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Conceptualization of technological innovation model in factoryless manufacturing in Iran

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Abstract

Despite some studies in the analysis of technological innovation systems and factoryless manufacturing, these two issues have been analyzed comprehensively and at the same time less, while entrepreneurship and employment development are among the first functions of technological innovation systems in countries. The aim of this study is to provide an integrated model for technological innovation in factoryless manufacturing in Iran. In this research, an integrated approach based on Grounded theory and structural-interpretive modeling has been used. The statistical population includes experts and experts in the field of factoryless producing. Using the purposive sampling approach, a total of 11 people were selected as participants in the study to the extent of theoretical saturation. Data were collected through interviews under the guidance of generalities and in a semi-structured manner and based on the data theory process, during the three stages of open, axial and selective coding, 71 concepts, 19 sub-categories and 6 main categories were identified and categorized. Then the final variables were graded by interpretive structural modeling at 4 levels of the main phenomenon, infrastructure, implementation and outcome. The results show that technological innovation acts as the main and effective basis for determining successful strategies in the field of factoryless manufacturing, which will lead to the interaction of the socio-economic environment in Iran.

Keywords: Technological innovation, Technological innovation systems, Factoryless manufacturing, Grounded Theory, Structural-interpretive modeling
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1 Introduction

The Fourth Industrial Revolution has significant consequences for emerging economies as well as developed countries and industries around the world. The introduction of the latest generation of intelligent and new technologies has led to extensive changes in production [16]. Hence, the Fourth Industrial Revolution is expected to transform economies with the help of intelligent technologies. On the other hand, the "factoryless production" model covers a large share of the world's industries, and factory-free producers outsource the production of products but retain control of the production process [3]. Prominent examples include Apple, which does not manufacture hardware, Nike, which does not manufacture shoes or clothing, and Dyson, which does not manufacture consumer goods [9].

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Capital inflows, labor, and technological advances are the forces that drive a country's economic growth [35]. Some economists have argued that the economic growth of some countries, including China, is at some point affected by capital and labor, and there is no focus on improving overall performance, and in these countries, the drivers of industrial development are mainly cheap labor, resources and large-scale production [17]. However, the industrial transformation and economic growth of many developed countries are mainly dedicated to the advancement of science and technology and the improvement of human capital [32]. They rely on technological advancement to advance the structure of the industry and are in a new era of technological development.

On the other hand, Rodrik hypothesizes that modern technologies, such as robots are replacing the unskilled labor force so that industrialization benefits a small group of highly productive companies that create limited job opportunities. Rodrik's hypothesis shows that when countries begin their productive activities, rapid productivity growth is automatically pursued through the transfer of modern knowledge and machinery across the global border [29, 7].

In recent years, the identification and evaluation of the functions or activities of innovation systems have attracted much attention. This "functional perspective" on innovation systems emphasizes the importance of what the system does, how it does it, or how it is structured and structured.

Various researches have been done in the field of connection with technology and factoryless production. Mao with the foresight of technology for social benefits through the social concepts of technological innovation by 2050 by a specialized survey, showed that technological innovation will benefit society by improving communication and supply chain productivity [22]. Nathan study of e-commerce for home businesses in emerging and developed economies show that home business owners' IT knowledge, risk perception and online trust are the most important factors in accepting e-commerce in-home business [27]. Anwar and Daniel study online home business in the UK and state that the characteristics of this type of job allow entrepreneurs to experience the necessary IT skills through self-training and testing [1]. Morikawa through a study on Japanese industries, states that factoryless goods producers (FGP) are more productive than other manufacturers and invest more extensively in intangible assets, including research and development and technological innovation [24]. Seyed Rezaei by examining the role of factoryless manufacturing in Iran's automotive industry showed that factoryless manufacturing means the transfer of managerial and operational activities, which reduce costs, increase productivity, focus on leadership activities, gain competitiveness, reduce risk, improve domestic manufacturing and development [30].

As can be seen, in these studies, various factors affecting the development of factoryless manufacturing were pointed out. But the holistic approach to the issue of factoryless manufacturing has been neglected. Therefore, the point of difference between this study and previous studies is to pay attention to the issue of factoryless production, considering the important role of technological innovation.

Of course, providing a suitable framework and providing scientific contexts is one of the concerns of all researches, especially the present research, but there is no complete literature in this field. This does not mean a lack of theoretical infrastructure in factoryless production. Rather, it argues that there are no independent scientific hypotheses or proprietary propositions in management science or economics about factoryless manufacturing and that the title "factoryless" can be applied to a wide range of types of productions. But the term is more commonly found in newspapers, business websites, and semi-specialized magazines, indicating that it is more practical and practically developed than in theory.

For this purpose, and considering the mentioned limitations and due to increasing the validity of the proposed framework, an attempt was made to identify and explain the most valid theoretical foundations of the technological innovation system and factoryless manufacturing in the literature in a comprehensive model. Therefore, the question arises what will be the development of factoryless manufacturing in Iran, according to the indicators of technological innovation? And the aim of the present study is to provide an indigenous model in the field of factoryless manufacturing, taking into account the principles of technological innovation and studying real and successful experiences in the country. Factoryless manufacturing is not just a type of production but covers a wide range of types of production, which adds to the importance of recognizing this issue.

Also, the author of this research has personally had many years of experience working in the field of factoryless manufacturing and home products and has managed from research and development to design and licensing, as well as product marketing and sales. This issue also created a great incentive for the need to conduct the present study. Now the question arises what are the dimensions and components of technological innovation systems in factoryless manufacturing in Iran?

2 Theoretical Foundations of Research

2.1 Technological Innovation

In one of the general classifications, innovations can be divided into two categories of administrative and technological innovations [25]. Technological innovation refers to innovative changes in products and their production processes. Office innovations, on the other hand, are more concerned with changes in work practices or what is called the day-to-day running of the organization. The distinction between technological and administrative innovations is important because the distinction between them defines the general distinction between technical and social structures in the organization [26].

The process of technological innovation is a complex set of activities that transforms and deforms ideas and scientific knowledge into physical reality and applications in the real world. It is a process that requires the integration and coherence of existing inventions and technologies to bring innovations to the market.

Technological innovation has different effects on society. Figure 1 shows the forecast of changes in society related to technological innovation by 2050.

