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The Impact of Knowledge Economy on Economic Growth for the Kingdom of Saudi Arabia over the Period 1992-2018

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Abstract:

This study aims to analyze the impact of some indicators of knowledge economy on economic growth in Saudi Arabia. Using a Vector Auto Regression (VAR) estimation of a dynamic model over the period of 1992-2018, we included a time series data set that consisted the annual economic growth rate for Saudi Arabia within the theoretical and empirical framework, applied to four indicators used for identifying the situation of the knowledge-based economy. The empirical results obtained showed that "Education and Human Resources" are the most important pillar that has a crucial impact on economic growth. These findings reinforce the policy maker's decision to shift the Saudi economy toward economic diversification and not just rely on oil resource.

Keywords: Knowledge Economy, Economic Growth, Information and Communications Technology (ICT), Education, Saudi Arabia

الملخص :

تهدف هذه الدراسة إلى تحليل تأثير بعض مؤشرات اقتصاد -المعرفة على النمو الاقتصادي في المملكة العربية السعودية. باستخدام تقدير القيمة المضافة للنموذج الديناميكي VAR خلال الفترة من عام 1992 إلى عام 2018 ، ادرجنا مجموعة بيانات السلاسل الزمنية التي تتكون من معدل النمو الاقتصادي السنوي للمملكة العربية السعودية ضمن الإطار النظري والتجريبي ، المطبق على أربعة مؤشرات تستخدم لتحديد الوضع الاقتصاد القائم على المعرفة.

أظهرت النتائج العملية التي تم الحصول عليها أن "التعليم والموارد البشرية" هي الركن الأكثر أهمية الذي له تأثير حاسم على النمو الاقتصادي. تعزز هذه النتائج قرار صانع القرار بتحويل الاقتصاد السعودي نحو التنويع الاقتصادي وليس الاعتماد فقط على الموارد النفطية.

الكلمات المفتاحية: اقتصاد -المعرفة، النمو الاقتصادي ، تكنولوجيا المعلومات والاتصالات (ICT)، التعليم ، المملكة العربية السعودية.

1. Introduction:

In the late 20th century, national economies throughout the world experienced huge economic challenges and opportunities. Technological changes, and the expansion of telecommunication infrastructure have affected the economic situation around the world.

Knowledge has become a driver for production and economic growth, and the principle of focusing on information and technology has become one of the main factors in the contemporary economy. The increase in the use of knowledge, information and technology, investment in knowledge has become one of the most important factor of production, as it increases the productivity. Hence, it is assumed that the countries that achieve the highest rates of economic growth have more knowledge capabilities.

The paper aims to investigate the importance of knowledge in improving the economic situation of countries. We focus on one of the most influent countries in the Middle East and North Africa (MENA) region which is Saudi Arabia. The paper present an important added value to the large debate on the reforms adopted in the Kingdom of Saudi Arabia (KSA) during the last five years.

In fact, after the oil crisis in 2015, KSA implements a large number of reforms through the National Transformation program and the Vision 2030 in order to reduce its dependence on oil revenues. The strategic decision of the Saudi government to transform its economy to rely on intellectual's assets rather than natural resources involve a large wide of knowledge intensive activities. So, the study raises a major question: What is the effect of the government's policies toward improving knowledge indicators in the KSA on the Gross Domestic Product (GDP) growth rate during the period 1992-2018?

The research methodology applied is a descriptive analytical approach by using a Vector Auto Regression (VAR) estimation of a dynamic model over the period of 1992-2018,

to determine the relationship between the knowledge indicators in the Kingdom and its impact on the economic growth. The paper examined three research hypothesis: First of all, knowledge indicators in the KSA affect positively and significantly the economic growth. Secondly, knowledge indicators in the KSA have a slight positive impact on the Saudi economic growth. And finally, knowledge indicators in the KSA negatively affect the economic growth.

In recognition of the role of knowledge as an economic resource that affects the improvement of the economies, many definitions have emerged. Jones (2001) considers that are three concepts about the knowledge economy: data, information and knowledge:

- Data is a set of discrete, objective facts about events. In an organizational context, data is described as structured records of transactions. Data provides no judgment or interpretation or basis of action.
- Information is a message, usually in the form of a document or an audible or visible communication. Information is meant to change the way the receiver perceives something. Unlike data, information has meaning. It should be noted, though, that information (or knowledge) should not be confused with the technology that delivers it: The medium is not the message.
- The word knowledge is very difficult to define comprehensively, as one should first understand what it means to know something.

