Electron Commer Res (2012) 12:455–484
DOI 10.1007/s10660-012-9100-1

Innovations, intellectual protection rights and information technology: an empirical investigation in the MENA region

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Published online: 16 October 2012

Abstract This paper examines innovation, patents, research and development, intellectual protection, information technology, and other related activities in the Middle East and North Africa regions. The paper primarily focuses on the importance of intellectual property rights, reforms, and information technology in affecting innovation, and finds strong positive associations with regards to quantity as well as the quality of innovations. Additionally, the paper finds support for the role of economic freedom, foreign direct investment, and bank loans in contributing to innovative activities.

Keywords Innovation · Patents · Research and development · Intellectual protection · Information technology · Middle East and North Africa

1 Introduction

Innovation is the outcome of creative ideas through which new products and processes provide companies and nations with comparative edges [2, 22, 57, 60]. In writing about the renewing power of "creative destruction" and the potential of new technologies to disrupt and even replace existing industries with superior products and services [56], Schumpeter clearly intended to emphasize not only the "destruction" aspect of creativity, but the "creative" aspect as well [21].

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In recent years, there have been various studies that examine innovation in countries and regions around the world. These studies focus on regions such as: the United States and Japan [52]; India and China [10]; Latin America [41]; Europe [19]; and Eastern Europe [42]. While these studies have provided an understanding of innovation in certain regions of the world, similar understandings in other regions are still lacking. Therefore, one aim of this paper is to seek to fill a knowledge gap by focusing on one important region, the Middle East and North Africa, (MENA). A cursory comparison between MENA countries and other countries or regions with similar economic backgrounds reveals low patenting and innovation activities, and further comparison within MENA countries reveals wide variability across countries. From a historical perspective this lag is striking, as scientists and scholars from the MENA region developed innovations in ancient mathematics, astronomy, and chemistry that fundamentally directed and shaped the discourse of modern science [63]. These findings, along with rising instability, stagnant economic performance, and high unemployment in many MENA countries, underscore the need for further examination of innovative activities in the MENA region. Such analysis becomes more pertinent in view of the positive role innovation can play in promoting entrepreneurship and economic growth [7, 64].

Authors have argued that "national innovation systems"—which include aspects of how intellectual property is protected and how research and development (R&D) is funded—are a major contributor to innovation activities [21, 29, 30, 50]. Geroski [23] points out that social and economic development can only be achieved when innovative activities are appropriately protected. While countries in the MENA regions have undertaken various steps to enhance innovation, they have tended to focus the majority of their attention on building the physical research infrastructure. They have not paid as much attention to developing the institutional aspects that serve to protect innovations. Research has shown that the strengthening intellectual property laws in countries with weak systems can have a significant impact in stimulating innovations [45], in improving the quantity and quality of Foreign Direct Investment [44] and in promoting national competitiveness and growth [34].[1] Countries with weak intellectual property rights (IPR) are less likely to be able to compete with nations that have strong IPR [45].

Therefore, in an effort to provide a more pertinent understanding of innovation in the MENA region, this paper will explore the impact of IPR and reforms on innovative activities. This paper will focus on innovations that are protected by a patent[2] and will examine the role of information technology, as well as the relative impact of literacy rate, economic freedom, foreign direct investment, bank credit, country risk, civil liberty, and economic environment on innovation in a given MENA country. Finally, in an attempt to generate a more comprehensive analysis, the paper will address aspects of both quantity and quality with regards to innovation.

[1] World Economic Forum, Global Competitiveness Report 2004-5. Also, see, MacInnes [47] and Regner, Barria, Pitt and Neville [54].

[2] In order to be protected by a patent and in turn be affected by IPR and reforms, an innovation must be patentable, be of practical use, display an element of novelty, and involve an inventive step. For more details, see the World Intellectual Property Organization: http://www.wipo.int/patentscope/en/patents_faq.html#inventions.

The paper will proceed as follows. First, it will begin with an overview of innovation and R&D environments in the MENA region. Next, it will review the literature on intellectual property rights and information technology and their corresponding impact on innovation in developing countries. Next, the paper will outline the methodology, beginning with a brief description of the World Intellectual Property Organization (WIPO), the international body responsible for protecting intellectual property and enacting related treaties. Finally, the paper will discuss the results and present the conclusion.

1.1 Innovation and R&D environments in the MENA region: an overview

Most overviews of the recent history of the MENA region tend to be overshadowed by references to wars and political, cultural, and religious instability. A deeper foray into the region's history, however, reveals a scientific legacy rife with contributions made by Arab and Muslim scholars whose work in diverse fields such as medicine, mechanics, cartography, chemistry, engineering, architecture, and astronomy effectively revolutionized science, technology, and rational discourse.[3] In fact, it was the Arabs who bestowed upon Europeans their ideological and intellectual identity [46]; during the Middle Ages when religion, superstition, and feudalism were pervasive throughout European culture, the MENA region was brimming with the thriving civilizations, discoveries, and scientific experimentations that helped to encourage a revival of learning in Europe and paved the way for the Renaissance and the Enlightenment [27]. One of the notable research and educational institutions during this period was the House of Wisdom in Bagdad, which was a magnet for knowledge-seekers from the 9th to the 13th centuries [47]. According to Lyons, the Renaissance and European scientific thought in general would have been inconceivable without imports from early Arab scholars.

Unfortunately, such a glorious history stands in sharp contrast to the level of scientific contributions that has been emanating from the MENA region in recent years. In 2005, the combined scientific publication output of 17 MENA Arab countries was smaller than the output of Harvard University. A 2002 survey of science identified only three subjects in which the MENA region excelled: desalination technologies, camel reproduction, and falconry research [63]. A 2009 Arab Knowledge Report (AKR) indicated that the Arab world accounts for only 1.1 % of global scientific publications. The report attributed this small percentage to the low level of investment in research. The report noted that in contrast to Finland, which spends over $1000 per person on scientific research every year, the Arab world spends less than $10 per person. The report added that expenditure on research in Arab countries averaged just 0.2 % of the GDP, as compared with a global average of 1.7 %. This lack of spending on R&D activities had led to low levels of innovation and a correspondingly minimal number of patents registered with Arab national institutions. While the lack of spending might be justified in some poor Arab countries like Yemen, two Arab countries that ranked among the lowest investors in research as a percentage of GDP were the oil-rich countries of Saudi Arabia and Kuwait [5].

[3] http://www.1001inventions.com; http://www.pbs.org/empires/islam/innoalgebra.html.

