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## Open Innovation and SMEs: Providing a Model for Business Development (an Application on Iranian Industrial Park)

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### Abstract

The aim of this study is providing a developed model for Small and Mid-size Enterprises (SMEs) in Open Innovation (OI) activities. In this regard, an appropriate model was defined by studying the literature. Then, after selecting a sample of 60 SMEs the data were collected by a questionnaire and were analyzed with the smart PLS software. In the third stage, the relative importance of factors was tested from the perspective of 10 experts in the field of OI along with experienced managers of the SMEs with more than 15 years of work experience with the help of ANP and Promethee methods. The results showed that these factors include the parameters: product characteristics, inter-organizational factors, and environmental factors. In addition, the most important factors include product characteristics. Finally, several implications were made such as changing the degree of SMEs' participation in Open Innovation Activities (OIA), over time according to continuous monitoring of these moderators.

**Keywords:** Small and mid-size enterprises, Open innovation, Product characteristics, Inter-organizational factors, Environmental factors.

## 1 | Introduction

Policymakers have lunched many initiatives to stimulate the adoption of Open Innovation (OI). Given the reluctance of Small and Mid-size Enterprises (SMEs) to engage in OI, policy initiatives strive to encourage them to open up in order to faster technological progress and economic growth. Public institutions even provide consulting services to counter associated risks [37]. However, SMEs are key levers in both developed and developing economies. This sector not only contributes to more than 90% of the number of businesses and half of the world's employment, including micro businesses (businesses with less than 10 employees), but also accounts for 97% of businesses in Iran and are important sources of innovation [1]. For these reasons, governments are looking for ways to increase the productivity of SMEs.

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Several researchers have identified OI as an important strategy to overcome the weaknesses of SMEs, such as resource constraints, capacity constraints, and exposure to various types of risks [2], [3]. OI, defining as "the purposeful knowledge flow into or out of the organization in order to accelerate innovation and expand markets to exploit innovation outside the organization" [4], provides more efficient use of technology and knowledge for companies, which couldn't be accessed in any other way. Thanks to OI, companies can take advantage of innovative organizational talent instead of relying solely on internal research and development resources [5], [6]. Additionally, companies can reduce the risks of developing intellectual properties, because using OI can reduce fix costs (such as R&D personnel costs) in return for more variable costs associated with the purchase of tangible intellectual properties (such as the purchase of a patent). OI, with the help of the combination of internal innovation and systematic scanning of external knowledge, is a powerful lever for increasing the flexibility and efficiency of a firm's internal and external resources. In general, companies are creating financial and non-financial benefits for themselves by utilizing the benefits of Open Innovation Strategies (OIS) [7], [8].

Definition of OI shows that the concept of openness is in line with internal innovation and external exploitation of innovation. Despite the fact that OI in the past was conceptually contradictory with closed innovation, newer studies suggest the relationship between them as a spectrum of innovation [9]. In other words, Cornell [9] suggests that the superiority of choosing an OI approach over the closed one depends on the organization's conditions. A company may benefit from OIS in order to fulfill some of its projects, and at the same time may utilize closed innovation strategies for its other projects. Also, in some competitive environments, especially in the development of defensive technologies, companies rely exclusively on closed innovation strategies. In other words, a company, regardless of the industry it is operating in, should not use OIS [10] in all its periods of operation, since no matter how strongly the laws protect the intellectual properties of a company, some of its trade techniques and knowledge will be vulnerable to expose to other competitors. Therefore, companies should not merely be bound by the use of open or closed innovation strategies, since both approaches can be beneficial for them depending on circumstances [9]. Hence, the understanding of innovation as a spectrum, which gets closed in the one hand and becomes open on the other hand depending on the degree of firms' participation in Open Innovation Activities (OIA), can be useful. One of the growing trends in the world is about SMEs to take advantage of OIS [11]. Given the reluctance of SMEs to engage in OI policy initiatives strive to encourage them to open up in order to foster technological progress and economic growth. Public institutions even provide consulting services to counter associate risks [37]. However, to effectively increase collaboration for innovation in SMEs, not all OIS, policy mechanisms and frameworks may be equally appropriate. Taking into account the fact that some firms, especially smaller ones, face resource and capability constraints or cognitive barriers regarding the adoption of OI, major benefits such as reaching external knowledge and distant experts with unrestricted scope may be difficult to use [38]. Researches in this field have shown that the use of OIS varies according to the characteristics of the industry. Also, the growth of the use of these strategies is depicted as sudden and unpredictable jumps over time instead of a steady rate of growth [12]. On the other hand, scholars have shown that there is still very few number of SMEs benefiting from OIS, and many more can benefit from them even with limited participation in OIA [9]. So far, many studies have examined the utilization of OI in large companies, and there have not been enough researches on why SMEs, particularly in Iran, are not willing to participate in OIA. Therefore, this research seeks key factors that influence the decision of SMEs to participate in OI in the environment of Iran.