Machlup (1980) define a knowledge-based economy as a new economy in which the numbers of employment in the knowledge-producing sectors exceed the numbers of employment in the rest of the other economic sectors. Machlup estimated the size of all sectors of the knowledge economy in the United States at nearly 30 percent of Gross National Product (GNP) in 1958.

The United Nations Development Program and the Mohammed bin Rashid Al Maktoum Foundation 2017 set the Global Knowledge Index as a composite index of seven composite sub-indicators that highlight the performance of six vital sectors: pre-university education, technical education & vocational training, higher education, information & communications technology, research development & innovation and economics; as well as a composite index specific to environments. Empowerment characterizes the social, political and economic context of these sectors (Karahan, 2012).

Finally, the Organization of Economic Cooperation and Development (OECD) define the "knowledge based economy as a component directly based on production, distribution and use of knowledge and information" (Enache and Vechiu, 2009).

Despite the important number of definitions of a knowledge based economy through the literature, we focus in this paper on the definition of the World Bank that divides the knowledge index into five sub-indicators and each of them has different axes. The first sub-index is economic performance, which in turn is divided into the average annual economic growth rate. The second sub-index is the incentives of the economy and the institutional system. The third sub-index is education and the human resource, it is divided into three main axes: the illiteracy rate among young people over 15 years, enrollment in secondary schools, enrollment in higher education. The fourth sub-index on the innovation system, which includes three sub-axis is the number of researchers in research and development per million of population, the number of patents granted per million of the population, articles of scientific and technical journals for every million of the population and the fifth and the last sub-axis is the information infrastructure and it includes three sub-axis are the number of phones per thousand of the population, computers per thousand of the population, the number of Internet users for every ten thousand people.

The World Bank and the European Bank for Reconstruction and Development were the pioneers to propose "Knowledge Assessment Method "to measure the progress of a country in transition to the knowledge economy, it includes four main pillars. The Table (1) below summarize these four index for both of them.

The knowledge economy seems to be one of the major key for success. Many economists tried to study the effect of the knowledge on the economic conditions. The economic, social and political changes that the world is witnessing have led to the necessity of shifting to a knowledge-based economy as a basic element for the development. This study emphasis the effect of the knowledge economy on economic growth using some dimensions of the four pillars listed above.

Table1: The comparison of components of the knowledge index for different institutions.

	World Bank			
Pillars	Global Facilities Index	Education and Human Resources Index	Technological Innovation Index	Information and Communication Technology Index
Dimensions	Customs Barriers regulatory Research and development costs	Average years of schooling	Application for patents and trademarks Scientific articles	Telephones per 1000 persons Computers per 1000 persons Internet users per 1000 persons
	European Bank for Reconstruction and Development (EBRD)			
Pillars	Institutions for innovation	Skills for innovation	Innovation system	ICT infrastructure
Dimensions	Economic openness Business environment Governance	General and specialized skills	Inputs/output linkage	ICT availability ICT sophistication

Source: World Bank and European Bank for Reconstruction and Development EBRD websites (2019)

2. Literature Review:

The impact of the knowledge economy on economic conditions is raised in different debates. Some economists such as Soete (1996) and Neef (1998) believe that: "Knowledge has an effect on the economic structure by creating structural and social changes in the size and type of unemployment, and on how to organize the work and production and the technology policy in place.

Simplice A. Asongu, Voxi H. S. Amavilah & Antonio R. Andres (2019) investigate the relation between economic performance and knowledge economy. They develop a dynamic model on 53 African countries over the period 1996-2010 and they conclude that there is a weak link between knowledge indicators and economic performance. Nonetheless, knowledge economy influenced performance plays a more important role in socioeconomic development than some of the conventional control variables like Foreign Direct Investment (FDI), foreign aid, and even private investment.

Al-Zamel, (2017) shows the role of education in improving the indicators of the knowledge economy, as the research problem of the study was the necessity of inevitable transition to a knowledge economy as a result of global competitiveness among the world. The author focus on the case of Saudi Arabia's interest in education to catch up with the knowledge economy worldwide, with the challenges and requirements that follow. Many research methods were used, including the descriptive analytical approach, the standard approach, based on statistics from the World Bank and the United Nations, and by using some statistical methods such as frequency, percentages, and the Pearson correlation coefficient, and the multiple regression analysis.

