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Research Paper

Factors Influencing the Establishment and Development of a Commercialization System of Research Findings and Determining the Knowledge of Those Involved in the Agricultural Sector of Iran

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Abstract

The agricultural sector is the centerpiece of Iran's economic development and is capable of turning the nation into an industrial country. But, this requires agriculture to become knowledge-intensive whose prerequisites are the commercialization of technological achievements. The present study was carried out by a survey design to identify the effective constructs underpinning the commercialization system of the agricultural research achievements in Iran. The statistical population was composed of faculty members and instructors of institutes for agricultural research and education (IAREs) in Iran. The sample size was determined as 190 people that were taken by the proportional random sampling technique. The face validity of the research instrument was confirmed by 10 experts of research commercialization, and its reliability was estimated by Cronbach's alpha. The results showed the involvement of three constructs in the process of the establishment and development of commercialization: i.e. 'motivational-behavioral', 'structural-organizational', and 'contextual-environmental'. Different groups of membership in knowledge-intensive firms, membership in scientific associations, and participation in startups were significantly distinctive based on the participants' opinions about commercialization. The level of knowledge and skills of those involved in the process of commercializing research achievements was found to be lower than average. Also according to the results, the respondents needed to be more familiar with technology transfer topics, teamwork techniques, national and international networking technology, science and technology growth parks and centers, intellectual property issues, and methods of successful commercialization of research achievements

Keywords:
Agricultural research findings; Iranian agricultural research; technology commercialization

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INTRODUCTION

The knowledge economy refers to an economic system in which planning and development are based on knowledge and technology (Bezuidenhout, 2018) and all its components operate to use knowledge and technology in commodity and service production processes consistently and continuously (Parandi et al., 2014). In this economy, non-applied knowledge and technologies are perceived to be "useless" and transformations are unavoidable in the paradigms of educational-research policies and the process of second academic revolution, or the so-called post-academic or post-pattern methods as named by Gibbons (2002). According to this approach, the policies on scientific research should focus on the prompt transfer of research outputs to public and private sector firms with the collaboration of executive agencies for the benefit of the public (Zieminski & Warda, 1999). Presently, changes in most economic models have made it imperative to commercialize research achievements of academic and research centers due to the emergence of the knowledge economy and the lack of adequate research funding (Namdarian & Naimi-Sadigh, 2018). In the context of the free economy, "privatization and market-orientation of training and research" is gradually growing in spite of the fact that policies are still made by governments.

The study of the evolutionary process of science and technology commercialization over the commercialization refers to the process of converting knowledge into products/services with practical and valuable applications (Reddy Metla, 2007).

The process of commercialization is composed of four phases. The first phase is related to 'capital' that should be supplied for research on a fostered idea. In the second phase, a 'marketing policy' is determined. The idea is turned into technology in the third phase – or 'the development phase'. When an achievement can be marketed, the fourth phase – 'commercialization' – commences during which questions are asked as to which industry will buy the technology and where and how it should be sold (Moghimi et al., 2010). In the agricultural sector, the most intricate step of this process is 'the transfer of research and educational findings to farms and/or relevant industries' – this is called 'knowledge and technology transfer from research to production' (Bandarian, 2010). One of the sub-processes of this step is 'the commercialization of agricultural technologies' and it depends on the process of technology transfer from educational centers to agribusinesses in farms or industries. To confirm these complexities, it has been documented that of about 3000 fresh ideas, just one or two ideas can achieve success in the market (Mirbolouk & Safari Alamouti, 2008) and the process of technology transfer and commercialization does not always turn out to be easy and viable (Pourezzat et al., 2011). The commercialization of academic research achievements is a complicated activity that supplements the process of idea conversion into technology and leads to wealth creation, employment creation, and financial independence of universities (Jahed & Arasteh, 2013). On the other hand, commercialization is a costly and long-term process whose output is highly unreliable. On average, commercialization costs 10-100 times greater than the development of new technology. Furthermore, the likelihood of its success is very low so that the success rate of the process of commercialization of new technologies is less than 5 percent. Even if the commercialization of technology is to succeed, it will take a long time (Asian and Pacific Center for Technology Transfer, 2005).

The investigation of approaches to commercializing technology knowledge discloses three main approaches in the world. In the first approach, technology commercialization is considered a chain from idea generation to sale and use of technology by the end-user. In this view, commercialization is perceived as a process during which technology turns into

successful economic products. According to the second approach, technology commercialization is synonymous with technology transfer. In other words, technology commercialization is defined as the transfer of knowledge and technology from one person/group to another person/group for the use in a system, process, product, or procedure. This view holds that technology is only transferred from research centers to the existing industries or new businesses. In the third approach, it is assumed that there are marketing and new product development professionals in enterprises, and technology commercialization is defined as the last step of the cycle of new product development (Parandi et al., 2014).

In Iran, the issue of the independence of educational institutions, especially in the financial aspect, was raised in the Fourth Development Plan and was highlighted even more in the next Development Plans (Badri et al., 2009). This has made it growingly possible to have an economic view on education and research. To adapt to this policy change, the paradigms of investment supply and the management styles of these institutions have undergone extensive developments (Ylijoki, 2000). Studies have shown that in advanced economies, the share of technological achievements of the service sector (68 %) is higher than other sectors in gross national product. This confirms that the technological achievements of IAREs, which are not mainly confined to the production of physical machinery and devices and/or agricultural inputs such as seeds, fertilizers, and biological pesticides, can play a significant role in meeting the technological needs of agriculture. Example achievements are optimal planting patterns and a development paradigm for new agribusinesses. The distinctive characteristic of these achievements is that they are "costlier" and "more time-consuming" than the technological achievements of research centers. In other words, these achievements are formed within the interaction of students, teachers, and users' community. On the other hand, their achievements penetrate and influence the marketplace at a faster pace. This can be attributed to the fact that since institutes for research and education (IREs) are in touch with production units and producers and their graduates and the centers themselves attend different academic and production symposiums and technology exhibits, these institutes have the chance of influencing markets and their customers more effectively.

