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Factors affecting the strategic design of open innovation and performance using fuzzy Delphi in the interpretive structural model framework

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Abstract

The present study aimed to identify the factors affecting the strategic design of open innovation and performance in small and medium enterprises. This study was applied in terms of objective and was descriptive-exploratory and mixed in terms of the data collection method. The method used in the present study was conducted in three steps. The first step was the use of qualitative content analysis and the reliability method was used to measure validity. The obtained result was the initial conceptual framework of the factors affecting the strategic design of open innovation and performance. In the second step, the effective factors obtained by the experts were approved in two phases of the Fuzzy Delphi technique. The population of eight scientific-practical experts such as the experts of small and medium enterprises in Yazd province were selected by theoretical sampling, judgmental, and snowball techniques. In the third step, the objective model of the experts was extracted and the content relationship and leveling of effective factors were conducted based on the interpretative structural modeling technique by 22 experts. Based on the analysis of the given opinions, all factors were identified and leveled in intra-organizational (14 factors), extra-organizational (12 factors) and hybrid (5 factors). Based on the analysis conducted in the intra-organizational dimension of organizational culture, organizational strategy, financial resources in the framework of extra-organizational organizations, economic factors, laws and regulations and in the framework of hybrid factors to the inside and outside of the organization, the factors of business space, strategic coordination, and joint venture have more significance and driving forces in affecting the strategic design of open innovation and performance.

Keywords: factors affecting the strategic design of open innovation and performance, qualitative analysis method, Fuzzy Delphi, interpretive structural modeling technique, small and medium enterprises
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1 Introduction

Today, businesses are increasingly facing dynamic environments and are obliged to adapt to environmental changes. Studies indicate that not many businesses are creative, innovative, or entrepreneurial. In addition, they are unable to

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keep up with the advances and changes of the present age and often continue working by using ineffective traditional methods. Nowadays, innovation in the production process is regarded as one of the most significant factors which determine the long-term development of economies in the theories of economic growth and development. Innovation increases the profits and market share of enterprises and leads to higher economic growth [24]. Innovative enterprises normally receive awards with increased profits from innovation in their products, services, and business models. The most innovative enterprises tend to have the highest market share in the long term and are mainly the most profitable. In addition, they have typically the most capability of surviving economic downturns [28]. Reviewing the scientific literature indicate that the output of measures for innovation at the enterprise level is generally measured with the concept of innovation performance. However, enterprises' efforts to achieve innovation are not successful equally. In other words, the innovation performance of enterprises varies from each other. Hence, it is highly significant to recognize the factors affecting the innovation performance of the enterprise. Numerous attempts aimed to explain the factors affecting the innovation performance of enterprises, most of which have sought to study their effects on innovation by considering only one or more limited factors. No accurate prescription has been provided in this field so far despite the empirical studies of the last four decades to identify the specific characteristics of innovative enterprises and the factors affecting the success or failure of innovation [18].

On the other hand, innovation remains a non-studied research field in developing countries. Open innovation has been introduced as a novel paradigm in innovation management and has turned into a broad innovation strategy at organizational and national levels. This approach has found new paths to boost innovation in both developed and developing countries. Nevertheless, it presents abundant advantages to commercial organizations and attracts extensive academic attention. In addition, open innovation has a considerable effect on industrial practices and practices in developed countries [29]. In this regard, some studies have merely investigated the intra-organizational factors affecting open innovation and others studied extra-organizational factors affecting open innovation. Furthermore, another group has studied the mutual factors affecting open innovation. The literature shows that no study has ever designed an integrated model of open innovation strategic measures in small and medium enterprises in Iran in which domestic, foreign and bilateral factors are leveled and the causal relationships of these variables are extracted. This study attempts to summarize the relevant factors and level them in a content framework as cause and effect relationships. In terms of content, this study aims to discover and design such a model to fill the gap of studies in the field of open innovation due to the lack of a model in the field of applying open innovation, particularly in small and medium industries in Iran. This study deals with open innovation and its performance and the factors affecting its strategic design extensively and completely to develop all the effective factors and a complete content model so that small and medium enterprises may improve their innovation. Accordingly, the main objective of the present study is to find the factors affecting the strategic design of open innovation and performance in small and medium enterprises in Iran and also the content relationship between them.

