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KNOWLEDGE, TECHNOLOGICAL CATCH-UP AND ECONOMIC GROWTH: A DYNAMIC PANEL DATA ANALYSIS FOR MENA AND LATIN AMERICA

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Abstract

This paper aims to investigate the role of various knowledge indicators (human capital, research and development, information and communication technologies and trade) in the economic growth and catch-up performance of 17 Middle East and North Africa (MENA) countries and 18 Latin American countries during the 1980-2014 period, by utilizing dynamic panel data techniques. The empirical results suggest a positive impact of knowledge indicators on the economic growth performances and that there is convergence to the common long-run equilibrium, in MENA and Latin American countries.

JEL Classification: O11, O33, O40, O47, O50

Keywords: economic growth, catch-up, knowledge, productivity, dynamic panel data, MENA and Latin America.

ملخص

تهدف هذه الورقة إلى دراســـة الدور المختلف لمؤشـــرات المعرفة (رأس المال البشـــري والبحث والتطوير وتكنولوجيا المعلومات والاتصالات والتجارة) في النمو الاقتصادي والأداء المتراكم ل 17 بلدا في الشرق الأوسط وشمال أفريقيا و 18 أمريكا اللاتينية البلدان خلال الفترة 1980-2014، من خلال الاســـتفادة من تقنيات البيانات لوحة ديناميكية. وتشـــير النتائج التجريبية إلى التأثير الإيجابي لمؤشرات المعرفة على أداء النمو الاقتصادي، وأن هناك تقاربا للتوازن المشترك على المدى الطويل في بلدان الشرق الأوسط وشمال أفريقيا وأمريكا اللاتينية.

1. Introduction

According to the classical economic growth theory the main determinants of sustainable economic growth are accumulation of physical capital, labor and total factor productivity (i.e. the ability of countries to adopt and implement advanced technologies). For a long time, it was assumed that technological progress was exogenous and freely available to everyone. However, as time progressed it was evident that technology was costly and moreover to use it countries needed to have a certain level of technological capability, i.e. knowledge. Thus, the new strand of economic growth theories drew attention to the endogenous nature of technological progress and introduced human capital an important determinant of the ability of countries to use the available technology to achieve higher growth rates (see, for example, Romer (1986) and Lucas (1988)).

Later, research and development (R&D) sector was argued to be the growth engine of economies.[1] The R&D sector was considered to be fundamental, because, it produced new knowledge (or innovation) that furthermore enhanced the economic growth performances of countries.

Trade was also considered as an important source for knowledge accumulation (Grossman and Helpman, 1989). It was argued that trade was a mean for countries (especially the developing countries) to transfer stock of knowledge (via imports) from other countries with higher technological capabilities.

The improvements in the information and communication technologies (ICTs) during the 20th century increased the volume, and the speed of information exchanged at a worldwide scale. Moreover, various economists found that ICTs were a major driver of technological progress in the overall economic growth performances of countries, during the late 20th century and early 21st century. [2]

In a study Chen and Dahlman (2004) postulated that the level of knowledge used in production would increase only if the economic and institutional regime, educated and skilled population, dynamic information infrastructure and efficient innovation system are strengthened. In turn the increase in the level of knowledge used in production would increase economic growth.

In sum, the most important channels (or pillars) of knowledge that helps countries to improve their technological capabilities and hence economic growth performances are mainly, human capital, trade, R&D and ICTs.

The aim of this paper is to analyze the impact of knowledge indicators on the growth performance of countries in the Middle East and North Africa (MENA) region and Latin America. First, we attempt to derive an augmented framework where human capital enters the model as an additional input together with capital stock and the variables that contribute to knowledge accumulation (i.e. trade, ICTs and R&D)[3] are included as shift factors in the production function. Then utilizing this model, we measure the impact of knowledge indicators on the growth performance of countries in both regions. Compared to the other regions in the world analyzing these two regions has been challenging in terms of two issues; the heterogeneous political and economic structures of the countries situated in these regions (especially in the MENA region) and the data availability problem for all of the countries concerned.

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[1] The pioneering researchers in this strand are Romer (1990), Grossman and Helpman (1994), and Aghion and Howitt (1992).

[2] See, for example, Wang (1990), Wang and Blomstrom (1992), Eaton and Kortum, (2001) and Glass and Saggi, (2001) for more details.

[3] They are refered to as knowledge indicators or pillars interchangeably through out the paper .

Compared to Latin America, there is no consensus on the definition of the MENA region. While the League of Arab States (LAS) and the Economic and Social Commission for Western Asia of the United Nations (UN-ESCWA) include 22 countries, the definition of the World Bank[4] includes 21 countries. Nevertheless, MENA area encompasses wide range of countries from Morocco to Iran. The region includes both oil rich countries Kuwait, Saudi Arabia, Iran and Iraq and countries that have scarce natural resources, such as, Egypt, Morocco, and Yemen.

As indicated, the MENA region is composed of countries that are heterogeneous in terms of socio-economic structure, natural resources and political structure. Most of these economies are dependent on their available natural resources or primary goods. Due to persistent political and social unrest, continuous wars within countries and between countries and fluctuations in oil prices, the region experiences remarkably high level of volatility of growth rates. Real GDP growth in MENA was its lowest level during 2012-2016 period, approximately 2.7%. In our analysis we have used the definition of the World Bank, however, due to data constraint we could only include 17 countries[5] in our analysis.

One of the aims in this study is to compare MENA and Latin America to see how the impact of knowledge indicators on the growth performances varies in these two regions. Similar to MENA region, the countries in Latin America also have important differences in socio-economic structures. Despite these differences, at the beginning of the millennium the favorable economic conditions within the Latin American region combined with strong external and internal demand during 2003-08 period led to a very high level of economic growth rate of almost 5%. However, after this period Latin America has experienced a severe downturn for about six years and only recently its growth rate has started to recover, in 2014 it was 1.5%. Once again mainly due to data limitations we could only include 18 Latin American countries in our analysis.[6]

The following section presents an overview of the literature followed by Section 3 which introduces our model, information regarding the data and the empirical results. Finally, the concluding remarks are provided in Section 4.

