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Abstract

This paper employs both the descriptive and comparative approaches and uses the definition of systems of innovation used in the literature to examine the existence, characteristics and implications of the regional systems of innovation in the Arab region. We examine three hypotheses, that the regional systems of innovation exist but are characterized by serious weaknesses in the Arab region compared with other world regions, that the structure of the economy has a significant effect in the performance of innovation systems in the Arab region, and that the poor Arab systems of innovation have serious implications in the Arab region. We explain two common characteristics of Arab regional systems of innovation concerning poor subsystems of education, S&T, R&D and ICT institutions in the Arab region and concentration of R&D activities within public and universities sectors and small contribution of the private sector in R&D activities. We find that the major implications are the poor performance of the Arab region in terms of S&T indicators, competitiveness indicators, technology achievement index and poor integration in the knowledge economy index. Therefore, it is essential for the Arab region to enhance the institutions of higher education, S&T, R&D and ICT to build the Arab regional systems of innovation and to achieve economic development in the Arab region.

Key words: Education, S&T, R&D, Systems of innovation, economic structure, Arab region.

JEL classification: O10, O11, O30

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Regional Systems of Innovation in the Arab Region

1. Introduction

This paper aims to discuss the characteristics and implications of Regional Systems of Innovation (RSI) in the Arab region and to contribute to recently published research studies that aim to improve understanding of the nature and performance of regional innovation system in the developing countries.[2] This paper addresses the following questions: Does the regional systems of innovation exist in the Arab region?; Does the economic structure affect the regional systems of innovation in the Arab region?; and What are the major implications?.

We examine three hypotheses, the first hypothesis is that the regional systems of innovation exist but characterized by serious weaknesses in the Arab region compared with other world regions. This hypothesis implies that the Arab region has manifestly lagged far behind other world regions in terms of S&T, innovation, knowledge, technological capabilities, spending on information and communication technology (ICT), competitiveness and integration in the world economy. We examine the second hypothesis that the structure of the economy has significant effect in the performance of innovations system in the Arab region. This hypothesis implies that the Arab region shows remarkable diversity not only regarding economic growth (per capita income/income level), structure of the economy, but also concerning systems of innovation, mainly, subsystems of education, science and technology (S&T), ICT and networking. We examine the third hypothesis that apart from the remarkable diversity in the Arab region, the poor Arab systems of innovation has serious implications. These serious implications appear in terms of poor competitiveness, integration in the global economy, knowledge economy index, share of high technology export, technology infrastructure, technology achievement index and capacity to create knowledge in the Arab region.

Several studies in the literature use different classifications of Arab countries according to the structure of the economy, geographical location and income level based on the World Bank classification of economies according to income level. Our analysis using the classification of Arab countries according to the structure of the economy is interesting to add new aspects and differs from the existing studies covering the Arab region. Particularly, because our study differ from the existing studies in the Arab literature that use different classifications of the Arab countries according to income level (Nour, 2011) and geographical location in Asia and Africa (cf. UNESCO, 2004) in the Gulf or Mediterranean (cf. Nour, 2003; 2005). Moreover, different from the existing studies in the Arab literature that use the classification of Arab countries according to the structure of the economy to discuss the economic and development issues in the Arab region (cf. Ali, 2004; ERF, 1998), our study use the same classification to discuss the regional systems of innovation in the Arab region. Particularly, we examine the poor performance of the regional systems of innovation in the Arab region according to certain criterion, mainly the classification of Arab countries according to the structure of the economy. We believe that the selection of this criterion seems quite consistent with the well known stylized facts and widely used standard classification of Arab countries

[2] The Arab region is composed of twenty two countries, including Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Mauritania, Morocco, Oman Occupied Palestine Territories, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates and Yemen.

according to their reliance on natural resources. Moreover, since, the level of income is closely related to economic structure, so the selection of this criterion is quite consistent with the conventional view concerning the positive relationship between knowledge necessary for building efficient systems of innovation and development/income level, since knowledge and innovative capabilities are concentrated in high income and developed countries as indicated in numerous studies (cf. UNESCO, 2004a; World Bank, 1999; OECD, 1997).[3] Moreover, we use recent and update data and provide more comprehensive study compared to few studies on the systems of innovation in the Arab region (cf. Djeflat, 1999). We fill the gap in the Arab literature by explaining the relationship between the regional systems of innovation and structure of the economy in the Arab region and the implications of the weak systems of innovation in the Arab region. Moreover, we support the efforts aim to enhance Arab innovation systems by improving understanding about the importance of enhancing institutions necessary for building innovation systems in the Arab region. The paper also refers to relevant literature on the regional systems of innovation in the following section. Hence, this paper is interesting as it integrates the most widely used indicators of the systems of innovation with the economic structure, and presents a new and more comprehensive analysis for the Arab region. Similar to the studies in the literature, we define the system of innovation by subsystems including education institutions, S&T institutions defined by S&T input-output indicators (R&D, patent and publications), and information (ICT)[4] institutions. Moreover, we use other indicators such as competitiveness indicators, high-technology export and knowledge economy index.

Regarding research method, we use the descriptive and comparative methods of analysis. We are aware of the fact that it would be useful to use as a research method Linstone's multiple perspectives approach that includes three types of technical, organizational and personal perspectives. However, our analysis will not use Linstone's multiple perspectives approach; due to practical problems related to scarcity of necessary data on the three types of technical, organizational and personal perspectives, we leave that for more in-depth analysis in the future based on data availability.[5]

One major limitation of our analysis in this paper is related to the relevance and implications of the systems of innovation described in the literature to the analysis of Arab region as part of developing countries (cf. Shulin, 1999). We are aware of the conceptual and methodological difficulties of applying the systems of innovation approach of the developed countries to the developing countries. We believe that due to limited studies focusing on the developing countries (cf. Shulin, 1999; Muchie, Gammeltoft, and Lundvall, 2003) the available literature still provides useful

[3] For instance, the OECD (1999) indicates two sources of diversity in national innovation systems: a first source of diversity is country size and level of development. Large and highly developed countries offer markets with advanced customers and opportunities to reap economies of scale while maintaining diversity in R&D activities. A second source relates to the respective roles of the main actors in innovation processes (firms, public and private research organisations, and government and other public institutions), and the forms, quality and intensity of their interactions. (OECD, 1999: 22)

[4] Information and Communication technology (ICT) is measured by the percentage of population using the Internet, fixed telephone and mobile.

[5] Linstone (1988) discusses the evolution of the multiple perspective approach and its range of applications over the past decade. The traditional technical perspective of systems analysis is augmented with organizational and personal perspectives. The three types of perspectives have inherently different characteristics and properties. The applications show that each perspective yields insights on a system that are not attainable with the others. The organizational and personal perspectives also focus more attention on problems of implementation. The concept is serving as an effective and practical vehicle to overcome the limitations of systems analysis in dealing with complex real-world situations. See Linstone, H. (1988) "Multiple perspectives: Concept, applications, and user guidelines," Systems practice, September 1989, Volume 2, Issue 3, pp 307-331. http://link.springer.com/article/10.1007%2FBF01059977?LI=true.

insights for our purpose and analysis in this paper, mainly because of special emphasis on institutional settings for enhancing efficient systems of innovation. The second limitation is related to the limited scope of our analysis, since our aim is to explain only the characteristics and implications of Arab regional innovation systems by investigating the subsystems of educational institutions, S&T and R&D institutions and information (ICT) institutions. While we admit that it is also essential to investigate the linkage and interaction between these institutions, however, due to scarcity of necessary information, our analysis will not cover the interaction between these institutions; we leave that for more in-depth analysis in the future. Apart from these limitations our paper is useful to improve understanding of the characteristics and implications of Arab regional systems of innovation.

The rest of this paper is organized as follows: Section 2 presents the conceptual framework and literature review. Section 3 shows the general socio-economic characteristics of Arab region. Section 4 discusses the characteristics of Arab regional systems of innovation. Section 5 explains the major implications of the systems of innovation in the Arab region. Finally, Section 6 provides the conclusions and policy recommendations.

2. Conceptual framework and literature review

The concept "systems of innovation" and the concepts innovation and diffusion (see Rogers, 1995) have been widely used and discussed in the literature.[6] Before examining the existence of Arab regional system of innovation and analysing the characteristics and implications of Arab regional system of innovation, it is convenient to show briefly the definition of the concept and review the literature on national and regional systems of innovation.

The term 'national systems of innovation' has been widely used in the literature to reflect the interrelationship between technical and institutional change. Early contribution by Freeman (1987) defines a national system of innovation as 'the network of institutions in the public and private sector whose activities and interactions initiate, import, modify and diffuse new technologies' (Freeman, 1987: 1).

Next pioneering contribution by Lundval (1992) provides a more clear and comprehensive definition of the concept of a national system of innovation. Lundval (1992) definition includes "all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring- the production system, the marketing system of finance present themselves as subsystems in which learning take place. A definition of the system of innovation must be kept open and flexible regarding which subsystems should be included and which processes should be studied. Determining in detail which subsystems and social institutions should be included, or excluded, in the analysis of the system is a task involving historical analysis as well as theoretical considerations…." (Lundvall, 1992, p. 12-13). Lundvall (1992) attempted a theoretical approach to link the national systems of innovation approach to innovation theory (Lundvall, 1992:1). Next contribution by Nelson (1993) provides an empirical analysis of the national systems of innovation approach.

Next Freeman and Soete (1997) argue that "The many national interactions (whether public

[6] See Rogers, E.M. "Diffusion of Innovation" The Free Press, New-York (1995, 4th ed): http://www2.gsu.edu/~wwwitr/docs/diffusion/

or private) between various institutions dealing with science and technology as well as with higher education, innovation and technology diffusion in the much broader sense, have become known as 'national systems of innovation'. A clear understanding of such national systemic interactions provides an essential bridge when moving from the micro- to the macro- economics of innovation. It is also essential for comprehending fully the growth dynamics of science and technology and the particularly striking way in which such growth dynamics appears to differ across countries" (Freeman and Soete, 1997: 291).

All the definitions of the systems of innovation approaches are consistent in highlighting the vital role of institutions in influencing innovation. Lundvall (1992) argues that " 'the structure of production' and 'institutional set-up' are the two most important dimensions, which 'jointly define a system of innovation….. the institutional set-up … is the second important dimension of the system of innovation' " (Lundvall, 1992:9, 10). Nelson (1993) mentions organizations supporting R&D, Nelson and Rosenberg stress (1993) 'the institutions and mechanisms supporting technological innovation' (Nelson and Rosenberg, 1993:1). Moreover, the OECD (1999) provides definition of the concept National Innovation System (NIS) "according to Metcalfe (1995) National innovation systems are defined as the "… set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies" (Metcalfe, 1995). Furthermore "the innovative performance of an economy depends not only on how the individual institutions (e.g. firms, research institutes, universities) perform in isolation, but also on "how they interact with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (such as values, norms, legal frameworks)" (Smith, 1996)" OECD, 1999: 24)

The concept 'regional innovation system' (RISs) reflects a regional perspective on innovation and industrial development, it has been developed since 1992 (see, for example, Cooke, 1992; 1996) from the contribution following the ((NSIs) literature (Lundvall, 1992; Nelson, 1993). One example is AnnaLee Saxenian's analysis of 'regional industrial system' which focuses on Silicon Valley California and Route 128 Massachusetts (Saxenian, 1994). [There is], considerable debate in the literature on the existence of regional innovation systems (RISs) and meaningful of the idea of 'regional innovation'. For instance, Braczyk, Cooke and Heidenreich (1998) express argument for focusing on the Regional innovation systems (RISs), indicating that change in the organization of production, policies and business location also mean the regional level has grown in importance as a source of innovation support for business. They indicate the interaction between technology and regional development policies and increasing attention in explaining the locational distribution and policy impact of regional high-technology industry that leads to the phenomenon of economically powerful "region-state". In addition to increasing interests to examine the extent of systemic innovation processes at regional level and the convergence or divergence among national innovation arrangements, particularly with the increasingly internationalization of science and technology and R&D, globalization and supranational innovation programmes. (Cooke, 1998: 2-6).

Other studies in the literature provide similar two interpretations of increasing concern about regional system of innovation. “The first one is that local and regional government in Europe and the US are now more active in technology policy than they were 20 years ago. This new regionalism can be seen as a paradoxical consequence of globalisation- the growing importance of locality as a site for innovation. Regional innovation systems become an important issue because of increasing need in order to preserve competitiveness of regions in a rapidly globalized world and to attract high-technology firms from outside the regions, or to facilitate the transfer of knowledge to regional firms” (Meeus, Oerlemans and van Dijck, 2000: 192). “The second interpretation is related to the basic idea behind regional innovation systems that proximity makes specific resources more readily available. On the other hand, compared to relationships on a larger spatial scale, local relationships between firms and institutional actors (local universities and research laboratories) facilitates the utilisation of resources because of cultural homogeneity (Lundvall, 1992, Morgan, 1997)” (Meeus, Oerlemans and van Dijck, 2000: 192).

