Int. J. Nonlinear Anal. Appl. 15 (2024) 4, 159–172
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2023.29764.4339

Providing an open innovation model for high-tech startups in the unit of industries related to information technology

Firoozeh Nafisi, Reza Mohammad Kazemi*

Faculty of Entrepreneurship, University of Tehran, Tehran, Iran

(Communicated by Javad Vahidi)

Abstract

This study aims to provide an open innovation model for hi-tech startups in the unit of industries related to information technology (IT). The research method of the present study is mixed and it is done with two types of qualitative and quantitative (mixed) approaches. In the qualitative part of the research, in order to collect data, interview questions were developed. In the following, the ISM questionnaire and the researcher-made questionnaire with a 5-point Likert scale were used. The statistical population in the qualitative and ISM sections consisted of 10 qualified experts who were selected using the purposeful and non-probability sampling method and in-depth and semi-structured interviews were conducted with them. The first step of the current study is to identify the main and sub-categories of the research by using the method of qualitative analysis of the theme (the approach of editing interviews, summarizing them and interpreting concepts and words). MAXQDA software was used for qualitative analysis. Then, in the second and quantitative part of the research, the structural-interpretive modeling method and MICMAC software were used to identify the causal relationships between the main categories of the research. In total, the pattern obtained consists of 10 main themes. The results showed that the strategic management of open innovation, investment and financing, and information technology infrastructure affect technology development in services and products and innovative leadership. Innovative leadership and technology development have an effect on knowledge management and human resource empowerment and lead to the participation of startups in open innovation and improving competence of startups. Through improving the competence and participation of hi-tech startups, it is finally possible to achieve open innovation.

Keywords: Open innovation model, high-tech startups, IT-related industries, hybrid approach
2020 MSC: 93C30

1 Introduction

By using new technology and creating a high capacity to attract educated human capital, high-tech startups have provided a suitable platform for employment, income generation, increasing welfare and access to new technologies. However, practical experience and scientific knowledge in this field indicate that despite the high entry rate in this field, the success rate is low.The statistics related to their failure rate also clearly confirm this. At the end of 2019, the failure rate of high-tech startups was around 90%. Research shows that 21.5% of these startups fail in the first year,

*Corresponding author
Email addresses: firoozenafisi@gmail.com (Firoozeh Nafisi), javadipour@ut ac.ir (Reza Mohammad Kazemi)

Received: January 2023 *Accepted:* March 2023

30% in the second year, 50% in the fifth year, and 70% in the tenth year of operation (SBEF, 2020). These statistics indicate the need for a model for business development of hi-tech companies.

Itech refers to the latest and most advanced technology, which is superior to other technologies in the current time frame. This concept consists of two words High meaning "high" and technology meaning "technology" and it is also translated as "high technology" in Farsi. In other words, it refers to the latest and newest stage of technology development. In parallel, concepts such as high-tech industries, high-tech architecture, high-tech exports, etc. have also been proposed. In a simple definition of the hi-tech industry, it is an industry where the role of "science" is greater than "experience". These industries have a high rate of transformation. From the perspective of technology management, the life of an advanced technology may be only one year, while in the traditional approach, the average life is more than ten years. From the point of view of human resource management, the focus is on human capital instead of manpower [11]. The emergence of high-tech startups in the knowledge-based economy has made a significant contribution to redefining and developing the role of innovation in emerging businesses. Startup companies can respond to the needs of people in dynamic interaction with society through the creation and development of the innovation ecosystem. The major enablers of innovation include co-creation and knowledge retrieval, opportunity seeking and capacity building through startups [5]. Hi-tech startup is an organization based on innovation, which was created with the aim of commercializing a new business plan. This type of company is founded by an entrepreneur to realize a business plan, generally based on new technologies. Usually, a successful start-up company has more growth potential than an established company, that is, it can have more growth with less capital, workforce or scope than older companies. Dynamic capabilities and organizational agility of innovative companies allow them to challenge old and traditional market competitors [6].

Hi-tech startups have many advantages and of course they have their own problems and limitations. These startups can be created in any shape and size. Investors are generally attracted to those startups that have a high risk-to-reward ratio and are more scalable. Therefore, they have lower startup costs, high risk and high potential to return capital [10]. High-tech startups need to attract capital for their rapid growth, and in this way, they have various options. Other companies or individual investors can help startups get off the ground by exchanging cash for equity. In practice, many startups are funded by their founders. Such companies have enjoyed significant growth thanks to the use of new technologies on the one hand and the increase in the number of educated people [14].

Today's knowledge-based economy is witnessing a transition from a business ecosystem to an innovation ecosystem. The key to understanding the difference between these two paradigms is the discussion of value. The business ecosystem emphasizes the importance of value acquisition, and in contrast, value creation is a central element in the innovation ecosystem [13, 18]. In such a situation, the sustainability of startups depends on the proper use of knowledge. In fact, achieving deep knowledge and understanding provides organizational success at all levels. It should be acknowledged that this increase in organizational knowledge provides the means for transformation and innovation, and this issue requires rational and appropriate management so that the organization is able to improve the functional efficiency of its transformation and innovation day by day [17]. Considering that startups are the axis of the country's innovative performance, therefore management in these organizations should be drawn based on innovative structures. For this reason, the main challenge of the issue is whether the innovative structures that arise from the organizational knowledge of these organizations always adhere to certain patterns or whether the dimensions and components of these patterns should be examined at any point in time [9].

