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Original Research

Effective Factors on Knowledge Commercialization in Payam-e-Noor University

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Abstract

Commercialization of research results refers to a set of efforts aimed at raising capital and increasing the relationship between the academic and research sector and economic and social sector. The present study intends to identify and rank the factors affecting the commercialization process of research results at Payam-e-Noor University in order to determine the extent of influence of the identified factors. Therefore, this is an applied research in terms of purpose, which studies the factors affecting the process of knowledge commercialization in previous studies, using the confirmatory factor analysis approach. Using fuzzy hierarchical analysis, it was determined that legal, economic, manpower, cultural, structural and political, and communicational and information-related barriers are the first to sixth barriers to the knowledge commercialization in Payam-e-Noor University. Using fuzzy DEMATEL technique, the effectiveness and affectability of factors involved in the process of knowledge commercialization were identified. Accordingly, weak legal framework for supporting idea people at the university, inefficiency and ineffectiveness of the rules and regulations for commercialization, lack of regulation for the apportionment of financial gain from commercialization among scholars, lack of skilled and expert human resources in the universities, lack of facilities and financial resources for research commercialization, and lack of mutual recognition between university and industry had the most affectability. In other words, these are the dependent/outcome variables of the model. On the other hand, inadequate knowledge of the faculty members, poor fund management in the university, weakness of universities in wealth creation, absence of university entrepreneurial missions, the absence of up-to-date and effective idea banks and databases in the universities, and lack of effective communication between students and industry sector's activists had the most effectiveness. In other words, these variables are the independent/causal variables of the model.

Keywords: Commercialization, research results, Knowledge Commercialization, Knowledge Commercialization Model, Payam-e-Noor University.

Introduction

Commercialization is an attempt to accelerate the development of goods and services is a byproduct of knowledge, innovations and technologies produced at universities and research institutes. Universities can promote commercialization through knowledge transfer programs, collaborative research agreements with industry section, applying for a patent and a license, marketing, nurturing students' talent, and collaborating with research institutes and parks. Commercialization activities are important mechanisms through which universities directly affect national and regional economic development (Etzkowitz, Webster, Gebhardt, & Terra, 2000; Nelles & Vorley, 2010). In recent years, knowledge valuation and commercialization have been considered as an important stimulus for economic growth(Biranvand, Seif, Safa & Mazloumian, 2019; Baycan & Stough, 2012; Etzkowitz, 1990; Viale & Etzkowitz, 2010; Litan, Mitchell & Reedy, 2007), and especially for improving the capacity development and economic performance in the region(Duch Brown, Garcia-Estevez & Parellada-Sabata, 2011; Goldstein & Renault, 2004; Shane, 2004). The introduction of new perspectives on the role of universities in knowledge production systems has gradually changed the traditional mission of universities, i.e. education and research, and universities adopted an additional third mission, namely "business activities" such as applying for a patent and a license and establishing companies(Baldini, 2006; Owen-Smith & Powell, 2003; Rasmussen, Moen & Gulbrandsen, 2006). Currently, universities are expected to strengthen and support economic growth, and to bring about economic growth by producing new knowledge and human capital, licensing of innovations, and establishing new companies. Knowledge commercialization reduces the dependence of universities to public budget. On the other hand, consideration of the commercialization of research results and innovations is the manifestation of recognizing the importance of science and technology and the approval of their direct effect on economic, social, cultural, and political development(Biranvand, 2018). The adoption of this approach is a promising start in removing the existing barriers to the formation of a knowledge based economy. The success of academic sections in commercialization of research results necessitates the provision of important and different prerequisites and requirements in the academic, industry, and the dominant socio-economic environment of the two sectors. Pazhouhesh Jahromi (2016) in his research asserts that, given the current academic philosophy, research commercialization at universities is necessary in order to fill up the income basket and to provide services to the community. However, despite its necessity, research commercialization is a difficult process and it might be followed by a lot of failures which are mainly due to the difference in cultural context and the environmental difference between the origin (university) and destination (industry) of the technology(Pazhouhesh Jahromi, 2016).

Trend of business environment and the global economy over the last few decades indicated that the development of any society is depended on scientific research and its application in economy. The hidden economic potential of scientific findings will be realized when we turn the findings into innovations in an effective way(Daynich & Wang, 2016). Therefore, the rate of scientific growth over the past few decades and the rapid movement of the world on knowledge based approaches today, essentially demanded further attention to science and knowledge transformation into commercial products; the development of science and technology is considered as an inevitable requirement for achieving knowledge based economy (Roknijo, Jafari, Yazdani & Alvani, 2017). Today, there are several barriers such as political, legal, economic, structural and organizational, communication, environmental, lack of market

understanding and sufficient human resource that hinder the process of development and commercialization in Iran (Biranvand, 2018); therefore, strengthening the relationship and cummunication between research and academic sector and industry in order to maximize commercialization opportunities is of vital importance. On the other hand, Payam-e-Noor University, due to its dependence on the non-governmental budget, obtains a large part of its budget from private revenues and student tuition. Therefore, it needs solutions to be able to obtain part of the required budget from commercialization of its research results. Therefore, in order to answer the main question of the research, "What are the factors of commercialization of research results in Payam-e-Noor University (PNU) and what strategic proposals can be presented in this field?", we will identify the factors of commercialization in PNU, provide a structural-interpretive model related to the barriers to knowledge commercialization, and provide appropriate strategic suggestions to remove barriers and improve the commercialization conditions for research results.

Literature Review

Commercialization at universities is a challenging issue, since business activities are in contrast to the traditional roles of the universities, that is the provision of education and research. However, it can be considered as a new goal in order to achieve economic benefits. The commercialization of knowledge in universities is influenced by two categories of preventive and progressive forces. Among preventive forces, we can mention barriers and challenges of knowledge commercialization at universities. Many studies have been conducted to identify barriers to knowledge commercialization and the related minor issues in this area. Factors such as lack of sufficient capital (Biranvand & Seif, 2018; Irani, hayak, & Asetmal, 2018; Rezaie, Karimi & Moghadam, 2015); absence of commercialization culture (Biranvand, 2018; Biranvand & Seif, 2018; Rezaie et al., 2015; Zahra, Kaul & Bolivar, 2018; Hmieleski & Powell, 2018); preventive policies (Biranvand, 2018; Zahra et al., 2018; Jahed, 2011); lack of communication between university and industry (Biranvand, 2018; Pazhouhesh Jahromi, 2016; Pourezzat & Gholipour, 2009; Rezaie et al., 2015); and the weakness of human resources (Abasi, 2017)has been investigated in previous studies. In the following, Barriers to the commercialization of knowledge in universities are listed in Table1:

Table1
Barriers to the commercialization of knowledge

Indexes	Results
Lack of investor / budget	(Pourezzat & Gholipour, 2009; Rezaei, Karimi, & Chorshab Moghaddam, 2015; Siegel, Waldman & Link, 2003)
Lack of academic policies and missions in the field of knowledge commercialization	(Hmieleski & Powell, 2018; Pourezzat & Gholipour, 2009; Pourezzat, Gholipour, & Nadirkhanloo, 2010; Rezaei et al., 2015)
Lack of knowledge-building culture in the university	(Biranvand, 2018; Hmieleski & Powell, 2018; Rezaei et al., 2015; Zahra, Kaul & Bolivar, 2018)
Existence of knowledge-based deterrent policies	(Pourazat, Gholoipour & NadirKhanloo, 2010; Pourezzat & Gholipour, 2009; Rezaei et al., 2015; Siegel, Waldman & Link, 2003; Zahra et al., 2018)

Indexes	Results
Lack of connection between university and industry	(Biranvand, 2018, 2018; Biranvand, Seif & Cheraghi, 2018; Pourazat et al., 2010; Pourezzat & Gholipour, 2009; Rezaei et al., 2015; Zahra et al., 2018)
Inefficiency of rules and regulations	(Hmieleski & Powell, 2018; Rezaei et al., 2015; Siegel, Waldman & Link, 2003; Zahra et al., 2018)
Lack of determination of sectoral priorities and main national priorities	(Hmieleski & Powell, 2018; Pazhouhesh Jahromi, 2016; Rezaei et al., 2015; Siegel, Waldman & Link, 2003; Zahra et al., 2018)
There are political obstacles, such as the embargo on raw materials	(Rezaei et al., 2015)
Lack of financial and human resources in academic technology transfer institutions	(Rezaei et al., 2015)
The difference between the views of industry and investors with the academic sector	(Rezaei et al., 2015; Siegel, Waldman & Link, 2003)
Lack of mutual trust between academia, industry, and investors	(Jung, Lee & Lee, 2015; Pourazat et al., 2010; Pourezzat & Gholipour, 2009; Rezaei et al., 2015; Siegel, Waldman, Atwater & Link, 2003; Zahra et al., 2018)
Weakness in the mutual recognition between university and industry	(Pourezzat & Gholipour, 2009; Rezaei et al., 2015; Zahra et al., 2018)

Research Objectives

The design of knowledge commercialization mechanisms and its operationalization, in the first place, requires identifying the effective factors on the commercialization of research results at universities. To this end, the present research aimed to identify the effective factors on the commercialization of research results at Payam-e-Noor University through experts' opinion in order to provide strategic recommendation and to introduce an interpretive structural model of the commercialization of research results at Payam-e-Noor University. In this regard, the following objectives are identified:

1. To identify and to prioritize factors that affect commercialization of the research results at Payam-e-Noor University;
2. To determine the cause-and-effect relationship between the factors that affect commercialization of the research results at Payam-e-Noor University;
3. To introduce an interpretative structural model of the effective factors on commercialization of the results research at Payam-e-Noor University;
4. To present strategic recommendation for the elimination of barriers to commercialization of the research result at Payam-e-Noor University.