Hollanders, Tarantola and Loschky (2009; 2010) The European Regional Innovation Scoreboard (RIS) (2010) provides a comparative assessment of innovation performance across the regions of the European Union and Norway and offers richer information to regional innovation policymakers, using more comprehensive and detailed, regional Community Innovation Survey (CIS) indicators. As the regional level is important for economic development and for the design and implementation of innovation policies, indicators to compare and benchmark innovation performance at regional level are important to inform policy priorities and to monitor trends. The RIS (2010) indicates that there is a considerable diversity in regional innovation performances, the most of the 2009 RIS innovative regions are typically in the most innovative countries, regions have different strengths and weaknesses, and regional performance appears relatively stable since 2004.[7]

McLeod (2001) focuses on regionalism, new regional geography, globalization, political economic space, the politics of scale, institutional-relational state theory and the regulation approach. McLeod (2001) argues that a synthesis of these perspectives might intensify our understanding of the social and political construction of regions, the uneven geography of growth, and the moments of re-scaled "regionalized" state power that now enframe the process of economic governance.[8]

Doloreux and Parto (2005) argue that in recent years, the concept of *regional innovation systems* has evolved into a widely used analytical framework that generates the empirical foundation for innovation policy making. Yet, the approaches that utilize this framework remain ambiguous on such key issues as the territorial dimension of innovation, i.e. the region, and the apparently important role played by ‘institutions’ or the institutional context in the emergence and sustenance of regional innovation systems. Doloreux and Parto (2005) review important ideas and arguments in the recent

[7] See Hollanders, H. Tarantola, S. and Loschky, A. (2010) "Regional Innovation Scoreboard (RIS) - Methodology report," (2010). See also the Regional Innovation Scoreboard: http://www.proinno-europe.eu/page/regional-innovation-scoreboard, accessed 6 January 2013.

[8] See McLeod, G. (2001) 'New regionalism reconsidered: Globalisation and remaking of political economic space', International Journal of Urban and Regional Research, No 25, 804-29. Blackwell Publishers Ltd 2001.

theorizing on regional innovation systems. They also examine such issues as definition confusion and empirical validation; the territorial aspect of regional innovation systems; and the role of institutions.[9]

D'Agostino (2001) finds that on average regions where innovation activities are more diffused tend to grow more, at least in the manufacturing sector, and following the literature, expects the causal link to go from innovation to growth and not vice-versa. He shows that regions with a wider diffusion of innovation activities are more dynamic, in terms of higher birth and death rate of firms and in terms of mergers and acquisitions, than regions with low innovation density. In order to attempt an identification of different (regional) systems of innovation, he has clustered the EU regions according to their main input, output and "environmental" characteristics. He finds that high innovation rates are combined to high rates of public participation and support, and indicates the importance of human capital and education, as measured for instance by education, as a prerequisite for successful innovation activities to take place. Thus fostering innovation performance could push for a twist in infrastructural policy in less developed regions, from physical infrastructures (e.g. roads) to infrastructures directly aimed at improving the technological and scientific level (e.g. polytechnics).[10]

Ramon, Jan and Cristina (2008) examine RIS and developing countries and linking firm technological capabilities to regional systems of innovation. They explore the role of regional innovation systems supporting capability building among indigenous SMEs in two different RIS in Mexico. They explicitly attempt at testing the validity of the underlying assumptions in RIS literature in the context of developing countries, such as the importance of interactive learning with foreign subsidiaries, universities and research centres or among firms in the system of innovation. They show that regional innovation systems in developing countries share central characteristics with RIS in developed countries and, in that respect, the approach is valid for the analysis of RIS in developing countries. Their analysis also highlights the importance of local conditions for catching-up and development. They argue that the same industry in the same country might perform very differently depending on the characteristics of local systems.[11]

Vang and Cristina (2007) show learning from the Bangalore experience and examine the role of universities in an emerging regional innovation system. They investigate the role of universities and public research organizations in initiating and sustaining the development of regional innovation systems in developing countries, focusing the discussion on the Bangalore software cluster and innovation systems. They paid significant attention to the importance of universities and other publicly financed research institutions as engines of growth and innovative performance in regions.[12]

Lundvall, Joseph and Cristina (2009) handbook of innovation and development gives an overview of the current state of the art for research that links innovation system analysis to economic

[9] See Doloreux, D. and Parto , S. (2005) "Regional innovation systems: Current discourse and unresolved issues," Available online 25 February 2005.: http://dx.doi.org/10.1016/j.techsoc.2005.01.002, See also Doloreux, and Parto, "Regional Innovation Systems: A Critical Review": http://www.ulb.ac.be/soco/asrdlf/documents/RIS_Doloreux-Parto_000.pdf.

[10] See D'Agostino, G. (2001) "Regional Patterns of Innovation: the Analysis of CIS Results and Lessons from Other Innovation Surveys," STEP Economics, Turin, pp. 2-3, 4-5, 6-10.

[11] See Padilla, R.; Vang, J. and Cristina, C. (2008) "RIS and Developing Countries: Linking firm technological capabilities to regional systems of innovation" Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund University - WP 2008/13. A pre-print version of a chapter published in Lundvall, B-A, Joseph, KJ., Cristina, C. and Vang, J. (Eds), *Handbook of Innovation systems and developing countries. Building domestic capabilities in a global setting*, http://www.e-elgar.co.uk: Edward Elgar Publishing, 2009.

[12] See Vang, J. and Cristina, C. (2007) "Learning from the Bangalore Experience: The Role of Universities in an Emerging Regional Innovation System," Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE) Lund University, WP 2007/04.

development, it gives room for a discussion of implications for public policy, and useful for policy makers interested in understanding how to engage in catching-up in the world economy.[13]

Astrid, Andrew and Cristina (2009) address the building systems of innovation in less developed countries and explain the role of intermediate organizations. They argue that the nature of innovation systems in developing countries differs substantially from those in developed countries (e.g. Arocena and Sutz, 2000; Cassiolato et al, 2003, Lundvall et al, forthcoming; Altenburg, forthcoming). Typically less developed countries are characterized by deficient socio-economic infrastructure, weaker institutional frameworks and low levels of interaction. Formal institutional, legal and regulatory, frameworks are generally weakly developed and usually have less reliable enforcement mechanisms. The composition of sectors tends to be different, less diversified, with simple consumer goods (in food and clothing) being central in local manufacturing, with a high degree of dependence on imported manufactured goods. Low levels of interaction among firms, as well as among different type of organizations (e.g. firms, universities, technology service providers) are typical. The limited number of innovative enterprises are often isolated and suffer from few upstream and downstream linkages in the value chain, as well as specific technology institutions in their field of expertise (Arocena and Sutz, 2001). Informality in business networks, dominated by micro-enterprises and small scale agricultural production is another key distinctive feature of the innovation systems in less developed countries (e.g. Bertelsen and Müller 2003), which is often linked to higher degrees of poverty (Altenburg, forthcoming).[14]

3. General socio-economic characteristics of the Arab region

Based on the above framework and before examining the existence of Arab regional systems of innovation and analysing the characteristics and implications of the Arab regional systems of innovation, it is useful to begin with the general socio-economic characteristics of Arab region, Figures 1-4 shows socio-economic and development characteristics of countries constituting the Arab region (economic growth (GNI per capita), life expectancy, mean years of schooling, literacy rate, gross enrolment ratio, growth rate of GDP and unemployment rates).[15] Our classification of Arab countries into four groups is based on the classification of countries according to the structure of the economy.[16] This classification implies that the structure of the Arab countries differs from resources oil based economies, mixed oil economies, diversified economies and primary export economies. For world, all

[13] See Lundvall, B-Å, Joseph, K. J. and Cristina, C. (2009) "Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Context," Edward Elgar Publishing, January, 2009.

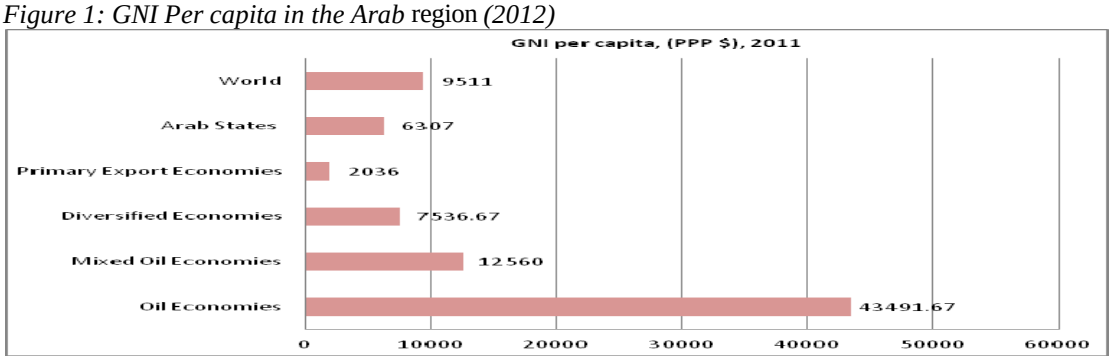
[14] See Astrid, S., Andrew, C., and Cristina, C. (2009) "Building systems of innovation in less developed countries: The role of intermediate organizations", Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE) Lund University, WP 2009/01. p. 3.

[15] Fergany (1999) uses the term Arab region instead of Arab countries and argues that "in spite of recently efforts to define alternatives: "Middle East", "MENA" or "Arab countries, Iran and Turkey", an "Arab region" is a coherent and meaningful historical entity. It is also so in the perspective of science, especially social sciences. ……. "Arab Homeland", used in Arabic, is laden with cultural and functional connotations. The common language, an essential medium for knowledge generation and utilisation, is a potent reason. A distinguished history of achievement in science at the zenith of Arab civilisation is another".

[16] According to the World Bank classification (2005), the Arab resources oil based economies includes only six countries: UAE, Qatar, Kuwait, Bahrain, Saudi Arabia and Oman, Arab mixed oil economies includes Algeria and Libya. Arab diversified economies include six countries: Egypt, Tunisia, Morocco, Syria, Lebanon and Jordan, oil primary exports economies includes Djibouti, Sudan, Mauritania and Yemen and Comoros. Other countries include: Iraq, Occupied Palestine Territories and Somalia. On that basis the share of oil, mixed oil, diversified, primary exports and other countries account for 27%; 9%; 27%; 23% and 14% respectively.

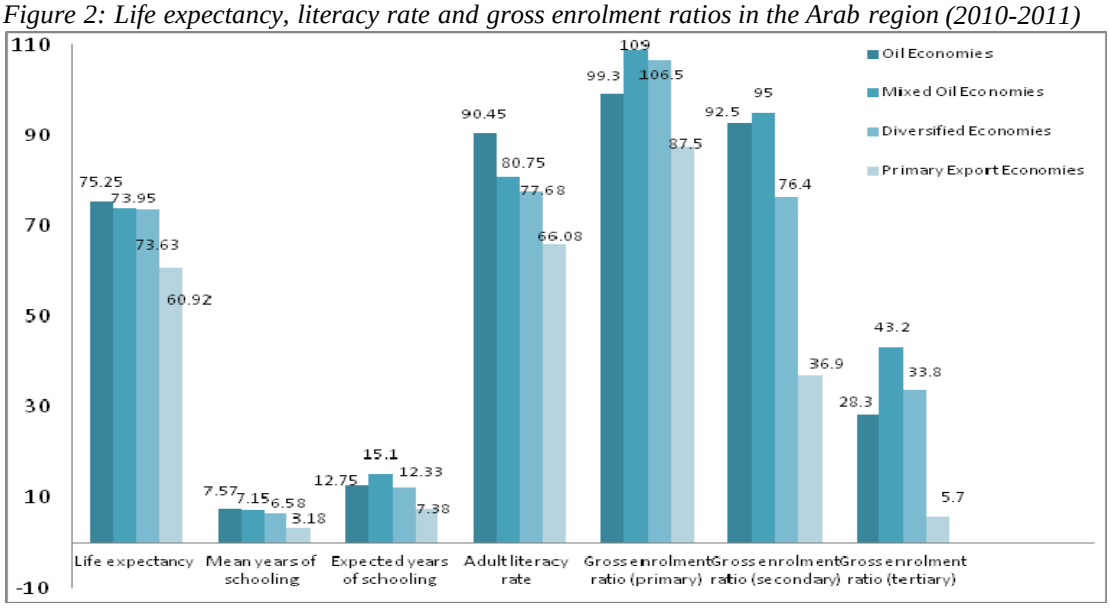
Arab, resources oil based economies, mixed oil economies, diversified economies and primary export economies average GNI per capita account for US$ 9511; US$ 6307; US$ 43491.67; US$ 12560; US$ 7536.67 and US$ 2036 respectively- see Figure 1. For all Arab resources oil based economies, mixed oil economies, diversified economies and primary export economies average life expectancy account for 75.25; 73.95; 73.63 and 60.92 respectively. For Arab resources oil based economies, mixed oil economies, diversified economies and primary export economies expected years of schooling account for 12.75; 15.1; 12.33 and 7.38 respectively, mean years of schooling account for 7.57; 7.15; 6.58 and 3.18 respectively and average literacy rate account for 90.45; 80.75; 77.68 and 66.08 respectively. For all Arab resources oil based economies, mixed oil economies, diversified economies and primary export economies gross enrolment in primary education account for 99.3, 109, 106.5 and 87.5 respectively, gross enrolment in secondary education account for 92.5; 95; 76.4 and 36.9 respectively and gross enrolment in tertiary education account for 28.3; 43.2; 33.8 and 5.7 respectively - see Figure 2. Moreover, the World Bank (2002) World Economic Outlook (2002), and the World Bank (2012)- World Development Indicators Database (2012) show rapid increase of unemployment rates and considerable fluctuation in the trend of real GDP growth rate. The low average unemployment rates and high average real GDP growth rates in the period 1995-2009 is reported for oil based economies, mixed oil economies, diversified economies and primary export economies respectively- see Figures 3-4.