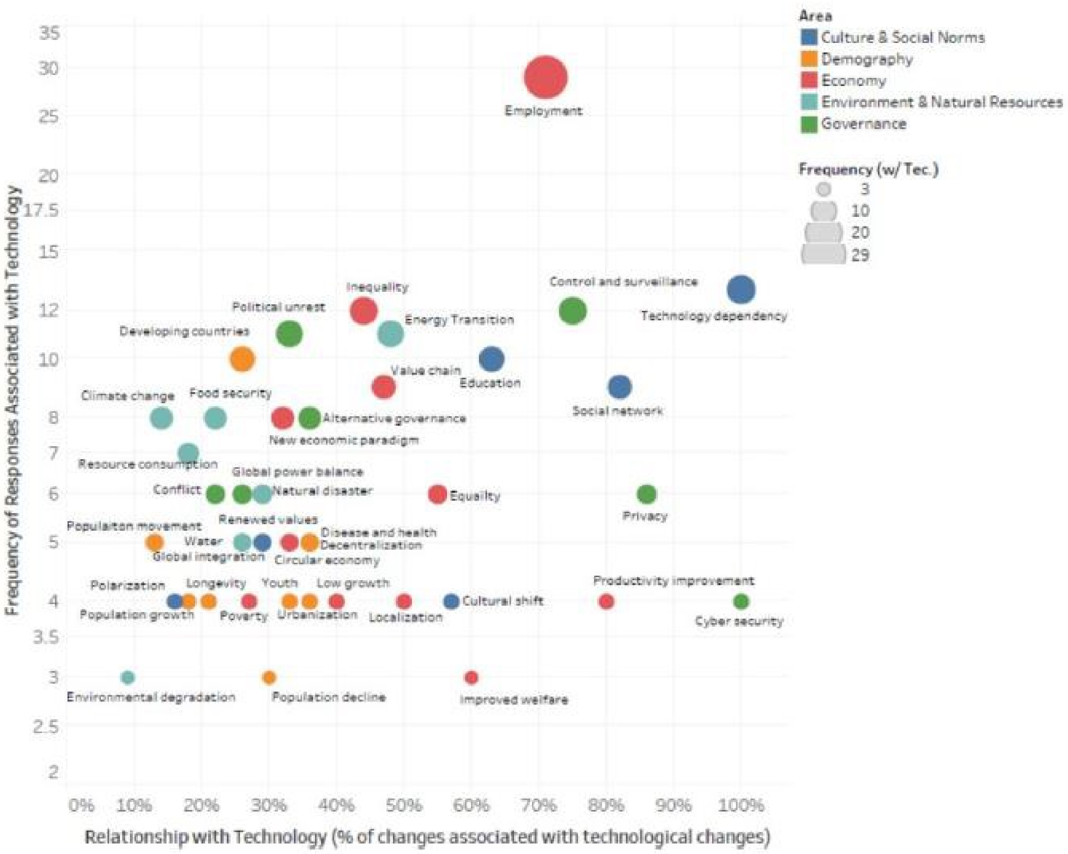

Figure 1: Changes in society related to technological innovation by 2050 [22]

The horizontal axis represents the relationship with technological innovation as a contribution to the changes associated with technological innovation. The vertical axis and bubble size reflect the technology-related responses.

2.2 Technological innovation systems

The concept of the technological innovation system is guaranteed the analyst changes from the perspective of institutional, organizational, economic, political and technical related to technology development. Bergak defined a technological innovation system as a set of components, including technologies, actors, networks, and institutions, that are active in developing a particular area of technology. The technological innovation system has three main pillars, structural factors, functional factors and contextual factors [5].

2.3 Structural factors

In fact, structural factors can be considered as components of the innovation system of all parts of the economic structure, which in a way affects the research and development. National structural factors can be considered as part of or related to a particular technology [18]. In another view, structural factors include three main categories: actors and their capabilities, networks and institutions [6].

2.4 Functional factors

Since technological changes cannot be analyzed by structural analysis of socio-technical systems alone, it is necessary to focus on their functions as a framework for process analysis. The functions of the system are based on the performance of its components and in fact on the processes that are important for the optimal performance of the innovation system. Some researchers have introduced the functions of the innovation system in line with its main function [4]. Based on this function, technological innovation systems have a general function. Following the innovation processes, or in other words, developing, disseminating and applying innovation, is considered to be the main function of innovation systems. The seven categories have the most citations in articles in this field, which include entrepreneurship, knowledge creation, knowledge dissemination, research orientation, resource provision and legitimacy [6, 15].

2.5 Background factors

Given that the technological innovation system has a technology-centred analytical framework, its analysis has always focused on technology-specific factors. A performance-based approach was formed in order to overcome the complexities of analyzing the technological innovation system and to integrate the factors influencing the performance of this system. But in this approach, too, little attention is paid to the background factors in the technological innovation system. In this regard, background factors were added to the framework of technological innovation system analysis.

External factors Influential in the technological innovation system are classified into three groups [15]:

- External effects resulting from international developments or the development of other countries in the field of technology;
- External effects due to inertia (stability) of the existing system;
- External effects from other emerging technological systems

Bergek while dividing the background environment (context) into these two types of external and structural relationships, relate them to two concepts of perspective and socio-technical systems. They present a total of four general types of background factors as follows: a) other technological innovation systems b) specific technological sector c) geographical factors and d) political factors [5].

To analyze the system of technological innovation, several methods have been considered that have evolved over different time periods. These methods include analysis based on output, system functions, system components, and the relationship between functions and structures. In general, the political structure can be considered as a set of institutional factors outside the innovation system that can act as a stimulus or obstacle to the development of technology.

In this research, the three main dimensions of technological innovation systems, which include structural, functional and contextual dimensions, will be examined as the basis of analysis in factoryless manufacturing.

2.6 Factoryless manufacturing

Factoryless manufacturing means starting a production-oriented business with the optimal use of existing facilities, capacities and infrastructure, without the need for major investment.