2 Literature review

Innovation is a term which is widely used and is often an answer to the question "What and how does the enterprise need to be successful?". This term has been defined differently over several decades and varies depending on such definitions [10]. From a more technical perspective, innovation is defined as the technical activities, design, manufacture, business management, and marketing of a new (or improved) process or equipment [27]. Chesbrough [7] presented the concept of open innovation to help innovation mechanisms through knowledge flow at the beginning of the 21st century. Since then, many researchers have helped the open innovation literature and studied approaches to improving innovation through inter-organizational communication and collaborative efforts [12]. Chesbrough and Bogers [9] defined open innovation as "a distributed innovation process according to managed knowledge flow to take advantage of ideas outside organizational boundaries" [14]. Open innovation refers to an innovation trend adopted by many large enterprises around the world [21]. Open innovation is considered a business management model for innovation promoting collaboration with people and organizations outside the enterprise [25]. Open innovation means opening the innovation process beyond the enterprise's boundaries to enhance its innovation potential through the active strategic use of the environment. Thus, innovation through the interaction of domestic and foreign ideas, technologies, processes and sales channels is more hopeful for the enterprise for developing innovative products [26]. Open innovation describes the inflow and outflow of knowledge for improving innovation performance and is extensively known as a significant method in innovation management. Accordingly, open innovation means the free and intentional inflow and outflow of knowledge to and out of the industry and also accelerates the innovation process. In addition, it is assumed that enterprises can take advantage of extra-organizational ideas in addition to intra-organizational ideas [23]. The innovation process includes the identification, development, and testing of new ideas. Innovation activities are regulated and controlled inside the enterprise. However, there has been a significant change during the last decade,

placing more emphasis on customer preferences, advances in technology, and the availability of different products and services [10]. Organizations have more reliance on better interactions with stakeholders in a broad ecosystem to gain critical knowledge increasing cross-research activities. As a result, this has resulted in wider adoption of the concept of open innovation [12].

The innovation and competitiveness of enterprises can increase through the absorption of new knowledge from foreign sources that could result speed up the organization's innovation activities [31]. Chesbrough [7] proposed the term "open innovation" to achieve the innovation mechanisms facilitating the interaction between enterprises and cooperation with foreign enterprises. Chesbrough [8] stated that open innovation models facilitate knowledge discovery. Similar attitudes were shared by other experts collecting evidence to support that targeted knowledge flows may establish opportunities for market expansion. Targeted knowledge flows are conscious efforts by enterprises to provide two-way knowledge flows. Open innovation contributes enterprises to satisfying customer needs and bringing competitiveness in markets [30]. Open innovation activities involve the exploration of foreign knowledge and its combination with foreign knowledge. In addition, such activities let knowledge be exploited by other organizations and are the combination of inbound and outbound open innovation processes [11]. There are two kinds of open innovation: Inbound open innovation, and outbound open innovation. Inbound open innovation includes opening an organization's innovation process to foreign knowledge. Inbound innovation processes enable organizations to share their knowledge with others (from inside). Outbound innovation activities happen as non-monetary benefits (improvements) and monetary benefits [16]. Outbound open innovation refers to the exploitation of domestic ideas or knowledge through licensing, patenting, or signing intellectual property contracts. Outbound innovation refers to the targeted commercialization and recording of internal ideas within the organization's external environment [30]. Many studies dealt with open innovation and performance in small and medium enterprises. Lu et al. [17] conducted a study entitled "The increase of innovation performance in small and medium enterprises through open innovation and absorptive capacity: "the moderating effect of the business model". This study particularly categorizes open innovation into inbound and outbound open innovation and evaluates their corresponding effects on the innovation performance of small and medium enterprises. Based on survey data from 218 Chinese small and medium enterprises, both inbound and outbound open innovation have positive effects on the innovation performance of small and medium enterprises. Carrasco-Carvajal et al. [4] conducted a study entitled "Measuring open innovation in small and medium enterprises: A review of the existing studies". This study analyzed the various methods used in the measurement of open innovation in the context of small and medium enterprises through a systematic review of the empirical literature. For this purpose, a two-step methodological approach was implemented such as systematic literature review and bibliometric analysis. The results indicated that the empirical literature applies a wide range of methods to measure open innovation activities. Vakil Alroaia [32] performed a study entitled "open innovation and small and medium enterprises: A model for business development". This study aimed to provide a developed model for small and medium enterprises in open innovation activities. Based on the results, these factors include product properties, intra-organizational factors, and environmental factors. Moreover, the most significant factors include product properties. Almeida [1] evaluated open innovation practices in Portuguese small and medium companies. The result revealed that the integration of foreign knowledge from suppliers and customers was the most common outside-in measures. In the inside-out model, the processes of licensing were more significant. However, joint ventures and network consortia were highlighted in the coupled (hybrid) model.