The study touched on many important points, including the role of education in growth. It built a multiple regression analysis model to identify the strongest sectoral indicators that predict the global knowledge index for 2017, where all seven sectoral indicators were included in the analysis, namely pre-university education, technical education and vocational training, higher education, research and development and innovation, Information and communications technology, the economy, and enabling environments, for all the countries included in the World Knowledge Report for the year 2017 and they are 131 countries.

The results show the existence of an important knowledge gap between Switzerland which is first ranked in the global knowledge index for 2017 and others countries. The Arab Gulf countries present a significant improvement in some of the sub-indices of knowledge, especially for human development. These findings were confirmed by Abdel Moneim and Qaloul, (2019) who confirm the presence of challenges facing the process of accurate measurement of the knowledge economy in the Arab Gulf countries. They recommended develop statistical indicators in a way that allows accurate identification of the role of knowledge economy and its contribution to the gross domestic product.

Muhammad (2016) compare indicators and initiatives to measure the knowledge-based economy. He focused on the role of libraries in building a knowledge-based economy in Egypt.

Amaacho, (2017) focuses on the concept of sustainable development and the role of the knowledge economy in achieving the dimensions of sustainable development. The study was limited to the use of the descriptive approach in clarifying concepts and indicators related to both sustainable development and knowledge economy with clarification on relationship between them.

One of the most important results of the study is that building a knowledge economy is one of the main goals of any country, and it requires to provide a qualified human capital in the modern technologies, including information and communication technology, in order to raise the productivity of different sectors. While most countries of the world transfer knowledge and technology and work to implement them in various economic, social and political activities. The knowledge economy for societies striving for sustainable development is also a very important issue. An economy is considered abundant by replacing knowledge and the human component with the irrational exploitation of natural resources that entail serious repercussions on the environment, and the knowledge economy contributes to achieving sustainable development through its inclusion in many aspects, such as e-commerce, e-government, and e-learning.

Glaeser (2000) and Raspe and Van Oort (2008) confirm the importance of knowledge work as the engines of regional economic growth.

3. Theoretical framework

3.1 The relationship between the components of the knowledge index and economic growth:

The term "new economy" or "knowledge economy" first appeared in the 1950s when researchers began to notice the upward development of new sectors in developed countries at the expense of the agricultural and industrial sectors. Alfred Marshall, (1890) defined the knowledge economy as production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific improvement, as well as rapid obsolescence. The key component of a knowledge economy is a greater reliance on intellectual capabilities than on physical inputs or natural resources, Powel & Snellman (2004).

According to the development of economic thought, there are many theories that explain the relationship between economic growth and some components of the knowledge index such as interest in human capital (education and training in the knowledge index) or interest in technology (communications and information technology in an index). This relationship can be inferred from the following theories:

3.1.1 Innovative growth theory of Schumpeter:

According to Schumpeter, the engine of development was the changes in the economic sphere. They were due to various reasons, but the main was entrepreneurial innovation, which caused the development. Schumpeter described the nature of economic development as the "carrying out of new combinations", which he defined rather widely as follows (Maddison, 1982): Introduction of new goods; Introduction of new methods of production; opening a new market; conquest of a new supply of raw materials; new organization of an industry (Sharipov, 2015).

3.1.2 Neoclassical growth theories and the exogenous theory of Robert Solow:

Robert Solow with other scholars opposed the state's intervention in the economy and were up for allowing large firms to achieve their growth potential in a competitive market, by using most of the resources available to them. Solow proceeds from the assumption that a necessary condition for equilibrium of the economic system is the equality of aggregate demand and aggregate supply. In his theory, aggregate supply is determined on the basis of the production function of Cobb-Douglas, which expresses the functional dependence between production volumes on the one hand, and the factors used and their combinations, on the other hand. Solow's theory can reveal interconnections between three sources of economic growth - investments, workforce and technological progress.

Thus, the theory of Solow highlights technological progress as the sole basis for sustainable growth of welfare and allows you to find the optimal variant of growth, providing maximum consumption.

3.1.3 Theory of endogenous economic growth:

It reflects the impact of imperfect competition and the role of possible changes in the profit rate. And most importantly - the scientific and technical progress has been considered as an endogenous, growth factor generated by internal causes in the theories of endogenous growth, technological progress is not the only possible cause of economic growth in the long term. The value of intensive, high-quality determinants of economic growth (parameter a in neoclassical theory) is defined in the theories of endogenous growth with the following factors:

The quality of human capital, which depends on investment in human development (education, health); creation of the necessary conditions and prerequisites for the protection of intellectual property rights in the conditions of imperfect competition; state support for the development of science and technology; the role of government in creating a favorable investment climate and attracting new technologies.

