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The Triple Helix of University, Government and Industry in the Field of Veterinary Science in Iran: Comparison of ISC and WOS publications

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Abstract

To achieve a sustainable development, each country requires a defined interaction between universities, government and industry. The economic, social and cultural development plans in Iran has emphasized on "accountability of scientific, research and educational centers for social, cultural and industrial demands". This is obvious also in the field of veterinary science. Also, the collaborations of colleges, organizations and industries in this field can contribute to enhance productivity, providing food security and achieving the goals of the resistance economy. Accordingly, using Triple Helix method, the present research investigates the status of university, government and industry interactions in scientific production of Iranians in the field of veterinary science during 2010-2018. The research population was scientific papers of veterinary science research area, indexed in Islamic World Science Citation Center (ISC) or Web of Science database (WOS) by at least one Iranian author during 2010 - 2018. Also, the interactions between UGI were calculated, using ISI.EXE for coding the affiliations and Shannon's information theory formulas. The results of the study showed that a very small percentage of articles published in veterinary science are written by non-university researchers or even by co-authorship of university and other sectors of the triple helix. Among bilateral relations, the UG interactions had the highest value. The best years for UGI interactions, were the year 2016 and 2013 for ISC articles and 2010 and 2011 for WOS articles. The results also, showed considering the scientific articles published in internal journals (ISC) have a high positive impact on the T-value of UGI interactions, as ISC trilateral interactions are remarkably better than WOS articles.

Keywords: Veterinary Science, Triple helix, industry, university, government, co-authorship

Introduction

In today's world, there is a direct relationship between technology development and social, economic and political development. Technology is a critical key factor in any country for creating wealth, knowledge, and ability and also a powerful tool in national development.

According to ESCAP technology can be defined as the application of scientific knowledge to develop techniques to produce a product and/or deliver a service or as the application of scientific knowledge for practical ends. Human, machine, organization, and information are four pillars of technology that their interacting with each other leads to economic growth and development (ESCAP, 2016). Among the four pillars of technology, human has a pivotal role. It is not possible to use the best and most modern machinery without skilled labor force. This is where the importance of the university becomes clearer. Because the university is the factory of training skilled human resources, and if these Human Capital can use its knowledge and expertise in the field of production and industry, it will lead to increasing development. Therefore, the relationship between industry and university in any country can have a decisive impact on economic growth there.

Studies show that there is a considerable gap between the scientific potentials of the country and the needs of industry sector which should be removed by making university- industry linkages. In developed countries, the continuous and dynamic link between industry and university has created a positive cycle through which they lead each other toward more growth and development. Such cycles rarely be seen in developing countries like Iran (Nili Pour-Tabataba'i, Liraii and Mirzaei Pour Golzadeh, 2007).

To achieve a sustainable development, each country requires a defined interaction between scientific, political and technical sectors which usually forms in the format of universities, government and industry. Considering that relations of these sectors form a single system, a deficiency in any of them, influence the entire system. Each of these sectors has its own components and elements that without having proper interaction within them will not be able to play its role in relation with others. One of the fundamental and structural problems in Iran is the island shape of these three sectors and the only way out of it, is to create a strong bridge between these separate islands. The fourth economic, social and cultural development plan in Iran has emphasized on "accountability of scientific, research and educational centers for social, cultural and industrial demands" (Islamic Parliament of Iran, 2005). Meanwhile, attention to industry as one of the major elements in economic programs and university as a place for producing and sharing knowledge are important to achieve the development goals of the country. It seems that the amount and quality of the relations between these two sectors will lead to success or failure of development plans.

As the Cricelli,, Greco, Greco, Grimaldi, Grimaldi, & Llanes Dueñas (2018) indicate accurate definition of research projects and approaches and pushing them toward industry needs, in addition to increase the effectiveness of university research approaches, led to the synergy and development of intellectual capital of universities and also more efficient and effective interactions with industry, in order to solve the industry problems and benefit from the knowledge and experience of industry experts.

University and Industry collaboration is an example of agreements relating to educational and scientific activities and is usually help both sectors as industries want to achieve the scientific capability of the universities and universities seek the experiences and facilities of industries (Anderson, 2000).

In general, collaboration between university and industry is a type of the formal and informal agreements which are aimed to more success. In this relation, the university and industry attempt to do

some of their scientific activities in a coherent way (Shafiee & Arasteh, 2004). Usually, every sector wants to benefit from such a cooperation. This is obvious also in the field of veterinary science. People's right to food is recognized as one of the fundamental human rights through all countries and international organizations, and the phenomenon of malnutrition is one of the most important challenges facing many of the developing countries. On the other hand, in our country, the main objective of the Development Plan is based on the economy without oil, on this basis, attention to livestock, poultry farming and aquaculture industry can be important in economic development of the country. Such a trend can be seen in developed and developing countries like Unites States, European Union countries, Brazil and China (Arias, D., Vieira, P. A., Contini, E., Farinelli, B., & Morris, M., 2017) , as an example the United States alone earned more than $16.2 billion from various meat and poultry exports in 2016 and $8 billion through the beef export in 2018 (USMEF, 2018). It is evident that the livestock and poultry industry and related fields play a great role in the economy of the United States: it contributes the GDP and is a means of occupation to the common people (Jegede, 2019). In addition, investment in agriculture and food industry is known as "crucial for economic growth, poverty reduction and improved food and nutrition security (Lowder, Carisma & Skoet, 2012)." The statistics show that middle-income countries spent more on agriculture and food than high-income countries in recent years (ibid). Totally in 2010, about $33.5 billion was investigated on public agriculture and food R&D worldwide (Pardey, Alston & Chan-Kang ,2012). All of these indicate the world attention to these sectors as vital fields to ensure the survival of mankind in the near future.

So, in addition to a direct role in increasing productivity of livestock production and preventing potential economic damage to the vast livestock, poultry and aquaculture industry, veterinary science, as a supportive field, also has contributed a substantial portion of employment in the field of agriculture (Moghtadaee, 2008).

Also, the collaborations of colleges, organizations and industries in the field of veterinary science can contribute to enhance productivity, providing food security and achieving the goals of the resistance economy. The main objective of the resistance economy is to promote *economic* self-reliance through being science-oriented, endogenous and using national funds and the country's scientific capacities .It requires the establishment of new structure for interactions of domestic dimensions of university, organization and industry. It should be noted that veterinary science sector can have 25 % profitability for livestock and poultry industry annually (IRNA, 2014).