IAREs, which have a mission to produce knowledge and technology and to train, promote and develop their applications on farms, are responsible for the development of the agricultural sector, the production, promotion, and training of modern agricultural knowledge and skills, and the introduction of innovations. AREs of MJA have played a significant role in the generation and commercialization of these achievements and have been involved in educational and training missions for applied research, the training of human resource, the education of future farmers, the training of agricultural users, and the development of current farmers' skills by holding short-term and long-term scientific and applied training courses since over half a century ago.

However, the achievements have not been commercialized well enough for several reasons such as the lack of mental readiness for the sale of this knowledge and technology in the market, the lack of efforts to introduce them into the market of the agricultural sector, and the poor financial status of users. On the other hand, given the existing regulations policies, and plans, no effective attempt is made to establish and institutionalize knowledge and technology commercialization in the agricultural researcher centers of Iran extensively, and the income of these centers is not compatible with their huge human resource, capital, and physical potentials at all so that they are even unable to afford the technical and input requirements for the implementation of their regionally-designed research and training plans of agriculture. The

present research aims to explore the effective constructs underpinning the establishment of a commercialization system for research findings in IAREs of Iran and to enumerate the educational needs of people mainly responsible for this process, i.e. agriculture researchers.

Studies show that Iran is in a suitable international position in the production of scientific papers, but its conditions are not favorable in the field of entrepreneurship and technology and the production of technological achievements (Faraji et al., 2019). According to the 20-Year Vision Document, Iran's economy should be knowledge-based by 2025 with its underlying being the knowledge-based industry. Also, given the general policies of a resilient economy, "supplying conditions and activating all the facilities, funds, and human and scientific resources of the country for developing entrepreneurship, maximizing the participation of the public in economic activities, and increasing the share of production and exports of knowledge-intensive commodities and services" should constitute the basis of Iran's plans and actions (Seifoddin, 2014). The translation of scientific papers and discoveries into action requires different mechanisms, frameworks, processes, and regulations, and arrangements should be made and operationalized to accelerate the growth of technology and gain experience of joining the circle of leading, or potentially leading, nations. These measures include the provision of more research credits and entrepreneurial credits. While developed countries are ahead of Iran by years in the route of technology growth, they allocate over 3percent of their GDP to research activities, whilst the share of these activities in Iran's GDP is as low as 0.5 percent (Jafarnejad et al., 2012). According to Tariq Mahmood et al. (2010), Iran was scored 0.325 and was ranked the 56th among 96 nations based on the technology achievement index (TAI) in 2009. In this report, countries were classified into four categories: leaders, potential leaders, dynamic adopters, and marginalized countries with their TAI being defined as ≥0.5, 035-0.49, 0.2-0.34, ≤0.2, respectively. In this classification, Iran is in the third group. Iran's rank was the 50th in 2001. This means that despite the fact that the number of published papers in scientific journals has increased the rank of technological achievements and the transfer of scientific findings towards the creation and dissemination of technology has declined (Zakersalehi & Zakerhosseini, 2010).

In the response, science and technology parks were founded in the universities in an attempt to provide long-term funding for universities and scientific and physical support for newly established companies, especially companies established by graduates, and it was attempted to make advanced enterprises come into research contracts with universities so that most student projects and research projects of academic teachers can be implemented within these contracts. This trend is indicative of an increase in cooperation with the industry. This has triggered the commercialization of scientific, educational, and research achievements and the issues of keeping their ownership and their valuation. In general, the issue of "technology transfer" from IREs to the executive and industry sectors emerged in a new form at this stage. For example, the issue of "agriculture extension' as a movement to encourage the user communities to buy and apply agricultural technologies underwent a tremendous transformation and, while the traditional ways of extension started to change, the private sector invested more in this system in developed countries.

IAREs try to bring technological achievements into the farms by implementing research projects and generating such achievements on the one hand and training agriculturally skilled human resources and providing unofficial educational to farmers on the other hand. However, most research findings are not introduced into the farms and the process of their commercialization is not pursued (Hajimirrahimi, 2012). A barrier

against implementing the system of technological achievement commercialization is poor rules and regulations to enforce the commercialization of research findings. Furthermore, there is no legitimate process to pursue the process of research findings commercializing by others. Most research projects proceed through the initial phase of idea generation to, at most, the production of prototype, but they are abandoned at the next phases, including practical trials in real conditions, the identification and attraction of investors, and finally, commercialization, due to various problems such as the lack of significant scientific rank for the person who is in charge of the project. On the other hand, technological achievements are not well documented. The outputs of plans, projects, and dissertations are unclear, and as long as the outputs are presented in the form of a paper or an ordinary book (without proper presentation of technological achievements), the outputs cannot be pursued for income generation purposes.

Another problem of commercialization of the technological achievements of IREs in Iran is the issue of "intellectual property" which has been neglected. Intellectual property is gaining growing importance in the world so that it plays a key role in commercial transactions at the international level. Intellectual property is now one of the most precious assets in commercial trades. However, the uncertainty of the faculty members about introducing technological achievements due to the fear of its acquisition by others has slowed down the commercialization process of these achievements (Valadan & Rezaei, 2016).

The lack of purposefulness and poor research results of IAREs are the new obstacles to the establishment and development of a commercialization system. These barriers were reported by Arabioun et al. (2012) for the agricultural biotechnology industry of Iran. As long as scientific and technological achievements cannot be exploited practically, it will be difficult to commercialize them. Consequently, technological achievements of the researchers and instructors of these centers lack competitiveness in the market, but incapable graduates are also trained who cannot be recruited by the market or cannot produce commercialization capability technologies (Hajimirrahimi, 2012). On the other hand, this has made IAREs not to consider market-orientation in planning and implementation of educational and research projects. The lack of organizational units with functions in developing creativity, innovation, and entrepreneurship, the lack of a mechanism for realizing the tasks pertaining to entrepreneurship development, and its consequences such as the incompatibility of the graduates of this system with the trend of changes and development of applied science and technology in manufacturing units, and the higher unemployment rate of agriculture graduates have rendered this system socioeconomically ineffective. Consequently, students and graduates do not propose creative and innovative initiatives, and even in case some innovations or inventions are made, they are incapable of commercialization.

