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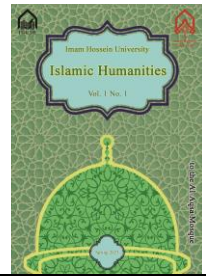

Analyzing the factors affecting the number of patents registered in the provinces of the country

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Patents, Knowledge-based Firms, Research and Development, Postgraduate education, Innovation output

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A B S T R A C T

Due to the importance of innovation, in recent years, several activities have been carried out to identify the factors affecting the creation of innovation. In this regard, since one of the important indicators of creating innovation is the number of patents registered, so the present study seeks to identify the most important factors affecting patents in the country. To achieve this goal, all patents registered during the years 1390 to 1395 were identified and analyzed by referring to the official Gazette of the country. Also, by reviewing the research literature and interviewing experts, the most important factors influencing the inventions were identified and five quantitative factors whose data were available for all provinces of the country were selected to continue the analysis. Then, using a regression analysis test, the effect of the factors on the number of patents registered in the provinces of the country was investigated. The results show that the per capita factor of the number of Knowledge-based Firms in each province has the greatest impact on the number of patents. Also, the factors of workshops with research and development licenses and the number of master and Ph.D. students have a great impact on the number of patents after the above factor and the factor of the distance between the province capital to Tehran has an inverse and moderate effect on the number Has patents registered in each province.

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4. Introduction

Innovation is a very important factor in survival and success for those organizations that upgrade their competitive base (Baumol, 2002). One of the most important indicators for evaluating innovation is the number of patents. But it must be borne in mind that an invention alone cannot guarantee commercial success, however, it represents some of the innovation output (Kemp, Folkeringa, De Jong & Wubben, 2003). In fact, invention data is very attractive for innovation research, especially for the following reasons: First, patent documents are rich and complete in that they are a solid foundation with a rich description of the technology. In addition, they have multifaceted information such as the inventors' information, the place of patenting, its applications, and so on. Second, a large amount of patent data is recorded in standard and systematic formats, which gives researchers high analytical power. Another reason is that the information in the patents is available and visible to everyone (Kim & Lee, 2015). Finally, patent documents do not change over time, because patent data is an important resource that allows researchers, managers, and policymakers to analyze innovation processes at the national (Kang, Huo & Motohashi, 2014), sectoral (Kang & Motohashi, 2014), corporate, and real levels (Kang, 2015). By analyzing the status of patents, senior managers and policymakers can identify and modify innovation development direction in different areas of the country to develop them; But to be able to modify the development of innovation (with the patent assessment tool) according to the needs of the country, they need access to the factors affecting patents. These are the factors that stimulate change in the development of inventions in the country.

Different researchers have studied the factors affecting inventions from different perspectives. Hu and Jefferson (2009), for example, examine the rising tide of patents in China and conclude that a focus on research and development can only partially explain this growth. The present study shows that the factors of foreign direct investment, the revision of the patent law (in 2000) as well as the revision of the property law have had a significant impact on the explosive growth of inventions in China (Albert Guangzhou Hu & Jefferson, 2009). Cheung and Lin (2004) also found a significant relationship between foreign direct investment and the number of patent applications in China between 1995 and 2000. Chen (2018) study shows that the growth of research and development is not enough alone cannot explain the growth of the number of inventions. The results show that China's R&D spending increased by more than 256 percent from 1999 to 2006; although the number of inventions during this period for all types of patents should have increased between five and nine percent, but in fact the number of inventions has grown by 896 percent, utility patents (applied patents) by 333 percent and design patents by 160 percent. Researchers in this study conclude that other factors besides research and development (such as foreign direct investment and patent grant programs) have been the cause of this event (H. Chen, Wang, & Singh, 2018). In the country, Farhangnejad et al. (1398) in their research seek to extract an integrated model of factors affecting the creation of patents and have counted their factors qualitatively (not quantitatively). Also, Bagheri et al. (2013) in their research examined the two factors of distance between the distance between the province capital to Tehran and the average level of household income as factors affecting the geographical distribution of inventions. The results of this study indicate the significant effect of geographical distance to Tehran and the lack of effect of the average household income level on patents (Bagheri, Samandarali Eshtehardi, Peymankhah & Shafiei, 1392). In fact, many factors affecting inventions have been qualitatively extracted; However, most of the researches have been done quantitatively (Table 2) in which only one or two factors have been studied and since in this research the identification of factors along with statistical data is considered; therefore, only quantitative factors that their data can be identified for the provinces have been analyzed. In general, present study seeks to identify more comprehensively and with statistical documentation those factors affecting patents in the country so that top managers can have effective tools to develop innovation.

Also, for data analysis, some descriptive statistics such as the trend of the number of inventions, women share in patents and the status of multi-inventions people have been examined. On the other hand, in order to enrich the research results as much as possible and through interviews with experts, some new factors (besides the factors enumerated from the literature) were added to the present research: the factor of the number of Knowledge-based Firms).

34. Literature Review

Farhangnejad et al. (1398) in their research seek to provide an integrated model of factors affecting the creation of patents. Patent process management, international interactions in R&D (foreign investment), R&D activities, intellectual property rights system, technology management services (including science and technology parks and technology transfer centers), knowledge management and macroeconomics environment from the perspective of these researchers are the most important factors influencing patents (Farhangnejad, Elahi, Ghazi Noori & Majid Poor, 1398).

Some studies have examined the role of knowledge management on patents. These studies emphasize the role of knowledge storage and tacit knowledge flow (Alletto, Bruccoleri, Mazzola & Ramanathan, 2017), knowledge spillovers (Agrawal, 2001; Tseng & Pai, 2014), using the information technology tools (Garcia-Muina & Gonzalez-Sanchez, 2017), access to knowledge resources (Kammoun & Rahmouni, 2014), and production of science and scientific publications in patents (Fabrizio, Poczter, & Zelner, 2017; Grimm & Jaenicke, 2015; Meyer, 2006). These factors increase the capacity for innovation, increase the production of technological knowledge, and finally lead to an increase in patents (Farhangnejad et. al., 1398). Sen and Sharma examined the relationship between scientific papers and the number of patents in the field of superconductors from 1951 to 2000. They concluded that the relationship between the two factors is nonlinear and that the growth in the number of scientific papers does not correlate linearly with the growth in the number of patents in this area. They assume the reason to the fact that there is a period of rest between the paper publication and patents (Sen & Sharma, 2006).

Some research also emphasizes the importance and role of technology transfer offices, supporting technology commercialization, granting royalties (Arque-Castells, Cartaxo, Garcia-Quevedo & Godinho, 2016; Kolympiris & Klein, 2017; Lee & Stuen, 2016) and the role of science and technology parks. Science and technology parks, through their role of mediation, coordinate research, and development-related collaborations and create a link between government, industry, and academia (Jongwanich et al., 2014). Science and technology parks, through their role of mediation, coordinate R&D-related collaborations and link government, industry, and academia. This infrastructural factor grows research and development activities, creates more connections in the form of research networks, and promotes the ability of researchers that finally increases patents (Farhangnejad et. al., 1398).

