creation of a collective corpus of knowledge rooted in organizational culture, work processes, and the remaining elements that form the "organizational memory" [49, 50]. Thus, the knowledge can be subsequently recovered and applied to different situations, guaranteeing the firm's constant learning in spite of the natural rotation of its members [51, 52].

2.1.9. Teamwork. In today's complex world, individuals need to help each other accomplish organizational objectives. Structures and systems in the organization need to encourage teamwork and group problem solving by employees and reduce the dependency on upper management. Teams need to also have the ability to work cross-functionally. By working in team, knowledge can be shared among organizational members and there is also a better understanding of other individuals, their needs, and how they work in different parts of the organization, encouraging knowledge transfer as well [20, 28].

2.1.10. Demonstration of Mission and Goals. The organization as a whole and each unit within it need to have a clearly articulated purpose. Employees need to understand this purpose and how the work they do contributes to attainment of the mission of the organization. In addition, the organization needs to promote employee commitment to these goals. [20, 53] and others have stated that "building a shared vision" especially of a future desired state creates tension that leads to learning. Employees understand the gap between the visions and the current state and can better strive to overcome that gap [54].

A summary of the OLC scales is given in Table 1.

3. Problem Description

In this paper, we focus on increasing the organizational learning capability. Organizational learning capability includes many dimensions. Here, we investigated ten dimensions of OLC dimensions for the better justification of our aim. We can choose each set of OLC dimensions for different purposes in the organization. In order to obtain the maximum level of learning capability, we should implement each dimension of OLC in the appropriate part of the organization at first; we should calculate the weight of each dimension in each part. To do that, we use k' measurement items that exist in OLC literature. Then, dimensions are clustered in the different parts of the organization according to their effects and the implementation cost of dimensions in each part by the proposed formulas. Finally, we have considered k implementation methods for implementing each dimension in each part of the organization. Implementation methods for each dimension are different in different organizations. Because people learn in different ways, there are different styles for organizational learning. Therefore, the organizations select different implementation methods for implementing OLC dimensions in different parts. Implementation methods are determined by the organization's knowledge management team. Organization's knowledge management team includes experts who are aware of the features of the organization's industry environment, adopted strategies, business culture, technology, available resources, and the history of the organization. The organization's budget which is considered to increase OLC is limited to a maximum value.

4. Mathematical Model

Our proposed model is described in six steps: (1) having k' measurement item, for measuring the weight of implementation item k of dimension i in part j, (2) determining the amount of measurement item, k', for measuring the weight of implementation item k of dimension i in part j, (3) calculating the numerical value of measurement item, k', which is determined to measure the weight of implementation item k of dimension i in part j, (4) calculating the weight of implementation item k of dimension i in part j, (5) determining the cost, labor, and capital of implementation item k of dimension i in part j, and (6) clustering dimensions according to the costs and weights of each dimension by the presented model.

Mathematical Notations

Indices

i: Index for dimensions

j: Index for parts

k: Index for implementation item

k': Index for measurement item

Parameters

C_{ijk}: The cost of the implementation item k of dimension i in part j

w_{ijk}: The k implementation item's value of dimension i in part j

$w_{ijkk'}$: The k' measurement item's numerical value, for measuring the weight of k implementation item of dimension i in part j

$N_{ijkk'}$: The amount of measurement item, k', for measuring the weight of implementation item k of dimension i in part j

A_j: The maximum cost that is considered for part j

M_j: The minimum weight that must be in part j

B: The maximum cost that is considered for increasing OLC

p'_{ijk}: The cost of capital unit for activating the implementation item k of dimension i in part j

p_{ijk}: The cost of labor unit for activating the implementation item k of dimension i in part j

ρ_{ijk}: The economic function's substitution parameter of implementation item k of dimension i in part j

δ_{ijk}: The economic function's distribution parameter of implementation item k of dimension i in part j

A_{ijk}: The economic function's performance parameter of implementation item k of dimension i in part j

f_{ijk}: The economic function of implementation item k of dimension i in part j

L_{ijk}: The required labor to activate the implementation item k of dimension i in part j

K_{ijk}: The required capital to activate the implementation item k of dimension i in part j

$\alpha, \beta, \gamma, a, b, c, d$: Constant coefficients

$$b_{ijkk'} = \begin{cases} 1, & \text{If measurement item, } k' \text{, is in part } j \\ & \text{for measuring the weight of} \\ & \text{implementationitem } k \text{ of dimension } i \\ 0, & \text{otherswise.} \end{cases} \quad (1)$$

Decision Variables

$$x_{ijk} = \begin{cases} 1, & \text{if the implementation item } k \\ & \text{of dimension } i \text{ is selected in part } j \\ 0, & \text{otherswise} \end{cases} \quad (2)$$

Table 1: Items composing the OLC scale.

