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# The impact of technological innovation on Economic Growth: A standard study for emerging countries during the period 1997-2018

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*Abstract ;*

*This research paper aims to study the impact of technological innovation on economic growth, Therefore, we used the methodology of panel cointegration for sixteen emerging countries: Argentina, Brazil, Bulgaria, China, the Czech Republic, Greece, Hungary, Malaysia, Mexico, Philippines, Poland, the Russian Federation, the Slovak Republic, South Africa, Thailand and Turkey.The results showed that the impact of technological innovation was weak, and economic growth in these countries was affected by investment and labor force.*

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**Keyword:**
- ✓ Economic growth
- ✓ Technological innovation.
- ✓ Panel cointegration.

## 1. *Introduction*

Economic growth is an economic indicator to measure the development of the state, therefore, Countries increase economic growth through economic reforms, by infrastructure construction, raising energy resources, increasing investments, and developing the financial and monetary system. But technical progress is an the most important determinants of economic growth at the present time, and the indicators that contributed the gap between countries, developed countries have a technology that allowed it to control the global economy, especially in globalization.

Countries are divided into developed, emerging and developing countries, according to several criteria. An emerging market economy refers to the economies of developing countries that have known integration in global markets and registered high growth rates. The economies of emerging countries are characterized by some characteristics of the economies of developed countries, enabling them to achieve integration of the global economy. in particular increasing the volume of foreign direct investment, increased foreign trade, increased liquidity and Local Shares, and developing financial institutions.

Some emerging countries, such as China, have achieved high economic growth rates and great development in their internal and external markets, and they are competing with developed countries in many fields, especially international exchange and attracting foreign investments. Therefore, the problematic is:

**Does technological innovation affect economic growth in emerging countries?**

This problem is divided into the following questions:

- What are the determinants of economic growth in emerging countries?

- Do technological innovation have a strong impact on economic growth in emerging countries?

**Study hypotheses:**

- Economic growth in emerging countries is determined by investment, labor force and technological innovation.

- The impact of innovations on economic growth is strong in emerging countries.

**Study Methodology:**

We used the descriptive analytical approach, with the use of statistical tools to explain the relationship between the explanatory variables and the dependent variable.

**The importance of the study is to:**

- Look for the determinants of economic growth in emerging countries.
- Detect the relation between innovation and economic growth.
- Use the panel cointegration methodology.

**Objectives of the study:**

The study aims to identify the determinants of economic growth, and to reveal the relationship between innovation affect and economic growth in emerging countries.

**The followed approach:**

In this research, we follow the descriptive approach and the analytical approach; this is through the use of the methodology of panel co-integration, In order to study the impact of technological innovation on the economic growth of sixteen emerging countries.

## 2. *The concept of economic growth :*

Economic growth indicate to the real rise in the volume of goods and services over the long -term in proportion to the increase in the population, This continuous rises depends on the aggregate supply of goods and services on the institutional and ideological adjustments, and advanced technology (Kuznets, Jun 1973, P 247). That is, economic growth indicates a continuous real increase in the volume of gross domestic product (GDP) or gross national product (GNP) produced in the country, and this increase must be compatible with the increase in population, to meet the needs of the growing and different population. Or it is the continuous and real increase in the GDP per capita.

Growth is usually calculated in real terms of the (GDP) to eliminate the effect of inflation on the price of goods and services produced. It is measured by calculating the annual change in real (GDP):

$$g_{gdp} = \frac{GDP_t - GDP_{t-1}}{GDP_{t-1}} \ldots \ldots \ldots (01)$$

$g_{gdp}$: Real (GDP) growth rate.

$GDP_t$: Real GDP at time (t).

$GDP_{t-1}$: Real GDP at time (t-1).

Equation (01) does not represent the rate of economic growth, but represent the rate of growth of real GDP.

We can calculate economic growth ($g$) by subtracting the population growth rate ($g_p$) from the GDP growth rate ($g_{gdp}$):

$$g = g_{gdp} - g_p \ldots \ldots \ldots . (02)$$

Economic growth ($g$) can also be measured by calculating the change in the GDP per capita growth:

$$g = \frac{GDP/pc_t - GDP/pc_{t-1}}{GDP/pc_{t-1}} \ldots \ldots . (03)$$

$GDP/pc_t$: GDP per capita at time (t).

$GDP/pc_{t-1}$: GDP per capita at time (t-1).

The definitions show that we cannot talk about the existence of economic growth unless the following conditions:

- The real increase in goods and services by fixing the general price level (eliminate effect of inflation) that is compatible with the rate of population growth. Recent studies have indicated that if the population growth rate in underdeveloped countries is at 1%, then economic growth should not be less than 6%.
- The increase must be over a long period by relying on new technologies, which are appropriate to the needs of the growing and different population.
- Structural changes in economic institutions from time to time and change of ideologies.
- Creating structural changes on economic institutions from time to time and changing ideologies.

- An increase in per capita income (GDP per capita) and the achievement of social justice.

***2.1. The Solow growth model:***

The Solow model relies on four variables: national product (Y), capital (K), labor force (L), and knowledge (A) “effectiveness of labor». At any time, the economy mixes some amount of capital, labor, and knowledge.The production function takes the form:

$$Y_t = F[K_t, A(t)L(t)] \dots\dots (04)$$

Where (t) denotes time.