A review of OI literature in relation to Iranian SMEs shows that OI is not well-suited in this sector [13] and SMEs in Iran has problems such as lack of resources, lack of strong enough cash flow, lack of R&D department, innovation weakness, and required raw material supplement problems that cause poor performance. Paying more attention to the causes of SMEs' tendencies to participate in OIA can minimize their weaknesses and enhance this section's development [6]. Recent experiences in many countries all around the world have shown the effectiveness of the OIS in promoting the performance of SMEs [14]. As any innovation system's final output must ultimately produce new products and deliver new services, the considered function is essential in the innovation system [39]. Additionally, the

knowledge that companies gain from cooperating with other organizations is very valuable to their success and gaining a competitive edge in the market [15]. What is evident is that the identification and the ranking of factors affecting the decision of SMEs to participate in OIA in order to assess the OI environment from the perspective of SMEs in Iran are the first prerequisites to increase the participation of this sector in OI environment in order to benefit from the advantages.

Due to the concept of OI, which was introduced in management literature in 2003, this research area still has a lot to study about [11]. There are several important research gaps in the study of OI literature [9]. This paper examines one of the most important research gaps proposed which is related to the critical need to identify key factors affecting the degree and the efficiency of SMEs' participation in OI environment [9], [16], [17]. In response to this need, the present study proposed a developed model of moderating factors affecting the decision of SMEs in Iran to exploit the benefits of OI or in other words, to identify the most important factors in accelerating or hindering the implementation of OIS in Iranian SMEs, which includes three broad categories such as product characteristics, inter-organizational factors and environmental factors. These factors are going to be explained in the literature review section. In the proposed model, the effect of factors such as technological turbulence and market turbulence has been investigated, which has not yet been sufficiently examined, especially in Iran.

The turbulent environment imposes various constraints on corporates' innovative performance that has not yet been examined as a factor influencing Iranian SMEs' decision to participate in OIA. Environmental changes include technological turbulence and market turbulence. Technological turbulence refers to the rate of changes in technology and the unpredictability of technology that rapidly abolishes the company's technical knowledge and requires the development of a new technology. Market turbulent refers to the rate of changes in customers' preferences and customers' demands that rapidly disrupt the current market knowledge of companies. Companies need to respond more quickly to unanticipated changes and supplant multiple alternatives to meet customer needs to maintain innovative market performance. In a highly turbulent market environment, the role of technological turbulence in OI should not be underestimated, because, in a rapidly changing market environment, companies do not know how to use these technologies in favor of the knowledge of market which is changing rapidly. A company that wants to prevent its technology from becoming obsolete should be able to rapidly commercialize it or develop it jointly [15]. In the field of OI, the effect of technological turbulence and market turbulence factors, which are less considered in the environment of Iranian SMEs, on these enterprises' tendency to take participate in OIA have been investigated. This model includes three general categories of product specifications, internal factors and environmental factors. Therefore, the main stimulus of the present research is to answer this main question: which factors moderate Iranian SMEs' degree of participation in OIA? In the following sections, the study includes a literature review, research methods, the empirical results, discussions, limitations, theoretical suggestions, and suggestions for future researches.

## 2 | Literature Review

Today, by increasing labor mobility, division of labor due to increasing globalization activities, increasing protection of intellectual properties due to the enactment of laws, and technical advances in remote cooperation, open source innovation has become a common strategy for businesses [5]. All of these factors facilitate and moderate the participation of businesses in the OI environment around the world. Other effective factors that influence (enhance / hinder) managers' decisions on the degree of participation in OIA, specifically SMEs, include three categories of factors: 1) product characteristics, 2) factors inter-organizational, and 3) environmental factors. Therefore, in line with the purpose of this study, which is to increase the participation of the SME sector in OIA, the following hypotheses are proposed:

## 2.1 | Product Characteristics Moderate the Degree of Iranian SMEs' Participation in OIA

OIA are more common in industries that produce more complicated products. Products with complex technology are more likely to require two or more innovative partners [10], [18], [19]. On the other hand, OI is more common in industries in which products have a shorter life cycle. The lifecycle of products often encourages SMEs to collaborate with other influential companies in the value chain in order to commercialize products more quickly. In other words, participation with other SMEs significantly reduces the innovative products' time of entering the market [9], [13]. Innovation are widely considered to be valuable capabilities associated with competitive advantage [40]. SMEs active in high-tech industries are seeking to take advantage of OI in line with their technological strategies [20]. It means in the initial and final stages of products maturity they tend to be more cooperative, especially with universities. After this stage, using more close innovation strategies, they enter the phase of innovation maturity, then again in the stage of innovation commercialization and marketing, they tend to participate more in OIA [9].

