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ORIGINAL ARTICLE

The impact of investment on human capital and innovation in oil-based economies

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Abstract: Nowadays, it is believed that innovation can be managed. Many factors affect innovation. An efficient national innovation system should be established to convert innovation on these inputs to appropriate innovation outputs. Interactions, culture, habits and relationships of the actors have a significant latent impact on the effectiveness of investment on inputs. However, in an economic system based on natural resources such as oil-based economies, investment on these input lacks proper efficiency and effectiveness. One of the important inputs is "human capital". It was found that in oil-based economies with public sector governance where investment on human factors and research and development is done by the public sector and supply impact, investment on human capital does not lead to innovation and wealth. To investigate this issue, the annual report of "Global Innovation Index" was used. In addition, an example of Iran's oil industry was described to show how governance, prioritizing and providing financial and non-financial resources by the public sector put innovative activities away of their objectives and markets.

Keywords: Innovation, human capital, oil-based economies, innovation evaluation, innovation in Iran's oil industry

Introduction

Many factors affect innovation. Human capital is one of the most important indicators influencing innovation. Usually, governments create human capital through establishment of infrastructure and attracting elite out of the country and employing them in different branches of innovation [1]. In economies based on natural resources, especially oil-based economic, the effect of these intangible assets and management views on innovation system is different and tends to management, decision-making and prioritizing in the public sector intentionally or unintentionally. Various models have been proposed to investigate the impact of human capital on innovation and economic growth. Most researchers investigate this issue at firm level and study a model of human capital at education level, experience and revenues of the company and pay less attention to this issue at national level [2].

Some studies have addressed this issue at regional level [3]. The important thing is that another variable like economic structure may have a significant impact on the performance of innovation process. The effect of oil-based economies on efficiency and effectiveness of wealth creation from innovation has not been widely investigated. This issue is of great importance in Iran, because post-sanction period will have a two-way influence on policy-making in this area. On the one hand, with the release of resources and relationships, there will be a greater access to global knowledge through various methods on the supply side. On the other hand, Iran will have an easier access to international markets where innovative products play a key role in determining its position in the international network and division of labor in post-sanction period. Therefore, it can be useful to identify facilitating components of innovation with regard to the general economic atmosphere. In addition to investigating the impact of human capital on innovation in oil-based economies, an example of Iran's oil industry is provided to show the impact of human capital in such economies.

2. Theoretical Background

Human capital is the most important engine of innovation. Human capital is one of the important factors leading countries to innovation. All levels of human capital are necessary to establish innovation in different sectors of society. Governments usually use two methods for innovation growth. First, they establish infrastructure such as schools, universities and research and development institutes to improve public knowledge in both technological and nontechnological areas at different levels from basic to advanced education. Second, governments use incentives to attract talented human resources from across the world and employ them in different branches of innovation [1].

Education is one of the key issues in innovation. To stimulate innovation engine, governments must train human capital. It is of great importance to promote education system for both industries and companies [4]. Innovation at firm level is dependent on knowledge, experience and commitment of staff as key inputs to the process of value creation [5, 6]. Knowledge is based on science and skills [7, 8]. Literature show the importance of knowledge and skills of human resources as valuable assets of companies in achieving innovative objectives and new technologies [9-15].

According to one view, human capital refers to individual knowledge and skills of human resources which should be converted to economic growth in practice [16]. There are different types of human capital. A specific type of human capital refers to skills and knowledge that are valuable only in a specific firm [17]. For example, there are studies on the impact of human capital on the success of newly established technological companies [18, 19]. Specific skills in companies gives them a competitive power with advantages over competitors and is not transferable to any other company [20].

The impact of human capital on innovation is associated with limitations in different industrial sectors or geographical areas. Valuable industrial human capital with skills in a particular area plays a key role in economic growth of an industry or a region. [22]. If specialized human capital is placed in a network of industrial professionals and key players of that cluster to be exposed to knowledge exchanges, they can play a major role in innovation [23, 24].