Figure 1: GNI Per capita in the Arab region *(2012)*



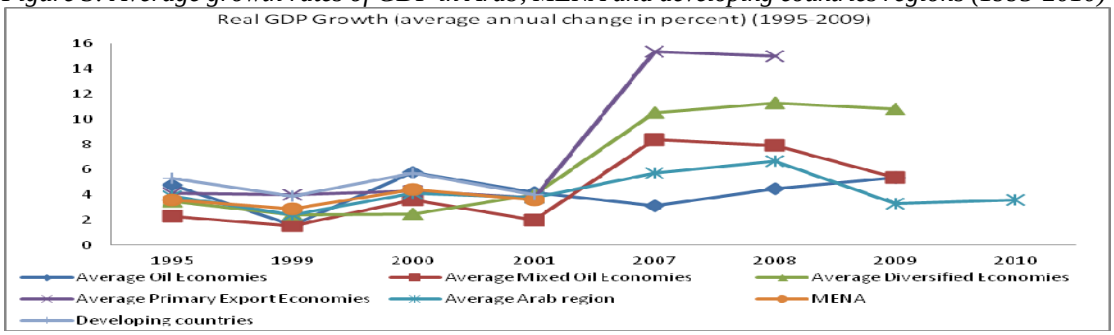
Source: Adapted from UNDP (2011)

Figure 2: Life expectancy, literacy rate and gross enrolment ratios in the Arab region (2010-2011)



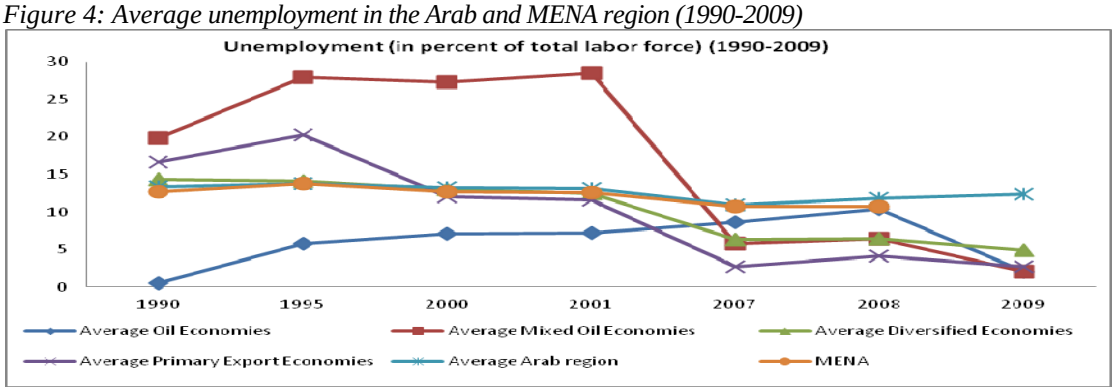
Source: Adapted from UNDP (2011)

Figure 3: Average growth rates of GDP in Arab, MENA and developing countries regions (1995-2010)



Sources: Adapted from the World Bank (2002): World Economic Outlook (2002) and the World Bank (2012) World Development Indicators Database (2012)

Figure 4: Average unemployment in the Arab and MENA region (1990-2009)



Sources: Adapted from the World Bank (2002): World Economic Outlook (2002) and the World Bank (2012)-World Development Indicators Database (2012)

We are aware of the fact that there is considerable diversity between the Arab countries in terms of the geographical, governmental, ethnicity, demographic composition, standards of economic development and growth (as measured by GNI per capita) and innovation. We are aware of the considerable variation across the Arab countries regarding the performance in many indicators related to innovation, which implies that probably, it is somewhat problematic to make generalization about the performance of the region as a whole as each country has had its own experience. Nevertheless, the Arab countries tend to share common problems regarding the weak performance in several indicators related to systems of innovation (e.g. institutions, poor quality of education, S&T, R&D, capacity for innovation, etc.). Apart from the observed differences, our analysis is based on the common problems hampering the systems of innovation in the Arab region as a whole. Therefore, this paper uses the existing literature and statistics in the Arab region to examine the regional systems of innovation in the Arab region (see Nour, 2012). Figures 1-4 above explain the great diversity across Arab countries in terms of socio-economic indicators (GNI per capita, literacy, life expectancy, schooling and gross enrolment ratios).[17] The great diversity in human development indicators and the use of ICT across the Arab

[17] Fergany (1998) recognizes the diversity amongst Arab countries, in particular, the heterogeneity of Arab employment conditions and argues that "The Arab region comprises quite a heterogeneous group of countries, both in terms of socio-economic structure and the nature of unemployment. On one hand, the six oil-rich GCC countries are major labour importers. Having been, to varying degrees, generous welfare states, these countries have been undergoing economic strains as a result of the declining fortunes of the international oil market. .... But about 90% of the Arab population resides in countries outside the GCC. This is also a very heterogeneous lot. On the human development index, in 1998, they include some at the top of the "medium" level countries as well as some near the bottom of the "low" tier" Fergany (1998). Ali (2004) uses the ERF (1998) classification of Arab countries and finds that "The Arab countries have very diverse characteristics in such areas as the structures of economies, level of development, geographical location and type of governance and institutions. To highlight the economic diversity of the region, ERF (1998) grouped the countries of the

states can be interpreted in relation to variation of economic growth indicators/ income level, particularly GNI per capita.[18,] We find that despite, the great variation in economic and development indicators across the Arab countries, however none of the Arab country established sufficient and efficient institutions to build the systems of innovation. All the Arab including resources rich oil based high income Gulf states still lack efficient institutions to build the systems of innovation due to failure to promote efficient educational system, S&T and skills, insignificant economic impacts of ICT, failure to attract FDI and heavy dependence on foreign technologies.[19]

4. The existence and characteristics of Arab regional systems of innovation:

This section examines the first research question and hypothesis that the regional systems of innovation exist but characterized by serious weaknesses in the Arab region compared with other world regions, it identifies two common characteristics of Arab systems of innovation, related to the serious weaknesses and falling behind advanced region. We investigate the second research question and hypothesis that the structure of the economy has significant effect in the performance of innovation systems in the Arab region, mainly, the sources of diversity in the performance of regional systems of innovation in the Arab region can be explained in relation to differences in the structure of the economy, subsystems of education, higher education, S&T, and ICT.[20]

4. 1. Subsystem of education and higher education institutions

Despite the relative decline in illiteracy rates, however, the illiterate population is approaching around 20 per cent of total Arab population. Illiteracy rates for the Arab region is higher than the World total, LCD's, Asia, Latin America and the Caribbean and seem comparable to those of Africa and Sub-Saharan Africa.[21] Moreover, the Arab region has manifestly lagged far behind other world regions in terms of major skills indicators defined by the percentage share of gross enrolment ratio in tertiary education, the share of tertiary students in science, math and engineering, Harbison Myers Index, technical enrolment index and engineering enrolment index- see Figures 5-9.[22] Mainly, average percentages share of gross enrolment ratio in tertiary education (19.636) and the share of tertiary students in science, math and engineering (12.091) for all Arab countries together fall far behind

region into four broad categories: mixed oil economies (MOE: Algeria, Iraq and Libya); oil economies (OE), which include the countries of the Gulf Cooperation Council of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE; diversified economies (DE: Egypt, Jordan, Lebanon, Morocco, Syria and Tunisia); and primary export economies (PEE: Comoros, Djibouti, Mauritania, Somalia, Sudan and Yemen)". (Ali, 1998: p. 11). All high income countries are clustered in the Gulf region and located in Asia, while, all low income are located in Africa, whereas, the medium income countries are distributed between Asia and Africa.

[18] See, for example, Nour (2002a). Figures 3-4 show that although the level of economic growth and unemployment rates varied enormously across the Arab countries, however, now the Arab states are facing the challenges of declining trend of economic growth rates and increasing unemployment rates- See Elbadawi (2002) and Makadisi et al. (2003) for recent analysis of slowing economic growth in the Arab world. Moreover, the presence of high poverty rate adds to the challenging situation in the medium and low income groups in the Arab countries. For instance, the results of Ali (2001) and Ali and Elbadawi (2000) indicate the high incidence of poverty in the Arab states, estimating about 22% of the Arab population were living below a real poverty line measured in term of purchasing power parity price (PPP) of $ 56 per person per month.

[19] See, for example, Muysken and Nour 2006). Nour (2002b) shows insignificant impacts of ICT in the Arab countries. For earlier analysis of S&T in the Arab region, see for example, Qasem (1998), Zahlan (1999, a; b) and Fergany (1999).

[20] These sources of diversity are indicated in the OECD (1999).

[21] See UNDP (2011).

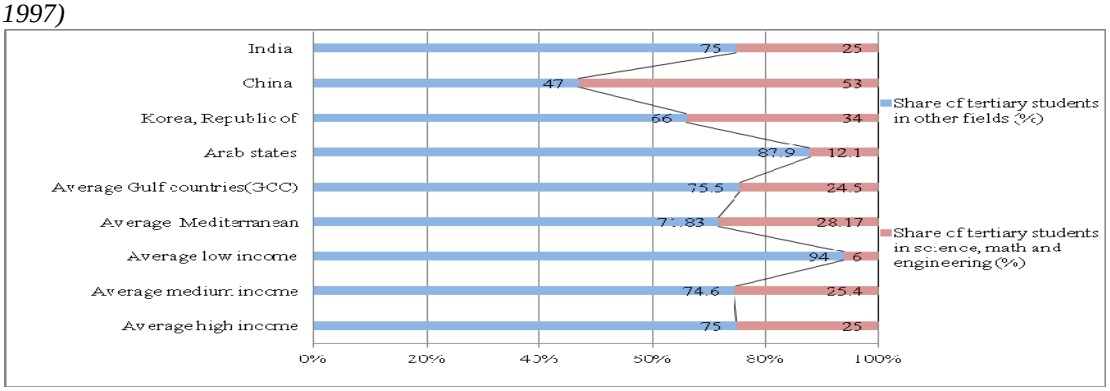
[22] "Harbison Myers Index is the sum of secondary enrolment and tertiary enrolment times 5, both as % of age group. Technical enrolment index is tertiary total enrolment (times 1000) plus tertiary enrolment in technical subjects (times 5000), both as % of population. Engineering skills index is the same as previous index, with tertiary enrolments in engineering instead of enrolment in technical subjects" (Lall, 1999).

Korea, Singapore, Malaysia and China- see Figures 5-9.

The problem of poor quality of higher educational system is the major constraint for innovation system in the Arab region.[23] The share of public spending on tertiary education in total public spending on education in the Arab region falls behind Singapore, Malaysia and India.[24] Another serious problematic feature of the tertiary education in the Arab countries is the (biases against) low share of tertiary students in science, math and engineering, with the exception of Algeria,[25] for all Arab countries average enrolment in sciences, math and engineering accounted only for 12.1 per cent compared to 87.9 per cent for other fields, the Arab region fall behind Singapore, Malaysia and India- see Figures 5-9.[26] The enrolment ratios vary across Arab countries; Nour (2005) finds that the biases are more serious for Arab Gulf compared to Arab Mediterranean countries. Furthermore, another problematic feature of higher education in the Arab countries appears from the relative distribution of tertiary education students by attainment levels. For the majority (83.8 per cent) of tertiary students in the Arab region the attainment was less than the university degree, while only few (14.92 per cent-1.29 per cent) obtained the first university degree or higher, falling far behind China (48 per cent) and Korea (41 per cent)- see Figure 9.

The performance of resources oil based economies, mixed oil economies and diversified economies are close to each other, but the gap between them and primary export economies is high in terms of total tertiary education student graduation ratio, first degree during (2005-2011). Average percentages share of graduation ratio in tertiary education in 2011 for diversified economies and mixed oil economies exceed resources oil based economies and the average percentage share of graduate tertiary students in science; math and engineering in 2011 for resources oil based economies exceed the diversified economies and mixed oil economies- see Figures 10-11.

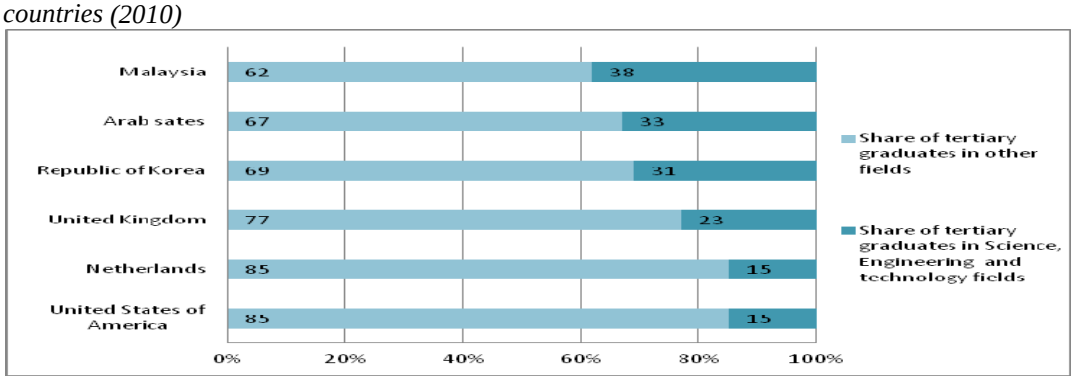
Figure 5: Distribution of tertiary education student by fields in the Arab and world countries (1994-1997)



Sources: Adapted from the UNDP (2002; 2003; 2004)

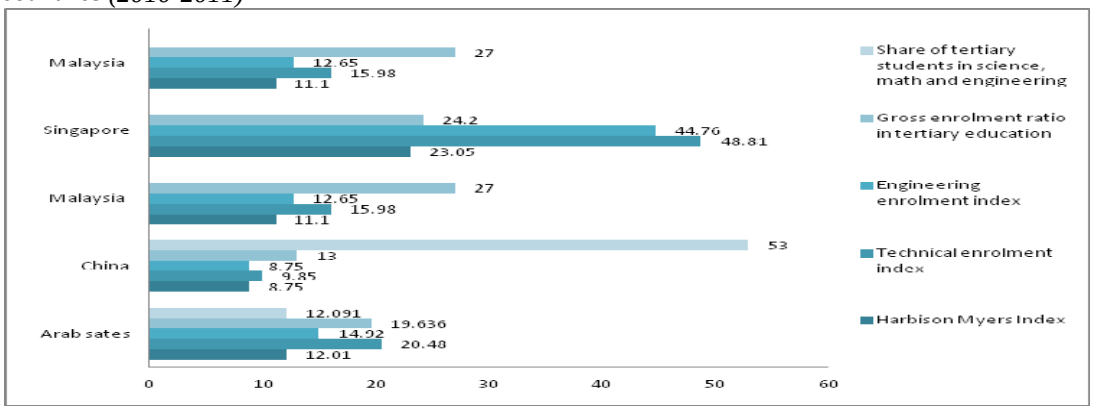
[23] See UNDP–AHDR, (2003).
[24] See UNDP (2003).
[25] See UNDP (2004).
[26] See Muysken and Nour (2006).