Another group of researchers has focused on the role of investment in the number of patents and concludes that state-owned companies (which have used foreign investment) have spent more on research and development than private companies (Acharya & Xu, 2017; Guerzoni, Aldridge, Audretsch & Desai, 2017). They have been able to patent better inventions. Hu and Jefferson (2009) concluded in their study that also foreign direct investment affects the number of inventions (Albert Guangzhou Hu& Jefferson, 2009). Also, the results of some other studies show that foreign direct investment has an impact on applied patents and design patents in China (Z. Chen & Zhang, 2019). The role of investment in inventions is also evident in the study of Gurzoni et al. They conclude that allocating academic resources to researchers leads them to be more willing to patent. Venture capital is another type of investment that, according to Bertoni and Tikova (2015), has a positive effect on patents (Bertoni & Tykvova, 2015).

The relationship between R&D and patents has been investigated in some studies (Griliches, 1981; Hausman, Hall & Griliches, 1984). Chen et al. (2019) concluded in their research that investment in research and development is one of the factors influencing increasing or decreasing the number of inventions. In their view, increasing research and development studies in China was one of the most important factors affecting the growth of inventions there (Z. Chen & Zhang, 2019). Coupe (2003) also examines academic inventions, points to the impact of research and development costs and confirms impact on the output of university inventions (Coupe, 2003). Unlike previous researches, Hu (2017) shows that the role of the R&D factor in patent applications is not very important (Albert GZ Hu, Zhang & Zhao, 2017).

The patent system in each country is also one of the factors that affect patents. A study by Ang et al. in China shows that the intellectual property rights system affects the ability of companies to attract foreign investment and leads companies to invest more in research and development, which finally leads to increased patents (Ang, Cheng & Wu, 2014); But studies in the United States and Japan show that intellectual property rights have a negligible impact on the number of inventions (Z. Chen & Zhang, 2019). For example, Sakakibara (2001) et al. studied the impact of the Japanese Patent Act revision on inventions but found no significant relationship between them (Sakakibara & Branstetter, 2001).

Table 8. Factors affecting patents

Factors affecting patents	Sources
Knowledge management (knowledge storage, tacit knowledge flow, knowledge spillover, using information technology tools, access to knowledge resources, science production and scientific publications)	(Alletto, Bruccoleri, Mazzola, & Ramanathan, 2017) ‹(Agrawal, 2001; Tseng & Pai, 2014) ‹ (García-Muiña & González-Sánchez, 2017) ‹ (Kammoun & Rahmouni, 2014) (Fabrizio, Poczter, & Zelner, 2017; Grimm & Jaenicke, 2015; Meyer, 2006), (Sen & Sharma, 2006).
Infrastructures (science and technology parks, technology transfer offices)	(Arqué-Castells, Cartaxo, García-Quevedo, & Godinho, 2016; Kolympiris & Klein, 2017; Lee & Stuen, 2016), (Jongwanich, Kohpaiboon, & Yang, 2014; Minguillo & Thelwall, 2015)
Investment (foreign investment, venture investment)	(Acharya & Xu, 2017), (Guerzoni, Aldridge, Audretsch, & Desai, 2017), (Albert Guangzhou Hu & Jefferson, 2009), (Chen & Zhang, 2019), (Bertoni & Tykvová, 2015).

Factors affecting patents	Sources
Research and Development	(Griliches, 1981; Hausman, Hall, & Griliches, 1984), (Chen & Zhang, 2019), (Coupe, 2003),
Patent's system	(Ang, Cheng, & Wu, 2014), (Chen & Zhang, 2019), (Sakakibara & Branstetter, 2001).
Science, technology and innovation policy making	(Fabrizio et al., 2017), (Del Giudice, Maggioni, Romano, & Nicotra, 2014), (Rizzo & Ramaciotti, 2014), (Verspagen, 2006; Zucker, Darby, Furner, Liu, & Ma, 2007).
Distance from provinces to Tehran	(Bagheri et. al., 1392)
Average household income level	(Bagheri et. al., 1392)
Access to resources	(Laplume, Xavier-Oliveira, Dass, & Thakur, 2015)
Tax policies	(Mukherjee, Singh, & Žaldokas, 2017)
The scientific reputation of the inventor	(Lee & Stuen, 2016)
Quality of previous inventions	(Sterzi & Lawson, 2014)
Provide financial and non-financial incentives	(Brander & Zhang, 2017)
Patent processes, macroeconomic environment, human resource management and empowerment, capabilities and records of companies and universities, demographic and psychological characteristics, absorption capacity, and innovation capacity	(Farhangnejad et. al., 1398)
Patent fee	(De Rassenfosse & Jaffe, 2018)

The policy-making role of science, technology, and innovation on patents has also been considered in some studies. Fabrizio et al. (2017) review energy-related data and conclude that these policies are associated with an increase in inventions (Fabrizio et. al., 2017). In their study, Del Giudice et al. (2014) conclude that patent-related activities are influenced by domestic policies and regulations of academic and research centers (Del Giudice, Maggioni, Romano & Nicorta, 2014). Another group of researchers also introduces the adoption of academic policies and regulations related to patents as a factor influencing the number of applications for academic patents (Rizzo & Ramaciotti, 2014).

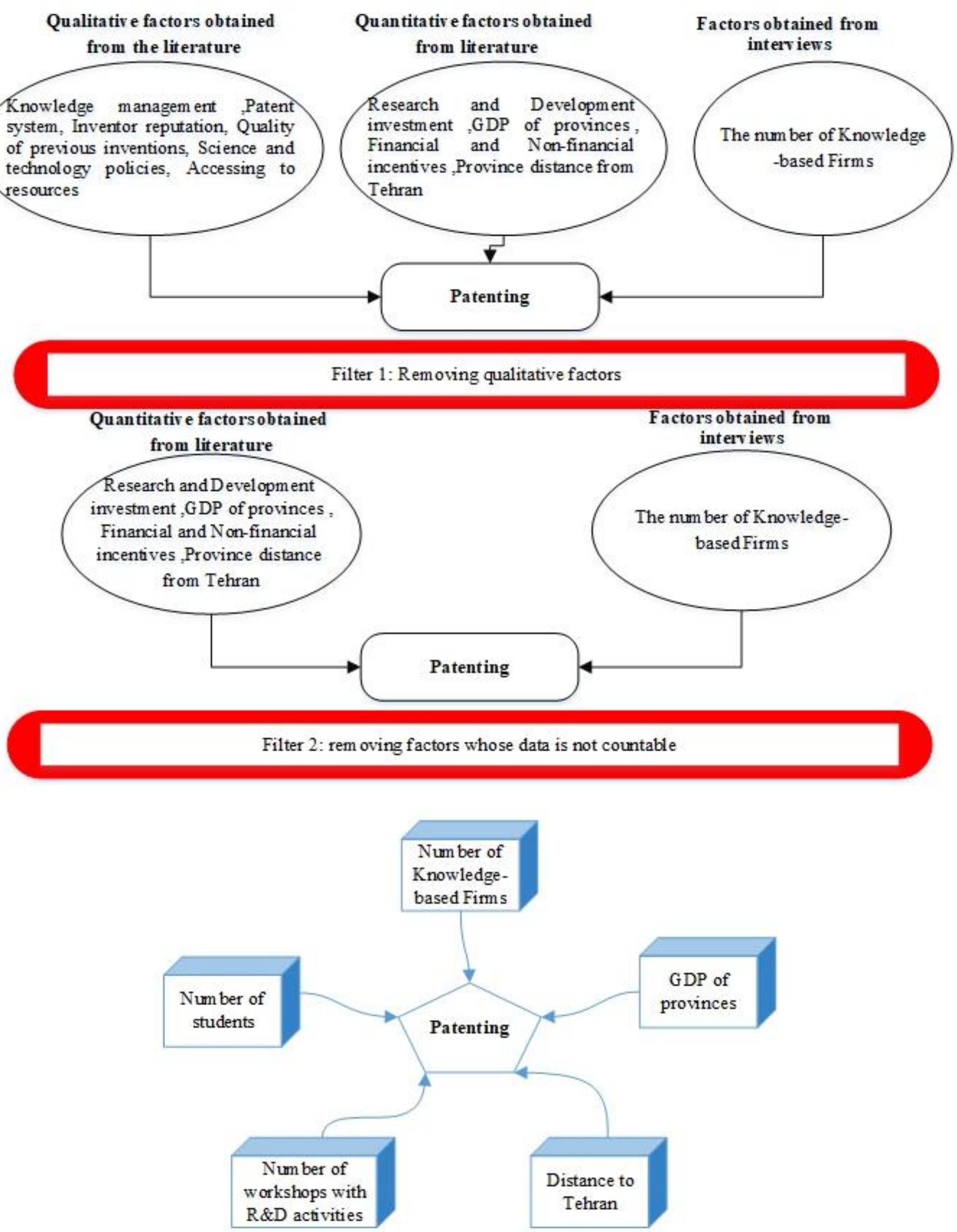
Other factors studied by various researchers include: Access to resources (Laplume, Xavier-Oliveira, Dass, & Thakur, 2015), Tax policies (Mukherjee, Singh, & Žaldokas, 2017), The scientific reputation of the inventor (Lee & Stuen, 2016), Quality of previous inventions (Sterzi & Lawson, 2014), Provide financial and non-financial incentives (Brander & Zhang, 2017), Patent processes, macroeconomic environment, human resource management and empowerment, capabilities and records of companies and universities, demographic and psychological characteristics, absorption capacity, and innovation capacity (Farhangnejad et. al., 1398).

