Innovation and economic performance in MENA region

Noha Sami Omar
Cairo University Faculty of Economics and Political Science, Giza, Egypt

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Abstract

Purpose – Innovation has become the engine of economic growth, especially with the Fourth Industrial Revolution. This paper aims at studying the association between innovation – measured by gross expenditure on research and development (GERD) – and economic performance – represented by real gross domestic product (GDP) – in MENA region over the period 1996-2016.

Design/methodology/approach – The paper uses the panel corrected standard error method to account for heteroskedacity and possible contemporaneous correlation across panels, and the first order autocorrelation within panel for unbalanced datasets.

Findings – The study concludes that R&D expenditure is positive and statistically significant in explaining GDP, but their relationship is weak. Specifically, a 10 per cent increase in R&D expenditure raises GDP by 4 per cent. In addition, human capital, labor force and fixed capital accumulation are found positive and statistically significant. These findings highlight on the importance of innovation and education on fostering economic growth, urging MENA governments to further invest in R&D and innovation sector.

Originality/value – To the best of the author's knowledge, this paper is the first to investigate the relationship between GERD and GDP in MENA region within the endogenous-growth model framework.

Keywords Innovation, MENA

Paper type Research paper

1. Introduction

Prosperity can increase when inputs of production are used in smarter and more efficient ways to fulfill constantly evolving human demands. Innovation represents a critical driver of productivity growth and value creation; this is even more essential in the age of the fourth Industrial Revolution. Innovation now is part of the Sustainable Development Goals (SDG9); countries are encouraged to "build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". The fuel of innovation is research and development (R&D) activities, for instance, SDG9.5 calls upon countries to increase substantially its public and private spending on R&D. OECD and East Asia have the highest R&D intensity regionally; at the country level, China and India are the centers of innovation in the world for the last decade (Schwab *et al.*, 2017).

In the past decades, Middle East and North Africa (MENA) countries have been concerned on improving and shifting their economies into knowledge-based economies. Despite undertaking several rounds of economic reforms in many of MENA countries, the region's economic performance is below its full potential. These countries are mono-sector and vulnerable to shocks. Their economic growth has mainly been driven by oil extraction and exportation of oil exporter countries, and tourism by oil importers. In the 1970s and 1980s, the boom in oil prices has made MENA countries enjoying a high economic growth rate. The countries in this region invested heavily in ambitious development projects, education, ICT, and public health (World Bank, 2016). In the past decade, with low oil prices, MENA countries' growth deteriorated, and budget deficit increased. Hence, they started to work on diversifying their economies by shifting to knowledge-based economy. They succeeded to a great extent in improving their ICT sector, but unfortunately, it has not yet translated to a developed and matured innovation sector.

Theories of economic growth look at technology and innovation as determinants of growth; technology and knowledge are not intentionally accumulated and they are created by accident as argued by Solow (1956), or endogenously and intentionally within the economic system, and explain the factors behind long-run growth as suggested by Romer (1986M, 1990); and further extended by Grossman and Helpman (1991). Many empirical studies investigated the relationship between innovation and economic performance at the regional, country and firm levels. Generally, there is a kind of consensus in the literature on the positive impact of R&D and innovation on economic performance (Nadiri, 1993; Griliches, 1992, 2000; Jones and Williams, 1998; Okubo *et al.*, 2006; Maza *et al.*, 2013; Wang and Wu, 2015; Akoum, 2016). However, some studies doubted about the robustness of this positive relationship between R&D and economic growth (Scherer, 1999; Braunerhjelm, 2011; Pessoa, 2010; Ejermo *et al.*, 2011; Westmore, 2013), especially in developing countries, arguing to the low level of development of these countries.

The present paper studies the association between innovation – measured by gross expenditure on research and development (GERD) – and economic performance – represented by real gross domestic product (GDP) – in MENA region over the period 2000-2016. To the best of my knowledge, this paper is the first to investigate this relationship quantitatively in MENA within the endogenous-growth model framework and GERD as innovation proxy following most empirical literature. Due to R&D data deficiency in MENA, only six MENA countries – Egypt, Iran, Kuwait, Saudi Arabia, Turkey and Tunisia – are considered in the analysis and estimation. Israel and Palestine are not considered in the analysis. Israel represents an outlier in the region; globally, it had the highest R&D of 4.3 per cent of GDP like Korea, while MENA countries have very limited R&D expenditure not exceeding 1.1 per cent of GDP spent by Turkey in 2015 (WDI, 2018). Palestine has uncertain circumstances, making GERD values not much accurate and reliable.

The paper uses unbalanced cross-sectional time series data that is estimated using the panel corrected standard error method using STATA 13.1. The model concludes that R&D expenditure is positive and statistically significant in explaining GDP with reasonable economic soundness. Specifically, a 10 per cent increase in R&D intensity raises GDP by 4 per cent. In addition, human capital, labor force and fixed capital accumulation are found positive significant. These findings highlight on the importance of innovation and education on fostering economic growth and urges MENA governments on further investment in these sectors.