Research Questions

1. What are the effective factors on commercialization of the research results and what is their order of priority?
2. What cause-and-effect relationships exist between the effective factors on commercialization of the research results at Payam-e-Noor University?
3. What is the interpretative structural model of the effective factors on commercialization of the results research at Payam-e-Noor University?

4. What strategic recommendation can be presented for commercialization of the research result at Payam-e-Noor University?

Materials and Methods

Given the applicable results of the present research, it is an applied research in practice and it is conducted based on confirmatory factor analysis. In this research, Data were collected through the review of previous studies, experts' opinion on knowledge commercialization, and Delphi method. Fuzzy Delphi method was used for validation and screening the identified factors, and fuzzy AHP was used for prioritizing barriers to commercialization. Fuzzy DEMATEL technique and interpretive structural modeling were used for the development of the model and the identification of the relationship between variables. The research questionnaire based on fuzzy DEMATEL technique aimed to identify the causal relationship pattern between the research variables. The research community is knowledge commercialization experts at Payam-e-Noor University. 30 people were selected among these experts based on purposive sampling. In the Delphi method, the criterion for selecting experts includes: theoretical mastery, practical experience, willingness and ability to participate in research and accessibility. Based on the characteristics of the people in this study and identifying people in the field of subject specialization and also the impact of these people in their field of expertise at PNU, a non-probabilistic approach was targeted or judged. Saati (1990) believes that ten experts are sufficient for studies based on pairwise comparison.

Results

To evaluate the research objectives, first the identified barriers to knowledge commercialization was presented, and then they were prioritized so that the driving and dependence power of each index could be measured through the interpretive structural equation modeling. Ultimately, the interpretive structural model related to the prioritization of the barriers is presented.

Descriptive Findings

The descriptive findings include information on the composition of the Delphi Panel and the calculation of the reliability coefficient of the questionnaire.

Composition of the Delphi panel

The composition of the Delphi panel is represented in Table2.

Table 2
Education Level and Academic Rank of Delphi Panel Members

Field of Study	Academic Rank	Number
physics	Instructor Assistant Professor Associate Professor	6
Chemistry	Assistant Professor	3
Agriculture	Assistant Professor	4
Industrial Management	Instructor Assistant Professor	2
Total		15

According to Table 2, most of the Delphi panel members are in the field of science.

Reliability Coefficient of the Questionnaire

Cronbach's alpha coefficient was used to calculate the reliability coefficient of the questionnaire. Reliability indicates, to what extent, the measurement instrument will produce the same result under equivalent conditions. If the Cronbach's alpha coefficient calculated for a scale is greater than 0.7, then the reliability of that scale is considered as desirable.

Table 3
Results of Cronbach's Alpha

Factor	Questions number	Cronbach's alpha
Legal	5	0.783
Human resource	4	0.770
Economic	5	0.738
Structural and policy	5	0.873
Communication and information	4	0.892
Cultural	5	0.886

Cronbach's alpha coefficient was greater than 0.7 for each factors and it was 0.895 for the whole questionnaire. Therefore, the reliability of the questionnaire has been evaluated as desirable.

Analytical Findings

Identifying and prioritizing factors of knowledge commercialization

In the first step, we identified and screened barriers to knowledge commercialization in the universities. Based on literature review, 28 indices were extracted from among the identified factors. In the next step, fuzzy Delphi method was used for identifying and screening the ultimate indices. Based on fuzzy 7 point scale (Table 4), the fuzzy mean and the defuzzified output values relevant to indices were calculated (Table 5). The defuzzified value above 0.7 is acceptable and any index scored less than 0.7 is eliminated.

Table 4
Fuzzy 7 Point Scale

Definitive equivalent	Language variable	Fuzzy Number Scale
1	Absolutely trivial	(0, 0, 0.1)
2	Very trivial	(0, 0.1, 0.3)
3	Trivial	(0.1, 0.3, 0.5)
4	Average	(0.3, 0.5, 0.75)
5	Important	(0.5, 0.75, 0.9)
6	Very important	(0.75, 0.9, 1)
7	Absolutely important	(0.9, 1, 1)

To find the sum of the respondents' opinions and to compute the fuzzy mean of their opinions, the following equation is used:

$$F_{AGR} = \left(min\{\mathrm{l}\}, \left\{ \frac{\sum m}{n} \right\}, max\{u\} \right)$$

In the next step, defuzzification of values is performed. Generally, the summation of triangular and trapezoidal fuzzy numbers can be summed up by a crisp value which is the best corresponding mean. The operation is called defuzzification. There are several defuzzification methods. In the present study, the center-of-area method is used for defuzzification, as follows:

$$DF_{ij} = \frac{\left[(u_{ij} - l_{ij}) + (m_{ij} - l_{ij})\right]}{3} + l_{ij}$$

The fuzzy mean and the defuzzified output of the values relevant to the indices, extracted from the review of the previous sources, are represented in Table 4. Accordingly, 28 indices have been approved as effective factors of knowledge commercialization at Payam-e-Noor University.

Table 5
Results Obtained from Index Screening

Code	Indexes	L	M	U	Crisp	Results
S_{01}	Weak legal framework for supporting idea people at the university	0.58	0.75	0.88	0.74	Accept
S_{02}	Inefficiency and ineffectiveness of the rules and regulations for commercialization, researchers	0.59	0.77	0.89	0.75	Accept
S_{03}	Lack of regulation for the apportionment of financial gain from commercialization among scholars	0.62	0.80	0.92	0.78	Accept
S_{04}	Lack of intellectual property rights ownership rights derived from joint research with industry	0.57	0.74	0.88	0.73	Accept
S_{05}	Lack of effective policies to improve the quality of academic research	0.67	0.83	0.93	0.81	Accept
S_{06}	Law intention towards commercialization	0.68	0.85	0.95	0.83	Accept
S_{07}	Lack of skilled and expert human resources	0.60	0.78	0.90	0.76	Accept
S_{08}	Weakness of the university with high motivation for human capital	0.61	0.80	0.92	0.78	Accept
S_{09}	Inadequate knowledge of the faculty members	0.60	0.78	0.91	0.77	Accept
S_{10}	The inadequacy of the scholar's share in the commercialization revenues	0.61	0.79	0.91	0.77	Accept
S_{11}	Poor fund management in the university	0.66	0.82	0.92	0.80	Accept
S_{12}	Weakness of universities in wealth creation	0.59	0.77	0.90	0.75	Accept
S_{13}	Lack of financial resources and facilities for commercialization of research results	0.62	0.80	0.92	0.78	Accept
S_{14}	Lack of university sponsorship from researchers to exploit production know-how	0.72	0.87	0.95	0.85	Accept
S_{15}	Lack of organized organization for the commercialization of academic research	0.65	0.81	0.92	0.79	Accept
S_{16}	Lack of bureaucratic flexibility	0.60	0.78	0.91	0.76	Accept
S_{17}	Absence of university entrepreneurial missions	0.59	0.75	0.87	0.74	Accept
S_{18}	Lack of a research leading university document	0.67	0.83	0.93	0.81	Accept
S_{19}	Lack of effective policies to improve the quality of academic research	0.62	0.79	0.91	0.77	Accept
S_{20}	The absence of up-to-date and effective idea banks and databases in the university	0.62	0.80	0.92	0.78	Accept

Code	Indexes	L	M	U	Crisp	Results
S_{21}	Weakness in mutual recognition of university and industry	0.63	0.81	0.92	0.78	Accept
S_{22}	Weakness in the mutual recognition between university and industry	0.64	0.81	0.93	0.79	Accept
S_{23}	Lack of communication and networks between investors, industry activists and academics	0.65	0.83	0.94	0.81	Accept
S_{24}	Weakness of university consulting services to the community	0.61	0.79	0.91	0.77	Accept
S_{25}	Weak research culture	0.59	0.77	0.90	0.75	Accept
S_{26}	Existence cultural differences between university and industry	0.55	0.75	0.89	0.73	Accept
S_{27}	Weakness of entrepreneurship culture	0.65	0.80	0.90	0.78	Accept
S_{28}	Uncompromising collective sensitivity to the commercialization of knowledge generated at universities	0.57	0.75	0.88	0.73	Accept

Prioritization of the Effective Factors on Knowledge Commercialization

The fuzzy AHP has been used to prioritize the identified indices. Thus, 28 factors were identified and classified into 6 main criteria including: legal, human resource, economic, structural and policy, communication and information, and cultural factors. The criteria are defined and the factors are classified according to the main criteria mentioned in the literature and in the specialized interviews with 3 experts of knowledge commercialization at Payam-e-Noor University. The criteria and indices of the research are named with a numerical index to be easily detected and studied during the research.