Table 9. Some of Previous Studies

Topic	Authors	Publication year	Variables	Research Method
A note on growth of superconductivity patents with two new indicators	Subir K. Sen, Hari Prasad Sharma	2006	Number of scientific papers	Quantitative
China As Number One? Evidence from China's most recent patenting surge	Albert G.Z. Hu, Zhang Peng, Zhao Lijing	2009	R&D, Foreign Direct Investment, Labor productivity	Quantitative, Regression analysis
Does enforcement of intellectual property rights matter in China? Evidence from financing and investment choices in the high-tech industry	James S. Ang, Yingmei Cheng, and Chaopeng Wu	2014	Intellectual property system	Quantitative
Royalty sharing, effort and invention in universities: Evidence from Portugal and Spain	Pere Arqué-Castells, Rui M. Cartaxo, Jose García-Quevedo, Manuel Mira Godinho	2016	Academic incentives (to inventors), division of ownership of inventions	Quantitative, Regression analysis, Qualitative
University reputation and technology commercialization: evidence from nanoscale science	Jeongsik Lee, Eric Stuen	2016	Inventor reputation, university reputation, technology transfer policies	Quantitative, Regression analysis,
Employee relations and innovation: an empirical analysis using patent data	James A. Brander & Wei Zhang	2016	Provide financial incentives (such as dividends and stock ownership) and non-financial incentives	Quantitative, Regression analysis,
The Effects of Academic Incubators on University Innovation	Christos Kolympiris, Peter G. Klein	2017	Academic incubators	Quantitative, Regression analysis,
Types of patents and driving forces behind the patent growth in China	Zhiyuan Chen, Jie Zhang	2018	Foreign direct investment, research and development growth, patent subsidy programs	Quantitative, Regression analysis,
An Analytical Look at The Geographically Distribution of Patented Inventions in Iran	Bagheri Seyed Kamran , Samandarali Eshtehardi Mojgan, Peymankhah Sadegh, Shafiei Leila	1392	Distance from province to capital, average household income	Quantitative, Correlative analysis,
Mapping the Patent Creation Affecting Factors Using Meta-Synthesis Method	Farhangnejad Mohammad Ali, Elahi shaban, Ghazinoory Seyed Sepehr, Majidpoor Mehdi	1398	Knowledge management, technology management services, patent process management, international R&D interactions, R&D activities, innovation capacity, networking, intellectual property rights system, access to organizational resources, human resource management and empowerment, environment Macroeconomics**,** financial resources from patent registration, participation of researchers in business, type of research and research policies, quality of inventions, financial and non-financial support for research and development in industry and academia, demographic psychological characteristics, capability and company/university records, Policies**,** Regulations and Motivational Criteria for Researchers and Absorption Capacity	Qualitative, Meta-Synthes

Table 2 shows some of the previous researches. In this table, the topic of the paper, publication year, the authors, and the studied variables are given. Figure 1 also shows the research framework and the method of achieving it. As it is known, based on the experts' view and literature review, the factors affecting patents were examined, filtered in two stages (once removing the qualitative factors and then eliminating the factors whose data cannot be counted for researchers), then reviewed by the research team (the R&D variable broken down into two variables: the number of graduate students and the number of researchers in research and development workshops), and finally, five factors entered the analysis phase.

Figure 5. Research framework and the method of achieving it



35. Methodology

The present study was conducted based on the quantitative approach, which means only quantitative factors and those whose data are available for all provinces entered the analysis phase. In this regard, to collect data, reference was made to related databases. Since statistics and information on the number of patents registered in the country (by provinces and years) were not available, so in the first step, reviewed the official newspaper of the country and extracted statistics related to patents registered in the country for the period 1390-95 (including more than twenty thousand inventions) during a process of several months. For each patent, information such as patent date, name of inventors, name of owners, type of patent ownership (real, corporate, or academic), number of inventors, number of female inventors, city, province, and country of the inventor, etc. obtained. In the literature, various factors studied that affect the number of patents, but as mentioned, many of these factors are qualitative and do not fall within the scope of quantitative research. On the other hand, the data of all quantitative variables also cannot be counted. As a result, in this study, the data of quantitative variables have been examined. Also, to enrich the literature and through interviews with some experts (three faculty members of the Technology Studies Institute and Mazandaran University who specialize in management and science and technology policy-making), the number of Knowledge-based Firms was added to the studied factors. They were provided with the results obtained from the literature and were asked to express the factors that can affect the number of inventions based on the conditions of the country. It is worth noting that although the literature does not directly address the impact of the number of NTBFs on patents, the literature review shows that in many studies, patents have been mentioned as the output of this group of companies (Lofsten, 2015; Rickne & Jacobsson, 1999) and a change in the number of NTBFs has the potential to change the number of patents. Some sources also indirectly mention the effect of the number of NTBFs on the number of patents. For example, Lofsten's paper (2015) states that NTBF companies based in growth centers can build networks and support public and patent development (Lofsten, 2015). In the next step, by examining the databases, statistics and information related to the main variables in 1390-95 were extracted (Table 3). The statistical population of the present study includes all 31 provinces of the country, and the period studied in the research is 1390-95. It is worth noting that in extracting data related to some variables, there were some considerations that are mentioned below. First, regarding the GDP variable, because there was no valid data related to 1395, so the study was conducted for the period 1390-94. Since the distance between province capitals and Tehran was constant and unchangeable, so in all the years studied, this number has been considered constant. Also, to change the number of Knowledge-based Firms, only the most up-to-date statistics related to Knowledge-based Firms have been used. Because the statistics related to the population of the province are not published annually, so in the present paper, the statistics related to the year 1395 have been used.

