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Investigating the Relation between the University, Industry and Government in the Innovation System of the Knowledge-Based Economy in Iran

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Abstract

The research aims to study the status of Iran in the sub-index of innovation as the main indicator of the knowledge economy and to assess the interactions of the university, industry and government in the research and innovation system of the country. This research takes advantage of the World Bank Knowledge Assessment Methodology (KAM) framework to measure the sub-index of innovation and Triple-Helix model to investigate the relationship between university, industry and government in one of the variables of the innovation system. For that purpose, the World Bank's formula for Knowledge Economy Index was employed to measure the sub-index of innovation in Iran's economy from 1996 to 2016. The results of the computation of the innovation sub-index indicate a stable growth in that area for Iran. Subsequently, the Triple-Helix model was used to evaluate the university, industry, and government interactions, illustrating a small contribution of the industrial sector in the country's research areas. The study showed that despite the growth of the innovation index, the interactions of the innovation system components are not desirable and require targeted investment and focused planning strategy.

Keywords: University, Industry, Government, Triple-Helix Model, Knowledge Economy, Innovation.

Introduction

Over the past 50 years, world economies have undergone some kind of gradual changes, with improvement of knowledge as the main development. Today developed countries, that have established a knowledge economy with effective learning management and research and innovation through systematic approach, have actually been able to improve the production of their goods and services and increase their economic added value through the development of technologies and increased productivity.

Thus, many developing countries are trying to acquire a new knowledge-based economy and create necessary infrastructure for its establishment. With the effect of basic knowledge in the current economy, various countries, including the Islamic Republic of Iran, have been seeking to pursue their economic development policies.

The general policies of Iran’s five-year development plans clearly prove the greater importance of the effect of knowledge on economy. Iran’s 20-year vision statement, which is the most important framework and basis for the regulation of economic affairs, emphasizes the promotion of knowledge in the development process of the country.

In the information century, the sovereignty of all states depends on the extent of technological development and ability to meet their industrial, economic and social needs. Therefore, Iranian government must play a key role in careful and accurate planning and adopt appropriate macro and strategic policies for better and more coherent communication with university and industry (Natario, Couto, & Almeida, 2012).

On the other hand, the innovation system has an advanced policy analysis and framework that has currently drawn the attention of the world's policymakers and is considered one of the main elements of knowledge-based economies. For example, the United Nations, too, has developed the third Millennium Development Goals (MDGs) (United Nations Department of Economic and Social Affairs, 2008) based on the innovation system. According to experts, the success of this framework in the country has been proven in areas of defense, health, nanotechnology, etc.

Therefore, the role of innovation system components, such as university, industry, government and environment, should be studied as well as the cooperation between the three components of the university, industry and government. The phenomenon of technology transfer and commercialization play an active role in the relationship between the university and industry. The role of the government is also evident as a strong pillar that strengthens and supports this relationship (Harbi, Amamou, & Anderson, 2009).

A Triple-Helix model has been used to measure the relationships between components of the innovation system in this research. The model examination illustrates that the main institutions that in the beginning defined the Triple-Helix model in the knowledge-based economy are the university, industry and government. These institutions are responsible for the establishment of the innovation system in the country in a two-layer network: the first layer interconnects institutions that interact with each other, and the second layer shows the operational relationships in which the expectations of institutions are mutually shaped.

For example, the relationship between the university and industry can be established through various institutional agreements such as the Office of Communications of the University and Industry, and spinoff companies (Etzkowitz and Leydesdorff, 1997). The difference between the knowledge economy and the market economy or political economy is that the market mechanism initially balances supply and demand, and the economic exchanges are set up by political institutions.

The argument is that recently in the social system, knowledge-based products have been added as a mechanism for third-party cooperation in the relationship between economic exchanges and political control (Gibbons, 1994).

Therefore, three sub-dynamics have been developed as the performance of knowledge economy:

- Generating wealth in economy
- Producing new products based on knowledge and technology
- Governance of interactions between the two sub-dynamics through policy-making in the government sector and management in the private sector

The economic, academic, and political systems can be considered relatively independent sub-systems of society, operating with different mechanisms (Leydesdorff, 2010).

The three identified sub-dynamic are built in social communication and are constantly being reconstructed. They can affect each other as three selected Triple-Helix with continuous monitoring. For example, a patent, a research paper or article can be considered the result of interaction mechanism (Luhmann, 1997). (Figure 1)

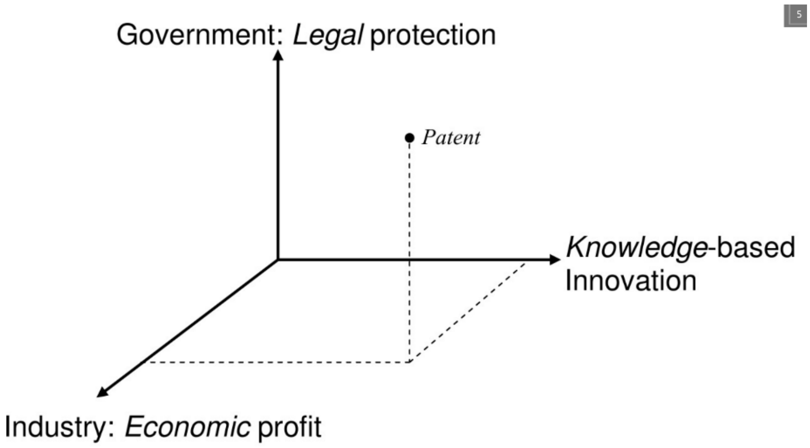

Figure 1. Inventions as an occurrence in three-dimensional space of Triple-Helix Interactions
Source: (Leydesdroff, 2010)

The analytical performance of the Triple-Helix model solves the dynamic complexity of the knowledge economy in terms of sub-dynamics. In fact, the Triple-Helix originates from science and technology studies (Mirowski and Sent, 2007).