Figure 6: Distribution of tertiary education student graduates by fields in the Arab and World countries (2010)



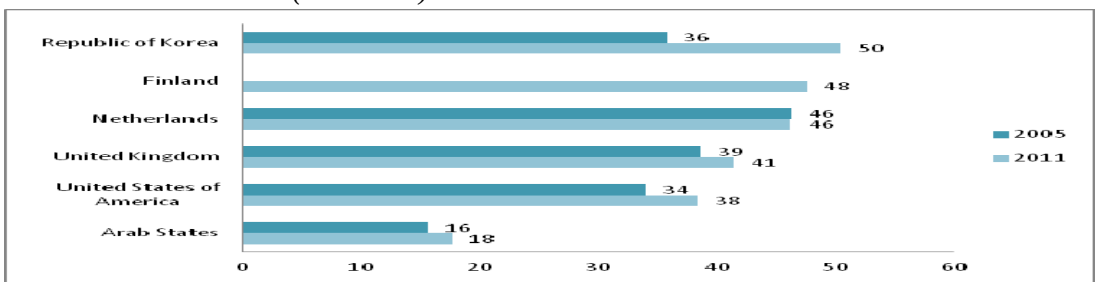
Source: Adapted from the UNESCO – UIS (2012)

Figure 7: Distribution of tertiary education student graduates by fields in the Arab and World countries (2010-2011)



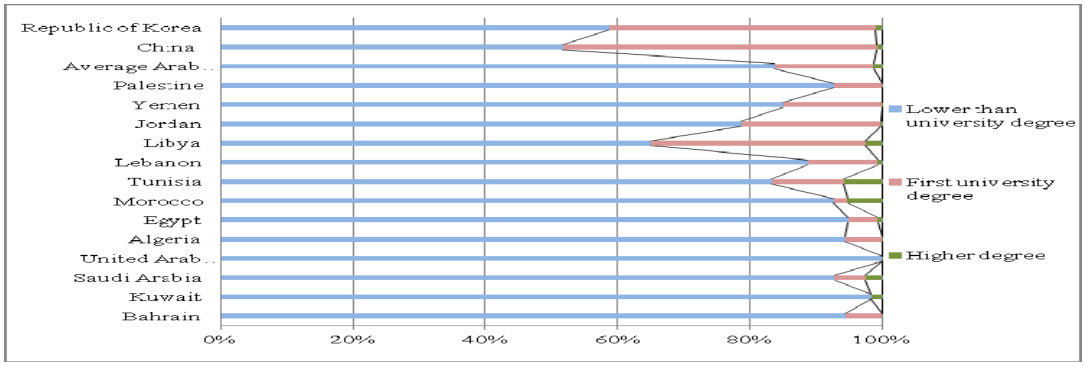
Source: Adapted from the UNDP (2002; 2003; 2004)

Figure 8: Distribution of total tertiary education student gross graduation ratio, first degree in the Arab and World countries (2005-2011)



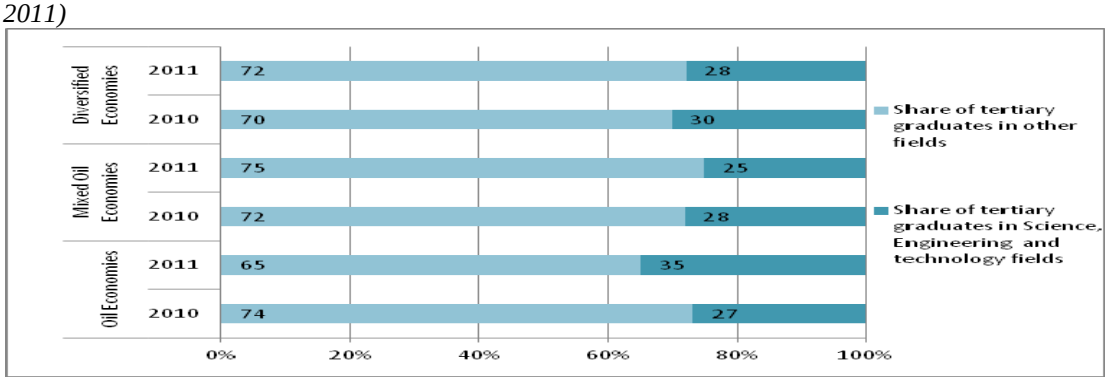
Source: Adapted from the UNESCO – UIS (2012)

Figure 9: Relative distribution of tertiary education students by level of higher education Arab and World countries (1999-2000)



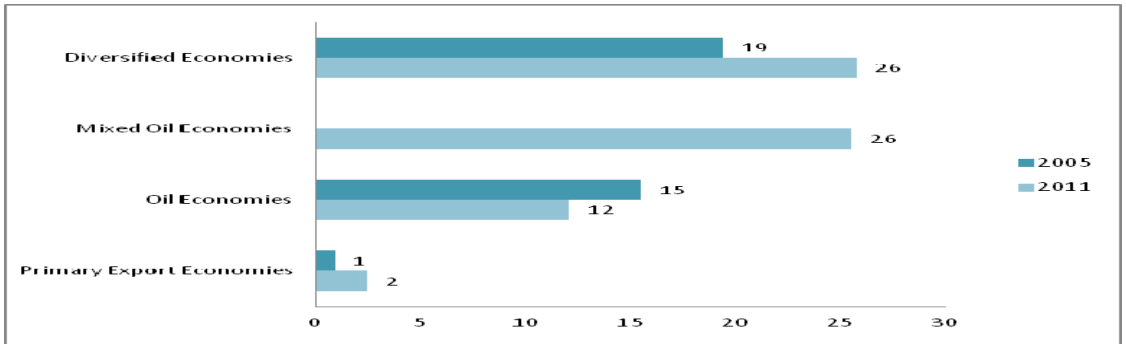
Source: Adapted from the UNDP – AHDR (2003)

Figure 10: Distribution of tertiary education student graduates by fields in the Arab region (2010-2011)



Sources: Adapted from the UNDP (2002; 2003; 2004)

Figure 11: Distribution of total tertiary education student gross graduation ratio, first degree in the in the Arab region (2005-2011)



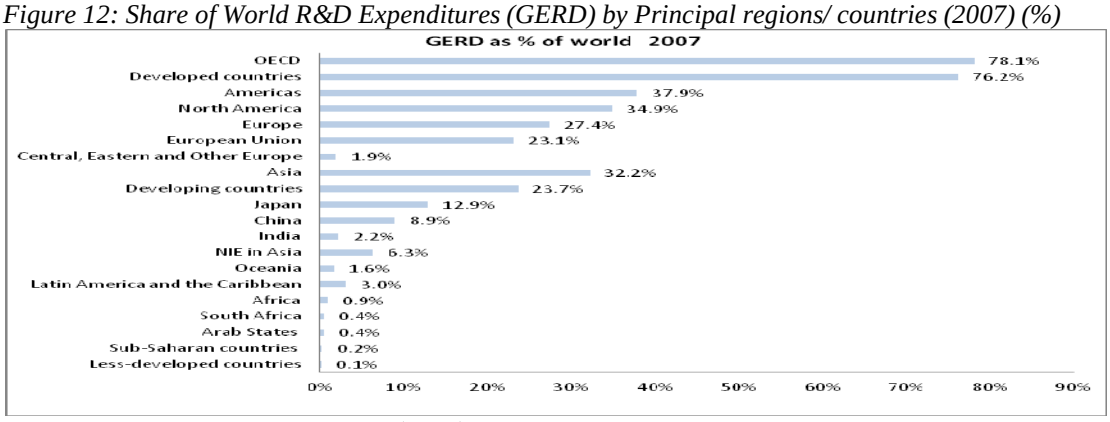
Source: Adapted from the UNESCO – UIS (2012)

4. 2. Subsystem of S&T and R&D institutions

The institutions of S&T, mainly R&D institutions show remarkable serious weaknesses in the Arab region. For instance, UNESCO (2004a) indicates that "Despite efforts to increase investment in R&D expenditures remain very low in developing countries. In 2000, developing countries spent 0.9 per cent of their GDP on R&D, still falling short of the target of 1 per cent mentioned in various S&T policy documents and international declarations for over 30 years. Nevertheless, there is considerable variation across countries. In the global picture the Arab states along with Sub-Saharan Africa and the smaller Pacific islands, showed much lower levels of R&D expenditures compared to New Industrialized Economies of South East Asia, such as China and India and also compared to Latin America" (cf. UNESCO, 2004a). S&T input indicator measured by spending on R&D as percentage of GDP for all Arab region accounts only for 0.4 of total World R&D expenditures, indicating that the

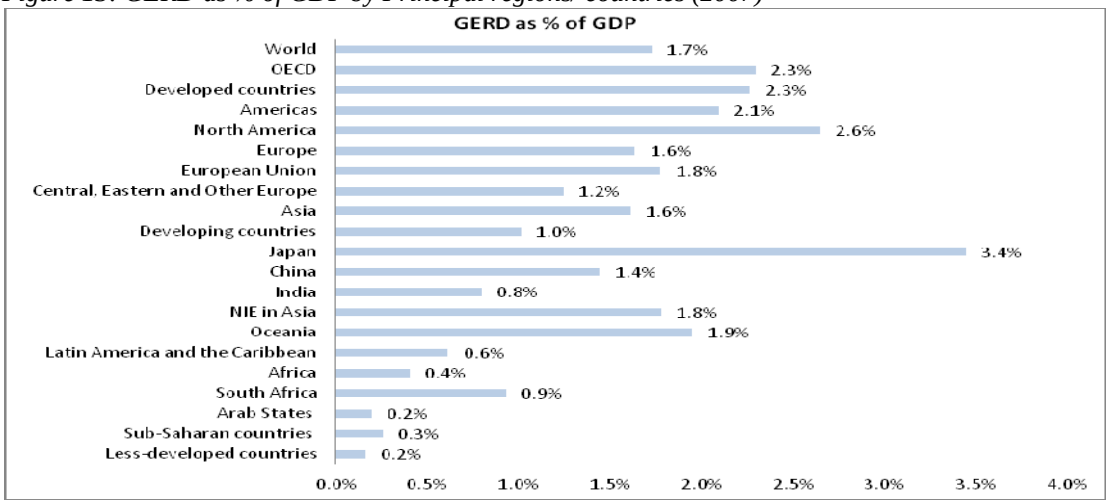
Arab region is lagging far behind other world regions and that the share of Arab region is insignificant when seen from a global perspective, because it accounts for less than 0.5 per cent of the world GERD, hence, lagging far behind not only advanced countries but also all other world regions, even Africa and Sub-Saharan Africa- see Figures 12-13. Further to insufficient number of researchers in the Arab countries compared to the advanced and developing countries like China- see Figures 14-15. In addition the Arab region shows low and constant trend in GERD as a percentage of GDP, low and declining trend in the share of World R&D expenditures (GERD) and low share of World researchers over the period (2002-2007) - see Figure 16. These figures imply poor and insufficient human and financial resources devoted to S&T activities in the Arab region compared to other world regions – see Figures 12-16. Therefore, these results support our first hypothesis that the regional systems of innovation exist but characterized by serious weaknesses in the Arab region compared with other world regions.