A major tool for institutionalization and commercialization of research findings in educational and research centers is the training of entrepreneurship and the promotion of entrepreneurship capabilities in human resources. On the other hand, entrepreneurship training plays a synergic role in enhancing the impact of job experiences on the development of entrepreneurial activities among graduates to initiate or develop a business (Stuetzer et al., 2013). In addition, the creation of a business atmosphere, the enhancement of self-confidence, and the promotion of entrepreneurial behaviors among experts are the consequence of entrepreneurship training (Unachukwu, 2009). Also, participation in entrepreneurship training courses can increase entrepreneurial knowledge and attitudes and the willingness of most agricultural experts to start small businesses (Savari et al., 2012; Zarifian et al., 2015). Therefore, planning for the development of entrepre-

neurship training at IREs will foster entrepreneurial beliefs and attitudes and enhance the capabilities of researchers and instructors of these centers in producing commercializable findings, and what keeps this field of work focused on continuous progress and development is creativity, innovation, and entrepreneurship.

According to Nadirkhanlou et al. (2012), the top priority for developing the commercialization of research results at IREs includes "the adoption of incentive policies in royalty sharing among faculty members" from the viewpoint of knowledge commercialization experts. The next priorities are "networking", "financial support", "the creation of necessary structure", and "the freedom of action of faculty members".

The research results of Pourfateh et al. (2017) showed that in the field of commercialization of agricultural innovations; Support for small and medium-sized enterprises, parks relations with universities and research centers is the most importance.

The successful commercialization of technological achievements requires a full understanding of the behavioral patterns of technology producers and consumers. Producers are IREs and consumers are industries, investors, government, and nonprofit organizations. Both producers and consumers seek their own goal for producing the technology needed by the manufacturing units and purchasing the technology needed to produce high-quality commodities and services required by the market in an economical manner. The deficiency or lack of technology production origin is the first factor that can be blamed for the failure of the technology commercialization industry. One of the most important aspects of technology transfer from IREs to users is to address the considerations of the activities, motivations, and perceptions of researchers, instructors, and managers of these institutes, technological companies, and entrepreneurs.

It is clear that there are many barriers to the effective commercialization of technological achievements. Conflict of cultures, bureaucratic inflexibility, poor remuneration systems, and inefficient management of technology transfer offices in IREs are some examples of these barriers (Siegel, 2003). Other factors involved in this ineffective commercialization are the slow pace of projects in IREs versus what the users expect and the inconsistency in their goals. At the same time, in some areas, IREs are far behind the user firms in terms of the level of applied technologies in some fields and their graduates are not well familiar with the new developments of these firms (Fontana, 2006).

From the perspective of economy and policy-making, governments play a unique role in economic growth, but the role of technology and innovation management in economic growth and development has been perceived to be more robust, stable, and coherent. This role can be more systematic and effective by supporting production. In this respect, governments have used their strong capabilities to set up and support growth centers and science and technology parks. With the establishment of new enterprises in these complexes and their enjoyment of financial and regulatory support, the ground is laid for economic development and growth.

A key approach to developing the commercialization of technological achievements is to formulate and enforce policies and practical measures and to develop supportive laws and regulations. In the Fourth Development Plan of Iran, the enactment and enforcement of the statute "How researchers gain a share in the profit from the commercialization of research results" and in the Fifth Development Plan of Iran, the continued support of knowledge-intensive enterprises and higher educational centers have greatly contributed to developing the commercialization of knowledge and technology in Iran (Ministry of Science Research and Technology, 2005). The establishment of the Vice President of Science and Technology of the Presidency, the development of growth centers and science and technology parks, the enactment of the

law to support knowledge-intensive enterprises, and the adoption of rules to support elites and researchers are other factors that have motivated researchers to produce applied science and technology. The commercialization of research findings, which is the main characteristic of an entrepreneurial university (Etzkowitz, 1998), requires multiple prerequisites, specializations, and factors among which external and extra-organizational factors are of crucial importance because of their ground-laying, facilitating and motivating role.

As mentioned earlier, to sum up, there are several factors that influence the commercialization of research. One is the 'motivational-behavioral' factors of researchers. In this regard, Saida Farhanah (2015) highlighted the role of the motivation factors in explaining the close link between the goals of academic researchers' commercialization activities and their personal goals. Also, Namdarian and Naimi-Sadigh (2018) enumerated the motivation and behavior of the actors as one of the most important barriers to the commercialization of research findings. Furthermore, the development of the commercialization of research findings is influenced by 'structural-organizational', and 'contextual-environmental'. Torkiantabar and Hashemi (2015) shed light on the impact of organizational and environmental factors on the commercialization of academic research results and in a study entitled "Extra-organizational factors influencing the commercialization of research results", Jahed and Arasteh (2013) concluded that extra-organizational factors including government forces, economic forces, educational system, macro regulation, technological developments, competition and competitiveness, and customer orientation can influence the commercialization of research results. Also, Ansari and Sanjabi (2013) concluded that organizational-financial and infrastructure-support factors have direct impacts on the commercialization of research findings. So, the present study aimed to identify the effective constructs underpinning the commercialization system of the agricultural research achievements in Iran. The theoretical framework of the research was drawn based on the review of the literature and the interpretations (Figure 1). Accordingly, the constructs underpinning the status of these constructs is influenced by personal and professional factors and characteristics of respondents and their cooperation in commercialization activities, which are shown in Figure 1.

