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Innovation and Scientific Research in the Context of Knowledge Economy: The case of GCC Countries

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Abstract: Innovation and scientific research represent two main pillars of knowledge-based economy. In this type of economy, the interdependency between industries, universities and governments is a critical requirement. The role of the government includes supervision, affordability of institutional framework and even direct investment. The role of the universities includes further engagement and interaction of academic institutions with industry.

In this context, this paper shows that the results of GCC countries in relation to innovation and scientific research are so far rather limited. An examination of the situation of GCC countries reveals that those economies need new approaches that look beyond the linear model of innovation, the classical dimensions of academic institutions and the lack of engagement of governments in the knowledge production process.

Keywords: Knowledge economy, scientific research, innovation, GCC countries.

1. INTRODUCTION

The world economy is witnessing profound changes characterized by an irreversible transition to knowledge economy. Resources invested in the production and spread of knowledge through research and development, education, training and information technology witness an exponential increase (UNESCO, 2012).

This form of economy focuses on the production and management of ideas, technology, data and information (Stehr, 2002). Those components constitute at present the main sources of productivity, growth and competitiveness. This type of economy is also characterized by an acceleration of innovations, with production of knowledge becoming increasingly interdependent at the level of firms and countries, causing massive growth of externalities, and offering development opportunities for developing economies.

Thus, knowledge economy has different features in comparison to previous economy. Those features have influenced and changed the perception about many economic concepts such as the concepts of

value, ownership, scarcity and economic performance. They also affected managerial and organizational methods as well as the type of relations between producers and consumers.

In this context, managing knowledge economy became unavoidable since it is important to link the traditional business visions with new requirements (Austin and Currie, 2003). The transformation from one to the other would include mainly investment in building human capacity, innovation and increasing research budgets.

Indeed, continuous innovation and scientific research represent necessary conditions for sustainable development in a knowledge economy. More specifically, innovation can be achieved through an effective system of research based on links between firms, academic institutions and other organizations. Those links help keep pace with the growing evolutions in knowledge in order to absorb them and adapt them to new uses.

This paper examines the transformations that affect the notions of innovation and scientific research in the context of knowledge economy. The Gulf Cooperation Council (GCC) countries are taken as a case study. In fact, those countries face the difficult task of moving from an oil-based economy towards an economic system led by knowledge economy indicators. The paper is structured as follows: Section 2 theorizes the economic shift towards the knowledge economy. Section 3 highlights the new model of innovation. Section 4 describes the increasing role of scientific research in knowledge economy in addition to the growing importance of roles played by governments and universities. Section 5 describes the status of innovation and scientific research in GCC countries. Finally, section 6 concludes.

2. ECONOMIC TRANSITION TO KNOWLEDGE ECONOMY

Since the 1970s, many countries experienced an important economic transition from a production based on manufacturing to a production based on services. The outcome of this change has been termed the post-industrial economy (Block, 1990). Later, another transition occurred through an increased dependency on knowledge in the production process (Powell and Snellman, 2004).

In the present world economy, knowledge has become one of the main factors of production along with land, labor and capital. Consequently, it has a direct impact on economic growth and on the determination of societies' standard of living (Levy et al., 2011).

It is to note that the nature of knowledge in the production process is unique. In previous economy, the increase in consumption was followed by a decrease in material resources (concept of scarcity). In knowledge economy, however, the increase in consumption causes an increase in knowledge resources (concept of abundance). Also, intellectual ownership becomes more difficult to specify and protect. Consequently, patents and copyrights are used to prevent knowledge from becoming entirely a public good (Lichtenthaler and Ernst, 2007).

In this new economy, classical and neo-classical models become irrelevant (Peters, 2003). In the classical theory, the main factors of production that affect economic growth are represented by labor and capital. This analysis postulates that economic growth reaches its maximum when the costs of labor and capital used in production are equal to the marginal value of the product. Therefore, in classical economics, the

law of diminishing returns represents an important concept. This law implies that returns on investment activities ultimately decrease overtime.