The paper is organized as follows. After introduction, Section 2 presents an overview of MENA region's innovation and economic performance. In Section 3, a literature review provides the theoretical and empirical work related to the links between R&D, output and productivity. In Section 4 discusses the data and methodology used in estimating the relationship between R&D intensity and GDP in MENA region. Section 5 presents the results, and finally Section 6 concludes.

2. Overview on MENA's economic and innovation performance

In the last decades, the growth performance of MENA countries has been consistently moderate, if compared with other emerging countries. From 1993 to 2010, the average annual growth rate amounted to 4 per cent in MENA countries (WDI, 2018). These rates are comparable to Latin American that grows by 3 per cent, on average. On the contrary, MENA's growth is still far from South Asia that grows by 6.4 per cent per annum. The positive average GDP growth rate in MENA is basically attributed to the favorable global economic trend characterized by growth in the oil market prices, the development of tourism, an increase in foreign investment and immigrant remittances, with the exception of Lebanon, Palestine and, to a lesser degree, Syria (Bosco and Mavilia, 2014).

Since 2011, a period of instability and tensions has been hindering growth in MENA region. The annual growth rate of MENA countries fell to 3.1 per cent and further to 2.4 per cent when high income Gulf Cooperation Council (GCC) countries are excluded. This is because of low oil prices affecting oil exporter countries, and conflicts and revolutions affecting oil importer countries (Figure 1). After 2011, MENA growth rate decreased from 5 to 2.5 per cent in 2011 and 2015, respectively. Once stability is reached with slightly higher oil prices, and resumption of construction activities in conflict-affected countries, MENA's growth improves but remains below its full potential. After an upsurge in growth to 4.6 per cent in 2016 driven by growth in rich-oil countries, growth fell to 1.8 per cent in 2017, because of a sharp decline in economic activity among oil exporters that are growth drivers of the region[1] (Figure 1).

Nevertheless, GDP per capita differs across MENA countries. Although, on average, MENA is classified as high-income region, countries are not homogenous; eight[2] countries are grouped as high, six upper-middle[3], five lower-middle[4] and two[5] low-income countries according to WB 2018 economies' classification[6]. In particular, GCC have the highest GDP per capita; namely, United Arab Emirates (UAE), Kuwait, Saudi Arabia's GDP per capita \$41K, \$35K and \$17K. To the contrary, Palestine and Egypt have the least per capita \$2.7K, in 2016 (WDI, 2018).

Many countries in the region, in the last decade, implemented reforms to increase economic diversification and mitigate their vulnerability to oil and gas prices' fluctuations. Heavy investment in digital and technological infrastructure has allowed major improvements in technological readiness, but innovation is still low in MENA and has generally fallen short of expectations. The technology readiness pillar in global

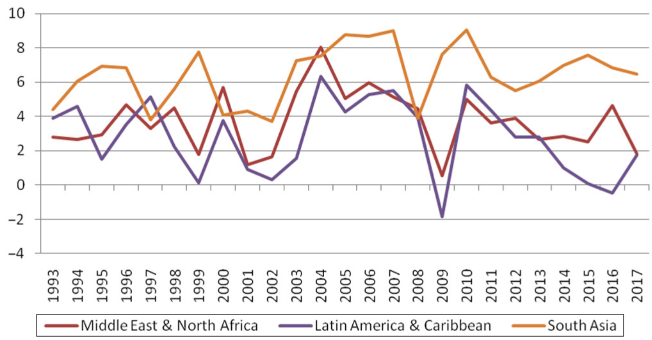

Figure 1. GDP Growth, over the period 1998-2017

Note: Values are in percentage terms
Source: Done by author, data from World Bank (2018)

competitiveness index over the period FY08-FY18 shows an upward trend in most countries, and even most countries' rank in this pillar is higher than the innovation pillar. The growth in innovation market size also slowed down after 2015 with the decrease in oil prices. On average, MENA succeeded to improve its competitiveness performance, with the most-improved country in FY18 is Egypt. Though Turkey stepped back a little after 2003, it is the country with highest potential in innovation improvement (Schwab *et al.*, 2017).

On average, MENA's investment in innovation is weak. Various indicators show the relative poor innovation performance in MENA to comparable economies; such as GERD, R&D intensity, patents applications, and number of scientific journal publications. This section describes the innovation literature's widely used indicators in its analysis: GERD and R&D intensity.

R&D intensity is estimated at 1 per cent in MENA in 2015, on average. This figure is above South Asia 0.6 per cent, but below all other regions, like East Asia and Europe with R&D more than 2 per cent of GDP. Similarly, at the country level, the average high-income countries R&D intensity is 2.6 per cent, while in UAE and Oman 0.87 and 0.24 per cent, respectively, in 2015. In addition, R&D intensity is approximately 0.4 per cent in Iran, which is far below the average of upper middle-income countries of 1.7 per cent. This drawback in R&D investment might be attributed to the weak industrial base in MENA, and their dependence on the service sector is the engine for prospective growth and as the oil reserves are due to be exhausted in 50 years or less (Bosco and Mavilia, 2014). The same performance is also observed using GERD indicator (Figure 2).

