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Paul Römer's 90 Model and South Korean Economic Growth: An Econometric Study

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Abstract: The South Korean economy has experienced rapid growth since the end of the Korean War. Industrial production became very important in its economy. The service industry has developed such as telecommunications, government services, trade, and transportation through the reliance on human capital. Many economic models and theories have interpreted economic growth through human capital and knowledge, such as Paul Römer's 90 model. This study aims to apply this model of economic growth in the case of South Korea during the period 1979-2018 using an econometric study. Our econometric study is based on the production function of the Paul Römer'90 model. We found that the labor force has a positive impact on the GDP and this effect increases in the long run by 5 doubles during the study period. For patents, their impact has increased also by 7.46 doubles. While the effect of capital accumulation decreased in the long run. We conclude that the human factor and patents have played a large role in the long run South Korean economic growth as stated in the Römer model.

Keywords: Economic growth; Paul Römer's 90 model; South Korea; Econometric study.

Introduction

After the Second World War and the Korean War (1950-1953), South Korea's economy was similar to the poorest African countries. This situation made many economists pessimistic about the future of the Republic of Korea. Now South Korea has become one of the strongest economies in the world. After GDP per capita was 160 dollars in the 1960s, it reached 31362 dollars in 2018 (World Bank, 2018). Its economic growth has experienced continuous acceleration during the past four decades. This was the result of great efforts by the country's governments, which made it among the first 10 countries in the world after it was economically collapsed after the Korean War in 1953.

South Korea has gone through several stages since the 1960s, it started growing rice, and based on small manufacturing sectors with labor-intensive (textiles, bicycles, and leather). During this period, it adopted the policy of manufacturing for export. Because of the low cost of its products it has been able to compete in the international market. It opened its markets to foreign investment, especially the USA and Japan. Capital accumulations, investment in education, and technologies obtained through foreign licensing have allowed the production of developed goods (Kwan, 1991, p.3).

In the 1970s, Korea witnessed a major transformation in the development of heavy industries such as (chemicals and shipbuilding). Policies were also developed to improve technological capabilities and technical and professional quality. In the 1980s, it liberalized trade and many different sectors, paid more attention to higher education, and began investing in research and development by establishing the National Research and Development Program (Kwan, 1991).

After the 1990s, Korea focused on manufacturing with high added value by encouraging innovation and establishing modern information infrastructure. There has also been a continuous expansion of research and development capabilities in Korean industries,

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which are based on the skilled workforce generated by the higher education system (Suh & Chen, 2007, p.7).

The financial crisis in 1997 led to a great recession due to the large decrease in consumption, investment, and exports, which are considered the basis for Korea's growth. In 1998, exports decreased by 20% compared to the previous year. During the third quarter of 1998, Korea posted a contraction of 8.1%, the lowest growth rate since the Korean government began compiling economic growth statistics in 1953 (Lee & Mcnulty, 2003, p.4).

Korea is witnessing a major development in all sectors, especially RD and TIC. According to the KEI Index for the year 2012, South Korea ranked 29 with a score of 7.97. It is located in the second row, which is between 5.96 and 8.1 determined by the World Bank (2012). The knowledge index reached 8.65, the economic incentives index at 5.93, and the indicators of creativity, education, and ITC have reached 8.8, 9.9, and 8.05, respectively. Thus, we note that the education index ranked first (World Bank, 2012).

Korea topped the list of countries in the world for the best educational system in cognitive skills and educational attainment. It also ranked fifth in the number of patents by owning the two largest companies in the world in the number of patents (Samsung and LG Electronics) (Pearson Report, 2014). It was ranked as the most innovative economy in the world and it also ranked first in the proportion of spending on RD for the year 2018 (Global Innovation Index, 2018).

The classic policies and institutions that have led Korea to higher levels of growth have become a hindrance to achieving sustainable economic growth in the new economic environment. Accordingly, great political efforts were made to transform the Korean economy into an economy based on knowledge where innovation can boost productivity and maintain economic growth (Suh & Chen, 2007, p.7).