The first assumption of this model is that the production function has constant return to scale in its two arguments, capital an effective labor. In other words, any doubling in the quantity of capital and effective labor permits a doubling of total output

The second assumption of this model it neglects other factors of production, especially land and natural resources. If natural resources are necessary, the doubling of capital and labor could less than double output. But in practice, however, the availability of natural resources cannot be a problem for growth. Assuming constant return to capital and labor alone therefore appears to be reasonable approximation (Romer, 2012, P 11).

The Solow model is based on the Cobb- Douglas production function and has constant return to scale:

$$F(K, AL) = K^{\alpha}(AL)^{1-\alpha} \qquad 0 < \alpha < 1 \dots\dots\dots (05)$$

to extract out the intensive form of the production function, we divide equation (5) by (AL):

$$f(k) = \left(\frac{K}{AL}, 1\right) = \left(\frac{K}{AL}\right)^{\alpha} \dots\dots\dots\dots\dots\dots\dots\dots\dots. (06)$$

$$f(k) = k^{\alpha}$$

$\frac{K}{AL}$: the amount of capital per unit of effective labor.

$\frac{Y}{AL}$: output per unit of effective labor.

Assuming constant return, equation (06) indicates that the individual product (output per unit of effective labor) relies on individual capital (capital per unit of effective labor), and$(f'(k) = \alpha k^{\alpha-1})$, note that the marginal productivity of amount of individual capital is positive, that it tends to infinity or zero as $(k)$ approaches zero or infinity, respectively.

$$\lim_{k\to 0} f'(k) = \infty \qquad \text{and} \qquad \lim_{k\to\infty} f'(k) = 0$$

The last assumption of the model is that labor and knowledge are growing at constant rate. Meaning that $(n)$ and $(g)$ are exogenous parameters.

$$\Delta L_t = nL(t) \dots\dots\dots\dots\dots. (07)$$

$$\Delta A(t) = gA(t) \dots\dots.\dots\dots (08)$$

$$F(K, \lambda AL) = \lambda F(K, AL) == \lambda Y$$

Since output is directed between consumption and investment, The portion devoted to investment $(s)$, is fixed and external, So each unit of new investment gives one unit of the new capital, and the capital depreciates at a rate of $(\delta)$.

$$\Delta K_t = sY_t - \delta K_t \dots\dots\dots (09)$$

We put $(k = \frac{K_t}{AL_t})$, then we calculate the derivatives:

$$\partial k_t = \frac{\partial K_t[A(t)L(t)] - K_t[\partial A_t L_t + \partial L_t A_t]}{(A_t L_t)^2}$$

$$\partial k_t = \frac{\partial K_t}{A_t L_t} - \frac{K_t}{A_t L_t} * \frac{\partial A_t}{A_t} - \frac{K_t}{A_t L_t} * \frac{\partial L_t}{L_t}$$

We know that Labor and knowledge growth rates are $\left(n = \frac{\partial L_t}{L_t}\right)$ and $\left(g = \frac{\partial A_t}{A_t}\right)$, respectively :

$$\partial k_t = \frac{\partial K_t}{A_t L_t} - g\frac{K_t}{A_t L_t} - n\frac{K_t}{A_t L_t}$$

$$\partial k_t = \frac{\partial K_t}{A_t L_t} - \frac{K_t}{A_t L_t}[n + g] \ldots\ldots\ldots\ldots (10)$$

From equation (09), $\left(\frac{\Delta K_t}{A_t L_t} = \frac{\partial K_t}{A_t L_t} = \frac{sY_t - \delta K_t}{A_t L_t}\right)$, We get out:

$$\partial k_t = sf(k_t) - \delta k_t - nk_t - gk_t$$

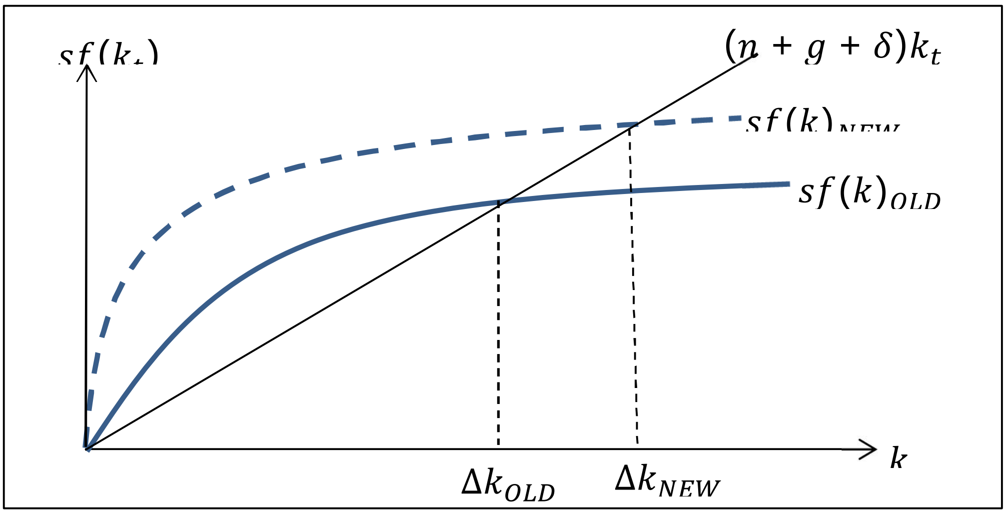
$$\Delta k_t = sf(k_t) - (n + g + \delta)k_t \ldots\ldots\ldots..(11)$$

Equation (11), indicates that the percentage change in the stock of individual capital (capital per unit of effective labor) is the difference between the actual investment per unit of labor force (individual investment) $(sf(k)$, and the break-even investment $(n + g + \delta)k$, This last indicates an amount of investment that needs to be made to keep capital $(k)$ at its current level.