A key factor in the endogenous growth theory of Paul Romer is the variable called "knowledge" or "information". It assumes that the information contained in the inventions and discoveries are available to everyone and can be used at the same time. The Romer's theory assumes that the total amount of human capital remains constant during the considered time interval. It is only possible its redistribution between the sphere of production and Research and development (R&D) (research and development activities) in accordance with the function of consumer preferences (Sharipov, 2015).

Thus, the study is based on all previous theories that support the role of technology, scientific research and human development as important elements to stimulate economic growth in any country.

Also, those theories and models support the validity of the structure of the knowledge index from several sub-indicators that include the previous elements, and the same elements will be used by the study in building the standard model to study the role of the knowledge index and some of its sub-components in stimulating economic growth in the KSA during the period 1992-2018.

4. Empirical investigation:

In our paper, we focus on one important economy in the MENA region especially the KSA. The economy of Saudi Arabia witnessed an important revolution following the discovery of oil more than three quarters of a century ago (March 1938). Saudi Arabia, a member of G20, is an oil-reliant nation as a large percentage of its GDP comes from oil resources. Oil dependency leaves the country at the mercy of the international crude market, and a decrease in the price of crude can seriously destabilize the economy of such nations (Alomari, 2019). After the 2015 oil crisis, the policies adopted by Saudi Arabia support the movement of the economy towards the other sources of revenues.

A shift from a resource based economy to a knowledge based economy will help Saudi Arabia become less reliant on its oil revenues for its economic stability and growth, (Nurunnabi, 2017).

Several challenges are faced by the country to move forward. Six aspects need to be considered in developing Saudi Arabia's knowledge economy: Human Capital, innovation, Information and Communications technology (ICT), the Economy, Education and Employment. The most important challenge is related to human capital, research and unemployment among the university educated females, (Alomari, 2019).

The Saudi vision 2030 and the National transformation program 2020 both focus on the importance of diversifying the economy through development of the knowledge economy. Through the model proposed in this paper, we provide insight, what the KSA knowledge economy looks like today and the potential policy issues related to how the economy might evolve into the future

4.1 Model description:

During the last decade, economists have tried to measure the impact of knowledge on economic growth in various ways. Barkhordi, Fattahi and Azimi (2019) used a dynamic panel data model over the period 2010-2015 including the annual economic growth and institutions, human capital and research, infrastructure, and business sophistication for some selected MENA countries.

Chen and Dahlman (2004) using a Cobb-Douglas production function, consider four pillars of knowledge economy which transforms knowledge into an effective engine of growth. These pillars are economic and institutional regime, educated and skilled population, dynamic information infrastructure and efficient innovation system.

In this paper, we use Roubini and Sala-i-Martin (1995) model. Starting by a simple and traditional growth model. The steady state solution for the level of output in the Solow (1956) growth model is:

$$Y^* = \left(\frac{s}{\delta+g+n}\right)^{\frac{\alpha}{1-\alpha}} A \qquad (1)$$

Where $Y^* = (\frac{Y}{L})$ is the steady state level of income per worker, s=the ratio of investment to income, δ= depreciation rate of capital, g= the rate of technical progress, n= the rate of growth of labor, A=the stock of knowledge and α= the exponent of capital in the Cobb-Douglas production function with constant returns. This implies that the steady state rate of growth per worker output, assuming that all other ratios and parameters are constant, is simply the Total Function Production (TFP):

$$\Delta lny^* = SSGR = \Delta lnA = TFP \quad (2)$$

However, the determinants of TFP are exogenous in the Solow (1956) growth model. We note that SSGR is estimated by the production function. We assume that the stock knowledge (A) depends on variables identified by the endogenous growth models. We present the Cobb-Douglas production function with constant returns:

$$Y_t = A_t K_t^{\alpha} L_t^{(1-\alpha)} \quad (3)$$

With $0 < \alpha < 1$, where Y_t is aggregate output, A_t the stock of knowledge, K_t the stock of physical capital and L_t the labor force in period t.