The macroeconomic models developed by Ramsey (1928), Cass (1965), and Koopmans (1965) are the theoretical basis for many economists for long-run economic growth. They consider that the rate of return on investment and the rate of GDP per capita lead to a decrease in returns of human capital over time. The Romer model provides a different view, he sees that GDP per capita can grow without restrictions, the rate of investment, and the rate of return on capital can rise. This is due to the hypothesis of these theories, which are the diminishing returns on capital per capita and the absence of technological progress. Technological progress is an endogenous variable and the accumulation of knowledge is the basis in the long run because knowledge will grow without limits, even if all other inputs remain constant (Romer, 1986, p.1004)

With all these accomplishments and given what the economic theories touched on the topic of economic growth, the Paul Romer's 90 model in particular, which spoke about the role of scientific research in economic growth in the long run, we present the following problem:

How compatible is South Korea's economic growth with the Paul Romer'90 model? We chose 1979-2018 as a period of study because it is the period of rapid growth in South Korea.

Research hypothesis: Human factors (Knowledge and innovation) play a major role in South Korea's economic growth.

Research importance: The importance of research is to know the extent to which human capital (knowledge and innovation) contributes to achieving the sustainable economic growth of countries by taking South Korea as an example. Demonstrate that investing in human capital requires a long period to achieve sustainable economic growth as stated in Romer'90 model. Therefore, in this context, we clarify the importance of economic

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theories for the advancement of the economy of countries, because there are many countries (especially underdeveloped and developing countries) that do not give much importance to economic theories.

Research methodology: To reach the result, we applied an econometric study by using Eviews 10. The data is taken from the World Bank (2018) database. We relied on the production function that Römer developed in 1990 as a model for the study (this is the difference between our study and other studies). The remainder of this paper is divided as follows: The following section reviews the literature on Paul Romer's model through the economic sectors on which the model relied to arrive at the production function, the most important criticisms of the model, and Romer's arguments for adopting the model. In this section, we also studied the characteristics of the Korean economy by highlighting its most important indicators such as the development of GDP, the rate of economic growth, and the most important indicators of the knowledge economy. We concluded this section with the most important ancient and recent studies on the topic. The second section explains the methodology applied in the econometric study by adopting the Paul Romer production function and based on ECM. The final section includes the concluding remarks and implications of the study.

Literature review

The concept of human capital has become an important part of economic growth strategies. Schultz (1972) believes that education is a major factor in increasing income. "The increase in national income was substantial through investment in human capital and the reversal of the increase in working hours and the increase in capital." (Schultz, 1972, p.13). Many economists have demonstrated the importance of human capital in the production process at the microeconomics and its importance in economic growth at the macroeconomics, such as the ideas of Gary (1980).

Among the most important models and theories in this topic is Romer's 90 model.

Paul Romer's 90 Model

The most important contribution of Romer'90 (an extension of the Solow model) model was the division of the economic goods into things and ideas: (Romer, 1990)

Things: The raw materials that come from nature (minerals, silicon, carbon atoms, oxygen ... etc.).

Ideas: The instructions that we use these things to be converted into (computer parts, phone, antibiotic ... etc).

New ideas are the optimal way to organize raw materials in more beneficial ways. The amount of raw materials in nature is relatively limited but the number of ways in which these raw materials are organized is unlimited. Therefore, economic growth occurs whenever better methods of using raw materials are discovered, or in other words, sustainable economic growth occurs because we discover new ideas.

The main idea from which Römer started is that ideas are not competitive. Did he give an example, how to save children from diarrhea that has caused millions of deaths? With a simple idea of oral rehydration therapy by dissolving a few minerals, salts, and sugar in water. This idea saves children's lives. Once this idea is discovered, it can be used to save any number of children every year. This chemical formula does not become rare as more people use it.