However, with the introduction of knowledge in production, returns on investments can potentially increase. For this reason, "developed countries can sustain growth and developing economies, even those with unlimited labor and ample capital, cannot attain growth" (Romer, 1994).

In the neo-classical theory, even though knowledge, education and intellectual capital are perceived to be potential significant factors of growth, they are considered to be exogenous factors to the economic system.

The new growth theory is a more recent theory that tries to focus on the causes of long-term growth. It considers that labor and capital play important endogenous roles in economic development. In this theory, investments in education, training and R&D of products are parts of capital as a factor of production (Hulten, 2000). In addition, labor includes the ideas and the creativity that reside within the human workforce. All mentioned components increase the productivity, and hence the output of the goods produced. More specifically, ideas and creativity represent special resources that afford increasing returns.

In this context, economic growth is only constrained by the lack of innovation (OECD, 1996). Knowledge acquisition and continuous innovation become a necessity in the framework of knowledge economy.

3. THE NEW MODEL OF INNOVATION: A SHIFT FROM THE LINEAR MODEL

In knowledge economy, the success of businesses and national economies in general depends more than ever on their ability in the collection and use of knowledge. Therefore, the knowledge economy attaches great importance to the creation of knowledge, as well as to its dissemination. Consequently, competence and strategic expertise are interactively developed and shared within subgroups and networks. In this context, the economy becomes a hierarchy of networks, driven by an acceleration in the pace of knowledge acquisition and innovation progress. This results in a network society in which the socio-economic position of individuals and businesses is determined by the opportunity to access and participate in intensive knowledge and learning processes (David and Foray, 1995).

In knowledge economy, this network configuration has emerged inducing modifications to the classical theory of innovation (Chesbrough, 2006). The classical model considers innovation to be a discovery process that evolves into different stages following fixed and linear sequences (Carayannis and Campbell, 2010). The first stage is related to scientific research, followed by the successive stages of product development, production process, marketing and finally sales of products. It is admitted today that innovation in knowledge economy does not necessarily follow a linear process. Rather, it can result from multiple sources such as better manufacturing capabilities and identification of customer needs. Therefore, innovation requires intense interconnection between the different stakeholders: companies, laboratories, academic institutions and consumers. Also, innovation today can take different forms: improvements made to existing products, use of new technologies to supply existing markets or application of technology to acquire new markets (Bogers and West, 2012).

Consequently, in a knowledge economy, companies try to promote interactive ties with other enterprises and external networks in addition to their partners (Frankenberger *et al.*, 2014; Schroll and Mild, 2011), and this in order to take advantage of mutual advantages and complementary strengths. This web of relationships help companies to decrease the costs and risks of innovation among a greater number of organizations, to acquire the latest research results, to have access to the newest technologies and to share the results of new products or processes of production. While they develop new products and processes, companies decide whether they intend to undertake production activities by themselves, or in collaboration with other companies, universities or research institutions (Dahlander and Gunn, 2010).

Innovation thus often results from multiple interactions of a number of economic agents and institutions which form the so-called national innovation system. National innovation systems extend today even to an international level. They focus on the movements and relations between governments, academic institutions and the different branches of industries. Therefore, in relation to knowledge production, there is a need for a shift from specific individual institutions to a global interactive model that integrates relations between industry, university and government.

4. SCIENTIFIC RESEARCH AND KNOWLEDGE ECONOMY

According to Foray (2000), two main reasons seem to be at the origin of entry to the knowledge economy era. The first is the intensification in the use of information technologies. The second is represented by increasing resources devoted to the production and diffusion of knowledge such as R&D, training and education.

4.1. The Growing Role of Research

The growing role of research can be shown through the change in the type of economic production and trade. Exports of high-technology goods (such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery) accounted for approximately 2.1 trillion US $ in 2014, against 1.7 trillion US $ in 2005, and represented around 18% of total world trade. Expenditures for R&D represented an average of 2.18% of world GDP during the period 2004-2015. In addition, scientific and technical journal articles published in the year 2013 have exceeded two million articles, and more than 50,000 patents were filed in 2014 in the European region alone (World Bank, 2015).