To alleviate such a deficit, several MENA governments have introduced various initiatives over the last few years to promote innovations, improve education, and enhance R&D activities in their respective countries, as well as in the region as a whole. In 2005, as members of the Organization of Islamic Cooperation, they joined a 10-year action program. The aim of the program is to spend 1.2 % of their respective GDPs on R&D by 2015 [63]. Consequently, in 2007 the Ruler of Dubai launched a $10bn foundation, the mission of which is to invest in knowledge and human development by focusing specifically on research and education.[4] In 2009, Saudi Arabia opened the $2.6bn King Abdullah University of Science and Technology, a research institution that is built on the promise of scientific freedom and features state-of-the-art laboratories and the world's 14th fastest supercomputer.[5] A similar initiative was also undertaken by Qatar in establishing a 2,500 acre Education City, the aim of which is to promote innovative education and research [9]. The Education City currently hosts campuses for 6 leading United States universities, with each focusing on a particular program.[6]

In addition to innovation and R&D, various countries in the MENA regions have also been investing in Information and Communication Technology (ICT). In 2008 their progress in technological performance exceeded that of all other regions of the world. Four Arab countries appeared within the top fifty nations most ready to utilize ICT, and eleven Arab countries witnessed a rise in the value of their ICT index in comparison with 1995 [5]. Although it is still too early to ascertain the success of these initiatives, nevertheless the recent 2011 Global Innovation Index ranked Qatar 26th out of 125 countries, above Spain (32) and Italy (35).[7]

Although tangible progress has been made in some areas, an overall significant gap nevertheless still exists between MENA countries and the rest of the world, as well as between individual MENA countries. For example, while UAE (34), Jordan (41), Bahrain (46), and Lebanon (49) ranked in the top 50 countries, Yemen, Sudan, and Algeria ranked in three last places at 123, 124, and 125 respectively.[8] Such variability in these rankings has been attributed to the lack of an enabling environment appropriate for the establishment of a knowledge society, particularly in relation to the key index of freedom [5].

[4] http://www2.weforum.org/en/media/Latest%20Press%20Releases/Foundation07PressRelease.html.

[5] "Elite Saudi university set to open": http://english.aljazeera.net/news/middleeast/2009/09/20099238549230496.html.

[6] http://www.qatar-national-symphony-orchestra.qa/output/page71.asp. The universities are as follows: Virginia Commonwealth University, opened 1998 (programs in arts and design); Weill Cornell Medical College, opened 2002 (programs in medicine); Texas A&M University, opened 2003 (programs in engineering); Carnegie Mellon University, opened 2004 (programs in computer science, business, information systems); Georgetown School of Foreign Service, opened 2005 (programs in international affairs); Northwestern University, opened 2008 (programs in journalism and communication).

[7] Global Innovation Index 2011: http://www.globalinnovationindex.org/gii/main/analysis/rankings.cfm?vno=#CGI.SCRIPT_NAME#.

[8] Ibid.

1.2 Innovations, intellectual property rights, and information technology

Various studies have explored the relationship between innovation and intellectual property rights. Research has found a positive association between strengthening IPR protection and innovation [12, 45]. IPR is believed to be necessary to provide incentives and financing, and to promote the dissemination of knowledge.[9] A recent study found that a higher degree of IPR protection led to an earlier switch to the strategy of aggressively pursuing innovation [66]. Another found that protection measures for IPR preserved incentives for the entry of inventors and improved the quality of innovation [59]. Another recent study determined that IPR protection enables innovators to reap the benefits of their innovation and to recover the costs of R&D investments [53].

Using panel data from 64 developing countries, Chen and Puttitanun [12] confirmed a positive impact of IPRs on innovations. Dutta and Sharma [17] suggested that stronger IPR could have divergent effects in poor countries. On the one hand, strong IPR can hurt small domestic businesses if they are unable to invest enough in R&D in order to compete with larger multinational corporations. On the other hand, strong IPR can benefit small businesses by protecting their ownership rights to future innovations, and in turn promote more R&D investment In analyzing the impact of a 1994 agreement that strengthened the protection and enforcement of IPR in India, Dutta and Sharma [17] found strong evidence that innovation-intensive industries increased their R&D expenditures and their application output for United States patents after signing the agreement. A more recent study based on a mixture of 25 developed, industrialized, developing and least developed countries confirmed the significant influence of IPR on R&D investment [61]. Finally, a study focusing on IPR reform in Latin America found that the foreign component of patent applications was significantly associated with the participation in the reform, while the domestic component was more closely linked with the local legal environment [41].

Another variable that has been associated with innovation and IPR is information technology. A technological advancement offers potential to both developed and developing countries, and especially to those industries most impacted by that particular technology. A fully established technological infrastructure in developing countries can mean more foreign investment or increased innovation activities. Yang and Marcus [67] provide evidence of the positive role IPR plays in the determination of technology transfer and licensing. They note that the further strengthening of patent laws above a certain threshold of patent protection positively affected United States receipts of unaffiliated royalties and license fees. Similarly Branstetter, Fisman, and Foley [8] found that strong local IPR regulations to be linked with the extent of technology transfer across nations. According to the authors, strengthening IPR lead to increased royalty payments for technology transfers, increased affiliate R&D expenditures, and increased foreign patent applications. More recently, a study found that stronger IPR protection in developing countries permanently increased the rate of international technology transfer within multinational firms and generated a temporary increase in the innovation rate in developed countries [15].

[9]International Chamber of Commerce the World Business Organization. Report on Intellectual Property: Source of Innovation, creativity, growth and progress. www.iccwbo.org.

Finally, among the other factors that have also been associated with the promotion of innovation and the innovative environment, various studies have cited FDI, especially in developing countries [14, 31], and [36]. Others point to the positive impact of economic freedom and transparency [57].[10] Studies show that the openness of the economy can greatly increase the knowledge transfer from outside sources and impact countries' total factor productivity [6, 13]. Knowledge generation has a positive impact on new invention and product development [62]. Similarly, education, universities, and other institutions were found to provide inputs and spillovers into the innovation process [18]. Yi [68] found that domestic innovation accelerates in countries with higher levels of economic development, educational attainment, and economic freedom.

2 Methodology

2.1 World intellectual property organization (WIPO)

Established in 1967, WIPO[11] is a specialized agency of the United Nations (UN) that works closely with the World Trade Organization (WTO) to help participating countries enact an appropriate Intellectual Property Rights (IPR) environment by encouraging them to join international treaties on different IPR initiatives. According to WIPO, intellectual property refers to creations of the mind, e.g., inventions, literary and artistic works and symbols, names, images, and designs used in commerce. Intellectual property is divided into two categories: industrial property, which includes inventions (patents), trademarks, industrial designs, and geographic indications of source; and copyright, which includes artistic and literary works including, novels, poems, plays, films, musical works, drawings, paintings, photographs, sculptures, and architectural designs.[12]

Intellectual property rights give the creator exclusive right over the use of his or her creation for a certain period of time.[13] WIPO currently has 184 member states and administers 24 major treaties under three broad areas: Intellectual Protection (IP) (14 treaties); Global Protection System (GPS) (6 treaties); and Classifications (4 treaties). The IP treaties are internationally agreed upon basic standards of intellectual property protection. The GPS treaties ensure that one international registration or filing will have effect in any of the relevant signatory countries. The Classification treaties create classification systems that organize information regarding inventions, trademarks, and industrial designs into indexed, manageable structures for easy retrieval.[14]

[10] Nurmilaakso [51], Zhuang and Lederer [69], and Grace-Farfaglia, Dekkers, Sundararajan, Peters, and Park [26] focused on the role of information and communication technology (ICT), information technology planning and use of webs uses on productivity, transparency, electronic commerce and social impact of online community respectively.

[11] WIPO, www.wipo.int.

[12] www.wipo.int and *WIPO Intellectual Property Handbook: Policy, Law, and Use*.

[13] http://www.wto.org/english/tratop_e/trips_e/intel1_e.htm.

[14] http://www.wipo.int/treaties/en/.