## 2.2 | Inter-Organizational Factors Moderate the Degree of Participation of Iranian SMEs in OIA

Cornell [9] believes that participation in OI needs an open business plan which helps an SME create a beneficial exchange of knowledge with the outside world. Business plan of a company affects its strategic management decisions in relation to participation in OIA [7]. For example, a SMEs may consist of several engineers and its business plan may be based on selling the patents of its inventions to other companies, while another SMEs products and commercializes its products through the acquisition of other companies' patents. On the other hand, the unique opportunity of a SMEs to gain access to resources and capabilities positively affect its ability to innovate and commercialize. A SMEs with more limited resources is looking for partnerships with other innovative partners. SMEs which do not have enough resources and capabilities needed to manage the whole process of exploration to exploitation of innovation are more willing to engage in OIA [21], [22]. Scholars have shown that there is a high correlation between the level of participation in OI and the need for more resources in SMEs. Accessing more resources can be seen in a variety of ways, such as increased funding, a more efficient supply chain, marketing capabilities, regulatory and legal resources, technical expertise, credit enhancement, and brand popularity and other assets and capabilities [3], [8]. Some scholars point out other vital elements that increase the effectiveness of participation in OIA for SMEs, including absorptive ability, search capability, cultural intelligence, effective organizational structure, and strong leadership [8], [9], [11], [21], [24], [25], [26], [27]. Absorptive capability is a dynamic and fundamental ability that is necessary for successful participation in OIA for SMEs and is related to the capability of a company in successful learning, analysis, and exploitation of external knowledge of the organization [23], [24], [28]. Such a capability requires the enhancement of an OI culture and sufficient experience to understand external innovation [3], [11], [25]-[28]. Also, search capability refers to the effective search in the environment in order to identify OI opportunities, and almost all SMEs are weak in searching due to their limited knowledge and limited ability to seek out externally-developed knowledge. Scholars have shown there is a high correlation between search capability and the SME's innovative performance [9], [24].

Cultural intelligence refers to the ability of an SME to create effective collaboration among members of diverse cultures. High cultural intelligence is an essential factor for working with foreign or local companies which have high cultural diversity [9], [13]. The use of organizational structures designed for OIS, such as organic structures, known for enhancing innovative capabilities in the organization, is necessary for SMEs willing to engage in OIA because such innovation structures encourage bottom-up innovation as well as the exchange of knowledge in the organization [8], [9]. On the other hand, strong leadership can positively affect the willingness of an SME to engage in OIA. They state that strong leadership is influential through resource management, performance management, and organizational motivation, the allocation of human and financial resources, the flow of knowledge, and the

management of processes. Leaders can continuously strengthen the willingness and ability of SMEs to participate in OIA, through planning, monitoring, communicating and providing performance feedback along with the provision of internal and external rewards, [11], [19], [25], [27].

Excessive confrontation with multiple risks can undermine innovation, especially radical ones. Scholars have shown that SMEs are more willing to engage in OIA when they encounter high-risk innovation projects. The advantage of collaborating in OIA is that the risks and rewards of the outcome will be distributed among partners. On the other hand, the risks associated with R&D activities decrease for SMEs. Scholars have also shown that the reduction of non-systematic risks of R&D projects can strengthen the competitive position of SMEs in an industry [13], [19].

Additionally, participation in OIA, according to researchers, requires OI culture [3], [19], [25], [27]. Such organizations are potentially willing to sell or buy intellectual properties' rights to/from other organizations or partners in order to develop and commercialize innovation [3]. If an SME is willing to participate actively in OIA, it will promote OI culture continually. Such a goal is achievable through encouraging adaptive learning culture and promoting appropriate collaboration as well as knowledge management in the field of OI [3], [25], [29]. Previous experiences of an SME in contributing to OIA affect its future participation, as an SME builds its future strategies based on what it has learned from past experiences [2]. In other words, the poor performance of an OI strategy in the past can lead to a lack of participation of an SME in future OIA and vice versa [9].

### 2.3 | Environmental Factors Moderate the Level of Participation of Iranian SMEs in OIA

Characteristics of industry affect the degree of SMEs' participation in OIA [12]. For example, OIA can bring economies of scale to members of a collaboration network, especially for highly scale-intensive industries. Japanese companies active in the electronics industry rely on R&D collaborations to reach economy of scale. He also states that OIA in different industries have been adapted in various ways. For example, while outward OI is more common in high-tech industries, inward OI is more popular in low-tech industries [9]. In line with confirming the role of product characteristics in SMEs' tendency to adopt OI approach. In some industries, such as food industry, the dominant strategy is secrecy, which means the characteristics of the industry and the company's central strategy play an important role in the desire to participate in OIA [12], [25]. Development of joint inter-organizational innovation and commercialization activities are dependent on efficient network structures because these structures reflect and influence the extent to which SMEs participate in OIA [8], [13], [27], [30]. Companies, which use OI, are heavily dependent on the communications network system and that the communications network is changing over time [10]. They also claim that the most efficient network for the innovation exploration stage is usually a relatively open system between partners. When innovation becomes mature, it is necessary to make this network more closed and between a smaller number of partners with limited relationships [10]. This strategy generally increases the efficiency and the speed of the commercialization process of production [13]. The risk of participation in long-term relationships between organizations in the form of collaborative networks is an issue that has been warned by numerous studies because researchers believe that this can lead to network stagnation, which means collaboration reduction, new thinking avoidance, and resistance toward expanding the network of cooperation with new partners. It is mentioned that network structure conduciveness depends on partners' commitment, trust among the members, and the extent to which they participate in sharing resources, capabilities, experiences, and expertise. Such criteria along with the easiness of entering OI networks affect an SME's tendency to collaborate in the field of OI [2], [3], [8], [11], [14], [24], [26], [27], [31]. If the cost-benefit ratio increases for collaborating in OIA, SMEs will be less willing to engage in such activities [9]. For example, the larger the network becomes, the more it is expensive and the more difficult it is to be managed [12], [29]. Costs of local and international cooperation are different because international cooperation can increase the costs of SMEs in certain circumstances, especially when talking about barriers of globalization such as different languages and logistical issues. SMEs often prefer to work in local markets rather than in international ones, in which they know