2. An Overview of Literature

The neoclassical (Solow) growth model is based on production functions which are characterized by strict neoclassical assumptions. The production functions exhibit constant returns to scale and diminishing returns to inputs. Only two factors, capital and labor, are considered in the production function. According to this model economic growth performance of a country is influenced by an exogenous factor, namely, technology[7] and population growth.[8] That is, technology is considered as exogenous variable and time is the only variable that affects the level of productivity. The aggregate production function is as follows:

$$Y = A(t)\, F(K, L) \qquad (1)$$

where Y is the level of aggregate output, K is the level of the capital stock, L is the size of the labor force, A is total factor productivity and t is time.

[4] Compared to LAS and UN-ESCWA when defining the MENA region the World bank excludes the Comoros Islands, Mauritania, Somalia, and Sudan; and includes Iran, Israel and Malta.

[5] These countries are; Algeria, Bahrain, Egypt, Israel, Iran, Iraq, Jordan, Kuwait, Mauritania, Morocco, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, United Arab Emirates and Yemen.

[6] There countries are; Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay and Venezuela.

[7] Which is available to every single country in the world because it is "manna from heaven".

[8] Technology, or total factor productivity, enters the production function as a residual, and is known as the Solow residual.

The most important prediction of the neoclassical (Solow) growth model is the convergence hypothesis. According to this hypothesis, in the long run, due to their higher growth rate poor countries would eventually converge to the per capita income levels of the rich countries. However, in reality with the exception of few East Asian countries, the income gap between the poor and rich countries have widened. Gerschenkron (1962) was one of the first economists who drew attention to the difficulty for follower countries to catch up with the leading countries. He underlined the institutional resistance to change and the high cost of factors of production, especially human capital which he refers to as the creation of industrial labor force (Gerschenkron, 1962:9). Thus, in reality, by the time the follower countries transfer and use the existing technology, the leader country moves forward to some new technological frontiers (Forbes and Wield, 2000). Thus, the rather than narrowing the technology gap between the leading country and the late followers widens even more.

Under the light of all these arguments, the endogenous factors within the economies became recognized as the main source of economic growth and the observed differences between the economic growth rates of countries (Romer, 1994). With their seminal papers Arrow (1962), Sheshinski (1967), Nelson and Phelps (1966) and Uzawa (1965) drew attention to the importance of education and learning by doing for economic growth. Later Griliches (1979), Lucas (1988) and Romer (1986) have also stressed the importance of knowledge (particularly human capital) and technological progress in growth theory. The production function was modified by adding human capital along capital and labor. Since then, human capital has been recognized as the most important factor that influences economic growth and the key input in R&D which accelerates technological progress (Romer, 1990).

Thus, another factor that has been considered as the driving force in economic growth is R&D. It is argued that the investment of rich countries in R&D led to higher levels of technological progress (or innovations) which in turn improved their capital (machinery or other intermediate) goods used in the production process and thus their growth rates accelerated. However, technological progress (via R&D) has a high cost[9] and it is available only to the countries that could afford to buy it. Thus, compared to the neoclassical growth theory, this strand of growth theory internalized technological progress and tried to explain the growth rates of countries by internalizing the factors of production into the models. The assumptions, in general, are more flexible and more realistic compared to the neoclassical models.

The improvements in the ICTs during the 20th century increased the volume, and the speed of information exchanged at a worldwide scale. Thus, during the late 20th century and early 21st century various economists[10] have found positive impact of different knowledge diffusion channels, such as trade and FDI, on the growth rates of countries. Becchetti and Adriani (2005) examined the impact of ICT on the level and growth rate of per capita income for 47 to 95 countries and for two periods (1991-1997 and 1983-1997). They found that technological progress in ICTs is a major driver of technological progress in the overall economy and technological progress in such sector depends upon the existence of bottlenecks.[11]

Chen and Dahlman (2004) postulated that information infrastructure was one of the four pillars (or preconditions) of knowledge economy which transforms knowledge into an effective engine of growth. As mentioned in the previous section according to Chen and Dahlman (2004) economic and institutional regime, educated and skilled population, dynamic information

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[9] That is, it was not a manna from heaven.

[10] See, for example, Wang (1990), Wang and Blomstrom (1992), Eaton and Kortum, (2001) and Glass and Saggi, (2001) for more detail.

[11] For example, the capacity of networks to transfer information and data, the access of individuals to such networks and the power of the instruments used to access the networks.

infrastructure and efficient innovation system as the four main pillars of knowledge. They argue that when these four pillars are strengthened this would increase the accumulation of quality knowledge used in production, and thus increase economic growth via affecting total factor productivity (TFP).

Chen and Dahlman (2004) suggested the following production function framework for the analysis of the role of knowledge on economic growth,

$$Y = A(g, e, r, i)\, F(K, L) \qquad (2)$$

where g represents institutional and/or economic regime of the economy, e represents education and training, r represents country's level of domestic innovation, i represents country's information and communication infrastructure and other variables are as defined before.

It is worth to emphasize that the knowledge indicators defined by Chen and Dahlman (2004) affect the output growth via total factor productivity (A), as is shown in Equation (2).

Chen and Dahlman (2004) have used cross-section analysis of 96 countries (1960-2000) to determine the impact of knowledge on long-run economic growth and found that human capital, ICTs, innovation and technological adaptation all had statistically significant positive effects on long-run economic growth.

Like Chen and Dahlman (2004), Chavula (2010) has used factors such as innovation, education and information infrastructure to examine the impact of knowledge on economic growth in Africa. He has used cross-sectional endogenous growth model to look at the impact of knowledge on the long term average growth rate of 49 African economies, during 1990-2008. He has found that there was a significant positive impact of ICTs on economic growth of these African countries.