Although all 24 types of treaties are important in creating an innovative environment, this study will focus on the IP treaties, and specifically on the more recognized Paris Convention treaty, which deals with foreign inventions applied for and secured within foreign patent systems. Khoury and Cuero-Cazurra [41] note that the Paris Convention is the treaty that is more relevant to patent activities. This is the treaty that deals with recognizing and respecting foreign inventions and property rights. Others point out that abiding by the Paris Convention benefits inventors in signatory nations due to its universal interpretation of international competition rules and its relatively higher transparency [25, 43].

2.2 Data and time period

In this paper we used various sources to construct our database to develop several proxies for innovation and to create measures for both quantity and quality of innovation. We used extensive data sources from the World Bank (WB) website and WB Development Indicators, WIPO, the University of Maryland Polity IV database, the Heritage Foundation and The Wall Street Journal database on Economic Freedom, DataStream, and in some cases, from the websites of individual companies.

We started with 25 countries—Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, and Yemen—and data spanning the period 1990–2011. However, we had to delete few countries (Djibouti, Palestine, Somalia, Sudan, and Yemen) due to the unavailability of some of the variables used in the regression estimations. Given the missing variables in certain years for some countries, we have restricted our empirical estimations for an unbalanced panel data for 15 years from 1996–2010.

2.3 Dependent variables

A major challenge in this paper was to determine what would be an appropriate proxy for innovation. In the past, scholars have used R&D as a measure of innovative activities [55]. Others used a count of the number of patents as a proxy for innovation [1]. Work by Jaffe, Trajtenberg, and Henderson [37] and Jaffe and Trajtenberg [38] suggested that patent data can be considered a measure of innovation. One criterion of a patent is "commercial applicability," which indicates the need for patent protection as a kind of insurance policy against appropriation [32]. In addition to other means of protecting intellectual property, economic agents are likely to file patents to protect the property rights generated by their private investment in R&D. Moreover, patent documents contain references to prior patent documents, and significant innovations tend to be heavily cited. Therefore, in some circumstances patent citations can be interpreted as knowledge flow from one invention to another [16, 20, 37],[15] and such citations can be used to identify those innovations with a breakthrough impact.

[15]Note: the structure of the United States National Innovation System, in which the applicants supply many prior art references, leads to this interpretation. However, it should be noted that in the International Patent Office, the examiners provide the prior art citations and thus any knowledge flow interpretations are unwarranted [33].

Although there are major problems associated with the use of patent data, there are several justifications why patent statistics can be an important indicator of innovation [35] noted that patenting databases provide richer information on the background of innovators and their respective projects. Furthermore, patents can be viewed as the output of inventive process, whereas R&D activities are considered as inputs.[16] Finally, the patent data allows us to construct both quantitative and qualitative aspects of innovation activities.

The patent data was extracted from PATSTAT (released April, 2007, and May, 2011). PATSTAT is a Patent Statistical Database developed by the European Patent Office-Organization for Economic Co-operation and Development (EPO-OECD) Taskforce on Patent Statistics. PATSTAT covers patent data from over 80 patent offices worldwide and is comprised of more than 59 million patent documents. We retrieved all the patents from PATSTAT whose applicants were from MENA countries. We also examined where these patents were granted. We were particularly interested in the patents that were granted from United States or United Kingdom patent offices, as well as the patent offices of the focus country. We cross-checked our data with the United States patent database from the National Bureau of Economic Research and examined the country of both the inventor and the assignee when applicable.

We used combinations of dependent variables to determine several alternative innovation measures. Although these variables are the best available proxies for innovations, they all suffer from limitations. In defining the term "quantity of innovation," we used the number of patents granted as a proportion of GDP as a primary measure. First, the paper used the actual number of patents granted to a respective country—regardless of where the patentee was located, as long as the company itself was headquartered in that country—as the primary measure. For example, if VESTEL—a Turkish company known for its innovative activities—was granted a patent in the Turkish patent database, the patent would be assigned to Turkey, which is where VESTEL is headquartered, regardless of the fact that the lab itself was located in China. We operationalized this variable in various ways: (1) number of patents granted per million dollars of R&D, (2) natural logarithm of the patents granted, and (3) R&D as a proportion to GDP (ratio of the total R&D expenditure in the country to total GDP). In cases where such numbers were not available at the macro level (e.g., Egypt), we simply summed up the R&D spending of all firms listed in the World-Scope, International Compustat, or Datastream databases. We agree that the variable has some limitations. The R&D spending of VESTEL, for instance, does not clarify in what country the funds were spent; the funds could have been spent in a lab in China, but the actual patent licensing reflects innovations in Turkey. More importantly, R&D in that hypothetical Chinese lab will be sensitive to the IP environment in China, but our focus is on the IP reforms in Turkey. We introduce an additional dependent variable: (4) innovation index—available from the World Bank—as proxy for innovation or innovative activities in a given country. This index, however, could represent both quantity and quality.

[16] Audretsch and Feldman [4] and Goel and Ram [24] used them as output, whereas Hasan and Tucci [35] used them as both output and input variables. Scientific and technological journals could be an alternative measure of innovation, as suggested by Murray [49], Spencer [58], and Carlsson [11]. However, we do not have consistent data on journal counts for most sample years for respective countries.

With regards to quality of innovation measures, the most appropriate approach would have been to acquire a quality measure based on the method established by Hall, Jaffe, and Trajtenberg [32] method—by using forward citations (CITA) of each patent relative to other patents in its technology class in the respective year aggregated to the country level. While collecting citation data, however, we observed that the number of citations is not reported consistently for firms in most MENA countries, and only in limited cases for the later period of our sample years seemed to be reasonable and reliable. As we are unable to defend the reliability of these citations numbers, as an alternative, we set up the variable PATABROAD, which represents the ratio of patents granted in the United States and Europe as a proportion of total patents granted by the country in a given year. Patent applications granted in the United States and Europe are likely to be important and are associated with significant innovations, and thus portray relative quality. We further attempt to develop a quality measure, RESTINV, by regressing R&D on innovation and taking the residual from this regression as a proxy for quality. The rationale for this approach is that while a patent (innovation) may be the product of the R&D input, it is also possible that due to several spillover effects from other unobserved variables that innovation may originate from factors beyond the proportion of the R&D expenditures [35].

2.4 Independent variables

Our key independent variables are: (1) the number of IPR reforms signed by the country out of all possible reform initiatives; (2) the length of participation in the Paris Convention within the IP group of IPR reforms. The Paris Convention has had several amendments over the past century; the most recent formal revision is the Stockholm Amendment of 1967, which required signatory countries to renew their membership to the treaty (WIPO, 2008). Given the variability in the adoption year, our sample provides a range of time frames in terms of implementation of patent-based IPR reforms. We measure duration of participation in IPR reform using the number of years since the adoption of the Paris Convention.

The other key variable, *Information Technology Index*, represents the technological preparedness or sophistication of respective countries. This index was developed using a number of variables related to information and communications technology expenditures, which include: computer hardware (computers, storage devices, printers, and other peripherals); computer software (operating systems, programming tools, utilities, applications, and internal software development); computer services (information technology consulting, computer and network systems integration, web hosting, data processing services, and other services); and communications services (voice and data communications services) and wired and wireless communications equipment. This variable also includes expenditures on electric power consumption (kWh per capita), fixed line and mobile phone subscribers (per 1,000 people), personal computers (per 1,000 people), and radios and telephone sets (per 1,000 people).