Therefore, the context of success and some challenges arisen in innovation path, for example, in Silicon Valley, can be expressed as cultural climate of communications in the network [25]. In the case of challenges, Arasti et al. (2012) investigated inter-organizational transfer of project management knowledge as the innovation key in project-based organizations considering international consortiums in oil industry. In international consortia in Iran's oil industry, managers focus primarily on direct and tangible outputs of a project like the physical progress and pay less attention to other important outcomes such as learning. Factors such as efforts and allocated resources, face to face communication, close interactions and communications, regulations, and some behavioral and cultural aspects like leadership style have been listed as parameters influencing innovation and learning.

Another aspect of individual knowledge of human capital is public experience and management knowledge that is applicable to different companies and industries [26]. This type of human capital knowledge is dependent on official and general education level [27]. Literature shows the significant impact of both individual and collective knowledge of human capital on creating innovation and economic growth at corporate and community levels.

Several models have been proposed to investigate the impact of human capital on innovation and economic growth [28]. Some examine this issue at firm level and consider human capital as the level of education, public experience and revenues of the company. But some studies show the impact of educational system in achieving innovation and economic growth at national level [29]. The researcher concludes that there should be a balance between investment and education policy and professional jobs. The educational system should train human capital in accordance with market demand for professional jobs. At the regional level, there is a study on intellectual capital in Arab countries. In this study, human capital is introduced as an important part of intangible assets and wealth of a nation and the effect of its inter-relationships is explored. The author also investigates the effect of oil revenues as a natural resource on the wealth of Arab nations and introduces the following reasons for the poor performance of human capital in Arab countries [30]:

- The lack of variety of industries
- The need for a strong educational system
- The lack of demand-driven training
- The lack of a proper structure to support spillover effects in different sectors

However, this study does not mention oil revenues as a parameter influencing the process of innovation. In economies based on natural resources, especially in oil-based economies, the impact of these intangible assets and management views on different elements of the innovation system is different. Accordingly, it is essential to explore and identify the relationships between important factors in such an economy. This issue is of great importance in Iran, because of its two-way influence on policy-making in this area in post-sanction period. On the one hand, with the release of resources and relationships, there will be a greater access to global knowledge through various methods on the supply side. On the other hand, Iran will have an easier access to international markets where innovative products play a key role in determining its position in the international network and division of labor in post-sanction period.

3. Conceptual Model

In general, innovation assessment indicators have been developed and improved over time. Table 1 shows different generations of innovation indicators.

Table 1: Various generations of innovation indicators derived from Innovation Center, George Washington University (2006)

1st generation, output indicators in 1950 and 1960	2nd generation, output indicators in 1970 and 1980	3rd generation, output indicators in 1990	4th generation, output indicators in 2000
Research and development costs Science and technology staff Capital Technological efforts	Patents Scientific articles Products Quality changes	Innovative assessment Evaluation of innovative capacities	Knowledge Intangible assets Networks Demand Clusters Management techniques Risk/rate of return System dynamicity

"Global Innovation Index" Institute evaluates indicators of innovation. The Institute provides and evaluates indicators applicable to developed and developing economies. Therefore, policymakers can evaluate the inputs and outputs of innovation in their country with a more comprehensive look and multidimensional data analysis.

The Institute has been able to establish its position in the field of innovation indicators in recent years to become a leading reference in the field of innovation. In this regard, Ban Ki-moon, Secretary-General of the United Nations says "Science, technology and innovation play a key role in sustainable development. The important point is that we should have access to correct and accurate data to be able to track the progress and strengths and weaknesses. Global Innovation Index (GII) has been able to provide access to detailed innovation indicators using an important and reliable tool" [53]. Therefore, this model has an international reputation. The model parameters are shown in Chart 1.