Popa et al. [22] studied the effect of organizational records and innovation atmosphere in open innovation, and the effect of its consequences on the performance of small and medium enterprises. The results indicated that organizational factors like practices based on the commitment of human resources leave a positive effect on the innovation atmosphere which helps innovation methods (inside-out and outside-in processes). Ayne et al. [2] conducted a study entitled "Design of an open innovation model using an entrepreneurial development approach (Case study: Border rural cooperatives affected by the COVID-19 Pandemic. Their study revealed that the factors affecting the design of an open innovation model using an entrepreneurial development approach include economic factors, organizational factors, environmental factors, technological factors, competitive advantage, laws and regulations, innovation and strategic implementation. Zarei et al. [33] carried out a study entitled "The effect of open innovation factors on organizational strategy and performance" (Case study: District 1, Tehran Municipality). The results of testing the hypotheses showed that production, process, and administrative factors have a higher effect on strategy and organizational performance, respectively. Bakhsham et al. [3] studied the challenges of open innovation in small and medium enterprises based on the steps of innovation projects. As a result, the lack of planning on project partners, inappropriate innovation strategy, unknown partners, inconsistency of objectives, lack of social trust, time pressure, lack of financial resources, inappropriate information and control systems, redefinition of objectives, negligence of efforts by partners, bureaucracy and administrative burdens, lack of inappropriate policies to accept advanced innovation and the failure to achieve the intended goals are regarded as the key challenges of small and medium enterprises in the acceptance of open

innovation. Moreover, Hakkaki et al. [13] presented a multi-level structural model for the successful implementation of open innovation. They came to the conclusion that economic factors (the most effective index), universities, research institutes, and information technology support systems were the most significant in the basic layer. Competitors, colleagues, organizational strategy, organizational learning, employees, and reward system were leveled in the strategy layer while suppliers, organizational structure, and environmental issues were leveled in the operation layer.

Generally, the thematic literature related to the factors affecting the strategic design of open innovation and performance in the field of small and medium enterprises has separately addressed an aspect of the effective dimensions. Most studies have merely focused on certain aspects of the factors and all the factors such as intra-organizational, extra-organizational, and hybrid criteria were not considered. Therefore, no study has comprehensively regarded all effective factors in all fields in the form of a conceptual model. To fill the existing research gap, the present study identifies the factors affecting the strategic design of open innovation and performance using the qualitative content analysis method. In addition, this study confirms it by experts with the Fuzzy Delphi technique and evaluates the content relationship between these factors using the interpretive structural modeling technique.

3 Methodology

From a methodological perspective, this study was based on the mixed research method since it used a combination of different methods in three steps according to a predetermined plan and the final result was a mixture of research methods, not merely a specific method. As a result, the modeling process in this study was conducted in three steps in the framework of mixed research methodology. The first and second steps were qualitative while the third step had a quantitative analysis approach. The research method used in this study was a documentary-survey. Based on the results of a library study on the theoretical foundations and literature of the study, the primary conceptual framework of the factors affecting the strategic design of open innovation and performance was elicited using the qualitative content analysis method. Then, the Fuzzy Delphi technique was used to reach a consensus among the experts due to the need for developing, integrating, and confirming the strategic factors of open innovation regarding the possibility of bias in the researcher's opinions. This aimed to ensure the validity, accuracy, applicability, and comprehensiveness of the identified stages. After confirming the factors in the second step, the content relationship and leveling of the effective factors were conducted by using the interpretive structural modeling technique.

Content analysis is considered one of the primary methods of observing documents by which texts and documents or any type of recorded documents and materials can be analyzed more regularly whether related to the past or the present. more accurate and most importantly with higher degrees of reliability. First, qualitative content analysis which is highly useful for textual data analysis was used in this study. In addition, reliability with four criteria of dependability, validity, transferability and verifiability were used for replacing validity and reliability in the first step of the study. The second step aimed to confirm the factors affecting the strategic design of open innovation and the performance of small and medium enterprises. Due to the possibility of bias in the researcher's opinions, the Fuzzy Delphi technique was used to reach a consensus among the experts to ensure the correctness, accuracy, applicability and comprehensiveness of the identified steps and eliminate the probable biases. The population in the second step included the experts of small and medium enterprises in Yazd province. The Fuzzy Delphi technique was conducted using the purposive sampling method and snowball method with eight experts in two phases. After identifying the intended variables, a questionnaire was developed based on the results of open coding, qualitative content analysis, and the Likert scale to reach a consensus by the experts on the accuracy of the identified variables. Then, the questionnaire was provided to the same experts of the previous step to determine the importance of each step (N=8). After collecting the questionnaires of the Delphi first step, the linguistic variables were first defined as triangular fuzzy numbers. In this regard, triangular fuzzy numbers were given to the opinion of each expert and the set of triangular fuzzy numbers for each expert was obtained by using Eq. (3.1). The average set $(A_m^{(i)})$ from all sets $(A^{(i)})$ was calculated through Eq. (3.2). Then, the disagreement of each expert from the average was calculated using Eq. (3.3).