We also added a number of other country-level control variables that are traditionally considered important for the development of innovative environments and innovative activities. *Economic Freedom* is used to determine the strength of the legal system and the status of property rights in the respective countries. *Foreign Direct Investments* (*FDI*) is operationalized as FDI to GDP ratio.[17] *Financing Environment* of the respective countries is measured by domestic bank credit to GDP ratio. And *Literacy Rate* (*LITRATE*), a common proxy for human capital, is operationalized in two ways: first by using the number of college graduates in the country, and second by using the proportion of that population that has graduated from secondary schools.

We also considered other variables, such as *GDP Values* (per capita GDP growth), to gain an understanding of the relative changes of sample countries that exhibited wide ranges of development. We used overall *Country Composite Risk*, which includes different types of risks such as financial risk and political risk. We proxied data from the available years and used them as substitutes to the nearest years in cases where data was not available for a given country for a given year. Finally, we also added a variable to capture the extent of the *Civil Liberty* (right to freedom of expression), which is considered important for innovation [41].[18] Appendix summarizes all the variables that are used in this paper.

2.5 Basic model specification

$$\begin{aligned}&\text{Innovation}\\&\quad = a_0 + b_1 \text{Log of the Total Number of IPR reformsAdopted by respected country}\\&\qquad + b_2 \text{ Log of the Number of Years sincethe major IPR reform is undertaken}\\&\qquad\quad \text{or signed}\\&\qquad + b_3 \text{ Information Technology Index} + \sum b_4 - b_{10} \text{ Control Variables} + \Box_i\end{aligned} \tag{1}$$

Where innovation is considered in two different perspectives: quantity versus quality. Quantity of innovation is represented by (1) Patents Granted to GDP ratio or (2) Log of Total Patents Granted or (3) Total R&D expenditure to GDP ratio or (4) Innovation Index. Quality of Innovation is primarily represented by the (a) Total Forward Citations awarded or (b) Proportion of Patents Granted in the US and Europe or (c) Other Countries as a proportion to Patents issued in the Country). Control variables considered are Economic Freedom, FDI to GDP ratio, Bank Loan to GDP, Literacy, logarithm of GDP Level, Composite Country Risk, and Civil Liberty Index. All estimations control for country.

[17] We realize that FDI activities may be caused by IPR reforms (Branstetter, Fishman, and Foley [8] and therefore may create an endogeneity problem. A two-stage simultaneous estimation with multiple dependent variables did not change our key points in the paper and we stayed with the OLS and Binomial Estimations. For additional applications on this issue in other industries and countries, especially for financial companies, can be found in Angelakopoulos and Mihiotis [3].

[18] We originally included a variable called the *Degree of Openness*, a measure that considers the ratio of Export and Import as a proportion to GDP, but excluded it later given its high correlation with FDI-GDP ratio.

3 Results

Table 1 reports innovative activity—Patent and R&D—of the key dependent variables by sample countries of the region. Table 2 reports on the landscape of intellectual protection reform treaties for the sample countries, along with the innovation index. Table 3 depicts the average statistics of all independent variables for the sample countries. Table 4 provides descriptive statistics and the correlation coefficient matrix of the final sample. Evidence indicates that the independent variables are not highly correlated in a fashion that would suggest any alarming multicollinearity issue. Egypt, Israel, Morocco, Saudi Arabia, and Turkey were found to be the leading countries in the region with respect of the number of patents owned, applied for, and granted. These countries, with the exception of Saudi Arabia, were also some of the leading signatories of the IPR reforms. Although Algeria, Bahrain, Oman, and Syria have also signed reformed IPR initiatives, the numbers of patents granted under their names were not as high, relatively speaking.

We report results of the OLS regressions and followed up with a negative binomial regression model. Given that some of the dependent variables are simply numbers, studies have suggested a preference of a binomial model over OLS or Poisson estimations [28, 65]. All our regression estimates controlled for year and country fixed effects. These results are reported in Table 5. Our focus is primarily on the influence of total number of IPR reforms and duration of key reforms in affecting innovation (six different alternative innovation variables). The first 4 columns represent estimations where the dependent variables are related to the quantity of innovation, while columns 5 and 6 are related to the quality of innovation. The result showed that the coefficient of the variable representing the frequency or total number of initiatives undertaken by respective countries to reform IPR to be positively and significantly associated with the innovation variables in all six estimations. However, their significance level is marginal at the 10 percent level in most cases.

Next, we examined the duration of participation in IPR reform. The result for this variable reported a stronger statistical significance level in most of the estimations with at least 5 percent statistical significance level for all estimations. Therefore, the experience to operate in an IPR reform environment results in even higher innovation. The significant associations for these two key variables also hold for their respective economic significances in affecting innovative activities in most of the reported estimations. Finally, we examined the Technology Index variable and found that the relative technological preparedness of the respective country did help in affecting both quality and quantity of innovation activities in most cases, although it seemed to have a stronger positive and significant association with the quality of innovation relative to the quantity of innovation. The results were relatively similar and stronger in most of the models in the next sets of estimations using the negative binomial regressions. These regressions also reveal that Economic Freedom, FDI ratio, and Bank Lending to be important determinants of innovations.

4 Robustness tests

We employ a number of robustness tests. First, we use an alternative measure for quantity of innovation following the measure described in the “dependent variable”

Table 1 Innovation activities in MENA countries

Country	Patents owned					Patents granted			R&D	
	Total	Patents from own country	Patents from UK	Patents from US	Patents from other countries	Total	Patents granted to domestic applicants	Patents granted to international applicants	R&D spending to GDP	Proportion of patents listed in the US-Europe
Algeria	391	98	40	4	249	1404	98	1306	0.31	4.65
Bahrain	113	0	31	16	66	0	0	0	0.82	6.32
Djibouti	2	0	0	0	2	3	0	3	0.00	0.00
Egypt	639	21	114	40	464	10318	21	10297	0.20	5.13
Iran	389	0	32	95	262	26	0	26	0.67	2.23
Iraq	36	0	6	8	22	0	0	0	0.00	1.32
Israel	79924	12842	2593	14120	50369	193553	12842	180711	4.11	17.76
Jordan	135	0	21	29	85	80	0	80	1.02	11.31
Kuwait	293	0	51	115	127	0	0	0	1.44	4.32
Lebanon	362	0	35	26	301	6	0	6	0.81	6.15
Libya	9	0	0	0	9	0	0	0	0.04	2.83
Malta	610	0	85	47	478	545	0	545	1.31	7.93
Mauritania	53	0	0	0	53	1	0	1	0.34	1.34
Morocco	2310	1681	13	35	581	9362	1681	7681	0.55	6.12
Oman	18	0	9	1	8	0	0	0	1.87	0.00
Qatar	43	0	19	3	21	0	0	0	0.68	7.95
Saudi Arabia	1171	0	91	361	719	64	0	64	2.02	6.47
Somalia	11	0	0	0	11	8	0	8	0.00	0.00

Table 1 (*Continued*)

Country	Patents owned					Patents granted			R&D	
	Total	Patents from own country	Patents from UK	Patents from US	Patents from other countries	Total	Patents granted to domestic applicants	Patents granted to international applicants	R&D spending to GDP	Proportion of patents listed in the US-Europe
Sudan	53	0	0	0	53	18	0	18	0.43	1.26
Syria	80	0	0	4	76	0	0	0	0.71	1.76
Tunisia	314	0	6	20	288	0	0	0	0.46	1.45
Turkey	13615	11052	77	142	2344	38967	11052	27915	0.59	4.36
U.A.E.	413	0	66	35	312	6	0	6	1.02	5.12
Yemen	9	0	0	1	8	0	0	0	0.00	0.00