The first step in creating positive developments in the above-mentioned triple relations is recognition and analysis of current situation. A popular method for investigating the relations of university, government and industry in different fields is to study their collaborations in production of scientific articles, which is known as triple helix researches. Using the same method, the present paper aims to study the prevailing situation in the scientific production of veterinary sciences in the last few years. The results would be used to fix the weaknesses and take advantage of the strengths.

An issue that should be noticed in Iran is that, a large number of journals are published in the country which have been approved by the Ministry of Science, Research and Technology, but not indexed at the WOS. So, when the authors use only WOS data for Triple Helix of UGI in Iran, a large amount of data is lost. This paper aims to consider internal journals and compare them with the WOS ones in the field of veterinary science. To ensure the quality of journals, published in Iran, the authors select the journals which are indexed by Islamic Science Citation Center (ISC).

Accordingly, the present research investigates the status of university, government and industry interactions in scientific production of Iranians in the field of veterinary science during 2010-2018 in internal journals in compare with WOS and would answer the following questions:

1. How is the Iranian scientific production in the field of veterinary science in ISC during 2010-2018?
2. How was the mutual university, government and industry relations in production of ISC scientific articles in the field of veterinary sciences?
3. Do the mutual UIG relations in production of ISC and WOS scientific articles in the field of veterinary science follow the same pattern during 2010-2018?

Literature review

The triple helix model of innovation refers to a set of interactions between academia, industry and governments, to foster economic and social development. This framework was first theorized in1995 by Henry Etzkowitz and Loet Leydesdorff in an article named “The Triple Helix, University-Industry-Government Relations: A laboratory for Knowledge-Based Economic Development”. Many studies have been done on Triple Helix model from the beginning of 2000. Most of them based on the method leydesdorff (2003) had proposed for measuring the mutual information in relations of UIG. The literature is reviewed in 2 parts. First, we review studies which used Triple Helix of UIG for scientific publications of a country or more:

The relationships among university–industry–government sectors on the basis of Japanese publication data in the ISI-databases measured by Sun & Negishi (2010). The results of this study showed that collaborations of UIG were getting weaker and that members of these sectors tended to collaborate much more with foreign researchers. It was also shown that universities used to play the central role in the national publication system and acted as a bridge between national sectors and foreign researchers. After that Shin, Lee & Kim (2011) analyzed the research productivity of Saudi academics using the Triple-Helix model. According to the results, research collaboration in Saudi Arabia, had negative uncertainty (negative T-value) while scientific productivity had been dramatically increasing since the late 2000s. Also, the authors found that technological development was not based on scientific researches in Saudi Arabia; rather, the technological development relied on prior technology. In another paper, Ye, Yu & Leydosdorff (2013) used data from the WOS to analyze the mutual information among university, industrial, and governmental addresses at the country level for some countries. The results show that the TH interactions among the UIG subsystems become less intensive over time, but unequally for different countries. The effect of globalization is more pronounced in

developed countries than in developing ones. In the dynamic analysis, they focused on a more detailed comparison between China and the USA. The Chinese Academy of the (Social) Sciences changes increasingly from a public research institute to an academic one, and this has a measurable effect on China's position in the globalization. The University capability as a micro-foundation for the Triple Helix model for China studied by Liu & Huang (2018). Based on qualitative data collected from two leading Chinese cities in innovation and regional development, the study empirically elucidated two different approaches to deal with university capability. The conceptualization of university capability may be a useful analytical tool to better understand the role of 'university' and its relationship with the other actors in the Triple Helix model.

In a newer study, Altaf, Hassan & Batool (2019) examined the scope of interactions among Office of Research, Innovation and Commercialization (ORIC) established universities, linked firms and government in Pakistan. Triple Helix model was used as framework of understanding these interactions. This study contributed to understanding of the current scope of ORIC in the evolution of the Triple Helix culture of innovation.

Meanwhile in Iran, the discussion of the university's interaction with governmental and industrial institutions has always been an important concern for the development of the country's innovation system. In this regard, even for several years, conferences have been held periodically. Various researchers have conducted studies, including:

Fiuzat, Taslimi Tehrani (2007) studied the socio-logical relation between University and Industry in Iran. In their opinion, according to structural-functional approach, society as a social system consists of different subsystems and institutions. Existence of dynamic balance and state of functional balance between these subsystems and institutions is one of the main causes of progress and development of each society. They also suggested some solutions for enhancing of university-industry collaborations, such as: making the academic researches applicable; support of industry from such researches, facilitates the employment of university graduates in related industry, formation of *joint university-industry research centers*, applying university professors as visiting researchers in related industries and determining the role of government in promoting this relationship. Also, the relationship between Iranian medical sciences universities and the industry examined by Ebrahimpour, Esmaeilzadeh, Dehnavieh, & Jafari Sirizi (2008). They mentioned that many universities have a clear understanding of the importance of cooperating with industries and their own duties about societies. The results showed that almost 64.5% of faculties have had mediated structure such as medical faculties and industries relation offices in the universities.There are no rewards and no specific work description for the staffs, and also no specific regulations policy in 80% of universities. The authors also believed that lack of understanding of universities abilities and the industries problems are main barriers that medical faculties and industries are facing with.

Flow of scientific production by focusing on the triple-helix model during 2007 to 2011 was the first investigation in Iran, based on Leydosdorff's Triple Helix of UIG done by Jowkar & Osareh (2014). Findings indicated among the three sectors, university researchers had the most participation and researchers from the industry sector had the lowest participation. Also, the results showed that UG collaboration was much higher than the UI or IG collaborations indicating that the gap between Industry and the two other sectors in Iran was

significantly big. GI interactions had a better condition. This can be explained due to the supports that research organizations receive from the government. Unfortunately, the T value is not strong for the trilateral collaboration of University, Industry and Government.

Another work but on Scopus data was done as a comparative scientometrics analysis of university- industry relation in Iran and Turkey by Noroozi Chakoli and Taheri (2015). The results of the study showed Iran had the highest scientific productions in technology based on the priorities of A to C and the lowest scientific productions was related to the humanities and art. Based on priorities, Turkey had the lowest production in the field of tourism and transport and the most production in the health and medicine. So, after more than two decades of the establishment of the Office of the relationship between industry and university in the country, the proper interaction between the two organizations in achieving the desired level in science and technology has not been established. In a qualitative study among Tehran university students, Shiri (2016) examined the relation between university and industry and its Challenges. As the results suggested, Tehran University PhD students believed there was no consistent and meaningful relation between universities and industries in Iran. As the PhD students stated, the absence of reciprocal needs including industry's no sense of need for universities as well as universities' lack of motivation for collaboration with industry were the factors preventing these two institutions from establishing a suitable relation. Also, Erfanmanesh, Moghiseh and Forouzandeh Shahraki (2018) have compared the share of scholarly output published through the collaboration between academic and corporates in Iran, Middle East, and the World during 2006 to 2015. Results of the study revealed that the share of publications from university-corporate publications in Iran was lower than that of the Middle East and the world. Although Iran has had a considerable growth in scientific productivity during the recent years. Moreover, researchers in Iran in the areas of engineering, computer sciences, and medicine have published the highest number of publications through university-industry collaboration. Lastly, Azizi & Moradi (2019) studied the status of Iran in the sub-index of innovation as the main indicator of the knowledge economy and assessed the interactions of the UIG in the research and innovation system of the country. This research takes advantage of the World Bank Knowledge Assessment Methodology framework and Triple-Helix model. The results of Triple Helix model were used to evaluate the university, industry, and government interactions, illustrating a small contribution of the industrial sector in the country's research areas. Also, it indicated 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.