GERD is the most indicative and widely used R&D indicator. According to UNESCO, GERD consists of the total expenditure (current and capital) on R&D by all resident companies, research institutes, university and government laboratories, etc. It excludes R&D expenditures financed by domestic firms but performed abroad. At the country level, though all countries had an increasing trend of GERD over the period 2000-2016, they differ in their investment levels. Over this period, Turkey has the highest and steepest increase in GERD reaching \$11m in 2016, while Bahrain and Iraq had the lowest R&D investment. Egypt had steady moderate increments in GERD attaining \$6m. The successful story of MENA is Saudi Arabia; after having negligible GERD during 2004-2009, its GERD boosts growing by 1165 per cent jumping from about PPP\$0.8m (0.07 per cent of GDP) to PPP \$10bn (0.9 per cent of GDP) in 2009 and 2010, respectively. Gradually, GERD in Saudi Arabia reached \$12m in 2016 (all values are in PPP terms, UNESCO, 2018). On the other hand, other countries like Kuwait and Tunisia spend more or less the same amount on R&D (UNESCO, 2018; and WDI, 2018) (Figure 3). Most R&D spending is by the public sector; on

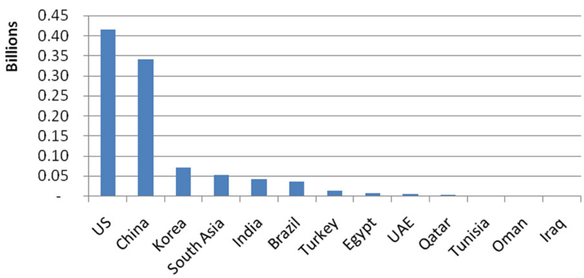

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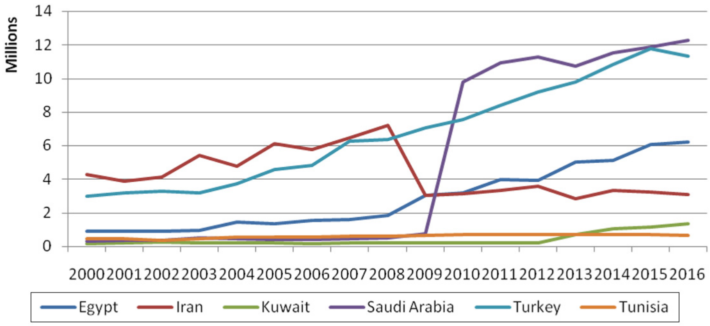
Figure 2.
GERD in 2015; selected countries



Source: Done by author, data from World Bank (2018)

Figure 3.
GERD Evolution in MENA countries, 2000-2016

average, around 90 per cent of spending comes from the public sector in MENA region as against around one third in the European countries.

Moreover, although MENA has a steady increase in patent applications and scientific and technical published research, they were below comparable regions. Patent applications reached its maximum in 2016 reaching 31 thousands that comprises only 50 per cent of Latin America's applications (58.5 thousands). This figure is very far below East Asia that has the highest number of patents, of around 2 million applications. On the other hand, MENA performance in patent's nationality is better; 61 per cent of patents in MENA are applied by residents, which is higher than North America (47 per cent) and Latin America (15 per cent) (Appendix 2). Similarly, the number of publications is still very low. MENA publishes around 98 thousands, which is a little above Latin America's publications of 96.6 thousands, but far below other regions such as both North America and East Asia and Pacific of 470 thousands published articles in 2016 (Appendix 3) (WDI, 2018). The same performance is observed at the country level in MENA.

The overall low R&D investment in MENA turns it to be the least region worldwide in high-technology exports. In 2016, MENA's high-technology exports share to total manufactured exports is 4.2 per cent, compared to 12 per cent in Latin America and 16 per cent in Europe. Tunisia has the highest high-tech exports of 6 per cent, followed by Morocco with around 4 per cent. These shares are negligible in the rest MENA countries, like Algeria and Egypt that have the least exports of only 0.34 and 0.5 per cent, respectively. All these figures are much below other regions' countries; such as, Korea 27 per cent, China 25 per cent, Israel 18 per cent, and Brazil 13.5 per cent.

The modest innovation performance in MENA region could be attributed to four factors: economic diversification, labor market inefficiency, poor quality of educational system, and private sector role in R&D. Concerning economic diversification, MENA countries are characterized with mono-sector services economy, either oil or tourism sectors' revenues. Oil revenues constitute around 16 per cent of GDP compared to only 1 per cent at maximum in Latin America in 2016. In addition, tourism receipts as a share of total exports is 10 per cent reaching 15 per cent excluding high-income countries, against 8 per cent in Latin America in 2016. Many studies, including Hesse (2008) and Leiderman and Maloney (2007), have established that diversified economies in the long term perform better than mono-sector economies.