There are two main reasons for increasing investment to prevent capital $(k)$ decline. First, the depreciated capital must be compensated, This is the δk term in equation (11). Second, the amount of effective labor is growing, so the volume of investments must be raised to maintain the stability of capital stock per unit of effective labor (K), since the effective labor is growing at rate $(n + g)$, capital stock should grow in the same proportion to hold k steady k steady. This is the $(n + g)$ $k$ (Romer, 2012, P 16).

Figure (1) shows that the continuous increase in the saving rate, at a constant rate, leads to an increase in the rate of growth of the output per unit of effective labor, which equals the rate of growth of knowledge, $g$, because $k$ is rising for a time.

**Fig.1. : The Effects of Increasing Saving Rate on Investment**




**Source : (Romer, 2012, P 19)**

The capital accumulation in the Solow model plays an important role in the short run, when marginal capital productivity is high, because labor is available and capital is scarce. In the long period, the rate of output growth is constant, as knowledge and population growth help to uphold the marginal productivity of capital. But Solow considered knowledge, as an exogenous parameter, and as a primary source of growth.

***2. 2. The Lucas model:***

Lucas (1988) proposed a model known in economic theories as human capital accumulation and endogenous growth. In this model, the individual allocates labor time between production and formation (lerning by doing), And the steady-state equilibrium rate of growth is achieved over the time allotted for formation.

Investing in the human element allows individuals to use the available technology through education and training. And we have two types of human capital:

- Human capital employed in production.
- Human capital employed in education and training, that improves labor efficiency.

The model propose $N$ workers, where skill levels ranging from 0 to ∞. must be skill levels of workers is, $h$, so we write $N = \int_0^\infty N(h)\,dh$. Assume further that a skilled worker $h$ devotes the fraction $u(h)$ Part of his time is devoted to production, and the remainder $1 - u(h)$ to the accumulation of human capital (lerning by doing) (Robert & Lucas, 1988, P17).

Under these assumptions, physical goods and learning by doing are generated by the same production function.

Rebelo (1991) relied on the Cobb-Douglas production function, that includes the two elements of factors of production, physical capital and human capital

$$Y = C + \dot{K} + \delta K = A(vK)^{\alpha}(uH)^{1-\propto} \quad / \quad 0 \leq\propto\leq 1 \ldots\ldots\ldots (12)$$

$$\dot{H} + \delta H = B[(1-v)K]^{\eta}[(1-u)H]^{1-\eta} \quad / \quad 0 \leq \eta \leq 1 \ldots\ldots (13)$$

where $Y$ is the production of goods (consumables and gross investment or physical capital); $A, B > 0$ , are technological progress parameters , $\propto$ and $\eta$: are the elasticity of the physical capital in the each sector, $(0 \leq u \leq 1)$ and $(0 \leq v \leq 1)$ are the proportions of human and physical capital, respectively, used in the production process. The corresponding proportions of physical and human capital used in lerning by doing that is, For human capital accumulation are $(1 - v)$ and $(1 - u)$.

The specification $\eta = 0$ implies that $v = 1$; i.e, Since physical capital $K$ is not productive in the human capital accumulation sector (education sector), Where every k used in goods sectors. So the Equations (12) and (13) They are as follows (Barro & Sala-i-Martin, 1999, P185):

$$Y = C + \dot{K} + \delta K = AK^{\alpha}(uH)^{1-\propto} \ldots\ldots\ldots (14)$$

$$\dot{H} + \delta H = B(1-u)H \ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

To simplify more , let us assume that $w = \frac{K}{H}$ and $x = \frac{C}{K}$. Therefore, we will have:

$$y_k = Au^{(1-\propto)}w^{-(1-\propto)} - x - \delta \ldots \ldots \ldots \ldots (16)$$

$$y_H = B(1-u) - \delta \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (17)$$

Where $y_k, y_h$ are growth rates of physical capital $K$ and human capital $H$.

The growth rate of $w$ is given then, by:

$$y_w = y_k K - y_H H = Au^{(1-\propto)}w^{-(1-\propto)} - B(1-u) - x \ldots \ldots (18)$$

Barro (1991) and Levine (1992) studies, have shown that in countries, where economic growth is faster, the educational level is better than in countries with low education. Whereas a study of Mac mahon (1991) on the American economy indicated that investment return in education in industrialized countries is similar to private investment in production, and is higher in developing countries, but it is decreasing.

Some economists have confirmed the decrease in human capital return. But "Lucas" assumed a constant return in human capital, as he believed that knowledge is a voluntary heritage, when individuals obtain knowledge from the preceding generations, they are obliged to improve and develop it. But, this theory relies on neoclassical hypotheses that are not appropriate for underdeveloped countries (Todaro, 2000 , PP 99-103).