At this stage, to prioritize the criteria and the classified factors in the previous step, first, we prioritized the main barriers based on the objective through a pairwise comparison; and then, we prioritized the sub-criteria in the relevant cluster through a pairwise comparison; and finally, we calculated the ultimate weight of indices in order to show the effectiveness of each factor in comparison to other factors.

Saaty's 9 point scale was used for pairwise comparison of the components. In the present study, a fuzzy method was used to quantify the values. Moreover, the geometric mean method is used to find the sum of expert opinions in the fuzzy AHP.

$$F_{AGR} = \left(\prod(l), \prod(m), \prod(u)\right)$$

The calculation results related to the prioritization of the identified factors are presented in Table 6.

Table 6

Prioritization of the Effective Factors on Knowledge Commercialization at Payam-e-Noor University.

Main criteria	W	Code	Indexes	W1	W2	Priority
Legal barriers	0.231	S_{11}	Weak legal framework for supporting idea people at the university	0.293	0.0676	1
		S_{12}	Inefficiency and ineffectiveness of the rules and regulations for commercialization, researchers	0.271	0.0626	2
		S_{13}	Lack of regulation for the apportionment of financial gain from commercialization among scholars	0.216	0.0500	6
		S_{14}	Lack of intellectual property rights ownership rights derived from joint research with industry	0.114	0.0265	19
		S_{15}	Lack of effective policies to improve the quality of academic research	0.106	0.0244	21
Human resource barriers	0.184	S_{21}	Law intention towards commercialization	0.310	0.0568	3
		S_{22}	Lack of skilled and expert human resources	0.245	0.0450	9
		S_{23}	Weakness of the university with high motivation for human capital	0.258	0.0474	8
		S_{24}	Inadequate knowledge of the faculty members	0.187	0.0343	15
Economic barriers	0.231	S_{31}	The inadequacy of the scholar's share in the commercialization revenues	0.264	0.0529	4
		S_{32}	Poor fund management in the university	0.171	0.0344	14
		S_{33}	Weakness of universities in wealth creation	0.241	0.0483	7
		S_{34}	Lack of financial resources and facilities for commercialization of research results	0.181	0.0362	13
		S_{35}	Lack of university sponsorship from researchers to exploit production know-how	0.144	0.0288	18
Structural and policy barriers	0.132	S_{41}	Lack of organized organization for the commercialization of academic research	0.279	0.0368	11
		S_{42}	Lack of bureaucratic flexibility	0.286	0.0377	10
		S_{43}	Absence of university entrepreneurial missions	0.171	0.0225	22
		S_{44}	Lack of a research leading university document	0.154	0.0203	25
		S_{45}	Lack of effective policies to improve the quality of academic research	0.110	0.0145	28
Communication and information barriers	0.114	S_{51}	The absence of up-to-date and effective idea banks and databases in the university	0.271	0.0308	16
		S_{52}	Weakness in mutual recognition of university and industry	0.190	0.0216	23
		S_{53}	Weakness in the mutual recognition between university and industry	0.228	0.0259	20
		S_{54}	Lack of communication and networks between investors, industry activists and academics	0.176	0.0200	26
		S_{55}	Weakness of university consulting services to the community	0.135	0.0153	27
Cultural barriers	0.139	S_{61}	Weak research culture	0.369	0.0514	5
		S_{62}	Existence cultural differences between university	0.261	0.0363	12

Main criteria	W	Code	Indexes	W1	W2	Priority
			and industry			
		S_{63}	Weakness of entrepreneurship culture	0.217	0.0301	17
		S_{64}	Uncompromising collective sensitivity to the commercialization of knowledge generated at universities	0.153	0.0213	24

According to the calculations, the ultimate weight of each effective criterion is calculated using fuzzy AHP. Given the results obtained in this phase, the most important criteria are mentioned in the following order of priority: legal, economic, human, cultural, structural-political, and communicational-information criteria. The prioritized factors listed in each criterion are described below.

Prioritizing the Legal Factors

Factors related to legal criterion are the following: weak legal framework for supporting idea people at the university (S_{11}), inefficiency and ineffectiveness of the rules and regulations for commercialization (S_{12}), lack of regulation for the apportionment of financial gain from commercialization among scholars (S_{13}), lack of regulation for the ownership rights of intellectual property gained from joint research between university and industry sector (S_{14}), absence of effective policies to improve the quality of academic research (S_{15}). The pairwise comparison matrix of legal indices is presented in Table 6.

The result for prioritization of factors related to the legal criterion is as follows:

- Priority 1: weak legal framework for supporting idea people at the university;
- Priority 2: inefficiency and ineffectiveness of the rules and regulations for commercialization;
- Priority 3: lack of regulation for the apportionment of financial gain from commercialization among scholars;
- Priority 4: lack of regulation for the ownership rights of intellectual property gained from joint research between university and industry sector;
- Priority 5: absence of effective policies to improve the quality of academic research.

Prioritizing the Human Factors

The factors related to the human criterion are the following: researchers' law intention towards commercialization (S_{21}), lack of skilled and expert human resources in the universities (S_{22}), lack of motivated human resources in the universities (S_{23}), inadequate knowledge of the faculty members (S_{24}). The pairwise comparison matrix of human resource barrier is presented in Table 5. The inconsistency ratio is around 0.045; therefore, the results are assured.

The result for prioritization of factors related to the human resource is represented in the order of importance, as follows:

- Priority 1: lack of motivation for commercialization among scholars;
- Priority 2: lack of skilled and expert human resources in the universities;
- Priority 3: lack of motivated human resources in the universities;
- Priority 4: inadequate knowledge of the faculty members.

Prioritizing Economic Barriers

The factors related to the economic criterion include: the inadequacy of the scholar's share in the commercialization revenues (S_{31}), weakness of universities in wealth creation (S_{32}), lack of financial resources for research commercialization (S_{33}), poor fund management in the university (S_{34}), lack of financial support for researchers to exploit the produced knowledge (S_{35}). The pairwise comparison matrix of economic barrier is presented in Table 5. The inconsistency ratio is around 0.024; therefore, the results are assured.

The result for prioritization of factors related to the economic criterion is represented in the order of importance, as follows:

- Priority 1: the inadequacy of the scholar's share in the commercialization revenues;
- Priority 2: weakness of universities in wealth creation;
- Priority 3: lack of financial resources for research commercialization;
- Priority 4: poor fund management in the university;
- Priority 5: lack of financial support for researchers to exploit the produced knowledge.

Prioritizing Structural and Policy Barriers

The factors related to the structural and policy criteria are the following: lack of organized units for academic research commercialization (S_{41}), the bureaucratic inflexibility (S_{42}), absence of university entrepreneurial missions (S_{43}), absence of research strategy document at universities (S_{44}), lack of effective policies to improve academic research quality (S_{45}). The pairwise comparison matrix of structural and policy barriers is presented in Table 5. The inconsistency ratio is around 0.039 which is smaller than 0.1; therefore, the results are assured.

The result of prioritizing structural and political criteria is as follows:

- Priority 1: bureaucratic inflexibility;
- Priority 2: lack of organized units for academic research commercialization;
- Priority 3: absence of university entrepreneurial missions;
- Priority 4: lack of research strategy document at universities;
- Priority 5: lack of effective policies to improve academic research quality.

Prioritizing Communication and Information Barriers

The factors related to the communication and information criteria include: the absence of up-to-date and effective idea banks and databases in the universities (S_{51}), lack of mutual recognition between university and industry (S_{52}), lack of effective communication between students and industry sector's activists (S_{53}), the lack of communications and networks among investors, industry activists and academic sector (S_{54}), absence of university consulting services in the society (S_{55}). The results obtained from the pairwise comparison matrix of communication and information barriers are presented in Table 5. The inconsistency ratio is around 0.039 which is smaller than 0.1; therefore, the results are assured.

The result of prioritizing the communication and information criteria is as follows:

- Priority 1: the absence of up-to-date and effective idea banks and databases in the universities;
- Priority 2: and the lack of effective communication between students and industry sector's activists;
- Priority 3: lack of mutual recognition between university and industry;
- Priority 4: the lack of communications and networks among investors, industry activists

and academic sector;

- Priority 5: absence of university consulting services in the society.

Prioritizing Cultural Barriers

The factors related to the cultural criteria include: weak research culture (S_{61}), cultural differences between university and industry (S_{62}), weak entrepreneur culture (S_{63}), the collective negative attitude towards commercialization of knowledge produced at universities (S_{64}). The pairwise comparison matrix of cultural barriers is presented in Table 5. The inconsistency ratio is around 0.025 which is smaller than 0.1; therefore, the results are assured. The result of Prioritizing factors related to cultural criteria is as follows:

- Priority 1: weak research culture;
- Priority 2: cultural differences between the universities and industry;
- Priority 3: weak entrepreneur culture;
- Priority 4: the collective negative attitude towards the commercialization of knowledge produced at universities.

Figure 1 shows the final priority of the main factors using AHP.