Recently, countries have been working on transforming their economies into more industrialization and export diversification to non-oil and tourism sectors. Consequently, oil exporters can mitigate risks of oil price fluctuations that are for instances affected by oil drilling techniques or in battery technology for automobiles. On the other hand, non-oil exporters can ease the negative impact of factors that affect tourism revenue like internal conflicts and terrorism that hit these countries since 2011. However, there are still many things to pave the way for a real economic diversification that helps fostering and sustaining economic growth.

Furthermore, MENA suffers from persistent high unemployment rate, especially among youth, low labor force participation and labor market inefficiency. In 2017, unemployment rate in MENA since 2010 reached about 10 per cent compared to 5 per cent, on average, in the world, and unemployment among youth is 27 per cent versus 13 per cent in the world. Low labor force participation confirms this picture too. Idle unemployed people leads to the loss of person's talent, creativity and innovation. High unemployment in many countries of the region might be partly explained by the high-energy subsidies leading to economic distortions that favor industries that make intense use of capital and energy rather than labor. In addition, the labor market does not find the needed skilled and qualified labor.

To meet efficiently labor market demands, education should be the focal point of MENA governments. Education is vital in improving human well-being and knowledge that can be translated into new ideas and innovation enhancing a country's capacity to produce higher-value-added of goods and services. Although MENA ranks reasonably well in enrollment rates compared with other regions, its quality is not good. For example, scores on international tests is low, especially in math and science. In addition, education does not graduate students with qualified skills (Pissarides, 2015[7]; Achoui, 2009). There is a scarcity of local graduates in technical and vocational training programs, and especially in resource-rich countries, domestic workers are less inclined to take jobs in the private sector. This has led to high unemployment among diploma holders and to a significant brain drain. In addition, enrollment in tertiary education still lags behind, especially in technical and scientific subjects. These factors weigh heavily on the countries' capacity to sift automatically from ICT connectivity to innovation ecosystems. This urges for improving human capital, quality of education and train the labor force to meet the region's economic needs (World Bank Group and World Economic Forum, 2016; Diaconu, 2011).

Nevertheless, the public sector is the main sponsor of R&D in MENA, but governments are still called to raise public investments in innovation to boost short-term demand and raise long-term growth potential. In addition, in parallel, governments should work on raising its competitiveness in attracting entrepreneurs and the private sector to invest in innovation by reforming and solving the problems of labor market and education to guarantee the sustainability of progress accumulated in previous years. In addition, according to the World Bank Group and World Economic Forum (2016), for instance, executives of oil importers show their concern about long-term unemployment or underemployment (56 per cent of Jordanian businesses), profound social instability (40 per cent of Tunisian businesses), and failure of national governance (38 per cent of Algerian businesses). The improvement in these factors and innovation increases MENA's competitiveness with higher productivity and sustained growth (Goedhuys *et al.*, 2011). The private sector engagement in innovation sector in MENA countries is essential to close the technological gap with other developed and emerging countries (Oukil, 2011). Although some MENA countries achieved some improvements in these aspects, these factors still hinder innovation and technological progress that hamper sustainable economic growth and MENA capacity to join effectively the Fourth Industrial Revolution.

3. Literature review

Long ago, the importance of technology and innovation for economic growth has been established. Schumpeter (1912, 1939) argued that economic growth represents a slowly and progressive change of the economic system, resulting from exogenous factors of the economic system that is innovation. His economic growth model suggests that innovation leads to competition, and with education economic growth is ensured. This idea has been more formalized by Solow's exogenous growth model (1956). Solow assumed that technology is exogenous and knowledge accumulation is left unspecified and determined outside the model. Consequently, there are no externalities to knowledge accumulation; each (homogeneous) worker reaps the benefits of exogenous technical progress in proportion to their contribution to output.

Later, Romer (1986, 1990) and Grossman and Helpman (1991) extended the Solow theory to a new economic growth theory that emphasized that productivity growth results from intentional innovation by rational, private sector profit-maximizing agents and is therefore endogenously determined (see also, Lucas, 1988). The innovation-based models of endogenous growth model examined the long run growth that is considered endogenously determined by technical change resulting from the private sector's R&D. In addition, they considered that R&D activities generate knowledge that prevents capital's decreasing returns to scale as a factor of production.

Generally, there is a kind of consensus in the empirical literature on the positive impact of R&D and innovation on economic performance (Nadiri, 1993; Griliches, 1992, 2000; Jones and Williams, 1998; Okubo *et al.*, 2006; Wang and Wu, 2015; Akoum, 2016). However, some studies doubted about the robustness of this positive relationship between R&D and economic growth (Scherer, 1999; Braunerhjelm, 2011; Pessoa, 2010; Ejermo *et al.*, 2011; Westmore, 2013), especially in developing countries, arguing to the low level of development of these countries. Most studies adopted the endogenous growth model framework in studying this relationship. This relationship is tested at different levels; firm, industry, country and regional levels. The present study follows the more recent vein of regional studies on MENA region.