Scientific research represents an organized and objective method of data collection and analysis at the aim of extracting and developing information that can be used in making decisions, or in reaching new findings and conclusions. It can be divided into two main categories:

- Applied research: is a type of research that generates knowledge and information able to feed future technological development. This type of research is usually conducted to respond to a necessity and aims to improve design and innovation in order to increase profitability.
- Fundamental (or basic) research: is a type of research generated by scientific curiosity and aims to create further contribution to knowledge with clear evidence of originality.

The economic globalization through knowledge economy has induced a decrease in the gap between research and utilization (Tidd *et al.,* 2001). This affected the relation between the theoretical and the practical sides of scientific research (Etzkowitz *et al.,* 2000).

Therefore, in knowledge economy, the scientific research becomes closely linked to economic growth. In this regard, the potential roles of governments and academic institutions are increasingly important (Villasalero *et al.,* 2011).

4.2. The Role of Government

Government policies may play an important role in affecting the context within which scientific research operates (Rosegrant and Lampe, 1992). The interconnection between government and research can be shown through the establishment of various laboratories, university research centers and other research and development institutes.

For instance, the role of the US government was fundamental in the development of information technology, as investment in R&D in this field was initiated by the Ministry of Defense. This has created a favorable environment for the spread of what was called the third industrial revolution and led to the achievement of high and sustained economic growth. In addition, the role of supervision done by the government appears to be an important determinant of investment in knowledge economy, which fosters innovation and technological progress. In addition, the government can act in terms of public investment. It can also help companies to innovate by offering the legal framework and using financial instruments such as tax credits.

4.3. The Role of Universities

The universities originally have been actively involved in practical industrial research (Jacob and Stewart, 2004), and "academe was perceived as doing the necessary fundamental science that often preceded application and industrial development" (Croissant and Restivo., 2001). Later, a gradual separation between applied industrial research and university occurred (Bercovitz and Feldmann, 2006). This separation left "control of commercial opportunities of academic research in the hands of industry whereas control over the direction of research and the choice of research topics was left to academic scientists" (Etzkowitz, 2002).

However, during the last part of the twentieth century, a tendency towards the capitalization of scientific research appeared in many fields notably in biotechnology. The development of technologies related to generic forms of knowledge represented the main cause of this shift (Baber, 2001). Therefore, the gap between fundamental and applied research narrowed, and there is an ongoing tendency in many universities in transforming academic intellectual property into patents, joint-venture companies and spin-off firms. This would have a positive impact on the socio-economic development (Balconi *et al.,* 2010).

With the entrenchment of the knowledge economy, the time period between discovery and use became shorter and the necessity of transforming research into products became greater (Villasalero, 2013). Therefore, we witness an increased dependency of industry on the knowledge originating from academic institutions. In this regard, universities are increasingly viewed as catalysts for a science-based economy. Thus, economic development represents a new dimension added to the main objectives of universities, namely teaching, research and community engagement (Perkmann *et al.,* 2013). An example of the interaction of academic engagement is represented by the establishment of industrial Ph.Ds. (Jacobsson and Perez Vico, 2010).

5. KNOWLEDGE ECONOMY IN GCC COUNTRIES

Because of the decrease in oil and gas prices and the necessity to create jobs for their nationals, the GCC countries are encouraged to undertake a new development pattern related to the concept of knowledge-based economy. Indeed, knowledge economy seems to fit well with the economies of the region (Hvidt, 2014). With the exception of Saudi Arabia, the GCC countries are small countries with low native population. Therefore, aiming for industries with higher knowledge content can be very beneficial to GCC economies.

It should be noted that the GCC countries have opportunities to move towards knowledge industries for several reasons such as their strong financial capacities and the existence of international partnerships in different fields such as medicine, energy, petrochemicals and others.

Actually, GCC states have sought to establish a sustainable and diversified economy based on high value-added activities, to encourage investment spirit of individuals, and to undertake special projects that have high degree of integration into the global economy. Those projects were often oriented towards the manufacturing sector because of its significant role in improving the density and interdependence of economic relations within the GCC member countries, especially in cases of potential recessions that would affect the sectors of real-estate, finance, tourism, etc.