Figure 12: Share of World R&D Expenditures (GERD) by Principal regions/ countries (2007) (%)



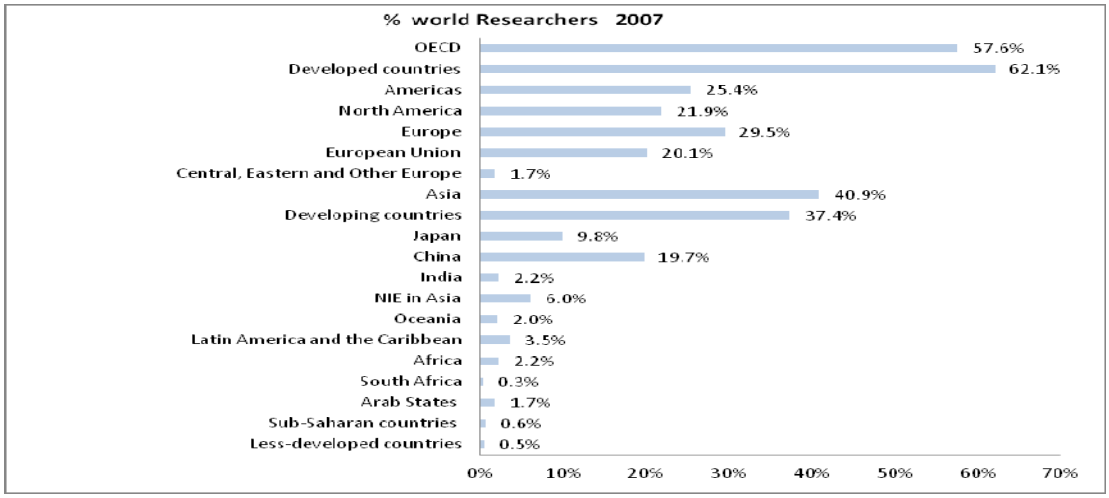
Source: UNESCO estimates August (2010)

Figure 13: GERD as % of GDP by Principal regions/ countries (2007)



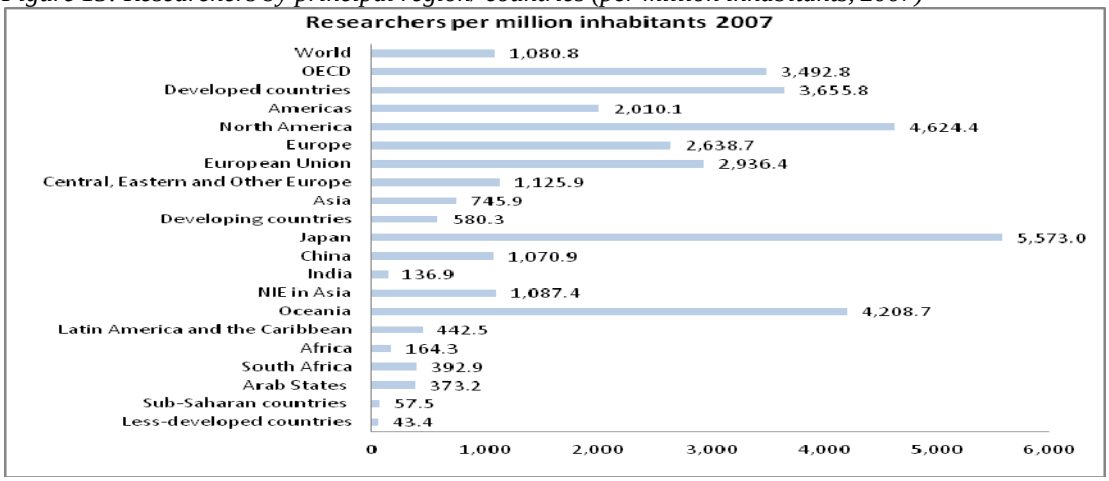
Source: UNESCO estimates August (2010)

Figure 14: Share of World Researchers by Principal regions/ countries (2007) (%)



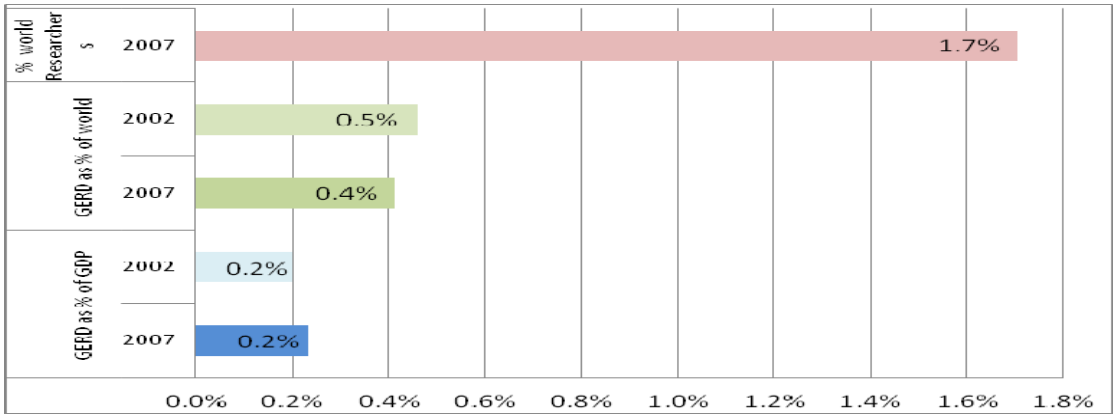
Source: UNESCO estimates August (2010)

Figure 15: Researchers by principal region/ countries (per million inhabitants, 2007)



Source: UNESCO estimates August (2010)

Figure 16- *GERD as % of GDP, Share of World R&D Expenditures (GERD) and Share of World Researchers*



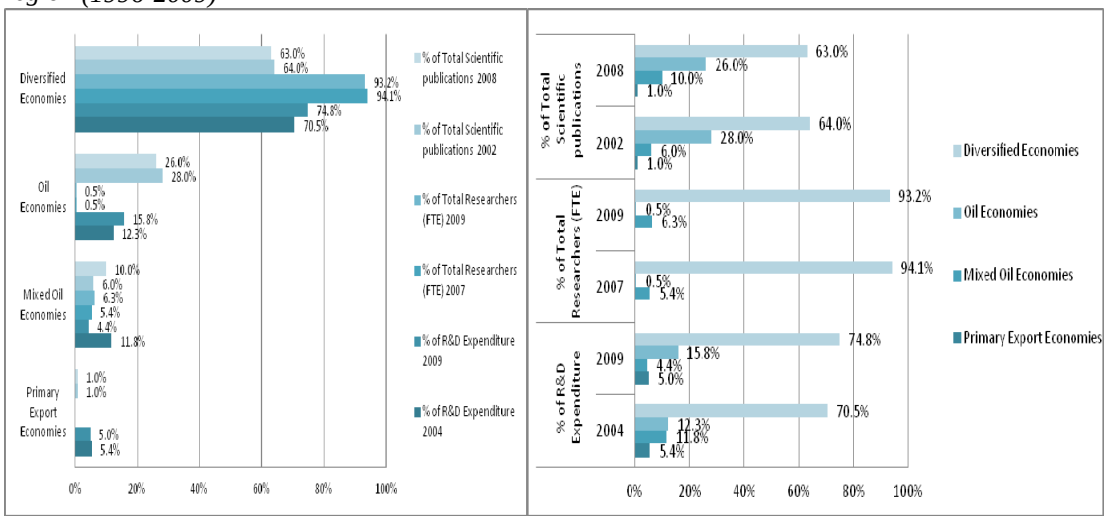
Source: UNESCO estimates August (2010)

We observe enormous variation between Arab resources oil based economies, mixed oil economies, diversified economies and primary export economies in terms of indicators related to innovation

systems, mainly, S&T input-output indicators, public spending on education as percentage of GDP, public spending on R&D as percentage of GDP, total number of researchers, S&E, patents and high technology export. In 2006-2009 for Arab resources oil based economies, mixed oil economies, diversified economies and primary export economies the average public spending on education as a percentage of GDP account for 3.52 per cent, 4.85 per cent, 6.17 per cent and 5.16 per cent respectively. In 2000-2007 for Arab resources oil based economies, mixed oil economies, diversified economies and primary export economies the average public spending on R&D as percentage of GDP account for 0.05 per cent, 0.10 per cent, 0.53 per cent and 0.30 per cent respectively, while the total number of researchers, S&E in research account for 402; 5593; and 82395 respectively. In 2010 the total number of patents granted for resources oil based economies, mixed oil economies, diversified economies and primary export economies account for 931; 806; 4333 and 91 respectively, while, the share of high-technology export in total export in 2002-2007 for resources oil based economies, mixed oil economies, diversified economies and primary export economies account for 0.6; 0.7; 2.8 and 0.5 respectively.

Moreover, we find considerable concentration of human and financial resources devoted to R&D in the Arab region. For instance, the average share of resources oil based economies, mixed oil economies, diversified economies and primary export economies in total Arab public spending on R&D accounts for 12.3 per cent; 11.8 per cent; 70.5 per cent and 5.4 per cent respectively in 2004, and accounts for 15.8 per cent; 4.4 per cent; 74.8 per cent and 5.0 per cent respectively in 2009. While, the average share of resources oil based economies, mixed oil economies and diversified economies in total number of Arab researchers account for 0.5 per cent; 5.4 per cent and 94.1 per cent respectively in 2007 and account for 0.5 per cent; 6.3 per cent and 93.2 per cent respectively in 2009. Therefore, it is not surprising that the average share of resources oil based economies, mixed oil economies, diversified economies and primary export economies in total publications account for 28 per cent; 6 per cent; 64 per cent and 1 per cent respectively in 2002 and account for 26 per cent; 10 per cent; 63 per cent and 1 per cent respectively in 2008 - see Figures 17-18.

Figures : 17-18- Distribution of total R&D expenditures, researchers and publications in the Arab region (1996-2009)



Sources: Author calculation from ESCWA (1998) and UNDP –AHDR (2002) and UNESCO (2012)

Therefore, these findings support our second hypothesis that the structure of the economy has significant effect in the performance of the innovation systems in the Arab region. This implies that with respect to most of S&T and innovation indicators in the Arab region the Arab diversified economies show relatively better performance than the Arab natural resources based economies (Arab oil economies, mixed oil economies and primary export economies). These results suggest a relationship between economic structure and institutions aimed at promoting S&T development indicators required for building innovation systems. They also imply the considerable diversity in the Arab region, but that should not hide the fact that none of the Arab countries offered adequate human and financial resources for S&T and efficient national innovation systems.

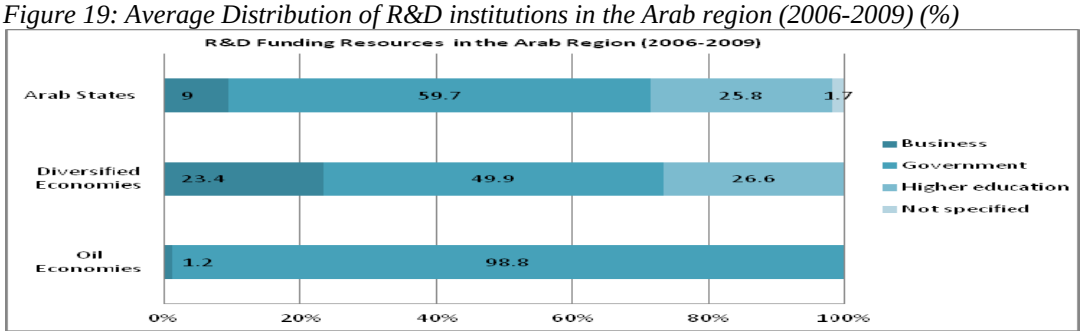
Furthermore, the distribution of R&D funding resources by sectors indicates that public institutions are responsible from most of R&D funding resources and R&D activities - see Figure 19. For instance, the share of public institutions in R&D activities contribute by 59.7 per cent; 98.8 per cent and 49.9 per cent of total R&D funding resources and R&D activities in all Arab States, oil economies and diversified economies respectively.[27] Next to the public sector, the universities sector contributes by 25.8 per cent and 26.6 per cent of total R&D funding resources in all Arab States and diversified economies respectively. While, the minor contribution comes from the private sector, which accounts only for 9 per cent; 1.2 per cent; and 23.4 per cent of total R&D funding resources in all Arab States, oil economies and diversified economies respectively. The oil economies appear to be more dependent on the public sector R&D funding resources compared to the diversified economies. Therefore, most of R&D and R&D funding resources and hence, S&T activities in all Arab States, oil economies and diversified economies are mostly allocated within both public and university sectors. While, the private sector and hence, industry have only minor contribution in total R&D funding resources and total R&D activities compared to public and university sectors- see Figures 19-22.

Furthermore, the majority of human resources available to R&D institutions, which is defined by the number of full-time equivalent (FTE)[28] researchers are employed by the public and university sectors- see Figures 20-22. For instance, the share of FTE researchers in the public sector estimated at 53.1 per cent; 100 per cent; 50 per cent; 39.4 per cent and 20 per cent of total FTE researchers in all Arab States; oil economies; mixed oil economies; diversified economies and primary export economies respectively.[29] Next to the public sector, the percentage share of FTE researchers in the universities accounts for 44.7 per cent; 43.5 per cent; 59.4 per cent and 78 per cent of total FTE researchers in all Arab States; mixed oil economies; diversified economies and primary export economies respectively. While the percentage share of private sector is very marginal and accounts for 2.2 per cent; 6.6 per cent; 1.3 per cent and 2 per cent of total FTE researchers in all Arab States; mixed oil economies; diversified economies and primary export economies respectively. The oil economies and mixed oil economies appear to be little more

[27] See data from ESCWA
[28] The concept of full – time equivalent researcher is adopted by UNESCO statistics on Research and Development (R&D) personnel.
[29] See data from ESCWA