Factoryless manufacturing is an industrial activity in which the manufacturer usually lacks production machinery and equipment (such as tools, testing equipment and supplies, etc.) and produce some products by focusing on marketing research and development, branding, and also using facilities, equipment and capacities are available. The output of the production process is both goods and services. The product can be divided into two main and auxiliary products [37]. Factoryless producers are those manufacturing companies that outsource the manufacturing of their goods and products. This system can be used in electronics, electrical, home appliances, food and pharmaceutical industries, mechanical engineering, automotive appliances, etc. This perspective includes the supply of raw materials, the supply of intermediate goods and parts, and even scientific knowledge and expertise to sales and marketing in the entire value chain [31].

Factoryless manufacturing does not mean that the factory is not in the production process, but it does mean that the amount of worries and problems caused by factory management for the craftsman is minimized because it uses other resources and facilities and the factory becomes more complementary. Table 1 shows the difference between factoryless manufacturing and factory-produced production.

Table 1: Difference between production system with factory and without factory [33]

Row	Topic	Factoryless Production	Production with Factory
1	investment	very little	very much
2	number of manpower required	very little	very much
3	management	simple	complicated
4	organization	little	big
5	ability to change production capacity	very much	very little
6	ability to produce a variety of products	very much	very little
7	parts production workshop	does not have	it has
8	manufacturing order units outside the industry	very strong	no or small
9	Quality control unit	Scattered	Concentrated
10	Need space and land	very little	very much
11	Design and engineering unit	Very strong and big	Medium and small
12	Planning and production	Macro and foreign	Wisdom and interior
13	Control	Outside the organization and overall	Intra-organizational and minor

It justifies the need for factoryless manufacturing, especially because of the variety of products, the short life of the product, the rapid change in technology, the sharp change in the market demand, and the economics of this method. Since traditional and common methods in all processes of design, procurement, construction, production, assembly, warehousing, distribution, etc., require huge costs and pave the way for the irregular growth of the organization, so with the aim of fast production cycles in high volume and with Lower cost, production with factoryless method has been proposed [19].

The general model of factoryless production is as follows, in which cooperation between the final parent company and suppliers is the basis of this model.

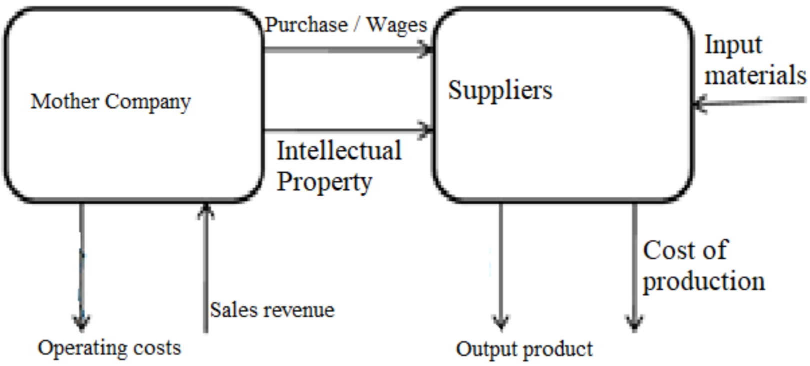

Figure 2: General model of production without factory [28]

Factoryless manufacturers fall into three categories [20]: First, companies that focus on research and development, engineering design, and product marketing. They are not involved in operations but distribute and sell the product of others with their own brand. The second group has technical knowledge and contracts in design and engineering with others and provides capital equipment and intermediate materials and parts. The third group are specialists who are capable in product design and sales and while starting activities in the production of various types of ICs and chips in the last three decades have been introduced as manufacturers without semiconductor factories and the term factoryless is more commonly used for this category as Phables. On the other hand, the Economic Classification

Policy Committee defines the characteristics of producers without factory goods as follows [36].

- The owner of the intellectual property right or design (whether independently developed or otherwise obtained) is the final product produced.
- May have or may not have input materials.
- Does not have production facilities.
- Does not perform transformation activities.
- They have the final product produced by production service partners.
- Sells the final product.

Factors that prepare the background for factoryless production include the segregation of activities along the value chain (outsourcing capacity), the availability of available manufacturing capacity, as well as pressures from competition or national, regional, and international conditions[31].

Some of the benefits of factoryless production are as follows:

- Use of existing infrastructure
- Activation of empty capacity of factories
- Reduce the cost of initial investment
- Brand registration without the need for a factory
- Production outsourcing
- High flexibility in the face of technological and market changes
- Increase employment
- Increase exports
- Increase the production of home businesses
- Helps reduce air pollution

With the creation and prosperity of such a production space in the country, units whose only job is production will be created. These companies are using newer technologies and techniques for production day by day. In such cases, other countries will also order production from such companies.

3 Factoryless manufacturing in Iran

In Iran, efforts have been made to develop factoryless manufacturing, and in this regard, the 40-article agenda for setting up and managing a production unit also directly refers to factoryless manufacturing, part of which is as follows:

Article 43. Factoryless manufacturing is recognized by observing the rules and receiving a business certificate. The product produced in this way is a new product that requires compliance with standards.

Note 1. A factoryless manufacturing unit can have a place for assembly or packaging, in which case the location, like other production capacities, includes the relevant criteria. Laboratories, research and development departments and engineering design of factoryless production units are not subject to these criteria.

Note 2. Factoryless production units are subject to the use of incentives and support.

Article 34. Production without a fixed location (such as fishing vessels that pack and process after fishing) is formalized by observing the rules and receiving a business certificate. The product produced in this way is a new product that requires compliance with standards.

Note 1. Production units without a fixed location are subject to the use of incentives and support [37].

Factory-free manufacturing has been common in Iran for a long time and now most of the country's handicraft products and some industrial products are produced through this. The production of handicrafts in the villages of the northern cities of the country, as well as the production of jams and pickles in these cities, the production of carpets in many villages of Kashan, Tabriz and Kerman and the production of Gabbeh and Kilim among the nomads and villagers of western Iran are examples of factoryless production. Examples of these include Mat weaving in Bushehr, Baluchi embroidery in Sistan and Baluchestan, Jajim and kilim weaving in Kohkiluyeh and Boyer Ahmad, pottery in Kashan and Hamedan.

At present, small family workshops around Tehran produce some of the finest casting and sewing parts of large factories such as Iran Khodro and Saipa, and many service jobs, such as product warranties for such factories, are also performed by people who are virtually operating out of the structure of the factory.

