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Original Research

A Study of Iranian Scientific Productions on Patenting and its Comparison with those of Scientifically Advanced Countries

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Abstract

This scientometric research was conducted through correlation-analysis, and intended to assess the correlation between publications and patents both in developed countries and in Iran. The present study was performed using scientometric methodology and used USPTO for patent data and Scopus for publication data from 2015 to 2019. This study applied both parametric and non-parametric statistical analyses. Moreover, the Spearman Correlation analysis was used to determine the correlation between variables and types of variables. The data analysis was conducted using SPSS1 software. The relationship between these two variables was significant in each of the years under study. Different types of scientific documents, such as books, articles, and conference papers, were assessed. The Pearson Correlation analysis between these types of documents showed significance at 0.01 level in the articles with the correlation coefficient of 0.858, books with the correlation coefficient of 0.867, and conference papers with the correlation coefficient of 0.874, which was related to the extent of patenting. The subject areas related to social sciences and humanities, engineering and technical sciences, medical sciences, and biological sciences with the correlation coefficients of 0.866, 0.861, 0.843, and 0.834, respectively, at 0.01 level, revealed a significant relationship between the studied countries' scientific output in these subject areas and the extent of patenting. The results of the present research showed that there was a positive relationship between the studied countries' scientific output and their level of patenting. The countries that enjoy high levels of scientific output have more inventions. However, the results for Iran indicated that the growth in scientific output has had an insignificant effect on the country's invention rate.

Keywords: Patent, Inventions, Scientific product, Scientometrics

Introduction

Scientific products in a country are suggestive of its researchers' scientific efforts, and are the basis for ranking that country from the scientific perspective. Articles that are indexed in renowned databases like Scopus or Web of Science enjoy high levels of scientific credit. The more articles a country has indexed in such databases, the higher its rank in terms of scientific output. The extent to which indexed articles are cited contributes to a country's ranking, and reflects its efficacy at the international level. Scientific outputs in countries are suggestive of researchers' scientific efforts and are the basis for ranking countries from the scientific perspective. The patenting licenses are considered as a measure of scientific production and indicate the innovative efforts within countries, regions, and institutions in the realm of science and technology. When there is coordination between technology and university, theoretical research can be put into practice. This development paves the way for a countries' growth since scientific outputs will be used in society and do not remain ineffective. In order to assess the significance of the relationship between the number of patenting licenses and the extent of scientific outputs in the developed countries and Iran, this study examined some variables such as the types of produced documents and the level of scientific production in different research areas. It also attempted to identify the correlation between scientific outputs and the level of patenting.

Literature Review

A number of significant studies have been conducted in this area. For instance, Norouzi Chakoli (2011) performed a study entitled "Outcome indicators of science and technology in the Islamic Republic of Iran: A review on the relationship between patents and scientific productions of Iranian inventors." The results indicated that, in terms of scientific productions and patent registrations among Iranian inventors, the correlation coefficient was 0.039 at the level of 95%, which showed no significant relationship between the two variables. In their study, Alaei Arani (2009) concluded that, for the scientific productions and patent registrations of the inventors, the correlation coefficient was 0.039 at the level of 95%, which showed no significant relationship between the two variables. A study by Majidi & Dehghani (2010) indicated that the highest numbers of patents were granted in the fields of chemistry and metallurgy. In a study, Farhangnejad, Elahi, Ghazi Noor & Majidpour (2019) reported that knowledge management, research and development, and scientific production had the greatest role in patenting. Another major study in this area was conducted by Abdekhoda, Norouzi & Ravand (2010), which indicated that the patents were significantly centralized in terms of their subjects. Research projects had greater potential for securing patents in the fields of chemistry and metallurgy compared to other fields. In addition, Franceschini & Maisano (2013) explored the similarities and differences between articles and patents, and identified: (1) the main scientific articles and conference papers including LSDM articles and (2) the main characteristics of LSDM patents, according to their dominant technologies and temporal distribution. Their analyses yielded two important results; first, the important innovations regarding the new LSDM systems were found to have been made before the end of the twentieth century. However, the scientific articles have appeared in the recent decade. Second, the vast majority of the patents concerned the laser interferometry technology. However, the articles were divided equally among available technologies, playing an important role which was less accurate but more affordable. In a similar vein, Verbeek, Debachere, Luwel, Andrles,