$$\widetilde{A}^{(i)} = (a_1^{(i)}, a_2^{(i)}, a_3^{(i)}), \quad i = 1, 2, 3, ..., n \tag{3.1}$$

$$\widetilde{A}_m = (a_{m1}, a_{m2}, a_{m3}) = \left(\frac{1}{n} \sum_{i=1}^{n} a_1^i, \frac{1}{n} \sum_{i=1}^{n} a_2^i, \frac{1}{n} \sum_{i=1}^{n} a_3^i \right) \tag{3.2}$$

$$(a_{m1} - a_1^{(i)}, a_{m2} - a_2^{(i)}, a_{m3} - a_3^{(i)}) = \left(\frac{1}{n} \sum_{i=1}^{n} a_1^i - a_1^{(i)}, \frac{1}{n} \sum_{i=1}^{n} a_2^i - a_2^{(i)}, \frac{1}{n} \sum_{i=1}^{n} a_3^i - a_3^{(i)} \right) \tag{3.3}$$

When the initial feedback was given to the experts and the second step of Delphi was conducted, the revised opinions of experts were defined in the form of triangular fuzzy numbers. Like the first step, here the average modified opinions of experts ($B_m^{(i)}$) were calculated through Eq. (3.5):

$$\widetilde{B}^{(i)} = (b_1^{(i)}, b_2^{(i)}, b_3^{(i)}), \quad i = 1, 2, 3, ..., n \tag{3.4}$$

$$\widetilde{B}_m = (b_{m1}, b_{m2}, b_{m3}) = \left(\frac{1}{n} \sum_{i=1}^{n} b_1^i, \frac{1}{n} \sum_{i=1}^{n} b_2^i, \frac{1}{n} \sum_{i=1}^{n} b_3^i \right) \tag{3.5}$$

Different methods are accessible for the defuzzification of the final values for each index. In this study, the center of gravity method was used based on Eq. (3.6) for the defuzzification of the values in each Delphi step [6]:

$$S_j = \frac{u_j + m_j + l_j}{3} \tag{3.6}$$

The lack of consensus among the experts in two Delphi steps was calculated through Eq. (3.7). The Delphi steps continue until the lack of consensus between two rounds of Delphi reaches less than a very low threshold (0.2). In this regard, the survey process stops [5]:

$$s(\widetilde{B}_m, \widetilde{A}_m) = \left| \frac{1}{3} [(b_{m1}, b_{m2}, b_{m3}) - (a_{m1}, a_{m2}, a_{m3})] \right| \tag{3.7}$$

Due to the broadness of the subject and its dimensions, the stages of its development should be determined according to collective wisdom. Thus, the Fuzzy Delphi method was used along with the content analysis method to achieve results close to reality, communicate with the experts of small and medium enterprises effectively, and reach a consensus among the experts quickly by using fuzzy numbers instead of definite numbers. Then, the interpretive structural modeling technique was used to identify the content relationship and leveling of the factors affecting the strategic design of open innovation and performance. The population of this study included experts with at least 20 years of work experience in the field of the manufacturing industry in small and medium enterprises in Yazd province and university professors (N=30). The convenience random method was used for sampling according to the quantitative research method. Furthermore, all members of the population were used in this section regarding the small number of the statistical population. This method is considered an interactive learning process where a set of various interrelated elements are structured in a comprehensive systematic model. This method helps the creation and direction of complex relationships between the elements of a system. As one of the main logics of this method, the elements which have more effect on other elements in a system are of higher significance. The model obtained with the help of this methodology indicates the structure of a complex subject, system, or field of stud that is a precisely designed model [19]. The different steps of interpretative structural modeling are as follows:

Step 1: The intended criteria or elements (in this study, factors affecting the strategic design of open innovation and performance) are listed.

Step 2: Using the criteria or variables determined in Step 1, a content relationship between the variables is defined based on each pair of criteria.

Step 3: A structural self-interaction matrix is developed to reveal the pairwise relationships of factors affecting the strategic design of open innovation and performance.

Step 4: The access matrix is developed with the help of the structural self-interaction matrix.

Interpretive structural modeling suggests that the opinions of experts should be used based on different management techniques such as the Delphi method, brainstorming, nominal group, etc., to develop content relationships between variables. In case of each pair of criteria, the experts are asked to express their views on the presence of a relationship between both criteria. In addition, four signs are used to indicate the relationship between the two parameters i and j (English letters are not used in the source to show the relationship easily but numbers -1, 0, 1, 2 were used).