In the traditional system of production of carpets, rugs and kilims and all kinds of carpets, whose workshops are mainly located in the house and residential environment of rural weavers, because of the provision of raw materials and intermediates and even capital (wool, fluff, yarn, carpet hanger and some tools) is impossible for weavers for a variety of reasons, including financial weakness, then this was done by some individuals as suppliers of capital. Thus, from the point of view of the employer (investor), it is as if production took place without the need for a workshop, but in fact production workshops, ie home workshops, existed externally, and the employer played the role of managing production and running tens or hundreds of producing households. Among other cases, we can mention Jet Pars Company, which, by using this strategy, has started to produce various types of trailers, and has created dynamism in the production and activities of this company.

Of course, the question of whether all of these definitions fit into the factoryless framework or not can be significant. The answer to this question is not easy and it must be admitted that factoryless production in developing countries has a different role than this method in developed countries.

3.1 Preventing and Promoting Factors of Factoryless manufacturing in Iran

The problems and challenges of factoryless production and the critiques of it are not of the same kind and have different natures, which, although sometimes overlapping, do not seem to fit into a particular category [14]. One of the biggest concerns of the country is to create economic prosperity and provide opportunities for increasing production and subsequent job creation in the country's industrial sector, which has made experts, professors and officials think. In this regard, various theories and strategies have been proposed to help the government get society out of this economic impasse. In the importance of this issue, it is enough that the years 2017 to 2020 in Iran have been registered with an emphasis on production and production prosperity.

Most of the programs and schemes that have been implemented to date, such as low-interest loans, tax exemptions and deferrals, etc., are familiar to residents and industry activists and have been used for several decades in recent decades. But the current state of the country's industry shows that all the problems in expanding the production of industries and increasing the efficiency of factories cannot be solved only by lending and budgeting, but a plan is needed to make the most of previous investments and prevent capital wastage.

Some of the challenges of this production system that the researcher has faced over the years are as follows:

- Administrative bureaucracies in the field of obtaining activity licenses
- Restrictions on brand assignment
- Problems of providing fixed and working capital to factoryless producers
- Costs of receiving management standards
- Development of culture of attention to factoryless production
- Lack of specialized and experienced manpower in the field of factoryless production [13]
- The challenge of informal and temporary employment and changing the nature of work [14]
- Managerial concerns in the field of challenges of changing the nature of work in factoryless production
- Lack of investment in research and development

- Information complexity and knowledge acquisition in a factoryless production system
- The issue of accounting and auditing and profit calculation in a factoryless production system [12].
- Weakness in design and engineering

In addition to the macro factors that emerged as a precursor or barrier to factoryless production, another important specialized factor is choosing the right type of activity in the factoryless production method. Because not every kind of activity can be successful in the framework of factoryless production method. Therefore, activities that have the following characteristics should be used to the factoryless manufacturing method [33]:

1. Investor activities
2. Activities that have a high risk
3. Activities in which the employment of human resources is difficult
4. Activities that can be broken down into specific and independent components
5. Activities that have a complex technology design and a wide variety of manufacturing operations

Also, according to the classification of economic activities, which includes 22 categories, category c, which is related to manufacturing activities, is considered the most suitable activity for factoryless production, which is presented in the table 2 [38].

Table 2: Category c activities in 24 disciplines with 2-digit ISIC code

Code	Title	Code	Title
10	Production of food products	22	Production of rubber and plastic products
11	Making drinks	23	Production of other non-metallic mineral products
12	Making tobacco	24	Production of basic metals
13	Making textiles	25	Manufacture of fabricated metal products, except machinery
14	Making clothes	26	Manufacture of computer, electronic and optical products
15	Manufacture of leather and related products	27	Production of electrical equipment
16	Manufacture of wood and wood products	28	Production of unclassified machinery and equipment
17	Production of paper and paper products	29	Production of motor vehicles, trailers
18	Print and duplicate recorded media	30	Production of other transportation products
19	Production of refined petroleum products	31	Production of furniture

4 Methodology

This research is an interdisciplinary research between the fields of entrepreneurship and technological innovation, and it is "applied" in nature and "descriptive-correlation" in terms of method.

4.1 Methodology in Entrepreneurship

Due to the interdisciplinary nature and the entry of researchers in other fields into the field of entrepreneurship, a variety of quantitative and qualitative methodologies of other fields can be used. But despite this methodological richness, entrepreneurship as a discipline still faces a lack of methodological diversity. Many researchers consider qualitative research methods to be more suitable for studying entrepreneurship [21]. Therefore, in this research, the combined method of data theory and foundation and structural-interpretive modelling have been used to present the model.

In order to study and analyze the research variables that were discussed in the research literature, and finally, to assess the ideas of the statistical community related to examine the key factors of technological innovation model in factoryless production in Iran, we used the opinion and experience of experts and specialists.

The main tools in the present study for collection are:

Primary sources: Gathering information through interviews and questionnaires among experts in the field of examining the key factors of the technological innovation model in factoryless manufacturing in Iran.

Secondary sources: library studies, review of documents, books, articles and use of Internet resources.

The interviews are semi-structured, providing a general framework for discussing the research issue, and providing the interviewee with a general understanding of the subject [8].

In this study, the statistical population was determined using the previous literature. The statistical population of the present study consists of experts who are among the most experienced and knowledgeable people in technology management or factoryless production in Iran. In the qualitative section, targeted sampling and available sample and snowball were used, and the experts are interviewed and the interview continues until the respondents' response reaches convergence and theoretical saturation and there is no need to continue the interview. Criteria for determining expertise in the present study are people with a focus on factory production without a factory who have 1- the idea of producing a product 2- their product has been produced 3- they have sold the product 4- they have been scientifically active in this field.

