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Original Research

The Technological Impact of Papers Published by Iranian Institutions: A Scientometric Analysis

Nadia Saniee
Assistant Prof., Medical Library and Information Science, Asadabad School of Medical Sciences, Asadabad, Iran.
nadiasanee@yahoo.com
ORCID iD: https://orcid.org/0000-0001-9424-1507

Homa Arshadi
Ph. D. Candidate in Medical Library and Information Science, Faculty of Management and Medical Information Sciences, Kerman University of Medical Sciences, Kerman, Iran.
Corresponding Author: homaarshadi@gmail.com
ORCID iD: http://orcid.org/0000-0001-9879-5451

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Abstract

Besides scientific impact, papers can also achieve a technological impact that remains less known in the scientific community. Cited papers in the patents are considered as the index to measure the technological impact. This study aimed to analyze the technological impact of Iranian publications using co-authorship and co-word map, their evolution, the journals, and the subject areas of these publications. This applied research focuses on the quantitative study and visualization with a scientometric approach. The research population was all studies (4554 records) that were published during 2011-2020 in one of the Iranian institutions and had been cited by one of the international patents. The data collection tool was the SciVal database. CiteSpace and Excel spreadsheets were used to analyze the data. Of the 4,554 papers cited by the scholarly outputs that have been cited in patents e patents, most of them were published in collaboration with the USA (9%). Islamic Azad University and Tehran University of Medical Sciences (13% each) were the most active Iranian universities. The number of Iranian papers cited in patents had a downward trend from 686 in 2011 to 57 in 2020. RSC Advances journal was the first top journal to publish these papers. Of 27 subject areas, engineering (24.1%) was the first popular subject that patents cite in their publications. The cluster analysis of keywords identified 8 clusters, including “x-ray diffraction,” “animal,” “adult,” “escherichia coli,” “tissue engineering,” “coronavirus infection,” “neural network,” and “methane.” The technological impact of Iranian research has declined in recent years. It is suggested that research policymakers should consider scholarly outputs that have been cited in patents, which, in a way, shows the flow of knowledge to the industry and encourages researchers to produce such papers.

Keywords: Patent-cited papers, Technological impact, CiteSpace, Patents, Iran.

Introduction

Science and technology are considered the most important elements for the development of countries, which together are trying to respond to the needs of society and resolve global challenges (Suresh, 2012). The relationship between science and technology is an important concept in academic studies and research (Hammarfelt, 2021; Li, Xie, Daim & Huang, 2019).

Shibata, Kajikawa and Sakata (2010) pointed out that science is the seed of technology and innovation. The ultimate goal of both is to contribute to the progress and welfare of society. Studies indicated the increasing trend of science and technology towards convergence to overcome global challenges and problems (Li et al., 2019; Wang, Fang & Chang, 2015).

Universities and Research and Development institutions (R&D) play a critical role in the economic, social, and cultural development of countries by producing science and technology outputs. They are the main source of new technology products in developing countries (Suresh, 2012). Industrial activists and academic researchers can take stronger steps to overcome problems and be more effective with more interaction and convergence (Barnes, Pashby & Gibbons, 2002). Scientific outputs are measured in different ways. The number of citations, the most widely used indicator, is considered a proxy for scientific impact (Ke, 2018). Despite many criticisms of using this indicator in research evaluations, it is still the most commonly used metric to evaluate the quality of publications, researchers, research centers, and universities (Tahamtan, Safipour Afshar & Ahamdzadeh, 2016) and it is used as a widely used indicator to assess the performance of research centers. This scientific indicator that generally reflects the impact or quality of research (Aksnes, Langfeldt & Wouters, 2019) is used to evaluate scientific development, scientific institutions, research areas and scientific papers (Yaminfirooz & Ardali, 2018).

Scholarly papers can have an impact on domains beyond the scientific community (Ke, 2018). One of the most favorite topics in science and technology studies is the bibliometric analysis of the ‘science-intensity’ or ‘science-dependence’ of technology (Meyer, Debackere & Glänzel, 2010). Patent references have been used as a statistical unit to measure the interaction between science and technology (Hammarfelt, 2021). Publications cited by patents are a strong indicator of the relevance that research could have to the industry (Colledge, 2019). Paper can be cited by patents, achieving technological impact (Ke, 2018). Citations from patents to scholarly outputs indicate a link between academia and industry, in other words, knowledge flows (Colledge, 2019). Receiving citations from patents has a higher value compared to citations received from papers. A study found that sleeping beauties were cited significantly more in patents than in "normal" articles (van Raan, 2017). “Sleeping beauty in science is a publication that goes unnoticed (‘sleeps’) for a long time and then, almost suddenly, attracts a lot of attention (‘is awakened by a prince’)”(van Raan, 2004). Interestingly, papers with delayed recognition show a stronger and longer technical impact and they are awakened more often and earlier by a patent rather than by a scientific paper (also called “prince”) (Du, Li, Haunschild, Sun & Tang, 2020). It is recommended that research policymakers pay more attention to the features of the publications cited in the patent due to their practicality. Therefore, monitoring research outputs, evaluating their technological impact, and measuring their impact on society is an undeniable necessity. This study aims to analyze the status of Iranian publications cited by patents in terms of the number, their journals, and contributions pattern of institutions and countries in ten years. On the other hand, this study determines the subject areas and the keyword network structure of these publications.

