Measuring Inter-Organizational Interactions for the Field of Electrical and Electronic Engineering in Iran through a Triple Helix Model Approach

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Abstract

The launch of a national innovation system in many countries stems from the flow of ideas and skills between universities, research centers and the economic sectors of society. Attention to the relationship between university, government, industry and other elements in the production of science and technology has led to the design of multiple helical models; models that are based on the mutual information approach and information entropy and are able to measure the interactions of agents from different sectors in converting science into technology. This study examined the cooperations between university, industry, government and international society sectors in publishing scientific articles in the field of electrical and electronic engineering in Iran, using a Quadruple Helix Model approach. Statistical population included the articles of the field of electrical and electronic engineering of Iran, which have been indexed in the Web of Science database during the years 2010-19 and contains 19802 records. According to the findings, the highest T indicator of university-industry-government-international society sector relations is appeared in 2017 and in 2011 this indicator showed a negative trend. Results reveal that in general, cooperation between the pillars of the model during the ten-year period under study has been associated with a lot of fluctuations and the interaction between the elements of the model is not favorable. Accordingly, it is necessary to develop some new science and technology policies and to make approperiate research and industrial strategies in Iran to advance interactions between these elements.

Keyword: Quadruple Helix Model, electrical and electronic engineering, scientific collaboration, co-authorship, university-industry-government interactions, scientific collaboration.

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Introduction

The national innovation system has evolved over time based on previous models of innovation. In the 1940s, linear models of innovation or typical knowledge pressure were introduced, where science was produced in universities without considering the needs of society, leading to failed market results. The government then invested in research and innovation along with industry and academia, resulting in social and economic growth by addressing the needs of society. The focus then shifted to innovation in the form of a complex system with feedbacks, loops, and nonlinear relationships known as the national innovation system.

The implementation of a national innovation system in many countries is based on the exchange of ideas and skills between universities, research centers, and the economic sectors of society. Attention to the relationship between academia, government, industry, and other pillars in the production of science and technology has led to the design of multiple spiral patterns. In this regard, one of the most significant events of the last decade has been the annual congresses of cooperation between government, industry, and academia, where determining elements are assessed, and solutions, definitions, and case studies are offered.

Currently, the relationship between these sectors is crucial, and the industry - the end-manufacturers of technology - needs to conduct more research and development to achieve technology and self-reliance (Sobhani, Ebrahimi & Jokar, 2017) for the purpose of national development.

The three helical elements - government (G), universities (U), and industry (I) - are so interdependent that the boundaries between them become blurred, even though each has its own unique role. Governments invest at risk in the areas of knowledge creation, innovation, technology, and the production of goods and services, while universities engage in entrepreneurship and industry creates and disseminates knowledge, in addition to producing goods and services. The importance of the relationship between these three sectors lies in the fact that a country's independence in the information age depends on its level of technological development and its ability to meet its economic, industrial, and social needs. This technological development can only occur through research and development.

In countries such as Iran, there is a weakness in the relationship between academia, industry, and government. The university environment is often disconnected from industry and government, resulting in a weak relationship between these sectors, which slows down the country's progress. To address this issue, the quadruple helix model was introduced, which includes a fourth factor: society or the general public, who are involved in the design of this helix to meet their needs. The quadruple helix model addresses one of the

weaknesses of the triple helix model, which is the lack of public participation in the production of knowledge, products, and law. The fourth pillar (society) participates with the media, the creative industries, culture, values, lifestyles, art, and the creative class.

In developed countries, the continuous and dynamic relationship between society and the university leads to mutual growth and development. However, in less developed countries, this relationship is often not established, and the university primarily transfers knowledge to students, while society operates independently. Studies based on the quadruple helix model in such countries, including Jafari, Akhavan, and Zarghami (2015), have considered scientific collaborations from the international society sector as the fourth pillar (F) and examined its interactions with other elements.

According to the quadruple helix model, a country's economic structure is based on four pillars: universities, corporations, government, and civil society (or the external sector). Economic growth can be achieved through categorization and a focus on talented and productive individuals. Some researchers argue that civil society's role in the economy is on the consumption side, where families demand and consume innovation, technology, products, and services in the form of final goods and total output of the economy.

In developed countries, the continuous and dynamic relationship between society and the university leads to mutual growth and development. However, in less developed countries, this relationship is often not established, and the university primarily transfers knowledge to students, while society operates independently. To evaluate the implementation of the national innovation system, the interaction between academia, industry, government, and the international society sector, cooperation is considered a critical variable. Cooperation acts as a driving force for innovation, and scientific cooperation is a reflection of the activities and approaches of the scientific community. Investigations into scientific cooperation can also help in understanding the sociology of science (Rahimi & Fattahi, 2008).

After reviewing the documents on the Web of Science website, it is apparent that Iran ranks among the top thirteen countries in the world in the production of scientific documents within the field of electrical and electronic engineering. Additionally, when compared to the countries of Southwest Asia, Iran ranks first in the production of scientific documents within this field.