Table 10. Research variables and their related source

Variables	Sources
Number of patents registered in each province by year	http://rrk.ir/news/newslist.aspx
GDP by provinces	www.amar.org.ir
Distance of each province from the Capital (Tehran)	https://www.bahesab.ir/map/distance
The number of Knowledge-based Firms	www.pub.daneshbonyan.ir
The number of researchers in research and development workshops	www.amar.org.ir
The number of postgraduates, Ph.D. and professional doctorate students	Statistics from the research and development workshops, reports from the Statistics Center of Iran
The population of each province	www.amar.org.ir

In general, the present study seeks to identify and analyze the factors affecting the number of patents in the provinces. Of course, as mentioned, the focus of this study is on factors whose data are quantitative and available for all provinces. Therefore, in general, according to the explanations provided, the research hypotheses are as follows:

Hypothesis 1: The number of Knowledge-based Firms in each province is a factor affecting the number of patents registered in that province.

Hypothesis 2: The GDP of each province is a factor affecting the number of patents registered in that province.

Hypothesis 3: The number of researchers in R&D workshops in each province is a factor affecting the number of patents registered in that province.

Hypothesis 4: The number of postgraduate, Ph.D. and professional doctorate students in each province is a factor affecting the number of patents registered in that province.

Hypothesis 5: The distance of each province's capital from Tehran is a factor affecting the number of patents registered in that province.

To test the above hypotheses and investigate the effect of each independent variable on the dependent variable (per capita number of patents registered in the provinces), ANOVA and regression analysis were used, and also, SPSS 22 and Excel software for analyzing data. These tests were used to investigate whether the regression model is significant to determine the relationship between independent and dependent variables at the 95% confidence level (5% error). It is necessary to mention that considering that the number of data is more than 30 and according to the theorem of the central limit, data distribution considered to be close to normal. It is worth mentioning that in the statistical tests for the variables affected by the population of each province, the per capita rate was used per one hundred thousand people. In fact, in this way, the effect of the population variable on outputs was neutralized. Therefore, in the whole of this research, the variables of number of patents, number of Knowledge-based Firms, number of postgraduate students, Ph.D., and professional doctorates, number of researchers in R&D workshops, and GDP per capita per 100,000 population are considered.

36. Data Analysis

At first, descriptive statistics are presented on registered patents in different provinces. It is interesting to note that in most of the provinces, the per capita number of patents for 1391 was higher compared to the other years in the period under review. In addition, the highest per capita in 1390-92 was related to Tehran province, while allocated to Semnan in 1393-95. The lowest per capita patent in the whole period was allocated to Sistan and Baluchestan province (Table 4).

Table 11. Per capita statistics on the number of patents registered in the country by the province in 1390-95 (per hundred thousand population)

Provinces	1390	1391	1392	1393	1394	1395	Average of 1390-1395
Ardabil	2.52	2.68	1.73	2.60	2.28	2.20	2.34
Isfahan	7.77	8.89	7.26	6.35	5.14	6.44	6.97
Alborz	3.94	7.56	6.41	4.68	3.28	4.65	5.09
Ilam	3.10	3.45	5.00	2.24	3.27	4.48	3.59
East Azerbaijan	4.45	5.68	4.63	3.91	2.58	4.73	4.33
West Azerbaijan	1.65	1.90	2.14	1.26	1.04	2.02	1.67
Bushehr	0.60	1.81	0.77	1.81	2.32	1.98	1.55
Tehran	9.29	12.61	9.62	8.89	7.09	8.67	9.36
Chaharmahal and Bakhtiari	4.11	6.23	3.69	3.27	3.06	4.96	4.22
South Khorasan	1.69	3.12	3.12	6.24	5.98	5.33	4.25
Razavi Khorasan	2.50	3.95	3.19	3.59	2.86	4.01	3.35
North Khorasan	2.32	2.78	2.43	1.62	1.97	2.55	2.28
Khuzestan	1.27	1.89	1.40	1.32	1.53	2.21	1.60
Zanjan	4.63	7.85	4.92	4.07	3.69	3.78	4.82
Semnan	6.69	12.53	5.27	10.68	7.12	10.68	8.83
Sistan& Baluchestan	0.22	1.19	0.61	0.68	0.47	0.65	0.64
Fars	4.23	6.00	4.16	4.21	2.82	4.72	4.36
Qazvin	2.12	6.12	3.69	3.14	2.59	2.51	3.36
Qom	3.64	3.56	1.55	2.55	2.01	4.02	2.89
Kordistan	1.31	2.99	3.56	2.37	2.31	2.93	2.58
Kerman	1.36	2.94	2.50	1.93	1.39	3.19	2.22
Kermanshah	3.59	7.07	3.94	3.74	2.92	3.38	4.11
Kohgiluyeh & Boyer-Ahmad	1.68	3.23	1.40	2.24	3.23	4.35	2.69
Golestan	1.34	3.96	2.78	2.19	1.55	2.62	2.41
Gilan	1.74	2.13	2.81	2.13	1.94	3.04	2.30
Lorestan	2.50	3.52	1.93	1.76	1.70	2.78	2.37
Mazandaran	3.11	4.63	3.47	3.50	2.65	5.18	3.76
Markazi	5.25	7.56	5.39	3.64	2.17	3.50	4.58
Hormozgan	1.18	3.38	2.03	2.25	1.46	4.00	2.38
Hamedan	3.57	6.16	2.76	3.85	2.42	4.26	3.84
Yazd	6.24	9.31	5.97	5.71	3.86	5.53	6.10
Whole country	3.21	5.05	3.55	3.50	2.86	4.04	3.70

Also, in Figure 2, the situation of the provinces of the country compared with each other in terms of the number of per capita inventions during different years based on population. In this figure, 31 provinces are divided into four categories. The first category marked in blue is the provinces with the most registered inventions concerning their population (including Tehran, Alborz, Zanjan, Markazi, Semnan, Isfahan, Yazd, and Fars). The least registered inventions, marked in yellow, belong to the North Khorasan, South Khorasan, Hormozgan, Kohgiluyeh and Boyer-Ahmad, Lorestan, Qom, and Kurdistan.