Research Questions

1. How was the trend of Iranian scholarly output cited in international patents between 2011 and 2020?
2. In which journals, Iranian scholarly outputs cited in the patents have been published most?
3. Which Iranian universities and which countries have the most contributions in producing scholarly outputs cited by patents in the period of 2011-2020?
4. To which subject areas are related most of the Iranian publications cited by patents?
5. What is the structure of the co-word map of Iranian scholarly output cited by patents?

Literature Review

Quantitative research emerged in the early 20th century, not as a specific research area. Pritchard (1969) proposed that a statistical bibliography is better replaced by bibliometrics. After that, bibliometrics became the basis of quantitative research in academic literature (Diem & Wolter, 2013). With the evolution of information technology and scientific visualization software, bibliometric and scientometric studies provided significant information compared to just counting the number of papers and citations. Exploration and prediction of research fronts and text mining have become a new aspect of bibliometrics. Based on the images and maps produced by such visualization software, we can understand the current status of research in a specific field and its possible directions in the future (Chen, 2013). There are different social network analysis software such as Ucinet, VxOrd, Pajek, and CiteSpace. Regarding citation analysis, it is necessary to select the appropriate software based on research data (Feng, Zhang, Du & Wang, 2015).

On the other hand, one of the hottest topics in recent years is university-industry collaboration and the technological impact of research can be analyzed in terms of papers cited by patents (Ke, 2018). For a long time, these studies were related to management, innovation, science and policy, science of science, and industrial organization research (Feng et al., 2015). Universities enable the development of science and technology and the exchange of experts by obtaining R&D funds from other companies and organizations. Also, industries can help the technical progress of universities by increasing their share and profit in the market (Cao, Zhang, Feng & Du, 2013). There are lots of details regarding science and technology collaboration that were provided by previous studies, but the technological impact was studied less than other topics in this regard. For instance, Thomas (1999) investigated the effect of technological impact on patent renewal decisions by patent citation analysis. He concluded that the technological impact of patents had a more significant effect on renewal decisions than the financial issues of their renewal. Cascajares, Alcayde, Garrido-Cardenas and Manzano-Agugliaro (2020) investigated the technological impact of Spanish medical research by analyzing the number of citations in international patents. Their study showed that medical research can provide opportunities for industrial and technological research and development. In another research, Hammarfelt (2021) studied the relationship between science and technology by patent-paper-citation analysis. His results showed that patents are legal, economic, and scientific products that emerged in the 1980s. Another study investigated the relationship between scientific novelty and technological impact. The results showed that the small proportion of novel scientific publications, as the 1% highly novel scientific publications in their field, are significantly more likely to have direct technological impact than comparable

non-novel publications. Novel science is also more likely to lead to patents which are themselves novel (Veugelers & Wang, 2019). Other studies were performed in recent years that confirmed importance of patent analysis to explore the technological impact of research in different fields and introduce new technological opportunities for improving the relationship between university and industry (De Paulo, Ribeiro & Porto, 2018; Lei, Zhao, Zhang, Chen, Huang & Zhao, 2012; Sun et al., 2022; Yoon & Kim, 2012; Zhou, Zhang, Porter, Guo & Zhu, 2014).

The concept of patent citations appeared because of the necessity of relevant metrics and the availability of databases. Patentometrics was developed based on studies and theories regarding the relationship between science and technology (Hammarfelt, 2021). Meyer et al. (2020) also said that patent citation analysis is among the most commonly used methods to track the strengths of links. They explored the relationship between patent citations and citation impact in nanoscience. Their results revealed that articles cited in patents are more likely to be cited also by other articles. Zhong, Pang and Tian (2023) concluded that further analysis of the main technological segments and research in the field of laser technology provides a detailed understanding of emerging innovations in this regard.

Based on the mentioned above, investigating the technological impact of research can lead to the introduction of new technological opportunities and an increase in on-demand research from society and industry attract more research financial resources to universities and improve their technical performance. However, the number of studies in this field is limited, especially for Iranian research which means to what extent Iranian research has been cited by patents in the world, and to what extent there is a relationship between Iranian universities and world industries. So, we answer these questions in the current study.