Zimmermann & Deleus (2002) discussed a method to design a linkage scheme that linked the technological and scientific systems using patent citation data. The results showed a wide distribution and enabled the authors to identify those fields of technology that were connected with science and the fields in which technology was independent from the scientific base and had more development. Alletto, Bruccoleri, Mazzola & Ramanathan (2017) argued that accumulating experience in supply chains of knowledge (SCoK) facilitates collaborations and development of new patents; being central and filling the structural holes within the SCoK are two means by which the experiences in SCoK collaborations are translated into new patents. Azagra Caro & Consoli (2016) conducted a study with the aim of uncovering the role of cross-organizational interactions and concluded that technological sophistication and research size have a positive effect on knowledge flows. King's research (2004) indicated that USA was the major producer of scientific information. England, Germany, Japan and France were ranked second to fifth, respectively, and Iran was in the thirtieth place. Accordingly, 84.5% of the most highly cited papers from 1993 to 2000 were published by the top eight countries, namely USA, England, Germany, Japan, France, Canada, Italy and Switzerland. The next 9 countries had published 13% of the papers, and the rest, including Iran, had produced 2.5% of the total papers. In the end, it was stated that 97.5% of the most highly cited papers were produced by 31 out of the total 193 countries of the world. A notable point was that among these 31 countries, the only Islamic country was Iran, and the only African country was South Africa. Wang & Guan (2010) argued that patenting activity does not adversely affect research output. Patenting, however, has negative impacts on both quantity and quality of academic researchers' publication output.

Gong, Nie, Peng, Peng & Liu (2020) assert that new scientific production generated by the interaction with the outside world in the process of patent commercialization was transmitted to the subject of knowledge innovation through forming a virtuous dynamic cycle. By analyzing the driving factors of the value chain of patent innovation in colleges and universities, they provided empirical evidence for the operation mechanism and policy formulation of college patents in China. Gong & Peng (2018) conducted a study and concluded that patents are the sources of national scientific and technological innovation. At present, the number of patent applications in China has risen sharply, and China has the largest number of patent applications in the world. The quantity of patent applications in universities has increased dramatically in recent years. According to The State Intellectual Property Office of Patent Statistical Yearbook (2018), the growth rate of invention patents in colleges and universities in China has accelerated significantly, from 1,548 in 2000 to 19,400 in 2018, a more than 125-fold increase. Nevertheless, the patent transfer rate of universities is only 1.4% (annual patent statistics of the National Intellectual Property Administration, 2018), and most patents are, regrettably, in a "sleep" state. According to statistics of the AUTM licensing activity survey (2018), in 2017, the number of patents disclosed by American universities and research institutes was 24,998, and the number of patent licenses was 7,798, with a licensing disclosure ratio of approximately 31.2%. Qin, Du, Liu, & Fan (2017) introduced the innovation value chain into the field of scientific research and divided the process into three stages, that is, knowledge acquisition, technological innovation and value transformation. Finally, another major study in this area was conducted by Mukherji & Silberman (2019), who indicated that the resources that universities obtain from the outside can, to a certain extent, represent the strength of the innovation network alliance established by universities. The academic quality

of universities and characteristics of their technology transfer office are found to positively affect their ability to diffuse knowledge.

Literature review indicates that an increasing number of seminal studies have been conducted on scientific productions, suggesting that this area of research is highly crucial in identifying new and active subject fields. However, to the best of the authors' knowledge, no research has been done to analyze the relationship between scientific production and patent registration in Iran. Thus, it is essential to study and assess the impact of productions on patents.

Research Questions

What is the relationship between the scientific outputs and the patenting extent in Iran and other countries?

1. Is there a meaningful relationship between the type of scientific documents and the extent of patenting?
2. Is there a significant relationship between Iranian and other countries' scientific outputs in research areas and the extent of their patenting?