In the second part of a review of literature, the focus is on some researches which examined triple helix of UIG in a particular field. The first is an article by Kim, Huang, Jin, Choe & Bodoff (2012) who investigated the agricultural innovation systems of South Korea and China and compared them from the perspective of triple helix innovation. Their focus was on agricultural innovation of the two countries and considers agricultural R&D investments and activities as well as the roles of university, industry, and government (UIG) from 1980 to 2010. The findings indicated that agricultural R&D in both Korea and China has been primarily conducted by the government and universities, and a large portion of R&D expenditure is funded by the government. In both countries, the UG collaboration has been higher than UI or

IG collaborations because the government plays a leading role in agricultural R&D. However, there is a difference between Korea and China in terms of the changes in collaboration.

Scientific production of Iranian researchers in the field of veterinary science in the ISI database from 1973 to the end of 2010 examined by Yousefi, Gilvari, Shahmirzadi, Hemmat, & Mirshahreza (2012). Findings showed that the number of articles increased in recent years, most of the papers were in English; Most collaboration of Iranian authors has been done with their counterparts from England; Veterinary articles has had the most interaction with the field animal husbandry; The average citation per paper in the field of veterinary was very lower than of the Iranian and global average; Tehran University was the most prolific university and the costs of 13.5% articles by Iranian and foreign universities and institutes were provided. In another study, Jafari, Akhavan and Zarghami (2015) measured the relationships among UIG in Nano sector using triple helix model. The findings showed, the capabilities of TH for improving policy making in science, technology and innovation (STI), especially in Nano sector and other technological sectors in Iran. Also, the results indicate weakness of the dynamics of knowledge-based relations among Iranian three sectors and international collaborations. Also, using Triple helix model, Jowkar and Morovati (2016) have studied the field of science and technology in Iran between 1985 and 2015, based on 267097 scientific outputs from the WOS. The results showed that UG mutual interactions, had the highest value and the lowest value accounted for IG interactions. But both ratios, in contrast to expectations, were declining. Trilateral collaboration of UIG has been decreasing in the last three decades and has trended toward zero during recent years. Undoubtedly, investments and implementation of sustainable policies for strengthening of the relations between the three sectors, and efforts to eliminate barriers to cooperation of these pillars will lead to positive results and a dramatic increase in triple helix indicators in scientific production in the country.

Overall, it can be concluded that the study of the interactions between the three sectors of university, government and industry from various points of view in recent decades has been highly regarded by researchers around the world. Many of these studies have been conducted through triple helix model based on the counting of interactions in scientific productions, and their results represent a low number of industry interactions in different countries. Although comparing the results of the researches shows that the level of these interactions in Iran is far more unsatisfactory than many other developing countries. On the other hand, most of them have studied the whole scientific production of a country. In order to better understanding the real state of the country, it is necessary to focus on the fields in which more interactions are expected between the industry and other sectors. Also, it is always a matter of concern that the accurate relation rates showcase in domestic scientific journals and not necessarily in articles indexed in the WOS. Therefore, to avoid missing any articles, in addition to WOS publications of Iranian veterinary researchers, this research for the first time, has also studied the articles of Iranian journals indexed in ISC, in which are many Persian language journals, and compared the flow of UGI interactions in both. So, the current paper tries to cover above mentioned issues and will open a new chapter for future researches.

Research methodology

Using scientometrics method, this research investigates the relationship between university, government and industry in scientific products of veterinary sciences. Accordingly, the research population was scientific products of veterinary science research area, indexed in Islamic World Science Citation Center (ISC) or Web of Science database (WOS) by at least one Iranian author during 2010 - 2018. In this study the whole population was studied and the sampling was not used. Hence, a quantity of 2656 articles from ISC database and 5782 articles from WOS core collection were studied[1].

The data was gathered from ISC and WOS databases[2]. In the first step, the ISC database was used to collect articles from internal journals. As the ISC do not use theme or research area tags for indexed articles, we used the list of authorized journals of MSRT[3] in the field of veterinary[4]. As such, all mentioned journals articles data were extracted first. Then, the data transferred to Microsoft Excell for sorting, coding and calculating the transmission of UIG. The entropy and transmition values were measured, using the formulas in Triple Helix model, which is explained in the following pages.

The rest of data was extracted from WOS, by searching articles with at least an Iranian author and the "veterinary science" as the research area. Using ISI.EXE, the WOS data then analyzed and transferred to Excel. The query inserted in WOS was as follows:

PY=2010-2018 AND AD=Iran AND SU=Veterinary Science

For coding the data, affiliations of the authors of each article were reviewed and a tag was assigned to each author as follows: an author from university with the code (U), an author from government with the code (G) and an author from industry with the code (I). Then all occurs of interactions in articles were counted for each year, using Excel. In the last step, the interactions between university, industry and government were calculated, using Triple Helix model formulas which are expressed in theorical framework.

The Triple - Helix model

The university, government and industry are the main pillars of any national system of innovation, each has its own specific functions. The main goal of this system is to produce knowledge and transfer it to practical applications in a country. Typically, industries and businesses are not concerned with the production of knowledge, but they use the science made in universities and or governmental research institutions. The government also plays a mediator role here and by supporting universities and research centers, promotes indigenous knowledge and sustaining innovation system in a country (Heidari, 2008).

In the scope of interactions between university, industry and government in knowledge-based communities, Etzkowitz and Leydesdorff, first proposed the "triple helix " model which is based on the same interactions (Etzkowitz & Leydesdorff, 1995, 2000). From this point of view, the national system of innovation is based on collective learning (Heidari, 2008). As Choie, Yang & Park, (2015) indicate in Triple Helix model, university, government and industry as the three actors need to collaborate with each other to achieve self-sustaining development or self-organization.