The innovation of this research is that hi-tech startups are generally very important based on scientific studies and practical activities. On the other hand, despite the very high rate of entry into this field, the failure rate is also very high. Therefore, high-tech startups should be looking for a model for success and survival in the highly competitive field. The number of high-tech companies is growing at an increasing rate, which has attracted the attention of academic communities. Therefore, many studies have been conducted in the field of hi-tech companies abroad. However, the main focus of the studies has been on the formation of high-tech companies and their entry into the market. While many of these companies are in the early stages of formation and need an efficient and effective model for business development. In the recent foreign studies that have been indexed in the reliable databases of Science Direct and Emerald, they have mainly been conducted around several main axes. In many studies, the high-tech industry has been addressed from the perspective of innovation [19]. In some other studies, high-tech exports have been emphasized and high-tech has been discussed from the perspective of entering international markets [8]. Studies have also been conducted with the focus of sustainability and development in the field of hi-tech [21]. In Iran, there have been very few studies in the field of high-tech, and among these limited studies, they have been questionably focused on the issue of export [11]. In various studies, the role of innovation in the growth and development of high-tech companies has not been explored. On the other hand, a large research gap is observed in the field of high-tech in internal studies. In general, few scientific-research articles on the subject of hi-tech have been registered in the

country's scientific portals, such as the comprehensive portal of humanities, Nurmagz and the Academic Jihad (Said) database. Therefore, this study can fill the theoretical gap in academic societies.

2 Research background and presentation of the research gap

A systematic review of research literature in the field of high-tech based on the Science Direct database shows that in general 935 studies with the keyword "High tech" in the title have been registered. These studies have been indexed in the ScienceDirect database between 1998 and 2021. The retrieved scientific productions show that these researches are all published in English. The diagram of research publication in the figure below shows that since 1998, scientific productions in the field of high-tech have started and have continued until now. Of course, it has had ups and downs in these years.

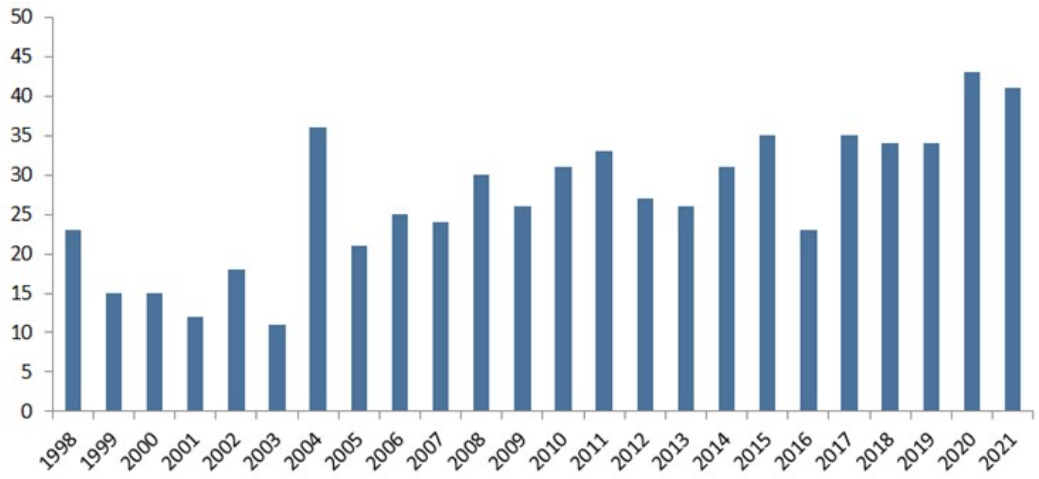

Figure 1: **Chart of the trend of published high-tech researches in the Science Direct database**

The graph of the trend of high-tech research published in the Science Direct database shows that this field has grown significantly in the years 2004 and later, and in 2020 it has been in the spotlight more than any other year. The published researches include 527 scientific researches (56%), 164 conference researches (18%), 17 review researches (2%), 61 book chapters (7%), 49 news articles (5%) and 117 miscellaneous articles (12 %) is.

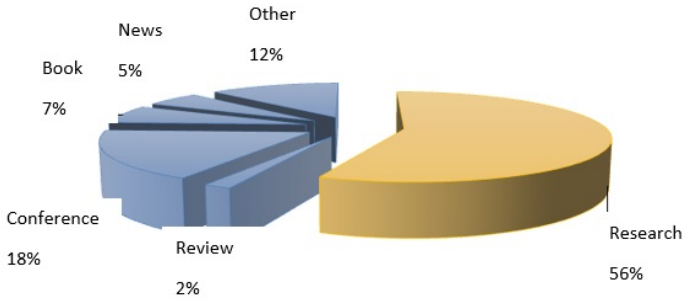

Figure 2: **The frequency of the types of studies conducted in the field of hi-tech**

In this study, research articles published in the last 5 years are focused. Therefore, 134 scientific researches have been examined in the period from 2017 to 2021. The complete list of published researches was obtained from the ScienceDirect website and analyzed using the Vos Viewer software.

The lexical analysis of scientific studies conducted in the field of hi-tech in the last 5 years shows that 10 keywords in three main clusters have been emphasized by different researchers. Among these, innovation (7 repetitions), innovation performance (6 repetitions) and innovation quality (3 repetitions) have been repeated the most. High-tech companies (3 repetitions), high-tech businesses (3 repetitions) and high-tech industries (4 repetitions) were among the most used keywords.