Methodology

This was a scientometrics research conducted through correlational-analysis method. The patents of 137 countries were extracted from the United States Patent and Trademark Office (USPTO). The levels of scientific productions and types of scientific documents of countries were extracted from Scopus citation database from 2015 to 2019. The search formula in Scopus database is as follows: In the advance search section, the phrase PUBYEAR AFT 1994 was entered, and the search was performed. Then the search results were limited to 2015, 2016, 2017, 2018 and 2019, and all the scientific productions of the countries of the world, including 137 countries registered so far, were displayed in Scopus. To search the USPTO database in the advance search section of this database, the names of each of the 137 countries were searched five times (for each of the years 2015, 2016, 2017, 2018, and 2019), and the results were entered into Excel software. To do this, we first extracted, from the "Country code" table in the USPTO, the abbreviation code for searching each country in this database, and then in the advance search of this database, the words ICN / Inventor Country and ISD / Issue Date were entered. The data were analyzed using SPSS software. Parametric and nonparametric tests were used according to data types. Moreover, to determine the correlation between the variables, the Spearman correlation test was used in accordance with the type of variables.

Results

A total number of 1764772 patent applications were registered by the countries. In addition, the descriptive information of patents registered in each year was extracted from 2015 to 2019. Table 1 shows the descriptive data and information of the top 50 patent-filing countries from 137 countries as announced by (USPTO).

Table1

Descriptive statistics of the top 50 patent registering countries in the USPTO

Row	Country	Number of patents	Row	Country	Number of patents
1	United States	712,937	26	Hong Kong	3,817
2	Japan	269,068	27	Saudi Arabia	3,354
3	South Korea	115,987	28	Brazil	2,866
4	Germany	103,554	29	New Zealand	2,434
5	China	87,387	30	Mexico	2,267
6	Taiwan	83,187	31	Czech Republic	2,134
7	United Kingdom	49,823	32	Poland	2,041
8	Canada	46,421	33	Malaysia	1,933
9	France	42,958	34	South Africa	1,318
10	India	29,333	35	Hungary	1,280
11	Israel	25,278	36	Turkey	1,245
12	Switzerland	20,022	37	Thailand	876
13	Italy	19,771	38	Greece	773
14	Netherlands	19,382	39	Portugal	754
15	Sweden	18,776	40	Argentina	748
16	Australia	12,314	41	Romania	726
17	Ireland	11,986	42	Luxembourg	724
18	Belgium	9,861	43	Ukraine	619
19	Austria	9,608	44	United Arab Emirates	600
20	Finland	9,291	45	Philippines	582
21	Denmark	7,560	46	Slovenia	417
22	Singapore	7,412	47	Chile	375
23	Spain	6,367	48	Slovakia	368
24	Norway	3,973	49	Egypt	352
25	Russian Federation	3,907	50	Bulgaria	348
….	…..	…	51	Iceland	344
….	….	….	52	Iran	317

Table1 shows that the top 50 patent registering countries in the USPTO in the time interval from 2015 to 2019 are located in North America, Eastern Asia and Europe. The USA is in the first place, Japan is the second, South Korea and Germany, and China are ranked third to fifth, respectively. Two countries, Taiwan and Britain, are in the sixth and seventh places, and Canada, France, and India are ranked eighth to tenth, respectively. Iran is in the 52th place with a number of 317 patents in this period. The significant difference in patent registering between the USA and Japan and other countries is evident in this table.