When the community is unlimited, the sample size is obtained from the following formula:

$$n = \frac{Z^2 pq}{d^2}$$

n : Sample size

d : Permitted error

Z : The value of a normal variable with a confidence level of $1 - \alpha$

p : The ratio of having the desired attribute

$q = (1 - p)$

And to calculate the sample size in terms of α and β, we do the following:

$$n = \frac{\sigma^2 \left(_\beta - Z_\alpha\right)^2}{d^2}$$

σ^2 : Community variance

Z_α : Critical value according to the confidence level

Z_β : Critical value according to the confidence level

d : The desired difference

If $\beta < 0.5$, we use the following formula:

$$n = \frac{\sigma^2 \left(\mid Z_\beta \mid - \mid Z_\alpha \mid\right)^2}{d^2}$$

Achieving sample size in qualitative research requires theoretical saturation. In this study, the sample size was up to 11 people, and the selection of interviews was such that it was effective in presenting a model of technological innovation in factoryless production. Therefore, in order to discover the appropriate findings, the researcher conducted in-depth interviews with experts. Sampling (interviews) in this method should be done as needed (theoretical saturation). The researcher tried, as needed, to maintain his creative analytical distance while entering the data. Interviews were conducted using simultaneous theoretical sampling, interview type and data. In each interview, the researcher conducted an interview using previous interviews, and he started the next interview according to the previous interviews. This round-trip process was such that we did not receive any new information from the ninth interview onwards. However, the researcher continued the interview to be more sure and to establish the reliability of the data and continued to work until the eleventh interview. Table 3 lists the interviewees.

For data analysis, the Foundation Data Theory method was used, which is the main method of data collection using a variety of interviews, and by analyzing and coding the text of the interviews, a paradigm model is presented. In the data theory method, the foundation is developed using a set of data. So that this theory, on a large scale, explains a process, action or interaction.

In qualitative research, reliability is the degree of stability observed in the measurement results of an instrument. Since qualitative research interprets the subject matter, there is no need to create and present the traditional concept of reliability. And the term "research audit" is used instead of the term reliability. In a research audit, the researcher

Table 3: Categories of interviewees

Code of Interviewee	Sex	Age	Expertise	Field of Activity
I_1	Male	58	PhD in Policy Making	Researcher of the Vice President for Science
I_2	Male	62	PhD in Entrepreneurship	Carpet production in East Azerbaijan
I_3	Male	43	PhD in Policy Making	Factory-free production researcher
I_4	Male	52	PhD in Industrial Management	Home Business Consultant
I_5	Male	36	PhD in Technology Management	Outsourcing clothing in rural areas
I_6	Male	60	PhD in Entrepreneurship	Carpet and kilim export consultant
I_7	Male	48	PhD in Business Administration	Internet Business Sales Consultant
I_8	Male	60	PhD in Economics	Factoryless production researcher
I_9	Female	35	Master of Handicrafts	Holder of handicraft sales site at the national level
I_{10}	Male	36	PhD in Technology Management	Factoryless production researcher
I_{11}	Female	31	PhD student in Technology Management	Manufacturer of dried fruit products and founder of the online store of food products nationally

must show the auditor how he or she collected the data. How categories are derived from them. According to the audit method of this research, which was interview, at each stage of data collection and analysis, the derived categories were shown to the interviewees to confirm the accuracy of the content. The questions were also reviewed by knowledgeable people and the appropriateness of how the questions were asked and the position of the interview were taken into consideration.

5 Data Analysis

In data analysis, content analysis method has been used in the form of coding and categorization. Coding based on data foundation theory consists of three stages of open, axial and selective coding. Here are some examples of coding methods.

The *binary repetition code* of length n or $BRC(n)$ is defined by the encoding function E

$$0 \to z, \quad 1 \to 0$$

For a given BRC(n), $P_d = 1$ and $P_c = \frac{1}{2}$ (for odd n). The ***minimum distance*** d of a ***linear code*** L equals the minimum among with weights of non-zero code words. Let L be a linear code of length n over F. Let $k \leq n$ be the dimension of L over F and choose a basis

$$X^1,\ X^2,\ \ldots,\ X^k$$

of L over F. Then any element in L is of the form

$$a_1X^1 + a_2X^2 + \ldots + a_kX^k$$

that is a linear combination of the basis elements. A message vector

$$a = (a_1a_2 \ldots a_k)$$

is thus encoded. $A[n, k, d]$ linear code has length n, dimension k, and minimum distance d. Examine the linear code L of length over B with basis

$$\mathbf{B} = \left\{ \begin{pmatrix} 1 \\ 1 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \\ 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \\ 1 \\ 0 \end{pmatrix} \right\}$$

then the encoding function maps the message words using linear combinations of elements of B as follows:

$$000 \to 0000; 001 \to 1010; 010 \to 0111; 100 \to 1100; 110 \to 1011; 101 \to 0110; 011 \to 1101; 111 \to 0001.$$

Notice that the set of code words is thus generated by **B**. Note the minimum distance is 1 since $wt(0001) = 1$. Thus L is a $(4, 8, 1)$-code and a $[4, 3, 1]$ linear code

$$P_d = P_c = 0.$$

A linear code L of length n over B is called **cyclic** if any cyclic shift of a **code word** is again a code word, i.e, if

$$(a_0; a_1, \ldots, a_{n-1}) \in L$$

then

$$(a_{n-1}, a_0, \ldots, a_{n-2}) \in L.$$

Define a map

$$\theta : V(n, 2) \to \frac{B[x]}{\langle x^n - 1\rangle},$$

where $\langle x^n - 1\rangle$ denotes the ideal of the polynomial ring $\mathbf{B}[x]$ generated by $x^n - 1$, by

$$\theta\left(a_0, a_1, \ldots, a_{n-1}\right) = a_0 + a_1 x + \ldots + a_{n-1}x^{n-1} + \left\langle x^n - 1\right\rangle.$$

Observe that

$$\frac{B[x]}{\langle x^n - 1\rangle}$$

is also a vector space over **B**, it is easy to show θ is a vector space isomorphism. Let L be a linear code of length n over **B**, i.e. L is a subspace of $V(n, q)$. Then, because θ is an isomorphism $\mathrm{Im}(L)$ is a subspace of

$$\frac{B[x]}{\langle x^n - 1\rangle}.$$

Let $(a_0, a_1, \ldots, a_{n-1}) \in L$. Then $(a_{n-1}, a_0, \ldots, a_{n-2}) \in L$ if and only if

$$a_{n-1} + a_0 x + \ldots + a_{n-2}x^{n-1} + \langle x^n - 1\rangle = \underline{x}\left(a_0 + a_1 x + \ldots + a_{n-1}x^{n-1}\right) + \langle x^n - 1\rangle$$