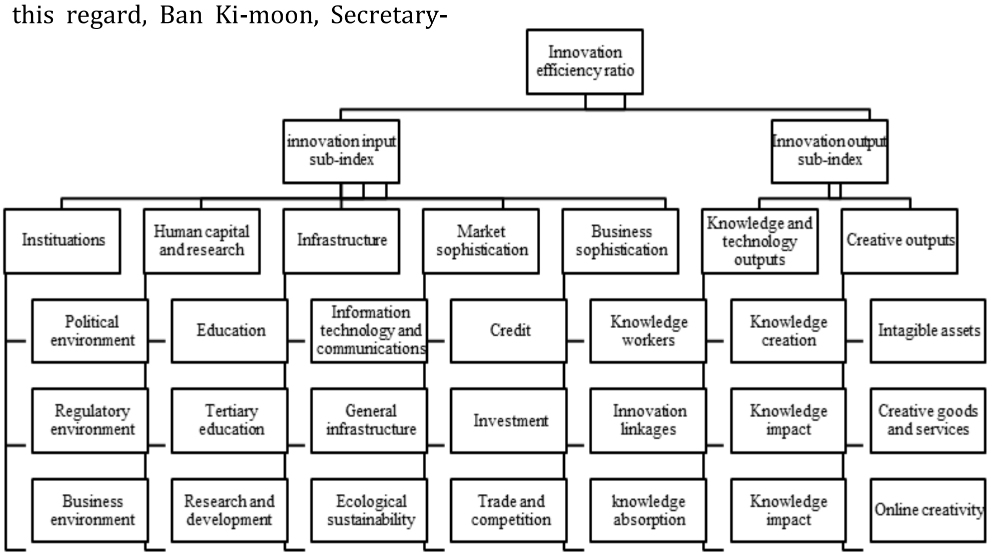

Chart 1: International sub-index for innovation assessment adopted from GII 2014

3.1. Human Capital

Human capital refers to the knowledge and skills of individuals that companies can achieve it by employing qualified individuals. To promote their human capital, companies train them. There is a two-way relationship between knowledge and skills and investments on training and development of workers with their salaries [6].

However, these parameters are somewhat different in different countries. The level and quality of education and research activities in a country are considered as the most important measure of innovation potential. This index is composed of three sub-index including education, tertiary education and research and development. Education refers to primary and secondary education levels. Investment on education and schools is an appropriate observed variable of this index and investment rate per capita can be used.

This qualitative index in GII is evaluated through "The Programme for International Student Assessment (PISA)" provided by the Organization for Economic Cooperation and Development (OECD). This program is an international test to assess the educational success of 15-year-old students around the world. In countries registered to run this program, a few schools are chosen randomly and all 15-year-old students in those schools participate in an international test. The results of this test show the educational success of students in science and mathematics and other indicators compared to other countries and the world average. The number of students per teacher is evaluated in this index. Tertiary education play a key role in the use of individuals in the production cycle and economy. Tertiary education refers to the graduates of the third level of educational system. Research and development measures the rate and quality of research and development. This index includes number of researchers, expenditure in this sector and the quality of scientific and research institutions. To determine the quality of educational institutions, 3 top educational institutes in each economy are evaluated by QS Institute (QS World University Rankings (by British Quacquarelli Symonds Company)) and all educational institutions are not monitored. Chart 2 shows human capital pillars (sub-index).