customers, industry characteristics, and regulations better. In other words, developing activities in large geographical and dispersed markets increase their costs [9]. Despite the benefits of OI, SMEs are cautious about establishing such collaborations. They compare the risks of participation in OI to its benefits. For example, financial instability increases the potential partners' bankruptcy and the risk of establishing cooperative relationships. Therefore, selecting an appropriate partner for OIA is an important issue [2], [12]. On the other hand, establishing such collaborations with customers in all aspects of R&D process increases the risk of disclosing intellectual properties, according to some scholars [2], [18], [29].

The legal environment varies from country to country. These laws and regulations affect the ability of SMEs to implement OIS. Legal instability leads to undermining of OIA. Countries that have firm laws about intellectual property protection boost OIA among SMEs. Therefore, SMEs, before participating in any OIA with other partners, take into account the laws and regulations that monitor the protection of intellectual property, since many companies' motivation to implement OIS is to access other organizations' intellectual properties [18].

On the other hand, Cornell [9] states that restricting laws in some countries prevent the withdrawal of technology and knowledge from the country. This phenomenon is especially common when it comes to countries' defensive technology and knowledge [8], [9]. Government decisions, whether in the form of support or interference, affect the decision of SMEs to participate in OIA. For example, in a country where tax incentives are set up to attract foreign companies' cooperation in R&D projects are one of the government supportive levers to encourage SMEs to participate in OI networks. Many OECD countries are actively seeking to increase OIA between industry and education through governmental funding [8], [12], [32].

On the other hand, technological turbulence means rapid technological changes in products and production processes, which significantly reduces the life cycle of products and challenges SMEs. High technological turbulence makes SMEs more likely to use OIS because such strategies help them increase technology return rate when the technology is new. Companies, in rapidly changing environments, need to have access to new knowledge and new competitive advantages [7], [15], [33]. In addition to technological turbulence, turbulence in the market also influences the decision of SMEs to participate in OIA. Market turbulence refers to the rate of changes in the composition of customers, their preferences, competitive market conditions, and the degree of ambiguity and risk of business processes. SMEs that operate in turbulent environments need more changes in their products and services, due to changes in customer needs and desires. They are also more likely to participate in OIA. In stable markets, companies are less willing to align their products with the changing needs of customers, and therefore they feel less willing to participate in OIA [7], [29], [34]. Explanations on the impact of technological turbulence and market turbulence on the degree of Iranian SMEs' participation in OIA lead to the following two hypotheses:

- I. Technical turbulence moderates the degree of Iranian SMEs' participation in OIA.
- II. Market turbulence moderates the degree of Iranian SMEs' participation in OIA.

Inspired by the results of previous literature, the importance of deciding to participate in OIA for SMEs is obvious. Despite the fact that previous researches have consistently emphasized the critical role of product characteristics, inter-organizational factors, and environmental factors, most of them, especially domestic scholars, have studied the role of these factors without considering technical turbulence and market turbulence in this issue.

Thus the present study, with the help of gathering many factors, has provided a developed model for factors moderating the decision of SMEs to participate in OIA as shown in *Fig. 1*.

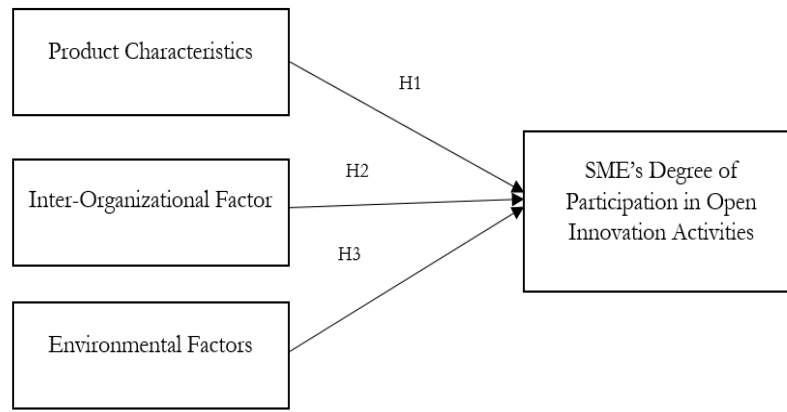


Fig. 1. The theoretical model.