Note: This table presents the innovation activities of the countries listed in the "Country" column. The "Patents Owned" section shows the number of patents owned by companies in these countries. Different columns demonstrate different patent authorities around the globe that grant the patents: their own country, UK, US, and other countries. "Patents Granted" section demonstrates the number of patents granted by the patent offices of these countries. This data is compiled from PATSTAT database by EPO and aggregated by years. The "R&D" section shows the R&D investment and number of R&D personnel from these countries

Table 2 Descriptive statistics on innovation activities

Country	Innovations climate			
	Innovation index	Yearly university degrees numbers	Number of IPR treaties	Adoption year of key IPR reform
Algeria	4.21	53,581	12	1966
Bahrain	3.55	2,032	12	1997
Djibouti	0.00	.	3	2002
Egypt	5.90	202,035	15	1955
Iran	3.23	260,341	10	1959
Iraq	2.60	77,061	2	1976
Israel	11.65	65,602	18	1950
Jordan	7.09	39,886	6	1976
Kuwait	6.04	14,464	1	1980
Lebanon	5.56	27,753	9	1924
Libya	1.56	1,449	4	1976
Malta	10.11	44,223	5	1967
Mauritania	0.36	2,058	5	1965
Morocco	4.85	165,230	13	1917
Oman	6.14	7,123	12	1999
Qatar	7.04	946	6	2000
Saudi Arabia	4.69	88,370	3	2004
Somalia	0.00	0	1	.
Sudan	0.54	5,400	6	1984
Syria	3.89	37,114	11	1924
Tunisia	5.73	32,556	12	1884
Turkey	7.14	266,523	17	1925
U.A.E.	8.20	2,988	7	1996
Yemen	2.23	1,021	2	2007

Note: The variable in the last column does not mean the year of Paris Convention. It is simply the year when the major IP laws were enacted/signed by that country (see WIPO Intellectual Property Handbook: Policy, Law, and Use and www.wipo.int for each specific country on the details of their signature years on different IPR protections.) For the empirical section of our paper, in the case of the Paris Convention, we use 1967 as the year for countries that have signed other key IPR regulations prior to 1967

section above. When counting the actual number of patents granted to a respective country we restrict where the patentee was located. In other words, we repeat the measurement of the innovation variable following the methods discussed earlier, except we count the number of patents or amount of R&D differently. In this case, we check the addresses associated with innovators for each patent application filed by companies (such as VESTEL), and whenever any of the reported address is not located in the home country (in the case of VESTEL, Turkey), we discard that particular patent application in counting the total number of innovations or in creating the total R&D measure. This method also suffers from limitations, as it is not pos-

Table 3 The mean value of key relevant variables

Country	Economic freedom index	Foreign direct in-vestment to GDP	Bank loan to GDP	Literacy rate	Information technology to GDP	GDP growth	GDP per capita	Composite risk index	Civil liberty	Degree of openness
Algeria	3.68	0.64	12.88	58.31	2.46	5.03	1,912	39.44	5.31	51.62
Bahrain	3.08	2.65	59.75	82.73	1.92	6.14	12,0875	41.76	5.44	83.76
Djibouti	4.80	3.97	33.81	51.46	.	3.01	986	76.15	5.56	104.01
Egypt	3.46	1.72	44.81	50.21	1.16	3.93	1,474	67.06	5.43	51.34
Iran	4.80	0.12	30.42	66.23	2.08	4.02	1,897	77.28	6.16	5176
Iraq	3.85	2.08	12.28	40.45	1.83	11.04	6.217	88.65	6.34	52.61
Israel	2.59	1.79	77.02	91.68	8.32	5.65	19,862	68.02	2.86	75.95
Jordan	2.87	2.85	73.81	82.45	8.98	6.45	2,081	72.95	4.28	80.17
Kuwait	3.01	0.54	57.45	79.22	1.97	6.98	19,845	54.42	4.65	93.65
Lebanon	3.45	4.66	71.45	81.16	3.02	2.02	3,076	55.96	4.38	75.56
Libyan	4.11	3.85	28.61	69.37	2.02	4.03	7,458	72.06	6.56	53.88
Malta	2.27	1.78	57.93	88.05	9.05	4.15	9,276	37.45	1.00	87.06
Mauritania	4.46	4.11	28.32	35.17	1.12	4.28	505	72.87	5.45	92.32
Morocco	2.94	1.87	52.77	41.16	5.69	2.04	1,278	67.74	4.43	54.51
Oman	2.87	1.05	34.61	59.24	2.42	3.54	7,905	41.37	5.32	90.47
Qatar	2.75	2.24	36.80	79.71	2.67	3.75	18,045	38.65	5.46	87.52
Saudi Arabia	2.82	1.89	57.43	69.59	2.83	6.01	19,286	45.18	6.06	89.64
Somalia	4.90	2.14	12.45	31.03	.	1.34	489	85.99	6.98	.
Sudan	4.86	3.27	5.93	45.16	1.08	6.05	418	83.56	6.94	29.74
Syria	3.90	1.26	11.76	66.17	1.45	3.14	1,652	75.95	4.73	65.75
Tunisia	2.85	2.49	60.34	63.56	5.92	4.02	2,053	68.84	4.17	83.38
Turkey	2.75	1.89	26.81	78.89	8.02	7.28	3,674	50.32	5.02	47.35
U.A.E.	2.77	2.05	46.54	74.29	3.72	6.75	23,126	42.95	5.21	91.29
Yemen	4.22	0.27	7.02	31.71	0.56	2.37	521	79.47	5.76	61.35

Table 4 Correlation coefficients

	Variables	Mean	Standard deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Patents Granted to GDP	**0.0180**	**0.0543**	1.00															
2	Log of Patent Granted	**1.4217**	**1.6545**	0.35	1.00														
3	R&D to GDP	**0.8109**	**0.8659**	0.30	0.34	1.00													
4	Innovation Index	**0.0354**	**0.0474**	0.43	0.40	0.33	1.00												
5	Proportion of Patents Granted in the US and Europe	**0.0427**	**0.0545**	0.40	0.29	0.26	0.16	1.00											
6	Other Innovative Quality	**0.0175**	**0.0144**	0.27	0.31	0.22	0.18	0.15	1.00										
7	Log of Number of IPR Reforms	**0.7704**	**0.3704**	0.49	0.37	0.24	0.21	0.18	0.21	1.00									
8	Log of Years Since Major IPR Reform	**1.4081**	**0.6615**	0.35	0.26	0.16	0.19	0.10	0.19	0.23	1.00								
9	Economic Freedom	**3.4417**	**0.7504**	0.28	0.18	0.10	0.16	0.09	0.09	0.20	0.29	1.00							
10	FDI to GDP Ratio	**0.0186**	**0.0217**	0.29	0.22	0.09	0.10	0.13	0.23	0.16	0.05	0.09	1.00						
11	Bank Loan to GDP	**0.3786**	**0.2186**	0.15	0.10	0.23	0.18	0.10	0.14	0.10	0.16	0.08	0.07	1.00					
12	Literacy	**0.58.57**	**0.1791**	0.29	0.17	0.17	0.14	0.06	0.18	0.09	0.18	0.14	0.10	0.16	1.00				
13	Information Technology Index	**0.0318**	**0.0223**	0.18	0.10	0.10	0.09	0.03	0.15	0.14	0.14	0.18	0.13	0.20	0.19	1.00			
14	Log of GDP	**0.0425**	**0.0174**	0.07	0.07	0.05	0.12	0.09	0.09	0.24	0.19	0.21	0.16	0.17	0.21	0.19	1.00		
15	Composite Risk	**0.5796**	**0.1518**	−0.02	−0.07	−0.06	0.02	0.04	0.11	0.09	0.18	0.15	0.07	0.14	0.14	0.12	0.13	1.00	
16	Civil Liberty	**0.0614**	**0.0194**	0.12	0.11	0.18	0.16	0.05	0.08	0.06	0.08	0.06	0.05	0.08	0.10	0.08	0.14	−0.08	1.00