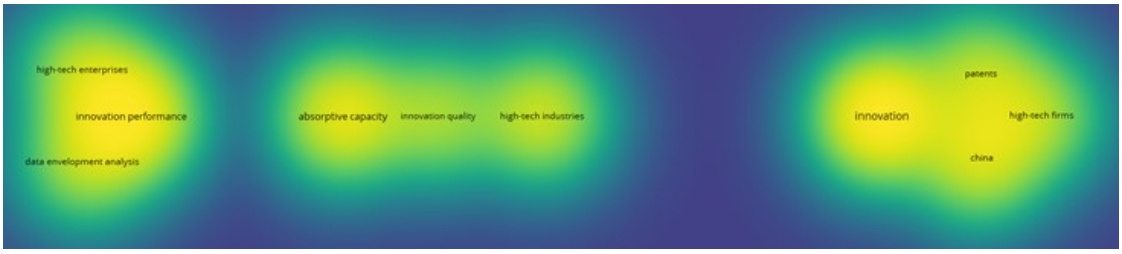

Figure 3: **Heating and density diagram of high-tech related keywords**

In each of the studies, researchers have addressed the issue of innovation from different perspectives. In some studies, it has been discussed from the perspective of the need to focus on innovation in high-tech industries [3, 12]. Chung et al. [4], and Xiao et al. [20], have examined the issue of innovation in high-tech industries from the perspective of entrepreneurship and emphasizing the absorption capacity. In some other studies, high-tech exports have been emphasized and high-tech has been discussed from the perspective of entering international markets [15, 20]. Studies have also been conducted with the focus of sustainability and development in the field of hi-tech [21]. In Iran, there have been very few studies in the field of hi-tech, and among these limited studies, the issue of export has been questionably focused [11]. In various studies, the role of innovation in the growth and development of high-tech companies has not been explored. On the other hand, a large research gap is observed in the field of high-tech in internal studies. In general, few scientific-research articles on the topic of hi-tech have been registered in the country's scientific portals, such as the comprehensive portal of humanities, Nurmagz and academic Jihad (Said) database. Since innovation has gone through various stages in its evolution, in the last two decades, the open innovation paradigm has been favored by researchers in this field as a superior approach. However, a systematic review of studies that have directly discussed innovation in high-tech industries shows that only Barrett et al. [2], have addressed the issue of open innovation in high-tech industries. Therefore, it seems that the discussion about a practical model for implementing open innovation in hi-tech businesses is a topic that should be addressed theoretically and practically. Therefore, a main observed gap is the discussion of open innovation in the field of hi-tech. On the other hand, high-tech is not exclusive to startups, but in the reviewed studies only five high-tech startups have been discussed, which are: [1, 7, 16].

As can be seen, none of the studies that have been conducted directly in the field of high-tech startups have addressed the issue of innovation. Therefore, a research gap is observed in the field of innovation in high-tech startups. Therefore, this study has focused on providing an open innovation model for high-tech startups.

3 Innovation on startup market share

Suppose the stock price at time t and μ is the expected rate of return, then the changes in price or return over time (dt) include two parts:

1). The predictable part of stock returns, which can be obtained by examining stock price trends. We denote this part by μ.

2). The unpredictable part that represents the random changes in the stock price over time (dt), such as external effects such as unexpected news about the stock price, etc., according to the constant value of σ and the random value of dBt, the unpredictable part of the stock return. we denote by $\sigma stdBt$. Therefore, stock price changes are equal to:

$$ds = \mu s_t dt + \sigma s_t dB_t \tag{3.1}$$

$$\frac{ds_t}{s_t} = \mu dt + \sigma dB_t. \tag{3.2}$$

The stochastic differential equation (3.1) is a Brownian motion based on the stock price change st, and equation (3.2) is the instantaneous rate of return of the stock price, which follows the Lemma Ito process over time. According to the Ito relation, we have:

$$\frac{ds_t}{s_t} = d(\ln s_t) = \ln(s_t) - \ln(s_{t-1}) = \ln(\frac{s_t}{s_{t-1}}) \tag{3.3}$$

$$\ln(\frac{s_t}{s_{t-1}}) = \mu dt + \sigma dB_t. \tag{3.4}$$

Consider the function (t, X) G such that in the condition of the stochastic differential equation:

$$dX = adt + bdB_t. \tag{3.5}$$

True, in this relation a and b are constant values and dBt is Brownian motion. Based on the Ito relation and the Taylor equation, we have the function $(X, t)G$:

$$\begin{cases} dG \cong \frac{\partial G}{\partial X}dX + \frac{\partial G}{\partial t}dt + \frac{1}{2}\left(\frac{\partial^2 G}{\partial X^2}(dX)^2 + \frac{\partial^2 G}{\partial t^2}(dt)^2\right), \; dX = adt + bdB_t \\ dG = \frac{\partial G}{\partial X}(adt + bdB) + \frac{\partial G}{\partial t}dt + \frac{1}{2}\left(\frac{\partial^2 G}{\partial X^2}b^2 dt\right) \\ dG = \left(\frac{\partial G}{\partial X}a + \frac{\partial G}{\partial t} + \frac{1}{2}\frac{\partial^2 G}{\partial X^2}b^2\right)dt + \frac{\partial G}{\partial X}dB \end{cases} \tag{3.6}$$

Now, if the function G is written as $G = \ln(st)$. Then we have

$$\frac{\partial G}{\partial S} = \frac{1}{s_t}, \quad \frac{\partial^2 G}{\partial S^2} = \frac{1}{s_t^2}, \quad \frac{\partial G}{\partial t} = 0.$$

Therefore, according to the above relations and placement in relation (3.6), we have:

$$d(\ln s_t) = \left[\mu s_t \frac{1}{s_t} + \frac{1}{2}\sigma^2 s_t^2(-\frac{1}{s_t})\right]dt + \sigma s_t \frac{1}{s_t}B_t. \tag{3.7}$$