In this model, the participation of university, industry and government for economic development creates a network of interactions that can be seen in the participation of above-mentioned dimensions in scientific products of a country, in the other words a co-authorship of university, industry and government researchers. Accounting the kind of relations, three types of Triple helix model is recognized by Etzkowitz, as bellow (Park & Leydosdorff, 2010; Zarghami, 2018):

I. The **statist model, in which** government offer a predefined policy framework and drive the capacity of universities and industry. Such a model was seen in former Soviet Union and some Latin American countries.

II. The **'*laissez faire*' model,** where industry has a more effective role and is leading the innovative capacity in a framework ruled by government and university has a supportive role in terms of knowledge. Samples of this model is seen in United States and Sweden.

III. The **balanced model** where the universities become more and more relevant and promote joint initiatives and partnership with two other actors. In this model a new generation of universities, which called enterprise university is defined (Etzkowitz, 2003). Also, the Government, pay special attention to innovation and production of knowledge, services and goods in high risk fields (Zarghami, 2018).

The Triple Helix model has been widely used by researchers around the world since its introduction, particularly in studies of the knowledge-based economy and innovation (e.g., Etzkowitz, 2008; Kim, Huang, Jin, Choe & Bodoff, 2012; Jacob, 2006; Jowkar & Osareh, 2014; Leydesdorff, 2003; 2010; Shin, Lee& Kim, 2011 ; Ye, Yu & Leydosdorff, 2013).

The measurement of interactions in triple helix model is based on Shannon's theory of information (1949). This means that the dynamic in the triple helix is represented by measuring the degree of uncertainty with the help of entropy and the calculation of the amount of transmission (T). Shannon defined the probabistic entropy (H) as:

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

When a new dimension is added, H can be measured as follows:

$$H_ij = -\sum_i \sum_j P_ij \log_2 (P_ij)$$

Here, the mutual information between these two dimensions is then equal to the transmission(T) of the uncertainty and a measure of the mutual dependence between the two variables, that is defined as follows (Jowkar & Osareh, 2014) for a sample university-government interaction:

Tug= Hu + Hg –Hug

For a three-dimension case like a university-industry-government, the formula can be changed as bellow:

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

As leydesdorff & Sun (2009) point (2009) points out the uncertainty of the variables (HU, HI, and HG) is reduced by the relations at interfaces between them, but the three-dimensional uncertainty adds positively to the uncertainty. So, the sign of resulting indicator (T) can be negative or positive (or zero) where the negative value means the reduction of the uncertainty dominant at the network level (Hossain, Moon, Kang, Lee & Choe, 2012). The zero value for Transmission (T) also represents the independence of dimensions in triple helix and lack of cooperation.

Findings

1. How is the Iranian scientific production in the field of veterinary science in ISC and WOS during 2010-2018?

As the results in table1 show, Iran veterinary science scientific production in ISC have had almost an increasing trend during 2010-2014, as the highest number of articles is returned to 2015 with a number of 524 articles.

After this year, a decreasing in the number of published articles is seen as in 2017, 279 articles were indexed in ISC and in 2018 up to the time of data gathering (Dec. 2018), the number of indexed articles in veterinary sciences were only 108 articles.

Table1

Role of university (U), government (G) and industry (I) in publication of articles in ISC Iranian journals in veterinary sciences.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
U	391	370	383	365	432	395	279	198	66
G	14	19	23	27	24	56	61	51	23
I	0	0	0	2	0	1	2	0	0
UG	27	31	30	38	41	61	47	30	19
UI	2	3	3	2	6	10	2	0	0
IG	0	0	0	1	1	0	0	0	0
UIG	0	0	2	0	4	1	0	0	0
Total	434	423	441	435	508	524	391	279	108

About the interactions of university, government and industry as expected, most articles were written by academic authors, e.g. in 2015 from 524 articles, a number of 395 were done by academic authors. After that were the articles with co-authors from university and government, e.g. a number of 61 articles in 2015.

Interactions among government and industry have also seen in almost every year with a great decrease in the number of articles, e.g. in 2015, only 10 articles had such a co-authorship. Other collaborations such as university- government- industry, as it's obvious in table 1, were only seen in few years and had a very low value.

Table 2, indicates the Role of university, government and industry in publication of articles in WOS journals. As it is obvious, from 2010 to 2012 the number of published articles per year is very close, thereafter a sudden drop is seen in 2013 that the number of articles decrease from 340 articles in 2012 to 231 articles in 2013. Then from 2014 to 2018 an increasing trend is seen as the 221 articles in 2014 increase to 332 in 2018.

Here, again, the academic authors had the most articles per year e.g. in 2012 from 350 articles, 287 ones were written by an academic author. The second rank refers to the articles with collaborations of university and government authors, e.g. a number of 68 articles in 2017 from total of 332. The other forms of authorship and collaborations such as governmental authors or co-authorship of university-industry can be seen during 2010-2018, but the number of articles per year is very low, e.g. in the best situation in 2014, from the total of 221 articles, only 6 ones were written by a governmental author and the same result is seen for a co-authorship of university-industry. The other form of interactions were only seen in some of the years, e.g. the collaboration of government-industry exists only in 2013 and 2016 with only 1 article in each year.

Table2

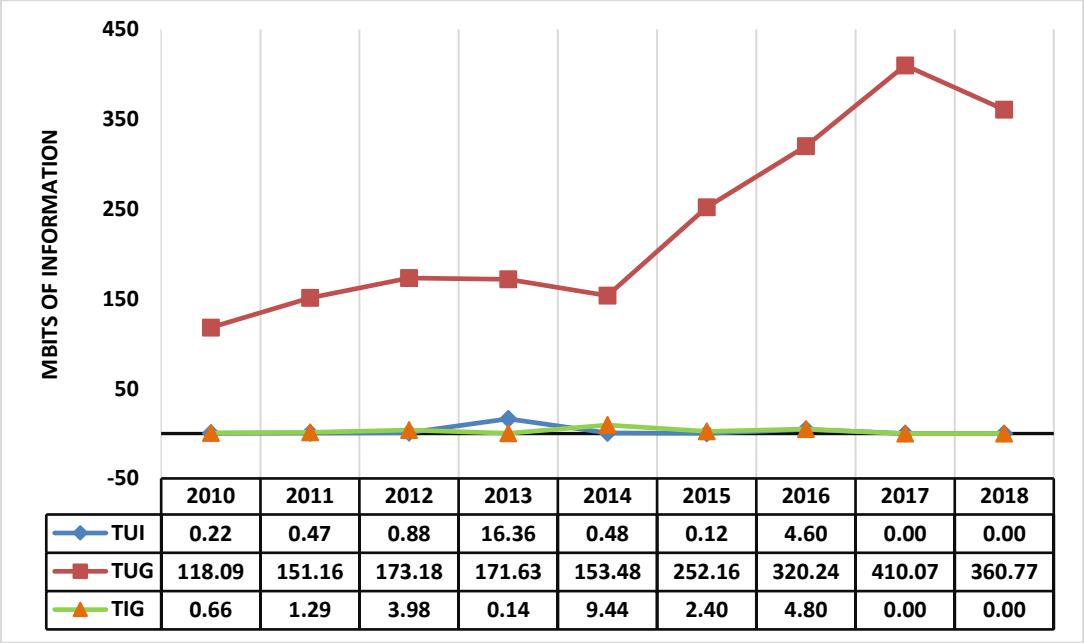
Role of university (U), government (G) and industry (I) in publication of articles in WOS journals in veterinary sciences.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
U	271	301	287	182	176	216	223	219	269
G	6	10	8	2	6	5	5	10	6
I	3	1	0	0	0	0	0	0	0
UG	44	32	41	44	33	39	53	68	52
UI	5	5	3	1	6	2	4	3	5
IG	0	0	0	1	0	0	1	0	0
UIG	1	1	1	1	0	3	1	0	0
Total	330	350	340	231	221	265	287	300	332