At the country level, Blanco *et al.* (2016) concluded that, during the period 1963-2007, private sector's R&D has a large positive effect on both output and productivity at the state level in the US in the long run, using dynamic ordinary least squares and pooled mean group methods. Authors pointed that the levels of human capital and economic development are very important to R&D investment (see also, Pece *et al.*, 2015-Checz Republic, Poland and Hungary-; and Bronzini and Piselli, 2006-Italy). This bells the ring to MENA governments on the urgency of improving their human capital through educational system quality improvement. In addition, Peng (2010) concluded a highly positive and strong relationship between R&D expenditures and economic growth in China. In Turkey, various papers found a positive significant relationship but weak between R&D and economic growth (Ustabaş and Ömer Ersin, 2016; Bozkurt, 2015, Taban and Şengür, 2013; Altın and Kaya, 2009). Bektaş *et al.* (2015) concluded the absence of long relationship between R&D and economic growth over the period 1990-2013, using cointegration and Granger causality tests. Authors attributed this to the fact that despite Turkey's effort in R&D investment, it is still a developing country.

At the regional level, Turedi (2016) found a two-way positive causality between R&D expenditures and economic growth, and a one-way positive causality from patent applications to economic growth on OECD countries for the period 1996-2011, using the GMM (Generalized Method of Moments) approach (Chatterjee *et al.*, 2017; Gulmez and Yardimcioglu, 2012; Saraç, 2009; Yanyun and Mingqian, 2004; Sylwester, 2001; Freire-Seren, 1999). Şimşek ve Behdioğlu (2006) suggested that Turkey lags behind OECD countries with regard to R&D investment though R&D has a positive impact on economic growth, adopting cluster analysis for the period 1999-2002. Later, Göçer (2013) reached the same conclusion. The author concluded a weaker positive association between R&D expenditure and economic growth in developing than developed countries, over the period 1996-2012. Alerasoul and Samimi (2009) reached no significance relationship between R&D and economic growth for 30 developing countries –Argentina, Armenia, Iran, Mexico, Tukey and Tunisia – for the period 2000-2006. The strength of R&D and economic growth relationship might be attributed to the different R&D resources that countries invest.

On MENA region, recently, Azimi *et al.* (2018) suggested a positive significant relationship between economic growth and innovation during the period 2010-2015, using the GMM approach. This conclusion is not very much relevant to indicators used in the analysis. Authors used the GII indicator of human capital that includes education and research, which are not similar to innovation. Using dynamic panel data techniques, Utku-İsmihan (2017) also recommended a positive R&D impact on economic growth during the period 1980-2014. Despite its effort in constructing its R&D index, the paper ignored an important and more relevant indictor that is the R&D investment besides using patents and trademark indicators. The present paper overcomes these two papers innovation's misconception by using the R&D expenditure to measure MENA countries' innovation performance, as widely used in literature.

In addition, some papers assumed that R&D and economic growth relationship might differ with respect to the degree of countries' development. Celikay and Gumus (2015), on 52 developed and developing countries over the period 1996-2010, used a dynamic panel data model and found that R&D expenditure has a positive significant effect on economic growth for all countries in the long run, but the effect is weak in the short run for developing countries. Similarly, on 20 OECD developed and 10 Non-OECD emerging economies, Ulker (2004), over the period 1981-1997, found a positive significant relationship between per capita GDP and innovation only for OECD with large markets. However, in contrary to the endogenous-growth model, OECD data did not support the constant returns to innovation, implying that innovation does not lead to permanent increases in economic growth (Frantzen, 2000). This shows that the degree of development of a country makes a difference by speeding up economic growth from R&D investment (Petrariu *et al.*, 2013; Gittleman and Wolff, 1995; Goel and Ram, 1994).

Furthermore, there are controversial conclusions about the impact of source of R&D expenditure, on economic growth. Lichtenberg (1992), using data for the period 1964-1989 from 74 countries, found that although there is a positive effect of R&D expenditure on growth, private sector R&D expenditures are more efficient and effective compared to public sector expenditures. Similarly, a recent paper by Wang and Wu (2015), they found in China, at the provincial level over the period 1997-2013, a strong and positive correlation between enterprise R&D and economic growth, while nearly zero correlation between government R&D expenditure and economic growth. Authors attributed this finding to government R&D expenditure that is more directed toward basic research, which does not directly promote economic growth. To the contrary, Van Pottelsbergh and Guellec (2004), examining 16 OECD countries over the period 1980-1998, concluded no difference on the positive significant effect of R&D expenditure on economic growth between public and private sectors.

Moreover, R&D's positive effects are not limited to its origin's boundaries. R&D has spatial spillover effects, across and within countries and regions. At the country level, Wang and Wu (2015) and Wu (2010) argued that R&D has a positive effect on the regional innovation rate in China, which in turn has a positive effect on productivity and economic growth at the provincial level (Blanco *et al.*, 2016-US-; and Bronzini and Piselli, 2006-Italy). Across countries, recently, Lee and Becker (2017), using the panel cointegration approach, suggested that R&D activity as a major determinant for economic performance, and as the creator of unique Group 20's competitive advantages, but with different magnitude's R&D effects between studied countries. It is also noteworthy that human capital and information technology are positively associated with countries' economic performance (Ulker, 2004; Eberhardt *et al.*'s, 2013). Also, Coe *et al.* (1997) argued that developing countries could benefit more from the R&D positive spillovers derived from exporting via high-tech goods and capital goods from developed countries than from investing in R&D themselves.