Then

$$\begin{aligned} &d(\ln s_t) = \ln(s_t) - \ln(s_{t-1}) = \ln(\tfrac{s_t}{s_{t-1}}) = \left(\mu - \tfrac{1}{2}\sigma^2\right)dt + \sigma dB_t \\ &= \left(\mu - \tfrac{1}{2}\sigma^2\right)dt + \sigma\varepsilon\sqrt{dt} \end{aligned} \tag{3.8}$$

In Equation (3.8), $d(\ln(st))$ has Brownian motion with stress and normal distribution with mean

$$\left(\mu - \frac{\sigma^{\frac{1}{2}}}{2}\right)dt$$

and the variance is α2dt, so we have:

$$\ln(s_t) = \ln(s_{t-1}) + \left(\mu - \frac{1}{2}\sigma^2\right)dt + \sigma\varepsilon\sqrt{dt} \tag{3.9}$$

$$s_t = s_{t-1}e^{\left(\mu - \frac{1}{2}\sigma^2\right)dt + \sigma\varepsilon\sqrt{dt}}. \tag{3.10}$$

The above relationship is based on the Brownian movement and the future stock price, which can be extended to any other time. Therefore, the future stock price can be obtained based on the internal price s0 and relation (3.10) during time t when $t = dt$. Therefore, we have:

$$s_t = s_{t-1}e^{\left(\mu - \frac{1}{2}\sigma^2\right)dt + \sigma\varepsilon\sqrt{dt}}. \tag{3.11}$$

Now we get the profit function and its variance in two states of confidence and uncertainty.

Security mode:

It means that a pharmaceutical company is confident about the market demand function of its products. This situation occurs when pharmaceutical companies do not spend on innovation and continue to produce their previous products (which always have demand). If the company has an inverse stochastic demand function θ in the market for its products and the sales quantity Q, then Its profit function can be written in reverse

$$\pi = (\theta - Q)Q.$$

We know that the optimal amount of profit for the monopoly firm is equal to

$$\pi_1 = \frac{\theta^2}{4}.$$

By placing

$$s_t = \frac{\theta_t^2}{4}.$$

We can express its evolution based on geometric Brownian motion as follows. Based on Q, we have equation (3.10)

$$ds = \mu s_t dt + \sigma s_t dB_t.$$

By solving the above stochastic differential equation based on equation (3.11), we have:

$$s_t = s_0 e^{\left(\mu_1 - \frac{1}{2}\sigma_1^2\right)t + \sigma_1 \varepsilon \sqrt{dt}}.$$

Now, the amount of expected profit according to the discount rate will be as follows:

$$\pi_1 = E\left[\int_0^\infty e^{-rt} s_t dt\right] = \frac{s_0}{r - \mu_1}. \tag{3.12}$$

4 State of uncertainty

It means that a pharmaceutical company is not sure about the market demand function of its products in the future. This situation happens when pharmaceutical companies spend in the field of innovation, we denote this cost in the model by I. Also, we express the uncertainty of the product demand function in the market with γ, so we seek to maximize the objective function

$$\gamma\left(\theta - Q\right)Q - I.$$

Therefore,

$$\max \pi_2 = \gamma x - I.$$

We have

$$d\gamma = \gamma\left[\mu_2 dt + \sigma_2 dB_t\right].$$

So that

$$corr(B_t, w_t) = 0.$$

Then

$$\begin{cases} d\gamma = \gamma\left[\mu_2 dt + \sigma_2 dB_t\right] \\ \gamma_t = \gamma_0 e^{\left(\mu_2 - \frac{1}{2}\sigma_2^2\right)t + \sigma_2 \varepsilon \sqrt{dt}} \end{cases} \tag{4.1}$$

Now the expected profit is as follows:

$$\pi_2 = E\left[\int_0^\infty e^{-rt} s_t \gamma_t dt\right] - I = \frac{s_0}{r - \mu_1 - \mu_2} - I. \tag{4.2}$$

By dividing the relation (3.11) by (3.12), we have

$$\frac{\pi_2}{\pi_1} \leq 1.$$

Therefore, the amount of profit in the state of uncertainty is lower than the state of certainty, and this means that uncertainty in the demand function and the reduction of fixed costs of companies that invest in the field of innovation will reduce the profit, the amount of sales and also the market share.

5 Research questions

5.1 The main question

What is the pattern of open innovation for high-tech startups in the unit of industries related to information technology (IT)?

Sub questions

1- What are the main effective dimensions of the open innovation model for hi-tech startups?

2- What are the influential sub-dimensions in the open innovation model for hi-tech startups?

3- How are the causal relationships between the categories of the open innovation model for hi-tech startups?

4- What is the pattern of open innovation for hi-tech startups?

6 Research methodology

The current research is based on the purpose of a fundamental research because it aims to provide an open innovation model for high-tech startups in the IT-related industries. The main research data collection tools are library studies, semi-structured interview, structural-interpretive modeling questionnaire and researcher-made questionnaire. In the first part, in order to study the theoretical topics related to the research topic and also to review the literature of the topic and the background of the research, written information will be used in this regard, including specialized books and articles related to the open innovation model for hi-tech startups. In the second part, interviews are conducted with a number of experts, managers and experts active in marketing and industries related to information technology in order to familiarize and gain knowledge and understanding of the open innovation model for high-tech startups, as well as further coordination and recognition of research variables. After identifying the primary indicators of the open innovation model for hi-tech startups, using the ISM standard questionnaire, the causal relationships between the research indicators and the initial model are identified. The statistical population in the qualitative part of this research includes academic experts and experimental experts. A) Theoretical experts: They include marketing professors who are experts in the field of marketing and management and have many books or articles in this field. They should also have more than ten years of teaching experience and be a member of the academic staff of the university. b) Experienced experts: Experienced experts include all managers and supervisors of IT-related industries that include designing and producing software packages for over 15 years in high-tech startups and have a graduate degree in the field of high-tech startups. The methods of data analysis include qualitative theme analysis, identifying the main and sub-categories of the open innovation model for high-tech startups using MAXQDA software, and the structural-interpretive method: presenting the open innovation model for high-tech startups using MICMAC software.