2. How was the mutual university, government and industry relations in production of ISC scientific articles in the field of veterinary sciences?

Figure 1 shows the results of national triple helix system for veterinary sciences during 2010 – 2018 for ISC and WOS articles. First of all, the ISC articles are discussed. As it is clear in the figure 1, the T-value for mutual information exchange among UI and IG has a stable pattern which is almost fits to zero. The highest T-value for these bilateral interactions can be seen in 2013 with the T-value of 16.36.

On the other hand, the UG relations shows an increasing trend during these years. The increasing trend was more intense among 2014 to 2017. As the T-value of 153.48 in 2014 increased to the value of 410.07 in 2017, in which the “veterinary science” benefits from the highest UG synergies, due to that positive T-value.

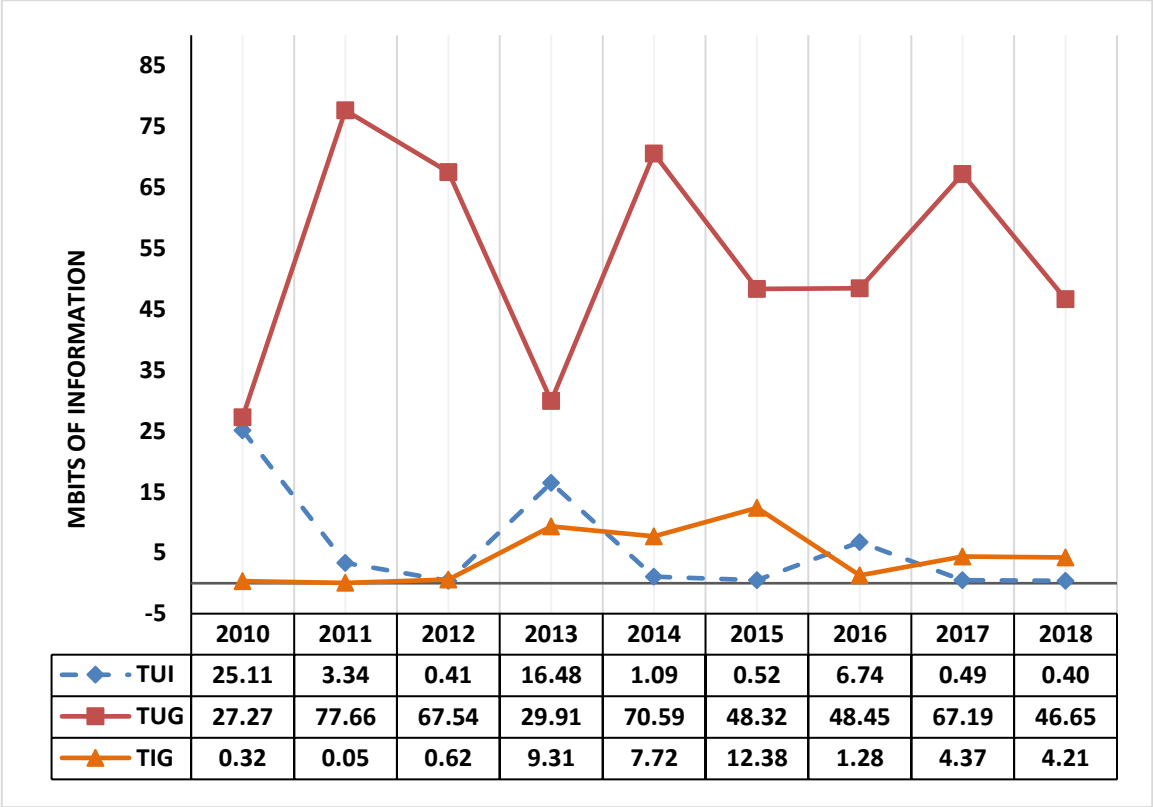


	2010	2011	2012	2013	2014	2015	2016	2017	2018
TUI	0.22	0.47	0.88	16.36	0.48	0.12	4.60	0.00	0.00
TUG	118.09	151.16	173.18	171.63	153.48	252.16	320.24	410.07	360.77
TIG	0.66	1.29	3.98	0.14	9.44	2.40	4.80	0.00	0.00

Figure 1. Mutual information measured in bilateral relations between the TH sectors in the ISC publications in Veterinary science.

For WOS articles, the results are shown in figure 2. Regarding the bilateral interactions, the positive values are desired. Based on this, as indicated in figure 2, the best T-value occurs in the UG interactions. But no specific trend can be defined for it during 2010-2018. The highest T-value refers to 2011 with the value of 77.66. Also, the situation in 2014 (T_{UG}= 70.59), 2012 (T_{UG}= 67.54) and 2017 (T_{UG}= 67.19) have been favorable with T-values which are close to each other. In other hands, the lowest T-values for university-government interactions (UG), can be seen in 2010 and 2013, respectively, with the values of 27.27 and 29.91.

As the industry enters the collaborations, T- values are reduced sharply, so that the T-value get closer to zero. Also, a certain trend cannot be found for industry interactions with other sectors. Only in 2013, the bilateral interactions of IG and IU are both positive and relatively high, while in this year the relationship between government and university has experienced a drastic decline. But overall, the most T-value for the IG interactions can be seen in 2015 (T_{IG}= 12.38) and for UI interactions in 2010 (T_{UI}= 25.11).