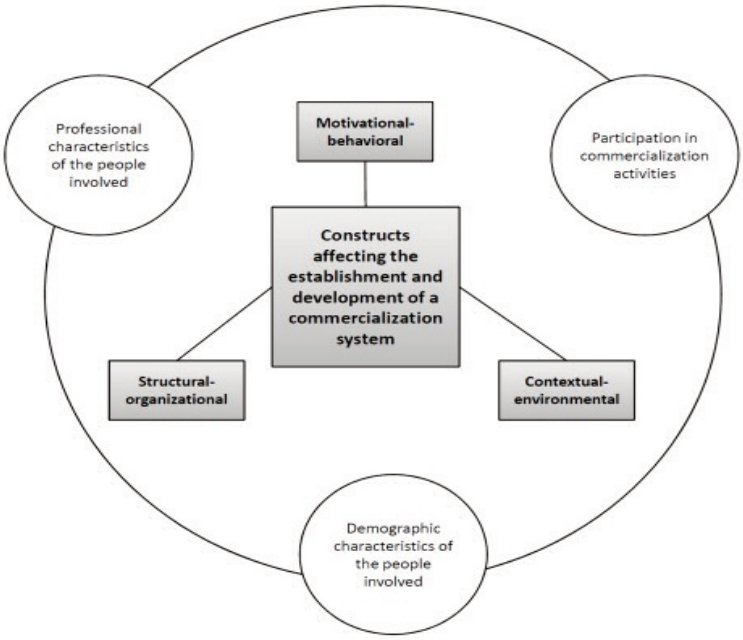

Figure1. The Theoretical Framework of the Research

METHODOLOGY

The research was conducted based on a quantitative approach by a descriptive survey design. It was applied in terms of its results and applications since the constructs affecting the establishment and development of plans and activities for the commercialization of technological achievements in the institutes for agricultural research and education (IAREs) were addressed. The main research tool was a questionnaire whose validity was confirmed by a panel of experts and its reliability was measured by calculating Cronbach's alpha (showing a range of 0.837-0.944 for different scales). The research tool was composed of several sections, i.e. (a) demographic characteristics of respondents, (b) items related to the 'structural-organizational' construct of the establishment of a commercialization system, (c) items related to the 'contextual-environmental' construct, (d) items related to the 'motivational-behavioral' construct, and (e) participants' knowledge about the commercialization of the research. Sections (b) to (e) were measured based on a 5-point Likert scale. The coefficient of variations (CV) has been used for ranking of the items related to these constructs. It known as relative standard deviation, is a standardized measure of dispersion of a probability distribution or frequency distribution. It is often expressed as a percentage, and is defined as the ratio of the standard deviation to the mean.

The target population of the study consisted of 2019 faculty members of AREEO out of which 663, who passed the following criteria, were selected as the target population;

The educational centers with scientific-applied higher education courses.

Instructors and faculty members who had at least two research projects confirmed by AREEO-affiliated scientific-technical committees in the last five years (2012-2016).

They amounted to people as per the data provided by the Research Affairs Monitoring Office of Vice-President in Research and Technology, AREEO.

The sample size was determined by the Cochran formula equal to 190 people as follow;

$$n = \frac{Nt^2 pq}{Nd^2 + t^2 pq}$$

in which n denotes research sample size, N represents the size of the research population, d is the probability of optimal accuracy, and p and q are the probability of opinion type. Since the opinion of the research sample was unknown about the factors underpinning the institutionalization of a commercialization system for research findings of IAREs, the value of p was set at 0.5.

$$t^2 = 1.962; p = 0.5; q = 0.5; d2 = 0.062$$

$$n = \frac{663 \times 1.96^2 (0.5)(0.5)}{663(0.06^2) + 1.96^2 (0.05)(0.5)} = \frac{636.7452}{2.3868 + 0.9604} = 190$$

Also, the proportional random sampling technique was applied to select the respondents as:

$$n_h = n \frac{N_h}{N}$$

N= the sample size to be selected from the research population,

n_h = the sample size to be selected from the h_{th} group,

N_h = the number of people in the h_{th} group,

N = the total size of the population.

The number of the eligible target population and the respondents sampled for each center are shown in Table 1.

Data were analyzed by the SPSS18 software package, and the findings were presented in two sections for descriptive and analytical statistics.

RESULTS

The results showed that the majority of the respondents had a Ph.D. (56.1 %) or M.Sc. degree (42.2 %) and the lowest percent (<1 %) was for those with a B.Sc. degree. Also, 1.1 percent of respondents didn't answer this question. With respect to the field of study,

Table 1
The List of IAREs and Number of Target Population and Final Respondents as a Sample

IAREs	Number of target population	The share of sample	IAREs	Number of target population	The share of sample
Khorasan Razavi	80	23	Imam Khomeini Higher Education Center	25	7
Kordestan	25	7	Sistan & Baloochestan	23	7
Boshehr	20	6	Mazandaran	40	12
Hamadan	40	12	Semnan	25	7
Golestan	45	13	Ardabil	20	6
Kerman	28	8	Fars	80	23
Isfahan	57	17	Hormozgan	30	9
Markazi	18	5	Qom	11	4
Zanjan	13	4	Tehran	29	8
Ghazvin	20	6	Charmahal & Bakhtiari	22	6
Kerman(Jiroft)	12	4	-	-	-
Target Population	663				
Sample size	194				

most respondents had a degree in water and soil science (15.9 %), animal science (13.6 %), agronomy (11.36 %), plant protection (10.8 %), natural resources (10.23 %), plant breeding (9.66 %), and horticultural science (7.95 %). It seems that all respondents had the specialty required for the research goals, implying the high quality of the data and results. Over 80 percent were members of research departments and 18.6 percent were members of educational departments of the studied centers. Also, 82.6 percent of the respondents were faculty members and 17.4 percent were not. Of all faculty members, 36.9 percent were lecturers, 56.4 percent were assistant professors, and the remaining 5.7 percent were associate professors, indicating the extensive experience, capabilities, and knowledge of the participants who answered the research questions. Based on the findings, almost 68 percent of the studied instructors and researchers had a management background. Seventy-five percent of the respondents were not members of knowledge-intensive enterprises while 75 percent were members of scientific associations. The average teaching and research experience of the respondents was 12.27 and 18.3 years, respectively, and most research and research faculty members were engaged in teaching in scientific-applied courses and in-training courses for the staff of MJA and in higher education centers.