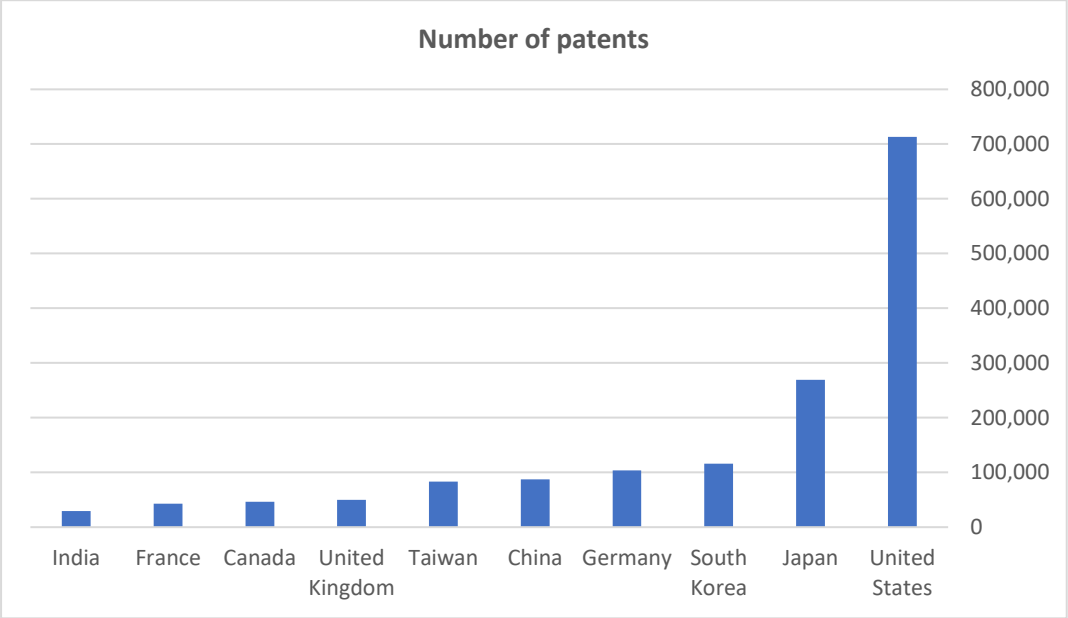

Figure 1. The top 10 countries in the field of patents

Scientific productions refer to all types of scientific outputs including papers, books, conference papers, annual reviews and critiques, etc. We mention the different types only to determine the number of scientific productions that are indexed in Scopus in the above templates. This table only contains the number of scientific productions, which is what we needed to study their relationship with patents. Therefore, there is no need to determine the number of each type of product in this table. Table 2 shows the descriptive statistics and information of the top 50 countries with the largest number of scientific productions in Scopus citation database from 2015 to 2019.

Table2

Descriptive statistics of top 50 countries in terms of scientific productions in Scopus

Row	Country	Scientific productions	Row	Country	Scientific productions
1	United States	3457729	26	Portugal	132584
2	China	2799133	27	Czech Republic	126844
3	United Kingdom	1068999	28	Mexico	124549
4	Germany	916656	29	Indonesia	123785
5	India	832072	30	South Africa	122998
6	Japan	664929	31	Norway	118664
7	France	617849	32	Saudi Arabia	114476
8	Italy	601418	33	Singapore	111885
9	Canada	556798	34	Israel	111035
10	Australia	520893	35	Hong Kong	109139
11	Spain	478923	36	Finland	107920
12	Russian Federation	462409	37	Egypt	102959
13	South Korea	426977	38	Greece	100285
14	Brazil	396524	39	Pakistan	90587
15	Netherlands	312822	40	Thailand	83837

Row	Country	Scientific productions	Row	Country	Scientific productions
16	Iran	279431	41	New Zealand	83512
17	Poland	243677	42	Romania	81046
18	Switzerland	242085	43	Ireland	76138
19	Turkey	232622	44	Argentina	72190
20	Sweden	216193	45	Chile	69887
21	Taiwan	189343	46	Ukraine	66001
22	Belgium	175111	47	Colombia	59353
23	Malaysia	163753	48	Hungary	58532
24	Denmark	145645	49	Slovakia	43185
25	Austria	134770	50	Nigeria	132584

Table 2 indicates that the top ten countries, in terms of scientific productions in Scopus from 2015 to 2019, are the United States, China, Britain, Germany, India , Japan, France, Italy, Canada and Australia, respectively. Iran is in the 16th place with a number of 279431 scientific productions in Scopus. A considerable difference in the number of scientific productions between the USA and China and other countries is evident in the table.