Materials and Methods

This applied research was carried out with a scientometric approach. The research population included the scholarly outputs published by Iranian institutions from 2011-2020, which have been cited by one of the international patents consisting of 4554 papers that the data were extracted on June 19, 2022. The data collection tool was the SciVal database. SciVal is a tool for measuring research performance, which has been released in 2009. It covers the five largest patent offices named EPO (European Patent Office), USPTO (US Patent Office), UK IPO (UK Intellectual Property Office), JPO (Japan Patent Office), and WIPO (World Intellectual Property Organization) (Colledge, 2019).

To extract data from Scival, the name of Iran was selected from the countries section. Time is limited to 2011-2020. The Patent-Cited Scholarly Output indicator and the All Patent Offices option were selected from the panel then the output was downloaded as CSV. For data analysis, an Excel spreadsheet was used to analyze the data and draw graphs and tables, and CiteSpace Version 6.1.R2 (Drexel University) was applied to visualize and analyze the network indices. Frequency, degree and burstiness were used to analyze the country collaboration network. The degree of a node is the total number of links, that indicates the number of connections it has with other neighboring nodes. The nodes with a high degree of centrality and frequency mean that they are likely to have the most participation with other members of the network. The burst detection in CiteSpace measures the sharp increase in citations. A country with a high burstness indicates a potentially interesting work that has attracted significant attention within a short time (Chen, 2016).

It should be noted that to visualize and analyze the data in CiteSpace software, we first converted CSV data extracted from SciVal to the default format of CiteSpace, which was WoS Format. For handling data, the original files in the CSV format were converted to a tab-delimited filename starting with 'download' using Excel. Using data directories in CiteSpace, the original files were imported into the input directory and the converted data were imported into the output directory the button named 'Scopus (Tab Delimited to WoS)' was pressed. In this process, CiteSpace will tell us how many records in each RIS file have been converted successfully. The valid references of this conversion were 98.0% which is a very decent successful rate. Then visualization, analysis, and calculation of indicators were done. For evaluating the journal's features, the latest versions of Scimago 2021 and JCR 2021 were used to extract the indicators of journals.

Results

Based on the findings the number of Iranian scientific publications cited by international patents from 2011 to 2020 was 4554, and almost all of these publications were journal articles (97%). Other types of publications constituted less than three percent of documents (Table1). Interestingly two of the papers cited in the patent had been retracted.

Table 1

Type of publications cited in patents

Document Type	Count
Article	3890
Review	546
Conference Paper	84
Letter	14
Editorial	8
Note	5
Short Survey	5
Retracted	2
Book Chapter	1

The trend of Iranian scholarly output cited in international patents

Figure 1 shows the trend of the number of scholarly outputs cited by patents in the 10 years. The number of Iranian publications that have been cited in patents has gradually decreased. In 2011, 686 Iranian publications were cited in the patents, which has declined to 57 by 2020.