Uncompetitive ideas are key to growth. It increases returns on a large scale. For example, if we want to double the production of computers, we create a new factory with the same capabilities as the first factory. It has the same returns. Here we do not need to reinvent the idea every time, where we can use the same idea, the same guidelines, and the same design in the new factory. Therefore, returns are growing on inputs and ideas. Increasing the number of factories leads to an increase in GDP (Jones, 2019, p.859).

The Roemer model takes into account the peculiarity of technological knowledge; it is an uncompetitive economic commodity. Where a person, several people, or institutions at the same time use it, it can be prevented in some cases, or sold as patents.

Based on this description, Romer (1990) proposed three sectors:

Research Sector

This sector produces ideas and knowledge; it depends on the amount of human capital allocated to the research and on the stock of knowledge available to researchers. Assuming that any person participating in the research has free access to the entire stock of knowledge because knowledge is not competitive and any researcher can rely on the research that preceded it.

The total stock of knowledge develops according to the following formula:

$$\dot{A} = \delta . L_A . A \qquad (1)$$

$\dot{A}$**:** The stock of knowledge changes.
A**:** Available stock knowledge.
L_A**:** Research Human Capital.
δ**:** Parameter describing the efficiency or productivity of the research sector such that 0 <δ

From equation (1), we find that allocating more human capital in the research sector increases the rate of new inventions. The high total stock of knowledge increases the productivity of the researcher who works in the research sector. For example, the researcher at present has more productivity, because he can benefit from a stock of knowledge accumulated years ago by previous researchers (Romer, 1990, p.88).

Intermediate Commodities Sector

In this sector, each invention produced by researchers leads to the production of the new machine or new intermediate commodity. The accumulation of capital is considered heterogeneous and it is the sum of different commodities, where:

$$K = \sum_{i=1}^{A} X_i \qquad (2)$$

X_i**:** The quantity available for any type of capital goods.
(*i*): The company that makes a specific type of capital goods.

It purchases patents for this invention at a fixed cost and it has the exclusive right to use it. Thus, it has a monopolistic position in the market (Romer, 1990, p.82).

Consumer Goods Sector

It is the sum of the companies that produce the final goods (homogeneous goods), depending on the capital goods that were produced by the previous sector with human capital. The production function is written according to the following formula:

$$\varphi = L_y^{1-\beta} \sum_{i=1}^{A} X_i^{\beta} \qquad (3)$$

L_y: Labor demand used in the production of goods, where 0 <β <1.
Equation (3) is the same as the Cobb-Douglas function, with the heterogeneity of capital (Romer, 1990, p.89).

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Doubling the capital by multiplying the quantity of each component is not the same if the sum of the components multiplied. The capital elasticity in the first case is equal to β and in the second it equals 1, and from it, the equation (4) is written as follows:

$$\varphi = L_y^{1-\beta}.A^{1-\beta}.K^{\beta} \qquad (4)$$

This model consists of an allocation of the total workforce between innovation and production activities and the product between consumption and investment. So the growth rate is determined by innovation and the physical capital. We get (g) the balanced growth rate and ($\dot{g}$) optimal social growth rate (Romer, 1990):

$$g = \frac{\delta.L - \left[\frac{P}{(1-\beta)}\right]}{1 + \left[\frac{1}{(1-\beta)}\right]} \qquad (5)$$

$$\dot{g} = \delta.L - P \qquad (6)$$

Three situations can be described for the dynamics of the economy (Guellec & Ralle, 2003):

- Total human capital is the determinant of the growth rate not the size of the economy because of the fixed cost of research activity;
- The balanced growth rate is below the optimal level because 1> β and the private clients do not take into account the external factors resulting from their activity;
- Public policy (which aims at rapid economic growth) should focus on research not investment because the increase in investment leads to the increase in balanced output, not the rate of growth.