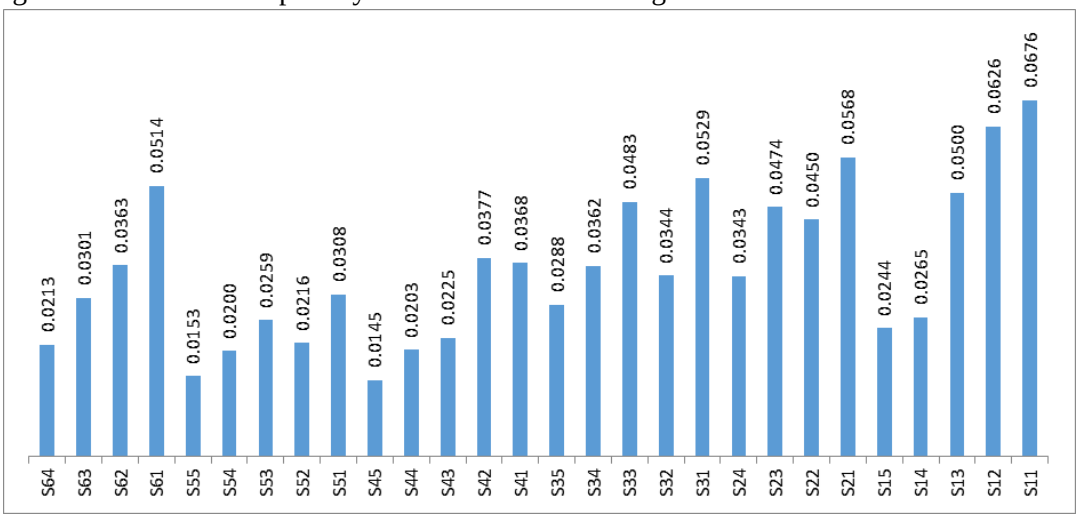

Figure 1: *Prioritization of the Effective Factors on Research Commercialization at Payam-e-Noor University*

Given the prioritization of the effective factors investigated in this research, the effective factors are identified in the following order of priority: weak legal framework for supporting idea people at the university, inefficiency and ineffectiveness of the rules and regulations for commercialization, researchers' law intention towards commercialization, the inadequacy of the scholar's share in the commercialization revenues, weak research culture, lack of regulation for the apportionment of financial gain from commercialization among scholars, and weakness of universities in wealth creation.

Interpretative Structural Modeling

In this phase, we determined the driving and dependence power of the factors we prioritized using interpretive structural modeling. Interpretive structural modeling is a method for creating and understanding the relationships between the elements of a complex system in which a set of different but relevant elements are structured in a systematic, comprehensive model.

Interpretive structural equation methodology helps establish order in the complex relationships between the elements of a system and help managers to prioritize and to partition the elements of a system. To develop an interpretive structural model, we first calculated the structural self-interaction matrix and then the reachability matrix of indices studied in the research.

The first step in interpretive structural modeling is to find the internal relationships between indices. The matrix obtained in this step shows that a specific variable affects which variables and are affected by which variables. The structural self-interaction matrix is formed by the dimensions and indices of the research and their comparison and using four modes of conceptual relations. The reachability matrix is obtained from the conversion of SSIM into a binary matrix in which all elements are 1 and 0.

In interpretive structural modeling, there are effective and reciprocal interactions between criteria; and the relationships between the criteria of different levels are well illustrated, which makes a better understanding of the decision space at the managers' disposal. To determine the key criteria, the driving and dependence power of the criteria are formed on the ultimate access matrix. Figure2 shows the power-dependence values for the studied variables.

Table 7

The Driving and Dependence Power of the Effective Factors on Research Commercialization at Payam-e-Noor University.

Code	Indexes	Driving Power	Dependence Power
S_{01}	Weak legal framework for supporting idea people at the university	2	5
S_{02}	Inefficiency and ineffectiveness of the rules and regulations for commercialization, researchers	2	4
S_{03}	Lack of regulation for the apportionment of financial gain from commercialization among scholars	1	6
S_{04}	Lack of intellectual property rights ownership rights derived from joint research with industry	9	11
S_{05}	Lack of effective policies to improve the quality of academic research	5	11
S_{06}	Law intention towards commercialization	2	9
S_{07}	Lack of skilled and expert human resources	1	8
S_{08}	Weakness of the university with high motivation for human capital	7	10
S_{09}	Inadequate knowledge of the faculty members	20	6
S_{10}	The inadequacy of the scholar's share in the commercialization revenues	5	7
S_{11}	Poor fund management in the university	21	8
S_{12}	Weakness of universities in wealth creation	13	4
S_{13}	Lack of financial resources and facilities for commercialization of research results	3	8
S_{14}	Lack of university sponsorship from researchers to exploit production know-how	12	8
S_{15}	Lack of organized organization for the commercialization of academic research	2	7
S_{16}	Lack of bureaucratic flexibility	9	6
S_{17}	Absence of university entrepreneurial missions	16	6
S_{18}	Lack of a research leading university document	4	11

Code	Indexes	Driving Power	Dependence Power
S_{19}	Lack of effective policies to improve the quality of academic research	6	7
S_{20}	The absence of up-to-date and effective idea banks and databases in the university	21	5
S_{21}	Weakness in mutual recognition of university and industry	1	8
S_{22}	Weakness in the mutual recognition between university and industry	6	3
S_{23}	Lack of communication and networks between investors, industry activists and academics	7	7
S_{24}	Weakness of university consulting services to the community	7	7
S_{25}	Weak research culture	3	8
S_{26}	Existence cultural differences between university and industry	7	11
S_{27}	Weakness of entrepreneurship culture	6	8
S_{28}	Uncompromising collective sensitivity to the commercialization of knowledge generated at universities	6	5

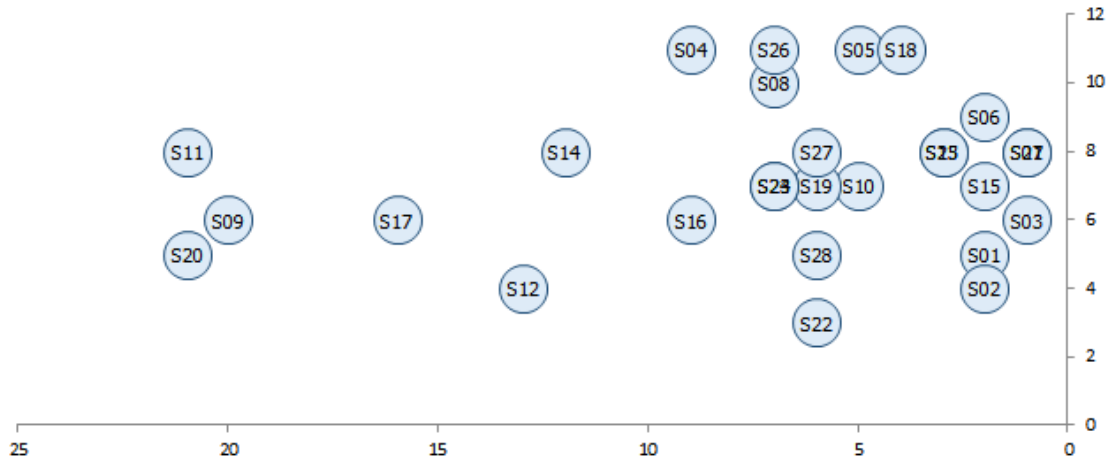

Figure 2: Power-Dependence Diagram of the Research Variables

According to the data on Table 7, the power-dependence diagram for the studied indices was plotted. As the diagram represents, at the left end of the diagram (horizontal axis), there are indices that have higher driving power and lower dependence than other indices. These indices include “inadequate knowledge of the faculty members”, “poor fund management in the university”, “the absence of up-to-date and effective idea banks and databases in the university”, “absence of university entrepreneurial missions”. The down trend of the driving power of the indices continues to the origin. Therefore, indices such as “weak legal framework for supporting idea people at the university”, “inefficiency and ineffectiveness of the rules and regulations for commercialization”, “lack of regulation for the apportionment of financial gain from commercialization among scholars”, and “lack of skilled and expert human resources” have the least driving power among the indices investigated in the study. In fact, this category of indices has a higher degree of dependence on other indices of the study. Obviously, the proximity to the upper points of the vertical axis indicates a higher dependence and lower driving power of the indices.

Identifying Cause-and-Effect Relationships between the Factors of Research Commercialization

To response the second question of the research, and in order to find the relationship and to partition the factors/variables, the output and input sets should be extracted for each factor of the access matrix. For the variable C_i, the reachability set (output or those that affect) includes variables that can be reached through the variable C_i. The antecedent set (input or those that are affected) includes variables through which the variable C_i can be reached.

Having determined the reachability and antecedent sets, intersection of the two sets is calculated. The first variable which is obtained from the intersection of the two sets and is equal to the reachability set (outputs) will be placed at Level 1. Therefore, the elements of Level 1 will be the most affectable in the model. After determining the level, the criterion whose level has been identified is removed from the entire set and then we form the input and output sets again, and we obtain the subsequent variable level.

Table8

Determining Level 1 Factors using Fuzzy AHP.