### *2. 3. Endogenous technological change : The Romer model:*

Romer presented work demonstrating the relation between technological progress and economic growth for long-term. Anyone can point that the technological advanced in recent years has changed the lives of people all over the world, especially in transportation and Telecommunications.

The term technological progress indicates to all discoveries such as the discovery of the structure of DNA, the invention of hybrid cars, new production methods, and so on. These discoveries indicate the role of scientific research in generating these inventions, but the truth is that most of the technological progress in modern advanced economies countries results from firms' activities in research and development (R&D). Industrial research and development expenditures represent between 2% and 3% of gross domestic product in the four major rich countries (the United States, France, Japan, and the United Kingdom). About 75% of USA researchers working and scientists are employed by firms in the field of research and development, and US companies' spending on research and development represents more than 20% of their spending (Blanchard, 2017, PP 268-269).

Public or private scientific research is the knowledge accumulated during a period, which can be applicable or not applicable. Expenditures on knowledge and research are part of the technical progress, that allows the creation of new technology.

Economists have identified two basic properties of any economic good: the degree to which it is rivalrous and the degree to which it is excludable. Rivalry is a characteristic only of technological, that indicates that the firm or person has a purely rival good commodity can precludes its used by another firms or persons; but purely non rival good cannot in any precludes other firms or persons from using it. Excludability is related to technology and the legal system, Where the good excludable is if the owner can prevent others from using it, for example, a trademark can be excludable by code, here these rights must be protected by activating the legal system represented in the patent system (Romer, 1990, PP 73-74).

In this model, Romer proposes three sectors. And the he four basic inputs are capital, labor, human capital, and an index of the level of the technology:

Research and development sector: Are accumulations of knowledge's, and in Rivalry property allows, of any researcher can exploit the previous knowledge's:

$$\dot{A} = \delta L_A A \ldots\ldots..(19)$$

Where $A$, $L_{A,}$ are stock of knowledge, or number of existing technologies, and total human capital employed in research, respectively.

The durable goods sector: The firm that owns the patent for the production the durable good (i) to be the only firm that manufactures it. but if the owner of the patent manufactures the good itself or licenses others to do so, it can get the same monopoly profit. Thus, rivalition between firms allows for displaying different types of equipment and machinery:

$$K = \eta \sum_{i=1}^{\infty} x_i = \eta \sum_{i=1}^{A} x_i \ldots\ldots\ldots..(20)$$

Where $K$ is related to the durable goods that are actually used in production.

$x_i$: is the list of inputs used by a firm that produces final output.

The producers of final output:, the producers of final output can access to a production technology that combines number labor with a intermediate inputs to produce final goods, Which are sold in the market at unit price. Here it can be written production function for firm $(i)$ as (Barro & Xavier Sala-i-Martin, 2004, PP 285-286):

$$Y(L_y, L, x) = L_y^{\propto} L^{\beta} \sum_{i=1}^{A} x_i^{1-\propto-\beta} \qquad / \quad 0 < \propto, \beta < 1 \ldots..(21)$$

Where $L_y$ is human capital allocated to final output, $(L\ )$is physical labor, $(K = \sum x_i)$ is physical capital.

Since $(A)$ represents the number of units of durable goods that can be produced, and $(\eta)$ It is the units of capital required of each unit of durable goods. Then the value can be solved for $\bar{x}$ from the equation $K = \eta A\bar{x}$. Finally, we write the output $Y$ equation as:

$$Y(L_y, L, x) = L_y^{\propto} L^{\beta} A \left(\frac{K}{A\eta}\right)^{1-\propto-\beta}$$

$$Y(L_y, L, x) = L_y^{\propto} L^{\beta} A\, A^{\propto+\beta-1} K^{1-\propto-\beta} \eta^{\propto+\beta-1}$$

$$Y(L_y, L, x) = (L_y\, A)^{\propto} (L\, A)^{\beta} K^{1-\propto-\beta} \eta^{\propto+\beta-1} \ldots \ldots .. (22)$$

Showing the equation (22) that this model acting just like the neoclassical model with labor and human capital which increases technology growth.. This is opposed the diminishing in returns.

If we assume that technological development $(A)$ is at a fixed level, then this will lead to an equilibrium with the steady state, in which level of capital $(K)$ is determined by the condition that the marginal productivity of capital is equal to the discount rate. But if technological development $(A)$ grew at an externally determined exponential rate, then capital will grow at the same exponential rate in $(A)$, so the economy will converge , as it does in the solow model. Along the transition path, the ratio of $(K)$ to $(A)$ would change, this means that $(r)$ and $(\overline{x})$ will also change. Along the balanced growth path, $(r)$, $(\overline{x})$, and the ratio of $(K)$ to $(A$ )are all constant (Romer, 1990, P 89).

***3. A standard study:***

In this section, we employ the panel cointegration technique, to study the relation of technological development with economic growth for the period 1997-2018 for a sixteen (16) of emerging countries: Argentina, Brazil, Bulgaria, China, the Czech Republic, Greece, Hungary, Malaysia, Mexico, Philippines, Poland, the Russian Federation, the Slovak Republic, South Africa, Thailand and Turkey.

According to the data avaibility , we write the model as follows:

$$gdp = A\,(P * L)^{\alpha} K^{\beta} \quad / \quad \beta = 1 - \alpha \ldots \ldots \ldots .. (23)$$

$GDP$: Gross Domestic Product (constant 2010 US$).