4. Data and methodology

4.1 Model specification

In estimating the relationship between economic performance and R&D, the endogenous growth theories framework is used. These theories explain the process of knowledge accumulation by relating it directly to human capital accumulation, or indirectly via research and development (R&D) activity. Specifically, Romer (1986, 1990) and Grossman and Helpman (1991) emphasize that productivity growth results from intentional innovation by rational, profit-maximizing agents and is therefore endogenously determined (Lucas, 1988):

$$Y = AK^{\alpha}L^{\beta}H^{\gamma}$$

where Y denotes output, A denotes the effectiveness of labor or technology that improves labor production or total factor productivity (TFP), and K, L and H refer to physical capital, labor and human labor, respectively. The coefficients α, β and γ represent the output elasticity of capital, labor and human capital, respectively, once the function is presented in logarithmic form:

$$LnY = \ln A + \alpha \ln K + \beta \ln L + \gamma \ln H + \varepsilon$$

Romer's model is based on three premises:

(1) growth is driven by technological change;

(2) technological change arises as a result of intentional actions taken by people who respond to market incentives, which indicates positive externalities and spillover effects of a knowledge-based economy which will lead to economic development; and

(3) blue prints (designs) used to produce new products are non-rival, i.e. they can be replicated with no additional cost.

Empirical literature has a kind of consensus on the Cobb-Douglas production function in estimating the impact of R&D investment on output, productivity growth or value added (Ulku, 2004; Yuen-Ping *et al.*; 2005; Inekwe, 2015; Van Elk, 2015; Akoum, 2016). This study uses a Cobb-Douglas production function regressing economic performance measure on conventional production inputs labor, physical capital, and human capital in addition to innovation. Following the literature, the model is:

$$LnGDP_{it} = \alpha_i + \beta_1 LnRD_{it} + \beta_2 LnFCF_{it} + \beta_3 LnEMP_{it} + \beta_4 LnSEnrl_{it} + \varepsilon_{it}$$

where i and t denotes the cross-sectional (country) and time dimensions (year) of panel data, and ε stands for the statistical error term. *GDP* refers to real GDP measured at constant US dollar prices at 2010. *RD* represents R&D expenditure; *FCF* refers to real gross fixed capital formation, *EMP* stands for employment rate and *SEnrl* stands for gross school enrollment in tertiary education.

4.2 Data sources

To study the impact of innovation on economic performance in MENA, this paper collects data on five variables: real GDP, real R&D intensity, real gross fixed capital formation, employment rate and gross school enrollment in tertiary education variables over the period 2000-2016 for six out of seventeen MENA countries, namely, Egypt, Iran, Kuwait, Saudi Arabia, Turkey and Tunisia that have data on R&D expenditure.

Real GDP at constant US$2,010 represents countries' macroeconomic performance. It is the measure of economic activity in a national economy, measured by the value of output (goods and services). The most commonly used data on innovative activities in one country is the real R&D expenditure. GDP and GERD are extracted from the World Development Indicators and United Nations Educational, Scientific and Cultural Organization (UNESCO) Databases, respectively.

The model is enriched by examining the impact of real gross fixed capital formation on real GDP. The level of gross fixed capital formation is a macroeconomic concept that shows the value of purchasing new or existing fixed assets by business entities, government, and households (excluding entrepreneurs), minus the value of alienated fixed assets. In a word, gross fixed capital formation is the component of GDP, aimed at investment, rather than personal consumption. In addition, the employment rate is used presenting the share of labor force aged 15 to 65 years, who are active and work. These variables too are extracted from the World Development Indicators Database. Also, human capital is gauged by the gross school enrollment in tertiary education indicator. This variable is important because a country neither thinks of R&D nor is able to innovate if it has low human capital. It is taken from UNESCO database.

For the sample, other than the chosen countries in estimation, the remaining MENA countries' data are not much reliable; Lebanon, Libya, Syria and Yemen do not have R&D data; while, though Qatar and Iraq have R&D data, their observations are missed in estimation due to capital formation and human capital data unavailability. When adding Algeria, Bahrain, Morocco, Oman, UAE and Jordan, the data became highly unbalanced to the extent that there are no enough common observations across panel to perform the different cross-sectional dependence tests (Pesaran, Friedmand or Frees's tests) and heteroscedasticity test. Moreover, Israel and Palestine are not considered in the analysis due to their special situation in the region.

5. Results

In estimating this regression, the Hausman test is first run to choose between fixed and random effect models, in deciding if time-invariant unobservable variables are correlated to other variables in the model. Accordingly, the null hypothesis of consistent and efficient random effect is rejected, and the model is to be estimated using the fixed effect approach. With panel data, heteroscedasticity, autocorrelation and cross-sectional dependence problems are suspected.