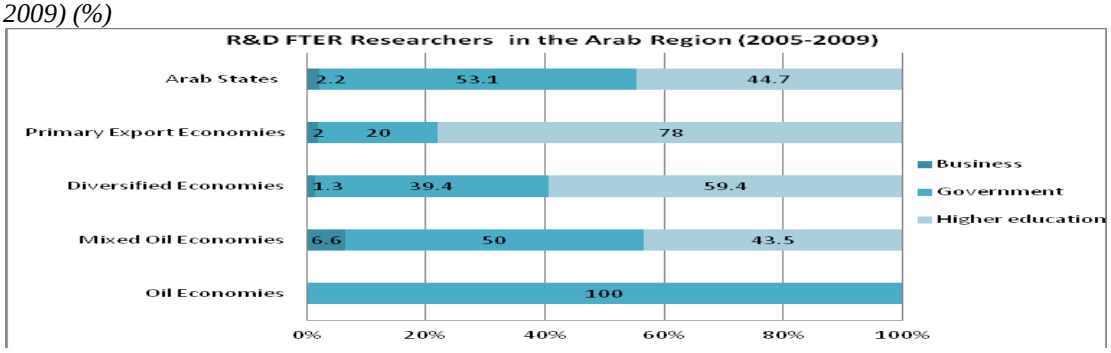
dependent on the public sector compared to the diversified economies and primary export economies. So, these results together with our results presented above imply the major share of both public and universities sectors and the minor contribution of the private sector in R&D activities and FTE researchers in all Arab States; oil economies; mixed oil economies; diversified economies and primary export economies. In the Arab region the share of public, university and private sectors in total R&D funding resources and researchers in R&D institutions account for 59.7 per cent; 25.8 per cent and 9 per cent and account for 53.1 per cent; 44.7 per cent and 2.2 per cent respectively in total R&D funding resources and in researchers in R&D institutions in (2005-2009) and (2006-2009) respectively. In the Arab region the share of public, university and private sectors in total R&D institutions accounts for 70 per cent, 28 per cent and 2 per cent respectively in 1996 and the share of public, university and private sectors in total FTE researchers accounts for 81 per cent; 13 per cent and 6 per cent in 1996 and for 59.7 per cent, 25.8 per cent 9 per cent and 5.4 per cent in (2006-2009) respectively - see Figures 21-22.[30]

Figure 19: Average Distribution of R&D institutions in the Arab region (2006-2009) (%)



Source: Author calculation from ESCWA (1998) and UNDP-AHDR (2009)

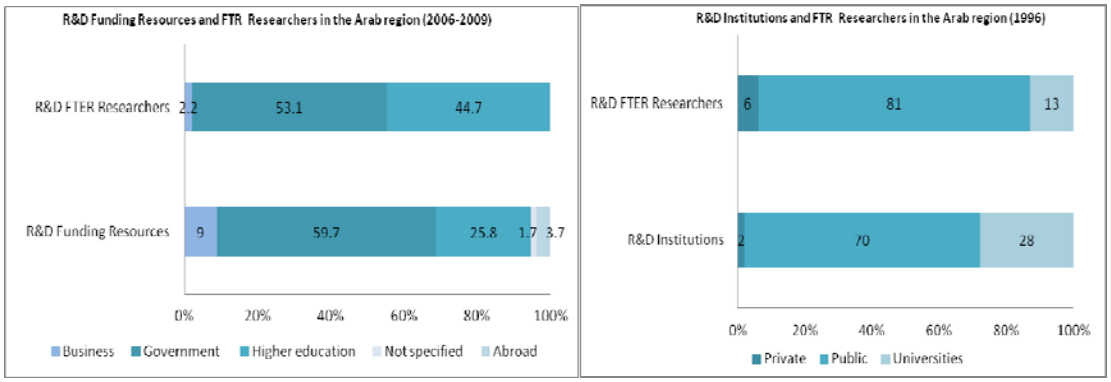
Figure 20: *Sectoral Distribution of researchers in R&D institutions in selected Arab countries (2005-2009) (%)*



Source: Author calculation from ESCWA (1998) and UNDP-AHDR (2009)

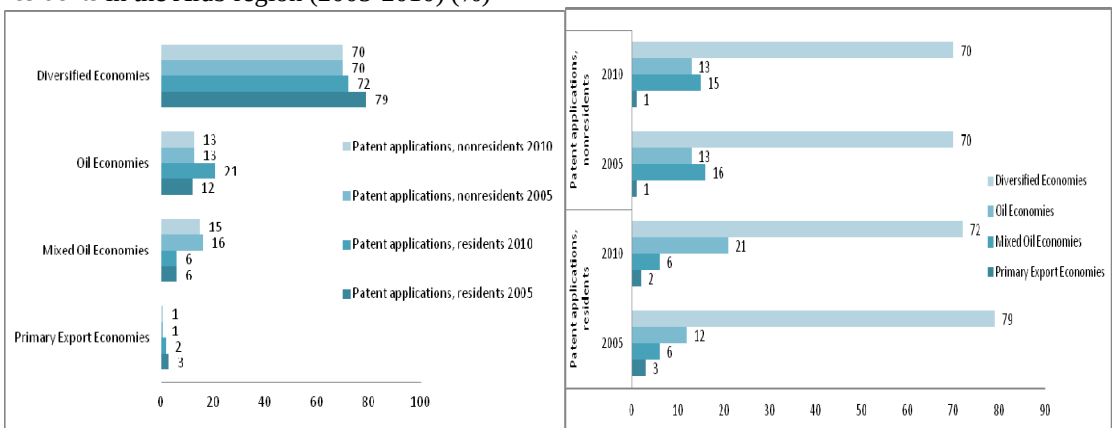
Figures 21-22: Average Distribution of researchers in R&D institutions in the Arab region (1996) (%)

[30] The institutions constituting the systems of R&D and hence innovation vary across the Arab countries, e.g. public research institutes may be important for R&D in one country, while research universities may perform a similar function in another. For instance, while all research activities are concentrated in the public sector in both Lebanon and Yemen, the university institutions perform all research activities in Qatar. In both Bahrain and UAE research activities are shared but mostly concentrated in the public institutions (75% and 60%) followed by the university institutions (25%-40%) respectively. Kuwait shows different structure due to the role of private sector, the research activities are shared but mostly concentrated in the public followed by the private institutions 73% and 27% respectively. On the other hand, Saudi Arabia shows another difference as the research activities are shared but concentrated in the university followed by public and private institutions 39%, 57% and 4% respectively. Egypt indicates another difference as the research activities are shared but concentrated in the public followed by university and private institutions 75%, 16% and 4% respectively. While, Jordan shows another difference as the research activities are shared but concentrated in the public institutions, followed by similar contribution from university and private institutions 75%, 12.5% and 12.5% respectively.



Source: Author calculation from ESCWA (1998) and UNDP-AHDR (2009)

Figures 23-24 Average Distribution of total number of patent applications by residents and non-residents in the Arab region (2005-2010) (%)



Source: Author calculation from the World Bank (2012)-World Development Indicators Database (2012)

Concerning S&T output indicators we examine only scientific publications and patent. Regarding S&T output indicator as measured by the number of scientific publications, we find that the average share of diversified economies and oil economies in total Arab publications and total patent applications are higher than mixed oil economies and primary export economies - see Figure 14. This might be interpreted as a consequence of better performance of diversified economies and oil economies compared to mixed oil economies; and primary export economies in most of S&T input indicators, particularly, in terms of R&D expenditures, R&D employees and R&D scientists and engineers. Earlier findings indicate that the average share of oil economies; mixed oil economies; diversified economies and primary export economies in total Arab public spending on R&D account for 15.8 per cent; 4.4 per cent; 74.8 per cent and 5.0 per cent and in total number of Arab researchers account for 0.5 per cent; 6.3 per cent and 93.2 per cent respectively in 2009. Therefore, it is not surprising that the average share of oil economies; mixed oil economies; diversified economies and primary export economies in total number of publications account for 26 per cent; 10 per cent; 63 per cent and 1 per cent respectively in 2008- see Figures 13-14. Moreover, S&T output indicator measured by total number of applications by residents for oil economies, mixed oil economies, diversified economies and primary export economies account for 12 per cent; 6 per cent; 79 per cent and 3 per cent in 2005 respectively and account for 21 per cent; 6 per cent; 72 per cent and 2 per cent in 2010 respectively. Patent applications by non-residents for oil economies, mixed oil economies, diversified economies and primary export economies account for 13 per cent; 16 per cent; 70 per cent and 1 per cent in 2005

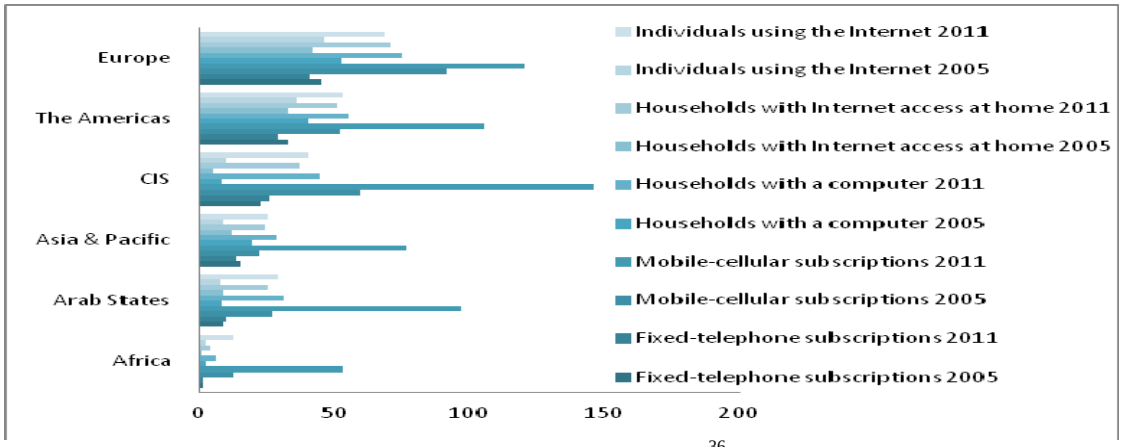
respectively and account for 13 per cent; 15 per cent; 70 per cent and 1 per cent in 2010, respectively. Moreover, S&T output indicator measured by total number of patents awarded to firms and individuals for some Arab countries falls below world average.[31] The poor performance and low patenting activities indicates the low innovative activities in the Arab countries compared to the advanced and developing countries, particularly, China and Korea. Moreover, S&T output indicator measured by the share of high-technology export in total export in 1997-2002 for Arab region fall behind Singapore, Malaysia, Korea and China. Therefore, in terms of S&T input-output indicators the performance of Arab region is lower than Singapore, Malaysia, Korea and China.

4. 3. Subsystem of ICT and networking institutions

The ICT institutions show remarkable improvement and increasing trend but still suffer from great weaknesses in the Arab region. When measuring the diffusion of ICT by the percentage of population using the Internet, telephone and mobile, we find that the average share of Arab population (per 100 inhabitants) with access to Internet, telephone and mobile are accounting only for 29, 10 and 97- see Figure 25.[32] This implies inadequate diffusion of ICT, which is obviously falling far behind the comparable percentages for the advanced and developing countries. Moreover, the status of ICT spending in the Arab region represented by Egypt and Gulf countries lag below the international level.[33] We observe great diversity across Arab oil economies; mixed oil economies; diversified economies and primary export economies in terms of ICT diffusion, mainly, in 2010-2011 the Internet users, telephone mainlines and cellular subscribers are concentrated in Arab high income oil economies followed by diversified economies; mixed oil economies and primary export economies respectively- see Figures 26-28. These results are not surprising since the use of ICT is often related to income level as reported in several studies in the literature.[34] The average share of oil economies; mixed oil economies; diversified economies and primary export economies in total Arab Internet users account for 58 per cent; 4 per cent; 32 per cent and 5 per cent respectively, in total Arab telephone mainlines account for 45 per cent; 12 per cent; 38 per cent and 6 per cent respectively and in total Arab cellular subscribers account for 25 per cent; 14 per cent; 49 per cent and 12 per cent respectively in 2011, 2010 and 2011 respectively- see Figures 26-28.[35]

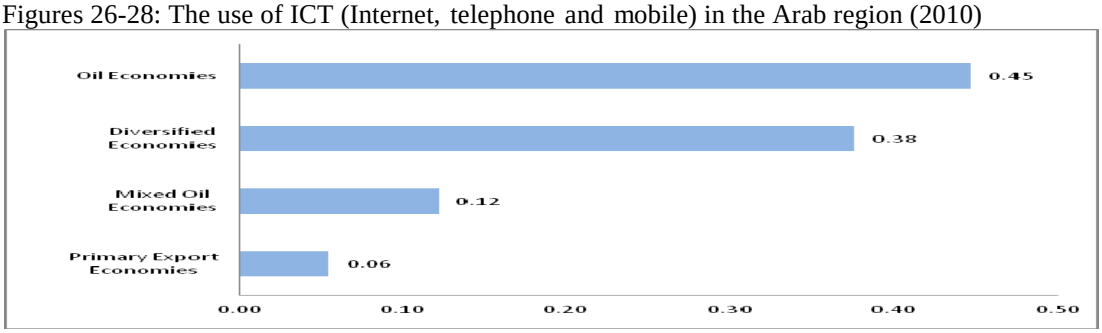
Figure 25- Key ICT indicators for the ITU/BDT regions (totals and penetration rates) (per 100 inhabitants) in the Arab and world regions (2005-2011)

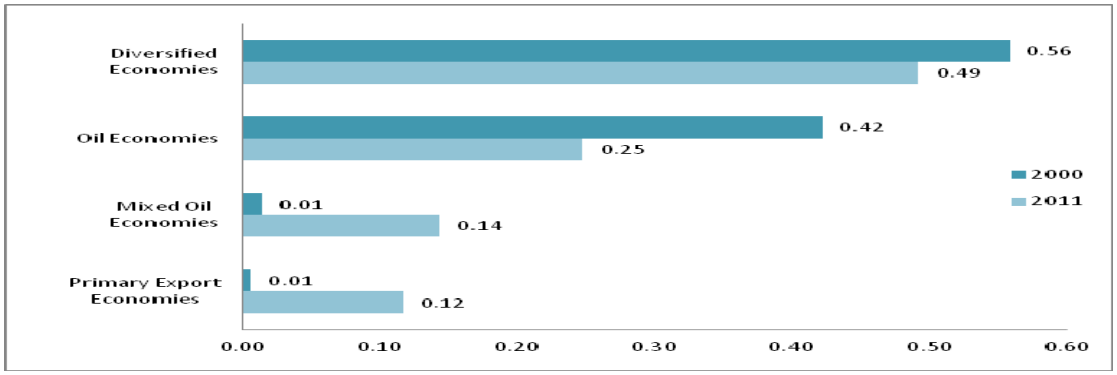
[31] See UNDP (2004).
[32] See UNDP (2004)
[33] See for instance, Nour, (2002b).
[34] See for instance, Nour, (2002a).
[35] See UNDP (2004).