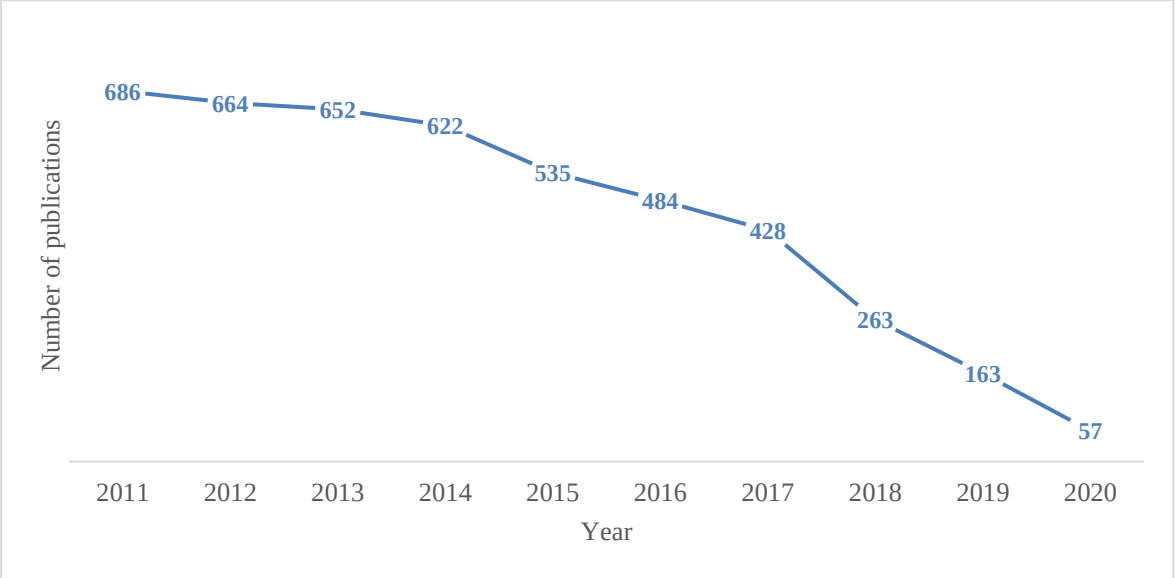

Figure: Iranian publications cited by international patents from 2011-2020

Top journals published the Iranian publications cited in patents

Table 1 shows the top journals that published the most publications of Iranian institutions that were cited in the patent. Among the top 10 journals, most of them were published by the United Kingdom and the Netherlands. The two Iranian journals named "Iranian Journal of Pharmaceutical Research" and "Iranian Journal of Basic Medical Sciences" have the lowest Impact Factor (1.96 versus 2.53). Most of these research were published in Q1 journal rankings of Scopus and Web of Science Core Collection (7/10 journals). These journals were more in chemistry and pharmacology fields in terms of SJR and JCR categories.

Table1
Top 10 Journals that published the Iranian publications cited in patents (Data 2022)

Journal Name	N	Country	SJR category	Rank in SJR	SJR	Scopus' CiteScore	SNIP	JCR category	Rank in JCR	IF (2 years in JCR)
RSC Advances	55	United Kingdom	Chemical engineering	219/674 -Q1	0.667	5.9	0.833	Chemistry, multidisciplinary	75/179-Q2	4.03
Iranian Journal of Pharmaceutical Research	36	Iran	Pharmacology, Toxicology and Pharmaceutics	464/717 -Q2	0.354	3.5	0.645	Pharmacology & Pharmacy	240/361-Q3	1.96
Iranian Journal of Basic Medical Sciences	30	Iran	Biochemistry	281/439 -Q3	0.499	4.1	0.819	Medicine, research & experimental/pharmacology & pharmacy	112/139-Q4; 205/279-Q3	2.53
Biosensors and Bioelectronics	29	United Kingdom	Biomedical engineering	14/248-Q1	2.11	20.2	1.74	Biophysics, biotechnology and applied microbiology, chemistry analytical, electrochemistry, nanoscience and nanotechnology	3/72-Q1; 10/158-Q1;3/87-Q1;3/30-Q1;16/109-Q1	12.54
Ceramics International	24	United Kingdom	Ceramics and composites	24/118-Q1	0.887	8.0	1.19	Materials science ceramics	3/29-Q1	5.53
International	24	Netherland	Economics and	169/708	1.1	11.6	1.44	Biochemistry and	46/296-	8.02

Journal Name	N	Country	SJR category	Rank in SJR	SJR	Scopus' CiteScore	SNIP	JCR category	Rank in JCR	IF (2 years in JCR)
Journal of Biological Macromolecules			econometrics	-Q1				molecular biology; chemistry, applied; polymer science	Q1; 8/72-Q1; 6/90-Q1	
Materials Science and Engineering:C	24	Netherland	Bioengineering	28/153-Q1	1.191	12.6	1.41	-Materials science, biomaterials	8/44-Q1	8.45
Biomedicine and Pharmacotherapy	23	France	Medicine	1019/7118-Q1	1.194	11.6	1.51	Medicine, research & experimental/pharmacology & pharmacy	30/139-Q1; 26/279-Q1	7.41
Desalination	23	Netherland	Chemical engineering	21/326-Q1	1.63	16.3	2.00	Engineering, chemical; water resources	10/142-Q1; 3/100-Q1	11.21
PLoS ONE	23	United States	Multidisciplinary	16/138-Q1	0.85	5.6	1.36	Multidisciplinary sciences	29/73-Q1	3.75

Countries, affiliations, and collaborations

The top 10 Iranian institutions that have mainly contributed to international patents with their publications are shown in Figure 2. Out of a total of 4554 articles cited in the patent, Islamic Azad University has the most frequency among the country's universities, with 608 articles. Concerning Islamic Azad University, due to the use of a single organizational affiliation for all branches of this university in Iran, it may not be correct to assume that the first rank is assigned to this university. Therefore, according to the findings of the current research, Tehran University of Medical Sciences (604 articles) has the first rank in receiving citations from international patents, and then Tehran University and Tarbiat Modarres University obtained the second to third ranks.