	2010	2011	2012	2013	2014	2015	2016	2017	2018
TUI	25.11	3.34	0.41	16.48	1.09	0.52	6.74	0.49	0.40
TUG	27.27	77.66	67.54	29.91	70.59	48.32	48.45	67.19	46.65
TIG	0.32	0.05	0.62	9.31	7.72	12.38	1.28	4.37	4.21

Figure 2. Mutual information measured in bilateral relations between the TH sectors in the WOS publications in Veterinary science.

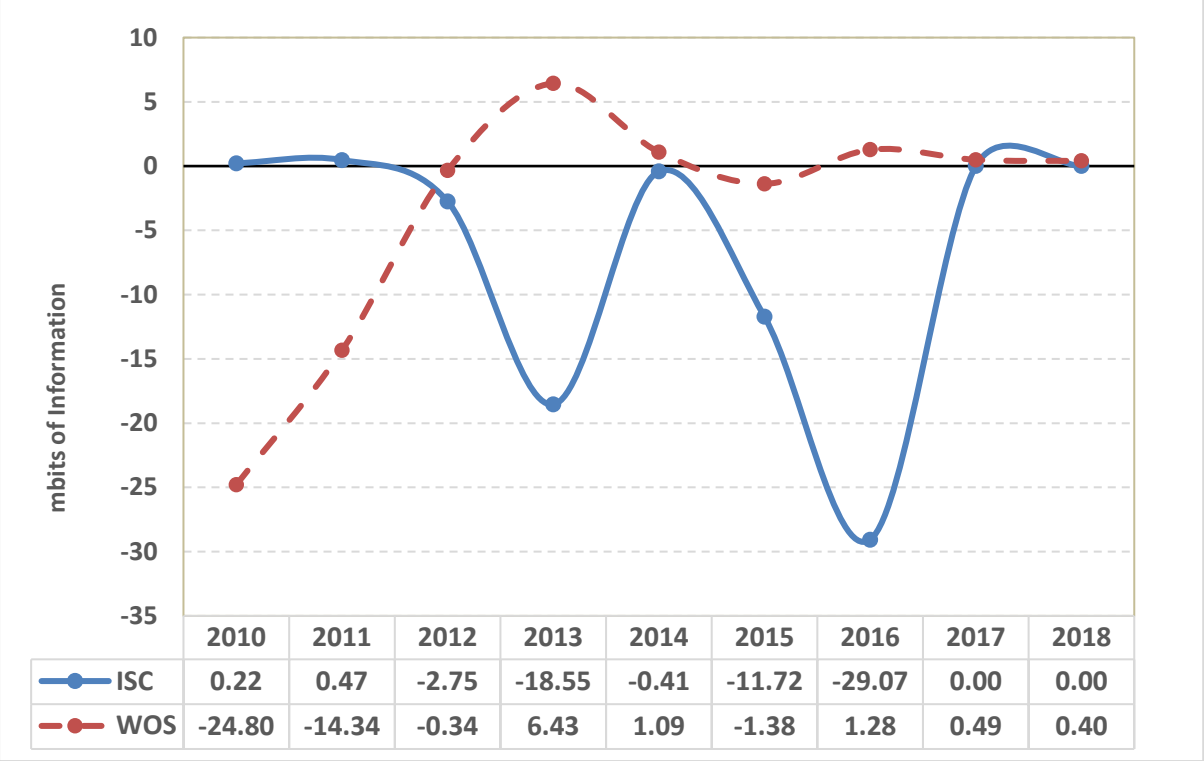
3. Do the mutual UIG relations in production of ISC and WOS scientific articles in the field of veterinary science follow a same pattern during 2010-2018?

The mutual UIG relations in ISC and WOS databases is shown in Figure3. For ISC articles, the T-value of the three domestic actors (UGI), as the figure 3 indicates, a fixed pattern is not seen. At the beginning of the decade (2010) the mutual relations are very weak and the T_{UIG} is even positive (+0.47), that refer to a high level of uncertainty. But in the years after, an increasing trend in T_{UIG} can be identified. As the negative values are desired in trilateral interactions, the strongest value is related to the year 2016, with the T-value of -29.07. This shows a powerful synergy among three actors of domestic TH in veterinary science and the decrease of uncertainty

The results for WOS articles are also obvious in Figure 3. The beginning year, 2010, was the best year in collaborations of university, government and industry in publishing WOS articles with the T_{UIG}-value of -24.80. Afterwards, a decreasing trend is seen in the mutual transmission of information among actors, up to 2013 that indicates the lowest synergy between actors with the positive T-value of 6.43. Then, from 2013 to 2018, the T-values close to zero, with little change. For example, in 2015, the transmission value is the negative value of -1.38 and in the year after 2016, it decreases to +1.28.

Lastly, for having an overall view of the trend of transmission of UIG, as it is obvious, the trilateral relationship in WOS database indicate a significant difference in comparison with ISC articles, with lower T-values in most years. For example, in 2013 in ISC articles, the T-value is -18.55 which shows a high level of interactions. In the same time, the transmission value of

WOS articles is the positive number of 6.33 that indicates the lack of interactions. Such a situation is also seen in 2016, in which although the UIG relations are desirable (T_{uig}= -30), in the same year, the WOS authors' interactions are close to zero and a little positive (T_{uig}= 1.28).



	2010	2011	2012	2013	2014	2015	2016	2017	2018
ISC	0.22	0.47	-2.75	-18.55	-0.41	-11.72	-29.07	0.00	0.00
WOS	-24.80	-14.34	-0.34	6.43	1.09	-1.38	1.28	0.49	0.40

Figure 2. Mutual information measured in trilateral relations between the TH sectors in the ISC and WOS articles in veterinary science.

Overall, the trilateral relationship in WOS articles experience a negative value only in 2011, 2012 and 2015 (Figure 3), which are also quite low and near zero in 2012 and 2015. However, in 2011 the T-value of UGI interactions is favorable (T_{uig}=-14.34) and better than ISC articles with the T-value of +0.47.

Discussion

As expected, this study also highlighted the important role of universities and then the government in scientific production in the field of veterinary science. A very small percentage of articles published in this field are written by non-university researchers or even by co-authorship of university and other sectors of the triple helix. In most previous researches, such as Sun & Negishi (2010), Shin, Lee and Kim (2011), Jowkar & Osareh (2014), Kim et al. (2012), Ye, Yu & Leydosdorff (2013), Jowkar & Morovati (2016) and Liu & Huang (2018) the same pattern is seen.

Among bilateral relations, the UG interactions are remarkable. In the field of veterinary science, it would be because of high range of collaborations of popular research institutions such as Razi Vaccine and Serum Research Institute, *Pasteur Institute of Iran* and the Veterinary Organization with the universities around the country. Here, the results are consistence with the ones obtained in Kim et.al. (2012), Jowkar & Osareh (2014), and Jowkar & Morovati (2016).