Sterlacchini (2006) has examined the relationship between knowledge and human capital and economic growth in the European regions belonging to twelve countries of the former EU15, during 1995–2002. He has found that education and the intensity of R&D expenditures in value-added emerge to be the most effective factors enhancing economic growth. However, while Sterlacchini (2006) has found that the educational variable has positive impact for the entire regions, the impact of R&D was significant only for regions with high per capita GDP. He has also observed that important disparities arise among regions of different countries with the exception of North European countries where he found a significant relationship between regional growth, intensity of R&D, higher education and economic growth.

The brief literature on endogenous growth models indicates that the main channels (or pillars) of knowledge that speeds up the technological capabilities of countries and hence economic growth performance are; R&D, trade and ICTs.[12] Now, taking previous studies as benchmarks we will briefly present the possible expected impacts of each pillar on the economic growth performances of countries.

R&D is considered to be both an important determinant of innovation and promoter of technology transfer by raising the absorptive capacity.[13] There seems to be ambiguity with regards the impact of R&D on TFP. While some economists have found that R&D had significant positive impact on TFP and thus on growth performances of the economies (see for example, Coe and Helpman (1995)) some economists have found significant negative impact

[12] In our model we have not included human capital as a knowledge variable because we will utilize a production function framework with skilled adjusted labor (human capital) in our analysis (see section 3 for more detail).

[13] See, for example, Griliches and Lichtenberg (1984), Griliches (1992) and Aghion and Howitt (1992) on R&D as the determinant of innovation and Geroski (2000) and Griffith et al. (2000) for R&D and absorptive capacity.

on TFP due to the uncertainty and ambiguity that R&D entails due to its nature (see for example, Cozzi and Giordani (2011)).[14]

Trade increases the innovation capability of a country through the transfer of embodied technology with the imported capital goods and ideas (patents and licenses) or feedbacks from exported goods.[15] Moreover, by importing technologically intensive products the follower countries can increase quality of their products and their production efficiency. Thus, as argued by Coe et al. (1997) if trade involves positive externalities such as embodied knowledge then it would have positive impact. However, the impact of openness on economic growth depends significantly on the absorptive capacity of the country. Fagerberg and Srholec (2008) in their analysis for 115 countries during 1992 -2004 periods found that the trade is influenced by the absorptive capacity of the country. That is, the absorptive and adaptation capacity of the country determines the impact of trade on economic growth.[16]

ICTs on the other hand provide a channel for fast and effective flow of technological knowledge which also has a positive impact on the domestic productivity.[17] The impact of ICTs on productivity occurs through various channels. For example, the continuously decreasing computer and software prices has led to the incentive of replacing other capital goods with them and this in turn contributed to higher total factor productivity growth. The computerization along with the developments in other ICTs, such as internet, made it much easier to acquire information from suppliers and/or customers to develop new products or processes. Some country specific studies have found that ICT usage had an important impact on TFP (see for example Jorgenson and Stiroh (2000)). Moreover, OECD (2012) in a report considers ICT to be a general-purpose technology that changed the world drastically. This can be attributed to ICTs both direct and indirect effect on growth and productivity.

Based on theory it is expected that all ICTs would boosts knowledge creation and have positive impact on TFP and thus economic growth of countries.[18] However, there seems to be ambiguity in terms of empirical studies. For example, Choi and Yi (2009) in their study for 162 countries (during 1991-2000 period) found that the internet had a positive and significant role in economic growth. However, OECD (2012) in a study on the impact of internet in OECD countries has found that the impact of internet on the per capita income growth varied across the countries, while there was positive impact in US, this did not hold for all the other OECD members (even in some of the European countries). This is true especially for less developed countries that have insufficient amount of capital to build the necessary internet infrastructure.[19] Thus, taking into consideration the evidence provided by the empirical research just like in the case of trade we do not have a priori expectations with regards ICT.

[14]See Welch (1975), Bartel and Lichtenberg (1987), Coe and Helpman (1995), Caselli and Coleman (2001), Caselli and Wilson (2004), Xu (2000) and Benhabib and Spiegel (2005) for more detail.

[15] Coe and Helpman (1995) have found that this had a positive impact on domestic productivity.

[16] Fagerberg and Srholec (2008) use trade and foreign direct investments to proxy for openness of an economy and find that "…openness to imports and foreign direct investment seems to matter more for the richer economies … poor countries due to lack of absorptive capacity are much less likely than other countries to benefit from foreign direct investments ... [a]lthough a positive correlation between openness and growth is reported … [it is] sensitive to changes in the composition of the sample…it is among the richer economies that openness to trade and foreign direct investment seems to matter most for growth (Fagerberg and Srholec, 2008: 1422-1427)".

[17] For example, the ICTs provide the opportunity of an efficient, continuous and permanent connection to the global markets, which increases the flow of information into the economy. This newly acquired information, in turn, contributes to productivity increase.

[18]See, for example Aghion and Howitt (1998) and Barro and Sala-i-Martin (2003).

[19]See, Kenny (2003) for more detail. Also, several other studies have negative impact of ICT on economic growth especially for the developing countries (Dewan and Kraemer (2001) and Satti and Nour (2003)).

In the following section we introduce our model that is used to analyze the impact of knowledge variables on the economic growth performance of the MENA and Latin American countries.

3. The Model

In this section following Bosworth and Collins (2003), Senhadji (2000) and Inklaar and Timmer (2013) we will develop a model where human capital is included as an input (a la Lucas) along with capital and labor in the production function. When human capital enters the model as an additional input of production it captures the role of human capital accumulation in the growth process (Lucas, 1988). Therefore, by following those studies we consider the following production function with a skilled adjusted labor (human capital) input,

$$Y = AK^{\alpha} H^{\beta} \tag{3}$$

where Y is output (real GDP), K is capital stockand A is total factor productivity, H is human capital and it is also called adjusted labor input (H=hL, where h is human capital per labor and L is total employment).