More recently, in light of global changes, the GCC countries have paid more attention to knowledge-based industries. This trend was emphasized in the national economic visions and the development strategies of the GCC countries. Nevertheless, in spite of the interest and willingness; the progress in the application is still modest, and well below the desired ambitions.

Table 1 shows the latest World Bank knowledge economy index (KEI) database. Gulf countries are situated in the positions from 42 to 64 in the KEI rank. This is generally above the world average. However, results show that the Gulf countries have clear weaknesses on the two pillars of innovation and education.

Table 1
Knowledge economy index (KEI) in GCC Countries (Year 2012)

Country	*Rank*	*Change of Rank (2007-2012)*	*KEI*	*Economic Incentive Regime*	*Innovation*	*Education*	*ICT*
UAE	42	7	6.94	6.5	6.6	5.8	8.88
Bahrain	43	9	6.9	6.69	4.61	6.78	9.54
KSA	47	19	6.14	6.96	5.88	5.23	8.37
Oman	50	0	5.96	5.68	4.14	5.65	6.49
Qatar	54	-12	5.84	6.87	6.42	3.41	6.65
Kuwait	64	-18	5.33	5.86	5.22	3.7	6.53
World Average	-	-	5.12	5.41	6.14	3.48	3.59

Source: World Bank Institute

5.1. The Status of Innovation

The GCC Countries are facing difficulties to move from an oil-based economy towards a knowledge-oriented economy. This comes with no surprise as this transition is not an easy task (Tadros, 2015). The low

performance of GCC economies in innovation, which is shown in Table 1, is also reflected by the Global Innovation Index (GII index, 2016). In this index,when the GII rank is related to GDP, all Gulf countries are shown to be underperformers.This indicates that the Gulf countries have not yet managed to translate their economic wealth into innovative strength.

Table 2
Number of Patents in GCC Countries

Country	*2011*	*2012*	*2013*	*2014*	*2015*	*Average (2011-15)*	*Total (1977-2015)*
UAE	13	21	19	60	56	33.8	254
Bahrain	0	1	2	3	1	1.4	13
KSA	61	173	239	294	364	226.2	1513
Oman	3	3	3	3	5	3.4	26
Qatar	1	4	9	5	8	5.4	27
Kuwait	24	33	86	101	64	61.6	448
Israel	2108	2598	3152	3618	3804	3056	35900

Source: US Patent and Trademark Office

In addition, the number of patents is generally considered as an important indicator of the innovative capacity of a specific country (Furman *et al.* 2002).Table 2 shows that the number of patents is very limited in Gulf countries. During the period 1977-2015, 35900 patents are granted to Israel by the US Patent and Trademark Office (USPTO) in comparison to only 2281 for GCC countries. The recent yearly average rate of patents in GCC countries (period 2011-2015) is 55.3 patents, with Saudi Arabia accountable for most of them.

Despite the low performance, there are attempts and initiatives destined to embrace and motivate the knowledge environment in the GCC countries. Those countries started to pay more attention to the role of science and technology in economic and social development. This is reflected in the establishment of a number of measures that may foster knowledge economy. Some of them are the following:

- The Gulf youth award for innovation and creativity: an annual prize in the Gulf region, organized in one of the Gulf capitals, designed to stimulate innovation by individuals and companies in commercial, industrial and technological projects.
- The youth creativity and innovation conference: an annual conference involving Gulf youth, individual investors and universities in order to exchange ideas and experiences between students, financiers and entrepreneurs.
- A legislative policy initiative by the General Secretariat of the Gulf states to save the intellectual property rights.
- Research and development funds: Gulf countries aim to afford incentives and facilities to businessmen and private companies in order to encourage them to contribute and support the projects of research and development in higher education institutions.

- Projects to build technology and technical schools: technology and technical schools are intended to set up at elementary, intermediate and secondary levels to consolidate the concepts of innovation, creativity and scientific research methods in the minds of the youth, and prepare them since childhood to the culture of inventions in the fields of technology.