We assume for the following that A_0 is the initial stock of knowledge, Z is a vector which consist of more than one variable, whereas S and W are assumed to consist of one variable and T is time.

$$A_t = A_0 e^{(\gamma Z_t T + \beta_1 S_t + \beta_2 S_t^2 + \beta_3 W_t)} \quad (4)$$

Substituting (4) and (3) gives:

$$Y_t = A_0 e^{(\gamma Z_t T + \beta_1 S_t + \beta_2 S_t^2 + \beta_3 W_t)} K_t^{\alpha} L_t^{1-\alpha} \quad (5)$$

Dividing both sides of equation (5) by L yields:

$$y_t = A_0 e^{(\gamma Z_t T + \beta_1 S_t + \beta_2 S_t^2 + \beta_3 W_t)} k_t^{\alpha} \quad (6)$$

Where $y = \frac{Y}{L}$ and $k = \frac{K}{L}$.

Applying the natural logarithmic transformation of (6), we obtain,

$$\ln y_t = lnA_0 + \gamma Z_t T + \beta_1 S_t + \beta_2 S_t^2 + \beta_3 W_t + \alpha \, Ln \, k_t \quad (7)$$

Equation (7) shows the actual level of per capita output due to two types of variables: factor accumulation and variables due to factors other than factor accumulation such as Z, S and W.

Specification of these other variables that may affect output in an empirical issue. Taking first differences of (7) gives:

$$\Delta Ln\, y_t = \gamma \Delta Z_t T + \beta_1 \Delta S_t + \beta_2 \Delta S_t^2 + \beta_3 \Delta W_t + \alpha \Delta lnk_t \quad (8)$$

Only trended variables (i.e., variables entering the vector multiplied by trend) have a permanent growth effect. For this reason, the variables in the Z vector are the sole determinants of the long-run steady state growth rate. The other two variables S and W have only a level effect on output (i.e., they can raise the economy's income level permanently but they have only transitory growth effects), but with an important difference. S influences the level of output in a non-linear manner, whereas W affects output in a linear manner.

In the empirical growth literature, we can find different variables influencing the output growth. We select in this framework to relate economic growth per capita rate to four indicators such as number of bachelor graduates and Gender Parity Index (GPI) to express the knowledge variable in the our model, number of technical Trainees to express the variable labor force and ICT technologies to present the physical capital in the model. Using equation (8) and the information above, we can express the model as follows:

$$Ln(y_t) = Ln(y_{t-1}) + \gamma_1 \Delta Ln(Grad_t) + \gamma_2 \Delta Ln(Train_t) + \gamma_3 \Delta Ln(GPI_t) + \alpha \Delta Ln(ICT_t) + \varepsilon_t$$

Where y_t is the GDP per capita growth during the period t (t=1990-2018), $Grad_t$ is the number of bachelor graduates, $Train_t$ is the number of trainees in four main regions in the KSA, GPI_t is the Gender Parity Index, ICT_t represents Information and Communication Technologies and ε_t is a stochastic error term.

By reviewing the time series of the selected indicators, we can stress that Saudi Arabia has no choice except to depend on human minds and capabilities. Development of education in terms of minimizing illiteracy and improving the quality of outcomes to be more competitive with international standards.

King Abdullah project for the development of general education and the establishment of the authority of education evaluation are among the important initiatives to improve the outcomes of education. Expansion of the vocational and technical training, and establishment of joint training programs with major manufacturing companies resampling private sector are among the successful steps to build capabilities of Saudi technicians, opening new universities, especially research and technology universities such as King Abdullah University for Science and Technology (KAUST) , and initiating king Abdullah program to financially support Saudi students to complete their graduation and undergraduate studies abroad in distinguished universities in medical, engineering , computers and communications sciences are among the efforts to empower Saudis to be highly skilled and qualified to execute sophisticated technological tasks.