Dimension	k' measurement item	Literature source
Risk taking	People are encouraged to take risks in this organization.	Amabile [55]
	People here often venture into unknown territory.	Isaksen et al. [56]
Interaction with the external environment	It is part of the work of all staff to collect, bring back, and report information about what is going on outside the company.	Pedler et al. [9]
	There are systems and procedures for receiving, collating, and sharing information from outside the company.	Pedler et al. [9]
	People are encouraged to interact with the environment: competitors, customers, technological institutes, universities, suppliers, and so forth.	Pedler et al. [9]
Dialogue	Employees are encouraged to communicate.	Templeton et al. [3]
	There is a free and open communication within my work group.	Amabile [55]
	Managers facilitate communication.	Pedler et al. [9]
	Cross-functional teamwork is a common practice here.	Tomas et al. [2]
Participative decision making	Managers in this organization frequently involve employees in important decisions.	Goh and Richards [1]
	Policies are significantly influenced by the view of employees.	Pedler et al. [9]
	People feel involved in main company decisions.	Pedler et al. [9]
Teamwork and group problem solving	Current approach of the organization encourages personnel to solve the problems cooperatively, before discussing them with managers.	Goh and Richards [1]
	We often cannot form unofficial groups to solve the problems of the organization.	Goh and Richards [1]
	Majority of problem solving groups are members of different operational environments.	Goh and Richards [1]
Demonstration of mission and goals	There is widespread support and acceptance of the organization's mission statement.	Goh and Richards [1]
	I do not understand how the mission of the organization is to be achieved (r).	Goh and Richards [1]
	The organization's mission statement identifies values to which all employees must conform.	Goh and Richards [1]
	We have opportunities for self-assessment with respect to goal attainment.	Goh and Richards [1]
Managerial commitment	The managers frequently involve their staff in important decision making processes.	Jerez-Gómez et al. [12]
	Employee learning is considered more of an expense than an investment.	
	The firm's management looks favorably on carrying out changes in any area to adapt to and/or keep ahead of new environmental situations.	
	Employee learning capability is considered a key factor in this firm.	
	In this firm, innovative ideas that work are rewarded.	
Systems perspective	All employees have generalized knowledge regarding this firm's objectives.	Jerez-Gómez et al. [12]
	All parts that make up this firm (departments, sections, work teams, and individuals) are well aware of how they contribute to achieving the overall objectives.	
	All parts that make up this firm are interconnected, working together in a coordinated fashion.	
Openness and experimentation	This firm promotes experimentation and innovation as a way of improving the work processes.	Jerez-Gómez et al. [12]
	This firm follows up what other firms in the sector are doing, adopting those practices and techniques it believes to be useful and interesting.	
	Experiences and ideas provided by external sources (advisors, customers, training firms, etc.) are considered a useful instrument for this firm's learning.	
	Part of this firm's culture is that employees can express their opinions and make suggestions regarding the procedures and methods in place for carrying out tasks.	
Knowledge transfer and integration	Errors and failures are always discussed and analyzed in this firm, on all levels.	Jerez-Gómez et al. [12]
	Employees have the chance to talk among themselves about new ideas, programs, and activities that might be of use to the firm.	
	In this firm, teamwork is not the usual way to work.	
	The firm has instruments (manuals, databases, files, organizational routines, etc.) that allow what has been learnt in past situations to remain valid, although the employees are no longer the same.	

$$s_{1ijkk'}, \ldots, s_{5ijkk'} \in \{0,1\}$$

$$y_{2ijkk'}, \ldots, y_{4jkk'} \in \{0,1\}$$

$$y'_{2ijkk'}, \ldots, y'_{4ijkk'} \in \{0,1\}.$$

Step 1 (determining $b_{ijkk'}$). If measurement item, k', exists for measuring the weight of implementation item k of dimension i in part j, $b_{ijkk'} = 1$; otherwise $b_{ijkk'} = 0$.

Step 2 (determining $N_{ijkk'}$). The amount of measurement item, k', for measuring the weight of implementation item k of dimension i in part j is determined by $N_{ijkk'}$. $N_{ijkk'}$ is expressed as of percentage, so $N_{ijkk'}$ gives a number between 0 and 100 which is determined by knowledge management team.

Step 3 (calculating $w_{ijkk'}$). According to the amount of $N_{ijkk'}$, we determine the numerical value of measurement item, k', to measure the weight of implementation item k of dimension i in part j. The organization's knowledge management team determines the value of $a, b, c, d, \alpha, \beta, \gamma$ in function, $W_{ijkk'}$:

$$w_{ijkk'} = \begin{cases} 0, & N_{ijkk'} < a \\ \alpha, & a \le N_{ijkk'} < b \\ \beta, & b \le N_{ijkk'} < c \\ \gamma, & c \le N_{ijkk'} < d \\ 100, & N_{ijkk'} \ge d. \end{cases} \tag{3}$$

Step 4 (calculating w_{ijk}). Calculating the weight of implementation item k of dimension i in part j as

$$w_{ijk} = \sum_{k'} b_{ijkk'} \cdot w_{ijkk'}. \tag{4}$$

Step 5 (determining $C_{ijk}, L_{ijk}, K_{ijk}$). Here we calculate the cost of the dimension k of factor i in part j.