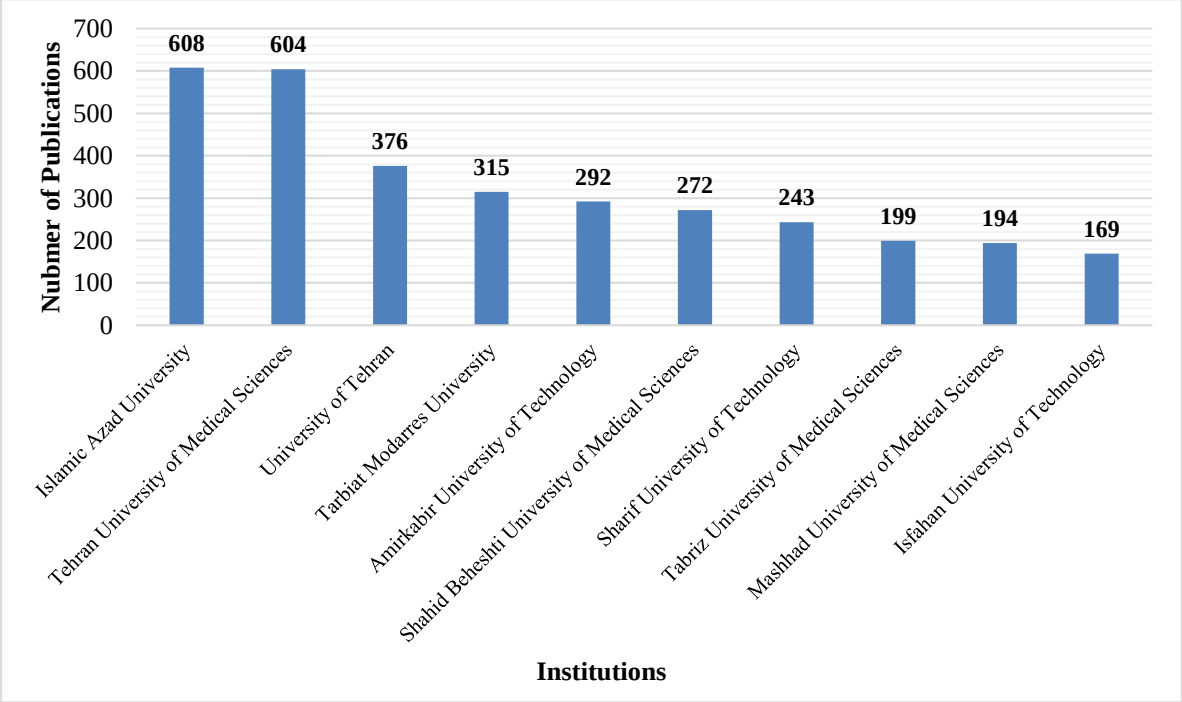

Figure 2: Top 10 institutions in Iranian publications that have been cited in patents

The results of the analysis of the countries' co-authorship network revealed that this network consists of 5 main clusters. Table 2 lists the top 10 influential countries that contributed to Iran based on three indicators Frequency, Bursts, and Degree. As can be seen, the United States with 408 joint publications with Iranian authors is the first rank for frequency followed by Canada and the United Kingdom. Poland, Vietnam, and Luxembourg are three countries that had the highest score on Burst.

Estonia has the highest degree value (85.27), followed by Sri Lanka and Slovakia (63), and Colombia (62). The degree shows the co-authorship score of a country with Iranian researchers in the network. To sum up, the first place for Frequency, Burstiness, and Degree belongs to the United States (408), Poland (6.48), and Estonia (78), respectively (Table 2).

Table 2
Top 10 Countries that contributed to the Iranian publications based on Degree, Bursts and Citation count

Freq	Country	Burst	Country	Degree	Country
408	United States	6.48	Poland	78	Estonia
241	Canada	4.15	Viet Nam	63	Sri Lanka
189	United Kingdom	3.56	Luxembourg	63	Slovakia
163	Germany	3.37	Kyrgyzstan	62	Colombia
156	Australia	3.24	Lebanon	58	Indonesia
138	Italy	3.22	Peru	58	Nigeria
127	Malaysia	3.18	Kazakhstan	58	United Arab Emirates
116	Netherlands	3.11	Algeria	56	Philippines
114	France	2.95	Indonesia	56	Greece
103	Sweden	2.94	Ethiopia	56	Ghana
100	Spain	2.88	Kuwait	55	Cameroon

Subject areas of the publications cited in the patent

Figure 3 highlights the Top 10 Subject area classifications of the Iranian publications cited in patents. Out of 4554 papers cited in the patent from 27 subject areas, 24.1% (1096 papers) belong to the engineering area. The second subject area that contributes most is chemistry, with 23.1%, followed by medicine, with 22.1%. It should be noted that some of these papers may be placed in more than one subject area; therefore, summarizing the articles of all areas together will be more than the sum of the total articles, i.e., 4554.