is in $\mathrm{Im}(L)$. Denote

$$a_0 + a_1 x + \ldots + a_{n-1}x^{n-1} = f(x).$$

Then if both $f(x)$ and $xf(x)$ are in $\mathrm{Im}(L), x^2 f(x)$ is in $\mathrm{Im}(L)$ and for $0 \leq i \leq n-1$, $x^i f(x)$ is in $\mathrm{Im}(L)$. Since $\mathrm{Im}(L)$ is a vector space, any linear combination of the vectors

$$f(x), xf(x), \ldots, x^{n-1}f(x)$$

is also in $\mathrm{Im}(L)$. Therefore, for every polynomial

$$p(x) = b_0 + b_1 x + \ldots + b_{n-1}x^{n-1}$$

in $\mathbf{B}[x]$,

$$p(x)f(x) = \left(b_0 + b_1 x + \ldots + b_{n-1}x^{n-1}\right) f(x) = b_0 f(x) + b_1 x f(x) + \ldots + b_{n-1}x^{n-1}f(x)$$

which is a sum of elements of $\mathrm{Im}(L)$ and is thus in $\mathrm{Im}(L)$. Hence, $\mathrm{Im}(L)$ is an ideal in $\frac{B[x]}{\langle x^n - 1\rangle}$ and we can see L as an ideal of $\frac{B[x]}{\langle x^n - 1\rangle}$. This generalizes easily to the ring of polynomials over any finite field.

5.1 Step One: Open Coding

At this stage, verbal evidence is extracted from the verbal propositions of the interviews. In this study, the recorded interviews after implementation were reviewed, conceptualized and categorized line by line. Then, based on the similarity, conceptual relationship and common features between open identifiers, concepts and categories (a class of concepts) were identified.

5.2 The second step: Categorize of items around the axis (axial coding)

In the second stage or axial coding, based on the paradigm model of axial coding, the main category was selected from the list of classes (previous steps) and was central to the axial coding process. In this step, the foundation data theorist selects an open identification step category and places it at the center of a process under consideration (as a Core category or phenomenon). These categories are: Causal conditions, Intervening conditions, Context conditions, Strategies, Consequences. In this study, according to the main purpose, which is the extraction of variables related to the pattern of technological innovation in factory-free production, this pattern is considered as the main phenomenon. Also, "structural factors", "functional", "contextual" and "operational structure of factory-free production" as conditions affecting the main phenomenon; Also, the category of "organizational arrangement" is considered as a strategy and the category of "interactions of the socio-economic environment" is considered as consequences. The coding performed in three categories of open source, subcategory and main category is as follows in table 4.

As shown in the table 4, 71 concepts, 19 sub-categories and 6 main categories were identified in the field of technological innovation model in factoryless production in Iran.

Table 4: were identified in the field of technological innovation model in factoryless manufacturing in Iran.

Row	ID	Open Codes	Subsidiary Category	Main Category
1	SF11	Strict institutions: rules, instructions in the field of factoryless production	Institutions SF1	Structural Factors (SF)
	SF12	Soft institutions: conventional practices and attitudes toward production in Iran		
	SF13	Existence of a specific trustee in the field of factoryless production		
2	SF21	Individual interactions for outsourcing	Interactions SF2	
	SF22	Group and organizational interactions for factoryless production and divestitures		
3	SF31	Physical infrastructure: tools, machinery, roads, buildings, ports	Infrastructure SF3	
	SF32	Knowledge infrastructure: knowledge, expertise, strategic information		
	SF33	Financial infrastructure: subsidies, financial programs, grants		
	SF34	Discussion of Intellectual Property Rights in Factoryless Production		
	SF35	Major legal issues in factoryless production		
	SF36	Issuance of national standard license		
4	SF41	The role of the government in the development of factoryless production platforms	Actors SF4	
	SF42	The role of civil society organizations, companies, start-ups, small and medium-sized companies, large companies in accompanying and developing factoryless production		
	SF43	The role of other sectors such as legal organizations, banks and financial organizations, intermediaries, technology traders, consultants in factoryless production		
5	FF11	The relationship between the political environment and the technological innovation system as the main axis of long-term transition processes	Political factors FF1	Functional Factors (FF)
	FF12	Government decisions and legislative bodies		
6	FF21	Communication with supply chain elements	Geographical factors FF2	
	FF22	Communication with other supply chains		
	FF23	Benefits of cheap labor and workplace		
7	FF31	Communications between different technological systems	Other innovation systems FF3	
	FF32	Attention to other technologies in the field		

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Row	**ID**	**Open Codes**	**Subsidiary Category**	**Main Category**
	FF33	Focus on the value chain of a particular technological field		
	FF34	The effect of technological changes on product development		
8	UF11	Discover business opportunities with factory-free production potential	Entre-preneurship UF1	Underlying factors (UF)
	UF12	Take advantage of technology-based opportunities		
	UF13	Redesigning the entrepreneurial value chain based on factoryless production methods		
9	UF21	Paying attention to technical and specific knowledge related to the job	Development and dissemination of knowledge	
	UF22	Market and network knowledge		
	UF23	Knowledge sharing process based on complementary empowerment		
	UF24	Creating processes for commercializing ideas		
10	UF31	Making technology competitive with existing technologies in the market	Shaping the market UF3	
	UF32	The issue of technology acceptance		
	UF33	Marketing and market segmentation		
11	UF41	Provide and coordinate input required for the development of a factoryless production innovation system	Providing resources UF4	
	UF42	Funding and hardware		
	UF43	Providing manpower and software		
12	OS11	Implement a logistics structure that connects businesses and corporations	Execution of operations without factory OS1	Operational structure (OS)
	OS12	Formation of communication channels, material flow, controls, financial flow		
	OS13	Determining the production method in factoryless production		
	OS14	Accounting, auditing and calculation of profit and loss in factoryless production		
	OS15	Design and quality control of products and services		
13	OS21	Determining communication structures	Cooperation structure OS2	
	OS22	Eliminate the barriers between organizational knowledge and external knowledge		
	OS23	Partner design (in terms of risk and cost)		
	OS24	Design cooperation with competitors		
14	OS31	Value chain analysis and identification of outsourced segments with priority	Outsourcing OS3	
	OS32	Identify and analyze suitable individuals and organizations to entrust work to them		
	OS33	Entrusting tasks to outsiders as a tool to improve productivity		
	OS34	Reduce costs as an advantage of outsourcing		
15	IA11	Determining the cooperation strategy for factoryless production	Network governance IA1	Institutional arrangements (IA)
	IA12	Networking and information pattern		
	IA13	Trans-organizational and factory organization that determines the way of cooperation and communication between firms		
16	IA21	Designing a new factoryless business model	New organizational model IA2	
	IA22	Redesign organizational processes for factoryless conditions		
	IA23	Pay attention to branding and brand management		
	IA24	Focus on research and development		
	IA25	Paying attention to the changing nature of work in the production method without factory		