$P$: Patent applications (residents + nonresidents) (technological innovation).

$L$: Labor force.

$K$: Gross capital formation (Investment) (constant 2010 US$).

Data source: World Bank Data 2019.

We can rewrite equation (23) as follows:

$$\ln(gdp) = \ln(A) + \alpha \ln(p * L) + \beta \ln(k) \ldots \ldots \ldots (24)$$

***3.1. Stationarity tests:***

Prior to conducting cointegration tests, All time series must have the same degree of integral. Therefore, they must have the unit root at the first level and be integrated of the same order $I(d)$.

Unit root examination is done with two tests :the Im, Pesaran, and Shin, and the Fisher-ADF and PP tests all allow for individual unit root processes so that may vary across cross-sections. The tests are all characterized by the combining of individual unit root tests to derive a panel-specific result.

**a. Im, Pesaran, and Shin (IPS):**

(IPS) permit for a heterogeneous coefficient of $Y_{it-1}$ and offer an alternative test based on an average individual unit root test. Im Pesaran and Shin denotes the average of the ADF tests when $u_{it}$ correlates sequentially with different serial correlation properties across cross-sectional units.. So We write the model with the following relation (Baltagi, 2005, P242):

$$\Delta y_{it} = \delta_i y_{it-1} + \sum_{j=1}^{\rho_i} \beta_{ij}\, \Delta y_{it-j} + \alpha_{mi} d_{mt} + \epsilon_{it} \qquad / \qquad m = 1,2,3 \ldots\ldots\ldots (25)$$

where the lag order $\rho_i$ is allowed to vary across individuals, $d_{mt}$ denotes a vector of deterministic variables and $\alpha_{mi}$ the vector corresponding to the coefficients of the model $m = 1,2,3$. Particularly, $d_{1t} = \{\emptyset \text{ empty set}\}$, $d_{2t} = \{1\}$ and $d_{3t} = \{1, t\}$. The $\delta_i$ coefficients are substitutions for $\rho - 1$.

We write then the null hypothesis:

$H_0$: $\delta_i = 0$ ; for all $i$

The alternative hypothesis is:

$H_1$: $\delta_i < 0$ ; for at least one $i$

After estimating the discrete ADF regressions, average the t-statistics of $\delta_i$ from the individual ADF regressions, $t_{iT_i}(\rho_i)$:

$$\overline{t_{NT}} = \frac{\left(\sum_{i=1}^{N} t_{iT_i}(\rho_i)\right)}{N} \ldots\ldots\ldots . (26)$$

In general, since the lag order in equation (25) may be non-zero for some cross-section, IPS demonstrates that a properly standardized $\overline{t_{NT}}$ has an asymptotic standard normal distribution:

$$W_{\overline{t_{NT}}} = \frac{\sqrt{N}\left(\overline{t_{NT}} - N^{-1}\sum_{i=1}^{N} E(\overline{t_{iT}}\,(\rho_i))\right)}{\sqrt{N^{-1}\sum_{i=1}^{N} \mathrm{Var}(\overline{t_{iT}}\,(\rho_i)}} \ldots\ldots\ldots (27)$$

This test takes the mean of the individual $t_i$ ADF statistics across sections and standardizes it with the expected mean and variance.

**b. Fisher-ADF and Fisher-PP:**

Fisher's (1932) used a new approach to test panel unit root results to derive tests that combine the p-values from individual unit root tests. Where this method was suggested by Maddala and Wu, and by Choi.

If we define $\pi_i$ as the p-value from any individual unit root test for cross-section $i$, then under the null of unit root for all $N$ cross-sections, we have the asymptotic result that

$$-2\sum_{i=1}^{N} \ln(\pi_i) \rightarrow \chi^2_{2N} \dots\dots\dots\dots\dots (28)$$

For both Fisher tests, you must specify the exogenous variables for the test equations. You may elect to include no exogenous regressors, to include individual constants (effects), or include individual constant and trend terms.

Table (1) reports the panel unit root tests for equation variables (24). Every test concludes that the variables are non-stationary in levels and integrated of order one $I(1)$.

**Table 1: Panel unit root test statistics**

| | IPS | | ADF-Fisher Chi-square | |
|---|---|---|---|---|
| Variable | Leve (lags=1) | Difference (lags=1) | Leve (lags=1) | difference(lags=1) |
| $\ln(gdp)$ | 2.73571 | -5.36301*** | 21.2923 | 87.7013*** |
| $\ln(P*L)$ | -1.00933 | -8.85256*** | 37.42267 | 145.595*** |
| $\ln(k)$ | 1.86486 | -8.74864*** | 16.7988 | 139.448*** |

Note : ***Indicates significance at 1% level.

**Source: prepared by the researcher, using Eviews program.**

### *3.2. Cointegration tests :*

In order to estimate the long run model, a co-integration relationship between the variables needs to be confirmed. To inspect this property we use two types of tests, the panel accommodated Johansen-Fisher test and Pedroni's Engle-Granger based tests.