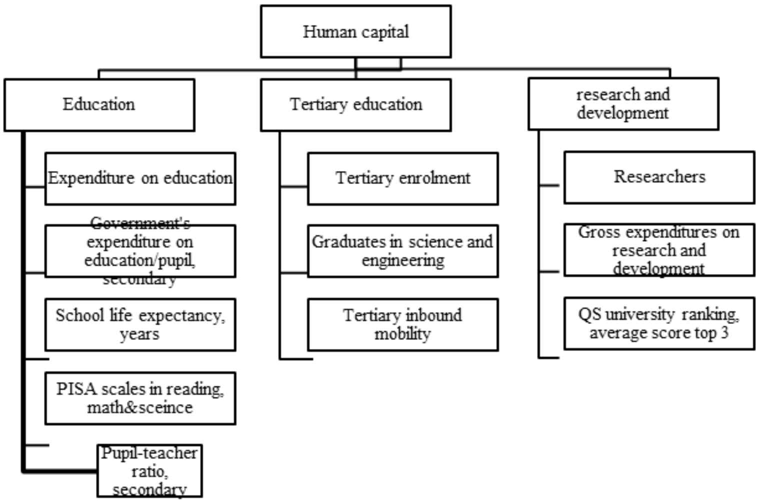

Chart 2: Human capital sub-index (pillars) adopted from GII 2014

3.2. Innovation outputs

Literature show three different types of innovation. Herein, we need those innovation indicators which can be assessed at international level to demonstrate the concept of innovation comprehensively. There is an international consensus on Oslo Manual set by the Organisation for Economic Cooperation and Development (OECD). This is the second manual of Frascati family with the aim of providing indicators and guidelines for measuring and evaluating innovation. The manual includes instructions for gathering and interpreting innovation information.

Oslo Manual covers all four types of innovative activities including all practical, technological, organizational, administrative and commercial steps leading to implementing and launching production innovation, organizational processes, marketing in business and commercial firms and institutions as well as its dissemination. The manual introduces 13 important indicators which can be classified in terms of human resources, knowledge creation, patents and transfer of knowledge, markets and financial outputs of innovation [31].

According to international consensus and access to information, the model used in this study is GII prepared according to the above manual. Chart 3 shows innovation outputs in this model.

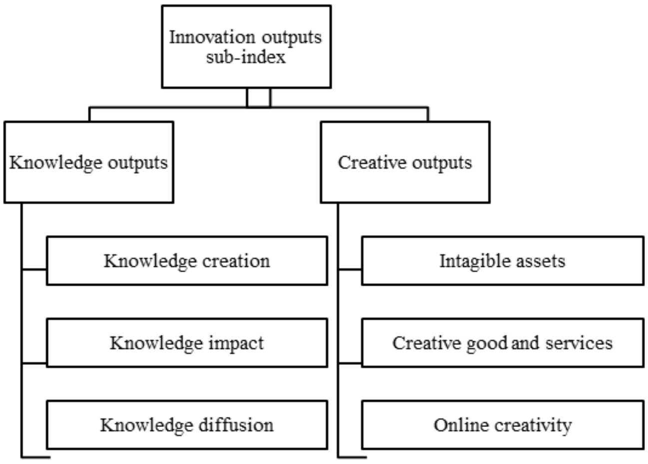

Chart 3: Innovation outputs sub-index adopted from GII 2014

In GII international standard, innovation outputs are divided into knowledge and creative outputs. Knowledge outputs are divided into three sub-index including knowledge creation, knowledge impact and knowledge diffusion. Knowledge creation is obtained from patents and published articles. Knowledge impact is calculated from increased productivity of staff, companies with quality management system certificates, the use of computers in companies and firms with high or median technologies. Knowledge diffusion is obtained from patents, licensing, export of superior technology, IT-based exports and the rate of direct foreign investments.

Creative outputs are divided into three categories of intangible assets, creative goods and services and online creativity. Intangible assets refer to the value of trademark and assessments of information technology and communications in firms. Creative good and services refer to what creates wealth from innovation. Online creative outputs refer to the development of knowledge in cyberspace and encyclopedias such as Wikipedia or software development [1].

3.3. Oil-based Economies

Many evidence in countries with vast natural resources, particularly oil and gas resources shows that this wealth has not been able to be a tool for economic development and more rapidly movement to a knowledge-based economy. In contrast, oil revenues often have negative effects on innovation and efficient use of these resources. Recently, economic literature has addressed this issue with titles such as Dutch disease, the paradox of wealth and the resource curse. Adverse results are seen in economy and technology due to the dominance of oil revenues in the state budget leading to the dominance of the public sector and weakening the private sector [32-35].