A modified Wald statistic for group-wise heteroskedasticity in the residuals of a fixed effect regression model concludes that the FE model suffers from heteroskedasticity of cross-sectional units. Autocorrelation problem is also found in the dataset. It is tested using

Wooldridge test (2002). In addition, the Breusch–Pagan statistic rejected the null hypothesis of cross-sectional independence in the residuals of a fixed effect regression model. Thereby, the model has contemporaneous correlations across cross-sectional units. The problem yields inefficient FE coefficients and biased standard errors. Correcting for these problems, the Panel corrected standard error (PCSE) technique is adopted (Beck and Katz, 1995).

The PCSE is robust to heteroskedacity across panels, and possible contemporaneous correlation across panels, also accounts for first order autocorrelation within panel that is assumed to differ across panels and is estimated using Durbin Watson method. In addition, this method can deal with unbalanced datasets. Since autocorrelation is specified, the PCSE produces Prais–Winsten estimates that are conditional on the estimates of the autocorrelation parameter(s). The estimate of the variance–covariance matrix of the parameters is asymptotically efficient under the assumed covariance structure of the disturbances and uses the FGLS estimate of the disturbance covariance matrix

The whole model is statistically significant. All variables are statistically significant with positive expected sign at the 0.05 level of significance. Data show moderate positive correlation between real GDP and real R&D expenditure in selected MENA countries, with correlation coefficient of 0.78, confirming endogenous-growth theories' literature (Appendix 1). Human capital variable has also positive correlation with real GDP, but weaker than R&D. The correlation coefficient is 0.47. Regression results confirm these associations in Table I.

The R&D elasticity of output signifies that 10 per cent increase in R&D expenditure yields about 4 per cent increase in real GDP, holding other factors constant. This indicates the positive but weak effect of R&D investment on fostering economic performance in MENA. The inelastic effect of R&D could be attributed to very low and roughly unchanging R&D intensity and low R&D expenditure in MENA.

As expected, human capital and labor force seem to be important determinants of real GDP. A 10 per cent increase in gross school enrollment in tertiary education and labor force increase real GDP by 3.4 and 4.4 per cent, respectively, *ceteris paribus*. In addition, output elasticity of fixed capital formation is positive significant; indicating an increase of real GDP by 1 for 10 per cent increase in real fixed capital formation. This is the lowest output elasticity and the result is consistent with the literature findings on the relationship between GDP and investment in MENA countries.

The paper's findings have policy implications for MENA countries. The results suggest that R&D spending and human capital contribute strongly to the economic growth of MENA countries. Therefore, MENA governments should support R&D sector in institutions and industries, and encourage the private sector's contribution in the innovation sector to promote higher growth, living standards, and social welfare (Schwab *et al.*, 2017;

Table I.
Real GDP fixed effect regression with panel corrected standard errors

R&D expenditure	0.38**
Fixed capital accumulation	0.1**
Labor force	0.44**
Gross school enrollment ratio in tertiary	0.34**
Constant	2.47**
Number of observations	90

Notes: R&D expenditure and fixed capital accumulation are in real terms, while employment rate and gross school enrollment ratio in tertiary are in percentage terms. All variables are in logarithmic terms. P-value is in parentheses, where $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$
Source: Done by author

World Bank Group and World Economic Forum, 2016; Arrow, 1962). Similar to various studies findings, coordinated R&D incentives in the MENA region across countries can increase economic growth of the entire region. However, the relationship between R&D and economic growth is not strong (Chatterjee *et al.*, 2017; Turedi, 2016; Göçer, 2013; and Şimşek ve Behdioğlu, 2006). Furthermore, findings highlight the continuing need for MENA countries to improve opportunities and attainment in education. This paper has the advantage of being the first to investigate the relationship between innovation and GDP in MENA countries quantitatively using GERD as a proxy to innovation. However, the study could be considered as preliminary investigation due to small sample data limitation and that the data quality is not much reliable.

Further research on R&D in MENA region is recommended to analyze the relationship between R&D and economic growth by economic activities to figure out the economic activities that MENA governments need to focus and invest more in R&D. When data give larger sample size, panel vector autoregressive approach is recommended to investigate the interaction between variables accounting for cross-sectional (countries) heterogeneity. Also, it is important to study the R&D spillover effect of trading with developed countries on different economic indicators like trade, economic growth, development, etc. As private sector contribution in R&D investment is limited, it might be of interest to investigate the effectiveness of R&D tax incentive schemes on R&D investment. In addition, due to data availability constraint, future studies might construct an innovation index comprising R&D intensity, patents applications and scientific publications.

6. Conclusion

This paper examines one of the effective determinants of GDP according to economic growth theories; namely, R&D expenditure. It estimates the relationship between R&D expenditure and GDP in MENA region over the period 2000-2016, using the panel corrected standard error approach. In line with endogenous-growth theories' literature, this study concluded that, on average, there is a positive statistically significant link between R&D expenditure and economic growth in MENA region, though weak. The weak association between innovation and economic growth in MENA could be due to the limited R&D investment in MENA countries, whether in absolute or relative terms. In addition, human capital has positive, though weak, effect on economic growth. The controlled variable gross fixed capital formation and employment rate have the same positive weak effect on economic growth.