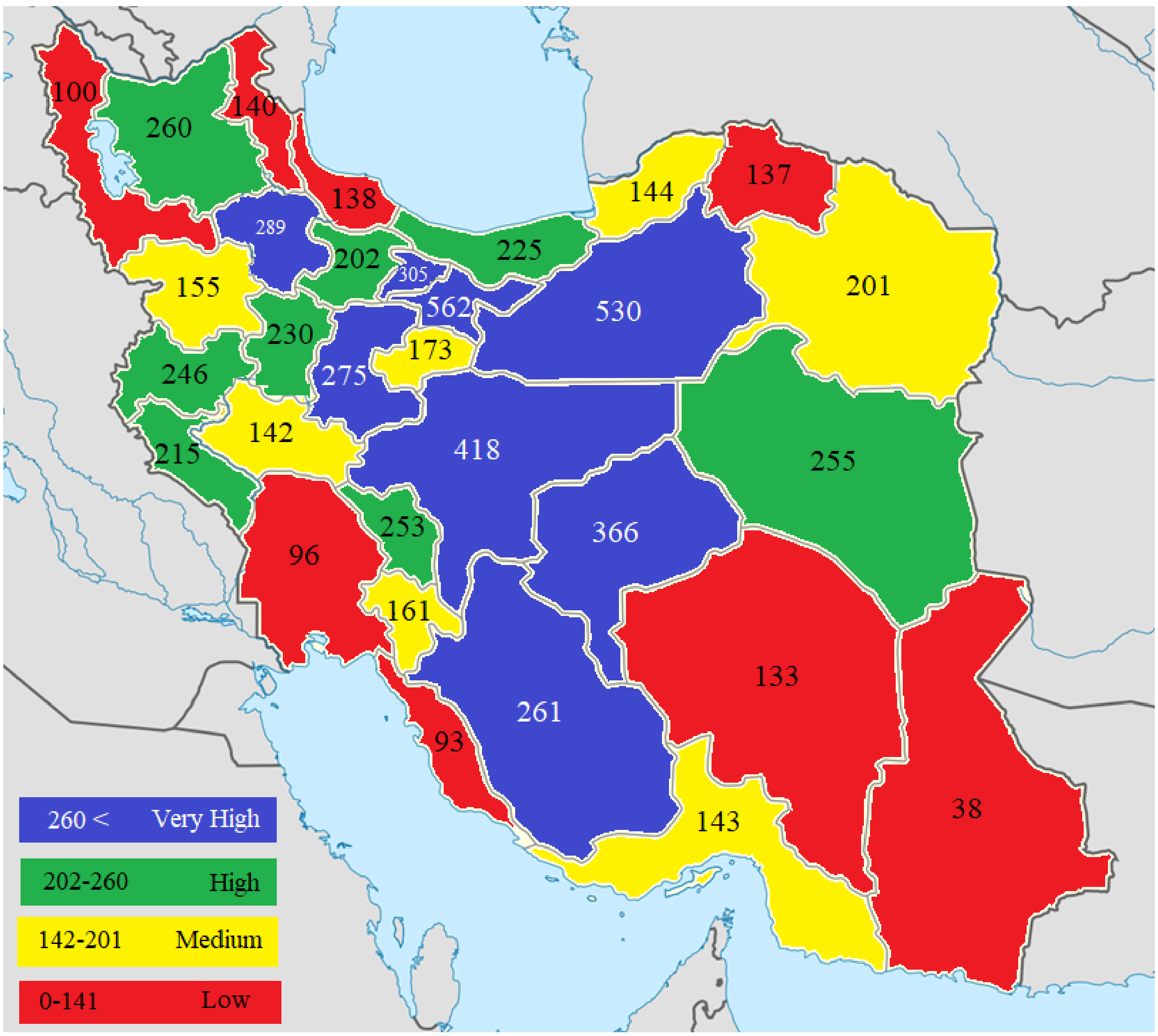


Figure 6. Number of patents per province per million population (1390-1395)

As it is clear from figure 3, this amount was decreased during the years 1391-1394 and increased again in 1395.

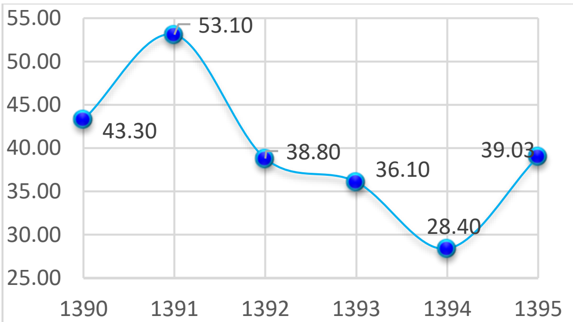


Figure 7. Number of inventions per million population

The change in the number of inventions during the years under review is shown in Figure 4. As it is known, the number of inventions increased significantly from 1390 to 1391, from 3690 to 4346 cases. And until 1394, we are witnessing a downward trend so that in 1394, the number of inventions is equal to 2384 cases. In 1395, the number of inventions has gone again in ascending trend.

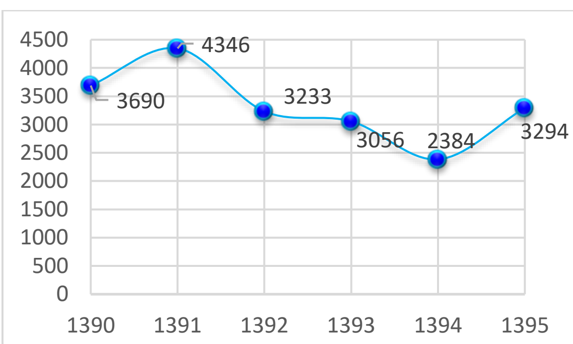


Figure 8. The trend of changing the number of inventions during the years 1390 to 1395

Figure 5 shows the changing trend of single- and multi-inventions. As it is known, during the years 1390 to 1395, the percentage of inventions registered with just a single inventor gradually decreased from 50% in 1390 to 43% in 1395.

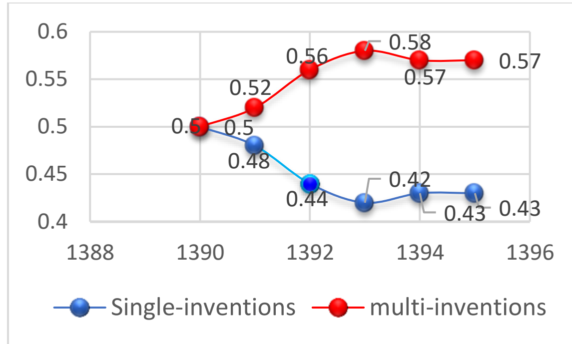


Figure 9. The trend of multi-inventions during the years 1390 to 1395

As shown in Figure 6, the percentage of inventions included a female inventor has increased from 1390 to 1393 and then until 1395 has taken a downward trend. Generally, the percentage of female inventors has had an upward trend during the years under study.

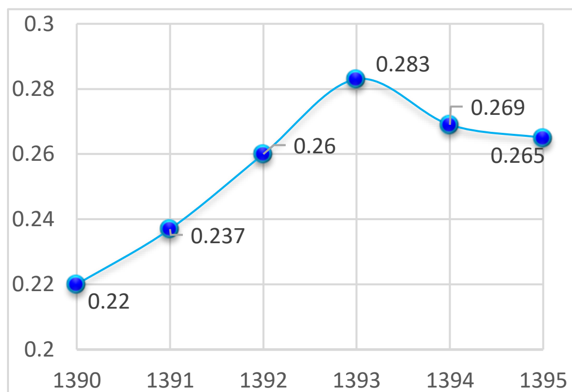


Figure 6. Women's share of inventions during the years 1390 to 1395

Figure 7 shows the inventors' ownership changes over the years under study. As can be seen, generally, most of the inventions in the country are registered by real people. However, during the years 1390 to 1395, the percentage of ownership for real entities has decreased relatively, from 82% of inventions in 1390 to 76% in 1395.