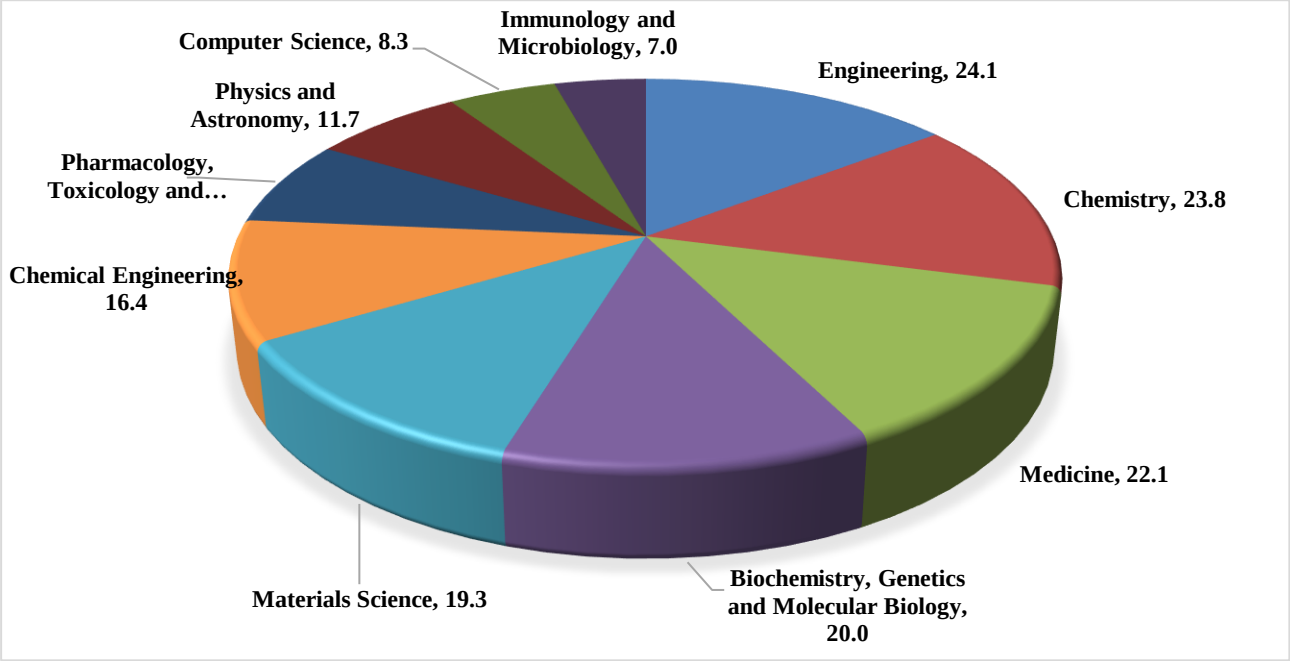

Figure 3: Top 10 subject areas in Iranian publications that have been cited in patents

Cluster analysis to detect high-frequency keywords

One of the networks that can be made through CiteSpace software is a co-occurrence map. A co-occurrence network of keywords extracted from titles and abstracts of papers is shown in Figure 4. The network of keywords consists of **8** clusters which were obtained by cluster analysis, and the Silhouette values for each of the 8 clusters were more than 0.8. The cluster names of the map are "x-ray diffraction", "animal", "adult", "escherichia coli", "tissue engineering", "coronavirus infection", "neural network", and "methane", respectively. According to the suggestion of the CiteSpace handbook, the labels of the clusters were LLR (log-likelihood ratio), which is the best method to obtain clustering results (Chen, 2016). It should be mentioned that the number of nodes in the co-occurrence network was 889.