Number 1: If criterion i affects criterion j.

Number 2: If criterion i affects j and criterion j affects i.

Number -1: If criterion j affects criterion i.

Number 0: If there is no effective relationship between two criteria i and j.

Then, the structural self-interaction matrix is converted into a matrix of zero and one, known as the initial access matrix. In this matrix, there are only numbers "0" and "1". The rule of replacing numbers 0 and 1 instead of the quadruple prime numbers (0, -1, 1, 2) is mentioned below:

If the intersection of criteria (j, i) in the structural self-interaction matrix equals 1, cell (j, i) will equal 1 and cell (i, j) will be 0 in the access matrix.

If the intersection of criteria (j,i) in the structural self-interaction matrix equals 2, both cell (j,i) and cell (i,j) will be equal to 1 in the access matrix.

If the intersection of criteria (j, i) in the structural self-interaction matrix equals 0, cell (j, i) and cell (i, j) will be equal to 0 in the access matrix.

If the intersection of criteria (j,i) in the structural self-interaction matrix equals -1, cell (j,i) will equal 0 and cell (i,j) will be 1 in the access matrix:

$$D = \begin{pmatrix} & C_1 & C_2 & \cdots & \cdots & C_n \\ C_1 & 0 & d_{12} & \cdots & \cdots & d_{1n} \\ C_2 & d_{21} & 0 & \cdots & \cdots & d_{2n} \\ \vdots & \vdots & \vdots & 0 & \cdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & 0 & \vdots \\ C_n & d_{m1} & d_{m2} & \cdots & \cdots & 0 \end{pmatrix} \tag{3.8}$$

in matrix D as the initial access matrix, numbers 0 and 1 are placed instead of each sign of d_{ij}. In addition, c_i and c_j represent the factors affecting the strategic design of open innovation and performance in small and medium enterprises in Yazd province.

Then, the final access matrix for the criteria is achieved by considering the relationship to adapt the initial access matrix. In this regard, the initial matrix should be raised to the power $k+1$ until a stable state is achieved ($MK = MK + 1$). Thus, some zero elements turn into 1 which are shown as (1^*). After establishing the relationship matrix or the initial access matrix, the final access matrix should be achieved by using the equations below (I is the identity matrix):

$$\begin{aligned} M &= D + I \\ M^* &= MK = MK + 1, \quad K > 1 \end{aligned} \tag{3.9}$$

It is assumed that every component in large complex systems can be obtained by itself. Thus, all the main diameters of the final matrix in the system are 1 all the time. For this purpose, the identity matrix is added to the initial access matrix to obtain the final matrix. The properties of the final matrix are as follows:

$$M2 = M \tag{3.10}$$

For this purpose, the obtained final matrix is raised to the power until the above-mentioned state occurs and the obtained matrix is the final matrix. The number of 1s in the first row shows the lines or effects which are caused by the first criterion. The number of 1s in the first column implies the effects on the first criterion. A component which affects all system components but is not affected by any component is called a source. The criteria are leveled after determining the accessible set and advanced set for each criterion and specifying the shared set. In this regard, the shared set is obtained by obtaining the share of two accessible and advanced sets. The criteria with the same shared set as their accessible set allocate the first level of priority. The levels of other criteria are determined by eliminating these criteria and repeating the same process for other criteria. The ISM diagram is drawn based on the determined levels and final matrix. Each level is specified by repeating the equation below [19]:

$$R(CJ) \cap A(CJ) = R(CJ), \quad v\ CJ \in C \tag{3.11}$$

4 Findings

Based on the research background and the theoretical foundations, the qualitative content analysis method was used during the coding stages to identify the factors affecting the strategic design of open innovation and performance in small and medium enterprises in three intra-organizational, extra-organizational and hybrid dimensions.

Table 1: Secondary codes identified in the first step of qualitative content analysis research

Organizational dimensions	**Secondary codes**
Intra-organizational	Organizational structure - Management attitude and style to innovation - Financial resources - Knowledge management - Organizational learning - Human resources – Teamwork- Rewarding system - Training - Organizational strategy - Organizational culture - Research and development unit - Organizational technology level - Individual and behavioral factors Related to entrepreneurship and innovation
Extra-organizational	Competitors - Universities and research institutes - Customers - Suppliers - Political factors - Economic factors - Social factors - Environmental factors - Laws and regulations - Government support - Manufacturing industry property - Consulting and partner companies
Hybrid	Strategic coordination - Business space - Joint venture - Internal and external technological infrastructure - Innovation networking

Table 1 displays the secondary codes in these three dimensions.