Although according to the large number of industries related to veterinary science, it was expected that R&D sections of those industries play an important role in producing scientific publications, alone or by collaborations with other sectors, but the results indicated that the total number of articles, written by or by the co-authorship of industry researchers, even is not reaching the number of 10 during the last decade. Unfortunately, in reviewing the name of industries involved in publishing articles, *the* name of most of popular and large *dairy* product or meat processing *companies in the country is absent.* It seems that not only the industries in this field don't believe in the importance of such collaborations, but also a specific policy or reward system from the government was not applied during these years, as it is reported by Ebrahimipour (2008), too. This finding supports the results of Ye, Yu & Leydesdorff (2013), jowkar and Osare (2014), Noroozi Chakoli & Taheri (2015), Jowkar and Morovati (2016) and Erfanmanesh et.al (2018) in which the industries had low interactions in producing scientific productions.

The lack of a clear pattern in the status of the Triple Helix in this field indicates the changing prevailing policies and conditions of the triple helix actors, UGI, which does not allow the existing plans to operate properly in order to increase their interactions. Although, there is hope that the new policy of MSRT for establishing collaborations with industry for faculty members and Ph.D. students can be an effective step in trilateral interactions. Of course, provided that its implementing mechanisms can provide the parties ' satisfaction and do not undergo abrupt changes.

It can be concluded that in order to achieve a successful relationship with the industry through research flows, it necessary to have a proper orientation in the research activities of universities and government research centers (Leal Filho, , Morgan, Godoy, Azeiteiro, Bacelar-Nicolau, Ávila & Hugé, 2018), otherwise, we only witness fragmented and non- synergistic actions. Also, to conclude the reported results of pervious researches, it's obvious that no sense of the needing and unfamiliarity of industries with the capabilities of universities on one hand and lack of incentive or any form of reward system in universities and government centers, on the other hand are the most important obstacles to the establishment of collaborations. Veterinary science has a good potential in this field, and little attempt from each of three actors of Triple Helix of UIG, would lead to remarkable changes in trilateral collaborations.

Conclusion

The veterinary science is a vital field to food industry. Effective cooperation between university, industry and government in this field can lead to efficiency in meat and poultry industry. However, the results of assessing these relations show that the trilateral and bilateral collaborations are not satisfactory. The role of universities in the amount of publications are very bold, but not a reasonable level of collaborations with industry and even the government can be seen. As it was mentioned earlier, veterinary science researches have a good potential to attract the researchers of university, industry and government. Leading to the peak of collaborations can happen if all three sectors reach a common point about the vitality of synergy and each take small steps. In this section, universities can encourage researchers and students to design collaborative projects with industry by strengthening their motivation system. The "Sabbatical *Leaves* with *Industry* "law, recently announced by the Ministry of Science,

Research & Technology, can be a good example. It is also necessary to facilitate the existing rules for cooperating with industry at the university level. The government should also define incentives such as tax breaks or the provision of facilities to the veterinary industries that can be achieved by cooperating with universities and research institutions and developing their R&D networks. Special consideration should also be given to expanding knowledge-based companies and investment in the establishment of knowledge systems in the field of veterinary science. In this regard, the successful patterns applied in the field of nanotechnology and biotechnology can be used.

Finally, the results show that considering the scientific articles published in internal journals have a high impact on the transmission of mutual information in triple helix of UGI. This can be attributed to the greater tendency of Iranian researchers to publish in Persian language or in internal journals. Maybe due to this fact that publishing in WOS journals is more difficult for researchers from the dimensions of cost, time and the probability of publication, in recent years. Therefore, it is suggested to perform triple helix researches in Iran, the internal journals take in to account and to be considered to obtain more realistic results. On the other hand, the considerable element in WOS articles of veterinary science is collaborations with foreign researchers, that can be the subject of another research.

Endnotes

1. This is the number of articles with at least an Iranian author.
2. Some of the articles were indexed in both databases, but it did not have an effect on the results of this study.
3. Ministry of Science, Research & Technology
4. The list is available at <https://rppc.msrt.ir/fa/download/category/208>

References

Altaf, A., Hassan, I. E. & Batool, S. (2019). The role of ORIC in the evolution of the triple helix culture of innovation: The case of Pakistan. *Technology in Society*, *56*, 157-166.

Anderson, M. (2000). University-industry partnerships. In higher education in the Unites States: An encyclopedia; James Forest and Kevin Kinser (Eds.). ABC-CLIO: Santa Barbara California.

Arias, D., Vieira, P. A., Contini, E., Farinelli, B., & Morris, M. (2017). Agriculture productivity growth in Brazil: Recent trends and future prospects. World Bank Group. Retrieved from http://documents.worldbank.org/curated/en/268351520343354377/Agriculture-productivity-growth-in-Brazil-recent-trends-and-future-prospects

Azizi, F. & Moradi, F. (2019). Investigating the relation between the university, industry and government in the innovation system of the knowledge-based economy in Iran. *International Journal of Information Science and Management (IJISM)*, 17(2), 1-18.

Choi, S., Yang, J. S., & Park, H. W. (2015). Quantifying the triple helix relationship in scientific research: Statistical analyses on the dividing pattern between developed and developing countries. *Quality & Quantity*, 49(4), 1381-1396.

Cricelli, L., Greco, M., Greco, M., Grimaldi, M., Grimaldi, M. & Llanes Dueñas, L. P. (2018). Intellectual capital and university performance in emerging countries: evidence from Colombian public universities. *Journal of Intellectual Capital*, *19*(1). 71-95.

Ebrahimpour, H, Esmaeilzadeh, H., Dehnavieh, R. & Jafari Sirizi, M. (2008). An assessment on Relations between Iran's Industries and Universities of Medical Sciences. *Journal of Health Administration*, 10(30), 25-32.

Erfanmanesh, M. A., Moghiseh, Z. & Forouzandeh, S. M. (2018). Comparing the share of scholarly output published through the collaboration between academic and corporates in Iran, Middle East and the World. *Rahyaft, 28*(69), 65-79. [in Persian]

ESCAP: Economic and Social Commission for Asia and the Pacific (2016). *Science, Technology and Innovation for Sustainable Development*. Note by the secretariat. Seventy-second session. Item 8 of the provisional agenda. Bangkok, 15-19 May. B16-00233

Etzkowitz, H. (2003). Innovation in innovation: The triple helix of university-industry-government relations. *Social science information*, 42(3), 293-337.