Since another objective is the minimization of costs, the cost of implementation item k of dimension i in part j is calculated based on the CES production function. Here, all the dimensions involved in knowledge management are limited to two variables, labor and capital:

$$\begin{aligned} &\text{Min} \quad C_{ijk} = p_{ijk} L_{ijk} + p'_{ijk} K_{ijk} \\ &\text{St:} \quad f_{ijk} = A_{ijk} \left[\delta_{ijk} K_{ijk}^{\rho_{ijk}} + \left(1 - \delta_{ijk}\right) L_{ijk}^{\rho_{ijk}} \right]^{1/\rho_{ijk}}. \end{aligned} \tag{5}$$

For an easy solution, the value of δ_{ijk} and $1 - \delta_{ijk}$ is replaced with $a_{ijk}^{\rho_{ijk}}$ and $b_{ijk}^{\rho_{ijk}}$:

$$A_{ijk}^{\rho_{ijk}} \left((aK)_{ijk}^{\rho_{ijk}} + (bL)_{ijk}^{\rho_{ijk}} \right) = f_{ijk}^{\rho_{ijk}}. \tag{6}$$

Using Lagrangian function and Lagrange multipliers,

$$\begin{aligned} &L\left(\lambda_{ijk}, L_{ijk}, K_{ijk}\right) \\ &\quad = p_{ijk} L_{ijk} + p'_{ijk} K_{ijk} \\ &\qquad - \lambda_{ijk} \left(A_{ijk}^{\rho_{ijk}} \left((aK)_{ijk}^{\rho_{ijk}} + (bL)_{ijk}^{\rho_{ijk}} \right) - f_{ijk}^{\rho_{ijk}} \right) \end{aligned} \tag{7}$$

$$p_{ijk} - \lambda_{ijk} b_{ijk}^{\rho_{ijk}} A_{ijk}^{\rho_{ijk}} \rho_{ijk} L_{ijk}^{\rho_{ijk}-1} = 0 \tag{8}$$

$$\begin{aligned} &p'_{ijk} - \lambda_{ijk} a_{ijk}^{\rho_{ijk}} A_{ijk}^{\rho_{ijk}} \rho_{ijk} K_{ijk}^{\rho_{ijk}-1} = 0 \\ &A_{ijk}^{\rho_{ijk}} \left((aK)_{ijk}^{\rho_{ijk}} + (bL)_{ijk}^{\rho_{ijk}} \right) = f_{ijk}^{\rho_{ijk}}. \end{aligned} \tag{9}$$

According to (8),

$$\begin{aligned} &p_{ijk} - \left(\lambda_{ijk} b_{ijk} A_{ijk} \rho_{ijk}\right) b_{ijk}^{\rho_{ijk}-1} A_{ijk}^{\rho_{ijk}-1} L_{ijk}^{\rho_{ijk}-1} = 0, \\ &p_{ijk} (\lambda_{ijk} b_{ijk} A_{ijk} \rho_{ijk})^{-1} = (AbL)_{ijk}^{\rho_{ijk}-1}, \\ &p_{ijk}^{1/(\rho_{ijk}-1)} (\lambda_{ijk} b_{ijk} A_{ijk} \rho_{ijk})^{-1/(\rho_{ijk}-1)} = (AbL)_{ijk}, \\ &(AbL)_{ijk}^{\rho_{ijk}} = p_{ijk}^{\rho_{ijk}/(\rho_{ijk}-1)} (\lambda_{ijk} b_{ijk} A_{ijk} \rho_{ijk})^{-\rho_{ijk}/(\rho_{ijk}-1)}. \end{aligned} \tag{10}$$

According to (9),

$$(AaK)_{ijk}^{\rho_{ijk}} = p_{ijk}'^{\rho_{ijk}/(\rho_{ijk}-1)} (\lambda_{ijk} a_{ijk} A_{ijk} \rho_{ijk})^{-\rho_{ijk}/(\rho_{ijk}-1)} \tag{11}$$

we collect these two equations:

$$\begin{aligned} &f_{ijk}^{\rho_{ijk}} = \left(\lambda_{ijk} A_{ijk} \rho_{ijk}\right)^{-\rho_{ijk}/(\rho_{ijk}-1)} \\ &\qquad \times \left(\left(\frac{p_{ijk}}{b_{ijk}} \right)^{\rho_{ijk}/(\rho_{ijk}-1)} + \left(\frac{p'_{ijk}}{a_{ijk}} \right)^{\rho_{ijk}/(\rho_{ijk}-1)} \right) \\ &\left(\lambda_{ijk} A_{ijk} \rho_{ijk}\right)^{-\rho_{ijk}/(\rho_{ijk}-1)} \\ &\qquad = f_{ijk}^{\rho_{ijk}} \left(\left(\frac{p_{ijk}}{b_{ijk}} \right)^{\rho_{ijk}/(\rho_{ijk}-1)} + \left(\frac{p'_{ijk}}{a_{ijk}} \right)^{\rho_{ijk}/(\rho_{ijk}-1)} \right)^{-1}. \end{aligned} \tag{12}$$

According to (10), (11), and (12) we have

$$\begin{aligned} &K\left(p_{ijk}, p'_{ijk}, f_{ijk}\right) \\ &\quad = \left(\frac{p'_{ijk}}{\delta_{ijk}} \right)^{1/(\rho_{ijk}-1)} \\ &\qquad \times \left(\frac{p'_{ijk}{}^{\rho_{ijk}/(\rho_{ijk}-1)}}{(\delta_{ijk})^{1/(\rho_{ijk}-1)}} + \frac{p_{ijk}{}^{\rho_{ijk}/(\rho_{ijk}-1)}}{(1-\delta_{ijk})^{1/(\rho_{ijk}-1)}} \right)^{-1/\rho_{ijk}} \\ &\qquad \times \frac{f_{ijk}}{A_{ijk}}, \end{aligned} \tag{13}$$