Then, the Fuzzy Delphi technique was used to develop and confirm the factors affecting the strategic design of open innovation and performance in small and medium enterprises. Accordingly, a questionnaire based on open coding results of qualitative content analysis using the Likert scale was developed and given to the experts to determine the significance of each factor and reach a consensus among the experts about the accuracy of the identified steps. The statistical population included eight experts in this step. Then, the triangular fuzzy average and the defuzzificated value of each step were achieved. The fuzzy values of participants' responses and strategy to calculate the fuzzy average and defuzzificated value of effective factors were conducted. In the first step of Delphi, the lack of consensus among the expert was calculated using the average opinions of the members in the expert panel. Hence, each member was provided with another questionnaire with the previous opinion of each expert and the lack of consensus with the average opinion of the panel members. Then, the results of the first step were compared to the results of the second step. The survey stopped in the second step since the lack of consensus among the experts was obtained less than the very low threshold (0.2) between the first and second steps of the Delphi implementation.

Table 2: Experts' opinions on factors affecting the strategic design of open innovation and performance (survey of the second step in Delphi)

Dimension	**Effective factors**	**Triangular fuzzy average (I,m,u)**	**Defuzzificated** S_2	$\lvert S_1 - S_2 \rvert$
intra-organizational	Organizational structure	(0.61-0.86-0.97)	0.81	0.03
	Attitude to innovation	(0.59-0.84-1)	0.81	0.01
	Financial resources	(0.62-0.84-0.95)	0.80	0.02
	Knowledge management	(0.55-0.80-0.95)	0.77	0.02
	Organizational learning	(0.53-0.78-0.97)	0.76	0.02
	Human resources	(0.66-0.91-1)	0.86	0.03
	Teamwork	(0.59-0.84-0.98)	0.80	0.01
	Rewarding system	(0.55-0.80-0.95)	0.77	0.03
	Training	(0.63-0.88-0.97)	0.83	0.04
	Organizational strategy	(0.61-0.86-0.97)	0.81	0.02
	Organizational culture	(0.50-0.75-0.94)	0.73	0.04
	Research and development unit	(0.61-0.88-0.97)	0.82	0.01
	Organizational technology level	(0.62-0.84-0.95)	0.80	0.01
	Individual and behavioral factors	(0.59-0.84-0.95)	0.79	0.02
Extra-organizational	Competitors	(0.66-0.91-1)	0.86	0.05
	Universities and research institutes	(0.62-0.84-0.95)	0.80	0.01
	Customers	(0.63-0.88-0.97)	0.83	0.01
	Suppliers	(0.61-0.88-0.97)	0.82	0.02
	Political factors	(0.55-0.80-0.97)	0.77	0.02
	Economic factors	(0.59-0.84-0.98)	0.80	0.03
	Social factors	(0.56-0.82-0.97)	0.78	0.01
	Environmental factors	(0.54-0.81-0.94)	0.76	0.02
	Laws and regulations	(0.61-0.88-0.97)	0.82	0.01

	Government support	(0.62-0.84-0.95)	0.80	0.02
	Manufacturing industry property	(0.5-0.75-0.94)	0.73	0.06
	Consulting and partner companies	(0.56-0.82-0.97)	0.78	0.01
Hybrid	Strategic coordination	(0.55-0.80-0.95)	0.77	0.04
	Business space	(0.63-0.88-0.97)	0.83	0.01
	Joint venture	(0.59-0.84-0.95)	0.79	0.03
	Technological infrastructure	(0.61-0.86-0.97)	0.81	0.01
	Innovation networking	(0.56-0.82-0.97)	0.78	0.01

Then, the interpretive structural modeling technique was used to know the content relationship and leveling of the factors affecting the strategic design of open innovation and performance. Based on the three dimensions and the criteria affecting the strategic design of open innovation and performance in small and medium enterprises determined by the experts, they were placed in the rows and columns of a matrix and then the experts were asked to give their opinions about the effectiveness of barriers in pairs. The mode of experts' opinions was used for completing cells 0 and 1 in the self-interaction matrix. Tables 3, 4 and 5 present the final received (access) matrix obtained using the opinion of experts in intra-organizational, extra-organizational and hybrid dimensions, respectively.