**a. Combined Individual Tests (Fisher/Johansen):**

Maddala and Wu, with the help of Fisher (1932), adjusted the Johansen test to panel data.

$$\Delta y_{it} = \Pi_i y_{it-1} + \sum_{j=1}^{\rho_i} \Gamma_{ij}\,\Delta y_{it-j} + q_i z_{it} + \epsilon_{it} \dots\dots (29)$$

$y_{it}$ is a $k \times 1$ vector of endogenous variables ($k$ is the number of variables and $\delta_i$ represents the long run $k \times k$ matrix. If $1 < \text{rank}(\delta_i) < k$, the matrix can be written as $\alpha_i\beta_i'$ , where $\beta_i$ is a $r \times k$ matrix which its rows are the co-integrating vectors, while $\alpha_i$ is a $r \times k$ matrix that gives the amount of each co-integrating vector entering the error correction model.

Johansen (1988) proposes two different approaches, one of them is the likelihood ratio trace statistics, where the other one is the maximum eigenvalue statistics, both of them are shown in equations (30) and (31) respectively, to determine the presence of co-integration vectors in non-stationary time series.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1-\lambda_i) \ldots\ldots (30)$$

$$\lambda_{max}(r, r+1) = -T \sum_{i=r+1}^{n} \ln\left(1-\hat{\lambda}_{r+1}\right) \ldots\ldots (31)$$

The Johansen-Fisher test statistic is computed in a similar way as in (28), just now it is summed over the $k$-values of the cross sectional trace or maximum eigenvalue cointegration tests.

**b. Pedroni's Engle-Granger based tests:**

Our first step is to compute the regression residuals from the hypothesized co-integrating regression. In the most general case, this may take the form:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i}x_{1it} + \beta_{2i}x_{2it} + \cdots + \beta_{kit}x_{kit} + e_{it} \ldots\ldots (32)$$

$$\text{For } t = 1,2 \ldots T\,;\, i = 1,2, \ldots N\,;\, k = 1,2, \ldots, K$$

We note that for some applications, we may also wish to include deterministic time trends which are specific to individual members of the panel, and are captured by the term ( $\delta_i t$ ) although it will also often be the case that we choose to omit these ( $\delta_i t$ ) terms.

Whether we include these member-specific fixed effects or member-specific time trends will in general affect the asymptotic distributions and the corresponding critical values just as in the conventional time series case. The reason for this is because in the presence of unit roots, sample averages such as $\bar{y}_i = T^{-1}\sum_{t=1}^{T} y_{it}$ taken over the time series dimension, $T$, do not converge to population means as $T$ grows large, but instead diverge at the rate $\sqrt{T}$ (Pedroni, 1999, P 656).

To solve this problem we additionally calculate Pedroni's within-dimension and between-dimension ADF and PP test statistics. For the within-dimension statistics the test for the null of no co-integration is implemented as a residual-based test of the null hypothesis $H_0: p_i = 1$ for all $i$, versus the alternative hypothesis $H_1: p_i = p < 1$ for all $i$. By contrast, for the between-dimension statistics the null of no co-integration is implemented as a residual-based test of the null hypothesis $H_0: p_i = 1$ for all $i$, versus the alternative hypothesis $H_1: p_i < 1$, so that it does not presume a common value $p_i = p$ under the alternative hypothesis.

Table (2) shows the results of the Panel Co-integration Tests, we see for different opportunity cost in both case of Fisher trace test and Fisher max-eigen test, where it reject the null hypothesis of less than two co-integrating vectors at any level, means that there is a co-integration relationship between the study variables $(\ln(gdp), \ln(p*L) \ln(K))$ $r \leq 2$.

**Table 2: Panel cointegration tests**

| Johansen-Fisher Panel Co-integration Test | $r = 0$ | $r \leq 1$ | $r \leq 2$ |
|---|---|---|---|
| Trace statistic<br>Max-Eigen statistic | 169.9***<br>144.6*** | 62.19***<br>44.13* | 73.99***<br>73.99*** |
| Pedroni Panel Cointegration Tests | Within-Dimension | Between-Dimension | |
| ADF statistics<br>PP statistics | -3.996775***<br>-5.198632*** | -2.316109**<br>-2.052254*** | |

Note: (***) (***) Indicates rejection of the null hypothesis at (1%) and (5%) respectively.
Lag lengths by Akaike Info Criterion.

**Source: prepared by the researcher, using Eviews program.**

***3.3. Estimation of cointegrating panels relationships:***

The tests have shown that the variables are integrated of order one $I(1)$, and there is a cointegration relationship between the study variables. But if we use the OLS method, we will have a problem Heterogeneous. Therefore, a method of fully modified OLS (FMOLS) or dynamic OLS (DOLS) must be used .