For example, political discussions can be separated from scientific discussions. In other words, the three interactive sub-dynamics are expected to generate the upper cycle (such as business cycle, selection cycle …) or to be between the constituent sub-dynamics (Richta et al, 1968).

The study of the dynamics of communication between the Triple-Helix components illustrates the role of the development of the university, industry, and government communications in the development of innovation and consequently, the movement towards the knowledge economy.

Given the ever-increasing focus on the subject of knowledge-based economy in recent decades and the planning of developed countries and a number of developing countries for the development and use of knowledge in the rise of innovation and technology-based products, the assessment of countries in the field of development innovation and permanence knowledge have become the subject of attention.

In 1999, the World Bank's Knowledge for Development Program introduced the knowledge assessment methodology (KAM), which is an interactive benchmarking tool. KAM helps the countries identify the challenges and opportunities they face in making the transition to the knowledge-based economy, make political and economic decisions and invest in the future with the knowledge-based economy approach (Gorji and Alipourian, 2011). The following explanation shows the variables, economic set and four pillars of the framework for knowledge-based economies.

The KAM derives a country’s overall indices - Knowledge Economy Index (KEI) and Knowledge Index (KI). In this paper, we will take into account the Knowledge Index (KI). KI measures a country's ability to generate, adopt and diffuse knowledge. Methodologically, the KI is the simple average of the normalized performance scores of a country on the key

variables in four knowledge economy pillars – (1)*Economic Incentive and Institutional Regime* , (2) education and human resources, (3) the innovation system and (4) information and communication technology (ICT). For the purposes of calculating KI, each pillar is represented by three key variables. In this study, we examined the pillar of the innovation system.

The pillar of Innovation System in KAM methodology consists of institutes, research centers, universities, advisors, etc., and has the ability to influence the growing knowledge of the world. It can adapt to local needs and transform into valuable products. In this index, indicators such as the contribution of research in the gross domestic product (GDP), per capita number of scholars, the number of patents and the number of scientific articles, and so on are important.

The analytic performance of the Triple-Helix model solves the dynamic complexity of the basic knowledge economy in terms of their constituents' sub-dynamics. In fact, the Triple-Helix model comes from science and technology studies (Mirowski & Sent, 2007).

With the formation of optimal interactions in the Triple-Helix model, the university, industry, and government are defined to develop a system of innovation with centralized tasks for the advancement of research and technology. With that approach, at times, the domain and roles of the university, industry and government, overlap in the innovation process.

In that case, in addition to its previous activities, the university creates a platform to commercialize ideas. Simultaneously, the industry, too, begins to produce knowledge and absorbs existing knowledge to improve production efficiency (Nasiri Aqdam Tazarjani, Rezaee & beykMohammadlo, 2011).

In this context, the government, along with traditional tasks such as producing goods and designing public policies, pursue high-risk investments or venture capital (VC) investments in the fields of knowledge production, innovation, and production of goods and services.

In some cases, the university also acts as a knowledge-based institute and provides knowledge-based entrepreneurship. Occasionally, the activities of the institute become knowledge-based, and the university and industry, in their joint engagement, create the venture capital market, technology market as well as human capital market. They also pave the ground for the development of knowledge products based on the requirements of the domestic and foreign markets (Amirinia, 2003).

Assessment of the sub-index of innovation position and measurement of the interactions between components (of one variable) of the innovation system are the main concerns of this research in a country that has initiated plans in knowledge-based economy. After computation of the sub-index innovation in the World Bank's Knowledge Economy Index, the study deals with the degree of university, industry, and government cooperation in the variable that make up the innovation indicator.

In other words, in this paper, once the status and progress of the sub-index of innovation in Iran's knowledge economy is reviewed, the analysis of the interaction between the three components of the Triple-Helix model, industry, university and government is addressed in the country's scientific products. The second part of the article overviews the national and international studies of Triple-Helix model components annex. The third part of the article evaluates the interaction between university, industry, and government in the Triple-Helix model after the research methodology for calculating the sub-index of innovation is presented. In the fourth section, the sub-index of innovation for the Iranian economy is calculated, and then the results of the Triple-Helix model for the Iranian economy are presented. The final section discusses the results.

Research questions

In this research two questions are answered:

- How's the process of changing the index innovation system been in the knowledge-based economy index in Iran during 1996-2016?
- How is the interaction between the university, industry and government in the components of the sub-index of innovation in the knowledge economy?

Overview of previous studies

The Knowledge Assessment Methodology was designed by World Bank to provide a basic assessment of countries' readiness for the knowledge economy and identifies sectors or specific areas where policymakers may need to focus more attention for future investments. According to the World Bank (2007, 2012), there are four fundamental pillars of a knowledge economy. For the purposes of calculating KEI, each pillar is represented by three key variables. The data set consists of 12 variables that represent the four pillars of the knowledge economy and are used to calculate countries' Knowledge Economy (KEI) indexes. The reports of the ranking of countries' KEI indexes publish during a determined period by the World Bank. There are plenty of studies that investigate the pillars of Knowledge economy in different countries. To sum up this part of the literature review we only review the studies which carried out in Iran.

Gorji and Alipourian (2011) studied the Knowledge Assessment Methodology which was designed to help countries identify problems and opportunities which respect to making the transition to the knowledge economy and find that Iran's global position in terms of the knowledge economy needs to develop coherent policies that place knowledge at the core of its development strategies. In another study, Mehrara and Rezaei (2015) studied Knowledge Economy Index (KEI) rankings 2012 for Iran in Comparison with other Countries of Region: the Vision 1404 Document extracted from the World Bank's Knowledge Assessment Methodology (KAM). They found that Iran's knowledge competitiveness has improved over the past 12 years, with the ranking rising from 95nd in 2000 to 94th in the current 2012 rankings. Based onresearch about investigating the KI, Azizi and Moradi (2018) used the Knowledge Assessment Methodology to calculate the KEI and its four pillars for Iran. The results of the sub-indices related to the four pillars of Knowledge-based Economy in Iran state that although Iran acquires a good position in the innovation system and mediocre in Education and human resources and the communications and information infrastructure, sub-index for Economic incentives and institutional regimes have been in an unfavorable situation.