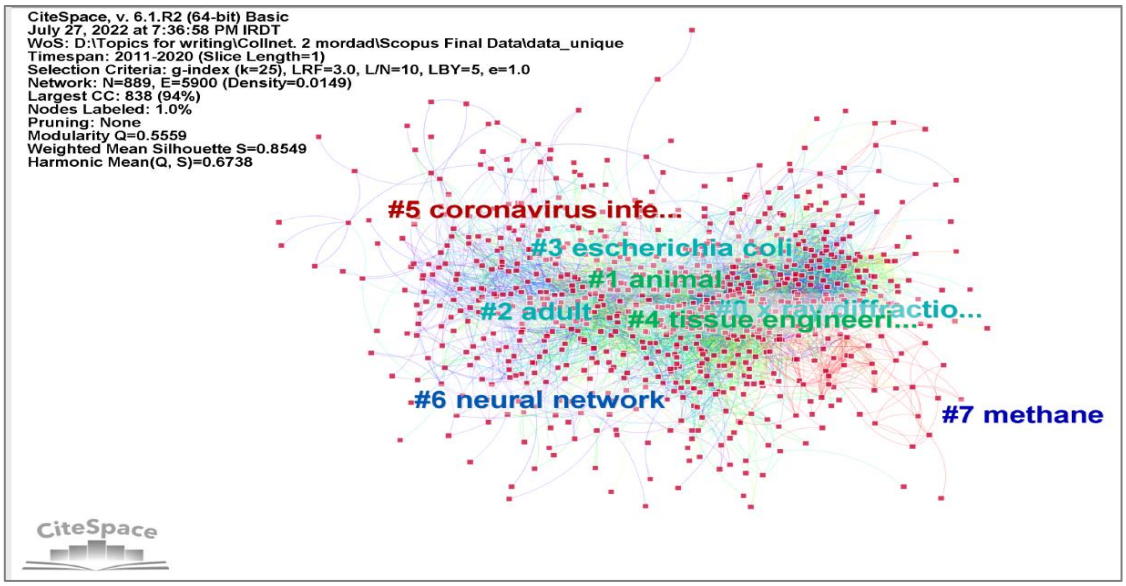

Figure 4: A Co-occurrence network of keywords

The largest cluster (#0 x-ray diffraction) includes 256 articles and the silhouette score is 0.824. In this cluster, most of the studies focused on topics such as scanning electron microscopy, nanocomposite, nanoparticle, and transmission electron microscopy. The subtopics of other clusters can be seen in Table 5. The largest 8 clusters are summarized as follows:

Table 5
Keyword clustering results for the Iranian papers cited in patents from 2011 to 2020

ClusterID	Size	Silhouette	Mean (Year)	Top terms (loglikelihood ratio)	Label (LLR)
0	256	0.824	2012	x-ray diffraction	scanning electron microscopy; nanocomposite; nanoparticle; transmission electron microscopy
1	182	0.837	2013	animal	cell differentiation; mouse; apoptosis; animal experiment
2	154	0.9	2013	adult	female; middle-aged; male; aged
3	98	0.817	2013	Escherichia coli	antibacterial activity; antioxidant; antioxidant activity; pseudomonas aeruginosa
4	83	0.868	2014	tissue engineering	drug delivery system; nanofiber; drug carrier; adult
5	34	0.939	2019	coronavirus infection	betacoronavirus; coronavirus disease 2019; virus pneumonia; covid 19
6	23	0.977	2013	neural network	artificial neural network; support vector machine; genetic algorithm; algorithm
7	8	0.999	2011	methane	carbon dioxide; oxygen; biogas; ethylene

Discussion

This study aims to analyze the Iranian studies which have been cited by patents using co-word and co-authorship as well as the evolution of these papers, the journals and the subject areas of these publications. The results showed that 4554 Iranian research were cited by international patents and most of them were journal articles. Among these publications, two retracted papers were cited in patents. These results show that Iranian scientific productions with technological impact have declined significantly over time. The downward trend in the number of Iranian papers cited in patents can indicate that citations are time-dependent, especially in the case of patents, which are published and cited later than articles. In general, papers cited in patents are more focused on practical and technological aspects of innovation. Since the number of Iranian papers cited in patents is decreasing, it can be analyzed that the Iranians' publications are not enough practical. This issue needs a more detailed investigation and comparison with the outputs of other countries of the world. In this regard, Feng et al (2015). analyzed scientific productions regarding university-industry collaboration in the Web of Science with CiteSpace. They concluded that the number of scientific productions and their citations have increased over time and decreased in 2013. The difference between their study and the present research was in the population and the source of information extraction. In the

present study, Iranian scientific productions were extracted from Scopus without subject limitation.

Cascajares et al. (2020) analyzed Spanish medical research with similar research methods to the current study. They concluded that the number of publications cited in international patents has decreased over time which is similar to the decreasing the number of Iranian scientific productions cited in patents. Meyer et al. (2010) also found that the number of nanoscience articles cited by patents was quite small. We can say that the low number of articles cited in patents in various fields of science can be due to the lack of familiarity of researchers with the importance of the technological impact of research, which requires universities and research centers to move towards financial investment for impactful research and make the scientific community aware of this concept.

In the current study, the original papers have been cited more by patents due to having more practical results than other types of scholarly outputs. However, to prevent threatening the scientific reputation of researchers who are active in the field of technology, it is necessary to make arrangements to prevent the use of retracted articles in their patents. This issue can be taken into consideration by organizations related to publishing and research ethics like COPE and ethical consideration of research committees in universities and research institutions. In this way, with the help of artificial intelligence algorithms and expert systems, it is possible to warn the researchers that invalid articles are cited in their patents. It can be studied in the future.