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Row	ID	Open Codes	Subsidiary Category	Main Category
	IA26	Staff training and empowerment		
	IA27	Continuous market monitoring and modern digital marketing		
	IA28	The new role of the consumer as a marketer and brand maker		
17	ISE11	Changing the attitude of the society towards accepting factoryless production	Environmental intelligence ISE1	Interaction of socio-economic environment
	ISE12	Coordinating the company's capabilities with environmental changes		
	ISE13	Better adaptation of products to rapid changes in customer demands		
18	ISE21	Analysis of economic and investment trends	Economic intelligence ISE2	
	ISE22	Analysis of signs of technology change		
	ISE23	Giving economic value to technical decisions through business model		
	ISE24	Use of empty production capacities		
19	ISE31	Job creation and self-employment	Social responsibility ISE3	
	ISE32	environmental issues		
	ISE33	Energy saving		
	ISE34	Involve customers in processes from idea to design and production		

5.3 The third step of selective coding

In the third stage or selective coding, an attempt was made to establish a logical connection between the classes produced in the previous stages in a systematic way. At this stage, based on the analysis of qualitative data, the axial coding stage was completed, according to which the relationships between the classes obtained from the first stage and the second stage were expressed through a narrative description. Selective coding is the process of integrating and improving categories. The following figure shows the pattern of the qualitative research process (figure 4). In fact, selective coding is the most important stage of theorizing in which the researcher connects the categories with each other and based on these connections tries to create an image or theory about the subject [10]. At this stage, the different conditions expressed in the axial coding stage are merged and a general analysis is performed.

Table 5: Structural self-interaction matrix

	Structural	Interaction	Technological pattern of production	Operational structure	Functional	Organizational makeup	Background
Structural		V	A	O	O	O	O
Interaction	A		A	A	O	A	A
Technological pattern of production	V	V		V	O	V	O
Operational structure	O	V	A		O	O	X
Functional	O	O	O	O		V	X
Organizational makeup	O	V	A	O	A		A
Background	O	V	O	X	X	V	

As shown in the table 5, a 7×7 matrix was provided to the experts and they determined the relationship between the elements based on the specified principles. By calculating the initial and final access matrix, the grading table of variables was obtained as follows (Table 6).

Finally, the following figure shows structural-interpretive modeling (Figure 5).

As shown in the figure above, the interpretive structural model of the technological innovation model in factoryless production is classified into four levels: main phenomenon, infrastructure level, brick level and result level.

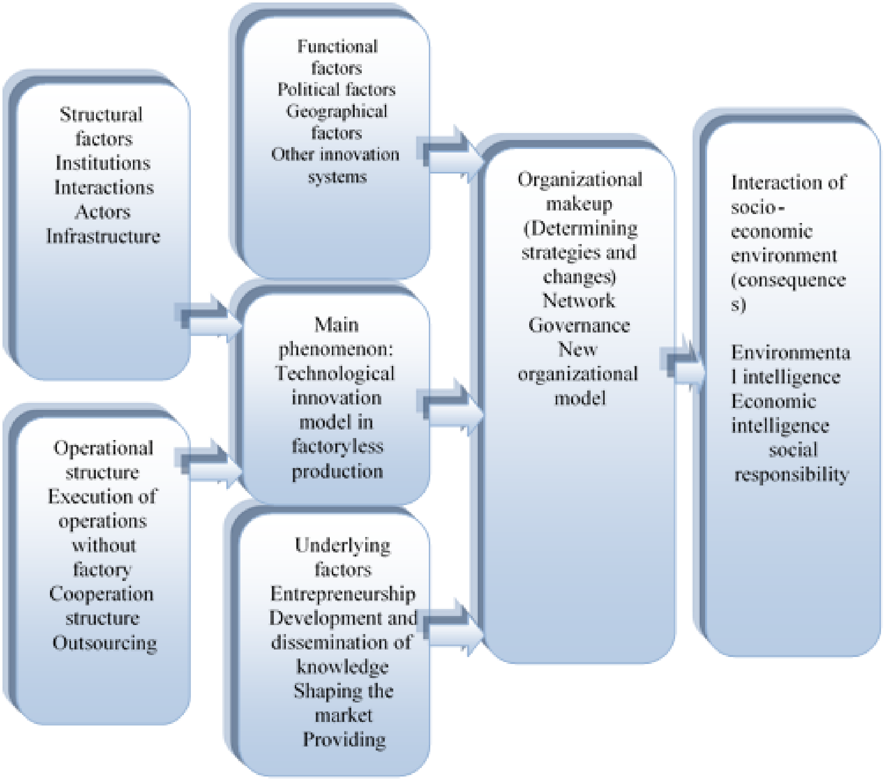

Figure 3: Technological innovation model in factoryless production in Iran

Table 6: Leveling of variables

Repetition	**Row**	**Inputs**	**Outputs**	**Subscriptions**	**Level**
First	3	1-2-3-4-5-6-7	3	3	First
Second	1-4-5-7	1 and 2	1	1	Second
		2-4-5-6-7	4 and 5-7	4 and 5-7	
		2-4-5-6-8	4 and 5-7	4 and 5-7	
		2-4-5-6-9	4 and 5-7	4 and 5-7	
Third	6	2 and 6	6	6	Third
Fourth	2	2	2 and 6	2	Fourth

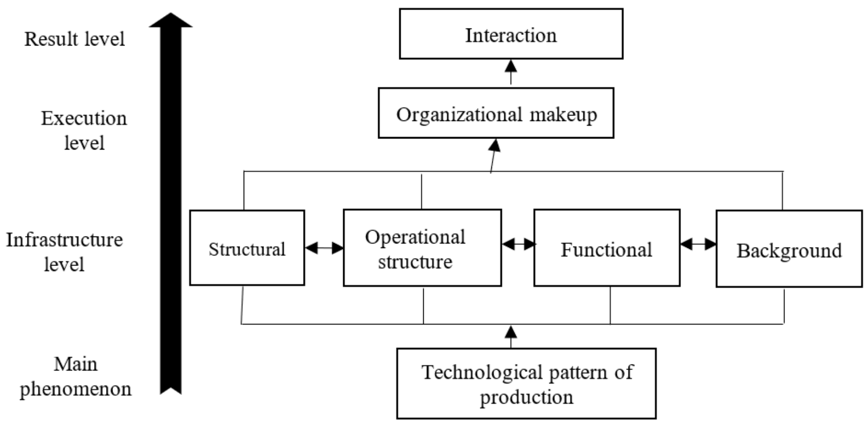

Figure 4: Technological model of factory-free production obtained from interpretive structural modeling

In the next step, based on MICMAC analysis, the examined criteria are drawn based on penetration power and dependency (Figure ??).