Vast oil resources do not always lead to adverse effects. For example, Canada with 175 billion barrels of oil has 12.58% of world oil reserves and is ranked third in terms of oil reserves. On the other hand, it was ranked 12 in term of innovation in 2014. Oil exports cannot be a good criterion in this regard. Norway and Canada respectively with 2.1 and 2 million barrels per day exports are ranked 8 and 9 in terms of oil exports and ranked 12 and 14 in terms of innovation in 2014, respectively. In terms of oil production, Canada with 3.59 million barrels per day accounts for 4.27% of world production and is ranked sixth in the world [36-37]. As a guideline to choose oil-based economies, the Organization of Petroleum Exporting Countries (OPEC) members are selected. These countries have a high proportion of oil revenues in their budget and this is one of the reasons for their membership in this organization [38]. OPEC consists of Algeria, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arabic Emirates, Ecuador, Angola and Venezuela.

4. Conceptual Model and Hypotheses

There are many models for relationship between intangible assets, human capital and innovative outputs [39-44]. The model employed in this study is based on the model provided by Stone et al. [45] (Chart 4).

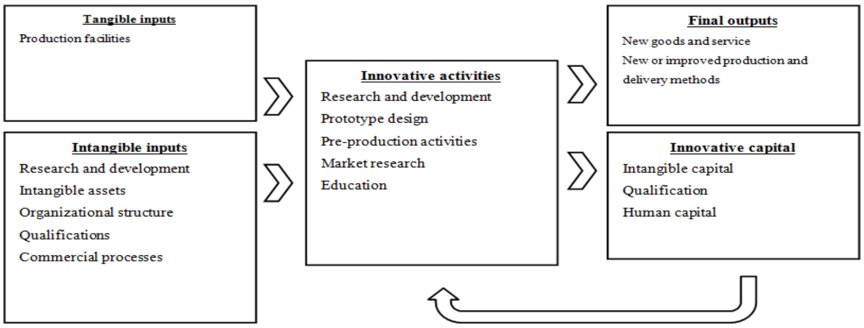

Chart 4: The relationship between tangible and intangible assets in innovation creation [45]

The model was modified according to experts' views and the research subject (Chart 5).

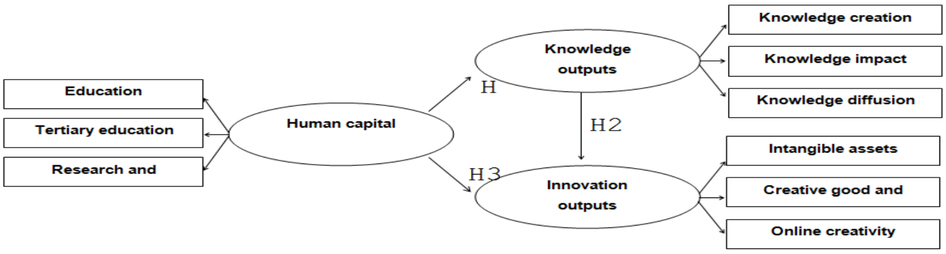

Chart 5: The conceptual model and hypotheses

Education, tertiary education and research and development are observed variables of the latent variable, human capital. Knowledge creation, knowledge impact and knowledge diffusion are observed variables of the latent variable, knowledge outputs. Intangible assets, creative goods and services and online creativity are observed variables of the latent variable, innovation outputs. The method used for calculation of observed variables was explained earlier. The weights of observed variables were calculated using experts' points of view (Table 2). To determine the weights, the effect of variables on the research objective was considered.

Table 2: The weights of variables

Innovation outputs		Knowledge outputs		Human capital	
Variable	Weight	Variable	Weight	Variable	Weight
Intangible assets	35	Knowledge creation	40	Education	20
Creative goods and services	50	Knowledge impact	25	Tertiary education	40
Online creativity	15	Knowledge diffusion	35	Research and development	40

According to the conceptual model, the research hypotheses are as follows:

First hypothesis: There is a significant relationship between investment on human capital and knowledge outputs in oil-based economies.

Second hypothesis: There is a significant relationship between investment on human capital and innovative outputs in oil-based economies.

Third hypothesis: There is a significant relationship between knowledge and innovative outputs in oil-based economies.

5. Methodology

This is an applied research from the perspective of the audience. Since it explains the reasons for events to develop and explain a theory, this is an explanation study in terms of objective. This research has not been conducted in a certain period, but explores statistics in a period of about eight years. In a case study on the Iran's oil industry, it examines the formation of innovative capabilities over time. Therefore, this is a longitudinal case study in terms of time. The population includes OPEC countries and the data provided by GII between 2007 and 2014 were used.