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{01}	S01,S02	S01,S02,S11,S15,S20	S01,S02	1
S_{02}	S01,S02	S01,S02,S11,S17	S01,S02	1
S_{03}	S03	S03,S09,S11,S12,S17,S20	S03	1
S_{04}	S04,S05,S06,S08,S18,S23,S24,S25,S26	S04,S09,S10,S11,S14,S16,S18,S20,S23,S24,S25	S04,S18,S23,S24,S25	
S_{05}	S05,S08,S13,S15,S21	S04,S05,S08,S09,S12,S17,S20,S23,S24,S27,S28	S05,S08	
S_{06}	S06,S07	S04,S06,S09,S10,S11,S23,S24,S27,S28	S06	
S_{07}	S07	S06,S07,S08,S09,S12,S17,S20,S26	S07	1
S_{08}	S05,S07,S08,S10,S13,S15,S21	S04,S05,S08,S10,S12,S20,S23,S24,S27,S28	S05,S08,S10	
S_{09}	S03,S04,S05,S06,S07,S09,S10,S11,S12,S13,S14,S16,S17,S18,S19,S21,S23,S24,S26,S27	S09,S11,S12,S13,S17,S19	S09,S11,S12,S13,S17,S19	
S_{10}	S04,S06,S08,S10,S14	S08,S09,S10,S11,S14,S20,S22	S08,S10,S14	
S_{11}	S01,S02,S03,S04,S06,S09,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20,S23,S24,S25,S27	S09,S11,S12,S13,S14,S16,S17,S20	S09,S11,S12,S13,S14,S16,S17,S20	
S_{12}	S03,S05,S07,S08,S09,S11,S12,S16,S17,S19,S21,S26,S28	S09,S11,S12,S17	S09,S11,S12,S17	
S_{13}	S09,S11,S13	S05,S08,S09,S11,S13,S17,S20,S26	S09,S11,S13	1
S_{14}	S04,S10,S11,S14,S15,S16,S19,S23,S24,S25,S27,S28	S09,S10,S11,S14,S16,S19,S20,S22	S10,S11,S14,S16,S19	
S_{15}	S01,S15	S05,S08,S11,S14,S15,S20,S26	S15	
S_{16}	S04,S11,S14,S16,S23,S24,S25,S27,S28	S09,S11,S12,S14,S16,S22	S11,S14,S16	
S_{17}	S02,S03,S05,S07,S09,S11,S12,S13,S17,S18,S19,S20,S22,S23,S25,S27	S09,S11,S12,S17,S20,S22	S09,S11,S12,S17,S20,S22	
S_{18}	S04,S18,S21,S26	S04,S09,S11,S17,S18,S20,S23,S24,S26,S27,S28	S04,S18,S26	

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{19}	S09,S14,S19,S25,S27,S28	S09,S11,S12,S14,S17,S19,S20	S09,S14,S19	
S_{20}	S01,S03,S04,S05,S07,S08,S10,S11,S13,S14,S15,S17,S18,S19,S20,S21,S22,S24,S25,S26,S27	S11,S17,S20,S22,S26	S11,S17,S20,S22,S26	
S_{21}	S21	S05,S08,S09,S12,S18,S20,S21,S26	S21	1
S_{22}	S10,S14,S16,S17,S20,S22	S17,S20,S22	S17,S20,S22	
S_{23}	S04,S05,S06,S08,S18,S23,S26	S04,S09,S11,S14,S16,S17,S23	S04,S23	
S_{24}	S04,S05,S06,S08,S18,S24,S26	S04,S09,S11,S14,S16,S20,S24	S04,S24	
S_{25}	S04,S25,S26	S04,S11,S14,S16,S17,S19,S20,S25	S04,S25	
S_{26}	S07,S13,S15,S18,S20,S21,S26	S04,S09,S12,S18,S20,S23,S24,S25,S26,S27,S28	S18,S20,S26	
S_{27}	S05,S06,S08,S18,S26,S27	S09,S11,S14,S16,S17,S19,S20,S27	S27	
S_{28}	S05,S06,S08,S18,S26,S28	S12,S14,S16,S19,S28	S28	

Therefore, the Level 1 factors include: weak legal framework for supporting idea people at the university (S_{01}), inefficiency and ineffectiveness of the rules and regulations for commercialization (S_{02}), lack of regulation for the apportionment of financial gain from commercialization among scholars (S_{03}), lack of skilled and expert human resources (S_{07}), lack of facilities and financial resources for commercialization (S_{13}), and lack of mutual recognition between university and industry (S_{21}). After identifying the Level 1 factors, these factors are removed and they are not considered in calculation of the input and output sets. The interaction set is identified and the factors whose interaction is equal to the input set are selected as Level 2 factors. The calculations for determining Level 2 factors using fuzzy AHP are presented in Table 8.

Table9

Determining Level 2 Factors using Fuzzy AHP.

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{04}	S04,S05,S06,S08,S18,S23,S24,S25,S26	S04,S09,S10,S11,S14,S16,S18,S20,S23,S24,S25	S04,S18,S23,S24,S25	
S_{05}	S05,S08,S13,S15,S21	S04,S05,S08,S09,S12,S17,S20,S23,S24,S27,S28	S05,S08	
S_{06}	S06,S07	S04,S06,S09,S10,S11,S23,S24,S27,S28	S06	2
S_{08}	S05,S07,S08,S10,S13,S15,S21	S04,S05,S08,S10,S12,S20,S23,S24,S27,S28	S05,S08,S10	
S_{09}	S03,S04,S05,S06,S07,S09,S10,S11,S12,S13,S14,S16,S17,S18,S19,S21,S23,S24,S26,S27	S09,S11,S12,S13,S17,S19	S09,S11,S12,S13,S17,S19	
S_{10}	S04,S06,S08,S10,S14	S08,S09,S10,S11,S14,S20,S22	S08,S10,S14	
S_{11}	S01,S02,S03,S04,S06,S09,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20,S23,S24,S25,S27	S09,S11,S12,S13,S14,S16,S17,S20	S09,S11,S12,S13,S14,S16,S17,S20	
S_{12}	S03,S05,S07,S08,S09,S11,S12,S16,S17,S19,S21,S26,S28	S09,S11,S12,S17	S09,S11,S12,S17	
S_{14}	S04,S10,S11,S14,S15,S16,S19,S23,S	S09,S10,S11,S14,S16,S19,S20,	S10,S11,S14,S1	

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
	24,S25,S27,S28	S22	6,S19	
S_{15}	S01,S15	S05,S08,S11,S14,S15,S20,S26	S15	2
S_{16}	S04,S11,S14,S16,S23,S24,S25,S27,S28	S09,S11,S12,S14,S16,S22	S11,S14,S16	
S_{17}	S02,S03,S05,S07,S09,S11,S12,S13,S17,S18,S19,S20,S22,S23,S25,S27	S09,S11,S12,S17,S20,S22	S09,S11,S12,S17,S20,S22	
S_{18}	S04,S18,S21,S26	S04,S09,S11,S17,S18,S20,S23,S24,S26,S27,S28	S04,S18,S26	2
S_{19}	S09,S14,S19,S25,S27,S28	S09,S11,S12,S14,S17,S19,S20	S09,S14,S19	
S_{20}	S01,S03,S04,S05,S07,S08,S10,S11,S13,S14,S15,S17,S18,S19,S20,S21,S22,S24,S25,S26,S27	S11,S17,S20,S22,S26	S11,S17,S20,S22,S26	
S_{22}	S10,S14,S16,S17,S20,S22	S17,S20,S22	S17,S20,S22	
S_{23}	S04,S05,S06,S08,S18,S23,S26	S04,S09,S11,S14,S16,S17,S23	S04,S23	
S_{24}	S04,S05,S06,S08,S18,S24,S26	S04,S09,S11,S14,S16,S20,S24	S04,S24	
S_{25}	S04,S25,S26	S04,S11,S14,S16,S17,S19,S20,S25	S04,S25	
S_{26}	S07,S13,S15,S18,S20,S21,S26	S04,S09,S12,S18,S20,S23,S24,S25,S26,S27,S28	S18,S20,S26	
S_{27}	S05,S06,S08,S18,S26,S27	S09,S11,S14,S16,S17,S19,S20,S27	S27	
S_{28}	S05,S06,S08,S18,S26,S28	S12,S14,S16,S19,S28	S28	

Given the Level 2 calculation output in Fuzzy AHP, the following items are among the Level 2 factors: researchers' law intention towards commercialization (S_{06}), lack of organized units for academic research commercialization (S_{15}), and absence of research strategy document in universities (S_{18}). To determine the elements of Level 3, the Level 2 factors are removed and they are not considered in calculation of the input and output sets. According to Table9, the interaction set is identified and the factors whose interaction is equal to the input set are selected as Level 3 factors.

Table10

Determining Level 3 Factors using Fuzzy AHP.