5.2. The role of GCC Governments

As can be seen in table 1, The Gulf economies exhibit remarkably high scores on the ICT pillar. However, this could be related to the availability of financial resources that would enable them to purchase and afford a good ICT infrastructure. Also, on the economic incentive regime pillar, the scores of the GCC countries are rather acceptable (above the world average). This is a reflection of relatively reliable governmental institutions, favorable fiscal environment and relative easiness in setting up business.

In contrast, other indicators show that the role of government is lacking. Table 3 shows the latest data related to the ratio of R&D expenditure as a percentage of GDP. Figures show that this ratio remains very low in GCC countries (between 0.1% in Bahrain and 0.49% in UAE). The GCC countries consider however improving this ratio. This is explicitly stated in different development plans such as the Kuwait's Four Year Development plan and the UAE Vision 2021.

Table 3
R&D expenditure as a percentage of GDP

Country	*R&D expenditure as a % of GDP*
UAE	0.489% (2011)
Bahrain	0.1% (2014)
KSA	0.073% (2009)
Oman	0.171% (2013)
Qatar	0.47% (2012)
Kuwait	0.302% (2013)
World Average	2.124% (2013)
South Korea	4.29% (2014)
Israel	4.109% (2014)

Source: World Bank Institute

Besides, there is a relatively weak involvement of the GCC governments in the relation between universities and the private sector (Hertog, 2013); in addition to the limited number of research institutes established by GCC governments (Meo *et al.,* 2016).

5.3. The Role of Universities

Various reports(Arab competitiveness report, 2016; Arab knowledge report, 2015; various World Bank reports) indicate that higher education and universities in GCC countries are facing different problems. Among those problems, we note the following:

- Limited focus on research in the universities of the region. Most time is allocated to teaching loads, and most universities are considered as "teaching universities". Figures in table 4 clearly reflect those findings.
- Lack of integration of the curriculum with the cycle of production and the needs of the labor market
- Limited amount of funds allocated to research
- Most students are enrolled in social sciences and very few students enrolled in technical sciences
- Weak relationship between higher education and economic growth since most nationals are ultimately employed in the public sector.
- Limited link between universities and the private sector.

Table 4
Number of ISI indexed journals and % of world scientific publication in GCC countries

Country	*Number of Universities*	*ISI Indexed journals*	*% of world scientific publications (Year 2013)*
UAE	33	16	0.12
Bahrain	11	1	0.02
KSA	68	9	0. 55
Oman	11	0	0.05
Qatar	12	0	0.07
Kuwait	6	5	0.05
Total	141	31	0.40

Source: Universities worldwide and ISI-web of Science

6. CONCLUSION

This paper examines the notions of innovation and scientific research in the context of knowledge economy. In its economic structure, the knowledge economy is characterized by a shift from an economy that relies on material production towards an economy based on knowledge inputs.

The knowledge economy represents a fundamental economic change on the global context. This change finds its essence in the rapid development of ICT technologies.The knowledge economy focuses on knowledge-based production and good education, and emphasizes continuous innovation and creation.Therefore, the boundary between fundamental and applied research is somewhat blurred. In this context, cooperation between industries, universities and governments becomes essential.

Because of the gap that exists at all levels of knowledge economy's indicators, the GCC countries face multiple challenges to achieve their development goals. The most important challenge consists on how to move from an oil-based economy towards an economic system led by knowledge economy indicators. This necessitates many measures that include a diversification and modernization of the production bases, a restructuring of the various economic sectors, a good preparation of national human resources and the setting of proper requirements and incentives to attract qualified workers.

An examination of the situation in GCC countries shows that the main problems faced by decision makers reside in the following aspects: The low spending on research and development comparing to other countries, the disparity in the relationship between developed infrastructure and the existence of different development issues and the weakness of creativity and innovation in most universities and research centers.

Since the transition from a rentier economy to knowledge economy is not easy- as it includes different aspects such as culture-, the overall performance shows that the GCC countries can be considered to be on the right track to improve knowledge indicators. GCC countries have the potential and the material capacity to overcome obstacles, and embark in a knowledge economy society.

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