To analyze the data, the Kolmogorov-Smirnov test was first used to assess the normality of variables. The results indicated normality of variables. Linear Structural Relationship Analysis (LISREL) was used for model analysis. The structural equation modeling examines the goodness of fit for the conceptual model. On the other hand, it tests significance of relations in the fitted model. The parameters used for the goodness of fit include RMSEA, GFI, AGFI and chi-square. Table 3 shows model characteristics along with values showing the goodness of the model [46].

Table 3: Standard LISREL indicators

Analysis indicator		Standard indicator	Reference
comparative fit index	CFI	CFI > 0.95	Bentler, 1990, 1992, 1995
goodness-of-fit	GFI	GFI > 0.9	Hu and Bentler, 1999
adjusted goodness-of-fit	AGFI	AGFI > 0.9	Hu and Bentler, 1999
normed fit index	NFI	NFI > 0.9	Bentler and Bonnet, 1980
root mean square error of approximation	RMSEA	RMSEA < 0.05	Browne and Cudeck, 1993, Hu and Bentler, 1999, McDonald and Ho, 2002, Steiger, 1990

6. Analysis of Results

As mentioned earlier, LISREL was used to analyze the model. The results of model analysis are shown in Chart 6 and following tables.

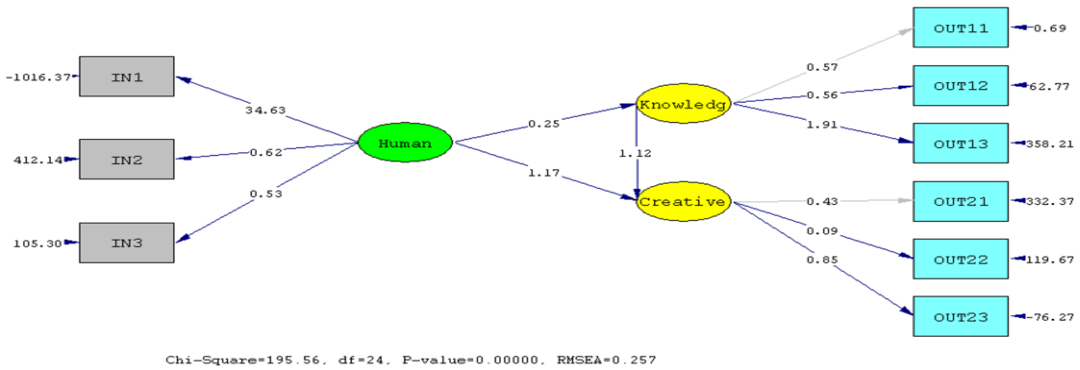

Chart 6: The results of model analysis by LISREL

Table 4 shows the results of analysis for important indicators. Details are given in Appendix A.

Table 4: The results of model analysis

Indicators		Results
N	Number of Observations	108
CFI	Comparative Fit Index	0.242
GFI	Goodness of Fit	0.736
AGFI	Adjusted Goodness of Fit	0.506
NFI	Normed Fit Index	0.255
RMSEA	Root Mean Square Error of Approximation	0.257

RMSEA demonstrates the goodness of fit and is higher than the standard value. Accordingly, the model lacks a good fitness. Chart 7 shows the T-value analysis.

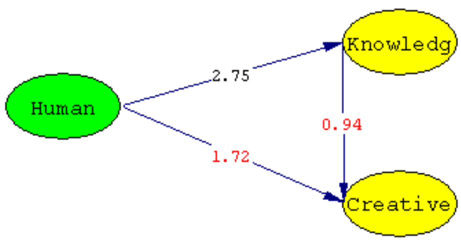

Chart 7: T-value analysis

As is shown in Figure 7, the red and black numbers respectively indicate uncorfirmation and confirmation of the relationship between variables. The results of the T-value analysis are follows:

First hypothesis: There is a significant relationship between investment on human capital and knowledge outputs in oil-based economies.