Note: If the coefficients are more than 0.16, 0.12, 0.09 then are significant at ***, **, * are significant at 1, 5, and 10 percent significance levels respectively for most variables

Table 5 Ordinary least squared regressions determining innovations

Variables	Ordinary Least Square Estimations (OLS)						Negative Binomial Regression Models (NBR)					
	Quantity of innovations				Quality of innovations		Quantity of innovations				Quality of innovations	
	Total patents granted to GDP	Log of total patents granted	R&D to GDP	Innovation index	Proportion of patents granted in the US and Europe	Other innovative quality (residual of patent on R&D	Total patents granted to GDP	Log of total patents granted	R&D to GDP	Innovation index	Proportion of patents granted in the US and Europe	Other innovative quality (residual of patent on R&D
	1	2	3	4	5	6	7	8	9	10	11	12
Intercept	−0.0126	0.0238*	0.0129	0.0183*	0.0145*	0.03065**	−3.0563***	−3.8638***	−6.1286***	−5.0877***	0.4318*	10.8704**
Log of Number of IPR Reforms	0.0645**	0.07965**	0.0962**	0.1287*	0.0390	0.0298	0.0625*	0.0474*	0.0187**	0.0398*	0.0317**	0.0421*
Log of Number of Years Since Major IPR Reform	0.0809***	0.0916**	0.1876***	0.1595***	0.0275*	0.0457**	0.0345**	0.0133**	0.0276**	0.0364**	0.0410**	0.0987*
Information Technology	0.0205	0.0342*	0.0464*	0.0118*	0.0248**	0.0516**	0.0385*	0.0439	0.0248	0.0339	0.0718*	0.2175*
Economic Freedom	0.0412*	0.1216*	0.3276**	0.1085**	0.0167	0.0329*	0.0145*	0.0278*	0.0317*	0.0673*	0.0187	0.1198*
FDI to GDP Ratio	0.2130*	0.1605*	0.1421**	0.0832**	0.1404*	0.0148*	0.1097	0.1518*	0.0876*	0.1095*	0.0654*	0.1765
Bank Loan to GDP	0.2564*	0.1925*	0.2383**	0.1620*	0.0789	0.0102	0.1651	0.1045	0.0543*	0.0612*	0.0217	0.7654*
Literacy (College)	0.1376	0.1095	0.1956*	0.1543*	0.1034	0.0597	0.0874	0.0912	0.1094**	0.0814**	0.0975*	0.9870
Log of GDP	0.1096	0.0676	0.0352*	0.0403*	0.1098*	0.0602	0.0359	0.0451	0.0218*	0.0316	0.0518	0.1187
Composite Risk	−0.0103	−0.0123	0.0784	0.0128	−0.0216	−0.0501	−0.0418	−0.0432	−0.0358	−0.0198	0.0165	−0.0186
Civil Liberty	0.0874	0.0817	0.0517	0.0379	0.0587	0.0351	0.1575	0.1318	0.1186	0.0476	0.0198	0.0417

Table 5 (*Continued*)

Variables	Ordinary Least Square Estimations (OLS)						Negative Binomial Regression Models (NBR)					
	Quantity of innovations				Quality of innovations		Quantity of innovations				Quality of innovations	
	Total patents granted to GDP	Log of total patents granted	R&D to GDP	Innovation index	Proportion of patents granted in the US and Europe	Other innovative quality (residual of patent on R&D	Total patents granted to GDP	Log of total patents granted	R&D to GDP	Innovation index	Proportion of patents granted in the US and Europe	Other innovative quality (residual of patent on R&D
	1	2	3	4	5	6	7	8	9	10	11	12
Year Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted R^2 (OLS Col 1–6) Log Likelihood (Negative Binomial Regression Col 7–12)	0.1976	0.1965	0.2053	0.2290	0.1542	0.1767	−1023.19	−1175.83	−1089.85	−1254.21	−906.16	−1177.43
F-Statistics (OLS) (1–6) Wald Chi-Squared (7–12)	26.49***	24.65***	21.89***	32.08***	31.28***	57.98***	509.46***	531.46***	409.32***	454.11***	375.48***	654.15***
No. of Observations	243	243	238	228	198	238	240	236	236	228	195	235

Note: For the OLS estimation, the standard errors are consistent estimates with White's Heteroscedasticity corrections

***, **, * are significant at 1, 5, and 10 percent significance levels respectively sible to guarantee that an innovator with a foreign address is actually located in that particular foreign country. It is entirely plausible for an innovator to have originated from and formerly worked in one country yet currently works for a foreign subsidiary of the same company. Moreover, in many cases the clear addresses associated with innovators were missing in the PATSTAT database for our sample institutions, and this gap drops our sample size by more than 50 percent of our original sample. Given we do not know the actual location of the innovators in many cases, is impossible to create a consistent measure for innovation using this definition. These estimations are reported in Table 6 (columns 1–4). Evidence indicates that the original results also hold in these estimations, i.e., the coefficient of the variable representing the IPR reform and duration of participation in IPR reform variables are significant to at least a 10 percent significance level in all estimations.

Second, we revisit the quality of innovation measures. Earlier, we avoided direct measures of quality—we used the forward citation measure outlined by Hall, Jaffe, and Trajtenberg [32], wherein forward citations in technology class are aggregated to the country level in a yearly basis)—and claimed that the sample citation data was not consistent and reliable. This unreliability of citation data in PATSTAT is true even for the developed countries. Except for a few OECD countries, the PATSTAT database simply does not provide consistent patent citation information. To be more specific, the reported data set on citations is prone to be wrong in certain years not only for our sample countries, but even for the most established developed countries. For example, according to PATSTAT, one of the companies in our sample shows that it has 11 citations in 1998 and 16 in 1999. The number of citations then jumps to 3,896 in year 2000, declines to a meager sum of 2 citations in 2001, and then wavers erratically with 22 in 2002, 48 in 2003, 450 in 2004, 6,466 in 2005, 8 in 2006, 122 in 2007, 162 in 2008, 243 in 2009, and 288 in 2010. We have worse examples of inconsistencies with missing values or zero associated citation numbers for companies in a given year, whereas the same companies reported high citation numbers (in the thousands) during the previous year. In such scenarios, we made assumptions that when the numbers are taking unusual shifts such as in the years 2000, 2001, 2005, and 2006 in the example above, we should drop these years in constructing the citation or quality of innovation variable. This lowers our sample size significantly, and despite the fact this new measure does not necessarily gives any boost in our confidence in capturing the quality of innovations, we still proceed with this simpler quality of innovation measure. These estimations are reported in Table 6 (columns 5–8). Once again, the IPR reform and duration of IPR reform variables are found to be statistically significant in influencing innovative activities with respect to quantity as well as quality.