$$L\left(p_{ijk}, p'_{ijk}, f_{ijk}\right) = \left(\frac{p_{ijk}}{1-\delta_{ijk}}\right)^{1/(\rho_{ijk}-1)} \times \left(\frac{p'^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(\delta_{ijk})^{1/(\rho_{ijk}-1)}} + \frac{p^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(1-\delta_{ijk})^{1/(\rho_{ijk}-1)}}\right)^{-1/\rho_{ijk}} \times \frac{f_{ijk}}{A_{ijk}}, \tag{14}$$

$$\begin{aligned} C\left(p_{ijk}, p'_{ijk}, f_{ijk}\right) &= p_{ijk} L_{ijk}\left(p_{ijk}, p'_{ijk}, f_{ijk}\right) + p'_{ijk} K_{ijk}\left(p_{ijk}, p'_{ijk}, f_{ijk}\right) \\ &= \left(\frac{p'^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(\delta_{ijk})^{1/(\rho_{ijk}-1)}} + \frac{p^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(1-\delta_{ijk})^{1/(\rho_{ijk}-1)}}\right)^{(\rho_{ijk}-1)/\rho_{ijk}} \times \frac{f_{ijk}}{A_{ijk}} = C_{ijk}. \end{aligned} \tag{15}$$

In (5), the function f_{ijk} is the constant elasticity of substitution production function. Here, the value of function f_{ijk} (the CES function) shows the effect that the organization expects on the implementation item k of dimension i in part j. Here $0 < \delta_{ijk} < 1$ is the share parameter and ρ_{ijk} determines the degree of substitutability of the inputs. The value of ρ_{ijk} is less than or equal to 1 and can be $-\infty$. $A_{ijk} > 0$ is an efficiency parameter. If $A_{ijk} > 1$, the efficiency of implementation item k of dimension i in part j, for labor L_{ijk} and capital K_{ijk}, is more than the organization's expectation. $A_{ijk} < 1$ means that the efficiency of implementation item k of dimension i in part j for labor L_{ijk} and capital K_{ijk} is less than the organization's expectation, and $A_{ijk} = 1$ means that the implementation item k of dimension i in part j for labor L_{ijk} and capital K_{ijk} creates the organization desired effect exactly. Equations (13), (14), and (15) determine the minimum required labor, capital, and cost for implementing item k of dimension i in part j.

Step 6 (clustering factors). With respect to the effect and cost of implementation item k of dimension i in part j and both objective functions, consider the proposed model clusters dimensions.

4.1. Proposed Formulation. After explaining the problem and the related steps for modelling, the mathematical formulation is as follows:

$$\text{Min} \quad \sum_i \sum_j \sum_k C_{ijk} x_{ijk} \tag{16}$$

$$\text{Max} \quad \sum_i \sum_j \sum_k w_{ijk} x_{ijk} \tag{17}$$

$$\text{s.t.} \quad w_{ijk} = \sum_{k'} b_{ijkk'}\left(\alpha s_{2ijkk'} + \beta s_{3ijkk'} + \gamma s_{4ijkk'} + 100 s_{5ijkk'}\right) \quad \forall i, j, k \tag{18}$$

$$\sum_i \sum_k c_{ijk} \cdot x_{ijk} \leq A_j \quad \forall j \tag{19}$$

$$\sum_i \sum_j \sum_k C_{ijk} x_{ijk} \leq B \tag{20}$$

$$\sum_i \sum_k w_{ijk} x_{ijk} \geq M_j \quad \forall j \tag{21}$$

$$\sum_i \sum_k x_{ijk} \geq 1 \quad \forall j \tag{22}$$

$$C_{ijk} = \left(\frac{p'^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(\delta_{ijk})^{1/(\rho_{ijk}-1)}} + \frac{p^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(1-\delta_{ijk})^{1/(\rho_{ijk}-1)}}\right)^{(\rho_{ijk}-1)/\rho_{ijk}} \times \frac{f_{ijk}}{A_{ijk}} \quad \forall ijk \quad 0 \neq \rho_{ijk} < 1 \quad A_{ijk} > 0 \quad 0 < \delta_{ijk} < 1 \tag{23}$$

$$L_{ijk} = \left(\left(\frac{p_{ijk}}{1-\delta_{ijk}}\right)^{1/(\rho_{ijk}-1)} \times \left(\frac{p'^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(\delta_{ijk})^{1/(\rho_{ijk}-1)}} + \frac{p^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(1-\delta_{ijk})^{1/(\rho_{ijk}-1)}}\right)^{-1/\rho_{ijk}} \times \frac{f_{ijk}}{A_{ijk}}\right) x_{ijk} \quad \forall ijk \tag{24}$$

$$K_{ijk} = \left(\left(\frac{p'_{ijk}}{\delta_{ijk}}\right)^{1/(\rho_{ijk}-1)} \times \left(\frac{p'^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(\delta_{ijk})^{1/(\rho_{ijk}-1)}} + \frac{p^{\rho_{ijk}/(\rho_{ijk}-1)}_{ijk}}{(1-\delta_{ijk})^{1/(\rho_{ijk}-1)}}\right)^{-1/\rho_{ijk}} \times \frac{f_{ijk}}{A_{ijk}}\right) x_{ijk} \quad \forall ijk \tag{25}$$

$$s_{1ijkk'} + s_{2ijkk'} + s_{3ijkk'} + s_{4ijkk'} + s_{5ijkk'} = 1 \quad \forall i, j, k, k' \tag{26}$$

$$2N_{ijkk'} s_{1ijkk'} - 2a s_{1ijkk'} < N_{ijkk'} - a \quad \forall i, j, k, k' \tag{27}$$

$$2N_{ijkk'} y_{2ijkk'} - 2a y_{2ijkk'} \geq N_{ijkk'} - a \quad \forall i, j, k, k' \tag{28}$$

Table 2: Values of fixed variables (unit of money).