In the second part of the literature review, we survey previous studies that used Triple-Helix model to investigate the interaction of university, industry and government. The notion of the Triple-Helix model was proposed by Etzkowitz and Leydsdroff (1997) in the mid-1990s to study the university, industry and government (UIG) collaboration at the local and regional level. Three different kinds of triple helix structures were studied, with particular reference to organizations.

The most researched triple helix structure is triple helix III, where all three rings overlap each other. Each ring takes part in the role of the others. Etzkowitz and Leydesdorff (1997) employed the model to study the knowledge-based economies. Leydesdorff, Perevodchikov & Uvarov (2014) measured the synergies between the national, provincial and local innovation systems to reduce uncertainty in the exchange of mutual information in the relationship between the Triple-Helix entities in Russia.

By using a Triple-Helix model amongst different interactions in various research fields, Ashraf Uddin and Singh (2016) measured the relationship between university, industry and government in their research. Another research which is done by Farinha, Ferreira & Gouveia (2016), based on the interconnections of the Triple-Helix components in Portugal, examined the ways of developing knowledge and technology transfer in the interaction between the university and industrial centers with a focus on communication between the Triple-Helix components in setting up an innovation network. Also, Triple-Helix model applied by Gouvea, Kassicieh & Montoya (2014) to exploration of ways to reach Sustainable Development Goals with regard to the development of natural resources. They made recommendations for the development of technology-based products in the model communication components.

Meanwhile, in Iran Triple-Helix model used in different studies to examine the connection between the university, industry and government.

In the Iranian context, there are different studies in this field and by applying this model. The interactions between the university, industry and government in science and technology of the country examined by Jowkar and Morovvati (2016). Based on the Triple-Helix model, they concluded that the relationship between the university, industry and government is not in a desirable condition and their interaction is getting close to zero. Using the Triple-Helix model, Momeni, Safardoost, Mohammad Rozesara. (2015) have analyzed the dimensions of the interactions between the university, industry and government in an innovation system in the country's defense industry and concluded that the gap between the components of the Triple-Helix model is in an unfavorable situation and requires serious attention. In other recent study, the dynamic interactions between the three pillars of the university, industry and government by using data from the country's scientific articles in nanotechnology, mutual information approach and the Triple-Helix model analyzed by Jafari, Akhavaan, & Zarghami (2015) to assess the uncertainty rate of conduction in the national and international interactions. Hatami and Naghshineh (2015) studied the bilateral and trilateral inter-organizational cooperation in scientific articles indexed on Scopus abstract and citation database, based on the spiral helix model. They found out that inter-department cooperation patterns in Iran are weak, although the country enjoys desirable science production. By using same model and coverage to this research, Jowkar and Osareh (2014) examined the country's science production flow and confirmed that the significant increase in Iran's science production, while the study showed the very low level of interaction between the university, industry and government. Furthermore, Triple-Helix mode used by Amirinia and Bita'ab (2009) to examine various types of innovation patterns and theories such as linear innovation model, innovation system and the Triple-Helix model in the evolution of the interaction of the university, industry and government in the world. Also, Sobhani, Ebrahimi, & Jowkar (2017) did a research by using the Triple-Helix model as an index for evaluating the interactions in order to determine the share of university ،industry and government in scientific productions in the field of agriculture reported by Web of Science during 2011-15. This research showed that although the cooperation level between the triple institutions in Iran was weak, but had a growing trend during recent years especially in the field of agriculture.

As it can be seen, in most of the studies, the relationship between university, industry, and government has been investigated in the specialized fields of science. The results indicate that the interactions of these three institutions in Iran are not desirable. But in this study, we perform a detailed UIG network characterization of Iranian research output during 5 years (2012–2016), while we already examined the position of Iran in Innovation pillar of Knowledge-Based economy(for 20 years) by applying KAM methodology of World Bank. As the number of scientific articles is one of the variables of the innovation system pillar which has the available statistic for three component of Triple-Helix model in WOS, we tried to examine the interaction of university, industry and government in innovation system pillar to found this systematic connection. It should be mentioned that as the interaction of university, industry and government were studied in other research like Jowkar and Osareh (2014) for scientific articles before 2012, we examined the latest trend of this interaction for 2012 to 2016 to investigate the recent trend of mentioned collaboration.

Material and Method

The method for computing sub-index of the innovation system in the knowledge Economic Index

To assess knowledge in Knowledge Assessment Methodology (KAM), the Knowledge Economics Index (KEI) is designed based on a specific formula that measures the four pillars. In this research, the sub-index is the pillar of the innovation system, which the calculation of its process and relationship defined in the Triple-Helix model has been considered in its variables.

To calculate sub-index of the innovation system, the variables "the number of patents, residents of the country", "the number of patents abroad (non-residents)" and "number of articles in scientific journals" are used. A defined formula is used to calculate the score of this pillar’s components and its sub-index of the core knowledge-based economy.

In the scoring method of the knowledge assessment methodology all variables are ranked between zero and ten, and the higher the number, the higher the degree of the knowledge-based economy. The following formula is used to normalize score for each country in relation to the total sample countries.

Formula 1 $$\text{Normalized}(u) = 10\ (NW/NC)$$

U is the number obtained for each variable; NC is the total number of countries in the study (the sample countries) and NW stands for the number of countries that are either below the desired target country or are at the same level (or have a weaker performance in that index). In all published documents, the methodology of the World Bank knowledge-based economy has been used from a simple mean (arithmetic) as a method of measuring the index and its sub-indexes (Gorji and Alipourian, 2011).

Research method for computing the Triple-Helix model

The analysis of the interactions between the university, industry and government is done by using the Triple-Helix model.