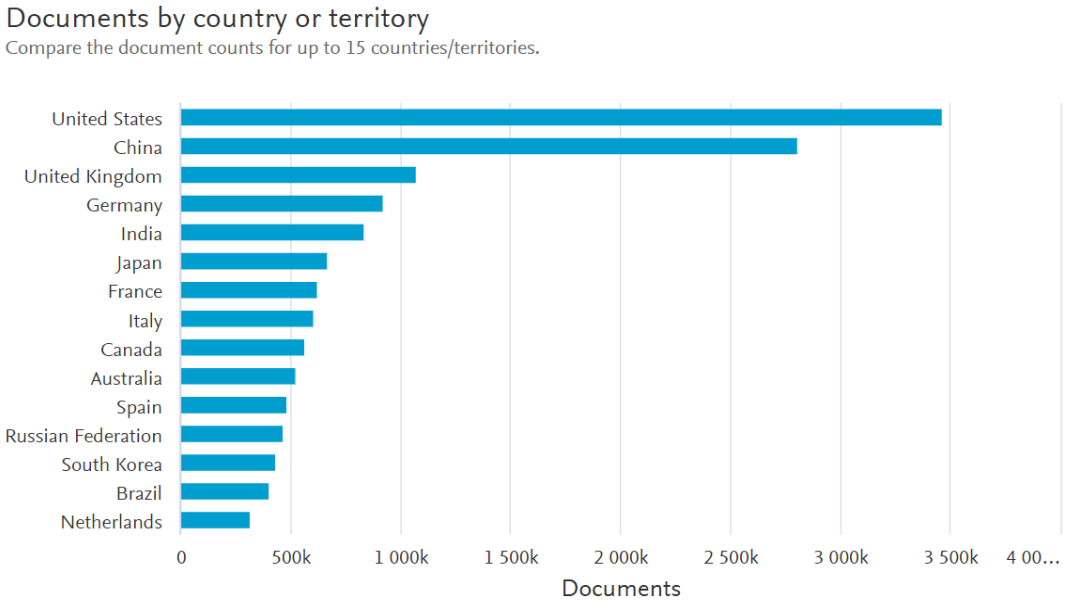

Figure 2. Top 15 countries in the scientific productions

Inferential Statistics

This section investigates the relationship between the registered patents and scientific productions of different countries. First, the Kolmogorov-Smirnov test is run to find out whether or not the studied data have normal distributions. Then, we examine the connection of the patents of various countries with the rest of their scientific productions using appropriate statistical tests. The Kolmogorov-Smirnov test is used as a matching distribution test for the quantitative data. Distribution normality tests are some of the most common tests for small samples with unknown normality. The variables of this research have the dimensions of

quantity. Therefore, their measurement scale is relative. If the foregoing variables are normal, parametric tests (in this case, the Pearson correlation test) are used; otherwise, nonparametric tests (in this case, the Spearman correlation test) are applied. There is a large distance between the patents and scientific productions of different countries. For instance, some countries like the United States and China have significantly high rates, while a number of other countries have extremely low rates. Therefore, the normality of the data is questionable. The Kolmogorov-Smirnov test for the data shows that none of our variables is normal. Thus, the relation we need for the statistical test in this research is the nonparametric statistical test of Spearman.

Question 1: What is the relationship between the scientific outputs and the patenting extent in Iran and other countries?

As stated before, the number of the registered patent applications of 137 countries was extracted from the USPTO, and the number of their scientific productions (including papers, books, conference papers, reviews and critiques, etc.) was extracted from Scopus citation database in the time interval from 2015 to 2019. The Spearman correlation test results for the scientific productions and registered patents of the countries are plotted in Table 3.

Table 3
Spearman Correlation Test for the Scientific Productions and Registered Patents of the Countries

Number of countries	Spearman correlation coefficient	Significance level
137	0.866**	0.000

** Significant at the 0.01 level

The information obtained from Spearman's test shows that the relationship between the number of scientific productions and registered patents of the countries is statistically significant. The correlation coefficient suggests that there is a high positive correlation between the number of scientific productions and the registered patents.

Question 2: Is there a meaningful relationship between the type of scientific documents and the extent of patenting?

To study the relationship between the different types of scientific documents and the number of registered patents, the production information of papers, books and conference papers was extracted for the 137 countries from Scopus citation database from 2015 to 2019. This information was also referred to in the descriptive statistics section. Table 5 shows the results of Spearman's correlation test between the different types of scientific documents of the countries, including papers, books and conference papers, and the number of their registered patents from 2015 to 2019.