7 Research findings

7.1 Quantitative demographic characteristics

In terms of gender, 244 people (64%) were men and 140 people (36%) were women. In terms of age, 115 people (30%) were less than 40 years old, 179 people (47%) were between 40 and 50 years old, and 90 people (23%) were 50 years old and older. In terms of education, 60 people (16%) had a bachelor's degree, 208 people (54%) had a master's degree, and 116 people (30%) had a doctorate. In terms of work experience, 111 people (29%) have less than 10 years of experience, 98 people (26%) have 10 to 15 years of experience, 85 people (22%) have 15 to 20 years of experience, and 90 people (23%) have more than 20 years of experience. they had.

Source: research findings

7.2 The steps of qualitative analysis

The six stages of qualitative analysis of the theme are explained below.

7.2.1 First step: getting to know the data

In order for the researcher to get to know the depth and scope of the content of the data, it is necessary to immerse himself in them to some extent. Immersion in data typically involves "repeating the data" and reading the data actively (i.e, looking for meanings and patterns). At this stage, it is attempted to identify the indicators related to providing an open innovation model for high-tech startups related to information technology (IT) from the interview texts. In the following figures, the method of coding interview texts in MAXQDA software is presented

Table 1: Demographic characteristics of employees

Demographic characteristics		**Abundance**	**Percent**
gender	Man	244	64%
	Female	140	36%
Age	30 to 40 years	115	30%
	40 to 50 years	179	47%
	More than 50 years	90	23%
education	Masters	60	16%
	Masters	208	54%
	P.H.D	116	30%
Work Experience	Less than 10 years	111	29%
	10 to 15 years	98	26%
	15 to 20 years	85	22%
	More than 20 years	90	23%
Total		384	384

7.2.2 Second step: creating initial codes

The second stage begins when the researcher has read the data and become familiar with them. This step involves creating initial codes from the data. Codes introduce a feature of the data that the analyst finds interesting. Coded data from different units of analysis.

Table 2: Initial coding of interview text one

Color	**Code**	**Segment**	**Area**	**Coverage %**
*	High growth rate in this field	The speed of technological development in this field is very high	43	2.35
*	Lack of time to change technology generation (Interview 1, Pos. 3)	Very little technology generation change time	30	1.64
*	Increase the speed of execution	Therefore, there should be a lot of speed in the execution	41	2.25
*	Increasing the probability of failure of idea implementation (Interview 1, Pos. 3)	Because the probability of failure to implement the idea increases	47	2.57
*	Human Resources Specialist (Interview 1, Pos. 3)	The main capital of the implementation of the idea in the desired field is the expert human resources	71	3.89

7.2.3 The third step: searching for themes

This step involves grouping the various codes into potential categories, and sorting all the coded data summaries into specified categories. In fact, the researcher begins the analysis of his codes and considers how different codes can be combined to create a general category. At this stage, by screening, removing duplicate codes and integrating synonymous codes, the indicators extracted from the interview texts are categorized.

7.2.4 The fourth step: Reviewing the themes

The fourth stage begins when the researcher creates a set of themes and reviews them. This stage includes two stages of reviewing and purifying themes. The first step includes a review at the level of coded summaries. In the second step, the validity of the themes in relation to the data set is considered. If the category map works well, then you can move on to the next step. However, if the map does not fit the data set well, the researcher should go back and continue coding until a satisfactory category map is created.

Table 3: Review of themes

Row	Basic concepts	Descriptive codes
1	Promoting the culture of innovation and technology in the organization	Promoting the culture of innovation in the organization
		Promotion of technological culture in the organization
2	Reprogramming for improvement and innovation	Examining functional weaknesses in the organization
		Innovative planning for improvement
3	Analyzing readiness for adaptability or organizational transformation	Adaptability
		Organizational transformation according to environmental challenges
4	A leader's ability to create a vision of a set of ideas	The ability of the leader in the integrity of the organization
		Creating a vision of a set of new ideas by the leader

7.2.5 The fifth step: defining and naming themes

The fifth step begins when there is a satisfactory map of categories. In this stage, the researcher defines and revises the themes presented for analysis, then analyzes the data inside them.

Table 4: Main and subcategories

Main article	Subcategory
Innovative leadership	Promoting the culture of innovation and technology in the organization
	Re-planning in line with improvement and innovation
	Analyzing readiness for adaptability or organizational transformation
	The leader's ability to create a vision of a set of ideas
Empowering human resources	Creating incentives for the development of innovative thinking
	Strengthening the culture of guiding and supporting human resources
	Promotion of attitude and innovative approach in human resources
	Coordination and effective communication between managers, human resources in high-tech startups
	Granting rewards and benefits commensurate with performance
	Resource-oriented foundation (providing space and required equipment)
	Development-oriented foundation (manpower training needs assessment)
knowledge management	Acquisition of knowledge from customers, environment and competitors
	Knowledge storage and maintenance mechanism
	Efficient ways of accessing and retrieving knowledge
	Creating a free flow of knowledge in high-tech startups

continued ...