Römer's 90 model has been criticized, and among the most important ones (Ben kana, 2012):

- Reliance on human capital for growth is not valid for all countries;
- The human capital stability hypothesis is incorrect, the human capital may grow with other factors constant, which leads to a significant increase in growth rates;
- Neglecting the substitution idea, the replenishment of the commodity stock does not eliminate the old stock.

Romer (1990) responded to these criticisms and said that countries should be compared with countries of their size and development, so we cannot compare the growth model of the USA with the growth model of South Korea.

The economy of South Korea

South Korea's economy ranks 15th in the world according to GDP and 12th in purchasing power parity, which makes South Korea among the G20. South Korea ranks among the high-income developed countries and is a member of the OECD. South Korea has an economy that was among the fastest-growing between the 1960s and 1990s, and also in the first decade of the 21st century.

Korea has no natural resources and is constantly suffering from overpopulation in a small area, which prompted it to adopt an export strategy to develop its economy, and among the most important indicators of its economy:

Economic Growth

South Korea has become one of the strongest economies in the world. After GDP per capita was 160 dollars in the 1960s, it reached 31362 dollars in 2018 (World Bank, 2018). Its economic growth has experienced continuous acceleration during the past four decades (Figure 1). This was the result of great efforts by the country's governments. Korea has instituted several reforms:

- Recapitalization of financial institutions;
- Eliminating bad loans;
- Supporting low-income families with financial facilities and social programs.

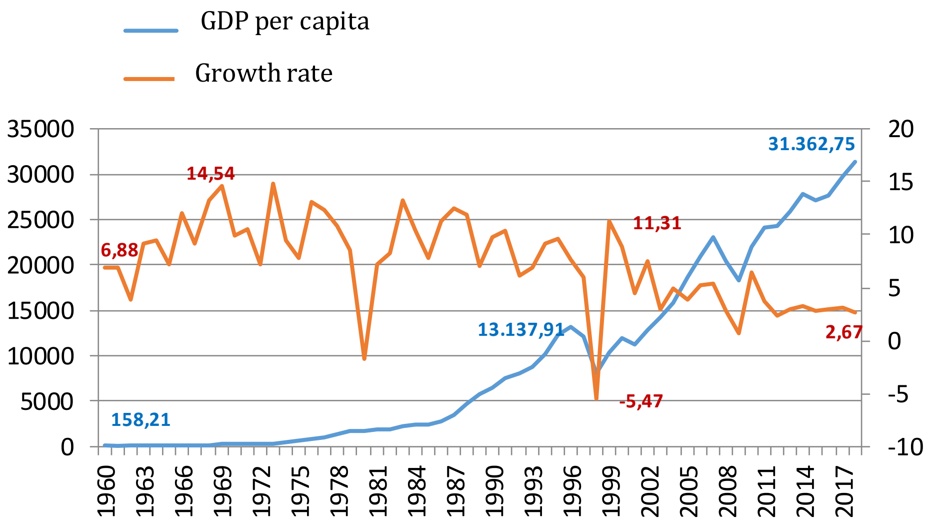

Figure 1. GDP per capita, growth rate
(World Bank, 2018)

Knowledge economy

Based on KEI, South Korea ranked 29 with a score of 7.97 in 2012. It is located in the second row based on the World Bank reports. The knowledge index reached 8.65, the economic incentives index at 5.93, and the indicators of creativity, education, and ITC have reached 8.8, 9.9, and 8.05, respectively (World Bank, 2012). Thus, we note that the education index ranked first (Figure 2).