Additionally, we also consider the role of R&D, ICTs and trade as important knowledge indicators in our model. More specifically, we use the following Cobb Douglas production function,

$$Y = K^{\alpha} H^{\beta} e^{\theta_1 R + \theta_2 T + \theta_3 C} \tag{4}$$

where C represents ICTs, T represents trade and all variables are defined as earlier.

Following the above-mentioned studies, we impose constant returns to scale assumption (α+β=1) and hence we transform Equation (4) to per efficient worker form (Y/H and K/H) as follows,

$$\left(\frac{Y}{H}\right) = \left(\frac{K}{H}\right)^{\alpha} e^{\theta_1 R + \theta_2 T + \theta_3 C} \tag{5}$$

where all variables are defined as earlier.

After taking the log of Equation (5) we obtain the following

$$y_{it} = \theta_0 + \theta_1 R_{it} + \theta_2 T_{it} + \theta_3 C_{it} + \alpha k_{it} \tag{6}$$

where y=ln(Y/H), k=ln(K/H) and all other variables are as defined earlier.

In sum, our model in line with Griliches (1979) and Eberhardt et al. (2013) includes the knowledge variables as a shift factor in the production function without affecting the returns to inputs. In the following section we will use Equation (6) as the main theoretical specification of our model.

3.1. Data and the empirical results

3.1.1. The definitions and the sources of data

The main variables that are used in the model are output, capital stock, human capital, R&D stock, trade, and ICTs. While the former three are obtained from PWT 8, the others are from the WDI database.[20,21]

[20]The World Development Indicators (WDI) data set of World Bank and recent version (July 2013) of the Penn World Tables (PWT 8) are used in this study.

[21]It is important to mention that PWT 8.0 provides two set of data for capital and output as well as productivity for cross country comparison and for country specific analysis. Since this essay is based on a cross country comparison we use the data set relevant for our analysis. See Feenstra et al. (2015) and Inklair and Timmer (2013) for more detail.

Output: is the real gross domestic product (GDP) at constant 2005 national prices (in million US$) from the PWT 8 data set.

Capital stock: is the capital stock at constant 2005 national prices (in million US$) from the PWT 8 data set. In the PWT 8 data, capital stocks are “estimated based on cumulating and depreciation past investments using the perpetual inventory method” (Inklaar and Timmer, 2013:5).

Human capital per worker: is obtained by calculating the index of human capital per person based on years of schooling (Barro and Lee, 2012) and returns to education (Psacharopoulos and Patrinos, 1994) from the PWT 8 data set. Education is an important indicator of the capacity of the labor force to use the available information. Barro and Lee (2012) use a combination of data sources to infer the percentage of each country's adult population (aged twenty-five and older) the particular level of education they obtained for each year. Census data provide direct measures of a country's stock of education but, especially, in developing countries such data are only available for selected years. Barro and Lee (2012) use enrollment data and data on literacy rates to interpolate between census years to fill the missing data.

R&D: due to lack of data by utilizing total patent and total trademark we have calculated R&D index. Since these two variables are in different units and have different ranges (minimums and maximums), we used the Human Development Index (HDI) methodology to obtain a common range for them. That is, a minimum and a maximum bound is set to each of the four indicators and a number (index value) is obtained for each of these indicators between 0 and 1. After this process all of the raw variables turned into unit free indices, between 0 and 1, that can be added together. With this conversion the two variables become dimension indices which are labeled as ITC and IPC. The two-dimension indices are calculated as follows:

$$IT_t = \frac{T_t - Min(t)}{Max(T) - Min(T)} \tag{7}$$

$$IP_t = \frac{P_t - Min(P)}{Max(P) - Min(P)} \tag{8}$$

where T_t and P_t, LNE_t LNO_t represents total trademark and total patent, respectively. Min (X) is the minimum value and Max (X) is the maximum value of variable X during the time interval that is being investigated. The minimum and maximum values of each variable during the 1980-2014 period.

After normalizing the indicators and obtaining the dimension indices next, we calculate the R&D Index (R) as a weighted average of the two sub-indices, as follows:

$$R= w_1 IC+ w_2 IT \tag{9}$$

where w_i’s denote weights of the respective dimension indices.

HDI used simple average methodology to determine the weights of each dimension index simply because all three dimensions were considered to be equally important. That is, the three-dimension indices (Life expectancy index, Education index and GNI index) were considered to have equal weights (1/3 each). We also used this methodology since trademarks and patents are equally important (½ each). The data for all variables were obtained from the WDI.

Trade: is measured by dividing total trade (exports plus imports) to GDP from the WDI. It gives us information about the economic structure of the country, regarding the degree of integration to the world economy via foreign trade. That is, the share of trade (exports and imports) in GDP can viewed as an indicator of that countries level of globalization and competition in the global economy. Foreign trade is also a channel for knowledge spillovers across national borders. That is, trade is a mean to access foreign knowledge which is embedded in the traded goods. Sometimes the imitation of this acquired new knowledge may spur innovation that will enhance economic growth.

However, it should be noted that "[d]espite the overwhelming popularity of the simple trade ratio measure, researchers should be aware that this measure is a measure of country size and integration into international markets rather than trade policy orientation … [T]he five *least* open countries are (in order) Japan, Argentina, Brazil, the United States, and India ... While it is clear that these countries have trade restrictions in varying degrees, it is difficult to believe that they are the most restrictive countries in the world in terms of trade policies." (David, 2007:9).

ICTs: telephone lines, internet hosts/active Internet Protocol (IP) addresses, mobile phones, personal computers are the variables used to capture the levels and the growth rates of ICT.