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{04}	S04,S05,S06,S08,S18,S23,S24,S25,S26	S04,S09,S10,S11,S14,S16,S18,S20,S23,S24,S25	S04,S18,S23,S24,S25	
S_{05}	S05,S08,S13,S15,S21	S04,S05,S08,S09,S12,S17,S20,S23,S24,S27,S28	S05,S08	3
S_{08}	S05,S07,S08,S10,S13,S15,S21	S04,S05,S08,S10,S12,S20,S23,S24,S27,S28	S05,S08,S10	3
S_{09}	S03,S04,S05,S06,S07,S09,S10,S11,S12,S13,S14,S16,S17,S18,S19,S21,S23,S24,S26,S27	S09,S11,S12,S13,S17,S19	S09,S11,S12,S13,S17,S19	
S_{10}	S04,S06,S08,S10,S14	S08,S09,S10,S11,S14,S20,S22	S08,S10,S14	
S_{11}	S01,S02,S03,S04,S06,S09,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20,S23,S24,S25,S27	S09,S11,S12,S13,S14,S16,S17,S20	S09,S11,S12,S13,S14,S16,S17,S20	
S_{12}	S03,S05,S07,S08,S09,S11,S12,S16,S17,S19,S21,S26,S28	S09,S11,S12,S17	S09,S11,S12,S17	

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{14}	S04,S10,S11,S14,S15,S16,S19,S23,S24,S25,S27,S28	S09,S10,S11,S14,S16,S19,S20,S22	S10,S11,S14,S16,S19	
S_{16}	S04,S11,S14,S16,S23,S24,S25,S27,S28	S09,S11,S12,S14,S16,S22	S11,S14,S16	
S_{17}	S02,S03,S05,S07,S09,S11,S12,S13,S17,S18,S19,S20,S22,S23,S25,S27	S09,S11,S12,S17,S20,S22	S09,S11,S12,S17,S20,S22	
S_{19}	S09,S14,S19,S25,S27,S28	S09,S11,S12,S14,S17,S19,S20	S09,S14,S19	
S_{20}	S01,S03,S04,S05,S07,S08,S10,S11,S13,S14,S15,S17,S18,S19,S20,S21,S22,S24,S25,S26,S27	S11,S17,S20,S22,S26	S11,S17,S20,S22,S26	
S_{22}	S10,S14,S16,S17,S20,S22	S17,S20,S22	S17,S20,S22	
S_{23}	S04,S05,S06,S08,S18,S23,S26	S04,S09,S11,S14,S16,S17,S23	S04,S23	
S_{24}	S04,S05,S06,S08,S18,S24,S26	S04,S09,S11,S14,S16,S20,S24	S04,S24	
S_{25}	S04,S25,S26	S04,S11,S14,S16,S17,S19,S20,S25	S04,S25	
S_{26}	S07,S13,S15,S18,S20,S21,S26	S04,S09,S12,S18,S20,S23,S24,S25,S26,S27,S28	S18,S20,S26	3
S_{27}	S05,S06,S08,S18,S26,S27	S09,S11,S14,S16,S17,S19,S20,S27	S27	
S_{28}	S05,S06,S08,S18,S26,S28	S12,S14,S16,S19,S28	S28	

Given the Level 3 calculation output in Fuzzy AHP, the following items are placed among the Level 3 factors: absence of effective policies to improve the quality of academic research (S_{05}), lack of motivated human resources in the universities (S_{08}), and cultural differences between university and industry (S_{26}).

Table11

Determining Level 4 Factors using Fuzzy AHP.

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{04}	S04,S05,S06,S08,S18,S23,S24,S25,S26	S04,S09,S10,S11,S14,S16,S18,S20,S23,S24,S25	S04,S18,S23,S24,S25	4
S_{09}	S03,S04,S05,S06,S07,S09,S10,S11,S12,S13,S14,S16,S17,S18,S19,S21,S23,S24,S26,S27	S09,S11,S12,S13,S17,S19	S09,S11,S12,S13,S17,S19	
S_{10}	S04,S06,S08,S10,S14	S08,S09,S10,S11,S14,S20,S22	S08,S10,S14	
S_{11}	S01,S02,S03,S04,S06,S09,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20,S23,S24,S25,S27	S09,S11,S12,S13,S14,S16,S17,S20	S09,S11,S12,S13,S14,S16,S17,S20	
S_{12}	S03,S05,S07,S08,S09,S11,S12,S16,S17,S19,S21,S26,S28	S09,S11,S12,S17	S09,S11,S12,S17	
S_{14}	S04,S10,S11,S14,S15,S16,S19,S23,S24,S25,S27,S28	S09,S10,S11,S14,S16,S19,S20,S22	S10,S11,S14,S16,S19	
S_{16}	S04,S11,S14,S16,S23,S24,S25,S27,S28	S09,S11,S12,S14,S16,S22	S11,S14,S16	
S_{17}	S02,S03,S05,S07,S09,S11,S12,S13,S17,S18,S19,S20,S22,S23,S25,S27	S09,S11,S12,S17,S20,S22	S09,S11,S12,S17,S20,S22	
S_{19}	S09,S14,S19,S25,S27,S28	S09,S11,S12,S14,S17,S19,S20	S09,S14,S19	
S_{20}	S01,S03,S04,S05,S07,S08,S10,S11,S13,S14,S15,S17,S18,S19,S20,S21,S22,S24,S25,S26,S27	S11,S17,S20,S22,S26	S11,S17,S20,S22,S26	

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{22}	S10,S14,S16,S17,S20,S22	S17,S20,S22	S17,S20,S22	
S_{23}	S04,S05,S06,S08,S18,S23,S26	S04,S09,S11,S14,S16,S17,S23	S04,S23	4
S_{24}	S04,S05,S06,S08,S18,S24,S26	S04,S09,S11,S14,S16,S20,S24	S04,S24	4
S_{25}	S04,S25,S26	S04,S11,S14,S16,S17,S19,S20, S25	S04,S25	4
S_{27}	S05,S06,S08,S18,S26,S27	S09,S11,S14,S16,S17,S19,S20, S27	S27	4
S_{28}	S05,S06,S08,S18,S26,S28	S12,S14,S16,S19,S28	S28	4

According to Table11, the following items are among the Level 4 factors: lack of regulation for the ownership rights of intellectual property gained from joint research between university and industry sector (S_{04}), the lack of communications and networks among investors, industry activists and academic sector (S_{23}), absence of university consulting services in the society (S_{24}), weak research culture (S_{25}), weak entrepreneur culture (S_{27}), and the collective negative attitude towards commercialization of knowledge produced at universities (S_{28}).

Table12

Determining Level 5 Factors using Fuzzy AHP.

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{09}	S03,S04,S05,S06,S07,S09,S10,S11,S12,S13,S14,S16,S17,S18,S19,S21,S23,S24,S26,S27	S09,S11,S12,S13,S17,S19	S09,S11,S12,S13,S17,S19	
S_{10}	S04,S06,S08,S10,S14	S08,S09,S10,S11,S14,S20,S22	S08,S10,S14	5
S_{11}	S01,S02,S03,S04,S06,S09,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20,S23,S24,S25,S27	S09,S11,S12,S13,S14,S16,S17, S20	S09,S11,S12,S13,S14,S16,S17, S20	
S_{12}	S03,S05,S07,S08,S09,S11,S12,S16,S17,S19,S21,S26,S28	S09,S11,S12,S17	S09,S11,S12,S17	
S_{14}	S04,S10,S11,S14,S15,S16,S19,S23,S24,S25,S27,S28	S09,S10,S11,S14,S16,S19,S20, S22	S10,S11,S14,S16,S19	5
S_{16}	S04,S11,S14,S16,S23,S24,S25,S27,S28	S09,S11,S12,S14,S16,S22	S11,S14,S16	5
S_{17}	S02,S03,S05,S07,S09,S11,S12,S13,S17,S18,S19,S20,S22,S23,S25,S27	S09,S11,S12,S17,S20,S22	S09,S11,S12,S17,S20,S22	
S_{19}	S09,S14,S19,S25,S27,S28	S09,S11,S12,S14,S17,S19,S20	S09,S14,S19	5
S_{20}	S01,S03,S04,S05,S07,S08,S10,S11,S13,S14,S15,S17,S18,S19,S20,S21,S22,S24,S25,S26,S27	S11,S17,S20,S22,S26	S11,S17,S20,S22,S26	
S_{22}	S10,S14,S16,S17,S20,S22	S17,S20,S22	S17,S20,S22	

Given the data on Table12, the following items are among the Level 5 factors in Fuzzy AHP: the inadequacy of the scholar's share in the commercialization revenues (S_{10}), lack of financial support for researchers to exploit the produced knowledge (S_{14}), bureaucratic inflexibility (S_{16}), and lack of effective policies to improve academic research quality (S_{19}).

Table 13
Determining Level 10 Factors using Fuzzy AHP.

Code	Output: Effectiveness	Input: Effectiveness	Interaction	Level
S_{09}	S03,S04,S05,S06,S07,S09,S10,S11,S12,S13,S14,S16,S17,S18,S19,S21,S23,S24,S26,S27	S09,S11,S12,S13,S17,S19	S09,S11,S12,S13,S17,S19	6
S_{11}	S01,S02,S03,S04,S06,S09,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20,S23,S24,S25,S27	S09,S11,S12,S13,S14,S16,S17, S20	S09,S11,S12,S13,S14,S16,S17, S20	6
S_{12}	S03,S05,S07,S08,S09,S11,S12,S16,S17,S19,S21,S26,S28	S09,S11,S12,S17	S09,S11,S12,S17	6
S_{17}	S02,S03,S05,S07,S09,S11,S12,S13,S17,S18,S19,S20,S22,S23,S25,S27	S09,S11,S12,S17,S20,S22	S09,S11,S12,S17,S20,S22	6
S_{20}	S01,S03,S04,S05,S07,S08,S10,S11,S13,S14,S15,S17,S18,S19,S20,S21,S22,S24,S25,S26,S27	S11,S17,S20,S22,S26	S11,S17,S20,S22,S26	6
S_{22}	S10,S14,S16,S17,S20,S22	S17,S20,S22	S17,S20,S22	6

Given the data on Table13, the following items are among the Level 6 factors in Fuzzy AHP: inadequate knowledge of the faculty members (S_{09}), poor fund management in the university (S_{11}), weakness of universities in wealth creation (S_{12}), absence of university entrepreneurial missions (S_{17}), absence of up-to-date and effective idea banks and databases in the universities (S_{20}), and lack of effective communication between students and industry sector's activists (S_{22}). Level 6 factors are proved to be the most effective factors in the present study.