### 3 | Research Methods

#### 3.1 | Data Collection and Sample

In this section, in order to achieve the research's objectives, we examine theoretically the hypotheses. Therefore, the place of study, sampling method, data collection, method of measuring variables, research tool and data analysis methods have been described. By purpose, this cross-sectional research is a qualitative one and, by the method, this survey-based research is a descriptive one. To assess the hypotheses, data were collected from the managers of SMEs, with at least 5 years of professional experience, operating in industrial park by the use of convenient sampling method through two questionnaires. To collect data, the questionnaires were designed through the study of literature, dissertations, articles, and databases related to the research topic (both domestic and foreign ones). The first questionnaire was designed to test the theoretical model for moderating factors affecting the degree of SMEs' participation in OIA. It was arranged based on the Likert scale and assessed the perspective of 60 SMEs which have 10 to 49 employees. To determine the validity of the internal structure of the questionnaire, the convergent validity method was used with the Average Variance Extracted (AVE) of more than 0.6 and the divergent validity method was used by Fornell and Larcker methods. Since the partial least squares method was used to test the model with PLS 2 software, so to calculate the reliability of the questionnaire and the model from indicators such as Cronbach's alpha (more than 0.7), combined reliability (more than 0.7) and coefficients factor loads (more than 0.6) have been used [40]. The result is shown in *Table 1*.

Table 1. Convergent reliability and reliability.

Latent Variables	Observable Variables	Convergent Validity AVE	Reliability Combined Reliability	Cronbach's Alpha
Product characteristics	Q <sub>1</sub> -Q <sub>3</sub>	0.619	0.866	0.794
Inter-organizational factors	Q <sub>4</sub> -Q <sub>9</sub>	0.759	0.925	0.885
Environmental factors	Q <sub>10</sub> -Q <sub>19</sub>	0.636	0.729	0.777

Subsequently, the second questionnaire, using the pairwise comparisons, determined the relative importance of the model's factors from the perspective of 10 experts in the field of OI along with experienced managers of the SMEs with more than 15 years of work experience. Therefore, in the present research, the field method is used to determine the key factors and confirm the theoretical model, the factors were weighed using the ANP method and were ranked using the Promethee method. In the following section, these methods are explained.

The power of the relations between the latent variable and the observable variable is defined by the factor loading ( $\lambda$ ). The value of factor loading is defined between zero and one. If the factor loading is less than 0.3, the relation between the variables is considered weak and is discarded. However, the acceptable value of factor loading is between 0.3-0.6 and values greater than 0.6 are desirable. In factor analysis, variables that measure a latent variable must have high factor loadings with that latent variable, and low factor loadings with other latent variables. The t-test is used to evaluate the significance of the relations between the variables with a significant level of 0.05. Therefore, if the t-value is calculated less than 1.96, the relation is not significant [35].

The Analytic Network Process (ANP) is a more general form of the Analytic Hierarchy Process (AHP) process used in Multi-Criteria Decision Making (MCDM). The ANP structures a decision problem into a network then use a system of pairwise comparisons to measure the weights of the components of the structure, and finally to rank the alternatives in the decision. The first step in the ANP method is creating a model and structure of the problem. The problem should be expressed clearly and be analyzed into a logical system like a network. Such a network structure can be achieved with the help of decision makers through brainstorming sessions or other appropriate methods. In the second step, pairwise comparisons are used to find out how the elements in the network are interacting [36]. The weights used at this stage are the input values to indicate the priorities of each criterion and sub-criterion in the Promethee method.

Promethee method is a multi-criteria decision-making methodology designed to discuss qualitative and discrete alternatives by Brans et al. [42]. This method is quite simple compared to other multi-criteria analysis methods, and it is especially appropriate for issues that require a limited number of actions to be ranked based on several criteria that are sometimes contradictory. This approach can be one of the most powerful decision-making methods that can help managers choose the best decision choices. The ranking of actions is performed by comparing the pair of actions in each criterion. The comparison is measured based on a predefined preference function with the domain  $[0, +1]$ . The preference function  $P$  is a function which compares two actions “a” and “b” in terms of the criterion  $j$  as follows:

$$P_j(a, b) = P[d_j(a, b)]. \tag{1}$$

$d_j(a, b) = f_j(a) - f_j(b)$  denotes the difference in the size of two actions for criterion  $f_j$ . This difference for criteria that have to be maximized will be significant only if  $f_j(a) > f_j(b)$ . For the criteria that have to be minimized, the opposite condition is true. When a preference function has been associated with each criterion by the decision maker, all comparisons between all pairs of actions can be done for all criteria. A multi-criteria preference degree is then computed to globally compare every couple of actions:

$$\Pi(a, b) = \frac{\sum_{i=1}^k \pi_i P_i(a, b)}{\sum_{i=1}^k \pi_i}. \tag{2}$$

In order to position every action with respect to all the other actions, two scores are computed:

$$\varphi^+(a) = \sum_{b \in k} \Pi(a, b). \tag{3}$$

$$\varphi^-(a) = \sum \Pi(a, b). \tag{4}$$

The positive preference flow quantifies how a given action is globally preferred to all the other actions while the negative preference flow quantifies how a given action is being globally preferred by all the other actions. The positive and negative preference flows are aggregated into the net preference flow:

$$\varphi(a) = \varphi^+(a) - \varphi^-(a). \tag{5}$$

This is the Promethee II complete ranking which is obtained by ordering the actions according to the decreasing values of the net flow scores. In other words, the criterion with the highest net flow has priority [42].