The results showed that in the last five years, over 57 percent of the respondents had not attended any courses on entrepreneurship and commercialization. In addition, only 21 percent had the experience to work in a startup company.

Regarding the research background, except for two respondents who left the question unanswered, all studied people had published/presented paper(s) in journals/conferences. As well, the rate of publication was about 35 scientific papers per person. Respectively, 94.44, 93.89, 69.89, 69.46, 68.33, and 67.22 percent of the participants had papers in scientific-research journals, national conferences, scientific-extension journals, ISI-indexed journals, and international conferences. This proves their serious attempt to publish the results of their research and field

studies. Also, 50 percent of the respondents had no commercialized research recorded while 22.5 percent had only one commercialized project, and only 3.3 percent had already over 10 commercialized projects. Meanwhile, 80 percent of the respondents had no certified patents. Based on the results, only 13.3 percent had been successful in selling their achievements and about 7 percent had failed to sell them. Thus, it is clear that over 86 percent of the research projects conducted in 2016-2017 have failed to directly turn into wealth; accordingly, only about 13 percent (23 respondents) have earned income from the sale of their technological achievements

The examination of the effective factors influencing the establishment of the commercialization system in IAREs showed that according to the means, 'motivational-behavioral', 'structural-organizational', and 'contextual-environmental' factors were the most important for the establishment of this system, respectively. Tables 2 to 4 show the ranking of the items related to these constructs.

Table 2

The Statistics of the Items Related to the 'Structural-Organizational' Construct of the Establishment of a Commercialization System

Item	Mean	SD*	CV**	Priority
Facilitating the joint investment of the private sector and IAREs in technology generation	4.207	0.762	0.181	1
Activating the office of relation with industry and its effective interaction with other units of IAREs	4.224	0.784	0.186	2
Appropriately investing in upgrading technology development infrastructure	4.274	0.813	0.190	3
Making arrangements for enhancing the research capabilities of researchers and instructors	4.180	0.817	0.196	4
Creating an organizational mechanism for safeguarding intellectual property and achievements	4.129	0.830	0.201	5
Implementing visions and missions related to technology development in IAREs	3.921	0.820	0.209	6
Implementing an integrated management system for the affairs of commercializing technological achievements	3.994	0.838	0.210	7
Developing an action plan for technology development in IAREs	3.994	0.851	0.213	8
Developing an active growth center in IAREs to facilitate commercialization	3.887	0.865	0.223	9
Facilitating the official process of patenting	3.955	0.882	0.223	10
Making the attachment of commercialization to research proposals compulsory	3.084	1.089	0.353	11
Forming a database of research and technological ideas	4.157	2.400	0.577	12

*SD = standard deviation; **CV = coefficient of variations; Mean = 4.005

Table 3

The Statistics of the Items Related to the 'Contextual-Environmental' Construct of the Establishment of a Commercialization System

Item	Mean	SD	CV	Priority
Identifying the needs of the agricultural sector for technological achievements	4.232	0.737	0.174	1
Making the commercialization of technological achievements cost-effective	3.948	0.777	0.197	2
Creating a supportive mechanism to help researchers and instructors launch knowledge-intensive enterprises	4.118	0.832	0.202	3
Fostering the atmosphere of group cooperation in technological achievements	3.933	0.811	0.206	4
Creating a mechanism to include the indices of technology commercialization in promotion of scientific rank of researchers and instructors	3.758	0.910	0.242	5
Ensuring practical commitment of IAREs to pursue their commercialization programs	3.623	0.913	0.252	6
Outsourcing some research affairs to the private sector	3.646	1.005	0.276	7
Fostering a competition atmosphere to commercialize research findings of IAREs	3.989	3.872	0.971	8

Mean = 3.900

Table 4

The Statistics of the Items Related to the 'Motivational-Behavioral' Construct of the Establishment of a Commercialization System

Item	Mean	SD	CV	Priority
Motivating managers to continuously support research commercialization	4.180	0.789	0.189	1
Supporting innovative activities in IAREs	4.251	0.813	0.191	2
Creating a mechanism of valuation for technological achievements	3.972	0.858	0.216	3
Providing incentives to people who commercialize technological achievements	4.134	0.902	0.218	4
Strengthening the morale of entrepreneurship among researchers and instructors	3.949	0.878	0.222	5
Developing the culture of preferring the generation of technological achievements in IAREs	3.821	0.862	0.226	6
Providing the facilities and equipment for the participation of researchers and instructors in symposiums	3.939	0.900	0.229	7
Continuously training researchers and instructors about the identification of the technological needs of the agricultural sector	4.106	0.939	0.229	8
Making researchers and instructors aware of the laws, regulations, and procedures of commercialization	3.899	0.906	0.232	9
Creating the culture of knowledge and technology commercialization in IAREs	3.807	0.909	0.238	10

Mean = 4.006

The results of the analysis of variance of the participants' opinions towards the influential factors are presented in Table 5. Evidently, there were not any significant differences between different educational levels regarding their opinions. Similar to the academic level, there were not any significant differences among different academic rank groups.

In another part of the research, it was found that the respondents who were members of a knowledge-intensive enterprise had a more favorable opinion about the constructs influencing the establishment of a commercialization system in IAREs compared with non-members. Also, the mean value of the opinion of members of the scientific association was significantly higher than non-members. Accordingly, the respondents who had participated in the startup programs had a significantly more favorable opinion about the constructs influencing the establishment of a commercialization system in IAREs compared.

With others, indicating that this participation motivates researchers and instructors to focus on the issues of 'research finding commercialization' (Table 6).