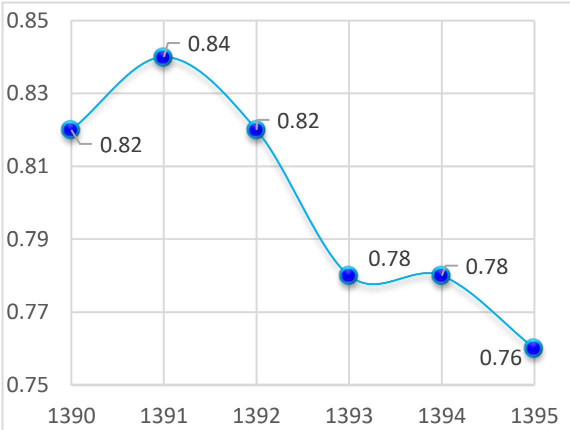


Figure 7. The trend of changes in the ownership of real and legal entities during the years 1390 to 1395.

Figure 8 shows the ratio of inventions registered in Provincial centers and Tehran to the total number registered in the country during the years 1390 to 1395. As it is known, the number of inventions of Provincial centers to the total number in the country has not changed significantly during these years; but the number of inventions in Tehran has increased from thirty-six percent to thirty-one percent.

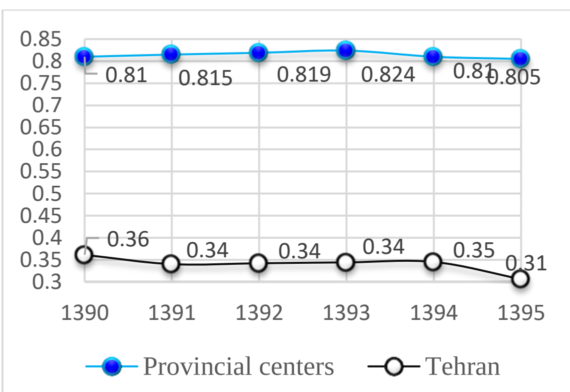


Figure 8. The ratio of inventions of provinces and Tehran to the total number registered in the country

To investigate the effect of independent variables including GDP, number of Knowledge-based Firms, number of researchers in R&D workshops, number of postgraduate students, Ph.D. and professional doctorate (all are per capita), and distance from the Tehran (km), on the dependent variable of number of patents per 100,000 population, using data collected from the database of the Patent Organization and the Statistics Center of Iran, SPSS 22, Regression and Variance analysis were used. In fact, in this section, the relationship between the independent variables and the per capita number of patents, and also their impact in the period 1390-95, has been studied separately for each year. In general, researchers in the present study sought to examine the following five hypotheses, which are:

Hypothesis 1: *The number of Knowledge-based Firms in each province is a factor affecting the number of patents registered in that province.*

The results of the regression analysis test indicate that the correlation coefficient between the per capita number of Knowledge-based Firms, and the per capita number of patents registered in each province of the country during the years 1390-95, is high and its minimum value was in 1390 equal to 0.71. For this reason, the lowest adjusted coefficient of determination is related to the year 1390 and equal to 0.49. Therefore, it can be said that during the years under review, the variable number of Knowledge-based Firms can predict and explain at least 50% of the changes in the number of patents registered in each province. Given that the significance level of the variance analysis in all years is less than 0.05 (zero), so it can be said that the present regression model significantly predicts the changes of the dependent variable.

Since the significance level in the regression test is less than 0.05, it can be concluded that in all years, the number of Knowledge-based Firms affects the number of patents in each province. Since the regression coefficient is positive and its minimum value is related to the year 1390 (0.714), so growing the number of Knowledge-based Firms in each province leads to an increase in the number of patents there.

Table 12. Regression test of the effect of the number of Knowledge-based Firms on patents in the provinces in 1390-95

Number of Knowledge-based Firms	Model			Variance analysis		Coefficients			
	R	R^2	R^2 Adjusted	F	Sig.	B	Beta	t	Sig.
1390	0.714	0.51	0.493	30.21	0	1.395	0.714	5.5	0
1391	0.76	0.577	0.562	39.53	0	1.85	0.76	6.29	0
1392	0.801	0.641	0.629	51.79	0	1.41	0.801	7.2	0
1393	0.83	0.689	0.678	64.14	0	1.597	0.83	8.01	0
1394	0.825	0.681	0.67	61.97	0	1.06	0.825	7.87	0
1395	0.845	0.713	0.704	72.21	0	1.53	0.845	8.49	0

Figure 9 shows a good positive relationship between the number of Knowledge-based Firms and the number of patents in the country's provinces.

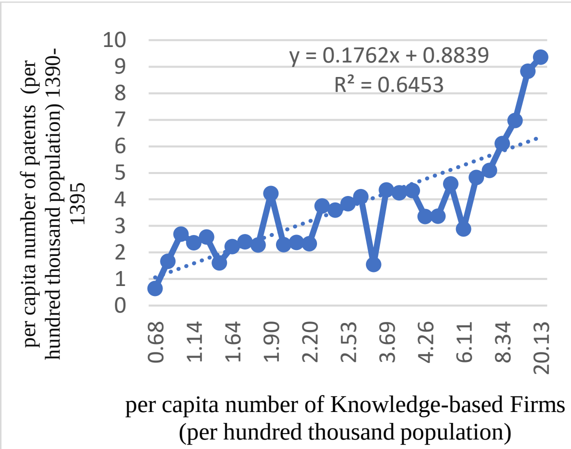


Figure 9. Relationship between the per capita number of patents in each province and the per capita number of Knowledge-based Firms

Hypothesis 2: *The GDP of each province is a factor affecting the number of patents registered in that province.*

The results of the regression analysis test indicate that the correlation coefficient between GDP per capita and the number of patents registered in the provinces during the years 1390-94, is low and its maximum is 0.119 relates to 1393. So, the highest coefficient of determination is related to the same year and equal to 0.014. Therefore, it can be concluded that the per capita variable of GDP does not cannot explain well the changes in the number of patents registered in each province. Also, given that the significance level of the analysis of variance test is greater than 0.05 (zero) for all years, it can be said that the present regression model does not significantly predict the changes of the dependent variable.

Table 13. Regression test of the impact of GDP on patents in the provinces in the period 1390-94

GDP Per Capita	Model			Variance analysis		Coefficients			
	R	R^2	R^2 Adjusted	F	Sig.	B	Beta	t	Sig.
1390	0.009	0	-0.034	0.002	0.962		-0.009	-0.048	0.962
1391	0.02	0	-0.034	0.012	0.915		0.02	0.108	0.915
1392	0.108	0.012	-0.023	0.34	0.564		-0.108	-0.583	0.564
1393	0.119	0.014	-0.02	0.414	0.525		-0.119	-0.644	0.525
1394	0.047	0.002	-0.032	0.064	0.802		0.047	0.253	0.802

According to Figure 10, it is clear that there is no strong and clear relationship between the per capita GDP of the provinces and that one of the registered patents.

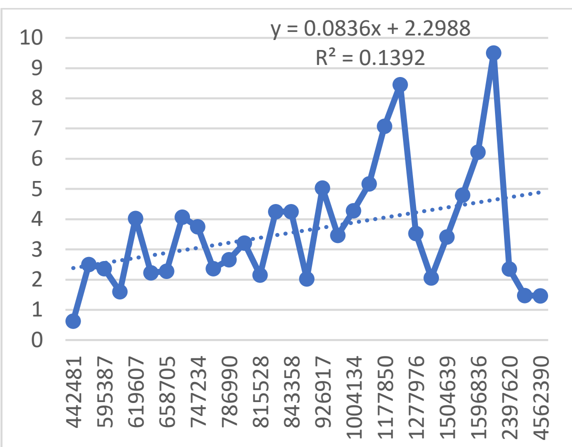


Figure 10. Relationship between the per capita number of patents in each province and the per capita GDP in the period 1390-95

Hypothesis 3: *The number of researchers in R&D workshops in each province is a factor affecting the number of patents registered in that province.*

The results of the regression analysis test show that the correlation coefficient between the per capita number of researchers in R&D workshops, and the per capita number of patents registered in each province during the years 1390-95, was relatively high, and only in 1993 it was less than 0.5 (equal to 0.469). The lowest coefficient is related to the year 1393, which is 0.22. Therefore, it can be said that during the years under study, at least 20% of the changes in the per capita number of patents can be explained using the number of researchers in R&D workshops. In addition, considering that the significance level of the analysis of variance test is less than 0.05 in all years, so, at the 95% confidence level, it can be concluded that the present regression model significantly predicts the changes in the dependent variable.