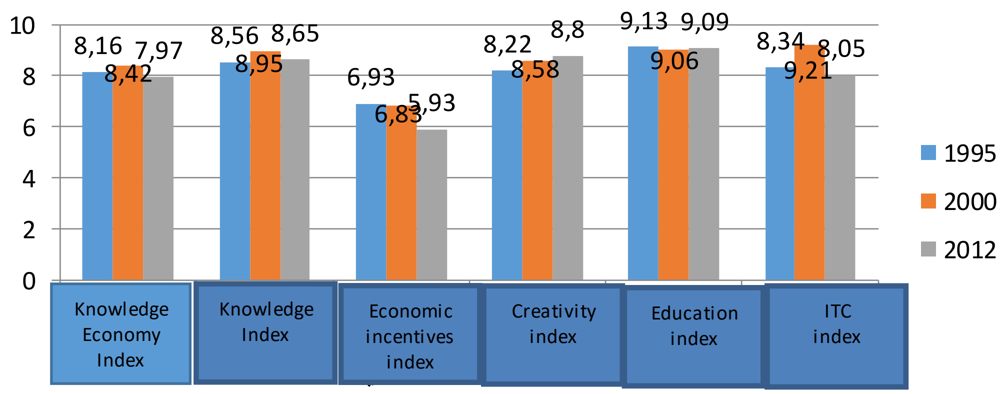

Figure 2. KEI
(World Bank, 2012)

These results were due to the volume of spending. Korea ranked first in the proportion of spending on research and development, which in 2016 amounted to 4.23% of the GDP (World Bank, 2018). The following figure shows the evolution of the volume of spending:

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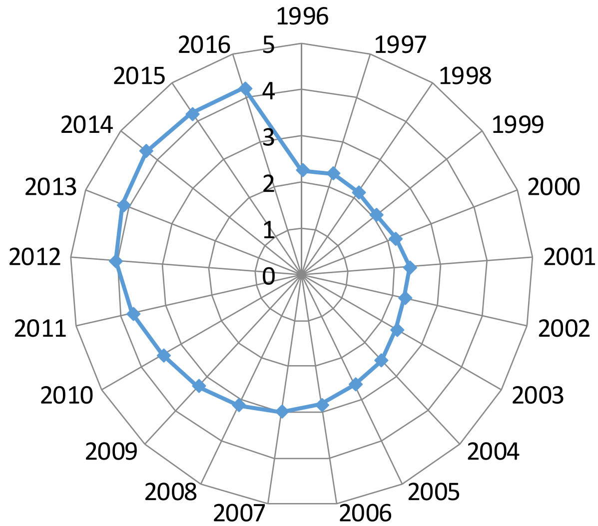

Figure 3. R&D Expenditure (% of GDP)
(World Bank, 2018)

Previous studies

Many studies have examined the relationship of capital human indicators (research and development) to economic growth in countries (Denison, 1962). The study was considered one of the most important studies on the sources of economic growth in the USA. He used the education factor to explain economic growth, and he found that increasing the average education factor for a worker by 2% leads to an increase in real GDP by 67%.

Barro and Lee (1993) described the educational attainment for 129 countries during 1960-1985. They used a percentage of school enrollment for males and females at four levels: no-schooling, primary secondary, and higher. They found that educational attainment had a significant impact on economic growth and male impact is greater than the female one.

Coe and Helpman (1995), using data from 21 OECD countries during the period 1971-1990, they found that local research and development and foreign knowledge stocks lead to an increase in productivity and growth (Coe, Helpman, & Hoffmaister, 1997). They demonstrated that developing countries through their international trade with developed countries can benefit more from research and development results than to invest in research and development. Bayoumi, Coe, and Helpman (1999) found that despite the long-run impact of local research and development on productivity, a country could achieve higher productivity by increasing the stock of knowledge relying on international trade.

Frantzen (2000) using a cross-country analysis of OECD countries, he found that economic growth is linked to innovation (which has been influenced by domestic and foreign research and development). Kang (2006) tested the key proposition of the endogenous growth model, namely the constant returns to scale in physical and human capital using time series data for South Korea for the two periods, 1962–1990 and 1954–1990. He found that physical capital does not seem to receive its social returns, suggesting the possibility of externalities. However, the test of externalities does not support it. The effect of externalities on TFP was examined and the presence of externalities due to human capital and exports was found only in 1962–1990.