Table 5

The Results of the Analysis of Variance of the Participants' Opinions About the Factors Influencing the Establishment of a Commercial System Based on the Variables of 'Educational Level' and 'Academic Rank'

Variable	Source of variance	SS*	df	MS**	F	*p*-value
Educational level	Between groups	174.629	2	87.315	0.274	0.761^{ns}
	Within groups	55754.635	175	318.598		
	Total	55929.264	177			
Academic rank	Between groups	683.073	2	341.536	1.463	0.235^{ns}
	Within groups	34095.102	146	233.528		
	Total	34778.174	148			

^{ns} not significant; *SS = some of squares; ** MS= Mean square

Table 6

The Results of the Comparison of the Participants' Opinions About the Factors Influencing the Establishment of a Commercialization System in IAREs

Variable	Respondent groups	Frequency	Mean	SD	Df	t-value	*p*-value
Organizational position	Faculty member	147	117.5	15.4	176	-0.056	0.956^{ns}
	Non-member	31	117.77	26.6			
Main job	Teaching	31	118.96	28.94	165	0.347	0.729^{ns}
	Research	136	117.72	14.58			
Membership inknowledge-intensive firms	Member	46	123.65	15.51	178	2.69	0.008**
	Non-member	134	115.65	17.97			
Membership inscientific associations	Member	135	119.65	17.56	178	2.60	0.010*
	Non-member	45	111.84	16.93			
Participation in startups	Participated	14	126.71	21.11	178	-2.00	0.047*
	Not participated	166	116.93	17.22			

* $p<0.05$, ** $p<0.01$

The constructs influencing the establishment and development of a commercialization system were examined by one-sample t-test with the cutoff value of 3 in which if the frequency of 'high' and 'very high' choices was significantly more than that of 'low' and 'very low' choices, the test would then be significant. The results showed that all items of the three constructs influenced the establishment and development of a commercialization system significantly except for the item 'making the attachment of commercialization to research proposals compulsory' Table 7.

In order to determine the educational needs of the studied researchers and instructors and to develop a plan for the educational workshop of 'the development of commercialization capabilities among instructors and researchers', it was tried to assess the respondents' knowledge of how to commercialize research. The results of 'mean' statistic showed that in total, the knowledge and skill of the studied sample was below average (mean=2.8) and they were most knowledgeable in 'teamwork techniques', 'how to establish a knowledge-intensive firm', 'the concepts, laws, and regulations of technology transfer', and 'the laws and regulations of intellectual property'. On the other hand, according to the calculated coefficient of variations, it is imperative for developing a training plan to enhance the knowledge and awareness of the research sample in the fields enumerated in Table 8. In the first step, the focus should be placed on the issues in which target audiences are weaker. In the first place, the respondents need to be more familiar with issues recognition of industrial clusters, methods to valuate technology, and principles and techniques of commercial negotiation.

To understand the differences between the respondents with respect to their knowledge, means comparison test was used. The results showed that there were no significant differences between different groups of the respondents regarding their knowledge of commercialization (Tables 9 and 10).

Finally, Table 11 revealed a relationship between the respondents' demographic features and their knowledge of commercialization. As it was shown, there was a positive relationship between knowledge and the variable of 'teaching experience' at the $p < 0.01$ level. This means that respondents with more years of experience in teaching were 95% more likely to be more knowledgeable about the issues of commercialization. Also, the individuals with more experience in participating in startup training courses were 99% more likely to have more knowledge of the commercialization issues.

DISCUSSION AND CONCLUSION

Given the deficiency of governmental funds, the Iranian IAREs need income generation by selling the research findings and technological achievements of their researchers and instructors. The sustainability of these institutes in the field of research, education, and development of human resources and agricultural productivity developments is to move towards market-orientation and the supply of market demand for capable and creative human resources and technologies that are compatible with their needs. So, this study was aimed to identify the effective constructs underpinning the establishment and development of a commercialization system for research findings and educational needs of the people involved in this process in the Iranian IAREs. Based on the review of the theoretical, conceptual, and empirical models of previous research as well as expert opinions, three constructs of 'motivational-behavioral', 'structural-organizational', and 'contextual-environmental' were identified as the most influential factors on the establishment and development of a commercialization system in these institutes, respectively.

According to the results, there is a need to focus on the improvement of the motivational-behavioral factors of researchers to improve the commercialization of the research activities. In this regard, motivating

Table 7

The Results of Means Comparison for the Factors Underpinning the Establishment of a Commercialization System in IAREs (test value = 3)

Subjects	Mean difference	df	t	*p*-value
Structural-organizational				
Implementing an integrated management system for the affairs of commercializing technological achievements	0.99	175	15.73	0.000
Facilitating the official process of patenting	.95	177	14.45	0.000
Creating an organizational mechanism for safeguarding intellectual property and achievements	1.13	177	18.14	0.000
Activating the office of relation with industry and its effective interaction with other units of AIREs	1.22	173	20.60	0.000
Forming a database of research and technological ideas	1.16	177	6.43	0.000
Developing an active growth center in IAREs to facilitate commercialization	0.89	176	13.64	0.000
Making arrangements for enhancing the research capabilities of researchers and instructors	1.18	177	19.26	0.000
Appropriately investing in upgrading technology development infrastructure	1.27	178	20.97	0.000
Implementing visions and missions related to technology development in IAREs	0.92	177	115.00	0.000
Developing an action plan for technology development in AIREs	0.99	178	15.63	0.000
Facilitating the joint investment of the private sector and IAREs in technology generation	1.21	173	20.88	0.000
Making the attachment of commercialization to research proposals compulsory	0.08	177	1.03	0.303
Contextual-environmental				
Fostering the atmosphere of group cooperation in technological achievements	0.93	178	15.38	0.000
Identifying the needs of the agricultural sector for technological achievements	1.23	176	22.24	0.000
Outsourcing some research affairs to the private sector	0.65	177	8.58	0.000
Making the commercialization of technological achievements cost-effective	0.95	173	16.09	0.000
Fostering a competition atmosphere to commercialize research findings of IAREs	0.99	177	3.41	0.001
Creating a supportive mechanism to help researchers and instructors launch knowledge-intensive enterprises	1.128	177	17.93	0.000
Ensuring practical commitment of IAREs to pursue their commercialization programs	0.62	174	9.03	0.000
Creating a mechanism to include the indices of technology commercialization in promotion of scientific rank of researchers and instructors	0.76	177	11.12	0.000
Motivational and behavioral				
Providing incentives to people who commercialize technological achievements	1.13	178	16.82	0.000
Creating a mechanism of valuation for technological achievements	0.97	175	15.02	0.000
Providing the facilities and equipment for the participation of researchers and instructors in symposiums	0.94	178	13.95	0.000
Developing the culture of preferring the generation of technological achievements in IAREs	0.82	178	12.75	0.000
Strengthening the morale of entrepreneurship among researchers and instructors	0.95	177	14.42	0.000
Making researchers and instructors aware of the laws, regulations, and procedures of commercialization	0.90	178	13.28	0.000
Continuously training researchers and instructors about the identification of the technological needs of the agricultural sector	1.11	178	15.76	0.000
Supporting innovative activities in IAREs	1.25	178	20.59	0.000
Motivating managers to continuously support research commercialization	1.18	177	19.94	0.000
Creating the culture of knowledge and technology commercialization in IAREs	0.81	176	11.82	0.000