In this study, in order to extend the time dimension and to incorporate all aspects of ICTs, we used the average of mobile phone subscribers per 100 people, telephone lines per 100 people and internet hosts/active Internet Protocol (IP) addresses per 100 people from the WDI.

The dataset that is used is formed by merging WDI data set and PWT data sets. The WDI provides various indicators, ranging from demographic to environmental topics and it contains more than 800 indicators for 214 countries for the years 1960 to 2016, compiled from officially recognized sources. Whereas the PWT provides 30 variables on purchasing power parity and national income accounts indicators for 167 countries for the 1950-2014 period.

The descriptive statistics of the variables are presented for the MENA countries and Latin American countries separately in Table 1.

The descriptive statistics indicate that the mean rate growth rate of per capita output (per efficient worker) is 11% and the growth rate of capital (per efficient worker) is 12% in the MENA region during the 1960-2014 period. The capital per efficient worker varied between, approximately, 9 and 15. The capital per efficient worker for each country has varied between 9 and 14, the within varied between 11 and 14.

The average percentage share of trade in GDP (openness) is around 72%, the mean level of ICT usage is 32 per 100 persons and the R&D .04 in the region during the same time period. As can be seen from Table 1, the variability in the means of capital and trade seems to be between individual variations rather than variability in time growth rate. [22] On the other hand we observe the opposite for ICTs. That is, the variability around the mean in the case of these variables is mostly attributed to variability across time, especially for ICTs.[23] For R&D there seems to be no difference between the individual and time variation around the mean (it is 0.07 for both cases). That is, the standard deviations for R&D indicate that the variation in R&D across countries is exactly the same as that observed within a country overtime. Among the three knowledge indicators the variability in ICTs is the highest followed by the variability in trade.

The descriptive statistics of the Latin America region indicates that the mean rate growth rate of per capita output (per efficient worker) is approximately the same as MENA and the growth

[22] The total variability in capital per efficient worker is 1.32; it is decomposed as an individual variability of 1.31 and as time variability of 0.33. The total variability in trade is 42.3 is decomposed into individual variability of approximately 31 and time variability of 30 (see Table 1).

[23] The total variability in ICTs is 48 and it is decomposed as 12.6 individual variability and 47 time variability (see Table 1).

rate of capital (per efficient worker) is slightly less than the MENA region with 11% during the 1960-2014 period. The average percentage share of trade in GDP (openness) and ICT usage are also less than the MENA region approximately 63% and 29 per 100 persons, respectively. Compared to the MENA region the R&D average is much higher in the Latin America with .31. The variability in the means of capital, trade and R&D in Latin America is between individual variations rather than variability in time growth rate. Only the variation in the mean of ICTs is mostly attributed to variability across time, similar to the MENA region. Among the three knowledge indicators the variability in ICTs (44) is the highest in Latin America followed by the variability in trade (36).

The correlation matrix provided in Table 2. With the exception of trade and R&D, we observe similar relationships between the variables in the two country groups. The directions of the association between the variables are the same for both country groups. The strongest relationship is between output per efficient worker and capital per efficient worker in both regions. There seems to be negative relationship between trade and three variables output per efficient worker, capital per efficient worker and R&D and statistically significant at 5% level. The relationships between the remaining variables are positive and statistically significant at 5% level.

The most striking differences between the two region is that R&Ds' relationship with output per efficient worker, capital per efficient worker and trade seems to be more profound in Latin America compared to MENA. Even though we observe negative relationship between R&D and trade in both regions, the difference in the magnitude of this relationship is striking. The relationship between those two variables in terms of magnitude is very weak in the MENA region. In Latin America the relationship is still close to weak however the magnitude is much higher than the other region.

3.1.2. Empirical results

There are various alternative methods that are used to analyze multi-country estimation that allow for parameter heterogeneity across countries. These alternative estimation methods are mean group (MG), pooled mean group (PMG) and dynamic fixed effects (DFE) model. The two extreme cases are MG which poses no constraint on the coefficients and DFE which restricts all parameters to be homogenous across countries. The PMG is in the middle. The important feature of the PMG model is that, the intercepts, short run coefficients and the error variances differ across countries, while the log run slope coefficients are restricted to be the same across countries.

In our paper, to analyze the relationship between knowledge indicators and economic growth we use pooled mean group (PMG) analysis.

We re-state Equation (6) for empirical purpose in stochastic form as follows,

$$y_{it} = \theta_0 + \theta_1 R_{it} + \theta_2 T_{it} + \theta_3 C_{it} + \alpha k_{it} + \varepsilon_{it} \tag{10}$$

where all the variables are as defined before and εis the error term.

Thus, the above (augmented) log linear production function can be thought as a long-run equilibrium relationship between factor inputs, knowledge variables and output.

Peseran and Smith (1995) argue that even though the dynamic specification is not common for all countries, in the long run the parameters might be common. Thus, they suggest

> either averaging the individual country estimates, or by pooling the long run parameters, if the data allows, and estimating the model as a system … [thus we can possess] the

efficiency of pooled estimation while avoiding the inconsistency problem following from pooling heterogeneous dynamic relationships (Asteriou and Hall, 2011:436).

As indicated previously, in the PMG estimator, only the long run coefficients are same across countries and the short run coefficients vary. For this exact reason, Bassanini et al. (2001) have used PMG estimators in their analysis of the long-run relationship between factor inputs and output in their sample of OECD countries over 27 years. Furthermore, as underlined by Asteriou and Hall (2011) another critical advantage of the PMG is that "the parameter estimates are consistent and asymptotically normal for both stationary [I(0)] and non-stationary I(1) regressors" (Asteriou and Hall, 2011:427).