Coe, Helpman, and Hoffmaister (2009) showed that countries with high levels of human capital and a better business environment benefit more from domestic and international research and development. Eberhardt, Christian, and Hubert (2013), through their studies, demonstrated the importance of research and development impacts on the economy.

We will summarize the modern studies in the following table:

Table 1. Summary of previous studies

Authors	Sample & Period	Purpose of the study	Results
Blanco, Prieger, and Gu (2016)	State of USA 1963-2007	the impact of R&D on total factor productivity	Positive impact
Hanushek (2013)	developing countries	The role of human capital in economic growth	Without improving school quality, developing countries will find it difficult to improve their long-run economic performance.
Li and Jiang (2016)	China 1995-2014	Contribution of spending on R&D and patents to economic growth	Positive impact
Akcigit, Celik, and Greenwood (2016)	USA 1980-2011	The analysis gauges how efficiency in the patent market affects growth	The market for patents may play an important role in correcting the misallocation of ideas across firms. It may also influence a firm's R&D decision
Prieto (2017)	Cross-country (74 countries) 2011-2014	Contribution of science and Technology Indicators to economic growth	Positive impact
Hanusch, Chakraborty, and Khurana (2017)	G 20 countries 2000-2010	Relationship between the specific categories of public expenditures (human capital formation, defense, infrastructure development, and technological innovation) and economic growth,	The impact of innovation spending is the higher
Raghupathi and Raghupathi (2017)	OECD countries 2000-2010	the role of economic indicators in country-level innovation	Education enrollment stimulates innovation
Li, Loyalka, Rozelle, and Wu (2017)	China 1980-2014	the sources and prospects for economic growth in China with a focus on human capital	China has made substantial strides both in the education level of its population and in the way that education is being rewarded in its labor markets
Khaled (2018)	6 Arab countries 2000-2014	Measuring the impact of R&D on economic growth	The very slow positive impact
Zaman, Khan, Ahmad, and Aamir (2018)	20 countries from (east Asia, the European Union, and OECD) 1980-2011	The relationship between R&D index, R&D expenditures, and researchers working in the field of R&D on economic growth	A long-run relationship

Econometric study

The model

Our model is the same as that of Romer (1990), which is written according to the following formula:

$$Y = (L_y.A)^{1-\beta}.K^{\beta}$$

The model form can be formulated as follows:

$$Y = f(L_y, A, K)$$

After entering the logarithm, we write the model in the following linear relationship:

$$lgY = C + \beta_1 lgL_y + \beta_2 lgA + B_3 lgK + \varepsilon i$$

Where:
Y: GDP;
L_y: Total labor force;
A: Patent applications;
K: Gross fixed capital formation;
ε_i : Random error;
C: Constant;
β_i : Parameters to be estimated.

Unit Root Test

We apply the ADF stationary test to make sure that all variables are stationary at a level I (0), at the first difference I (1), or at the second difference I (2). The ADF test depends on the lag length and it is defined as a zero-based on the partial auto-correlation function. The following table summarizes the ADF test:

Table 2. Unit Root Test

Variables		Model type	Prob	Decision
LgY	First Difference	Trend & C	0.00	I(1)
LgL_y	First Difference	Trend & C	0.00	I(1)
LgA	First Difference	Trend & C	0.00	I(1)
LgK	First Difference	Trend & C	0.00	I(1)

From the results shown in the table above, we notice that all the variables are stationary at the first difference. This indicates the possibility of a co-integration and long-run relationship. To prove this, we apply the Johansen test, which is based on two tests, the trace test, and the Maximum Eigenvalue test.

Co-integration Test According to Johansson Method

Table 3. Trace Test

Unrestricted Co-integration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob**
None *	0.504944	42.49759	40.17493	0.0286
At most 1	0.179172	15.78035	24.27596	0.3957
At most 2	0.158818	8.277565	12.32090	0.2160
At most 3	0.043891	1.705561	4.129906	0.2251

Table 4. Maximum Eigenvalue Test

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob**
None *	0.504944	26.71724	24.15921	0.0221
At most 1	0.179172	7.502788	17.79730	0.7597
At most 2	0.158818	6.572004	11.22480	0.2891
At most 3	0.043891	1.705561	4.129906	0.2251

After conducting the co-integration test according to the Johansson method and from Tables 3 and 4, we note that there is at most one co-integration equation. From this, it is possible to estimate the model using ECM.