	$B = 85000\$$	
j	A_j	M_j
1	17000$	70
2	16000$	75
3	22000$	70
4	17000$	70
5	18000$	80
6	16000$	74
7	15000$	71

$$2N_{ijkk'} y'_{2ijkk'} - 2by'_{2ijkk'} < N_{ijkk'} - b \quad \forall i, j, k, k' \tag{29}$$

$$2N_{ijkk'} y_{3ijkk'} - 2by_{3ijkk'} \geq N_{ijkk'} - b \quad \forall i, j, k, k' \tag{30}$$

$$2N_{ijkk'} y'_{3ijkk'} - 2cy'_{3ijkk'} < N_{ijkk'} - c \quad \forall i, j, k, k' \tag{31}$$

$$2N_{ijkk'} y_{4ijkk'} - 2cy_{4ijkk'} \geq N_{ijkk'} - c \quad \forall i, j, k, k' \tag{32}$$

$$2N_{ijkk'} y'_{4ijkk'} - 2dy'_{4ijkk'} < N_{ijkk'} - d \quad \forall i, j, k, k' \tag{33}$$

$$2N_{ijkk'} s_{5ijkk'} - 2ds_{5ijkk'} \geq N_{ijkk'} - d \quad \forall i, j, k, k' \tag{34}$$

$$\frac{\left(y'_{2ijkk'} + y_{2ijkk'}\right)}{2} \geq s_{2ijkk'} \quad \forall i, j, k, k' \tag{35}$$

$$\left(y'_{2ijkk'} + y_{2ijkk'}\right) - 2 < s_{2ijkk'} \quad \forall i, j, k, k' \tag{36}$$

$$\frac{\left(y'_{3ijkk'} + y_{3ijkk'}\right)}{2} \geq s_{3ijkk'} \quad \forall i, j, k, k' \tag{37}$$

$$\left(y'_{3ijkk'} + y_{3ijkk'}\right) - 2 < s_{3ijkk'} \quad \forall i, j, k, k' \tag{38}$$

$$\frac{\left(y'_{4ijkk'} + y_{4ijkk'}\right)}{2} \geq s_{4ijkk'} \quad \forall i, j, k, k' \tag{39}$$

$$\left(y'_{4ijkk'} + y_{4ijkk'}\right) - 2 < s_{4ijkk'} \quad \forall i, j, k, k' \tag{40}$$

$$x_{ijk} \in \{0, 1\} \quad \forall i, j, k \tag{41}$$

$$s_{1ijkk'}, \ldots, s_{5ijkk'} \in \{0, 1\} \quad \forall i, j, k, k' \tag{42}$$

$$y'_{2ijkk'}, \ldots, y'_{4ijkk'} \in \{0, 1\} \quad \forall i, j, k, k' \tag{43}$$

$$y_{2ijkk'}, \ldots, y_{4jkk'} \in \{0, 1\} \quad \forall i, j, k, k'. \tag{44}$$

In (16), the first objective function indicates the total cost of implementation that should be minimized. Equation (17) shows the second objective function that maximized the total effects of dimensions being implemented in organization's parts. Equation (18) calculates the weight of implementation item k of dimension i in part j. Equation (19) certifies that the total implementation cost for activating dimensions in part j is limited to a maximum value. Equation (20) ensures that the total budget which is considered to increase the learning capability of organization is limited to a maximum value. Equation (21) indicates that the total effects in each part are limited to a minimum value. Equation (22) ensures that at least one dimension is implemented in each part. Equations (26)–(44) indicate the linearization of $w_{ijkk'}$. $s_{1ijkk'}, \ldots, s_{5ijkk'}, y'_{2ijkk'}, \ldots, y'_{4ijkk'}, y_{2ijkk'}, \ldots, y_{4jkk'}$ are used in the linearization of $w_{ijkk'}$.

Table 3: Values of constant coefficients.

α	β	γ	a	b	c	d
23	42	63	10	35	50	80

5. Computational Results

Here, a numerical example is illustrated to show the applicability and effectiveness of the proposed approach. We have considered an organization having 7 parts, 3 measurement items, and 3 implementation items for each factor. Total budget of the organization is allocated to increase the learning capability; the total implementation cost for implementing dimensions in part j and the total effects in each part are shown in Table 2. It is not important that the total budget, B, be equal to the sum costs of all parts, because the model may implement one dimension in several parts and additional cost is allocated in other parts.

Constant coefficients $\alpha, \beta, \gamma, a, b, c, d$ for calculation of w_{ijk} are shown in Table 3. This coefficient is determined by the organization's knowledge management team. We choose other parameters in the following ranges:

$$\begin{gathered} 60\$ \leq p_{ijk} \leq 150\$, \quad 0.2 \leq p'_{ijk} \leq 0.36, \\ 0.7 \leq A_{ijk} \leq 2.5, \quad -4 \leq \rho_{ijk} \leq -1 \\ 0.4 \leq \delta_{ijk} \leq 0.87, \quad 60 \leq f_{ijk} \leq 100, \\ 10 \leq N_{ijkk'} \leq 87. \end{gathered} \tag{45}$$

The dimensions which are implemented in each part are shown in Table 4, ($x_{ijk} = 1$). The implementation methods of each dimension in each part are shown in this table. We have considered 3 implementation methods for each dimension ($k = 1, 2, 3$). Implementation methods for each dimension are different in different organizations. The minimum cost, labor, and capital that are required to implement dimension i in part j by implementing k are shown in this table.