## 4 | Results

### 4.1 | The PLS Output

Table 2 shows the output of Smart PLS software which contains the factor loadings of the model's criteria. As mentioned, factor loadings above 0.3 are acceptable and criteria with factor loadings lower than 0.3 are excluded. According to the results, all model's factors have been confirmed. Also, the t-value was extracted as follows which are all greater than 1.96, thus, they're all acceptable.

**Table 2. The smart PLS software output for t-values and factor loadings of the research model's criteria.**

Latent Variables	Observable Variables	T-Value	Factor Loadig	Confirmed/not Confirmed
Product characteristics	More complicated products	274.139	0.978	✓
	Short product life cycle	317.906	0.959	✓
	Be in the earliest and latest stages of a product maturity (using more close innovation activities in between)	140.001	0.985	✓
Inter-organizational factors	High openness of firms' business models	266.000	0.977	✓
	Increase in need to access others' complementary resources and capabilities	52.338	0.936	✓
	Firms' high OI capabilities (absorptive capacity, search capabilities, cultural intelligence, conduciveness of organizational structure, strong leadership)	123.909	0.970	✓
	Increase in need to share project failure risks	81.671	0.963	✓
	Stronger OI culture	116.424	0.972	✓
	Increase in successful OI experiences	65.879	0.939	✓
Environmental factors	High scale-intensiveness an industry	476.452	0.991	✓
	High conduciveness of the network structure	98.137	0.968	✓
	High-tech and knowledge-intensive an industry	738.247	0.993	✓
	Low degree of industry reliance on secrecy	319.997	0.987	✓
	High easiness of entering OI networks	251.580	0.973	✓
	Low costs and risks of OI (costs associated with the size of the network, language diversity, cultural constraints along with the risks associated with the disclosure of intellectual property, reducing the cost-benefit ratio of OIA, partner insolvency)	99.954	0.974	✓
	High technological turbulence (high rate of rapid technological change in products and processes)	527.244	0.992	✓
	Low legal interventions and high legal stability and protection of intellectual property (local and international)	158.229	0.977	✓
	High market turbulence (high rate of rapid changes in the composition of customers, their preferences, and competitive market conditions)	367.924	0.989	✓
	High governmental support and funding	258.462	0.984	✓

### 4.2 | Weight Measurements and Ranking the Model's Criteria and Sub-Criteria Using ANP and Promethee Methods

After designing the ANP hierarchy model in super decision software and entering the data collected from the pairwise comparisons questionnaire, the weights of all criteria were calculated. In the third stage, in order to rank criteria, the value of the index  $\Phi$  was calculated by Promethee software. Based on the outputs, we determined that the model's inconsistency is 0.08, which is less than 0.1, so the system's consistency is confirmed. Due to the system compatibility, we introduce the data of the paired comparisons into the

Super Decision software and calculate the weight of each of the factors. The output of this part is shown in *Table 3*.

**Table 3. The model's main factors' weights and ranking.**

Factor	Weight	$\Phi$	Rank
Product characteristics	0.55	0.50	1
Inter-organizational factors	0.37	0.23	2
Environmental factors	0.08	-0.73	3

Given the output of Promethee software, the value of  $\Phi$  for the first criterion, which is Product Characteristics, is 0.50 and more than other criteria. Therefore, it is the most prior criterion. Now, by assessing each sub-criterion of each factor, the weight and rank of each sub-criterion will be extracted. In the next step, we calculate the weight associated with the indicators for the product characteristics. By performing Super Decision software, the value of inconsistency for “product characteristics” criterion is equal to 0.00, which is less than 0.1, so the system's consistency is proven. In the following, we calculate the weight of the sub-criteria of this element using Super Decision and ranking them using the Promethee software. The result is shown in *Table 4*.

**Table 4. The weight and ranking of sub-criteria relative to the factor of product characteristics.**

Sub-Criterion	Weight	$\Phi$	Rank
More complicated products	0.61	0.54	1
Short product life cycle	0.31	0.46	2
Be in the earliest and latest stages of a product maturity (using more close innovation activities in between)	0.08	-1.00	3

Given the output of Promethee software, the value of  $\Phi$  for the first criterion, which is more complicated products, is 0.54 and more than other sub-criteria. Therefore, it is the most prior sub-criterion of Product Characteristics. By performing Super Decision software, the value of inconsistency for “inter-organizational factors” criterion is equal to 0.08, which is less than 0.1, so the system's consistency is proven. In the following, we calculate the weight of the sub-criteria of this element using Super Decision and ranking them using the Promethee software. The result is shown in *Table 5*.