. . . continued

Main article	Subcategory
	Creating new knowledge in high-tech startups
Development of technology in services and products	Advancing in the production and supply of new products and services
	Using a new process (modification and improvement of processes)
	Accelerating and clarifying the accountability process
	Reducing costs and increasing quality compared to competitors
	Increasing the quality of products and services
	Providing a diverse and customer-friendly product portfolio
Investment and financing	Budget planning and financing
	Estimating the cost of capital provision compared to competitors
	Obtaining tax exemption
	Attracting investors through cooperation with other institutions (government, suppliers, etc.)
	Access to other financing options (loans, bank facilities, etc.)
Competence of high-tech startups to develop open innovation	Forming a creative team within high-tech startups
	Considering the personal characteristics of different people
	Considering the cultures of different hi-tech startups
	Reduction of administrative bureaucracy
	Investigating opportunities, threats, strengths and weaknesses of hi-tech startups
	Transparency in access to ideas and data
Strategic management of open innovation	Choosing specific areas for ideation
	Management agility and maturity in decision-making processes
	Discovering and understanding the needs of the market and customers
	Developing goals to improve the performance of high-tech startups
Information Technology (IT) infrastructure	Innovation based on modern information technology science
	Increasing accessibility and ease of use
	Increasing cyber security
	Search for solutions based on information technology (IT Base solution)
	Updating the software and hardware infrastructure
Participation of high-tech startups in open innovation	Increasing the capacity of open innovation in high-tech startups
	Material and spiritual support for people
	Increasing the risk-taking mentality and the desire to develop ideas
	Supporting and encouraging people with innovative ideas
	Maintain, maintain and develop market share
Open innovation	Access to new knowledge and innovative ideas
	Using new perspectives and correct practices
	Increasing expert human resources
	Speeding up the development process
	Reducing development risk
	9Improving profitability and efficiency in high-tech startups

7.2.6 The sixth step: preparation of the report

The sixth stage begins when the researcher has a set of well-defined themes. This stage includes the final analysis and report writing. Therefore, the present research has identified 53 sub-themes by examining and categorizing the descriptive codes from the interview texts, and according to their similarity and semantic affinity, in 10 main themes including: innovative leadership, human resources empowerment, knowledge management, technology development in services and It has categorized products, investment and financing, competence of high-tech startups to develop open innovation, strategic management of open innovation, information technology (IT) infrastructure, participation of high-tech startups in open innovation and open innovation.

7.3 Interpretive-structural modeling

The ISM method was used to present the primary open innovation model of hi-tech startups. Structural-Interpretive Modeling (ISM) is an exploratory method to identify the relationships of structures and their stratification. In fact, using this method, the impact of a structure on other structures is checked. In this method, the relationships of the structures can be identified and a structural-interpretive model of the structures can be presented and finally the structures can be classified based on the power of penetration and the degree of dependence. The studied structures to present the primary open innovation model of hi-tech startups are: "innovative leadership"; "Empowering human resources"; "knowledge management"; "Development of technology in services and products"; "Investment and financing"; "Competence of high-tech startups to develop open innovation"; "Strategic management of open innovation"; "Information technology infrastructures"; "Participation of high-tech startups in open innovation"; "Open Innovation".

The set of outputs includes the structure itself and the structures that are affected by it. The set of inputs includes the structure itself and the structures that affect it. Then the set of two-way relations of the structures is specified. For structure C_i, the reach set (outputs or effects) includes structures that can be reached through structure C_i. The prerequisite set (inputs or effects) includes structures through which structure C_i can be reached. After determining the achievement set and the prerequisite set, the subscription of the two sets is calculated. The first structure where the commonality of the two sets is equal to the reachable set (outputs) will be the first level. Therefore, the structures of the first level will have the most influence in the model. After determining the level, the structure whose level is known is removed from the whole set and the set of inputs and outputs is formed again, and the level of the next structure is obtained. Based on the results of the calculations, the sequence of structures in this research is as follows:

Open innovation (C10) is at the first level.

The competency of high-tech startups for the development of open innovation (C06) and the participation of high-tech startups in open innovation (C09) are at level two.

Human resource empowerment (C02) and knowledge management (C03) are at level three.

Innovative leadership (C01) and technology development in services and products (C04) are at level four.

Investment and financing (C05), strategic management of open innovation (C07) and IT infrastructure (C08) are at level five.

The basic pattern of the levels of the identified structures is shown in the figure below. In this diagram, only the meaningful relationships of the elements of each level on the elements of the lower level, as well as the meaningful internal relationships of the elements of each row, are considered.

8 Discussion

The findings of this research showed that there are 10 variables in the model and all these 10 variables have one or more relationships with other model variables. The stratification results showed:

Open innovation is at the first level. The competency of high-tech startups for the development of open innovation and the participation of high-tech startups in open innovation are at the second level. Empowerment of human resources and knowledge management are at level three. Innovative leadership and technology development in services and products are at level four. Investment and financing, strategic management of open innovation and IT infrastructure are at level five. According to the findings of the current research, the components of investment and financing, strategic management of open innovation, and information technology infrastructure have the greatest impact on the research model.