5.1. Epsilon Constraint. We solve the presented model using Lingo 14.0 software. The optimal solution is obtained by the epsilon constraint method, since the model is a multiobjective one. The optimal points are shown as the Pareto fronts in Figure 1. Each point on the Pareto fronts can be chosen as the optimal point according to the opinion of the organization's knowledge management team. The obtained values in one of the optimal points are shown in Table 4. Since we have allocated more cost on the labor, the capital has smaller share than the labor in costs.

Table 4: Output results.

Obj 1 = 57161\$, Obj 2 = 1278				
(i, j, k)	x_{ijk}	C_{ijk} \$	L_{ijk}	K_{ijk} \$
(3, 1, 1)	1	3106	31	185
(6, 1, 2)	1	2832	25	244
(7, 1, 2)	1	2704	25	209
(10, 1, 1)	1	1489	14	200
(11, 1, 3)	1	2338	19	248
(7, 2, 2)	1	3123	27	240
(11, 2, 1)	1	2297	23	222
(7, 3, 2)	1	3654	29	195
(8, 3, 2)	1	2688	27	346
(7, 4, 2)	1	3517	28	187
(11, 4, 1)	1	2440	20	266
(3, 5, 1)	1	3761	28	187
(10, 5, 2)	1	2608	19	537
(11, 5, 1)	1	2075	17	241
(2, 6, 2)	1	3948	31	188
(7, 6, 2)	1	3220	28	389
(8, 6, 1)	1	1755	16	255
(7, 7, 2)	1	3064	27	243
(11, 7, 1)	1	2249	19	241

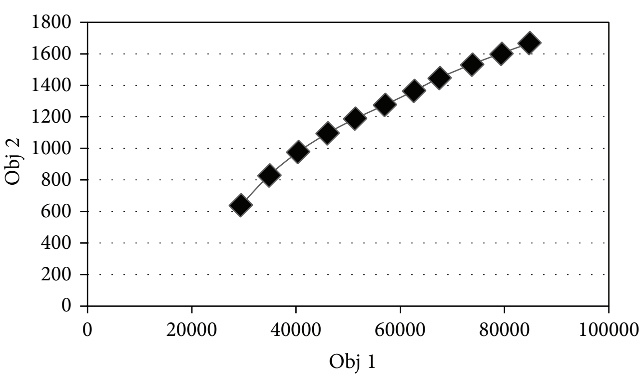

Figure 1: The results obtained by the ε-constraint method.

Steps of ε-constraint method are as follows.

(1) Choose one of the objective functions as the main function.

(2) Solve the problem by considering one of the objective functions at any time and obtain optimal points of each objective function:

$$\begin{aligned} \text{Min} \quad & f_1(x) \\ \text{St.} \quad & f_2(x) \le \varepsilon_2 \\ & \vdots \\ & f_n(x) \le \varepsilon_n \\ & X \in S. \end{aligned} \tag{46}$$

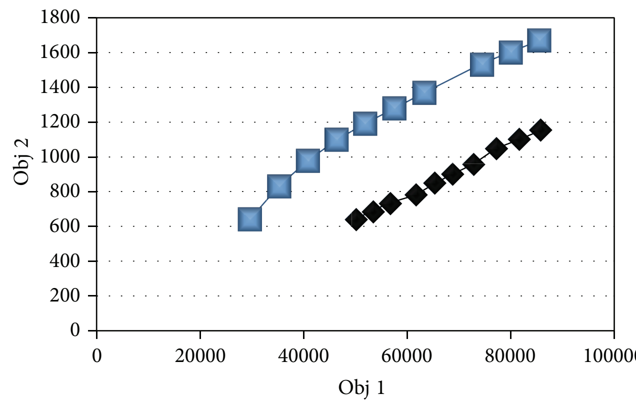

Figure 2: Increasing p_{ijk}.

(3) Divide the interval between two optimal values of subobjective functions to the definite number and obtain a table of values for $\varepsilon_2, \ldots, \varepsilon_n$.

(4) Solve the problem with the main objective function using each value of $\varepsilon_2, \ldots, \varepsilon_n$ at any time.

(5) Present the Pareto fronts of obtained solutions.

5.2. Model Validation. For model validation, since there is no similar research in the literature for comparison purpose, we evaluate the model's behavior by changing the value of the parameters. If the behavior of the model is close to what we expect in reality, the model will be valid. The behavior of the model after changing the value of the parameters is shown with black color.

5.2.1. Increasing p_{ijk}. When p_{ijk} is increased, the cost of labor unit and the total cost will be increased, and the chart will be pulled to the right side in Figure 2 that is shown with black color. Since each part of the organization is limited to a maximum cost and the cost of implementing each dimension is increased, the number of selected dimensions and the total effect will be reduced and the chart will be pulled down in Figure 2.