**Table 5. The weight and ranking of sub-criteria relative to the factor of inter-organizational factors.**

Sub-Criterion	Weight	$\Phi$	Rank
High openness of firms' business models	0.08	-0.15	4
Increase in need to access others' complementary resources and capabilities	0.03	-0.55	6
Firms' high OI capabilities (absorptive capacity, search capabilities, cultural intelligence, conduciveness of organizational structure, strong leadership)	0.13	0.29	2
Increase in need to share project failure risks	0.04	-0.48	5
Stronger OI culture	0.16	-0.07	3
Increase in successful OI experiences	0.56	0.96	1

Given the output of Promethee software, the value of  $\Phi$  for the first criterion, which is increase in successful OI experiences, is 0.96 and more than other sub-criteria. Therefore, it is the most prior sub-criterion of inter-organizational factors. By performing Super Decision software, the value of inconsistency for “environmental factors” criterion is equal to 0.06, which is less than 0.1, so the system's consistency is proven. In the following, we calculate the weight of the sub-criteria of this element using super decision and ranking them using the Promethee software. The result is shown in *Table 6*.

**Table 6. The weight and ranking of sub-criteria relative to the factor of environmental factors.**

Sub-Criterion	Weight	$\Phi$	Rank
High scale-intensiveness an industry	0.06	0.09	5
High conduciveness of the network structure	0.34	0.92	1
High-tech and knowledge-intensive an industry	0.13	0.16	4
Low degree of industry reliance on secrecy	0.02	-0.64	9
High easiness of entering OI networks	0.02	-0.66	10
Low costs and risks of OI (costs associated with the size of the network, language diversity, cultural constraints along with the risks associated with the disclosure of intellectual property, reducing the cost-benefit ratio of OIA, partner insolvency)	0.03	-0.43	8
High technological turbulence (high rate of rapid technological change in products and processes)	0.06	-0.19	7
Low legal interventions and high legal stability and protection of intellectual property (local and international)	0.17	0.63	2
High market turbulence (high rate of rapid changes in the composition of customers, their preferences, and competitive market conditions)	0.06	-0.15	6
High governmental support and funding	0.11	0.26	3

Given the output of Promethee software, the value of  $\Phi$  for the first criterion, which is high conduciveness of the network structure, is 0.92 and more than other sub-criteria. Therefore, it is the most prior sub-criterion of Environmental Factors.

## 5 | Discussion

In this study, inspired by the research literature, the importance of increasing the participation of SMEs in OIA is identified. Despite the fact that literature continuously emphasizes the critical role of OIS in increasing the productivity of SMEs, most of the previous researches, especially domestic ones, have studied the role of product characteristics, inter-organizational and environmental factors. Therefore, the potential impact of technological turbulence and market turbulence, especially in Iran, have been less considered. The present study has been helpful in collecting a number of moderating factors that have contributed to the degree of SMEs' participation in OIA in Iran.

One of the categories of factors moderating Iranian SMEs' degree of participation in OIA is product characteristics. Product characteristics can enhance or hinder the probability of SMEs benefiting from OIA. These characteristics include the complexity of products, the product life cycle, and the product's earliest and latest stages of maturity. This research confirms the relative priority of the product characteristics in Iranian SMEs' degree of participation in OIA by analyzing the collected data. Due to the reasons given by experts, product characteristics include high complexity of products, short product life cycle, and being in the product's earliest and latest stages of maturity, increase the degree of Iranian SMEs' participation in OIA. In other words, these factors increase the likelihood of benefiting from participating in OIA by SMEs. Experts assert that the production process of technologically complicated products is often longer and it requires more financial resources. It is apparent, therefore, that SMEs with more limited financial resources and capabilities would be more willing to collaborate in OIA. Also, the risk of pursuing an advanced technology project is high. Innovation collaboration between companies enables them to divide this risk by allocating less funding by each partner. On the other hand, products with more sophisticated technology will expose the company to the risk of intellectual property disclosure, because complex products often consist of relevant products. Experts believe this reason is one of the main motivations for SMEs to participate in OIA. Such a result is in line with other studies [9], [10], [13], [19], [20]. Although it is rarely possible to find a study examining the environment of Iran. Therefore, the first hypothesis (H1), that is the product characteristics moderate the degree of Iranian SMEs' participation in OIA, is approved.

The research emphasizes the undeniable moderating role of inter-organizational factors in Iranian SMEs' degree of participation in OIA. These factors include openness of firms' business models, the need to access others' complementary resources and capabilities, SMEs' OI capabilities (absorptive capacity, search

capabilities, cultural intelligence, conduciveness of organizational structure, and strong leadership), the need to share project failure risks, OI culture, and successful OI experiences. This conclusion confirms a large body of literature on the subject that inter-organizational factors have proven to have moderating impact on the degree of SMEs' participation in OIA [2], [3], [7]-[9], [11], [13], [19], [21]-[29]. Due to the importance of this issue, experts point out that the SMEs' managers' beliefs about the effectiveness and efficiency of participating in OIA depend heavily on the success or the failure of their past experiences and if their expectations don't meet the desired outcomes it may even lead to the formation of a cognitive bias against participating in such activities. They believe that acquiring successful experiences in the past will lead to optimism and willingness to participate in this field in the future. Therefore, the second hypothesis is confirmed. In other words, inter-organizational factors moderate the Iranian SMEs' degree of participation in OIA.