Table 3: Final access matrix of intra-organizational dimension affecting the strategic design of open innovation and performance

	c1	**c2**	**c3**	**c4**	**c5**	**c6**	**c7**	**c8**	**c9**	**c10**	**c11**	**c12**	**c13**	**c14**	**Influence rate**
Organizational structure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Attitude to innovation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Financial resources	1	1	1	1	1	1	1	1	1	1	0	1	1	1	13
knowledge management	1	1	1	1	1	1	1	1	1	1	0	1	1	1	13
Organizational learning	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Human resources	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Teamwork	0	0	0	0	0	0	1	1	1	0	0	0	0	0	3
Rewarding system	0	1	0	1	1	1	1	1	1	0	0	1	1	1	10
Training	1	1	1	1	1	1	1	1	1	1	0	1	1	1	13
Organizational strategy	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Organizational culture	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Research and development unit	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Organizational technology level	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Individual and behavioral factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Dependence level	10	11	10	11	11	11	12	12	12	10	7	13	13	11	

Table 4: Final access matrix of extra-organizational dimension affecting the strategic design of open innovation and performance

	c1	**c2**	**c3**	**c4**	**c5**	**c6**	**c7**	**c8**	**c9**	**c10**	**c11**	**c12**	**Influence rate**
Competitors	1	0	1	1	0	0	0	0	0	0	0	0	3
Universities and research institutes	1	1	1	1	0	0	0	0	0	0	1	0	5
Customers	1	0	1	1	0	0	0	0	0	0	0	0	3
Suppliers	1	0	1	1	0	0	0	0	0	0	0	0	3
Political factors	1	0	1	1	1	1	1	1	1	1	1	1	11
Economic factors	1	0	1	1	1	1	1	1	1	1	1	1	11
Social factors	1	0	1	1	1	1	1	1	1	1	1	1	11
Environmental factors	1	0	1	1	1	1	1	1	0	1	1	1	10
Terms and conditions	1	0	1	1	1	1	1	1	1	1	1	1	11
Government support	1	0	1	1	1	1	1	1	1	1	1	1	11
Manufacturing industry property	1	0	1	1	0	0	0	0	0	0	1	0	4
Consulting and partner companies	1	0	1	1	1	0	1	1	1	1	1	1	10
Dependence level	12	1	12	12	7	6	7	7	6	7	9	7	

Table 5: Final access matrix of the hybrid dimension affecting the strategic design of open innovation and performance

	C1	C2	C3	C4	C5	Influence rate
Strategic coordination	1	0	1	1	1	4
Business space	1	1	1	1	1	5
Joint venture	0	0	1	1	1	3
Technological infrastructure	0	0	0	1	1	2
Innovation networking	0	0	0	1	1	2
Dependence level	2	1	3	5	5	

Regarding the above tables and final access matrices, the driving force (influence rate) (the effect of each factor on other factors), the highest effect in the intra-organizational dimension is related to organizational structure, attitude and style towards innovation, organizational learning, human resources, organizational strategy, organization culture and individual and behavioral factors has the influence rate of 14. In addition, this effect in the extra-organizational dimension is related to political, economic, social factors, laws and regulations and government support with the driving force of 11 and in the hybrid dimension, business space has the highest effect with the driving force of 5.

Table 6 shows the leveling of each factor affecting the strategic design of open innovation and performance in the three identified dimensions.

Table 6: Leveling of factors affecting the strategic design of open innovation and performance

Organizational dimensions	Level 1	Level 2	Level 3	Level 4
Intra-organizational	Teamwork - research and development unit - level of organizational technology	Attitude to innovation - knowledge management - organizational learning - human resources - rewarding system - training - individual and behavioral factors	Organizational structure - financial resources - organizational strategy	Organizational culture
Extra-organizational	Competitors- customers- suppliers	Manufacturing industry property	Universities and research institutes - political factors - social factors - environmental factors - government support - consulting and partner companies	Economic factors - laws and regulations
Hybrid	Technological infrastructure - innovation networking	Joint venture	Strategic coordination	Business space

Based on the above table, the factors in the fourth level have the maximum effect and driving force on the strategic design of open innovation and performance in small and medium enterprises.

5 Discussion and conclusion

This study aimed to identify and level the factors affecting the strategic design of open innovation and performance in small and medium enterprises. In general, the results of the present study in the qualitative content analysis step are as follows: After reviewing the literature and research background on open innovation and performance, as well as considering the theoretical framework and research background, and also interviewing the organizational experts, 31 effective factors were identified in three dimensions of intra-organizational (14 factors), extra-organizational (12 factors) and hybrid (5 factors). By considering the obtained results and identifying 31 factors from the analysis of interviews and comparison with the research findings, it can be concluded that the study is consistent with the studies such as Liu et al. [15], Carrasco-Carvajal et al. [4], Almeida [1], and Hakkaki et al. [13] in terms of intra-organizational dimension. In addition, the study is consistent with Vakil Alroaia [32], Popa et al. [22], Ayne et al. [2], Zarei et al. [33], and Bakhsham et al. [3] in terms of extra-organizational and hybrid dimensions by identifying 17 factors.