Third, we recognize that there is an initiative in Europe called "The European Neighborhood Policy" that began in 2003 and was later implemented on a larger scale in the MENA region (see http://ec.europa.eu/world/enp/policy_en.htm) where some of the countries—in particular, Morocco, Tunisia, and to some extent, Algeria[19]—are active participants in these privileged EU and ENP cooperative agreements. Given that most of the cooperation agreements and initiatives have begun after 2005, we create an additional dummy variable, EUCOOP, which takes a value of 1 for sample

[19] Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Syria, and Tunisia are in our sample.

Table 6 Ordinary least squared regressions determining innovations**

Variables	Quantity of innovations				Quality of innovations			
	Ordinary least square estimations (OLS)		Negative binomial regression models (NBR)		Ordinary least square estimations (OLS)		Negative binomial regression models (NBR)	
	Total patents granted to GDP	R&D to GDP innovation index	Total patents granted to GDP	R&D to GDP innovation index	Total citation to total patents	Proportion of patents granted in the US and Europe	Total citation to total patents	Proportion of patents granted in the US and Europe
	1	2	3	4	5	6	7	8
Intercept	0.0187	0.0098	−1.2189*	−2.6593*	0.0124*	0.0198*	0.0984**	0.1154**
Log of Number of IPR Reforms	0.0154*	0.0417*	0.0186*	0.0223*	0.0175*	0.0276	0.0296*	0.0397*
Log of Number of Years Since Major IPR Reform	0.0515*	0.0938*	0.0245*	0.0306*	0.0317**	0.0263*	0.0218*	0.0317*
Information Technology	0.0658*	0.0513*	0.0119	0.0203	0.0298	0.0156*	0.0164	0.0143
Economic Freedom	0.0658*	0.0516*	0.0319*	0.0416*	0.0317	0.0245	0.0258	0.0162
FDI to GDP Ratio	0.1098*	0.0762*	0.0892*	0.0619*	0.0417	0.0754*	0.0651	0.0539
Bank Loan to GDP	0.0217*	0.0756*	0.0615*	0.0518*	0.0187	0.0494	0.0198*	0.0231*
Literacy (College)	0.0616	0.0981	0.07630	0.0417	0.0418*	0.0852	0.0298*	0.0613*
Log of GDP	0.0187	0.0318	0.0318	0.0219	0.0206	0.0175	0.0109	0.0045
Composite Risk	−0.0123	0.0128	−0.0432	−0.0198	−0.0613	−0.0187	−0.0416	−0.0217
Civil Liberty	0.0817	0.0379	0.1318	0.0476	0.0871*	0.0417	0.0548	0.0317
European Neighborhood Policy Initiative Dummy—EUCOOP	0.0216	0.0316	0.0417	0.0215*	0.0216	0.1404*	0.0176	0.1651*

Table 6 (*Continued*)

Variables	Quantity of innovations				Quality of innovations			
	Ordinary least square estimations (OLS)		Negative binomial regression models (NBR)		Ordinary least square estimations (OLS)		Negative binomial regression models (NBR)	
	Total patents granted to GDP	R&D to GDP innovation index	Total patents granted to GDP	R&D to GDP innovation index	Total citation to total patents	Proportion of patents granted in the US and Europe	Total citation to total patents	Proportion of patents granted in the US and Europe
	1	2	3	4	5	6	7	8
Year Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted R^2 (OLS Col 1–2 and 5–6) Log Likelihood (Negative Binomial Regression Col 3–4 and 7–8)	0.2093	0.2316	−865.43	−912.93	0.1217	0.1495	−706.34	−804.51
F-Statistics (OLS) (1–2 and 5–6) Wald Chi-Squared (3–4 and 7–8)	20.84***	28.96***	531.46***	454.11***	10.19**	14.65**	414.87***	398.95**
No. of Observations	176	176	176	176	81	81	81	81

Note:** Robustness tests. Patent count does not include if innovator's address is in a different country. For quality of innovation, available relatively cleaner citation data are aggregated. For the OLS estimation, the standard errors are consistent estimates with White's Heteroscedasticity corrections. ***, **, * are significant at 1, 5, and 10 percent significance levels respectively years beyond 2005 and a value of zero for other years.[20] Our goal is to see whether these increased innovative activities are influenced by EU-initiated trade and cooperation in the region, and, importantly, whether the introduction of this variable lowers the significance of our key IPR variables or not.

Indeed, we find a significant increase in innovative activities in the region. The EUCOOP variable came out to be significant in some of the models, thus indicating that EU initiatives are at least helpful in enhancing innovative activities in our sample countries that are involved in such cooperative relationships. Importantly, however, our key focused variables, the IPR reform and length of IPR reform variables, remained statistically significant in all estimations. Our robustness tests confirm our conclusions that IPR reforms do create a more innovative environment, irrespective of models, definitions, and related initiatives.

5 Conclusion

The lack of empirical studies analyzing innovation activities and initiatives in the MENA region motivated this research. Using 1996–2010 data from various sources, the paper specifically focused on the role of intellectual property rights and reforms and information technology in affecting innovation in MENA countries. It investigated several potential factors considered to be significant in influencing the innovative environment and activities in that region. By and large, the results showed that initiatives to reform IPR and enact key amendments do have an impact on the innovative environment and consequently on the overall innovative activities, both with regards to quantity as well as quality of innovations. The results also revealed strong associations between information technologies—in terms of preparedness and sophistication—and quality of innovations.

This paper contributes to the literature by providing better an understanding of innovations in an emerging region that has been neglected in related research. This often unstable part of the world is facing a bleak future with dramatic economic and social implications if significant steps are not taken to revitalize its various economies and generate more employment. Innovation, which is often considered central to boosting growth and jobs—especially by young firms—is believed to play a key role toward that end.[21] In the United States, for example, firms less than five years old have accounted for nearly the entirety of the increase in employment in the private sector in the past 25 years.[22] Implementing steps to promote innovation and job growth is crucial for the MENA region, which has one of the highest unemployment rates in the world and the highest global unemployment rate among young people (14–24 years

[20] We also create the dummy variable assigning a value of one for the dummy variable that considers the post-2003 era as the ENPI cooperation year. For our purposes, the results remain unchanged.

[21] Andrew Wyckoff , OECD innovation expert: Innovation central to boosting growth and jobs http://www.oecd.org/document/36/0,3343,en_2649_34273_45324068_1_1_1_1,00.html.

[22] See above footnote.

old). It is estimated that the MENA region needs to create 80 million new jobs in the first two decades of the 21st century just to absorb new labor force entrances.[23]

This paper also contributes by focusing on IPR reforms. Although MENA countries have started to implement various initiatives to promote innovations, so far their actions have primarily focused on the "hardware" aspects, such as building infrastructure and investing in state of the art research institutions and educational facilities. They have not paid as much attention to the "software" aspects associated with reforming and protecting intellectual property. Authors have found several beneficial effects of strengthening intellectual property protection in countries with weak system, such as stimulating innovations [45], reducing cost [66], improving the quality of innovation [59], and encouraging domestic R&D, as well as promoting technology transfer between developed and developing countries [17]. Strengthening IPR has also been shown to generate other beneficial effects such as an improvement in quantity as well as in quality of FDI in respective countries. Strengthening patent protection by just 1 % has been found to generate 0.45 % increase in the stock of United States investments in the respective country [48], while weak IPR was found to discourage FDI in high-tech sectors and to shift the focus from local production toward the distribution of imported goods [39]. Therefore, by focusing on IPR reforms and emphasizing related benefits, our finding of a significant positive association between reform and innovation further indicates to MENA policy makers the importance of coupling their investments in physical infrastructure with reform in order to maximize the return on their investments.