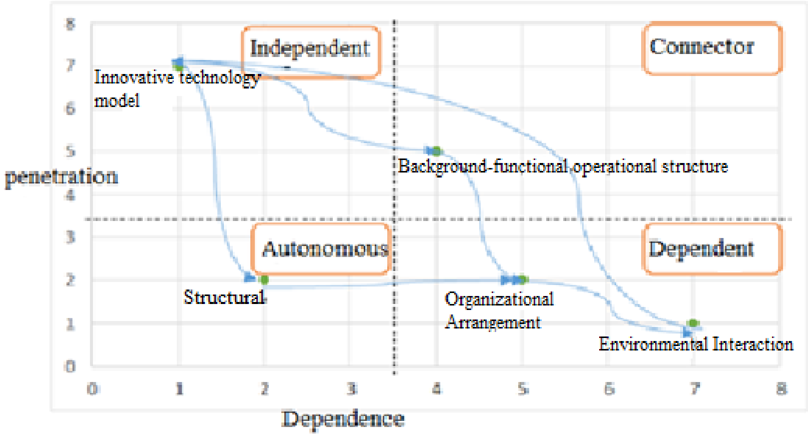

Figure 5: Penetration-dependency matrix

The results show the types of changes based on the coordinates of the Mick Mac diagram as follows:

Independent: The factor of technological innovation model as an independent factor and influencing other factors. These variables have low dependence and high conductivity, in other words, high impact and low impact are the characteristics of these variables.

Autonomous: The structural factor is in the range of autonomous agents. This area shows that they have little dependence and conductivity.

Dependent: Organizational makeup factors and environmental interactions are located in this area. These variables have strong dependence and poor conductivity. These variables generally have a high impact and little impact on the system.

Interface: The contextual, functional, and operational structure variables are located in this area. These variables have high dependence and high conductivity, in other words, the effectiveness of these criteria is very high and any small change on these variables causes fundamental changes in the system.

6 Conclusion and Recommendations

The purpose of this study was to present a model of technological innovation in factoryless production in Iran. In this regard, after studying and summarizing the theoretical foundations and research records and interviewing experts, the research gap was identified and based on this, the research question and the research process were identified. The analysis of the interviews led to the identification of six main categories as "structural factors", "functional", "contextual" and "operational structure of factoryless manufacturing", "organizational arrangement" and "interactions of the socio-economic environment".

Based on the model drawn in the data theory method, the propositional propositions (theorems) of the research are presented as follows. Judicial propositions or research theorems that refer to the interrelationships of categories are considered the product of selective identification. Theoretical theorems are the same theorems or hypotheses that express the relationships between categories with the central phenomenon. Based on the axial identification factors of this research, the following theorems are obtained:

Theorem 6.1. Factors affecting the model of technological innovation in factoryless production include structural factors (including institutions, interactions, actors and infrastructure) and factory-based production operational structure (including factoryless operation, cooperation structure, outsourcing), which directly effects the main phenomenon.

Theorem 6.2. Functional factors (including political factors, geographical factors and other innovation systems) and contextual factors (including entrepreneurship, knowledge development and dissemination, market formation and resource supply) according to the main phenomenon effect on the definition of strategies.

Theorem 6.3. Network governance as one of the foundations of the strategy determined by determining the strategy of cooperation for factoryless production, networking and defining information model and extra-organizational organization, affects the factory-free production process and leads to consequences in this regard.

Theorem 6.4. New organizational model as another strategic production plant without using the new business model design method, redesign of organizations for factoryless conditions, attention to branding and brand management, development, research and development, attention to changing the nature of work in the factoryless production method, training and skills development of employees, continuous market monitoring and modern digital marketing and defining the new role of the consumer as a marketer and brand maker will affect this project.

Theorem 6.5. The category of "interactions of socio-economic environment" in this study was considered as the consequences of the model, which includes environmental intelligence, economic intelligence and social responsibility.

Given the current situation in the country and the need to pay attention to employment and development of domestic production, the method of factoryless production can be an effective solution in this area. The results of the present study on the effect of factoryless production on increasing production capacity and productivity and national production growth are consistent with the research of Seyed Rezaei and Namamian [23, 30].

According to the study of successful cases of factoryless manufacturing in Iran, it seems that if progress has been made in this field, it is mainly based on manpower and previous experiences, and technological innovation has played a lesser role in it. Therefore, considering the importance of new technologies and technological innovation systems in the future of businesses and products, as well as the function of this system, as an appropriate response to external pressures and changes, we conclude that technological innovation system can provide a good model for the development of factoryless production in Iran. Wang and Dehghani Soltani have also emphasized the key role of technological innovation in production systems [11, 34]. Also, the leveling of the main variables in the second part of the research showed that technological innovation acts as a basic level and a bedrock in the development of factoryless production. Baldwin also states that new technologies have provided many opportunities for the development of factoryless production [2].

Another important point is to choose a suitable industry for development by factoryless production method according to the conditions and priorities of the country. For example, factoryless production in the United Kingdom has been more in the field of chemicals and pharmaceuticals, but more developed in the United States in the electronics industry [9]. It is recommended that future research examine the context of the companies and the industry in which they operate as a moderating variable in the model.

Also, considering the importance of cultural issues and attitudes in the field of factoryless production, it is recommended that future research consider the mentioned variables in the proposed model and the factors affecting the acceptance and development of factoryless production as a production method, be considered more comprehensively.

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