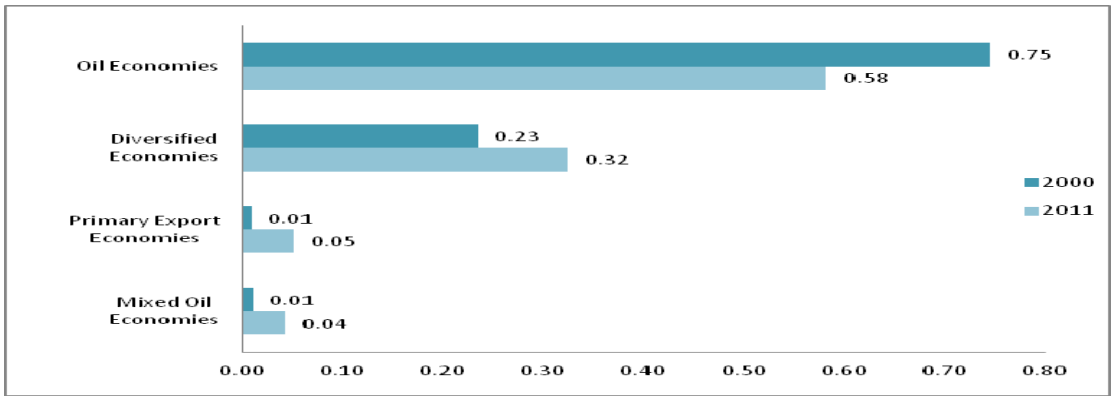


Source: International Telecommunication Union, 2012, accessed 16 January 2013.[36]

Figures 26-28: The use of ICT (Internet, telephone and mobile) in the Arab region (2010)







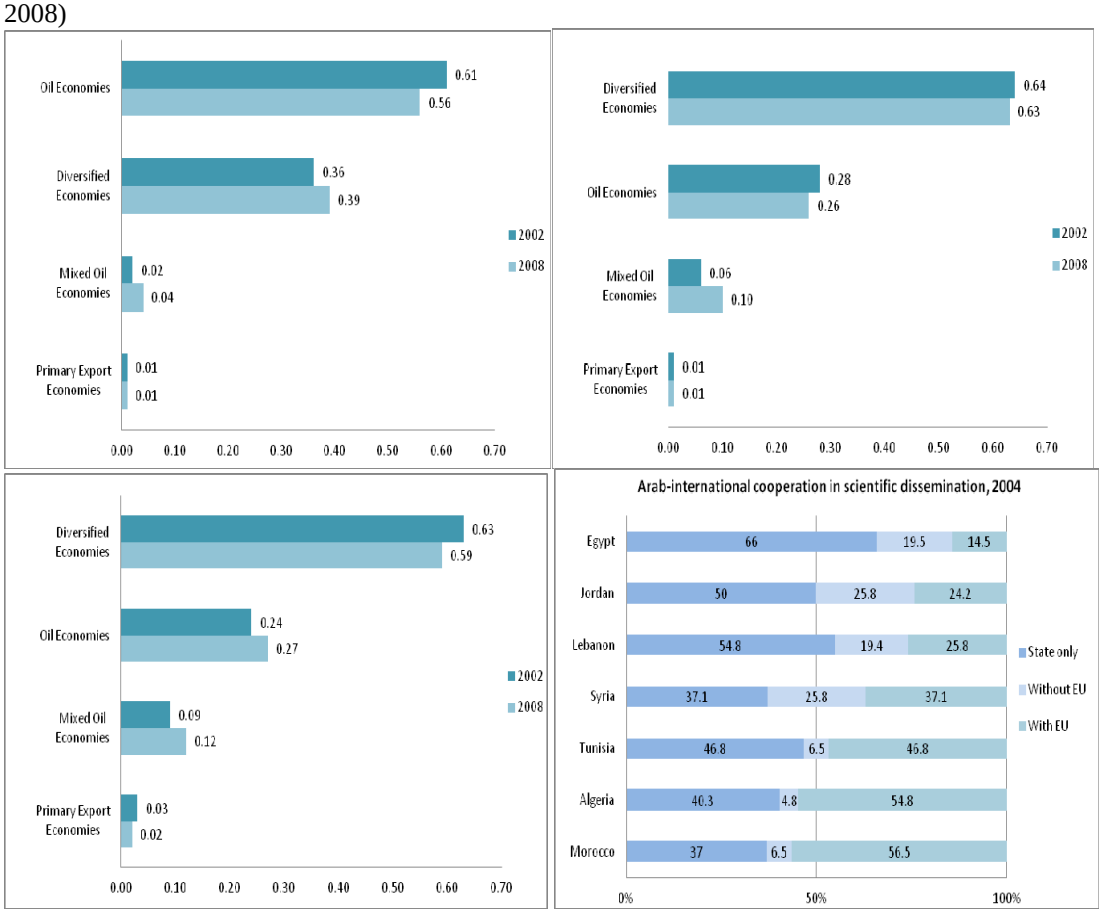
Sources: Adapted from UNDP (2011)

Despite, the increasing importance of networking between regional and international institutions as measured by scientific cooperation among scientists, however, Arab regional system of innovation is

[36] Regions in this table are based on the ITU BDT Regions, see: http://www.itu.int/ITU-D/ict/definitions/regions/index.html.

characterized by very limited scientific cooperation within and between Arab countries. The geographical proximity and social homogeneity (sharing similar culture, language, etc.) have limited effect to encourage regional scientific cooperation within the Arab region. Distribution of scientific publications and international cooperation vary in the Arab region, for instance, the share of resources oil based economies, mixed oil economies, diversified economies and primary export economies in total Arab scientific publications and international cooperation accounts for 24 per cent; 9 per cent; 63 per cent and 3 per cent respectively in 2002, and accounts for 27 per cent; 12 per cent; 59 per cent and 2 per cent respectively in 2008- see Figures 29-32. [37]

Figures 29-32: Scientific publications and international cooperation in the Arab countries (2002-2008)



Sources: Adapted from UNDP – AHDR (2009)

[37] For instance, "Zahlan, (1999a), explains the very limited cooperation as indicated by the number of joint publications and co-authorship amongst scientists in both the Arab Gulf and Mediterranean countries. Particularly, there is no significant cooperation amongst the Gulf countries scientists; for instance, figures indicate that scientific cooperation amongst Gulf countries accounts for less than 2 percent of their worldwide cooperation. Zahlan, (1999a) finds that in 1990, co-authorship within the Gulf countries was only 1.4 per cent of all co– authored papers; this increased to 3 per cent in 1995. The limited regional cooperation also holds for the Mediterranean countries. For instance, Zahlan (1999a) finds that "in 1995, of total publications of scientists in Algeria, Morocco and Tunisia, very surprisingly only 11% of the co-authored publication involved scientists from two Maghreb countries[37] and only one (of the 11) did not involve an OECD partner. In addition there is limited scientific cooperation and co-authorship of scientists between both Arab Gulf and Mediterranean countries and between them and other Arab countries. The Gulf countries cooperation with Arab scientists tends to be limited to fewer number of Arab countries, e.g., Egypt is the major partner, according to Zahlan (1999a), joint co-authorship with non Gulf Arab countries merely reflects the fact that Gulf countries universities employ professors from other Arab universities. The limited cooperation with other Arab scientists also holds for the Mediterranean countries, for instance, Zahlan (1999a) finds that the cooperation between Maghreb countries and other Arab scientists accounts only for 3% and 3.5% of total joint published papers in 1990 and 1995 respectively. (Zahlan, 1999a: p. 15)" (Nour (2005).

The findings in this section support the first and second hypotheses that the regional systems of innovation exist but characterized by serious weaknesses in the Arab region compared with other world regions and that the structure of the economy has significant effect in the performance of innovation systems in the Arab region. These results also imply that none of the Arab countries offered adequate human and financial resources for S&T and efficient national innovation systems. The poor Arab systems of innovation can be attributed to many obstacles, mainly, the Arab system of innovation is hampered by major constraints. For instance, UNDP-AHDR (2003) indicates that the low spending on R&D, the relatively small number of qualified knowledge workers and number of scientists and engineers working in R&D and number of students enrolling in scientific disciplines in higher education, poor institutional support and a political and social context inimical to the development and promotion of science in the Arab states.[38] Moreover, similar, to typically less developed countries the regional systems of innovation in the Arab region is inhibited by the deficient socio-economic infrastructure, weaker institutional frameworks, low levels of interaction, weak formal institutional, legal and regulatory frameworks, low levels of interaction among firms, as well as among different type of organizations (e.g. firms, universities, technology service providers) and the limited number of innovative enterprises.

The results in this section discussed above already pointing to the failure of Arab governmental systems to build dynamic systems of innovation. From the above findings we understand that the failure of the innovation systems in the Arab region is attributed to several multi-dimensional causes or factors related to political, economic, social and cultural issues (Arab Spring issue). The reason that Arab governments spend very little on research when they know that economic systems cannot improve until the workforce is educated and can compete internationally, is probably because of lack of coherent policy to prioritize spending on R&D, lack of R&D culture and lack of resources in poor Arab countries. Even the allocation of the very limited resources devoted for building the Arab regional systems of innovation in the Arab region is largely wasted with no "meritocracy" in the system, and the Arab regional systems of innovation is immensely imbedded by the lack of meritocracy. The Arab regional systems of innovation are also hindered by the prevalent corruption in the institutions constituting the innovation systems. For instance, the lack of meritocracy in the higher education system together with the observed corruption implies that the selection of enrolment of students in the tertiary education system and sending students abroad for higher education are based on tribal affiliations (father's connections) rather than meritocracy (exam scores). The Arab regional systems of innovation is also imbedded by the lack of meritocracy in terms of employment, since the lack of meritocracy happens in the Arab region, so universities cannot become bastions of learning when the deserving people are not hired there.

5. Implications of poor Arab regional systems of innovation

Based on the above results about the weak institutions necessary for promoting innovation systems in the Arab region, in this section it is useful to address the third research question and hypothesis that the poor Arab systems of innovation has serious implications in the Arab region. Mainly, the

[38] See United Nations Development Programme (UNDP)-Arab Human Development Report (AHDR) (2003). pp. 5-6, 109-113.

serious implications of weak systems of innovation appear in terms of poor competitiveness indicators, integration in the global economy, knowledge economy index, share of high technology export, technology infrastructure and technology achievement index in the Arab region.[39, 40]

The Arab region is lagging behind world regions in terms of competitiveness and integration in the global economy that appears from the poor competitiveness indicators and the poor ability to attract FDI, create basic and high technology infrastructure, small share of high-technology export as percentage of total export.

The low ability to attract Net Foreign Direct Investment Inflows (NFDI) to the Arab region compared to other world regions implies poor competitiveness and integration in the global economy. For instance, the share of Arab states accounts only for 1 per cent-3 per cent of the regional distribution of the world NFDI as percentage of GDP (NFDI/GDP), it is insignificant when seen from a global perspective and lagging far behind not only the OECD, but also all other world regions, even LDC's, developing countries, Africa and Sub-Saharan Africa- see Figure 33. Furthermore, UNCTAD (2002) indicates that in 2001, the total amount of FDI attracted by all Arab countries is less than the total amount attracted by Singapore alone, implying poor attractiveness and competitiveness in the Arab countries.[41] UNDP-AHDR (2003) indicates that the lack of national innovation systems in Arab countries represented, in effect, a waste of investment in industrial infrastructure and fixed capital (buildings, factories, machinery and equipment). Such investments did not bring the wealth that Arab societies had sought through means other than the depletion of raw materials, nor expected social returns. Moreover, the Arab countries have not succeeded in becoming important poles of attraction for foreign direct investment (FDI). None of them figures among the top ten FDI attracting countries in the developing world, probably due to lack of an organizational context that provides incentives for knowledge production and consolidates linkages between R&D institutions and the production and service sectors and promote national capabilities for innovation. The report perceives that the weak national innovation systems and institutional frameworks largely account for relatively meagre technology returns on FDI The report observes that the weak [and the absence of effective] national innovation systems and institutional frameworks and the general absence of coherent, action-oriented scientific and technological policies largely account for the failure of the

[39] The results in this section are consistent with the findings of Lall (1999) and Belkacem (2002). For instance, Belkacem (2002), indicates that "despite the huge efforts made by many Arab countries in stabilizing and adjusting their economies as part of their economic reforms programs, their performance is unfortunately below their potential and are not taking full advantage of the opportunities that the global economy has offered to them. This is reflected in the weak record of Arab growth as compared to growth in LDC's. Low GDP growth rates coupled with high population growth rates meant stagnant per capita GDP growth rates. At the same time Arab Countries have attracted very little of net private capital which surged to LDC's in recent years. Arab exports growth which averaged only 1.5 % per annum during 1990-95 is far below LDC's performance where growth reached 10 % during the same period. Added to this slow growth of exports, most of it is made of traditional exports. These facts reflect that Arab countries are far from being prepared to face globalization challenges. Given their resource endowments Arab countries are under-achievers and are falling behind in an increasingly competitive world" (c.f. Belkacem (2002)).