Iran’s science production in terms of number of articles in scientific journals is included in the index of innovations, because the only source of the Knowledge-Based Economics Index, which has a breakdown of information in terms of collaboration between the three sectors of the university, industry and government, was the country's research work, and give the fact that the relationship between university and industry depends on the amount of research and development in the country.

Therefore, Iran’s science production, available on WoS website, from 2012 to 2016 has been selected as the population study in this article. It should be highlighted that this period is the latest unexamined period to investigate UIG collaboration as it was reviewed in the previous section. Furthermore, WOS is the only approved source that creates an opportunity for researchers to differentiate the contribution of university, industry and government and to compare the results with other countries, so the reports of this website are used commonly to applying Triple-Helix model in similar studies. Accordingly, all articles were extracted with at least one address from Iran in that period, including 167,628 articles from various indexed sections of WoS website. The publication co-authors between the university, industry, and government are used as the Triple-Helix model index (Leydesdorff and Meyer, 2003).

Of course, measuring the relationships between different units of this model is technically-operationally difficult and time-consuming. Leydesdorff presented the mutual information approach in 2003 as the most commonly used method for such research (Sun and Negishi 2010).

He extensively examined the approach, described and interpreted the measurement methods in detail (Leydesdorff 2003). This approach is an introduction to the application of the Triple-Helix model in scientific research which is used by researchers in different fields. A summary of this method will be discussed later.

To use the data in the Triple-Helix model, all authors' addresses were identified, and to analyze the data, all the articles were first grouped into three distinct academics, industrial and governmental categories.

Then, two-way communications, called the collaboration of two institutions and triple interactions, were considered to illustrate the cooperation between the three entities with identifying codes. During the precise and timely process (in some papers and international studies, the time required for this encoding is 15 days), codes were assigned to each article.

Thus, the ISI.exe software was used to extract necessary data from the WoS site. An SPSS software version 22 and an excel version 2016 were also employed to analyze the collected data.

The computation method in the Triple-Helix model

Previous studies have named the Triple-Helix model a research methodology. The dynamic measurement in the Triple-Helix model is based on Entropy concept (First introduced in Shannone's mathematical theory of communication)

Entropy is used to measure uncertainty or disorder in a set of elements and components. If there are few arrangements, then the entropy must be low and vice versa. (Kim, Huang Jin, Bodoff, Moon & Choe., 2012). Accordingly, the uncertainty of the university's (Hu) presence is calculated as follows:

Formula 2 $$H = -\sum_{i=}^{n} \mathrm{P}_i \log_2 P_i$$

H is known as Entropy or uncertainty and its value describes the data mean.

Accordingly, Pi in the formula is the probability of selecting the message i, and when H has the maximum value, there is a probability that all messages will be selected.

In the Triple-Helix Entropy, for example, in the university (Hu) the following formula is used.

Formula 3 $$H_u = -\sum_{u} P_u \log_2 P_u,$$

Here, since Pu is used in academic articles, it refers to the organizational relationship of the author of an article. Similarly, H can be calculated for other units in the model. To calculate the relationship between units at a two-dimensional level, such as when the relationship between the university and the government is measured, it is likely that there is at least one university-based writer and one government-affiliated author. In that case, the formula is:

Formula 4 $$H_{ui} = \sum_{u=0}^{1}\sum_{i=0}^{1} P_{ui} \log_2 \frac{1}{P_{ui}} = P_{10} \log_2 \frac{1}{P_{10}} + P_{01} \log_2 \frac{1}{P_{01}} + P_{11} \log_2 \frac{1}{P_{11}}$$

Similarly, more dimensions can be added to these calculations to compute more complex relationships such as Huig. The Triple-Helix interaction or the mutual information between dimensions of the Triple-Helix in the probability functions is ultimately measured on the basis of the uncertainty conductor (T).

The value of T denotes the difference in uncertainty (arbitrarily) in the combination of probability distribution among different helix dimensions. The value of T, which can be positive, negative or zero, is calculated in a two-dimensional relationship, as described above. A three-dimensional relationship is calculated as follows and by adding a new factor, the distribution gets more complicated.

Formula 5 $T_{ug} = H_u + H_g - H_{ug}$

Formula 6 $T_{uig} = H_u + H_i + H_g - H_{ui} - H_{ug} - H_{ig} + H_{uig}$

In the above formulas, two-way relationships (interactions) reduce the uncertainty of variables, while triple interactions increase it. Accordingly, the value of T in the triple relationships can be and is desirable to be negative.

In the three-way relationships, the negative value of T shows a decrease in the degree of uncertainty and an increase in the dynamics of cooperation (information mutuality), in other words, the stability of the system.

On the contrary, the positive and zero values of T indicate instability of the system (for example, the system of scientific production (park, Hong, & Leydosdorff, 2005; Leydesdorf, 2003; Jowkar and Osareh, 2014). On the other hand, the zero value of T indicates a lack of collaboration between the pillars and proves their independence.

Results

Calculating innovation sub-index in the knowledge-based economy

The first part of research results tries to answer the first question of research. So, we calculate the sub-index of the knowledge-based economy of Iran for the last 20 years or so. As previously mentioned, to obtain the data on sub-index of the innovation system, we use the World Bank Data which for the three variables include: ‘Scientific and technical journal articles’, ‘patent applications, nonresidents’, and ‘patent applications, residents’. Now, we calculate the scores of these three variables, using the formula for knowledge assessment methodology for Iran.