**a. Fully-modified OLS:**

Phillips and Moon (1999), Pedroni (2000), and Kao and Chiang (2000) offer extensions of the Phillips and Hansen (1990) fully-modified OLS (FMOLS) estimator to panel settings.

$$Y_{it} = \beta X_{it} + \varepsilon_{it} \dots \dots \dots \dots \dots . \dots (33) \text{ and}$$

$$X_{it} = X_{it-1} + u_{xit} \dots \dots \dots \dots \dots . . (34)$$

Where an estimator by the (OLS) method for equation (33) is given by:

$$\hat{\beta}_{NT} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}X'_{it}\right]^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T} Y_{it}X'_{it}\right] \dots \dots \dots . . (35)$$

Under the assumption of bias in the panel regression, the expectation of the components in the numerator of $\sqrt{N}(\beta_{NT} - \beta)$ is generally nonzero.

$$\hat{\beta}_{NT} = B + \sum_{i=1}^{N}\sum_{t=1}^{T} e_{it}X'_{it}\left(\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}X'_{it}\right)^{-1} = \beta + \Lambda_{eX} \dots \dots \dots \dots . (36)$$

Thus, if $e_{it}$ and $u_{xit}$ are uncorrelated, so that the one sided long-run covariance $\Lambda_{eX} = 0$ , the pooled estimator $\hat{\beta}_{NT}$ is $\sqrt{NT}$ consistent, and has a limiting normal distribution in joint asymptotics as $(N, T \to \infty)$ when $N/T \to \infty$.

when $\Lambda_{eX} = 0$, we do not attain $\sqrt{NT}$ consistency with the pooled least squares estimator $\hat{\beta}_{NT}$, because of the persistence of bias effects. However, we may "fully modify " the regresor y to eliminate the serial correction $\Lambda_{eX}$ (Peter, Hyungsik & Moon, 1999, P 1084).

For $i = 1,2, \dots, N$, the vector of errors $(\varepsilon_{it}, u_{xit})'$ is stationary with asymptotic covariance matrix $\Omega_i$. The pooled FMOLS estimator is then given by

$$\hat{\beta}_{FMOLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{X}_{it}\tilde{X}'_{it}\right]^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{Y}^{*}_{it}\tilde{X}'_{it} - NT\hat{\Lambda}^{*}_{eX}\right] \dots\dots\dots (37)$$

Where $\tilde{Y}_{it} = (Y_{it} - \bar{Y})$ and $\tilde{X}_{it} = (X_{it} - \bar{X})$ are the time demeaned versions of the variables, and the FMOLS corrections are now such that

$$Y^{*}_{it} = \tilde{Y}_{it} - \hat{\Omega}_{eX}\Omega^{-1}_{XX}\Delta\tilde{X}_{it} \dots\dots\dots\dots\dots (38)$$

$$\hat{\Lambda}^{*}_{eX} = \hat{\Lambda}_{eX} - \hat{\Omega}_{eX}\Omega^{-1}_{XX}\hat{\Lambda}_{XX} \dots\dots\dots (39)$$

Pedroni (2000, 2001) proposes a grouped-mean FMOLS estimator which averages over the individual cross-section FMOLS estimates: The group mean FMOLS estimator

$$\hat{\beta}_{GMOLS} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(\sum_{t=1}^{T}\tilde{X}_{it}\tilde{X}'_{it}\right)^{-1}\left(\sum_{t=1}^{T}\tilde{Y}^{*}_{it}\tilde{X}'_{it} - NT\hat{\Lambda}^{*}_{eX}\right)\right] \dots\dots\dots (40)$$

**b. Dynamic OLS:**

Kao and Chiang (2000) describe the pooled DOLS estimator in which we use ordinary least squares to estimate an augmented co-integrating regression equation:

$$\tilde{Y}_{it} = \beta\tilde{X}_{it} + \sum_{j=-k_i}^{k_i} Q_{ij}\,\Delta\tilde{X}_{it+j} + \tilde{v}_{it} \dots\dots\dots\dots (41)$$

Where $\tilde{Y}_{it}$ and $\tilde{X}_{it}$ are the data purged of the individual deterministic trends.

Let $\tilde{Z}_{it}$ be regressors formed by interacting the $\Delta\tilde{X}_{it+j}$ terms with cross-section dummy variables, and let $\tilde{W}_{it} = (\tilde{X}_{it}\ \tilde{Z}_{it})$. Then the pooled DOLS estimator may be written as

$$\hat{\beta}_{DOLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{W}_{it}\tilde{W}'_{it}\right]^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{Y}^{*}_{it}\tilde{W}'_{it}\right] \dots\dots\dots\dots\dots (42)$$

Pedroni (2001) extends the grouped estimator concept to DOLS estimation by averaging over the individual cross-section DOLS estimates:

$$\hat{\beta}_{GDOLS} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(\sum_{t=1}^{T}\tilde{W}_{it}\tilde{W}'_{it}\right)^{-1}\left(\sum_{t=1}^{T}\tilde{Y}^{*}_{it}\tilde{W}'_{it}\right)\right] \dots\dots\dots\dots\dots (43)$$

The within-dimension DOLS estimates for the coefficients on the effective labor force or subsidized labor force $\ln(P * L)$ and gross capital formation (investment) $\ln(K)$ in column 1 of the left part of Table (3). We note that, $\ln(K)$ Is positive and highly significant, and $\ln(P * L)$ is also positive, but not significant. The results show that in the long run, if effective labor force increases by 1%, the GDP will grow by 0.022%. Similarly, if the gross capital formation (investment) increases by 1%, the GDP will grow by 0.69%. But as we said, the coefficient of effective labor force is not significant.

The between-dimension DOLS estimates for the coefficients on the effective labor force $\ln(P * L)$ and gross capital formation (investment) $\ln(K)$ in column 1 of the left part of Table (3). We note that the estimated coefficients of both $\ln(P * L)$ and $\ln(K)$ , are positive and highly significant. The results show that in the long run, if effective labor force increases by 1%, the GDP will grow by 0. 07%. Similarly, if the gross capital formation (investment) increases by 1%, the GDP will grow by 0.50%.