Interpretative Structural Model of Effective Factors on Knowledge Commercialization at Payam-e-Noor University

The model of level partitioning for the identified factors is presented in Figure 2. In this graph we depicted the significant relationships between the elements of each level and the elements of one level below, and also the significant internal relations between the elements of each level.

Considering the effectiveness and affectability of each variable with respect to other variables in the analyses, the level partitioning of the factors and the pattern of relationships between them are shown in Figure 1. Level 1 variables have the most affectability and least effectiveness and Level 6 variables have the least affectability and the most effectiveness on the process of knowledge commercialization at Payam-e-Noor University. Moving from Level 6 to Level 1 of the model, the amount of effectiveness decreases and affectability increases.

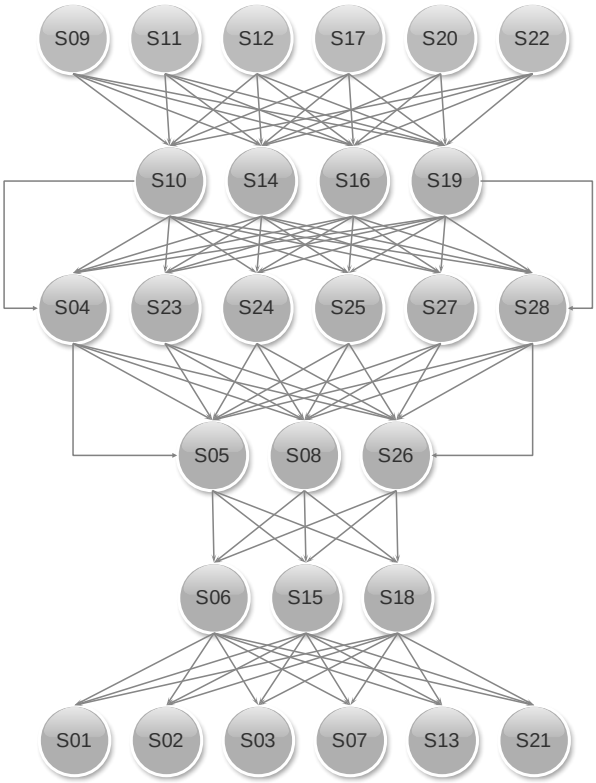

Figure 2: Interpretative Structural Model of Effective Factors on Knowledge Commercialization at Payam-e-Noor University

Discussion and Conclusion

The knowledge-based economic system would be beyond our reach if we have no knowledge-based industry and entrepreneurial universities. An established relationship between industry and higher education and its continuity based on their coexistence and mutual cooperation can make a knowledge-based economy via the mediating role of the government. The establishment of knowledge-based enterprises, science and technology parks, and entrepreneurship centers in the universities will be effective if the commercialized product or knowledge is in demand in Iran and international markets. The concept of knowledge commercialization is not just about a single brand registration and holding a production license for the product; it is the ability to raise capital from the knowledge produced by a research project.

The design of knowledge commercialization mechanisms and its operationalization, in the first phase, requires the identification of effective factors on knowledge commercialization in the universities. To this end, in the present research, to answer the first question of the research, "what are the effective factors on commercialization of the research results and what is their order of priority?" 28 factors were identified through the review of previous studies and they were presented to experts in order to receive their opinions. Fuzzy Delphi method was used for validation and screening the variables. Fuzzy AHP was used for prioritizing the identified factors. The summation of experts' opinions has led to the categorization of identified factors into 6 main criteria. The fuzzy AHP technique used to prioritize the 6 criteria in their order of importance including: legal barriers, economic barriers, human resource barriers, cultural barriers, structural and policy barriers, and communication and information barriers. Moreover, the results of this part of the research are consistent with research results by Biranvand (2018),

and Pazhouhesh Jahromi (2016); they showed that among barriers to commercialization, the legal barrier is the first on the list of priorities. After the identification of effective factors on commercialization and the prioritization of criteria using fuzzy AHP, the ultimate weight of each index represented the indices in their order of importance, as follows, weak legal framework for supporting idea people at the university, inefficiency and ineffectiveness of the rules and regulations for commercialization, researchers' law intention towards commercialization, the inadequacy of the scholar's share in the commercialization revenues, weak research culture, lack of regulation for the apportionment of financial gain from commercialization among scholars, and weakness of universities in wealth creation. One of the results of fuzzy AHP is the pairwise comparison of the sub-set indices of a particular criterion. The results obtained from the prioritization of barriers identified in this research along with managerial decisions can help improve the status quo.

The reachability matrix and self-interaction matrix were calculated to answer the second question of the research, "What cause-and-effect relationships exist between the factors that affect commercialization of the research results at Payam-e-Noor University?" The results of the reachability matrix have led to the calculation of the driving and the dependence power of each factor with respect to other factors. Then, using the fuzzy DEMATEL technique, the effectiveness and affectability of each factor were identified. Accordingly, weak legal framework for supporting idea people at the university, inefficiency and ineffectiveness of the rules and regulations for commercialization, lack of regulation for the apportionment of financial gain from commercialization among scholars, lack of skilled and expert human resources in the universities, lack of facilities and financial resources for research commercialization, and lack of mutual recognition between university and industry are placed at Level 1 of the model and have the most affectability. In other words, these are the dependent/outcome variables of the model. On the other hand, the independent/causal variables of the model are place at Level 6; they include: inadequate knowledge of the faculty members, poor fund management in the university, weakness of universities in wealth creation, absence of university entrepreneurial missions, the absence of up-to-date and effective idea banks and databases in the universities, and lack of effective communication between students and industry sector's activists. In fact, Level 6 factors raise lower level factors (Figure 2).

Based on information obtained from level partitioning of the factors in this research, the answer provided to the third question of the research, "What is the interpretative structural model of the effective factors on commercialization of the results research at Payam-e-Noor University?" shows that the commercialization of the research results can be classified into 6 levels. There is a cause-and-effect relationship between each level and the lower level. Therefore, the Level 6 factors introduced as the highest level factors in the interpretative structural model of this research and they cause the Level 5 factors, and the Level 5 factors cause Level 4 factors. This hierarchy continues to the lowest level (Level 1). In fact, factors at Level 1 are the dependent variables of the model and they are outcome of the higher order variables. Information about the level partitioning of the factors /variables is mentioned.

Given the response provided to the fourth question of the research, "What strategic recommendation can be presented for commercialization of the research result at Payam-e-Noor University?" and based on the basic factors at Level 6 of the interpretative structural model, it is recommended that:

- The faculty members should have up-to-date knowledge about research result

commercialization methods. Problems posed by lack of familiarity with the commercialization process, the duration of implementation, and the presentation of the results or products which have commercialization capacity, may result in the failure of the of idea commercialization process or delays in presentation. Awareness about supportive laws and regulations, and consultation with experts in the field of knowledge commercialization can be effective in this regard(Biranvand, 2018).

- Fund management in universities should be well performed. When the research fund is not provided to the researcher on time, it causes anxiety among the researchers and even occasionally hinders the research process, and, in some cases, it results in unsatisfactory results. Thus providing financial resources for commercialization of ideas will lead to successful commercialization. Successful commercialization is based on market demand. Providing financial resources for commercialization projects depends on the idea commercialization result in the marketplace. The commercialization projects based on market needs will attract investors. Therefore, in order to provide financial resources and generate capital, it is necessary to have a plan project that ensures the return on invested capital and reduces the risk of investment.
- Entrepreneurial activities should be considered in university missions. Knowledge in its pure sense is nothing more than knowledge, and it usually fails in raising economic productivity when it is not strongly reinforced. Reinforcing knowledge will bring about change and successful and important results. Experts(Bruneel, D'Este & Salter, 2010) argue that the reinforcement occurs through entrepreneurship. The role of the entrepreneur is to discover the opportunity in knowledge(Schumpeter, 1934). Successful entrepreneur takes opportunities that others have not yet noticed(Kirzner, 1973). The role of the entrepreneur in the process of technological change has made entrepreneurship a focal point of research, not only in technological change, development, and public policy but also in the field of regional science. Entrepreneurship is one of the most important insights that arise from endogenous growth theory(Romer, 1986); in this theory, technological change is primarily considered as a local regional phenomenon. Technological change as a local stimulus in economic development, which is in fact the result of knowledge and its transformation into useful economic knowledge (by the entrepreneur), has created a new and dynamic enlightenment in the study of regional economic development(Stimson, Stough & Salazar, 2009).
- There should be up-to-date and effective idea banks and databases in the universities. The absence of ideal banks and appropriate information systems may hinder effective communication between researchers and industry, or it may result in researchers' inadequate and inaccurate information about the idea commercialization process. The lack of knowledge leads to the failure of idea commercialization at the next steps.
- There should be effective communication between students and industry sector's activists. The acceptance of knowledge commercialization mission by universities is not a radical behavior (a form of effort to break the relationship with the past and abandon the mission of education and research), but it is an attempt to preserve scientific values influenced by new goals and new social demands and to provide benefits for the universities. The commercialization phenomenon is a dynamic concept and a resultant of pressure (university) and tension (industry) forces. The commercialization phenomenon will properly occur when the cooperation between industry and university is not completely of "theoretical" or "practical" type alone. Given the importance of effective variables, it is possible to improve the dependent variables of the model and, as a result, to improve the knowledge commercialization status.