Table 4
*Spearman Correlation Results of Productions and Patents in each Year from 2015 to 20**19***

Year	Number of countries	Spearman correlation coefficient	Significance level
2015	137	0.803**	0.000
2016	137	0.842**	0.000
2017	137	0.863**	0.000
2018	137	0.877**	0.000
2019	137	0.861**	0.000

Table5
Spearman Correlation Test for Scientific Documents and the Patents from 2015 to 2019

Type of document	Number of countries	Spearman correlation coefficient	Significance level
Papers	137	0.858**	0.000
Books	137	0.867**	0.000
Conference papers	137	0.874**	0.000

**Significant at the 0.01 level

The information obtained from the Spearman correlation coefficient shows that the relationship between the countries' production rates of papers, books and conference papers and the number of their registered patents is statistically significant. The correlation coefficient is positive, therefore, the production rate of papers, books and conference papers has a direct relationship with the number of patents in the studied time interval. Thus, countries with higher production rates of papers, books and conference papers have registered more patents.

Question 3: Is there a significant relationship between Iranian and other countries' scientific outputs in research areas and the extent of their patenting?

In this question, the different subject categories refer to the four categories of social and human sciences, technical sciences, medical sciences and life sciences. Table 6 shows the results of Spearman's correlation test between the scientific productions of countries in the four subject categories of social and human sciences, technical sciences, medical sciences and life sciences, and the number of their patents from 2015 to 2019.

Table 6
Spearman Correlation Test for the Scientific Productions of the Studied Countries in Different Subject Categories and the Number of their Registered Patents from 2015 to 2019

Subject category	Number of countries	Spearman correlation	Significance level
Social & human sciences	137	0.866**	0.000
Technical sciences	137	0.861**	0.000
Medical sciences	137	0.843**	0.000
Life sciences	137	0.834**	0.000

** Significant at the 0.01 level

The information obtained from the Spearman correlation test shows that there is a direct and significant statistical relationship between the scientific productions of the countries in the four subject categories of social and human sciences, technical sciences, medical sciences and

life sciences, and the number of their registered patents. Thus, countries with higher production rates in these four categories have registered more patents.

Discussion

Patents*:* The descriptive statistics and information of the patents of 137 countries were extracted from the United States Patent and Trademark Office (USPTO) in the time interval from 2015 to 2019. These countries were found to have registered a total number of 1764772 patents in this period. The results imply that the top ten patent-filing countries are located in North America, Eastern Asia and Europe. The United States is in the first place, Japan is the second; South Korea and Germany, China, Taiwan, Britain, Canada, France, and Italy are ranked third to tenth, respectively. It can be seen that from the top eight industrialized countries of the world, known as G8 or Group of Eight (France, Germany, Britain, Italy, Japan, the U.S.A, Russia and Canada), seven are among the top ten patent-filing countries; only Russia is excluded. Alongside these seven industrialized countries, three countries from Eastern Asia; namely, South Korea, Taiwan and China have registered the highest numbers of patent applications.

Scientific Productions*:* Scientific productions refer to all types of scientific documents including papers, books, conference papers, annual reviews and critiques, etc. According to Scopus citation database, the top ten countries with the highest number of scientific productions from 2015 to 2019 are the United States, China, Britain, Germany, India, Japan, France, Italy, Canada and Australia, respectively.

King (2004) studied the scientific productions of 31 countries by investigating their published papers and the citation rates of these papers in the Science Citation Index (SCI). Some of his obtained results indicate that the USA is the major producer of scientific information, and England, Germany, Japan and France are ranked second to fifth, respectively. Thus, it can be concluded that in the last few years, China has beaten other countries to the punch and reached the second place in scientific productions.

Scientific productions in the field of social and human sciences*:* According to Scopus citation database, the top ten countries with the highest number of scientific productions in the subject category of social and human sciences from 2015 to 2019 are the United States, Britain, China, Germany, Canada, Australia, France, Spain, Netherlands and Italy, respectively. The inclusion of Australia and Netherlands in the top ten countries in social and human sciences is noteworthy. These two countries have removed Japan and India from the list. Moreover, the significant difference between the United States and other countries in the field of social and human sciences is evident.