This paper also found a significant positive relationship between information technology and quality of innovation. From a policy perspective, this result is also significant to the MENA region considering the large investments several MENA countries have been making in promoting R&D and building state of the art research institutions. In order to capitalize on these investments and enhance the quality of innovation, these countries need to make concerted efforts to promote joint R&D between universities and businesses to ensure that efforts are targeted toward quality innovations that enhance productivity and promote competitiveness. These efforts will be further enhanced with IPR reforms, which were also found to have an impact on national competitiveness. In 2004, the World Economic Forum (WEF) reported that the top 20 countries perceived as having the most stringent intellectual property protection were ranked among the top 27 countries on the growth and competitiveness index, while the 20 countries perceived as having the weakest IPRs were ranked among the bottom 36 for growth and competitiveness.[24]

Finally, another noteworthy result in the paper is the role of the time span and experience of operating in a reformed IPR environment, which was found to have a strong impact on innovation. Such a finding is important within the MENA region, where reform can proceed very slowly and with many bureaucratic delays.[25] On average, Arab countries—which constitute the majority of the MENA region—ranked

[23] World Bank MENA Region Development reports on Governance, Gender, Employment, Trade and Investment. http://www.medea.be/index.html?doc=1711.

[24] World Economic Forum, Global Competitiveness Report, 2004-5.

[25] Economic and Social Commission for Western Asia. Foreign Direct Investment Report. United Nations, New York, 2008.

107 out of 175 in terms of the amount of red tape involved in setting up a business,[26] and 103 out of 183 in terms of the ease of doing business.[27] A recent paper focusing on the adoption, timing, and presence of IPR reform in Latin America and the Caribbean region found that the economic benefits drawn from greater innovation were contingent on having a longer history of respecting foreign IPR with the Paris Convention [40]. Considering the high rate of unemployment in the region and the positive role innovation can play in fostering job creation, the *timely* implementation of reform—along with measures to combat bureaucracy and red tape—is particularly salient if the region is to gain from the by-products of innovation and in turn minimize potential economic crises.

Therefore, although the MENA countries have made significant investments in building the physical infrastructure that will promote innovation, it is unlikely that they will be able to reap the full benefits in terms of economic growth and job creation unless they also take timely concerted efforts to strengthen their IPR and promote a business friendly environment. The MENA region is not disinclined to innovation. As noted earlier, only a few centuries ago it was the center for technological and scientific contributions. Strengthening their IPR and creating a more supportive social, legal, and economic infrastructure will enhance their opportunities for the resurgence of an environment where innovation might flourish once again.

Finally, we should recognize the limitation of the patent variable as a proxy for innovation. As in some cases, patents may not reflect the total R&D initiatives or may not be inclusive of overall innovative initiatives in respective countries. It is plausible that many innovations in some of these developing economies come in the form of process improvement or constitute alternative uses of existing products that are not necessarily patentable.

Acknowledgements The authors are grateful to Liang Song for his research help and suggestions. The authors would also like to thank Christopher Tucci and the participants of the Economic Research Forum Conference for their insightful comments. This work has benefited from a financial grant from the Economic Research Forum. The contents and recommendations do not necessarily reflect the views of the Economic Research Forum. The usual caveats apply.

[26] http://www2.weforum.org/en/media/Latest%20Press%20Releases/Foundation07PressRelease.html.

[27] Doing Business in the Arab World, 2010. A publication of the World Bank and the International Finance Corporation.

Appendix

Table 7 Variable definitions

	Variable name	Measurement	Source of data	Data year
1	*Total Number of Patents*	Total number of patents owned	PATSTAT Database	1996–2010
2	*Number of Domestic Patents*	Domestic patents	PATSTAT Database	1996–2010
3	*Number of Patents in Europe*	Patents owned in the Europe	PATSTAT Database	1996–2010
4	*Number of Patents in US*	Patents owned in the USA	PATSTAT Database	1996–2010
5	*Number of Patents in Other Countries*	Patents owned in other countries	PATSTAT Database	1996–2010
6	*Total Number of Patents Granted*	Total patents granted	PATSTAT Database	1996–2010
7	*Number of Patents Granted to Domestic Applicants*	Granted to domestic applicants	PATSTAT Database	1996–2010
8	*Number of Patents Granted to International Applicants*	Granted to International applicants	PATSTAT Database	1996–2010
9	*Innovation Index*	The simple average of the normalized scores on three key variables: Researchers in R&D, Patent Applications Granted by the US Patent and Trademark Office, and Scientific and Technical Journal Articles.	World Bank	1996–2010
10	*Education-Literacy*	The simple average of the normalized scores on three key variables: Adult literacy Rate, Secondary Enrollment, Tertiary Enrollment.	World Bank	1996–2010
11	*R&D Expenditure (% of GDP)*	Expenditures for R&D are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.	World Bank	1996–2010
12	*GDP per capita (constant 2000 US$)*	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant US dollars.	World Development Index (WDI) Disk-2008	1996–2010

Table 7 (*Continued*)

	Variable name	Measurement	Source of data	Data year
13	*Foreign direct investment, net inflows (% of GDP)*	Foreign direct investment is the net inflow of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows in the reporting economy and is divided by GDP.	World Development Index (WDI) Disk-2008	1996–2010
14	*Information Technology To GDP*	Information and communications technology expenditures include computer hardware (computers, storage devices, printers, and other peripherals); computer software (operating systems, programming tools, utilities, applications, and internal software development); computer services (information technology consulting, computer and network systems integration, Web hosting, data processing services, and other services); and communications services (voice and data communications services) and wired and wireless communications equipment.	World Development Index (WDI) Disk-2008	1996–2010
15	*First university degrees*	Number of individuals with university degree in a given year.	Science and Engineering Indicators 2008	2004 or most recent year
16	*Number of IPR Treaties)*	The number of intellectual property treaties the counties have adopted	WIPO	2007
17	*Year of the Reform of IPR Laws*	Adoption year of Paris convention	WIPO	2007
18	*R&D Spending To GDP*	R & D expenditure (% of GDP)	WIPO	1996–2010
19	*Bank Loan to GDP*	Domestic credit to private sector (% of GDP)	WIPO	1996–2010
20	*Literacy rate*	Alternatively, College Education as a Proportion of Adult population; Secondary School Graduate as a Proportion of Population.	World Development Index 2007	1996–2010
21	*Composite Risk Index*	Combinations of Different Risks e.g. Financial, Political.	International Country Risk Guidelines	1996–2010
22	*Economic Freedom Index*	The index measures economic freedom (legal index, property rights, degree of openness and deregulatory environment of different financial sectors).	Wall Street Journal and Heritage Foundation (www.heritage.org/index)	1996–2010

Table 7 (*Continued*)

	Variable name	Measurement	Source of data	Data year
23	*Civil liberty*	The Civil Liberties index measures freedom of expression, assembly, association, and religion. Freedom House rates civil liberties on a scale of 1 to 7, with 1 representing the most free and 7 representing the least free.	Freedom House	1996–2010

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