Following Peseran et al. (1999) we use the following error correction model in our empirical analysis;

$$\Delta\hat{y}_{it} = \varphi_{it} + \omega_{it}\Delta k_{it} + \zeta_{it}\Delta R_{it} + \psi_{it}\Delta T_{it} + \varpi_{it}\Delta C_{it}$$

$$+\lambda_i(y_{it-1} - \theta_0 - \theta_1 R_{it} - \theta_2 T_{it} - \theta_3 C_{it} - \alpha k_{it}) + \varepsilon_{it} \quad (11)$$

where ω_{it}, ζ_{it}, ψ_{it} and ϖ_{it} are the short run parameters and λ_i is the error correction term. The term in the brackets represents the deviation from the long run relationship in the previous period.

The results of PMG and MG estimation of the long run and short run coefficients and the convergence coefficient are also provided in Table 3.

At first glance we see that the long-run estimation results are different both in terms of signs and statistical significance for MG and PMG, in both regions. The PMG estimates of the production function, for both regions, is in line with theory and statistically significant. However, MG estimates are not consistent with the theory (in terms of signs and/or magnitudes of estimates) and are statistically insignificant. Thus, the PMG estimates seem to offer more efficient estimates under the assumption of long run homogeneity compared to MG.

In order to make choice between the two estimators we use the Hausman test results. This test shows us whether there is significant difference between the two estimators. The results of the Hausman test statistic are also provided in Table 3. For both regions, the Hausman test indicates that the restriction of homogeneity in the long-run cannot be rejected at 1% statistical significance level. That is, the efficient estimator under the null hypothesis (PMG) is not rejected indicating that PMG estimation is the appropriate estimation method to be used in our analysis.

According to our results the error correction (convergence) coefficient (λ) has the expected sign and is statistically significant at 1% level for both regions. The negative error correction term for both estimates confirms that there exists a long-run relationship in both regions. Thus, our results indicate that there is convergence among the MENA countries and Latin American countries in the long-run. However, the adjustment coefficient is slightly higher for Latin America (-.2796) compared to MENA (-.2305) implying that the speed of adjustment is slightly faster in Latin America. When we compare the error correction terms MG estimate suggests faster adjustment than PMG, this is an expected outcome since MG is less restrictive estimation method.

In terms of the other variables, a 1% increase in capital stock increases output per efficient worker by 0.48% in the MENA region and by .82% in Latin America, this indicates that capital increases per efficient worker is nearly double in Latin America compared to the MENA region. In terms of R&D, interestingly the MENA regions performance is way much better then Latin American countries. The result of ICTs indicates that while it has negative effect on the output per efficient worker in Latin America, it has positive effect in the MENA region. Trade seems to increase the output per efficient worker in both regions. Thus, according to the results of our analysis in the long run, knowledge variables, especially the R&D stock, seems to play an important role in the economic growth performances s of MENA region compared to the Latin America.

Compared to the long run not all of the PMG coefficients are significant in the short run. The short run results indicate that the short run relationship between output per efficient worker and two of the knowledge indicators, i.e. trade and R&D, are statistically insignificant for both regions. Considering scope of R&D it is not surprising that results are not statistically significant in the short run, due to its nature R&D is a long run investment. In terms of trade, rather than its statistical significance the change in its sign for both regions indicates that trade has adverse effect on output growth in the short-run.

Using the full option of xtpmg command in STATA we estimated the model for all countries separately. For PMG, this command gives us the long run coefficients for the whole region (i.e. the normalized cointegrating vector) and the individual short run coefficients for each country separately. We estimated PMG and MG estimates using the full option of xtpmg command. The Hausman test preferred PMG (Prob>chi2 = 0.9356) estimation. Thus, we only reported the results of individual country PMG estimation for the MENA region in Table 4.

With the exception of Bahrain and Mauritania speed of adjustment estimates (error correction terms) of PMG in MENA countries implies long run adjustment in terms of expected signs.[24] However, it is important to note that even though the error correction terms of Israel and Kuwait have the expected signs they are not statistically significant. The error correction coefficients for the rest of the countries are negative and range from -0.83 to -0.09. So, we can say that with the exception of these four countries the convergence to equilibrium in MENA varies between 9% and 83%. The speed of adjustment has been relatively fast in Turkey, Iran and Iraq during the 1980-2014 period in the MENA region.

With the exception of United Arab Emirates all countries have the expected sign for capital per efficient worker in the short run. However, the capital per efficient worker is statistically significant only in Algeria, Iran, Israel, Jordan, Qatar, Syria, Turkey, Yemen and Mauritania. In terms of the knowledge indicators trade is statistically significant in more countries compared to the other indicators.

Not surprisingly, trade has positive and statistically significant impact on the output in Saudi Arabia. In Jordan, Syria, Turkey, Kuwait and Morocco trade has negative and statistically significant impact on the output. The impact of trade is the highest on Kuwait. A unit change in trade yields a 1.1% decrease in Kuwait's output. According to our estimation results ICTs seem to have positive and statistically significant effect on the output growth of Algeria, Iran, Jordan, Syria, Turkey and Yemen. The highest impact of ICTs in the short run is on output growth of Syria (1.3%).

As expected in the short-run compared to the other knowledge indicators R&D has the virtually no or negative impact on the economic growth performances of the countries in the region with the exception of Israel (which is also minimal but it is statistically significant). As indicated before, it takes very long time for the economy to obtain the returns of R&D investments, if it is successful. So, in sum among the three knowledge indicators only ICTs seems to have positive effect on the output growth in the countries in the MENA region.

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[24] The error correction estimation results are also statistically insignificant for both countries.

Similarly, we estimated PMG and MG estimates of Latin American countries using the full option of xtpmg command. Once again, the Hausman test indicated that the PMG (Prob>chi2 = 0.4414) estimates were preferable to MG estimates for Latin America as well. Table 5 reports the PMG estimation results of Latin America.

The speed of adjustment estimates (error correction terms) of PMG has the expected signs for all countries in Latin America. However, the error correction terms are not statistically significant for Belize, Colombia, Honduras, Paraguay and Uruguay. The error correction coefficients for the rest of the countries are all statistically significant and range from -0.78 to -0.18. This confirms the relationship between output and knowledge indicators in Latin America and it varies between 18% and 78%. While Chile has demonstrated fastest speed of adjustment the lowest speed of adjustment is observed for Bolivia, in Latin America, during the 1980-2014 period.