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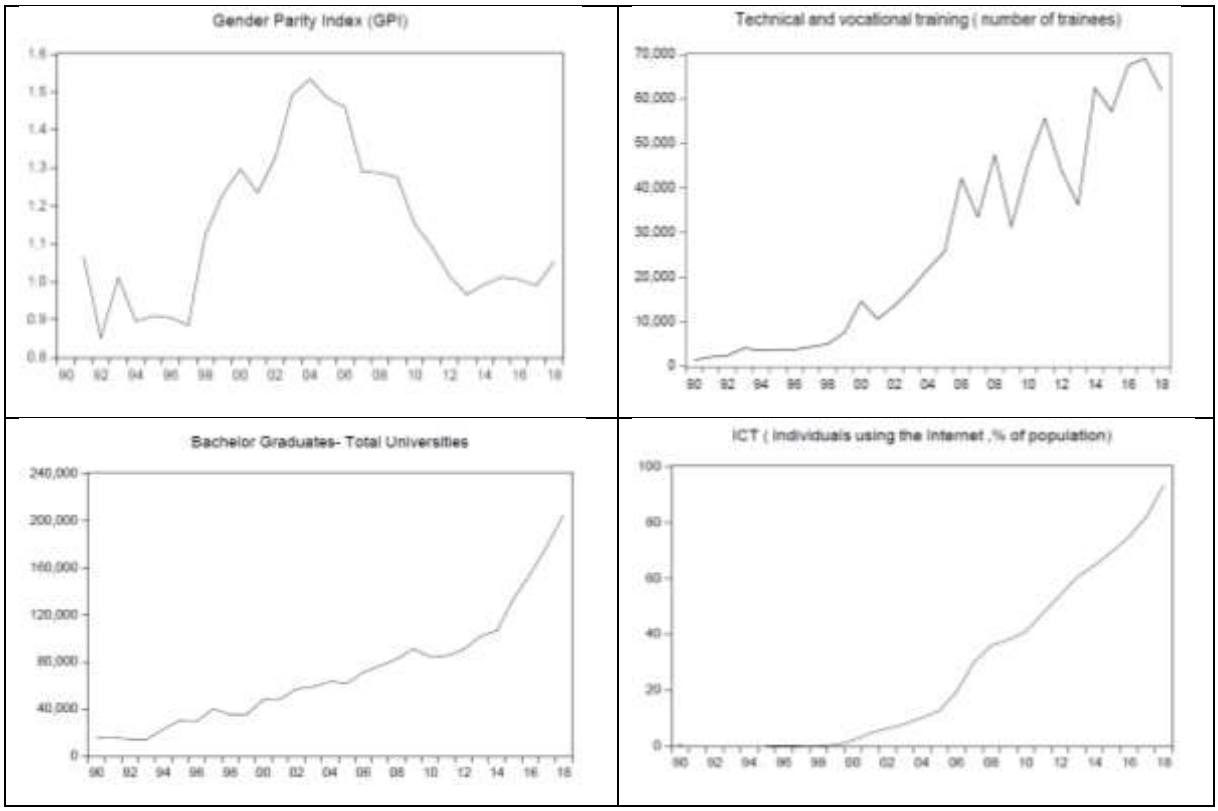
4.2 The knowledge Indicators trends:

In order to test the impact of knowledge on economic growth, we select four components that reflects the importance of knowledge in Saudi Arabia. We use the method proposed by the World Bank "the knowledge assessment method". We select only two pillars which are the Education & Human Resources Index (EHRI) and Information and Communications Technology Index .We choose to ignore the remaining pillars due to the lack of data.

The selected indicators are the number of females and males graduates from all universities in Saudi Arabia, the number of females and males trainees in four main cities in the country, the total number of internet users and the GPI which measure the gender disparities in access to education.



Source: World Bank, 2019

Figure. 1: Selected indicators

Figure (1) provides the time plots of the four indicators; namely Gender Parity Index (GPI), number of graduates, Information and Communication Technologies (ICT) and number of trainees over the period 1990-2018 in the KSA.

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Figure (1) shows that the number of trainees including males and females and the number of graduates from universities in Saudi Arabia increase significantly after 2000. This results can be explained by the reduction of the cultural and social burden in the country, so the families accept easily to send their kids (especially females) to school and since 2000 it's allowed to the females to work and become an important part of the labor force in Saudi Arabia. The same finding is for the number of individuals using the internet. Since 2002 Saudi Arabia has placed great importance on diffusing technologies throughout the nation–across the public and private sectors and civil society. Therefore according to the Figure (1) above, the number of internet users is approaching 95% of the total population in 2019.

Table (2) provides the average value, median, mean and dispersion of all the indicators in the sample. It shows that the mean value of GDP is highest rate of changes among all the variables whereas the mean value of GPI have lowest rate of changes. The maximum value of standard deviation is for the number of bachelor graduates in Saudi Arabia. This finding can be explained by the unstable educational system in Saudi Arabia over the selected period. The minimum value of standard deviation is 0.2030 and it is for the GPI.