In addition, the positive regression coefficient in all years indicates that the number of researchers in R&D workshops has a positive and significant effect on the per capita number of patents registered in each province. Therefore, the increase (decrease) of researchers in R&D workshops leads to an increase (decrease) in the number of patents registered in each province.

Table 14. Regression test for investigating the effect of the number of researchers in R&D workshops on patents in the provinces of the country in the period 1390-95

Number of researchers in workshops	Model			Variance analysis		Coefficients			
	R	R^2	R^2 Adjusted	F	Sig.	B	Beta	t	Sig.
1390	0.792	0.627	0.614	48.75	0	45.9	0.792	6.98	0
1391	0.691	0.477	0.459	26.49	0	50.01	0.691	5.147	0
1392	0.807	0.652	0.64	54.23	0	42.14	0.807	7.36	0
1393	0.469	0.22	0.193	8.18	0.008	26.79	0.469	2.68	0.008
1394	0.713	0.508	0.491	29.91	0	27.32	0.713	5.47	0
1395	0.645	0.416	0.396	20.65	0	34.67	0.645	4.54	0

Figure 11 shows well there is a positive relationship between the number of researchers in R&D workshops and the number of patents in the provinces.

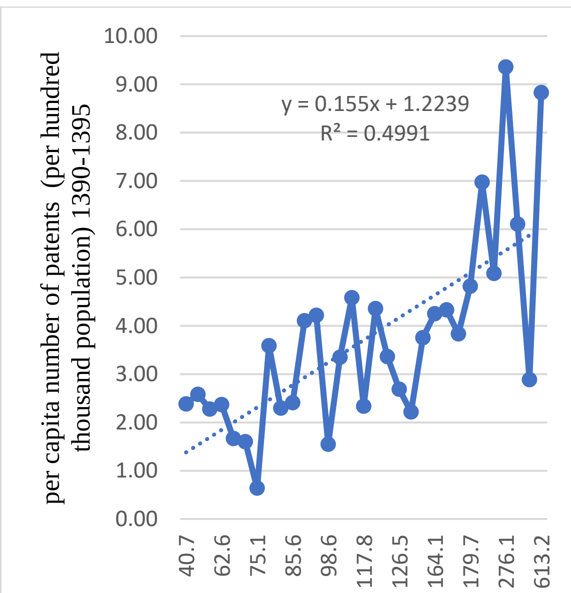


Figure 11. Relationship between the number of per capita patents in each province and the number of researchers in R&D workshops in the period 1390-95

Hypothesis 4: *The number of postgraduate, Ph.D. and professional doctorate students in each province is a factor affecting the number of patents registered in that province.*

The results of the regression analysis test show that the correlation coefficient between the number of postgraduate students, Ph.D. and professional doctorate and the number of patents registered per province in the country during the years 1390-95 was relatively high and only in 1393 was less than 0.5 (equal to 0.489). In this regard, the lowest coefficient is related to the year 1393 that is equal to 0.24. Therefore, it can be said that during the years under review, at least 20% of the per capita changes in the number of patents can be explained using the number of postgraduate, Ph.D., and professional doctorates. In addition, considering that the significance level of the analysis of variance test is less than 0.05 in all years, so, at the 95% confidence level, it can be concluded that the present regression model significantly predicts the dependent variable changes.

In addition, the positive regression coefficient in all years indicates that the number of postgraduate, Ph.D., and professional doctorate students has a positive and significant effect on the per capita number of patents registered in each province. Therefore, increasing (decreasing) the number of postgraduate, Ph.D., and professional doctorate students leads to increasing (decreasing) the number of patents registered in each province.

Table 15. Regression test of the effect of the number of postgraduate, Ph.D., and students on patents in the provinces in the period 1390-95

Number of researchers in workshops	Model			Variance analysis		Coefficients			
	R	R^2	R^2 Adjusted	F	Sig.	B	Beta	t	Sig.
1390	0.793	0.629	0.616	49.08	0	276.3	0.793	7	0
1391	0.686	0.47	0.452	25.72	0	298.3	0.686	5.07	0
1392	0.793	0.628	0.615	49.01	0	248.74	0.793	7	0
1393	0.489	0.24	0.213	9.13	0.005	168.02	0.489	3.02	0.005
1394	0.738	0.544	0.528	34.59	0	170.02	0.738	5.88	0
1395	0.635	0.403	0.383	19.59	0	205.23	0.635	4.43	0

Figure 12 indicates well a positive relationship between the number of postgraduate, Ph.D., and professional doctorate students and the number of patents in the provinces.

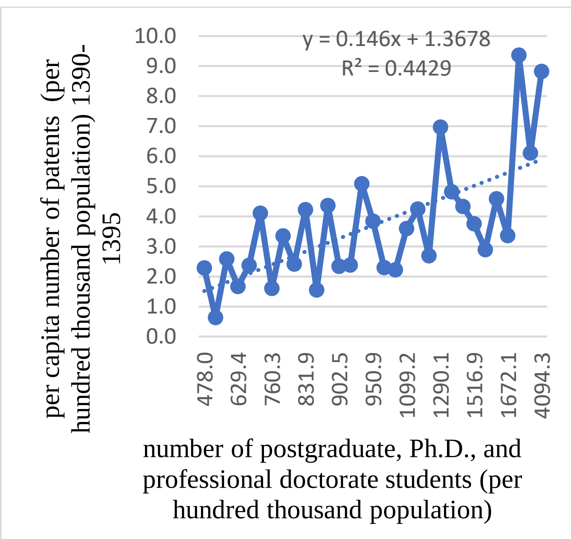


Figure 12. Relationship between the number of per capita patents in each province and the number of postgraduate, Ph.D., and professional doctorate students

Hypothesis 5: *The distance of each province's capital from Tehran is a factor affecting the number of patents registered in that province.*

The results of the regression analysis test indicate that the correlation coefficient between the distance of provinces from Tehran and the per capita number of patents registered in each province during the years 1390-95 was an average amount. The lowest correlation is 0.372 related to 1391, and the highest correlation is 0.635 related to 1394. Therefore, it can be said that 1394 is the best since approximately 40% of the number of patents per capita is explained using the distance variable from Tehran. In addition, considering that the significance level of the analysis of variance test is less than 0.05 in all years, so at the 95% confidence level, it can be concluded that the present regression model significantly predicts the changes of the dependent variable, however, it cannot explain well.

In addition, the negative regression coefficient in all years indicates that the variable distance from Tehran has a negative and significant effect on the per capita number of patents registered in each province. Therefore, increasing (decreasing) the distance from Tehran leads to decreasing (increasing) the number of patents registered in each province.