Error Correction Model Estimation

Table 5. Short-Run Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLGL$_Y$	0.059719	0.074348	0.803237	0.4274
DLGA	0.026167	0.056705	0.461463	0.6474
DLGK	0.777858	0.046636	16.67945	0.0000
RT(-1)	-0.18501	0.090649	-2.040951	0.0491
C	0.016323	0.007067	2.309837	0.0271
R^2	0.935313	D-W		1.961359
Adj R^2	0.927703	Prob(F-statistic)		0.000000

From Table 5 we note that the probability of fisher statistic is less than 0.05, i.e. the model is significant. The adjusted correlation coefficient R^2adj equals 0.927, meaning that the independent variables explain the dependent variable by 92%. For the parameters of the model, the labor force and patent applications are not significant, because according to the Römer model, they affect growth in the long run. The gross fixed capital formation is significant. The error correction parameter is negative and significant.

The model is written as follows:

$$DLgY = 0.05\ DLgL_Y + 0.02\ DLgA + 0.77\ DLgK - 0.18\ RT(-1) + 0.01$$
$$(0.4) \quad (0.6) \quad (0.00) \quad (0.04) \quad (0.02)$$

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Table 6. Long-Run Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LgL_Y	0.291472	0.140096	2.080524	0.0447
LgA	0.193868	0.044775	4.329815	0.0001
LgK	0.698981	0.052368	13.34737	0.0000
C	1.831184	2.157787	0.848640	0.4017
R^2	0.996170	D-W		1.912385
Adj R^2	0.995851	Prob(F-statistic)		0.000000

From Table 6 we note that the probability of fisher statistic is less than 0.05, i.e. the model is significant. The adjusted correlation coefficient R^2adj equals 0.995, meaning that the independent variables explain the dependent variable by 99%. For the parameters of the model, they are all significant at 5%. The model is written as follows:

$$LgY = 0.291\ LgL_Y + 0.194\ LgA + 0.699\ LgK + 1.831$$
$$(0.04) \quad (0.00) \quad (0.00) \quad (0.4)$$

Diagnostic Tests

From table 7 we denote the following observations:

- The Serial Correlation LM test indicates that Fisher's probability (0.68) is greater than the 5%, so we accept the null hypothesis implying that there is no autocorrelation of residuals;
- The heteroskedasticity test indicates that Fisher's probability (0.68) is greater than 5%, so we accept the null hypothesis; the variance is stable;
- The normality test indicates that Jarque-Bera's probability (0.35c) is greater than 5%, so we accept the null hypothesis; the residuals are normally distributed;
- Ramsey Reset test indicates that Fisher's probability (0.65) is greater than 5%, so we accept the null hypothesis; the model is correctly specified.
-

Table 7. The Diagnostic Tests Outcomes

Breusch-Godfrey Serial Correlation LM Test			
Null hypothesis (H0): There is no auto-correlation of residuals			
0.6800	Prob. F(1,36)	1.711242	F-Statistic
0.6699	Prob. Chi-Square(1)	3.664683	Obs*R-squared
Heteroskedasticity Test ARCH			
Null hypothesis (H0): stability of variance			
0.6800	Prob. F(1,36)	0.172952	F-Statistique
0.6699	Prob. Chi-Square(1)	0.181687	Obs*R-Squared
Jarque-Bera Normality test			
Null hypothesis (H0): Residuals are normality distributed			
0.3588	Prob	2.044304	Jarque-Bera
Ramsey Reset Test			
Null hypothesis (H0): the model is correctly specified			
0.65	Prob	0.45	t-Statistique
0.65	Prob	0.20	F-Statistique