The results for Latin America demonstrate positive sign for short run capital per efficient worker as expected. However, the capital per efficient worker is not statistically significant for Honduras, Paraguay and Uruguay. In terms of the knowledge indicators in Latin America ICTs is statistically significant in more countries compared to the other indicators. With the exception of Mexico ICTs impact on output is positive, indicating that this region has an advanced ICTs infrastructure that contributes to the economic growth performance of countries.

Trade has positive and significant impact on the output for Belize, Colombia, El Salvador, Honduras and Panama during the 1980-2014 period. Interestingly, compared to MENA region in the short-run R&D has higher impact on output. For example, a unit change in R&D yields a 68% increase in Bolivia's output; 45% increase in Honduras's output; 34% increase in Peru's output; and 12% increase in Mexico's output. Thus, this indicates that Latin America is giving more importance to R&D compared to the MENA region.

In sum, regression results for both regions indicates that; first, PMG is an appropriate method to investigate the relationship between knowledge variables and output per efficient worker; secondly, the error correction terms indicate that there is convergence in the long-run in both regions; and finally, the short run error correction terms are different for each country as expected (i.e. this reflects the uniqueness of each country). The results of the short run error correction terms indicate that the convergence among the Latin American countries is more profound compared to the MENA countries, during the 1980-2014 period.

4. Concluding Remarks

In this paper we have attempted to analyze the impact of knowledge indicators on the growth performance of countries in MENA and Latin America during 1980-2014 period, with an augmented production function framework in which human capital enters the model as an additional input together with capital stock. The other variables that contribute to knowledge accumulation were introduced as shift factors in the production function without affecting the returns to inputs.

The main challenge in this study has been the data availability. The limitation in data has restricted the sample size both in terms of countries and time. Unfortunately, as a result of the data limitations we could only include 17 MENA countries and 18 Latin American countries in our study for the 1980-2014 period.

In our empirical analysis we have used the PMG estimation technique because our data set for both country groups had complex country specific short-term dynamics which cannot be captured imposing the same parameters on all countries. Thus, because the PMG estimator does not impose restrictions on short term coefficients. More importantly, it provides us important information on country specific values of the speed of convergence to common long-run equilibrium represented by the augmented knowledge production function.

Overall, the sign and magnitude of the error correction (convergence) term of the PMG estimates in both regions confirms that there is convergence among the MENA countries and among the Latin American countries in the long-run.

In Latin America the error correction terms of PMG have the expected signs for all countries and in the MENA region it has the expected sign with the exception of two countries (Bahrain and Mauritania). Our results indicate that while the relationship between output and knowledge indicators, convergence in Latin America varies between 18% and 78%, and varies between 9% and 83% in MENA, during the 1980-2014 period. In the MENA region the speed of adjustment has been relatively fast in Turkey, Iran and Iraq and in Latin America Chile has demonstrated fastest speed of adjustment during the sample period.

According to our estimation results all of the knowledge indicators have positive effect on the output per efficient worker in both regions. In terms of R&D, in the long run, MENA region as a whole has performed much better then Latin America. However, at individual country level the R&D results are much stronger in Latin America compared to MENA. Trade also seems to increase the output per efficient worker in both regions.

The only knowledge indicator that has reverse effects in the two regions in the long run is ICTs. In the long run ICTs had a negative effect on the output per efficient worker in Latin America while it has positive effect in the MENA region.

In sum, while all of the knowledge indicators (R&D, trade and ICTs) have contributed to the economic growth performances of MENA region, only two of the knowledge indicators (R&D and trade) have contributed to the economic growth performances of Latin America, during the 1980-2014 period.

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Table 1: Descriptive Statistics of the Variables

Variable		MENA COUNTRIES					LATIN AMERICAN COUNTRIES					
		Obs	Mean	Std. Dev.	Min	Max		Obs	Mean	Std. Dev.	Min	Max
	overall	N =585	11.17	1.31	8.11	13.35	overall	N =595	10.46	1.81	5.52	13.97
Output per efficient worker	between	n =17		1.30	8.44	13.06	between	n =17		1.84	6.13	13.79
	within	T-bar = 34.41		0.32	10.08	12.44	within	T =35		0.27	9.75	11.30
	overall	N =585	12.20	1.32	8.85	14.51	overall	N =595	11.47	1.92	6.48	15.39
Capital per efficient worker	between	n =17		1.31	9.21	14.04	between	n =17		1.95	6.90	15.17
	within	T-bar = 34.41		0.33	11.34	13.61	within	T =35		0.29	10.65	12.43
	overall	N =699	71.91	42.43	0	251.14	overall	N =630	62.92	36.00	0	187.14
Trade	between	n = 20		30.98	31.63	160.32	between	n =18		31.92	21.12	144.53
	within	T-bar=34.95		29.78	-15.46	198.64	within	T =35		18.23	-4.87	124.12
	overall	N =699	31.52	48.47	0.00	218.43	overall	N =630	28.93	44.41	0	180.70
ICTs	between	n =20		12.56	12.09	53.11	between	n =18		7.00	17.72	41.11
	within	T-bar =34.95		46.90	-21.59	206.39	within	T =35		43.89	-12.18	168.51
	overall	N =699	0.042	0.09	0	0.67	overall	N =630	0.31	0.50	0	3.15
R&D	between	n = 20		0.07	0	0.21	between	n =18		0.44	0.01	1.62
	within	T-bar =34.95		0.07	-0.17	0.54	within	T =35		0.27	-1.31	1.84