To calculate the sub-index of the innovation system, the average values of the variables of this pillar should be used. Therefore, the average of the three variables above is calculated and the value is considered the sub-index of the pillar of the innovation system from the index of the knowledge-based economy. The results for the calculation of this indicator are as follows:

Table 1
The result of calculation sub-index for 1996-2014 for Iranian economy

year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Sub-index	4.71	4.00	4.23	4.49	4.46	5.02	5.10	5.42	5.87	6.10	6.55
year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Sub-index	6.60	6.81	6.74	6.69	6.82	6.91	6.87	7.23	6.40	7.23	

The process of changing the sub-index of the innovation system and its position in the deciles are shown in the Figure below:

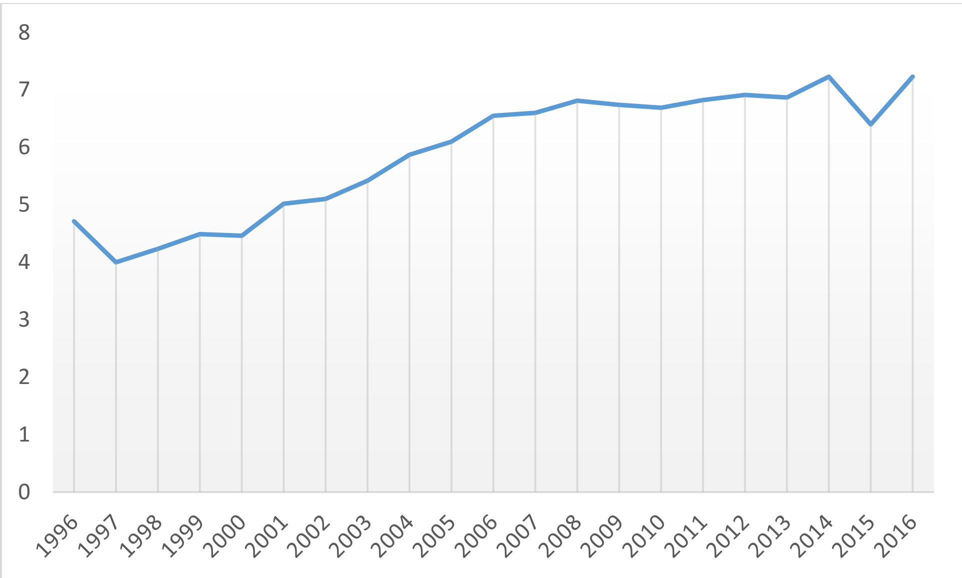

Figure 2. The results of Iran’s innovation system sub-index from 1996 to 2014

As shown in the chart above, the sub-index of the innovation system during the given years had a steady and considerable upward trend. This sub-index started from the fifth decile from 1996 to 2000 with a slow and steady growth rate and from 2001 to 2004, the score of the sub-index was in the sixth decile. Subsequently, the calculated value for the sub-index in the years 2005 to 2013 was in the seventh decile, which reflects the considerable growth and good level of Iran in the most important sub-index of the knowledge economy.

In 2015, the index has declined to some extent, apparently due to the reduction in the variable of 'patent applications, nonresidents'. Although, it seems that the World Bank database is yet to complete the data on this variable in the year 2015 and 2016.

Results of the Triple-Helix model calculation; assessing the cooperation between university, industry and government in Iran

In order to analyze the interaction between the three entities - university, industry and government - as the components of the innovation system sub-index in the knowledge-based economy, and to reply to the second question of this research, we measure the relationship between these three entities is based on the scientometrics methods. Based on the results obtained from the Web of Science, WoS, database, science production with at least one Iranian address in the years 2012-2016 is shown in the table below. The largest number of articles published and retrieved from WoS citation database happened in 2016.

After having reviewed all retrieved documents and checked the addresses of articles in each year, we excluded the invalid addresses as invalid data and encoded the remaining addresses. The authors of articles were, then, divided into three groups, university authors (u), authors affiliated with the government (g), and industry-related authors (i).

Table 2
Articles published on WoS with at least one Iranian address from 2012 to 2016

Title	2012	2013	2014	2015	2016
Articles with proper address	30511	31069	32828	34557	36606
Articles with invalid address	296	251	570	540	400
Total	30807	31320	33398	35097	37006

The following graph shows the contribution of the Iranian authors, affiliated with each of the three institutions, to scientific and technical journals from 2012 to 2016. It is clear that most of the papers published during this period have a minimum university-affiliated author.

The preliminary results show that the growth in the higher education system has led to an increase in Iran's research products, but with no effect on the level of interactions between the industry and government with university, with somehow least interaction with industry. Therefore, perhaps there was no need to create knowledge-based products based on the needs of industry and markets in universities.

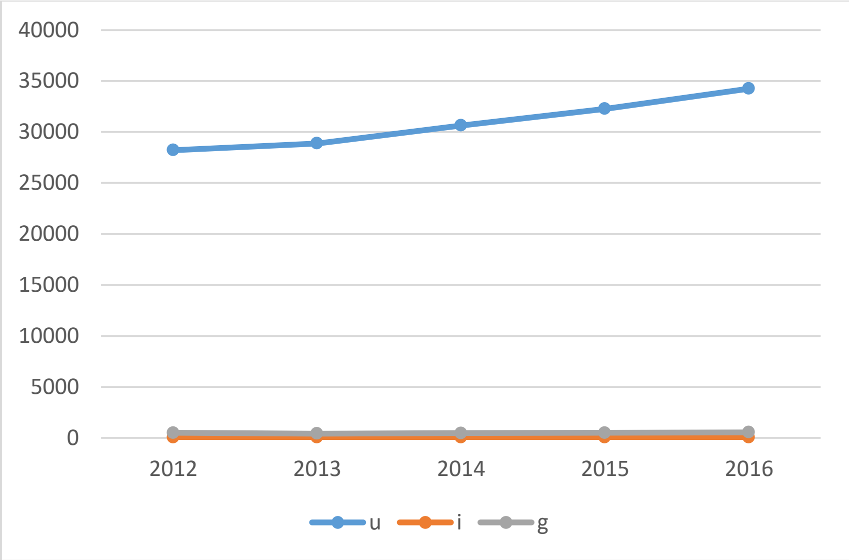

Figure 3. Contribution of the authors to each of the three institutions

As figure 3 shows, the country's science production rate has risen in the given period, with the total number of articles published from 30,807 in 2012 to 37,046 in 2016. The articles written by the university-affiliated authors (group u) were significantly more than other types of institutions, and the second best place was articles by university and government writers (group ug) (figure 4). In addition, the number of articles written in the given period with other types of joint-cooperation, such as cooperation between government and industry, or university and industry, or all three institutions shows a low level of collaboration, as the curves changed to a horizontal line on the graph.