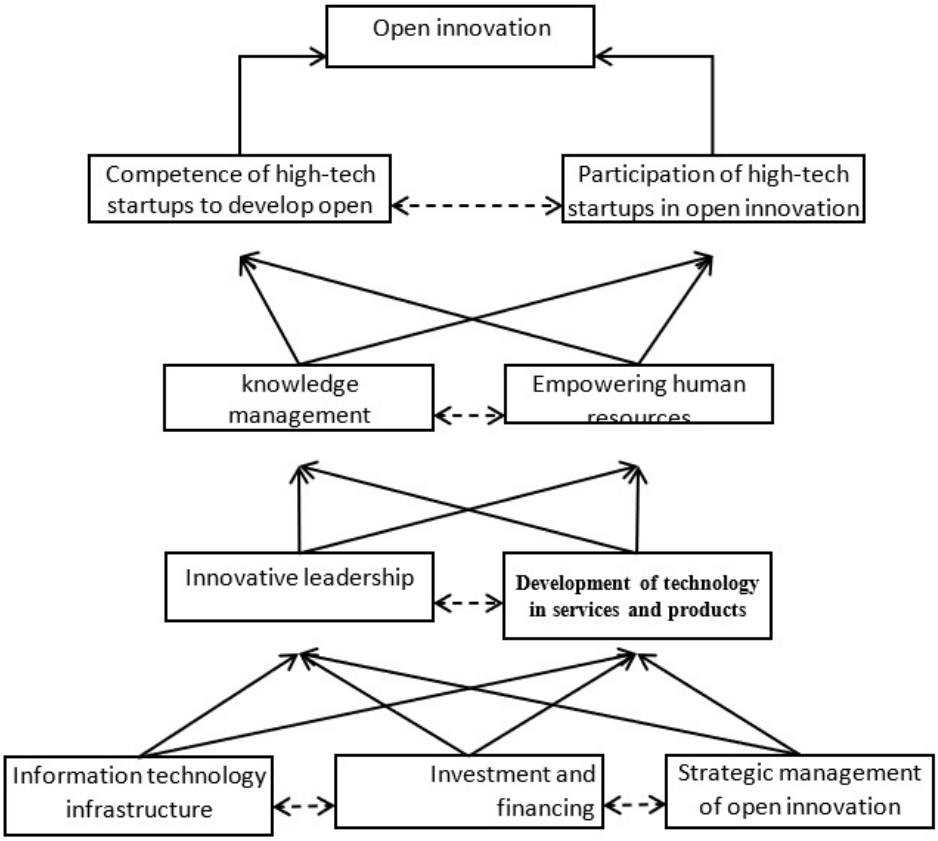

Figure 4: **Open innovation model for high-tech startups**

Based on the diagram of influence power-dependence of investment and financing structures, strategic management of open innovation, information technology infrastructures have high influence power and have little influence and are placed in the area of independent structures. Structures of open innovation, competence of high-tech startups to develop open innovation, participation of high-tech startups in open innovation also have high dependence but little influence, so they are considered dependent structures. The structures of human resource empowerment, knowledge management, innovative leadership, technology development in services and products have similar power of penetration and degree of dependence, so they are linked structures. No structure was placed in the first quarter, i.e., the autonomous region.

Based on the obtained results, the following practical suggestions are provided:

Regarding innovative leadership, it is suggested to initially promote the culture of innovation and technology in high-tech startups in the unit of industries related to information technology (IT) to accompany and align people with organizational goals. In this regard, there is a need for re-planning in the direction of improvement and innovation and analyzing readiness for adaptability or organizational transformation, which relevant managers must take the necessary measures. Also, the role and ability of the leader in creating a vision of a set of ideas in open innovation for high-tech startups in the IT-related industries unit cannot be ignored. Regarding the empowerment of human resources, it is suggested that by creating incentives for the development of innovative thinking for the beneficiaries and employees, they should prepare for the establishment of open innovation for high-tech startups in the unit of industries related to information technology (IT). In this regard, it is necessary to strengthen the culture of guiding and supporting human resources and promoting innovative attitude and approach in human resources. It is also suggested to facilitate the achievement of open innovation goals for high-tech startups in the unit of industries related to information technology (IT) by establishing effective coordination and communication between managers and human resources in hi-tech startups. In this area, awarding rewards and benefits in proportion to performance depends on resource-oriented infrastructure (providing space and required equipment) and development-oriented infrastructure (manpower training needs assessment).

In terms of knowledge management, it is suggested that relevant managers take appropriate measures to acquire

knowledge from customers, the environment, and competitors. Also, gaining knowledge about the mechanism of knowledge storage and maintenance and efficient ways of accessing and retrieving knowledge is also important in open innovation for hi-tech startups in the unit of industries related to information technology (IT). The recommendation of the present research to the aforementioned managers is to create a free flow of knowledge in high-tech startups and create new knowledge in high-tech startups. Regarding the development of technology in services and products, it is suggested, by advancing in the production and supply of new products and services and using new processes (correction and improvement of processes) in the way of achieving the goals of open innovation for high-tech startups in the unit of industries related to information technology (IT). move Also, speeding up and clarifying the response process and reducing costs and increasing quality in front of competitors is also one of the consequences of technology development, which should be given more attention by relevant managers. In this regard, it is recommended to increase the quality of products and services and provide a diverse and customer-friendly product portfolio with the help of technology development.

Regarding investment and financing, it is suggested that relevant managers should try to overcome economic challenges by planning the budget and financing and estimating the cost of financing compared to competitors. In the meantime, obtaining tax exemption and attracting investors through cooperation with other institutions (government, suppliers, etc.) and access to other financing options (loans, bank facilities, etc.) is a great help to establish an open innovation model for Hi-tech startups are in the unit of industries related to information technology (IT). Regarding the competence of high-tech startups for the development of open innovation, it is suggested that they first consider forming a creative team within high-tech startups. Also, by taking into account the personal characteristics of different people and the cultures of different high-tech startups, it is possible to achieve the goals of open innovation for high-tech startups in the unit of industries related to information technology (IT). By reducing the administrative bureaucracy and examining the opportunities, threats, strengths and weaknesses of high-tech startups, relevant managers can achieve transparency in accessing ideas and data and surpass their environmental competitors.