Table 2: Descriptive statistics for the indicators

Date: 11/18/19 Time: 12:35
Sample: 1990 2018

	GDP	ICT	TRAIN	GRAD	GPI
Mean	4.70E+11	30.24005	27394.10	70820.41	1.137403
Median	4.37E+11	19.45955	21809.00	61732.00	1.078815
Maximum	7.00E+11	93.31000	69084.00	204951.0	1.534260
Minimum	2.94E+11	0.000000	1341.000	14364.00	0.851770
Std. Dev.	1.30E+11	30.38661	23288.20	48955.83	0.203086
Skewness	0.549951	0.587552	0.425373	1.087859	0.484177
Kurtosis	1.852231	1.982479	1.726233	3.731359	2.087342
Jarque-Bera	3.053649	2.516893	2.835055	6.366266	2.065763
Probability	0.217224	0.284095	0.242312	0.041456	0.355980
Sum	1.36E+13	756.0011	794429.0	2053792.	31.84728
Sum Sq. Dev.	4.75E+23	22160.31	1.52E+10	6.71E+10	1.113589
Observations	29	25	29	29	28

Where:

ICT: Information and communication technologies

TRAIN: Number of Trainees In four main regions in Saudi Arabia

GRAD: Number of graduates from universities

GPI: Gender Parity Index

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4.3 Correlation and causality of the indicators:

As specified before, construction of a knowledge index from the indicated sub-indices, would provide us with a comprehensive measure of the knowledge in the economy. Moreover, using this index we can prevent a problem of multi-collinearity in the empirical analysis since the indicators of knowledge economy are highly correlated.

Table (3) shows the result of correlation coefficient that indicates there is a negative and insignificant relationship between the GDP growth and the GPI. From the correlation result it is demonstrated that the relationship between GDP and the others indicators is positive and significant.

Table 3: Correlation Matrix

Correlation

	LN_GDP	LN_GPI	LN_GRAD	LN_ICT	LN_TRAIN
LN_GDP	1.000000	-0.043036	0.908203	0.830154	0.908900
LN_GPI	-0.043036	1.000000	0.206415	0.315946	0.321599
LN_GRAD	0.908203	0.206415	1.000000	0.777947	0.943132
LN_ICT	0.830154	0.315946	0.777947	1.000000	0.887100
LN_TRAIN	0.908900	0.321599	0.943132	0.887100	1.000000

The table (4) indicates the result of pair wise Granger causality test that shows the causal relationship among GDP, number of graduates, number of trainees and ICT.

In Granger causality test all variables are independent with each other and the null hypothesis is Ho: the endogenous variable (Economic growth in the model) do not Granger cause the dependent variables (Knowledge indicators).

Table 4: Granger Test

Pairwise Granger Causality Tests
Date: 12/08/19 Time: 20:53
Sample: 1990 2018
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LN_GPI does not Granger Cause LN_GDP	26	1.52147	0.2415
LN_GDP does not Granger Cause LN_GPI		1.34852	0.2812
LN_GRAD does not Granger Cause LN_GDP	27	1.41206	0.2649
LN_GDP does not Granger Cause LN_GRAD		4.36291	0.0254
LN_ICT does not Granger Cause LN_GDP	27	1.43253	0.2601
LN_GDP does not Granger Cause LN_ICT		1.00310	0.3829
LN_TRAIN does not Granger Cause LN_GDP	27	1.60011	0.2245
LN_GDP does not Granger Cause LN_TRAIN		0.19854	0.8214
LN_GRAD does not Granger Cause LN_GPI	26	0.25608	0.7765
LN_GPI does not Granger Cause LN_GRAD		0.88292	0.4284
LN_ICT does not Granger Cause LN_GPI	26	2.16622	0.1395
LN_GPI does not Granger Cause LN_ICT		2.46867	0.1089
LN_TRAIN does not Granger Cause LN_GPI	26	1.50959	0.2440
LN_GPI does not Granger Cause LN_TRAIN		0.92569	0.4118
LN_ICT does not Granger Cause LN_GRAD	27	0.52379	0.5995
LN_GRAD does not Granger Cause LN_ICT		14.4291	0.0001
LN_TRAIN does not Granger Cause LN_GRAD	27	1.22740	0.3124
LN_GRAD does not Granger Cause LN_TRAIN		4.00519	0.0329
LN_TRAIN does not Granger Cause LN_ICT	27	4.16641	0.0292
LN_ICT does not Granger Cause LN_TRAIN		0.98945	0.3877

According to our results the null hypothesis cannot be rejected for almost all the relationships at the 5% Confidence level. Therefore, we cannot reject the hypothesis for Ln-gdp, Ln-ICT, Ln-train and Ln-gpi. But the conclusion is different for the variable Ln-grad, we can reject the null hypothesis for the variable ln-grad and ln-gdp, Ln-ict and ln-train.