[40] For definition and details about TAI see UNDP (2001). According to UNDP (2001), the technology achievement index (TAI) focuses on four dimensions of technological capacity that are important for reaping the benefits of the network age. TAI includes: (1) Creation of technology as measured by the number of patents granted per capita and receipt of royalty and licenses fees from abroad. (2) Diffusion of recent innovations as measured by diffusion of Internet and export of high and medium technology products as a share of all exports. (3) Diffusion of old innovations as measured by diffusion of telephone and electricity. (4) Human skills as measured by mean years of schooling and gross enrolment ratio of tertiary students enrolled in science, mathematics and engineering. (UNDP, 2001)

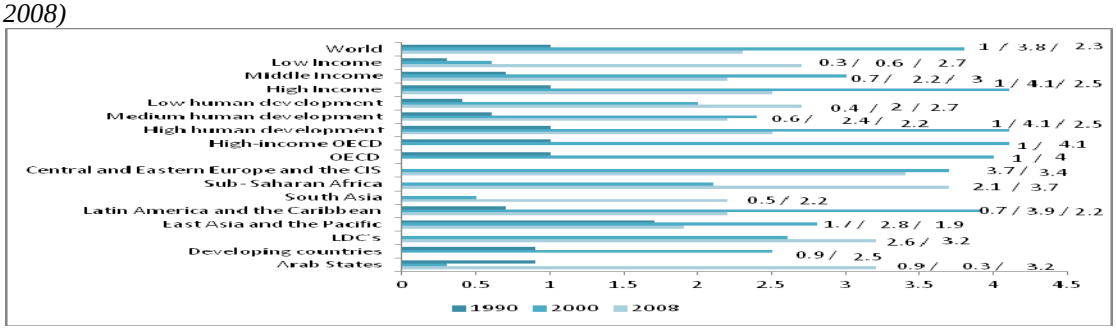
[41] See UNCTAD International Investment Report (2002). Moreover, the report indicates that within the Arab region only Bahrain is classified among the high performance country in terms of attracting FDI. While, the group of UAE, Syria, Oman, Lebanon, Qatar, Kuwait, Egypt and Saudi Arabia and the group of Libya, Morocco and Yemen are classified as low and very low attracting countries respectively.

Arab countries' experience with the transfer and adaptation of knowledge through technology, and their efforts to organise and make effective use of their own accumulated human and natural capital is outcome.[42]

Moreover, the poor competitiveness in the Arab countries particularly appears from the small share of high-technology export as percentage of total export for all Arab countries compared to developed and developing countries over the period (2002-2007), the Arab region is lagging behind all world countries and regions, including China, Singapore, Korea, Mexico and Brazil, LDCs, Latin America, Caribbean and Sub-Saharan Africa- see Figure 34-35.[43, 44] Furthermore, the poor competitiveness, particularly, appears from the poor performance of the Arab countries compared to comparator countries in all competitiveness indicators including composite competitiveness index, current competitiveness index and intangible competitiveness index in 2011- see Figure 36.[45]

Furthermore, technological capability defined by the shares of basic and high technology infrastructure implies that the share of basic technology infrastructure is higher than the shares of high technology infrastructure in the Arab countries.[46] Rasiah (2002) study implies that the shares of basic and high technology infrastructure in all Arab countries are inadequate for building the local technological capability and innovative systems and clearly lagging far behind advanced countries such as Singapore, Korea and Hong Kong. Moreover, according to UNDP (2001) technology achievement index in the Arab countries falls far behind advanced and developing countries. Furthermore, innovation and knowledge economy index in the Arab region fall behind world regions (1995-2010)- see Figures 37-38. The results in this section support the third hypothesis that the poor Arab systems of innovation have serious implications in the Arab region.

Figure: 33- Net Foreign Direct Investment Inflow (as % of GDP) in the Arab and world region (1990-2008)



Sources: Adapted from UNDP (2002), UNDP (2011)

Figures 34-35 - The share of high-technology export as percentage of total export in the Arab region (2002-2007)

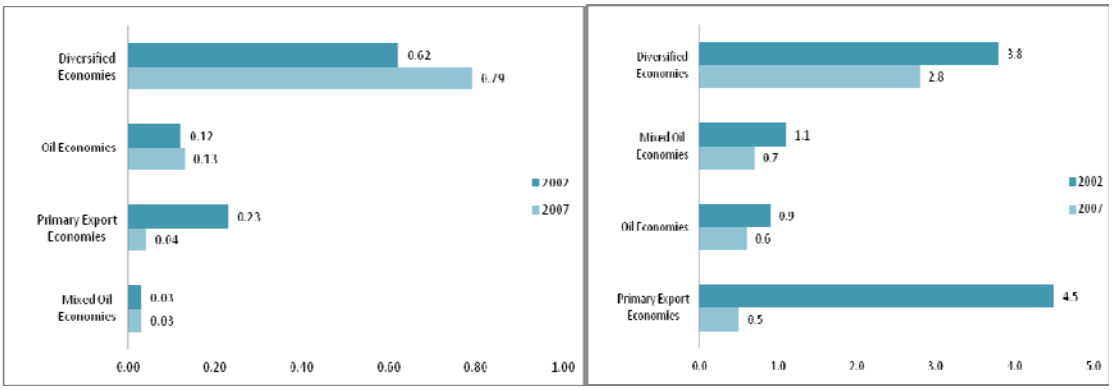
[42] See United Nations Development Programme (UNDP)-Arab Human Development Report (AHDR) (2003). pp. 5-6, 109-113.

[43] Comparator countries include Argentina, Brazil, China, Chile, Czech, Greece, Ireland, Malaysia, Mexico, Portugal, Singapore, South Africa, South Korea and Turkey.

[44] Because of the significance of high- technology exports, many studies used high-technology exports to define the degree of competitiveness in the technological market.

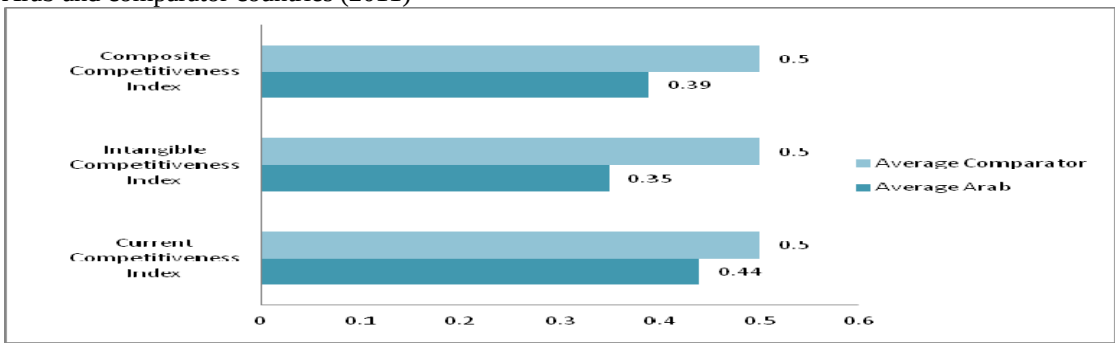
[45] See Arab Planning Institute "Competitiveness Report" (2012), Arab Planning institute, Kuwait, 2012.

[46] Rasiah (2002) defines basic technology infrastructure (BII) as weighted proxies representing basic education (enrolment in primary schools), health (physicians per thousand people) and communications (main telephone lines per thousand people). And defines high technology infrastructure (HII) as weighted proxies represents R&D investment in Gross National Investment and R&D scientists and engineers per million people. Rasiah (2002) argues that BII is an essential but not sufficient condition for economies to achieve technological capabilities, the incidence of economies generating innovation is higher when they also have the high technology support institutions, the lower BII the lower the capacity and resources for high technology development.



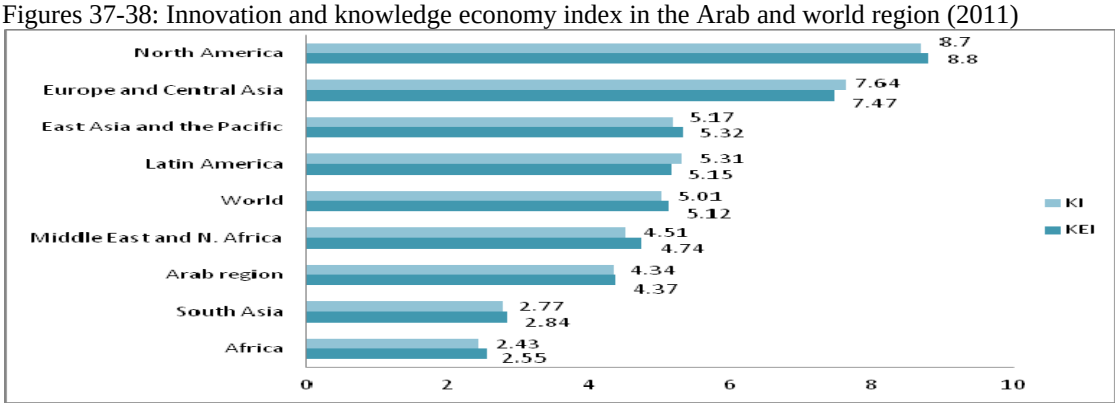
Source: Adapted from UNDP (2011)

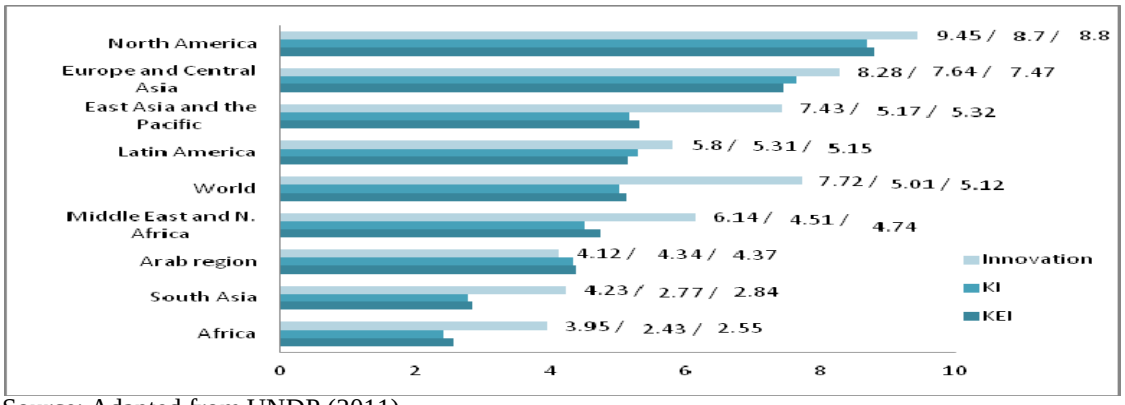
Figure 36: Composite Competitiveness Index, current and intangible Competitiveness Indices in the Arab and comparator countries (2011)



Sources: Adapted from Arab Planning Institute - Arab Competitiveness Report (2012), Table 1, p. 28.

Figures 37-38: Innovation and knowledge economy index in the Arab and world region (2011)





Source: Adapted from UNDP (2011)

6. Conclusions

This paper discusses the characteristics and implications of regional systems of innovation in the Arab region and contributes to recently published research studies that aim to improve understanding of the nature and performance of regional innovation system in the developing countries.

Sections 4 and 5 investigate three hypotheses and discuss the characteristics and major implications of Arab regional systems of innovation. We examine the first hypothesis that the regional systems of innovation exist but characterized by serious weaknesses in the Arab region compared with other world regions. This hypothesis implies that the Arab region has manifestly lagged far behind other world regions in terms of S&T, innovation, knowledge, spending on information and communication technology. We examine the second hypothesis that the structure of the economy has significant effect in the performance of innovations system in the Arab region. This hypothesis implies that the Arab region shows remarkable diversity not only regarding economic growth (per capita income/income level), structure of the economy, but also concerning systems of innovation, mainly, subsystems of education, science and technology S&T), ICT and networking. We examine the third hypothesis that apart from the remarkable diversity in the Arab region, the poor Arab systems of innovation has serious implications that appear in terms of poor competitiveness indicators, integration in the global economy, knowledge economy index, share of high technology export, technology infrastructure, technology achievement index in the Arab region.

The findings in Section 4 support the first and second hypotheses that the regional systems of innovation exist but characterized by serious weaknesses in the Arab region compared with other world regions and that the structure of the economy has significant effect in the performance of innovation systems in the Arab region. These results also imply that none of the Arab countries offered adequate human and financial resources for S&T and efficient national innovation systems. The poor Arab systems of innovation can be attributed to many obstacles that hampered the Arab system of innovation. The low spending on R&D, the relatively small number of qualified knowledge workers and number of scientists and engineers working in R&D and number of students enrolling in scientific disciplines in higher education, poor institutional support and a political and social context inimical to the development and promotion of science in the Arab states.

Therefore, for building efficient innovative system, the Arab countries need to create the appropriate economic, political and scientific institutions and build technological infrastructure. Mainly Arab countries need to improve the performance of educational and training systems, S&T and ICT institutions, increase financial and human investment to build local technological capabilities and innovation system and to learn from the experiences of other innovative regions to promote the system of innovation in the region.

In addition, the policy instruments that can be done to change the poor performance and dynamics should include adoption of coherent policy to put special emphasis on increasing prioritizing and increasing resources for spending on R&D, improve culture and awareness of the importance of R&D. this might be hard due to the political sensitivity of the subject. The policies should be implemented to change the observed corruption is the commitment to meritocracy in the higher education system in terms of students enrolment and employment of staff; this is where meritocracy plays a part in the other systems. So, the Arab universities will become bastions of

learning when the deserving people are hired there. So, that is what the Arab Spring needs to solve: not "democracy" but "meritocracy".

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