Although various research works have observed the interactions between the pillars of innovation in the dimensions of university, industry, and government, little attention has been given to the importance of international society sector cooperation in this regard. As a result, there is a growing need to accurately understand the status of interactions between the various elements of the four-dimensional helical model to inform policy-making and

research planning. The creators of this method emphasize that this model is capable of measuring more dimensions, and considering additional dimensions can lead to increased accuracy in research results.

At present, it remains unclear whether the Iranian government is investing in the field of electrical and electronic engineering, and if so, to what extent this investment has contributed to increased scientific production in the field. Furthermore, it is unclear whether the scientific production in this field has been accepted by the industry, and what role the international society sector has played in this regard. The relationship between the university, industry, government, and international society sectors in the production of scientific articles within the field of electrical and electronic engineering in Iran is also unclear, including which interactions between the pillars of the quadruple helix model have been most prevalent.

Therefore, this study aims to determine the contribution of each of the four pillars in the production of Iranian scientific articles in the field of electrical and electronic engineering, analyze the interactions between the different pillars based on the quadruple helix model, and identify any significant relationships. In their article titled "The Triple Helix Model Theorists: Past, Present, and Future," Cai and Etzkowitz (2020) analyzed past and recent literature on the triple helix model and proposed solutions for its theoretical development.

In their study titled "Dynamics of university-industry-government relations in nanoscience: a comparative study of the relations of the triple helix model in Iran and Switzerland," Souzanchi Kashani and Zarghami (2019) found that Switzerland had a higher proportion of scientific production resulting from the participation of two or three elements of the helical model compared to Iran. Specifically, about 60% of Switzerland's scientific production was the result of two or three sectors partnerships, while for Iran, this number was less than 20%. The total amount of three sectors partnerships in Iran was 0.57, whereas in Switzerland it was 26.57. Chen, Zhang & Fu (2019) conducted a study examining international research collaboration as a new field for innovative studies between 1957 and 2015. The study found that co-authorship was the most common method used, and the field of international research collaboration research was classified into five independent subject areas: stimuli, patterns, effects, networks, and measurements.

Azizi and Moradi (2019) conducted a research article that examined the Innovation Index as an indicator for the knowledge-based economy in Iran and analyzed the interactions between universities, industry, and government in the research and innovation system. The study found that while Iran was at an almost good level in terms of innovation index and was in a moderate level in terms of education, manpower, and communication and information

infrastructure, it was in an unfavorable situation in terms of economic incentives and institutional support. This has hindered the transformation of theoretical and scientific knowledge into practical and commercial knowledge. The study recommended the formulation and implementation of a purposeful strategy and special planning to address this issue.

Methodology

The present study is a scientometric research that employs an applied research approach with a quantitative methodology. The study aims to determine the share of each of the four helical elements in the scientific products of the field of electrical and electronic engineering in Iran, namely H (U), H (F), H (G), H (I), using the theory of information entropy. The study also calculates the uncertainty index (T) using this concept. The research population includes all scientific articles in the field of electrical and electronic engineering in Iran, which were indexed in the Web of Science database from 2010 to 2019. The study retrieved 19,802 articles using 19 search strategies.

Findings

Based on the findings of the current study, it was observed that the university-government interaction had the highest level of engagement in 2010, suggesting that the government had invested heavily in the university. On the other hand, the interaction between the government and the international society sector had the lowest engagement level, often appearing on the horizontal line and remaining close to zero in most years, indicating that the government has not invested significantly in the international society sector.

The study's results also demonstrate a contrast between the university-government interaction and interactions between the university-international society sector, industry-international society sector, and university-industry. This outcome is expected because the government typically does not invest in the international society sector or industry. As the government's role diminishes, the role of the industry and international society sector increases. It's worth noting that around 30% of scientific products in the electrical and electronic engineering field in Iran were produced in collaboration with foreign partners.

Another significant finding of the study is that the interactions between the university-government-international society sectors and university-industry-international society sectors were aligned and had a negative impact on the interactions of the four pillars over time. The lowest interaction between the four pillars occurred in 2011, whereas that year saw the highest interaction among the triple pillars. This finding suggests that when the university and industry interact with each other and the international society sector, and when

the university and the government interact with each other and the international society sector, the government has not invested significantly in industry.

Based on the research findings, the interaction between the industry-government-international society sector is typically near the zero line of the chart, except for in 2017 and 2018, where an increasing trend was observed. This trend could indicate that during those years, the government invested more in the industrial sector, and the industry had more interaction with the international society sector due to its potential.

Conclusion

One of the most significant findings of this research is the importance of government presence and its potential to support other sectors, thus playing an effective role in interactions. It is apparent that in earlier years, this sector played a more prominent role than in later years. To promote technology development and encourage greater interaction between the university and industry pillars, government support and guidance policies are crucial. If these policies are devised more intelligently, they may pave the way for demand-driven and problem-oriented academic research, promote innovation and technology development in the industrial sector, and increase the utilization of the abundant capital of the university sector in the country. In light of these findings, it is recommended that policymakers from both public and private sectors identify and address the gaps that have reduced cooperation between the industry and government with other institutions in the field of electrical and electronic engineering in Iran. By doing so, the field can make greater progress in the future.

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