Second hypothesis: There is not a significant relationship between investment on human capital and innovative outputs in oil-based economies.

Three hypothesis: There is not a significant relationship between knowledge and innovation outputs in oil-based economies.

7. An Evidence from Iran's Oil Industry

The usual interpretation of innovation is to offer new goods and services. But in general, innovation efforts and research and development activities have different meanings. In an environment of import substitution, research and development means localization and its activities lead to learning from other companies. In laboratories of companies, research and development is to improve existing products. In some cases, research and development is not a tool, but is an objective and the main activity of an entity. In some cases, research and development is done to increase knowledge and bargaining power to enhance position in value creation network [48].

In this case study, research and innovative efforts in an environment of import substitution in Iran's oil industry to enhance oil recovery (EOR) from oil reservoirs are discussed. EOR refers to all processes which accelerate and increase oil production. There are various methods to increase oil production from reservoirs including primary, secondary and tertiary methods. In the primary methods, various drilling methods are used to enhance natural draining. Of course, artificial lift methods should be added to the primary methods. The aim of secondary methods is to stabilize or increase reservoir pressure to prevent the loss of production and thereby to increase production rate. Water and gas injection are most common secondary recovery methods.

In the tertiary method, new methods and the result of the latest scientific advances such as thermal methods including steam and hot water injection, in-situ combustion methods, chemical methods, magnetic methods, carbon dioxide injection, polymer injection and so on are employed to make maximum use of the reservoirs. The importance of this issue has been well understood in Iran. For this reason, a committee called the preservation and enhance recovery of oil and gas reservoirs was established to implement Article 30 of the Fifth Development Plan. The time considered for each oil reservoir is 10 years. Measures required to preserve the reserves and enhance recovery are determined in two five-year terms.

These measures include data collection, better identification of the reservoir, research projects and finally implementation of a coherent EOR program. Part of the budget and funding for the project is dedicated for preservation. In the Fifth Development Plan, 10% of the value of crude oil, condensates and natural gas liquids is allocated to EOR projects for implementing gas injection projects, increasing gas production in South Pars and collecting associated gases. According to the Sixth Development Plan, a 1000 trillion IRR agreement was signed between universities and the Ministry of Petroleum for EOR projects.

Universities, oil industry and government are the major actors of research projects. Three main steps of EOR projects include establishment of EOR consortium, preparation of EOR packages for oilfields and providing new technologies for enhanced oil recovery. The consortium was formed with the aim of strengthening and applying scientific and technological capacities in universities and scientific research centers in Iran as the support of science-based technology movement in the field of oil and gas, integration of facilities, equipment and skilled manpower and applying them to conduct EOR research and studies and large EOR projects and to boost national oil company value chain in the field of EOR research, innovation and technology.

The consortium, as the major actor of network, aims at identifying the relationship between the oil industry and universities. Commission members are appointed by the Minister of Petroleum and includes representatives of the State in the fields of research and technology, exploration, planning and supervision on hydrocarbon resources, engineering and supervision of projects, Research Institute of Petroleum Industry and some major manufacturing companies in the of oil industry. Academic EOR Consortium is composed of six top universities including Sharif University of Technology, Amirkabir University of Technology, Sahand University of Technology, Shiraz, Tehran and Petroleum University of Technology. More than 50 percent of academic projects in the field of oil industry are related to enhanced oil recovery methods. In addition, related laboratories have been well equipped.

Despite good facilities established over the years, the project has not been able to achieve its defined objectives. Seismic technologies are used for EOR projects in Iran with at least a 30-year delay. Three-dimensional seismic technologies are also used with a delay of 25 years. Although four-dimensional seismic techniques are used across the world for 12 years, this technology has not been used in Iran. Many projects have been defined in this area, but sufficient funding is not available to implement them. One of the adverse effect is the lack of practical work for specialists and graduates which leads to brain drain. As one of the prioritization criteria in recent years, only projects with more than 80% physical progress have been selected. Bureaucracy and the lack of decision-making in organizations resulted in a slow decision-making process. The public sector has played a major role in all policies and decisions. Another influential factor is sanctions.