Regarding the strategic management of open innovation, it is suggested to provide the necessary preparations for agility and managerial maturity in decision-making processes by choosing specific fields for ideation. What is important in open innovation for high-tech startups in the unit of industries related to information technology (IT) is to discover and understand the needs of the market and customers and formulate goals to improve the performance of high-tech startups. Regarding information technology (IT) infrastructure, it is suggested to strengthen information technology infrastructure by providing innovation based on modern information technology science and increasing accessibility and ease of use. Also, the increase in cyber security and the search for solutions based on information technology (IT Base solution) are also effective in this field, which should be paid more attention by managers. In addition to the mentioned items, updating the software and hardware infrastructure is also important. Regarding the participation of high-tech startups in open innovation, it is suggested that by increasing the capacity of open innovation in high-tech startups and of course providing material and spiritual support to people, they will achieve an increase in risk-taking mentality and the desire to create ideas. Relevant managers should pay attention to the fact that the model of open innovation for high-tech startups in the unit of industries related to information technology (IT) needs to support and encourage people with innovative ideas and maintain, maintain and develop market share.

References

[1] P. Adler, R. Florida, K. King, and C. Mellander, *The city and high-tech startups: The spatial organization of Schumpeterian entrepreneurship*, Cities **87** (2019), 121–130.

[2] G. Barrett, L. Dooleye, and J. Bogue, *Open innovation within high-tech SMEs: A study of the entrepreneurial founder's influence on open innovation practices*, Technovation **103** (2021), 102232.

[3] X. Chen, Z. Liu, and Q. Zhu, *Reprint of" Performance evaluation of China's high-tech innovation process: Analysis based on the innovation value chain"*, Technovation **94** (2020), 102094.

[4] D. Chung, H. Jung, and Y. Lee, *Investigating the relationship of high-tech entrepreneurship and innovation efficacy: The moderating role of absorptive capacity*, Technovation **111** (2022), 102393.

[5] V.F. De Faria, V.P. Santos, and F.H. Zaidan, *The business model innovation and lean startup process supporting startup sustainability*, Procedia Comput. Sci. **181** (2021), 93–101.

[6] N. Foster, A. Zandiatashbar, and S. Hamidi, *High-tech business location, transportation accessibility, and implications for sustainability: Evaluating the differences between high-tech specializations using empirical evidence from us booming regions*, Sustain. Cities Soc. **50** (2019), 101648.

[7] X. Luo, F. Huang, X. Tang, and J. Li, *Government subsidies and firm performance: Evidence from high-tech start-ups in China*, Emerg. Markets Rev. **49** (2021), 100756.

[8] T. H. Malik, T. Xiang, and C. Huo, *The transformation of national patents for high-technology exports: Moderating effects of national cultures*, Int. Bus. Rev. **30** (2021), no. 1, 101771.

[9] H. Moghdisi, *Startup networks and presentation of political strategies*, J. Politic. Media History **3** (2019), no. 10, 103–124.

[10] R. Nadafi and M. Ahmadvand, *Identifying and prioritizing drivers of new business development (startups)*, Entrepreneur. Dev. Quart. **10** (2016), no. 4, 517–534.

[11] N. Nowrozpour, A. Ebrahimi, H. Vali-Beigi, and H. Dedekhani, *Export development strategies of single industries of Iran using performance-importance analysis*, Sci. Res. Quart. Econ. Strategy **9** (2019), no. 32, 39–73.

[12] M.O. Parvez, *Use of machine learning technology for tourist and organizational services: high-tech innovation in the hospitality industry*, J. Tourism Futures **7** (2020), no. 2, 240–244.

[13] P. Ritala, V. Agouridas, D. Assimakopoulos, and O. Gies, *Value creation and capture mechanisms in innovation ecosystems: a comparative case study*, Int. J. Technol. Mana. **63** (2013), no. 3-4, 244–267.

[14] N. Del Sarto, D.A. Isabelle, and A. Di Minin, *The role of accelerators in firm survival: An fsQCA analysis of Italian startups*, Technovation **90** (2020), 102102.

[15] Y. Song, C. Yu, L. Hao, and X. Chen, *Path for China's high-tech industry to participate in the reconstruction of global value chains*, Technol. Soc. **65** (2021), 101486.

[16] D.M. Sullivan, M.R. Marvel, and M.T. Wolfe, *With a little help from my friends? how learning activities and network ties impact performance for high tech startups in incubators*, Technovation **101** (2021), 102209.

[17] S. L. Suni, V. Z. Chen, S. A. Sunny, and J. Chen, *Venture capital as an innovation ecosystem engineer in an emerging market*, Int. Bus. Rev. **28** (2019), no. 5, 101485.

[18] J. Trischler, M. Johnson, and P. Kristensson, *A service ecosystem perspective on the diffusion of sustainability-oriented user innovations*, J. Bus. Res. **116** (2020), 552–560.

[19] Y. Wang, J. F. Pan, R. Pei, B. W. Yi, and G. L. Yang, *Assessing the technological innovation efficiency of China's high-tech industries with a two-stage network DEA approach*, Socio-Econ. Plann. Sci.**71** (2020), 100810.

[20] S.S. Xiao, Y.K. Lew, and B.I. Park, *International new product development performance, entrepreneurial capability, and network in high-tech ventures*, J. Bus. Res.**124** (2021), 38–46.

[21] M. Yang and J. X. Wang, *Marine high-tech enterprise ecosystem based on sustainable development*, Sustainable Comput.: Inf. Syst. **28** (2020), 100399.