The findings of this paper provide the opportunity for some policy implications regarding the knowledge-based economy and growth performance in the MENA region. Although MENA countries' devoted effort in past years to improve connectivity, digital uptake, and their initiative toward adopting a knowledge-based economy, there is still a large gap in the innovation sector. In addition, governments need to adopt clear vision about upgrading their human capital by education and labor market institutions reforms. Education, Labor market and innovation sectors will not be very effective, if these countries lack business sophistication.

The improvement in innovation, human capital, institutions, the quantity and quality of public and private infrastructures, building capacity of knowledge workers and supporting policies to provide incentives for the private sector are important to enhance economic growth performance and productivity in MENA countries. Nevertheless, MENA countries have to improve the periodicity and coverage of national R&D surveys across institutional sectors and industries that are worth for policy decision-making and research. If MENA countries succeeded in these fronts, they will catch-up with the Fourth Industrial Revolution and developed countries.

Notes

1. – is expected to increase to 3.1 percent in 2018. The increase is broad-based; almost all countries will experience an uptick in growth this year.
2. Bahrain, Israel, Kuwait, Malta, Oman, Qatar, Saudi Arabia and UAE.
3. Algeria, Iran, Iraq, Jordan, Lebanon and Libya.
4. Djibouti, Egypt, Morocco, Tunisia and Palestine.
5. Syria and Yemen.
6. For operational and analytical purposes, economies are divided among income groups according to 2017 gross national income (GNI) per capita, calculated using the World Bank Atlas method. The groups are: low income, $995 or less; lower middle income, $996-3,895; upper middle income, $3,896-12,055; and high income, $12,056 or more. The effective operational cutoff for IDA eligibility is $1,145 or less.
7. Labor markets and economic growth in the MENA region.

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Appendix 1

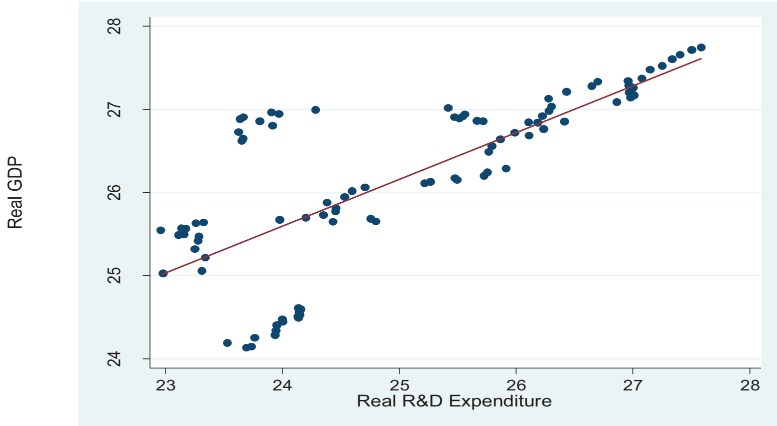


Figure A1. Real GDP and Real R&D Expenditure in Selected MENA countries, 2000-2016

Source: Done by author, data from World Bank (2018)

Appendix 2

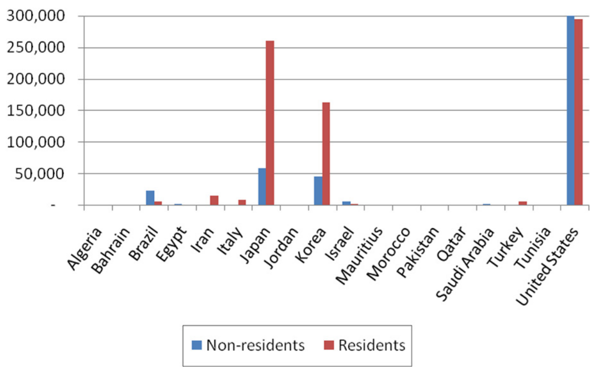
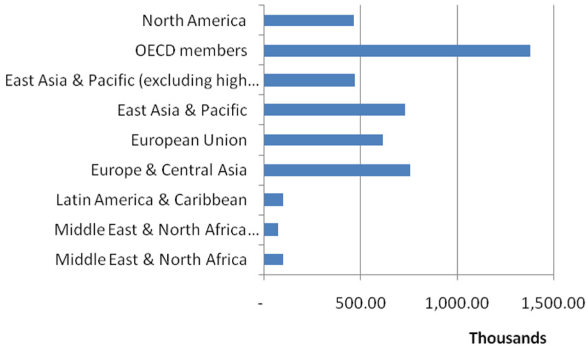


Figure A2. Patent applications, 2015; selected countries

Appendix 3



Source: Done by author, data from World Bank (2018)

Figure A3. Scientific and Technical Journal Articles across Regions, 2016

Corresponding author
Noha Sami Omar can be contacted at: nomar@feps.edu.eg