Sanctions as an important side variable affect the policies and goals [49-52].

8. Conclusion

Innovation is affected by many input parameters. Some of these inputs are more important than others. Human capital is one of these parameters. According to literature, only investment on inputs does not result in innovation and wealth creation like a production system, but an innovation system is needed and facilitating parameters must be available. Learning and communication are the most important components of these drivers. Interactions, habits, behaviors and history of cooperation are of components influencing this system. The system leadership should be a combination of all stakeholders and should be managed by a council of all actors.

According to the results, the model lacks a good fit. One of the reasons is the lack of relationship between supply and demand in investment on human capital in oil-based economies. Another reason is to consider temporary and additive quantitative variables. Future studies are recommended to provide qualitative learning-based variables with gradual and synergistic features. Due to the lack of access to this type of variables in the target countries, this study was conducted using quantitative variables. Analysis of the model showed that knowledge outputs can be achieved by investing on human capital in oil-based economies, but investment and knowledge outputs do not convert into wealth.

With an evidence from the Iran's oil industry, the negative effect of governance, prioritizing and providing financial and non-financial resources solely by the government on realistic goals and markets was demonstrated. This issue and its main reasons are of great importance in Iran, because post-sanction period has a two-way impact on policy-making in this area. On the one hand, with the release of resources and relationships, there will be a greater access to global knowledge through various methods on the supply side. On the other hand, Iran will have an easier access to international markets where innovative products have a key role in determining its position in international networks and division of labor in post-sanction period.

The case study on the use of new EOR methods in the Iran's oil industry showed that cultural factors, management, human resources and skills prevent the formation of main drivers of innovation in the network of actors, i.e. communication and learning, in public sector, universities and research centers. Due to the lack of the necessary commitment and determination in the public sector to stimulate the other actors, other sectors move slowly toward the goal. One of the important issues is regulations in the public sector. Regulations must able to meet legal obligations on the one hand and create the motivation necessary for the dynamicity and lubrication of different actors on the other hand. In the case study, many factors influencing the lack of effectiveness of policies were mentioned. As another recommendation, future quantitative research may classify and weight influential factors. Qualitative studies are also recommended to identify their roots and causes.

9. Appendix A (Details of Model Analysis)

Goodness of Fit Statistics

Degrees of Freedom for (C1)-(C2)	24
Maximum Likelihood Ratio Chi-Square (C1)	195.558 (P = 0.0000)
Browne's (1984) ADF Chi-Square (C2_NT)	145.296 (P = 0.0000)
Estimated Non-centrality Parameter (NCP)	171.558
90 Percent Confidence Interval for NCP	(130.668 ; 219.928)
Minimum Fit Function Value	1.811
Population Discrepancy Function Value (F0)	1.589
90 Percent Confidence Interval for F0	(1.210 ; 2.036)
Root Mean Square Error of Approximation (RMSEA)	0.257
90 Percent Confidence Interval for RMSEA	(0.225 ; 0.291)
P-Value for Test of Close Fit (RMSEA < 0.05)	0.000
Expected Cross-Validation Index (ECVI)	2.200
90 Percent Confidence Interval for ECVI	(1.821 ; 2.647)
ECVI for Saturated Model	0.833
ECVI for Independence Model	2.619
Chi-Square for Independence Model (36 df)	264.819
Normed Fit Index (NFI)	0.255
Non-Normed Fit Index (NNFI)	-0.137
Parsimony Normed Fit Index (PNFI)	0.170
Comparative Fit Index (CFI)	0.242
Incremental Fit Index (IFI)	0.280
Relative Fit Index (RFI)	-0.118
Critical N (CN)	24.517
Root Mean Square Residual (RMR)	45.766
Standardized RMR	0.197
Goodness of Fit Index (GFI)	0.736
Adjusted Goodness of Fit Index (AGFI)	0.506
Parsimony Goodness of Fit Index (PGFI)	0.393

Time used 0.062 seconds

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