In addition to that, table (3) also provides the estimates of within-dimension and between-dimension FMOLS estimates. We show the results for of within-dimension FMOLS estimates in column 1 of the right part, for the coefficients on the effective labor force $\ln(P * L)$ and gross capital formation (investment) $\ln(K)$. As it was indicated, $\ln(K)$ is positive and highly significant, and $\ln(P * L)$ is negative but not significant. The results show that in the long run, if effective labor force increases by 1%, the GDP will Decreases by 0.001%, meaning that the effect of effective labor force is weak. On the contrary, if the gross capital formation increases by 1%, the GDP will grow by 0.64%.

Finally, we show the between-dimension FMOLS estimates in column 2 of the right part of table (3). We note that, both $\ln(P * L)$ and $\ln(K)$ are positive and highly significant.

Also, as we have seen from the table (3) the within-dimension DOLS and FMOLS estimates, the coefficients and standard deviations are roughly the same. As well as the case of the between-dimension DOLS and FMOLS estimates, there is an exact match for the coefficients and the standard deviations. On the other hand, the between-dimension estimator allows for cross-sectional slope variation and is calculated as the average of the individual cross section $\hat{\beta}_G$ coefficients and the t-statistic is the average of the individual t-statistics. So, the robustness check shows that the elasticity of GDP on both the effective labor force and gross capital formation (investment) does not vary over different estimation methods. This allows us to conclude that there are no specification problems.

**Table 3: DOLS and FMOLS Estimates of the Long Run Relationship**

| Dependent variable : $\ln(gdp)$ | | | | |
|---|---|---|---|---|
| | DOLS | | FMOLS | |
| Variables | Within-demension | Between-demension | Within-demension | Between-demension |
| $\ln(P * L)$ | 0.022<br>(0.95) | 0.07<br>(2.69) *** | -0.001<br>(-0.05) | 0.08<br>(2.69) *** |
| $\ln(K)$ | 0.69<br>(19.53) *** | 0.50<br>(11.84) *** | 0.64<br>(39.48) *** | 0.50<br>(11.84) *** |

Notes: The t-student value in parentheses.

Lead and lag lengths for DOLS are suggested by Akaike Info Criterion.

(***) Indicates significance at 1%.

**Source: prepared by the researcher, using Eviews program**

Finally, We conclude that economic growth in the emergent countries surveyed sixteen countries is largely determined by both gross capital formation (investment) and the labor force, but the impact of technological innovation is weak.

**4. CONCLUSION**

The study, which included sixteen emerging countries from different regions of the world, indicated that economic growth is affected by both the gross capital formation (investment) and the labor force, but the impact of technological innovation was weak, Therefore, we believe that the economic growth in emergent countries recorded by some countries such as China is mainly due to direct and indirect foreign investment and lower labor costs, We also refer to China, where the internal market is weak because the GDP per capita is low compared to the developed countries.

The limited impact of technological innovation, is due to the recentness of this sector and the modernity of these countries in most economic fields, especially industry and foreign trade. There is also, a big gap between them and the developed countries that have reached this level of technological progress after a long period. Finally, we present the following recommendations and suggestions:

- the involvement of the private sector in scientific research and technological innovation.
- The necessity of periodic reforms in the sectors of education and scientific research.
- Knowing the business sector needs of appropriate technological innovations and presenting them to the scientific research sector, meaning linking the business sector with scientific research.
- Increasing the number of researchers in the country, because the greater their number, the greater the technological innovation

**5. *Bibliography List* :**

***Books* :**

- Baltagi, B, H. (2005). Econometric Analysis of Panel Data, 3rd Ed, England: John Wiley & Sons Ltd.
- Barro, R. & Sala-i-Martin X. (2004). Economic growth. 2nd ed, England: The MIT Press Cambridge.
- Barro R. & Sala-i-Martin X. (1999). Economic growth. 1st ed, England. The MIT Press Cambridge.
- Blanchard, O. (2017). Macroeconomics. (7th Ed), England: PEARSON.
- Osipian, A. L. (2009), the impact of human capital on economic growth. USA: palgrave macmillan press.
- Romer, D. (2012). Advanced macroeconomics. 4th ed, United States of America: McGraw-Hill Irwin.
- Todaro, M. (2000). economic development, 7th Ed, Addisonwesley.
- Tsionas, M. (2019). Panel Data Econometrics: Empirical Applications. 1st ed, USA: Academic Press.
- Wooldridge, J. (2001). Econometric Analysis of Cross Section and Panel Data. England: MIT press.

**1. *Journal article***

- Kuznets S, (Jun 1973), Modern Economic Growth: Findings and Reflections, American Economic Association, USA, Vol 63, N0 3.
- Lucas, R ,E. (1988). On the mechanics of economic development, Journal of Monetary Economics, North-Holland, Vol 22.
- Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors, Oxford Bulletin of Economics and statistics, 61(S1), 653-670.
- Peter, C. B. Hyungsik, P& Moon, R. (1999). linear regression limit theory for nonstationary panel data, Econometrica, Vol 67, N05, 1057-1111.
- Romer, P. M. (1990). Technological Change, The Journal of Political Economy, USA: University of Chicago Press, Vol.98, N05, Part 2.