In addition, the findings of this study show the moderating effect of environmental factors on Iranian SMEs' degree of participation in OIA. Environmental factors contain scale-intensiveness of an industry, conduciveness of the network structure, high-technology and knowledge-intensiveness of an industry, degree of industry reliance on secrecy, the easiness of entering OI networks, the costs and the risks of OI (costs associated with the size of the network, language diversity, cultural constraints along with the risks associated with the disclosure of intellectual property, reducing the cost-benefit ratio of OIA, and partner insolvency), technological turbulence, legal interventions and high legal stability and protection of intellectual property (local and international), market turbulence, and governmental support and funding. Many studies confirm this conclusion [2], [3], [7]-[13], [15], [18], [19], [24]-[27], [30]-[34]. Particularly, experts point out the higher the team members of an OI network conduciveness, the higher the SMEs' willingness to participate in OIA. Higher conduciveness means committed partners in allocating resources, capabilities, experiences, trust, and expertise. Experts believe that conduciveness of the network structure also depends on the commitment of partners to actively participate in the collaboration network, acceptance of new ideas, and acceptance of new partners. Consequently, the third hypothesis (H3) is approved. In other words, environmental factors moderate Iranian SMEs' degree of participation in OIA.

Finally, despite the less-considered role of technological turbulence and market turbulence in scholars, particularly domestic ones, and despite their rankings as the sixth and seventh important factors, this research has strongly confirmed its positive impact on Iranian SMEs' degree of participation in innovation activities. Due to the strong moderating impact of these factors on Iranian SMEs' degree of participation in innovation activities, along with their relatively low priority, experts point out different reasons. They justify that when the SMEs' market environment becomes more turbulent and vague, under which circumstance the needs and preferences of customers frequently change, these organizations should strive to compete with other companies and stay ahead of the competition and need to acquire and exploit externally-developed knowledge and technology. The competitive environment is chaotic when there is a rapid change in technology that will create new expectations in the market, but because the costs of shifting to a new technology is high, due to the current economic conditions in Iran, and the type of industry in the assessment of this criterion is very influential, the role of these two factors, despite their high impact, is considered less important than other factors. By the way, the ambiguity in the environment (turbulent environment) and the low technologically developed SMEs (non-turbulent technology status) in Iran could have caused such a result, according to the experts. Therefore, two sub-hypotheses of this research were also confirmed. In other words, technical turbulence moderates Iranian SMEs' degree of participation in OIA (H31); and market turbulence moderates Iranian SMEs' degree of participation in OIA (H32).

## 6 | Theoretical Suggestions

As said, positive and negative findings regarding the impact of SMEs' participation in OIA in various researches show that, as many SMEs all over the world benefit from these types of activities, some of them may be reversely affected [28]. This indicates the existence of moderating factors affecting the

degree and the effectiveness of SMEs' participation in OIA. Therefore, this research aims to collect the set of these factors and categorize them into three groups (product characteristics, inter-organizational factors, and environmental factors) considering the role of technological turbulence and market turbulence according to the environment of Iran as shown in a developed model in *Fig. 1*. In other words, these factors or conditions affect the probability of an SME to benefit from participation in OIA. Therefore, the following theoretical suggestions can be offered to SMEs' managers before they decide to engage in OI contributions:

- I. SMEs should explicitly outline the degree and the scope of participation in joint activities in the field of OI.
- II. SMEs need to evaluate the OI strategic options before deciding to take part in the OI area. According to the model presented in this study, there are moderating factors that affect the probability of benefiting from the strategic decisions in the field of OI that should be taken into consideration.
- III. SMEs should continuously monitor the changes of the moderating factors, in order to adjust their degree of participation in OIA, and thus, maximize their profitability of participating in this field, besides minimizing the disadvantages of OIA such as costs and risks.

## 7 | Limitations and Directions for Future Research

The present research has been subject to some limitations in spite of the importance of its findings to identify the moderating factors that increase or hinder the participation of SMEs in OIA. This research is based on a convenient sampling method with the focus on managers and experts of SMEs in the industrial parks. Therefore, it is recommended that in order to generalize the results more accurately and achieve a comprehensive view in other parts of Iran and with a larger sample further researches are helpful. Additionally, few studies have been done to analyze the strategies that SMEs should implement confronting each moderating factor and the success rate of SMEs under such circumstances. For example, further research will be needed to assess the factors affecting SME participation in OIA and the effectiveness of SME performance including the role of OIS. Also, a better understanding of how SMEs can increase their success through OIA at the regional, national, and international levels is a matter that requires future scholars' attention.

### Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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Younos Vakil Alroaia performed conceptualization, methodology, software, and literature review and manuscript preparation. Vakil Alroaia performed data correction, writing original draft preparation, writing reviewing and editing references.

### Author Agreement

I am submitting a manuscript for consideration of publication in JARIE. The manuscript is entitled "OI and SMEs: Providing a Model for Business Development". It has not been published elsewhere and that it has not been submitted simultaneously for publication elsewhere.



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