Table 2: Correlation Matrix of MENA and Latin American Countries

Correlation Matrix of MENA Countries

	lnYH	lnKH	Trade	ICTs	R&D
lnYH	1				
lnKH	0.9495*	1			
Trade	-0.4359*	-0.4107*	1		
ICTs	0.1695*	0.1984*	0.2858*	1	
R&D	0.3669*	0.3801*	-0.0900*	0.2736*	1

Correlation Matrix of Latin American Countries

	lnYH	lnKH	Trade	ICTs	R&D
lnYH	1				
lnKH	0.9910*	1			
Trade	-0.6068*	-0.6018*	1		
ICTs	0.1666*	0.1658*	0.1877*	1	
R&D	0.6732*	0.6693*	-0.3455*	0.2305*	1

Notes: * p<0.05

Table 3: Pooled Estimates of Augmented Production Function

	MENA Countries		Latin American Countries	
	LONG RUN RESULTS			
VARIABLES	MG	PMG	MG	PMG
ecm, λ	-.4884***	-.2305***	-.46589***	-.2796***
Capital per efficient worker ($\hat{k}$), α	-.16789	.46357***	.71104***	.81583***
R&D (r), γ	15.39*	.20516***	.8621	.02115**
ICT (c), ϕ	-.00247	.00049***	.00012	-.00062***
Trade (o), ς	.00476	.00411***	.00105	.00058*
	SHORT RUN RESULTS			
Capital per efficient worker ($\hat{k}$), α	0.9537***	0.7641***	1.3248***	1.3798***
R&D (r), γ	-4.5725	0.197	-0.0701	0.0778
ICT (c), ϕ	0.0009	0.002**	0.0008*	0.0012**
Trade (o), ς	0.0009	-0.0009	-0.0009*	-0.0006
constant	2.9024**	1.3276***	1.5043***	0.3042***
Observations	568	568	578	578
Number of countries	17	17	17	17
Log Likelihood		1000.9		1333.21
Hausman	[Prob>chi2= 0.7470]		[Prob>chi2= 0.4414]	

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table 4: PMG Results for MENA Countries 1980-2014 Period (Δ lnYH)

Country	ECT	Δ Capital	Δ Trade	Δ ICTs	Δ R&D	Constant
Algeria	-0.22052***	0.86038***	0.00057	0.00107*	0	1.23283***
Bahrain	0.03151	0.3186	-0.00032	0.00173	0	-0.11267
Egypt, Arab Rep.	-0.07147**	0.15325	-0.00051	0.00022	0	0.47000**
Iran, Islamic Rep.	-0.54870***	2.02824***	0.00219	0.00280*	0	3.38471***
Iraq	-0.52399***	1.14275	-0.00054	0.00607	-0.00012	2.82377***
Israel	-0.00623	0.59025***	-0.00022	-0.00005	0.00001***	0.04174
Jordan	-0.09987**	1.01645***	-0.00106*	0.00235**	0	0.40149**
Qatar	-0.10626*	0.76144***	-0.00044	-0.00089	0.00001	0.53075*
Saudi Arabia	-0.26613***	0.87709	0.00499**	-0.00097	-0.00003*	1.58790***
Syrian Arab Republic	-0.34153***	1.25589**	-0.00192**	0.01335***	-0.00001	1.59963***
Tunisia	-0.01206	0.31024	0.00043	0.00012	0	0.06785
Turkey	-0.83216***	1.72985***	-0.00222***	0.00126*	0	5.08323***
United Arab Emirates	-0.12305*	-0.53677	-0.00046	0.00266	0.00001	0.67557*
Yemen, Rep.	-0.28595***	1.18095***	0.00021	0.00619**	0	1.50371***
Kuwait	-0.00798	0.42693	-0.01116***	-0.00063	0.00005	0.04628
Morocco	-0.35632***	0.05928	-0.00358***	0.00175	0	1.81752***
Mauritania	0.00734	0.39592**	-0.00048	-0.00002	0	-0.018

Notes: *** p<0.01, ** p<0.05, * p<0

Table 5: PMG Results for Latin American Countries 1980-2014 period (Δ lnYH)

Country	ECT	Δ Capital	Δ Trade	Δ ICTs	Δ R&D	Constant
Argentina	-0.33099***	2.20801***	-0.00417***	-0.00013	0.00684	0.47183***
Belize	-0.02226	1.00058***	0.00085*	-0.00029	-0.38254	0.0184
Bolivia	-0.18081**	0.98624***	0.0004	0.00147*	0.65829**	0.21295*
Brazil	-0.55349***	0.90781***	-0.00603***	0.00414***	-0.00085	0.73694***
Chile	-0.77978***	2.81024***	-0.00059	0.00151**	-0.00806	0.87909***
Colombia	-0.04035	0.87423***	0.00373***	0.00087*	0.04096	0.04907
Costa Rica	-0.39479***	2.20914***	-0.00047	0.00117**	0.06226	0.34891***
Ecuador	-0.59170***	1.62901***	-0.00026	0.00167*	0.00627	0.54592***
El Salvador	-0.51162***	1.29878***	0.00106**	-0.00045	-0.02002	0.64059***
Honduras	-0.06003	0.17009	0.00081*	0.00056	0.45762*	0.05742
Mexico	-0.20852***	1.54615***	-0.00155	-0.00416***	0.11898***	0.30533**
Nicaragua	-0.30158***	3.10595***	-0.00091***	0.00427***	-0.14789	0.14351**
Panama	-0.22157**	1.14963***	0.00156***	0.00057	0.2282	0.20154**
Paraguay	-0.04415	0.25204	0.00018	0.00193*	-0.01445	0.04938
Peru	-0.21583***	1.17569***	-0.00367**	0.0009	0.33728***	0.26569***
Uruguay	-0.07591	0.65971	-0.00169	0.00129	0.01428	0.04616
Venezuela	-0.22016***	1.47361**	0.00104	0.00498***	-0.03383	0.19912**

Notes: *** p<0.01, ** p<0.05, * p<0