Scientific productions in the field of technical sciences*:* The top ten countries with the highest number of scientific productions in the subject category of technical sciences from 2015 to 2019 are China, the United States, Germany, Japan, Britain, France, India, Italy, Canada and South Korea, respectively. A noteworthy point is the presence of four Asian countries among the top ten countries with major productions in technical sciences. In addition, China has overtaken the USA as the major producer of scientific documents in the field of technical sciences. Another point is the significant difference between the United States and China, and other countries in terms of their scientific productions in the field of technical sciences.

Scientific productions in the field of life sciences*:* The top ten countries with the highest number of scientific productions in the subject category of life and agriculture sciences from

2015 to 2019 are the United States, China, Britain, Germany, Japan, India, France, Canada, Italy and Spain, respectively. The USA is greatly distanced from other countries in terms of scientific productions in the field of life sciences. For example, the amount of the United States' scientific productions is almost three times higher than that of China's, which is in the second place.

Scientific productions in the field of medical sciences*:* The top ten countries with the highest number of scientific productions in the subject category of medical sciences from 2015 to 2019 are the United States, Britain, China, Germany, Japan, Italy, France, Canada, Australia and Spain, respectively. Again, the USA is significantly distanced from other countries in terms of its scientific productions in the field of medical sciences, approximately three times larger than that of Britain's, which is in the second place.

Papers*:* The top ten countries with the highest production rates of papers from 2015 to 2019 are the United States, China, Britain, Germany, Japan, France, India, Canada, Italy and Spain, respectively. The USA and China, in comparison to other countries, had significantly larger numbers of articles.

Books*:* The top ten countries with the highest production rates of books from 2015 to 2019 are the United States, Britain, Canada, Australia, Germany, Italy, France, Netherlands, Japan and Spain, respectively. The noteworthy point in the information obtained from Scopus regarding the production of books is that China is not among the top ten. Instead, English-speaking countries have been more successful in producing books in Scopus, and the top four countries are English speaking. The presence of Canada and Australia in the third and fourth places also encourages the assertion that English-speaking countries are more dedicated to producing books in Scopus. The status of the USA and Britain is more significant in producing books as compared to other countries.

Conference papers*:* The top ten countries with the highest production rates of conference papers from 2015 to 2019 are China, the United States, Japan, Germany, Britain, France, Italy, Canada, India and South Korea, respectively. China's presence in the first place is noteworthy. In general, it is evident that non-English speaking countries, especially Asian countries, have been active in conferences. The status of China and the US is more significant in producing conference papers as compared to other countries.

The scientific productions of Iran have developed in the field of technical sciences and have a significant difference with the other categories. From the perspective of document types, the number of published papers in Iran in the time interval from 2015 to 2019 is greater than that of books and conference papers. The total number of Iran's scientific productions in this time interval is 279431, and the number of patents is 317. According to the results of the research, the correlation tests, and the information of other countries, this data do not confirm a significant relationship between the scientific productions and patents of Iran. The results of Spearman's test in Table 3 indicate a linear positive correlation between the number of scientific productions and registered patents in different countries. This means that the number of the registered patents in these countries has improved with the increase of their scientific productions. Scientific productions characterize development in science, and patents indicate development in technology. Studies on scientific productions and patents were performed to determine the relationship between science and technology. It is assumed that the correlation between scientific productions and patents may be a relative sign of the relationship and interaction of science and technology. Thus, it can be stated that a direct relationship exists

between science and technology. In other words, countries with more scientific progress possess more advanced technologies. The observed relationship between scientific productions and patents was different for Iran. In the time interval from 2015 to 2019, Iran is ranked 52th in the USPTO with 317 patents and 16th in Scopus database with 279431 scientific productions. Therefore, a solution must be presented regarding the low ranking of the number of patents in Iran. More attention must be paid to innovation as a characteristic of technology in the science policies of the country. A research project is already conducted with the title of "An analysis on the status of two indicators: The number of scientific papers in the Institute for Scientific Information (ISI) and the number of the registered patents throughout the world from 1981 to 2001, and the status of Iran among them". Verbeek et al. (2002) conducted a study entitled "Linking science to technology: using bibliographic references in patents to build linkage schemes". They drew on a method to design a linkage scheme that linked the systems of science and technology using patent citation data. After the conceptual embedding of the linkage scheme in the interactions of science and technology, some methods and algorithms were used in the paper to develop the linkage scheme in detail. Subsequently, this method was tested and used for a subset of patents registered in the USPTO. The results showed a wide distribution and enabled the authors to identify those fields of technology that were linked to science and the fields in which technology was independent from the scientific base and had more development. With regard to the fields of interaction between science and technology in this paper, there is a direct relationship between the two. Thus, the findings of the current research conform to the results of Verbeek et al. (2002), verifying a direct relationship between science and technology.