Of course, we cannot ignore the significant role of universities in the science production of the world, which has always had an upward trend. In this study, interactions with only one institution (university) are more than 90 percent. This is the difference between developing and developed countries in research collaborations and products based on industrial needs.

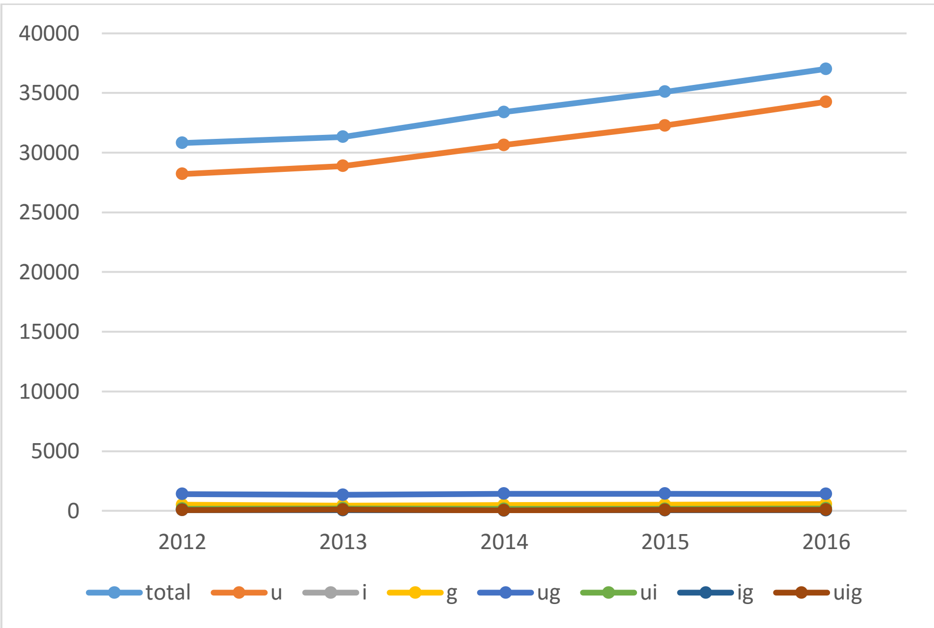

Figure 4. Articles published in the five-year period by the three institutions

To find more complex communication, first, the uncertainty (H) for each type of participation of the three institutions was evaluated in the publication of their articles. For example, the degree of university uncertainty (Hu), or the uncertainty for the university and government (Hug) is calculated. That means at least one author from a government institution and one from the university, write an article together, and then, based on that, the conduction values (T) were also calculated with the same process for each type.

The results of these calculations are presented in Table 3. Moreover, TH, TH4 software was used to obtain the conduction values (T).

Table 3 shows that most of the interactions are with the helix of university and government. On the other hand, the values of T in the industry-related interactions, such as Tui and Tig are more or less in numbers equal to or less than zero. Given the formula for calculating T in the relations of the two institutions, the optimal value of T is negative and large. Thus, the closer the value of T is to zero in the two-dimensional relationship, the more independent of the operation of the helix components and the greater the uncertainty. More uncertainty in this model also indicates fewer interactions. In fact, the results obtained in Iran over that period show the negligible role of industry in the interaction with the other two institutions: university and government.

Table 3
T values in the triple helix interactions of university, industry and government over the period of 2012-2016

Year	Tui	TUg	Tig	Tuig
2012	11.93	48.41	5.58	2.55
2013	9.56	42.4	8.55	2.37
2014	6.12	32.43	1.38	0.86
2015	5.31	35.11	5.45	0.57
2016	5.63	42.05	42.05	0.17

To provide a better understanding, the process of interactions based on the values of T is presented in figure 5. During the five-year period of 2012-2016, the dual interaction between the various components of the helix of university, industry, and the government in the field of scientific production has undergone a steady trend with no significant increase or decrease.

Figure 5 also confirms the stability in the process of inter-institutional interaction between industry, university and government. The degree of interactions between university and government with industry has been almost steady and runs low with an almost horizontal line on the graph, which indicates a bit of the interactions between these institutions.

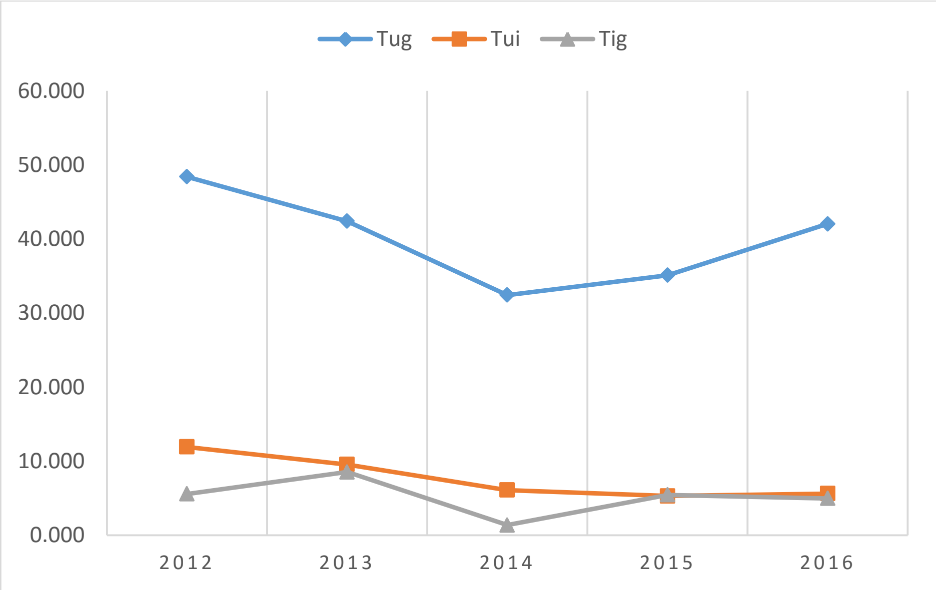

Figure 5. The process of variations in the amount of conduction in the two-and triple-helix model

In order to calculate the triple interactions, since the H values of the dual relations Hug, Hui, and Hig have been omitted from the results, negative values are more desirable.