5.2.2. Increasing p'_{ijk}. When the cost of capital unit is increased, because the capital has small share in f_{ijk}, we do not see a significant difference in the behavior of model and charts are coincidence nearly (see Figure 3).

5.2.3. Increasing A_{ijk}. When the performance of each dimension is increased in each part, each implementation dimension will need less labor and capital; thus the total cost will be reduced and the chart will be pulled to the left side. Also a number of selected dimensions and total effect will be increased and the chart will be pulled upward in Figure 4.

5.2.4. $\rho_{ijk} \approx 1$. When the substitution parameter is close to one, the substitution of capital and labor will be increased, and the model will select variables which have less cost; thus the total cost will be reduced, and the chart will be pulled to

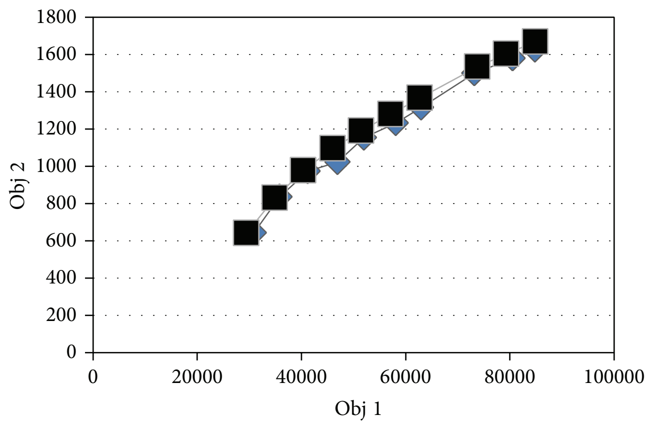

Figure 3: Increasing p'_{ijk}.

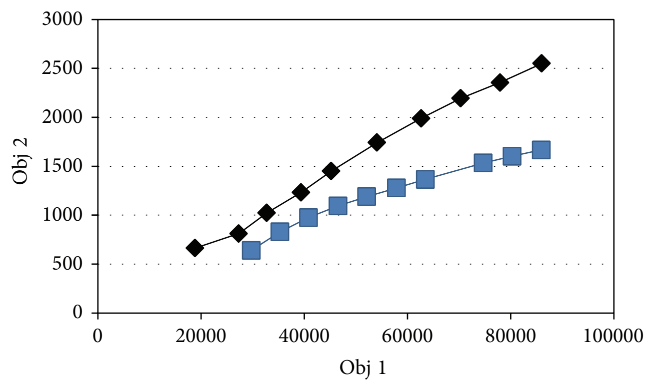

Figure 4: Increasing A_{ijk}.

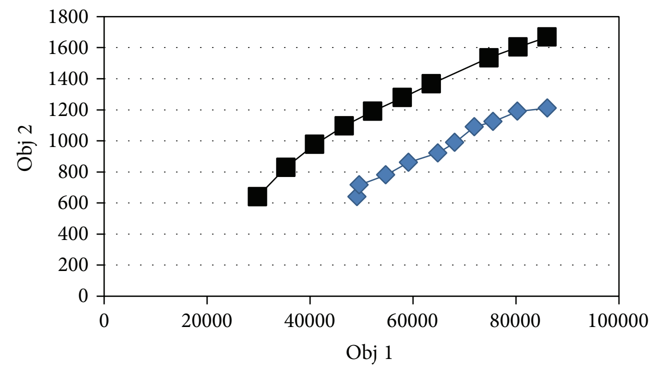

Figure 5: $\rho_{ijk} \approx 1$.

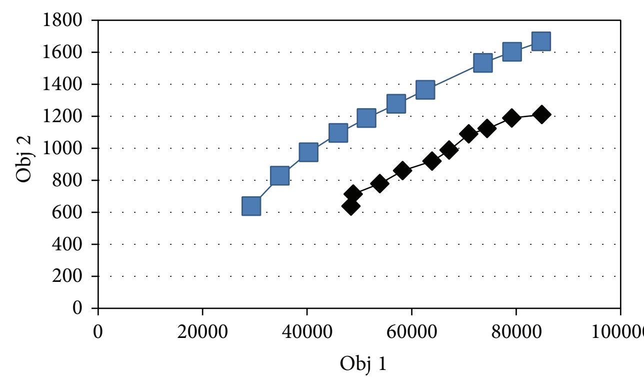

Figure 6: Reducing δ_{ijk}.

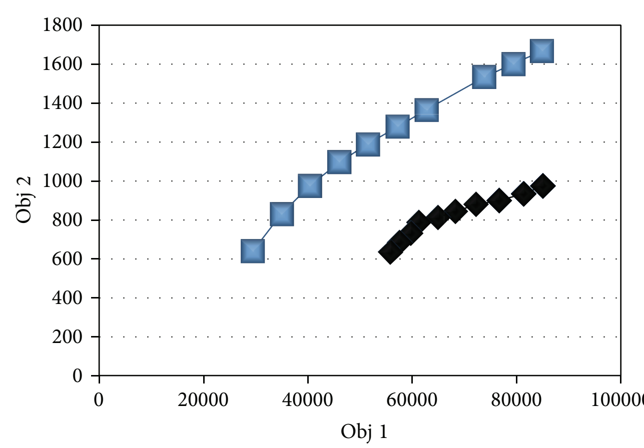

Figure 7: Reducing $N_{ijkk'}$.

the left in Figure 5. In this case, more dimensions are chosen, so the total effect is increased and chart is pulled upward.