Unfortunately, Granger Wald test does not provide clear cut results, since the "Granger causality" should not be interpreted according to the normal meaning of "causality". In other words Granger causality does not imply real causality. I would say that Granger causality measures if statistically "A happens before B" rather than "A is the cause of B".

5. Model Results:

To study the relationship between economic growth per capita rate and four selected indicators of knowledge such as Bachelor graduates, Technical Trainees, GPI and ICT technologies, we follow Sala-i-Martin and Barro (1995) and Roubini and Sala-i-Martin (1995) model.

We used a dynamic model over the period of 1992-2018. It includes a panel data set that consisted the annual economic growth rate for Saudi Arabia within the theoretical and empirical framework, applied the four indicators used for identifying the situation of the knowledge-based economy. The empirical results obtained using dynamic panel indicates Education and Human Resources to be the most important pillar of the knowledge based economy that have an important impact on economic growth. From the Table (5), we can see that the sub-indices number of total graduates and the number of trainees affect positively and significantly the economic growth in Saudi Arabia.

The contribution of the Saudi Arabia's information and communications technology (ICT) sector growth slowly over the last decade. The percentage of Technologies and Communication's Imports (TCI) represented in 1990 more than 79% of the total commercial service imports but attaint 33% in 2018. Thus, the total spending on imports on information and communications technology (ICT) sector decreased. Therefore, we suspect an improvement in the impact of ITC on Saudi economy. Overall the period, the results shows an insignificant negative impact of ITC on economic growth that can be explained as presented above by the large spending of KSA on imports of new technologies of communication and information. As we know Saudi Arabia is newly implemented in the technologies market and its imports in ITC exceed its exports in ITC in large proportion.

The GPI is a socioeconomic index usually designed to measure the relative access to education of males and females. For several years, in Saudi Arabia, the access to education for the females was constrained by many social and cultural restrictions. The results present a negative effect of GPI on economic growth that can be explained by the particular situation of the Saudi society compared to others countries. We suggest that government should consider the knowledge-related policies for accelerating transiting to a knowledge based economy in order to improve the economic performance, Barkhordi, Fattahi and Azimi (2019).

Table 5: Results of Vector Autoregression Estimates

Vector Autoregression Estimates Sample (adjusted): 1992 2018 Included observations: 27 after adjustments Standard errors in ( ) & t-statistics in [ ]	
	LN GDP
LN_GDP(-1)	0.891794 (0.17807) [5.00820]
LN_GDP(-2)	-0.242223 (0.18677) [-1.29692]
C	8.522779 (3.64087) [2.34086]
ΔLN_ICT	-0.000933 (0.00671) [-0.13903]
ΔLN_GRAD	0.007674 (0.03836) [0.20003]
ΔLN_TRAIN	0.085487 (0.03126) [2.73499]
ΔLN_GPI	-0.170143 (0.08992) [-1.89210]
R-squared	0.987979
Adj. R-squared	0.984372
Sum sq. resids	0.020750
S.E. equation	0.032210
F-statistic	273.9502
Log likelihood	58.49790
Akaike AIC	-3.814659
Schwarz SC	-3.478701
Mean dependent	26.86770
S.D. dependent	0.257658

6. Conclusion:

Knowledge has been considered for a long time as an important factor of production alongside labor, capital and resources. However, due to the limited natural resources and the abundance of knowledge as a resource as well as it's potential to improve productivity as well as economic growth more emphasis is now placed on the importance of knowledge.

Since 2015, Saudi Arabia is strongly committed to a transition away from an oil based economy. Even if the oil resources are abundant and oil nations continue to prosper, the dependence on oil revenues is not sustainable due to the instable world economic situation.

The results show on one hand, a significant and positive impact of the number of graduates and the number of trainees on the economic growth of Saudi Arabia. This can be explained by the policies implemented by the Saudi government to sustain the educational sector which represent 193 billion SAR of 2020's budget.

Indeed, the kingdom has set its road map to join the ranks of nations that embrace the potential of a knowledge economy. The main improvement that Saudi Arabia success to set, is the increase of investment in human capital, education and the access to funding for technological companies. The Saudi vision 2030 and the National Transformation Program 2020 introduced new directives aimed at promoting education.

On the other hand, the results showed insignificant and negative impact of Information's and Communication Technologies (ICT) on the economic growth. This finding is attributed to the large proportion of ITC imports that represented in 2018 more than 33% of the total commercial service imported.

Recently, the policy of the country has been changed and the government apply massive ICT investment transforming Saudi Arabia to an innovative economy, enhanced development and growing productivity.

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