The results of Spearman's test in Table 4 indicate a direct relationship between the number of scientific productions and the registered patents of the studied countries in each year from 2015 to 2019. This means that the increase in the amount of the scientific productions of these countries led to an increase in the number of their registered patents in these years. The trend between the correlation coefficients increases with a mild slope, which means that the correlation between science and technology is increasing, and they are coming to be more entwined every day. The results of Spearman's test in Table 5 indicate a direct relationship between the countries' production rates of papers, books and conference papers, and the number of their registered patents. This means that countries with higher production rates of papers, books and conference papers registered more patents. As mentioned in the analysis section, the different subject categories refer to the four categories of social and human sciences, technical sciences, medical sciences and life sciences. The results of Spearman's test in Table 6 indicate a direct relationship between the scientific productions of countries in the four subject categories of social and human sciences, technical sciences, medical sciences and life sciences, and the number of their patents from 2015 to 2019. This means that countries with higher production rates in these four categories registered more patents.

Conclusion

The results of this research imply that there is an insignificant relationship between the number of scientific productions and registered patents in Iran. It denotes that the number of the registered patents in Iran has not improved with the increase in the scientific productions. In other words, there is no significant relationship between science and technology in Iran, which is in sharp contrast with the studied countries in which more scientific progress leads to

more advanced technologies. In the time interval from 2015 to 2019, Iran is ranked 52th in the (USPTO) with 317 patents and 16th in Scopus database with 279431 scientific productions. Moreover, there is an insignificant relationship between the number of scientific productions and the registered patents of Iran in each year from 2015 to 2019. It signifies that the increase in the number of the scientific productions in Iran has not led to an increase in the number of the registered patents in the aforementioned years. The results of the study done by Alai (2009) showed no significant relationship between scientific productions and patent registration in Iran. This may be due to the lack of cooperation of Iranian offices and organizations in patent registration. In Iran, the institutions reserve only 13% of patents, while more than 50% of patent offices are in the US, Canada and the UK. Japan and Switzerland were in the next ranks. Among the universities with registered patents, only Tehran University has less than 10% of the contributions made by all universities; other universities contributions to patent registration were negligible. This shows that effective and applied researches have been overlooked in institutions and universities that have a high contribution to science production in Iran. Furthermore, there is no significant relationship between the production rates of papers, books and conference papers, and the number of the registered patents in Iran. This is in contrast with the studied countries whose higher production rates of papers, books, and conference papers have led to more patents. Finally, the results of this investigation indicated an insignificant relationship between the scientific productions of Iran in the four subject categories of social and human sciences, technical sciences, medical sciences, and life sciences, and the number of the patents from 2015 to 2019. This means that, in Iran, higher production rates in these four categories have not contributed to more patents. Therefore, a solution must be presented regarding the low ranking of the number of patents in Iran, and more attention must be paid to innovation as a characteristic of technology in the Iranian science policies.

Research limitations

The major limitation of this research is the lack of access to some specific information. In SCOPUS citation database, the report file for researchers and organizations in one country includes only the first 159 results. Therefore, finding the number of researchers and organizations of one country is practically unfeasible in SCOPUS. No other database was found that presented valid information and statistics about the number of researchers and research organizations of different countries. Furthermore, minimal literature related to our subject was found. Therefore, the results of this research cannot be precisely used as a reference for scientific decisions and policies in Iran, and we suggest that the relationship between the number of active researchers/organizations and the number of registered patents in Iran should be evaluated in a new research in order to further clarify the lack of a significant relationship between scientific productions and patent registration in Iran.

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