Table 8

Ranking of the Respondents' Knowledge of and Awareness With Commercialization

Items	Mean	SD	CV	Priority
Awareness with the concepts, laws, and regulations of technology transfer	3.078	0.720	0.234	1
Awareness with teamwork techniques	3.233	0.866	0.268	2
Awareness with technology management and its national and international networking	2.754	0.746	0.271	3
Awareness with the concepts, laws, and regulations of science and technology parks and growth centers	2.983	0.811	0.272	4
Awareness with the concepts, laws, and regulations of intellectual property	3.072	0.872	0.284	5
Awareness with the principles of commercializing research findings	2.838	0.815	0.287	6
Awareness with how to establish knowledge-intensive enterprises	3.162	0.949	0.300	7
Awareness with the techniques of creativity	2.915	0.881	0.302	8
Awareness with entrepreneurship and self-employment skill	2.983	0.915	0.307	9
Awareness with how to interact with industrial and production units of the agricultural sector	2.822	0.892	0.316	10
Awareness with how to found and manage a firm	3.067	0.986	0.322	11
Awareness with the methods of technology market analysis of Iran	2.570	0.886	0.345	12
Awareness with how to found and manage a growth center	2.715	0.996	0.367	13
Awareness with startups and how to establish and manage them	2.590	0.954	0.368	14
Awareness with the development of a business plan	2.732	1.025	0.375	15
Awareness with strategic management	2.624	1.008	0.384	16
Awareness with technical knowledge sale techniques	2.539	0.981	0.386	17
Awareness with the principles and techniques of commercial negotiation	2.601	1.032	0.397	18
Awareness with methods to valuate technology	2.458	0.990	0.403	19
Awareness with the recognition of industrial clusters	2.446	1.027	0.420	20

Mean = 2.81

Table 9

The Results of Means Comparison Test (t-test) for the Respondents' Knowledge of Commercialization

Independent variables		n	Mean	SD	SE*	df	*t*-value	*p*-value
Position	Faculty member	147	55.95	14.10	1.16328	176	-0.327	0.744
	Instructor	31	56.87	14.70	2.63995			
Main job	Teaching	31	54.90	16.79	3.01514	165	0.288	0.774
	Research	136	55.71	13.49	1.15672			
Knowledge-intensiveenterprise	Member	46	57.97	14.42	2.12587	178	1.081	0.281
	Non-member	134	55.36	14.04	1.21292			
Scientific association	Member	135	56.58	14.08	1.21154	178	0.894	0.373
	Non-member	45	54.40	14.38	2.14321			
Participation in startups	Yes	166	54.90	13.54	1.05114	178	-3.850**	0.000
	No	14	69.50	14.65	3.91636			

*SE= Standard error, ** $p<0.01$

Table 10

The Results of Variance Analysis (F-test) for the Respondents' Knowledge of Commercialization

Independent variables	Groups	SS	df	MS	F	*p*-value
Education level	Between groups	15.41	55	0.280	1.125	0.294
	Within groups	30.41	122	0.249		
	Total	45.82	177			
Academic rank	Between groups	18.99	50	0.380	1.149	0.277
	Within groups	32.41	98	0.331		
	Total	51.41	148			
Experience in teaching	Between groups	32.11	51	0.630	1.224	0.205
	Within groups	42.19	82	0.515		
	Total	74.31	133			
Experience in research	Between groups	28.82	54	0.534	1.060	0.389
	Within groups	58.88	117	0.503		
	Total	87.70	171			
Experience in management	Between groups	24.71	47	0.526	1.362	0.115
	Within groups	28.94	75	0.386		
	Total	53.66	122			

Table 11

The Results of Correlation Test for the Respondents' Knowledge of Commercialization With Some Demographic and Professional Characteristics

Variables	Correlation coefficient test	Value	*p*-value
Educational level	Spearman	0.071	0.345
Academic rank	Spearman	0.094	0.253
Grade	Pearson	0.013	0.895
Teaching experience	Pearson	0.170*	0.049
Research experience	Pearson	0.065	0.394
Management experience	Pearson	0.141	0.119
Project purchase history	Pearson	-0.114	0.502
History of project use	Pearson	0.046	0.612
Participation in start-up	Spearman	0.277**	0.000

* $p<0.05$, ** $p<0.01$

managers to continuously support research commercialization, supporting innovative activities in IAREs, and creating a mechanism of valuation for technological achievements would be useful. Samsom and Gurdon (1993) and Namdarian and Naimi-Sadigh (2018) have mentioned the motivational and behavioral factors as a barrier to commercializing research. To overcome the lack of researchers' motivation to commercialize their research findings, it is suggested to change the faculty members' status promotion guidelines. Also, Vanderford and Marcinkowski (2015) suggested greater per-

sonal benefits including more royalty pay and increasing financial support.

The structural-organizational factors were another main construct of the development of commercialization. Based on the finding, facilitating the joint investment of the private sector and IAREs in technology generation, activating the office of relation with industry and its effective interaction with other units of IAREs, and appropriately investing in upgrading technology development infrastructure are suitable ways to facilitate research commercialization.