The structural stability test of the model (CUSUM test) indicates that the model is structurally stable:

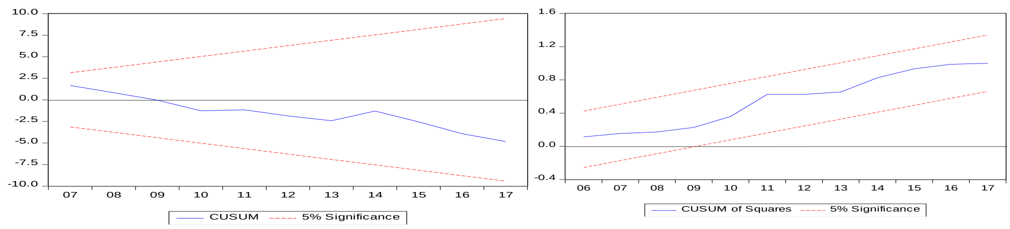

Figure 4. CUSUM and CUSUM² Tests

Concluding remarks

South Korea's economy occupied a good place at the international level and it became a developed country in a short period. Its economic growth has become one of the highest in the world; this is due to the large investment in education and training, encouraging innovation through large expenditures on research and development, and the exploitation of knowledge in economic activity. It became the owner of the biggest companies in the world in the field of technology and services.

Through this study, we shed light on an important aspect of the success of this experience for this country, which has already achieved a miracle in a short period. It is knowledge through the contribution of human capital to its economic growth. In this study, we relied on the model developed by Romer (1990), which considers that long-term economic growth depends on discoveries and ideas, among which are the number of patents.

In this study, we relied on four variables, which are the same as in the Romer (1990) model: GDP as a dependent variable, total labor force, patents and total fixed capital formation are independent variables in the period 1979-2018, which is the period that witnessed a major transformation for South Korea. To know the impact of these variables on the GDP; Two models were formulated; a short-term model and a long-term model and the results were as follows:
- From the short-run equation, we note that the labor force, patents and fixed capital accumulation have a positive effect on GDP. An increase of 1% of the labor force, patents and fixed capital formation leads to an increase of the GDP by 0.059%, 0.026% and 0.778% respectively.
- In the long run, all variables also have a positive effect on GDP. An increase of 1% of the labor force, patents, and fixed capital accumulation leads to an increase in the GDP by 0.291%, 19.04%, and 0.699% respectively.
- From the two equations, we notice that the effect of the labor force increased in the long run by 5 doubles, the impact of patents increased by 7.46 doubles and the effect of fixed capital accumulation had not changed.

Through our study on South Korea's economic growth using the Römer model of 1990, we found that South Korea's economic growth is in line with what Römer decided in his model, which requires that long-run economic growth is determined by new inventions and ideas. We noted also from this study that the effect of fixed capital accumulation decreased in the long run, unlike the labor force and patents. These results indicate that the economic growth of South Korea during this period was able to achieve high rates due to human capital and new inventions (so we accept our research hypothesis). As Blanco et al. (2016), Li and Jiang (2016), and Zaman et al. (2018) studies, our study proved that human capital through labor force and patents had a significant impact on long-run economic growth.

Our study differs from other studies in the applied model. We studied the impact of labor force and patents (Romer's model variables) on fast economic growth in the world (South Korean economic growth) while most of the previous studies have shown the impact of R&D through the rate of school enrollment and volume of spending on education on economic growth for a group of development or developing countries.

Finally, we can benefit from South Korea's experience and apply it to other developing countries. The states must give more attention to human capital, which is the only way to build a competitive economic model, by:

- Building a successful educational system;
- Giving more attention to universities and research centers;
- Pushing the private sector to participate in scientific research to benefit from it;
- Increasing public spending and providing the necessary capabilities.

Therefore, through this experience, we can say that economic theory (as the Romer'90 model) was developed to apply it and not just to read it.

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