Formula 7 Tuig= Hu +Hi+ Hg – Hui -Hug –Hig +Huig

In other words, larger negative numbers indicate more interactions between the triangular elements (Tuig) in this study. According to the Tuig values, which were from 2.55 to 0.17, based on the information on the previous table, it can be concluded that the distance in the interactions of the three institutions in the Triple-Helix model in Iran is significant.

Thus, to improve the relationship between university, industry and government in Iran, proper planning, policy making, and establishment of various structures should be on the agenda. In addition, more practical solutions should be identified with regard to the problems encountered in establishing such communications.

Discussion and Conclusion

The sub-index of the innovation system in the knowledge-based economy index shows that although Iran's sub-index of the innovation system is in the 8th decile with a stable upward trend, the country is still not in a desirable position with regard to 1404 vision policy. The multiplicity of documents and regulations in areas related to technology and innovation reflects the attention of policymakers to the issue of innovation. Although proper legal infrastructure is considered very important and necessary in innovation, it is not sufficient. In other words, Iran’s 1404 vision policy requires more and continuous efforts of enforcing and monitoring the implementation of policies.

Based on the Knowledge-Based Economy statistics in World Bank Database the KBI for Iran is increasing, so in this research, we investigated the sub-index of the innovation system pillar of KBI for Iran. The results confirmed that the innovation system pillar has had an increasing trend during the last 20 years. However, in the second section of the empirical results, we examined the contribution of three players of one of the variables for the innovation system pillar, which is as the number of scientific articles. The findings for Iran showed that interaction of university, government and industry is very weak. This results emphasized that the trend of KBI index cannot approve the increasing trend of the knowledge-based economy in the economy, as it can be seen the government and universities (which are state universities) had the main role to increase the one variable of the innovation pillar, while the contribution of industry was really weak. The results of the survey of cooperation between university, industry and government in the Triple-Helix model showed that the participation rate of universities in all target years in the research area of the country was over 90 percent, and university has taken the majority of that load.

While the role of government as the only institution that has been able to cooperate with the university has been partly found in this study, government-affiliated researchers have had the highest proportion of cooperation with academics in writing scientific and technical articles in Iran. Perhaps the most important reason for relatively good interaction between university and the government can be the state's supportive policies of academic research, as well as the employment of faculty members of universities in government-affiliated institutions. However, the low interaction of industry with the other two institutions and the insignificant amount of cooperation between university, industry and government are the most important and most challenging result of this research.

The separation of university and government research from the industry could possibly indicate that industry does seek advice from universities in its research areas, which can encourage the use of foreign research results in Iran's industrial sector. While in the case of proper interaction between industry and university, it is possible to carry out research in accordance with the demand of the industrial sector and to respond appropriately to the research demand of industries in the academic community of the country and government-sector researchers.

Also, comparing the studies carried out in different research area in the country, which is on the relationship between industry, university and government in scientific areas such as science and technology, defense, and nanoscience, confirms the results of this research. Although most of the mentioned studies covered a particular area of subjects of scientific journals, they confirmed our studies in their particular field for determined periods. Also, Jowkar and Osareh (2014) confirmed the results of our research for all scientific articles for the fifth years period before this study. In various fields of science (Momeni et al., (2015), Jafari et al., (2015), Jowkar and Osareh (2014), Sobhani, et al., (2017)), the interaction of the triple helix components is not in a satisfactory state, so as the gap between the components of the model. These results indicate that in other fields of science, in which some of them have different custodians in the development of university, industry, and government communications, special attention has not been paid to the development of such communications in shaping the country's innovation system. In countries such as China (Kim, et al., 2012; Zhao & Guangdong, 2017) and Portugal (Natario, et al. 2012) planning in the field of inventions and research and development has also led to an acceptable collaboration between the model components. As emphasized in most international studies (Leydesdorff, et al., 2014; Park, et al., 2005), Sun and Negishi 2010), the strong link between university, industry and government is a critical factor in the flourishing of innovation and technology in the country.

Undoubtedly, intensive and targeted investments and the implementation of stable policies to strengthen the relationship between the components of the Triple-Helix model can lead to positive results. In addition, efforts to remove barriers in the way will have a significant increase in the communication of these institutions in science production, inventions and research and development of the country.

To improve the triple interactions studied in this paper, the following suggestions have been made:

The role of these three pillars in the new economic system of the country should be redefined i.e., moving towards a knowledge-based economy.

The role of university in trilateral cooperation should shift from the sheer manpower supplier to the provision of research and technology services to the industry. In this regard, the research demand of industry should be considered as research subjects for thesis and dissertations in university. This way, the structure of the university in the country should go towards servility and create a commercial structure alongside the traditional educational and research structure.

In order to commercialize the country’s science production, it is essential for universities to reduce their dependence on government research funding, through commercialization of research projects, technology marketing, and the creation of knowledge-based enterprises and the source of income by providing research service for industry.

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References

Amirinia, H,and Bitaab, A. (2009). The appropriate pattern of cooperation among government, university and industry *.university and industry journal*, 5(6), 25-34. [in Persian]

Amirinia, H. (2003). The Role of University-Industry-Government Relations in the Promotion of Industrial Innovation in Iranian Composite Industry. *David Livingstone Institute of Overseas Development Studies, Engineering Faculty, University of Strathclyde University*.

Ashraf Uddin, R. and Singh, V. (2016). Measuring the university-industry-government collaboration in Indian research output. *Current Science,* 110(10), 1904-1909.