5.2.5. Reducing δ_{ijk}. When the distribution parameter is decreased, the share of capital in the f_{ijk} function will be reduced and the share of labor will be increased, so the implementation of each dimension in each part needs more labor; because the large share of the costs in the cost function is assigned to labor, the total costs will be increased, and the chart will be pulled to the right side in Figure 6. Since the cost of implementation of each dimension will be increased, the number of selected factors and the total effect will be reduced and the chart will be pulled down.

5.2.6. Reducing $N_{ijkk'}$. When the amount of a measurement item is reduced, its effect will be reduced and the total effect will be reduced and the chart will be pulled down in Figure 7. Since we have limited the total effect to a minimum value in each part of the organization, more dimensions will be activated, so the total cost will be increased and the chart will be pulled to the right side.

6. Conclusions

This paper proposed a mathematical model to evaluate organizational learning capability within the context of knowledge management in companies. Since the simplification and development of learning level in any organization seems to be necessary, in this paper we presented a mathematical model to maximize organizational learning capability. The proposed mathematical model focused on required cost, labor, and capital, for implementation of some effective dimensions on learning capability in different parts of an organization. Computational results confirmed the effectiveness of the model by reporting the effective dimensions in different parts of an organization implemented by several items. The model was optimized by epsilon constraint while it was multiobjective one. The validation of the model was also reported to emphasize the validity and applicability of the proposed methodology. The validation was performed showing the variation of parameters and their impacts on other ones.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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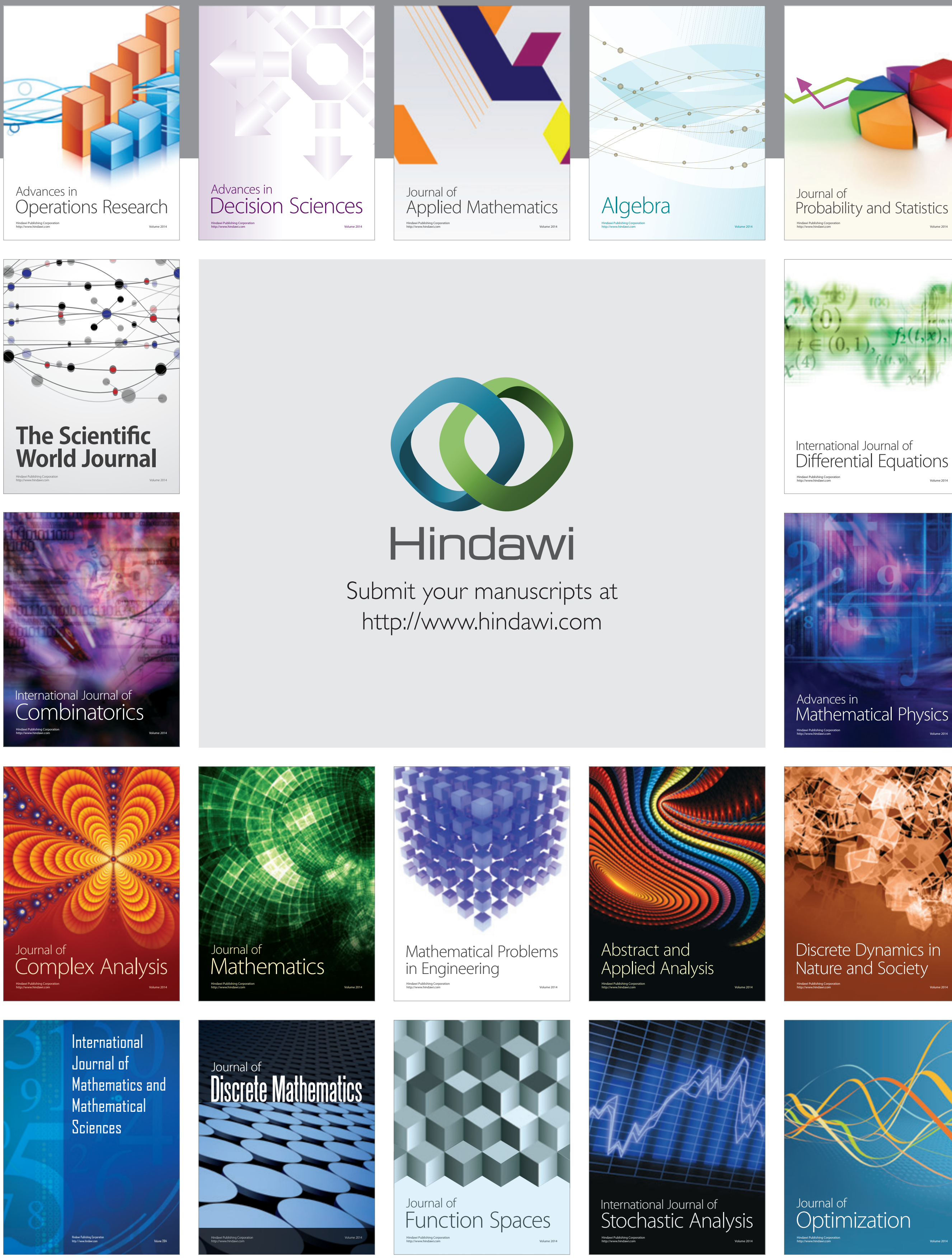
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