Table 16. Regression test to evaluate the effect of distance from Tehran on the number of patents registered in the provinces in the period 1390-95

Distance from Tehran	Model			Variance analysis		Coefficients			
	R	R^2	R^2 Adjusted	F	Sig.	B	Beta	t	Sig.
1390	0.428	0.183	0.155	6.517	0.016	-80.092	-0.428	-2.55	0.016
1391	0.372	0.138	0.108	4.65	0.04	-86.767	-0.327	-2.156	0.04
1392	0.451	0.203	0.176	7.392	0.011	-75.878	-0.451	-2.719	0.011
1393	0.589	0.347	0.324	15.406	0	-108.495	-0.589	-3.925	0
1394	0.635	0.404	0.383	19.634	0	-78.579	-0.635	-4.431	0
1395	0.617	0.381	0.36	17.871	0	-107.081	-0.617	-4.227	0

Figure 13 indicates well the inverse relationship between the variable of distance from Tehran and the number of patents in the provinces.

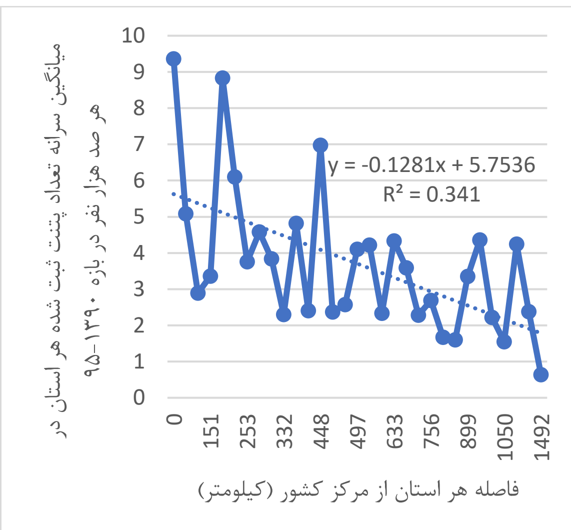


Figure 13. Relationship between the variable distance of each province from Tehran and the per capita number of patents registered in that province per one hundred thousand people in 1390-95

37. Conclusion

In recent decades, inventions have been considered as a valuable resource for the study of innovation and technological evolution, which can affect the performance of companies and the economy as a whole (Z. Chen& Zhang, 2019). On the other hand, the analysis of patents is useful and effective for many researchers for many reasons (mentioned earlier). But what is most useful to managers and policymakers is analyzing the factors affecting the patents. But it seems that analyzing the factors that affect patents is most useful to managers and policymakers since it can be used as the initial data for their policy-making at the macro level. In this study, the patents registered in the country during the years 1390 to 1395 and their relationship with quantifiable variables (distance of each province from Tehran, number of postgraduate, Ph.D., and professional doctorate students, per capita researchers in R&D workshops, per capita GDP, per capita number of Knowledge-based Firms) in each province were analyzed.

The present paper shows that the variable per capita GDP in each province does not have a significant effect on the number of inventions in that province, but the other four factors have a significant correlation with the variable under study. For example, the number of Knowledge-based Firms in each province, on average, has the greatest impact on the number of inventions, so that it can explain more than 60% of the changes in variable of the number of inventions. Two factors, the number of research and development workshops and the number of master's, Ph.D., and professional doctorate students, also have a high impact on inventions, and finally, the distance of province from Tehran has a moderate and inverse effect on the study factor.

As mentioned, several studies have been conducted to investigate the factors affecting inventions. Many of these studies have been conducted qualitatively (H. Chen et al., 2018; Farhangnejad et al., 1398), and many other studies have examined only one factor (foreign direct investment) (Cheung & Ping, 2004) or two (Bagheri et al., 1392). However, in this study, we tried to examine the various factors, the data of which are quantitatively available, comprehensively, and together. The factors of the number of R&D workshops and the number of master and Ph.D. students studied in this research are almost similar to the effect of research and development on the number of inventions that have been studied in previous studies (Z. Chen & Zhang, 2019; Coupe). According to researchers, these factors have a high impact on registered patents. The factor of geographical distance, which according to the results of the present study, has a moderate effect on inventions, was previously studied by Bagheri et al. (Based on data from 1387 to 1389); But in their view, this factor has a large impact on the number of inventions (while the results of the present study show that the impact of this factor is moderate). The results of both studies emphasize the effectiveness of this factor, but the level of effectiveness is different. It seems that the impact of this factor on inventions in the provinces has decreased significantly over time (from 0.68 to 0.4 or even 0.13). Investigating the root of this difference requires in-depth study; However, as mentioned, the per capita number of Knowledge-based Firms in each province in terms of this research has a very high impact on the number of inventions. Since the Law on the Protection of Knowledge-based Firms and Institutions was passed in the country in 1389 and since then the growth and development of Knowledge-based Firms in the country have begun, it may be possible to link decreasing the impact of geographical distance on inventions to the growing interest in the development of Knowledge-based Firms.

Considering that one of the factors affecting the number of patents registered in the provinces is Knowledge-based Firms; Therefore, to increase this type of companies in the provinces, it is necessary to establish universities, research institutes, and science and technology parks that examine the existing scientific and technological capacities and potentials in the provinces, to plan to encourage researchers and related technologists to launch a knowledge-based company and follow up their activities in the form of such companies.

One of the main sources of idea formation and innovation is the number of research activities of companies and industrial and service workshops active in the province, the output of which is usually registered in the form of an invention to protect against competitors. Therefore, to increase patents registered in the provinces, it is necessary first, the organizations of the industry, mine, and trade of the provinces by using and offering the facilitators and incentives, encourage companies, and workshops to establish research and development centers and offices. Secondly, by providing the necessary incentives, make it possible to recruit postgraduate personnel in research and development offices of companies and workshops.

One of the research findings is that the number of single inventions has decreased over time, and vice versa, the number of multi-inventions has increased significantly. This statistic shows that individuals have tried to move towards joint and multi-person partnerships, and therefore managers and policymakers in this sector can encourage this type of joint partnership by adopting appropriate policies and programs. Examples of these policies could be team building, networking inventors, or even encouraging them to establish Knowledge-based Firms. Another result of this research is that the share of women in inventions has increased over time; However, the role of women as half of society is still not desirable. Therefore, managers and policymakers can provide programs and policies to increase women's participation in this field.

One of the limitations of the present study is the lack of information in many fields in the country. For example, there are no accurate statistics on foreign direct investment, venture capital, R&D spending, financial and tax incentives, and patent fees in the country, broken down by province. Establishing a system to monitor the value of these variables in the country, in addition to being able to help policy in the field of innovation output, can also be very useful for other parts of the country. This will be possible through the cooperation of the Statistics Center of Iran with the responsible agencies (such as the Planning Organization, the Innovation Fund, etc.). In addition, for future research, by extracting data from a larger set of factors by provinces, the effect of a wide range of factors on patent registration should be investigated.

Given the lack of confirmation of the relationship between GDP and the number of patents registered in each province, it can be concluded that despite the costly process of patent registration, lack of access to financial resources is not necessarily one of the reasons for inventors not to register their patents. It is to some extent due to a lack of awareness and lack of information about patent filing processes. Therefore, it is suggested that the government increase the level of knowledge of inventors about the patent registration process and its benefits through various means such as holding extensions and educational programs.

38. Resources

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