Azizi, F,and Moradi, F. (2018). Calculating the Index and Sub-Indices of Knowledge-Based Economy for Iran. *Journal of Economic Research and Policies, 26*(85), 243-270. [in Persian]

Etzkowitz, H. and Leydesdorff, L.A. (1997). *Universities and the Global Knowledge Economy: A Triple Helix of University-Industry-Government Relations.* London and New York: Pinter.

Farinha, L., Ferreira, J., and Gouveia, B. (2016). Networks of Innovation and Competitiveness: A Triple Helix Case Study. *Journal of the Knowledge Economy, 7*(1), 259-275.

Gibbons, M. (1994). *The New Production of Knowledge: The Dynamics of Science and*

Research in Contemporary Societies. London: Sage Publications.

Gorji. E. and Alipourian. M. (2011). The Knowledge Economy & the Knowledge Assessment Methodology (The case study of Iran & Some other Countries). *Iranian Economic Review*, *15*(29), 43-72.

Gouvea, R., Kassicieh, S., and Montoya, M. J. R. (2014). Using the quadruple helix to design strategies for the green economy. *Technological Forecasting and Social Change*, *80*(2), 221-230.

Harbi, S, Amamou, M and Anderson, AR. (2009). Establishing high-tech industry: The Tunisian ICT experience. *Technovation*, *29*(6-7), 465-480.

Hatami, M and Naqshineh, N. (2015). Quantitive analysis and visualization of cooperation among organizations in I.R.Iran Scientific Documents in Scopus. *Journal of Scientometrics*, 1(1), 69-92. [in Persian]

Jafari, M, Akhavaan, P, Zarghami, H.. (2015). Easuring the interactions among university, industry and government in scientific article of Nanotechnology with Triple-Helix Approach .*Academic Librariansh Information Research*, 49(3), 413-438. [in Persian]

Jowkar, T, and Morovvati, M. (2016). Triple helix of University-Industry-Government in the Scientific Articles of Iran. *Science and Technology Policy*, *8*(3), 71-84. [in Persian]

Jowkar, T, and Osareh, F. (2014). Flow of Scientific Publications in Iran during 2007 to 2011, Based on Triple Helix of University, Industry and Government. *Iranian Journal of Information Processing and managent*, *29*(2), 505-533. [in Persian]

Kim, H., Huang, M., Jin, F., Bodoff, D., Moon, J., and Choe, Y. (2012). Triple helix in the agricultural sector of Northeast Asian countries: a comparative study between Korea and China. *Scientometrics*, *90*(1), 101-120.

Leydesdorff, L. (2003). The knowledge base of an economy: what is it? Can it be measured? Can it be modeled? *Amsterdam School of Communications Research*. Retrieved from http://www.leydesdorff.net.

Leydesdorff, L. (2010). The Knowledge-Based Economy and the Triple Helix Model. *Annual Review of Information Science*, 44, 367-417.

Leydesdorff, L. and Meyer, M. (2003). The Triple Helix of university-industry-government relations. *Scientometrics*, *58*(2), 207-222.

Leydesdorff, L., Perevodchikov, E., and Uvarov, A. (2014). Measuring triple-helix synergy in the Russian innovation systems at regional, provincial, and national levels. *Journal of the Association for Information Science and Technology*, *66*(6), 1229-1238.

Luhmann, N. (1997). *Die Gesellschaft der Gesellschaft.* Frankfurt: Surhkamp.

Mehrara, M and Rezaei, A. (2015). Knowledge Economy Index (KEI) in Iran and Comparison with other Countries of Region: the Vision 1404 Document,. *International Journal of Applied Economic Studies*, *3*(2), 1-7.

Mirowski, P., and Sent, E. M. (2007). The Commercialization of Science, and the Response of STS. In Edward Hackett, Olga Amsterdamska, Michael Lynch & Judy Wajcman (eds.), *The Handbook of Science and Technology Studies*, (pp. 635-89) MIT Press.

Momeni, F, Safardoost, A, Mohammad Rozesara, M. (2015). Analysis of Triple-Helix Model on defense Industry. *Management of developing technology journal*, *3*(3), 81-110. [in Persian]

Nasiri Aghdam, A, Tazarjani, A, Rezaee, A, beykMohammadlo, H.. (2011). Influence of innovation on Economic growth .*Research on educational management*,3(1), 159-182.

[in Persian]

Natário, M, Couto, J, and Almeida, C. F. R. d. (2012). The triple helix model and dynamics of innovation. *Journal of Knowledge-based Innovation in China, 4*(1), 36-54.

Park, H. W., Hong, H. D, and Leydosdorff, L. (2005). A comparison of the knowledge-based innovation systems in the economies of South Korea and the Netherlands using Triple Helix indicators. *Scientometrics, 65*(1), 3-27.

Richta, R., et al. (1968). *Politische Oekonomie des 20* . Prague and Frankfurt: Jahrhunderts.

Sobhani F, Ebrahimi, S and Jowkar A. (2017). Scientific interactions between university, industry and government in the field of agriculture in Iran: based on Triple Helix Model. *Research and Planing in Higer Education, 23*(3), 21-41. [in Persian]

Sun, Y., and Negishi, M. (2010). Measuring the relationships among university, industry and other sectors in Japan's national innovation system: a comparison of new approaches with mutual information indicators. *Scientometrics, 82*(3), 677-685.

The World Bank. (2007). *Knowledge Economy Index (KEI) 2007 Ranking.* the World Bank.

The World Bank. (2012). *Knowledge Economy Index (KEI) 2012 Ranking.* The World Bank.

United Nations. (2008). *The Millennium Development Goals Report, United Nations.* Department of Economic and Social Affairs. United Nations. Retrieved from http://temoa.tec.mx/node/18070

Zhao, J. and Guangdong W. (2017). Evolution of the Chinese Industry-University-Research Collaborative Innovation System. Retrieved from https://doi.org/10.1155/2017/4215805.