Etzkowitz, H. (2008). The triple helix: university-industry-government innovation in action. London: Routledge.

Etzkowitz, H. & Leydesdorff, L. (1995). The triple helix--university-industry-government relations: A laboratory for knowledge based economic development. *EASST Review*, *14* (1) 11-19.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from national systems and 'mode 2' to a triple helix of university-industry-government relations. *Research Policy*, 29(2), 109-123.

Fiuzat, E. & Taslimi Tehrani, R. (2007) Sociological research of relation between university and Industry in Iran today. *Human Sciences*. 53, 129-150. [in Persian]

Heidari, H. (2008). The national innovation system as a framework for innovation analysis: a theoretical approach. *Iranian Journal of Economic research*, 9(33), 129-163. [in Persian]

Hossain, M. D., Moon, J., Kang, H. G., Lee, S. C., & Choe, Y. C. (2012). Mapping the dynamics of knowledge base of innovations of r&d in bangladesh: triple helix perspective. *Scientometrics*, 90(1), 57-83.

IRNA (18 Nov 2014). The 25% share of the veterinary organization in the national economy of Iran. Islamic Republic of Iran News Agency. Retrieved from www.irna.ir/news /81379428/ [in Persian]

Islamic Parliament of Iran (2005). *Law on the fourth five-year economic, social and cultural development plan of the Islamic Republic of Iran*. Retrieved from http://www.ilo.org/dyn/natlex/docs/ELECTRONIC/91720/106519/F-2093574466/IRN91720.pdf [in Persian]

Jacob, M. (2006). Utilization of social science knowledge in science policy: Systems of Innovation, triple helix and VINNOVA. *Social Science Information, 45*(3), 431-462.

Jafari, M., akhavan, P., & Zarghami, H. R. (2015). Measuring the relationships among university, industry and government in nano sector using triple helix model. *Journal of Academic Librarianship & Information Research*. *49*(3): 413-438. [in Persian]

Jegede, A. (2019). Largest meat producing countries in the world. *The Daily Records.* Rec.:14456. Retrieved from http://www.thedailyrecords.com

Jowkar, T. & Morovati, 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. & 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 & Management,* 29 (2), 505-533. [in Persian]

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

Leal Filho, W., Morgan, E. A., Godoy, E. S., Azeiteiro, U. M., Bacelar-Nicolau, P., Ávila, L. V. & Hugé, J. (2018). Implementing climate change research at universities: Barriers, potential and actions. *Journal of Cleaner Production*, 170, 269-277.

Leydesdorff, L. (2003). The mutual information of university-industry-government relations: An indicator of the triple helix dynamics. *Scientometrics, 58*(2), 445-467.

Leydesdorff, L., & Sun, Y. (2009). National and international dimensions of the triple helix in japan: University–industry–government versus international coauthorship relations. *Journal of the American Society for Information Science and Technology*, 60(4), 778-788.

Leydesdorff, L., (2010). The knowledge-based economy and the triple helix model. *Annual Review of Information Science and Technology*, Blaise Cronin (Ed.). *44*, 367-417.

Liu, Y., & Huang, Q. (2018). University capability as a micro-foundation for the triple helix model: The case of China. *Technovation*, 76-77, 40-50.

Lowder, S., Carisma, B., & Skoet, J. (2012). Who invests in agriculture and how much. *FAO, Rome*.

Mirowski, P., & Sent, E. M. (2007). The commercialization of science, and the response of STS. In E. J. Hackett, O. Amsterdamska, M. Lynch & J. Wajcman (Eds.), *Handbook of Science, Technology and Society Studies* (pp. 635-689). Cambridge, MA/London: MIT Press.

Moghtadaee, E. (2008). The role of veterinary science in national economy and job creation. Presented in *the 15th Iranian Veterinary Congress, Tehran, Iran Veterinarians Society*. Retrieved from https://www.civilica.com/Paper-THVC15-THVC15_491.html

Nili Pour-Tabataba'i, S.A., Liraii, R. and Mirzaei Pour Galzehzkhah, N. (2007). Industry, university and government relations in wealth production. Presented in the *first national conference on industry, students and sustainable development*. Tehran: Iran University of Science and Technology.

Noroozi chakoli A. & Taheri B. (2015). Comparative analysis of university- industry relation in Iran and Turkey: scientometrics study. *Caspian Journal of Scientometrics*. *2* (1), 39-49. [in Persian]

Pardey, P. G., Alston, J. M., & Chan-Kang, C. (2012). Agricultural production, productivity and r&d; over the past half century: an emerging new world order (No. 1701-2016-138800). Invited plenary paper presented at *the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August*, 2012.Retrieved from https://www.researchgate.net/publication/254387577_Agricultural_Production_Productivity_and_RD_over_the_Past_Half_Century_An_Emerging_New_World_Order

Park, H. W., & Leydesdorff, L. (2010). Longitudinal trends in networks of university, industry, government relations in South Korea: The Role of Programmatic Incentives. *Research policy*, 39(5), 640-649.

Shafiei, M & Arasteh, H. (2004). University and industry cooperation. In Encyclopedia of Higher Education. Nadergoli Gourchian, Hamid Reza Arasteh, & Parivash Jafari (Eds). Tehran: Farsi Encyclopedia Foundation. [in Persian]

Shannon, C.E. & Weaver, W. (1949). *The mathematical theory of communication*. Urbana: University of Illinois Press.

Shin, J. C., Lee, S. J., & Kim, Y. (2011). Knowledge-based innovation and collaboration: a triple-helix approach in Saudi Arabia. *Scientometrics*, *90*(1), 311-326.

Shiri, H. (2016). The relation between university and industry and its challenges: A qualitative study among Tehran University students. *Journal of Industry & University*, 8(29), 1-10. [in Persian]

Sun, Y., & 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.

USMEF (2018). *US meat federation annual report 2018*. Retrieved from https://www.usmef.org/downloads/ USMEF-2018 -Annual-Report.pdf

Ye, F. Y., Yu, S. S., & Leydesdorff, L. (2013). The triple helix of university-industry-government relations at the country level and its dynamic evolution under the pressures of globalization. *Journal of the American Society for Information Science and Technology*, *64*(11), 2317-2325.

Yousefi, A., Gilvari, A., Shahmirzadi, T., Hemmat, M., & Mirshahreza, S. (2012). A survey of scientific production of Iranian researchers in the field of veterinary science in the ISI database. *Veterinary Researches & Biological Products*, *25*(2), 32-40. [in Persian]

Zarghami, H. (2018). An overview of the patterns of development of university, industry and government relations to promote innovation. *Science and Technology Policy Letters*, 8(2), 103-112. [in Persian]