The results of the current study indicated that most of the Iranian research was published in high-ranked journals (Q1 journals) from the United Kingdom and the Netherlands in chemistry and pharmacology categories. This shows that high-quality journals are more likely to publish articles that are cited in patents. Moreover, "The Iranian Journal of Pharmaceutical Research of Iran" and "The Iranian Journal of Basic Medical Sciences of Iran", which were the top journals contributing to the publishing of papers with technological impact could be considered potentially valuable journals in Iran. Cascajares et al. (2020) pointed out that some journals don’t have a significant influence or relative place in their fields, but they have great relevance in the area of patent support. Journals that have a higher percentage of papers cited by patents with a Field-Weighted Citation Impact (FWCI) of more than 1 and higher transference index in patents (TIP) score can be ranked as top journals publishing these papers. In the present study, the journals publishing Iranian research that were cited in the patents had a high scientific rank among their peers. Therefore, it can be suggested to rank scientific journals in terms of citations of patents in future research.

Also, medical and engineering fields such as pharmacy and chemistry are more likely to publish articles with high technological impact than other science fields due to the basic and applied nature of their research. Feng et al. (2015) showed that most of the university-industry collaboration research was published in chemical journals which is similar to the present study. Among productive institutions in the current study, concerning the Islamic Azad University, due to the use of a single organizational affiliation for all branches of this university in Iran, it may not be a correct interpretation that the first rank is assigned to this university. So, the Tehran University of Medical Sciences obtained the first rank for the highest number of publications cited by the international patents. Regarding Spanish research publications, Cascajares et al. (2020) found that CSIC (Consejo Superior de Investigaciones Científicas) and the University of Barcelona were the Spanish institutions that had the highest number of publications that were cited by the international patents.

In terms of the co-authorship network in the current study, Iran had the most collaboration with the United States, Canada, and the United Kingdom, respectively. Poland, Vietnam, and Luxembourg are the three countries that had the highest score in Burst. Estonia has the highest degree value among other countries. The degree indicates the ability of countries to collaborate (Luo & Hsu, 2009). Cascajares et al. (2020) similar to the present study found that Spanish medical researchers had the most collaboration with the United States, after that, the United Kingdom and Germany which is different from our study.

Also, out of 4554 papers cited in patents from 27 subject areas, most of them belong to engineering, chemistry, and medicine, respectively. Cascajares et al. (2020) found that genetics, molecular biology, biochemistry, and medicine together consisted of almost 40% of the total publications which is somewhat similar to the results of the present study. The finding of these two studies shows that the fields of medicine, engineering, and chemistry have more citations in patents, and it indicates the applicability of research results in these fields compared to others.

Based on the co-occurrence map, the network of keywords consists of 8 clusters and the Sihouette values for each of the 8 clusters were more than 0.8. It can be interpreted that the quality of the network is good. We can conclude that the Iranian scientific outputs in the map are x-ray diffraction, animal, adult, escherichia coli, tissue engineering, coronavirus infection, neural network, and methane have received more attention from industry in the world than other fields of science. The largest cluster was x-ray diffraction. In this cluster, most of the studies focused on topics such as scanning electron microscopy, nanocomposite, nanoparticle, and transmission electron microscopy. The five most frequent keywords in Feng et al.'s (2015) study were innovation, science, research and development, knowledge, and technology transfer which differ from our results. The most common keywords in Spanish medical research were related to Alzheimer Disease, Carcinoma, Human Immunodeficiency Virus (HIV), and Neoplasms. Oncology was the leading keyword (Cascajares et al., 2020). These keywords were different from the keywords obtained in the present study.

In this study, only the citations from international patents of 5 world patent offices including EPO, USPTO, UK IPO, JPO, and WIPO to Iranian publications indexed in the Scopus database are considered. Therefore, the publications that are not indexed in the Scopus database and are cited in one of the patents are not included in the present study. In addition, the Iranian publications indexed in the Scopus, which are cited by the patents of other patent offices have not been considered, which can be a limitation of the research.

Conclusion

The results showed that the number of Iranian publications, which were cited in international patents decreased over time. So, the technological impact of Iranian research has declined in recent years. It is suggested that research policymakers familiarize researchers with the concept of the technological impact of research and provide them with sufficient financial resources to produce such papers that are considered in industry and technology. Also, it is necessary to create new indicators in citation databases for ranking universities, researchers, and journals based on their cited papers in patents. It is suggested to conduct such studies on the scientific outputs of other countries in the world and compare them with each other.

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