References

Abasi, H. (2017). Designing the Model for Commercialization of University Research Using Structural Equation Modeling- Partial Least Squares Method (SEM-PLS). *Institute for Trade Staudies and Research*, 21(82), 1-21. Retrieved from http://pajooheshnameh.itsr.ir/article_23754.html

Baldini, N. (2006). *The entrepreneurial university: A debate* (SSRN scholarly paper no. ID 1097325). Rochester, NY: Social Science Research Network. Retrieved from https://papers.ssrn.com /abstract=1097325

Baycan, T. & Stough, R. R. (2012). Bridging knowledge to commercialization: the good, the bad, and the challenging. *The Annals of Regional Science*, 50, 367-405. https://doi.org/10.1007/s00168-012-0510-8

Biranvand, A. (2018). *Identification of affected factors on the knowledge commercialization in the Iranian integrated universities under MSRT to present practical suggestions: The case of study UI.* (Phd Desertation). University of Isfahan, Isfahan.

Biranvand, A. & Seif, H. (2018). Prioritizing the effective factors on knowledge commercialization using fuzzy analytic hierarchy process: A case study. *Library Philosophy and Practice (e-journal).* Retrieved from http://digitalcommons.unl.edu/libphilprac/2094

Biranvand, A., Seif, M. H., & Cheraghi, Z. (2018). Interpretive Structural Modeling of Barriers to Knowledge Commercialization. *Journal of Library and Information Science Studies*, 25(26), 27-42. https://doi.org/10.22055/slis.2019.14850

Biranvand, A., Seif, M. H., Safa, S. & Mazloumian, S. (2019). An investigation into the effective factors on the intention to commercialization of knowledge in a university: A case study. *Library Philosophy and Practice (e-journal)*. Retrieved from https://digitalcommons.unl.edu/ libphilprac/2216

Bruneel, J., D'Este, P. & Salter, A. (2010). Investigating the factors that diminish the barriers to university–industry collaboration. *Research Policy*, 39(7), 858-868. https://doi.org/10.1016/ j.respol.2010.03.006

Daynich, A. & Wang, Y. (2016). Dynich, A., & Wang, Y. (2016). On the e-commercialization... - Google Scholar. *Electronic Commerce Research and Applications*, 20, 183-188.

Duch Brown, N., Garcia-Estevez, J. & Parellada-Sabata, M. (2011). *Universities and regional economic growth in Spanish regions* (Working Papers No. 2011/6). Institut d'Economia de Barcelona (IEB). Retrieved from https://ideas.repec.org/p/ieb/wpaper/2011-4-doc2011-6.html

Etzkowitz, H. (1990). The Capitalization of Knowledge: The Decentralization of United States Industrial and Science Policy from Washington to the States. *Theory and Society*, *19*(1), 107-121. https://doi.org/10.2307/657765

Etzkowitz, H., Webster, A., Gebhardt, C. & Terra, B. R. C. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, *29*(2), 313-330. https://doi.org/10.1016/S0048-7333(99)00069-4

Goldstein, H. & Renault, C. (2004). Contributions of Universities to Regional Economic Development: A Quasi-experimental Approach. *Regional Studies*, 38(7), 733-746. https://doi.org/10.1080/ 0034340042000265232

Hmieleski, K. M. & Powell, E. E. (2018). The Psychological Foundations of University Science Commercialization: A Review of the Literature and Directions for Future Research. *Academy of Management Perspectives*, 32(1), 43-77. https://doi.org/10.5465/amp.2016.0139

Irani, F. N. H., hayak, K. & Asetmal, E. K. (2018). Identifying and prioritizing barriers to commercializing researches and innovations in east Azerbaijan University with AHP techniques and providing appropriate strategies. *European Journal of Sustainable Development*, *7*(2). https://doi.org/10.14207/ejsd.2018.v7n2p121

Jahed, H. (2011). Explaining of Individual Factors Influencing Commercialization of Research Results; The Case of Islamic Azad University of Science and Research Branch. *Journal of Science & Technology Policy*, 4(1), 1-17. Retrieved from http://jstp.nrisp.ac.ir/En/Forms/ArticleDetails.aspx?ID=535151

Jung, M., Lee, Y. & Lee, H. (2015). Classifying and prioritizing the success and failure factors of technology commercialization of public R&D in South Korea: using classification tree analysis. *The Journal of Technology Transfer*, 40(5), 877-898. https://doi.org/10.1007/s10961-014-9376-5

Kirzner, I. M. (1973). *Competition and Entrepreneurship* (SSRN Scholarly Paper No. ID 1496174). Rochester, NY: Social Science Research Network. Retrieved from https://papers.ssrn.com/abstract=1496174

Litan, R. E., Mitchell, L. & Reedy, E. J. (2007). Commercializing university innovations: alternative approaches. *Innovation Policy and the Economy*, *8*, 31-57. https://doi.org/10.1086/ipe.8.25056198

Nelles, J. & Vorley, T. (2010). Constructing an entrepreneurial architecture: an emergent framework for studying the contemporary university beyond the entrepreneurial turn. *Innovative Higher Education*, *35*(3), 161-176. https://doi.org/10.1007/s10755-009-9130-3

Owen-Smith, J. & Powell, W. W. (2003). The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity. *Research Policy*, 9(32), 1695-1711. https://doi.org/10.1016/S0048-7333(03)00045-3

Pazhouhesh Jahromi, A. (2016). *Designing and Explanation of a University Researches Results Commercialization Model (Case: Tehran State Technical Colleges)* (Phd Desertation). University of Tehran, Tehran.

Pourazat, A. A., Gholoipour, A. & NadirKhanloo. (2010). Explaining Barriers to Academic Entrepreneurship and Knowledge Commercialization at Tehran University. *Science and Technology Policy*, 2 (4), 65-76. Retrieved from https://www.sid.ir/Fa/Journal/ViewPaper.aspx?ID=110012

Pourezzat, A. A. & Gholipour, A. (2009). Representating Barriers to Academic Entrepreneurship and Knowledge Commercialization at University of Tehran, 2(4), 65-77. Retrieved fromhttp://jstp.nrisp.ac.ir/article_12797_en.html

Pourezzat, A. A., Gholipour, A., & Nadirkhanloo, S. (2010). Representation barriers to academic entrepreneurship and knowledge commercialization at University of Tehran. *Journal of Science and Technology Policy*, *2*(4), 65-76. Retrieved from https://www.sid.ir/En/Journal/ViewPaper.aspx?ID=194386

Rasmussen, E., Moen, ystein & Gulbrandsen, M. (2006). Initiatives to promote commercialization of university knowledge. *Technovation*, 26(4), 518-533. https://doi.org/10.1016/j.technovation.2004.11.005

Rezaei, M. R., Karimi, M. & Charkhtab Moghaddam, J. (2015). Identify the challenges of technology commercialization and provide a model for coping strategies. *Journal of Logistics*, 14(52), 117-130. Retrieved from https://www.magiran.com/paper/1475236 [in Persian]

Roknijo, S. M., Jafari, S. M. B., Yazdani, H. R. & Alvani, S. M. (2017). Study of barriers for the successful implementation of knowledge management in universities and providing guidelines. *College of Farabi, University of Tehran*, 15(2), 445-464.https://doi.org/10.22059/jomc.2017.62527

Romer, P. M. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy*, 94(5), 1002-1037. https://doi.org/10.1086/261420

Schumpeter, J. A. (1934). *The Theory of Economic Development: An Inquiry Into Profits, Capital, Credit, Interest, and the Business Cycle*. Transaction Publishers.

Shane, S. A. (2004). *Academic entrepreneurship: university spinoffs and wealth creation*. Edward Elgar Publishing.

Siegel, D. S., Waldman, D. A., Atwater, L. E. & Link, A. N. (2003). Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration. *The Journal of High Technology Management Research*, 14(1), 111-133. https://doi.org/10.1016/S1047-8310(03)00007-5

Siegel, D. S., Waldman, D., & Link, A. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. *Research policy*, 32(1), 27–48. Retrieved from http://www.sciencedirect.com/science/article/pii/S0048733301001962

Stimson, R. J., Stough, R. & Salazar, M. (2009). *Leadership and Institutions in Regional Endogenous Development*. Edward Elgar Publishing.

Viale, R. & Etzkowitz, H. (2010). *The Capitalization of Knowledge: A Triple Helix of University-industry-government*. Edward Elgar Publishing.

Zahra, S. A., Kaul, A. & Bolivar, M. T. (2018). Why corporate science commercialization fails: Integrating diverse perspectives. *Academy of Management Perspectives*, 32(1), 156-176.https://doi.org/10.5465/amp.2016.0132