The third main construct of the commercialization of research findings was contextual-environmental. The research findings indicated that identifying the needs of the agricultural sector for technological achievements, making the commercialization of technological achievements cost-effective, and creating a supportive mechanism to help researchers and instructors launch knowledge-intensive enterprises are a desirable way to develop commercialization. Bulsara et al. (2010), Tahvanainen and Nikulainen (2011), and Namdarian and Naimi-Sadigh (2018) have pointed to the organizational challenges that drive the commercialization process. In this regard, Vanderford and Marcinkowski (2015) emphasize the increasing links to industry.

In the meantime, the main ways to establish and develop a commercialization system in the studied institutes are to create a favorable attitude in managers for the continuous support of research commercialization, to facilitate the investment of the private sector and the institutes on technology production and on the identification of the technological needs of the agricultural sector, to provide economic benefits in the commercialization of technological achievements, and to create a supportive mechanism to help researchers and instructors launch knowledge-intensive enterprises. These findings are consistent with the results of Nadirkhanlou et al. (2012). Our results about the need for considering supportive policies and approaches and developing communication with the industry are in agreement with the findings of Bezuidenhout (2018).

On the other hand, among the independent variables studied, the variables of 'membership in knowledge-intensive enterprises', 'membership in scientific associations' and 'participation in startups' had a significant effect on the viewpoints of the respondents about the constructs influencing the establishment and development of a commercialization system for IAREs. This is of crucial importance to the process of the establishment and development of a commercialization system given the effect of these memberships, the attendance in the programs of the generation of new ideas and innovations, and the presence of investors in startup programs and its significance for the commercialization of research findings of instructors and researchers. These results are consistent with the findings of Unachukwu (2009) about creating a suitable work environment, increasing self-confidence, and promoting entrepreneurial behaviors in human resources.

Another part of the research showed that the participants had less than moderate knowledge of commercialization. Since over 57 percent of them had not participated in any entrepreneurial and commercialization training programs in the last five years, and approximately 14% had only taken one program, and on the other hand, about 80% had not appeared in any startup programs, it seems that either there have been no appropriate and long-term programs for the empowerment of instructors and researchers in IAREs or these programs have not been welcomed adequately. Maybe this is why 50% of them lacked any research whose achievements had been commercialized, and about 80 percent lacked any patents. These findings are consistent with the results of Stuetzer et al. (2013), Arabioun et al. (2012), and Hajimirrahimi (2012), about the poor capabilities of researchers in commercialization and the achievement to uncommercializable re-

sults in their research projects.

The results of the research confirmed that to empower researchers and instructors, they should mainly be trained about the concepts, laws, and regulations of technology transfer, teamwork techniques, technology management and its networking at the national and international levels, laws and regulations of science and technology parks and growth centers, and concepts, laws, and regulations of intellectual property. Our finding of the need to focus on intellectual property is in agreement with Valadan and Rezaei (2016). At the same time, only two variables of 'teaching experience' and 'participation in startup programs' had a significant and positive relationship with the participants' knowledge and awareness level. Accordingly, more teaching experience and more participation in startup programs enrich the experience of researchers and instructors and their awareness of the technology needs of the agricultural sector so that they have been involved in research projects whose results have tackled a problem of the agricultural sector.

Basically, in the age of knowledge economy, IREs will make no sense if they do not commercialize their research achievements because if there is no customer for achievement, the production and/or testing of an idea will be profitless. The involvement of these institutions in the trade and marketing of their products and the consideration of market requirements and customer standards will create good opportunities and positive consequences – the consequences whose least advantage will be to contribute to the self-reliance of the institutions and their most advantage will be to contribute to the improvement of life standards (safety and security), life quality, wealth production, and economic growth. However, gaining the ability to convert market-driven research ideas into technical-economic technologies can, in particular, change raw material selling nations into nations that sell technical-economic knowledge. Undoubtedly, financial stability ',' financial resources development and 'the design and implementation of effective projects and programs' are the most important indicators of the sustainability of effectively and efficiently managed IREs. To achieve such a situation, it is necessary to consider the constructs underpinning the establishment and development of a commercialization system of research findings and the empowerment of their specialized human resource.

In the end, the following recommendations can be drawn from the research findings:

Given the top priority of motivational-behavioral constructs and the low level of the participants' knowledge and awareness, training courses should be developed to empower researchers and instructors about the commercialization of research finding and the relative issues with emphasis on the concepts, laws, and regulations of technology transfer, teamwork techniques, technology management and its national and international networking, concepts, laws and regulations of science and technology parks and growth centers, and intellectual property.

With respect to the impact of the variables of membership in knowledge-intensive enterprises, in scientific associations, and in startups on the participants' opinions about the constructs affecting the establishment and development of a commercialization system, it is recommended to provide financial and non-financial support for researchers and instructors to participate in knowledge-intensive enterprises, scientific associations, and startups.

Given the constructs and methods that are effective in establishing and developing a commercialization system in the studied institutes, it is recommended

To develop and implement a specifically-designed training course to create a favorable attitude in managers for the continuous support of research commercialization.

To prioritize the facilitation of joint investment of the private sector and the institutes on technology generation and the identifica-

tion of the technological needs of the agricultural sector by using the existing laws and regulations.

To make arrangements for the cost-effectiveness of the commercialization of technological achievements.

To develop specifically-designed supporting mechanisms for researchers and instructors to motivate them to launch knowledge-intensive firms in order to exploit the legal opportunities and capacities.

There were several limitations to the process of doing this study. The broad scope of defining the concept of commercialization and the different perceptions of respondents were two of the limitations of the research, which the researcher attempted to overcome by explaining the key concept of commercialization. There was also insufficient up-to-date information on the commercialization of research results. The next limitation was the lack of a specific idea or patent registration structure. Time constraint and low financial credit of the project made the implementation of the project even more challenging. Also, some respondents were reluctant to fill in the questionnaires or answer them incompletely.

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