Regarding the confirmation of factors affecting the strategic design of open innovation and performance in small and medium enterprises in the second step, the Fuzzy Delphi technique was used by the statistical population of the

first step. Thus, it can be concluded that all the factors extracted from the qualitative content analysis were approved by the experts, minimizing the possible bias of the researcher as much as possible. The results obtained in the third step and the analysis conducted in three dimensions in the framework of the interpretive structural equations technique revealed organizational culture, organizational strategy, and financial resources were more important with a higher amount of driving force and influence in intra-organizational dimension. In other words, the managers of small and medium enterprises should focus more on the above-mentioned parameters. In addition, Almeida [1] and Hakkaki et al. [13] concluded that such factors have a higher effect on open innovation in enterprises. Moreover, economic factors, laws and regulations, etc. have higher significance and influence in affecting the strategic design of open innovation and performance within the extra-organizational framework. In this regard, Popa et al. [22] and Vakil Alroaia [32] concluded that such factors have a higher effect on open innovation in enterprises. Furthermore, business environment, strategic coordination, joint venture, etc. are more critical in affecting the strategic design of open innovation and have performance within the framework of hybrid factors. In this regard, Almeida [1], Mazzola et al. [20] and Chesbrough and Bogers [9] concluded that these factors have a higher effect on open innovation in enterprises.

Nowadays, the globalization approach, increased technological complexity, and environmental changes have caused organizations to take their concentration from closed innovation and prioritize open innovation as a growing trend for gaining competitive advantage. In spite of considering open innovation, the studies on innovation have not comprehensively dealt with open innovation strategies in improving the performance of small and medium enterprises. For this purpose, this study evaluated the theoretical concepts and identified the factors affecting the strategic design of open innovation and performance using the tools and approaches of content analysis, Delphi and interpretive structural equations to enhance knowledge in innovation studies and present an appropriate road map for managers to apply open innovation. The factors such as economic factors, as well as laws and regulations are considered among the most effective extra-organizational factors on open innovation and the performance of small and medium enterprises in this study. Thus, it is suggested that government officials should help the production of this industry by providing convenience in the economy, balancing all the parameters which affect the promotion of open innovation in small and medium enterprises, and redesigning the laws and regulations related to this sector.

Regarding the limitations of intra-organizational resources, small and medium enterprises can take advantage of external communication and inter-organizational collaborations for developing innovation. External communication makes companies access to new knowledge resources and establishes a basis for continuous learning. In external communications, enterprises attempt to find source technology in cooperation with service providers or conduct networking with the help of advanced and innovative companies. Applying external resources can decrease the time, risk and cost of innovation and also enhance flexibility and feasibility. External communications with innovative companies, NGOs, research institutions, universities, customers, suppliers, competitors, as well as public and private partners are raised as the main objective of manufacturing enterprises to create, implement, disseminate ideas, and improve the open innovation process. Considering organizational culture is one of the most critical requirements in the development of open innovation in small and medium enterprises that is possible only through continuous training, learning, and internal communication. Internal communications emphasize active cooperation and involvement of employees in the process of implementing open innovation. Cooperation among different units and employees leaves a positive effect on the elimination of task walls and the sharing of knowledge in different departments of the organization. In addition, it results in the development of insight into the existing expertise and capabilities of the organization. Intra-organizational communication results in a bridge between various stakeholders in the organization and different units for achieving a better understanding of innovative opportunities. Nevertheless, implementing internal communications and creating cooperation in the organization is a highly difficult task. It is suggested that the small and medium enterprises in Yazd should use technology infrastructure such as weblogs, social networks, online forums, and other communication technologies for reinforcing internal communication and enriching the innovative activities of employees and shareholders. Based on some significant and results of the present study, the following paths are suggested for further studies: By regarding other strategies and factors and using mathematical programming, it is feasible to determine the best combination of strategic goals for implementation in other industries and types of services in future periods. Further, the present study developed the framework related to the factors affecting the design of open innovation strategies at a theoretical level but the proposed framework was not tested in a specific enterprise. Accordingly, it is useful to conduct a case study in a selected enterprise and asses it using the proposed framework. This study identified the factors affecting the design of open innovation strategies and performance. Conducting other quantitative and qualitative studies can help identify the factors and strategies affecting the open innovation approach more precisely. This study can be used by managers, officials, and activists of small and medium enterprises to improve their performance.

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