Indian Journal of Economics and Business
Vol. 20 No. 2 (July-December, 2021)

http://www.ashwinanokha.com/IJEB.php

Using Artificial neural networks to recognize the determinants of economic growth: new approach "evidence from developing countries"

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Received: 15th June 2021
Revised: 17th July 2021
Accepted: 12th August 2021

Abstract: There are many theories and empirical studies that search about the determinants of economic growth in developed countries. Since developed countries have characteristics that differ from developing countries, this study aimed to know the determinants of economic growth in developing countries. To achieve this purpose, the study used a new approach, named artificial neural networks (ANN), and applied to 27 developing countries from 2000 to 2018. The study showed that the main determinants of economic growth in developing countries are consumption, followed by savings, and capital accumulation. Other factors emphasized by modern and traditional theories such as technological progress, human development, institutional quality, governance, foreign direct investment, economic freedom, and political stability are not the determinants of economic growth in these countries.

Keywords: Artificial neural networks; Determinants; Economic growth; Developing countries

1. Introduction

Studying economic growth is one of the topics that has garnered the most attention among economists because of its importance in identifying the most influential factors (Durlauf & Blume, 2016). Economic growth is one of the essential aggregate indicators of State's economic activity, which is reflected in per capita income and welfare. Therefore, rising economic growth is a fundamental objective of any economic or political system, and most policies and proceedings taken by Governments are geared towards achieving this goal, both directly and indirectly. In addition to that, the extent of progress and success is usually evaluated, whether for the economic, political system, or for policies taken based on the growth rates achieved.

Therefore, economists have been interested in explaining how this growth occurs by knowing its determinants, both theoretical and practical, during the various economic thought stages. In addition, there have been numerous applied studies and theories that have been dealt with this topic over time.

Concerning theories, it began with the traditional approach, which considered that the determinants of economic growth were concentrated in two main factors, labor, and capital (Puaschunder, 2020). Then, another approach emerged in the 1930s and showed that other additional determinants affected the growth rate. This approach began with the Hard-Domar model developed by Singer (1939-1949), which showed that society's economic growth rate depended on three factors: savings rate, investment productivity, and population growth rate. The Solo model then emerged in 1956, which relied on the classic production function but in a new dress to include additional determinants affecting economic growth, namely technological progress. Then, in the 1980s and 1990s, new models of endogenous -growth emerged, which has introduced technological level, innovation, and population as influential variables in long-term growth, as well as the assumption of increased returns of scale for output, and the increasing importance of human capital through investment in education and health, because of the resulting processes of innovation and renovation and its direct impact on technological progress and, consequently, in raising the rate of economic growth. Thus, integrating human capital with physical capital is one of the basic determinants of society's long-term growth rate (Lucas, 1988; Romer, 1990; Aghion & Howitt, 1992; Baro, 1996).

In applied studies, several studies have thought to identify the determinants of economic growth for different countries (Kogid et al., 2010; Masoud, 2014; Škare & Lacmanović 2015; Tru, 2018; Myro, 2019; Chiu et al., 2020; Xu et al., 2021). These studies agreed on specific underlying factors for economic growth, Labor, physical and human capital, and technological progress. Moreover, they differed among themselves in other determinants, with some adding to previous factors, trade, financial openness, and government expenditure. Others added the extent to which economic stability was achieved, both internal and external, the development of the financial sector, political and social conditions, as well as the efficiency of government economic policies. For example, (Collins et al., 1996) showed that the increase in economic growth rates achieved by South-East Asian countries from 1970-1986 was mainly due to increased savings rates and capital accumulation. (Barro,1991) also showed that the determinants of growth in more than 100 countries were due to the level of education, the ratio of investment to GDP, and political stability. (Sala-i-Martin, 1994; 1992; 1990) found that the determinants of economic growth may be political variables such as the quality of government and the strength of the law, as well as other variables related to investment growth, the extent to which the state relies on raw materials for export, as well as the degree of economic openness of the state.

Furthermore, (Rahman & Salahuddin, 2010) showed that the traditional determinants of growth are: Labor and its productivity, savings, investment in general, and FDI, in particular, are well-established facts, but (Barro, 1996) showed that most recent interpretations focus on growth through increased productivity of production factors. Moreover, the degree of openness to the external world commercially and financially, in addition to political and social conditions conducive to growth and the rule of law. In the same context, (Caporaso & Madeira, 2012; Mbulawa, 2015; Chiu et al., 2020; Xu et al., 2021) identified governance and institutional quality as one of the determinants of economic growth. Furthermore, (Sloboda, 2020) showed

that the most critical determinants of economic growth for the ECOWAS, including 25 of West African countries, were inflation and domestic savings.

Finally, it can be said that all the theories that searched for the determinants of economic growth were mainly seeking to know its determinants in developed countries and to explain how much growth occurred in these countries. However, there is no doubt that developed countries have different characteristics from developing countries. Therefore, the study problem revolves around knowing whether the factors identified by these theories are valid as determinants of economic growth in developing countries. If it does not apply to developing countries, what are the determinants of growth for these countries?

Hence, this study aimed to identify the main determinants of economic growth in developing countries to recognize means to accelerate their growth rate to catch up with developed countries. For this purpose, this study has been divided into four sections as follows: Section (I): Theoretical Framework and Introduction. Section (II): a literature review. Section (III): Data and Methodology. Section (IV): Results and Conclusion.

Theoretical framework

Many theories deal with the issue of economic growth and its determinants. Theories of economic growth began with the classical approach, which held that capital accumulation resulting either from the increase in the effectiveness of specialization and division of labor in Adam Smith's theory or from the rise in the rate of profits in the views of Ricardo and Malthus, is the main determinant of economic growth (Appleyard & Field, 2001; Gupta, 2009; Lanza, 2012).

Then new classical emerged, led by Schumpeter, who formulated his theory of economic growth based on two elements:

(1)**Innovation**: According to him, innovation, renewal, and modern technology are essential elements that support the production process and growth.

(2) **Enterpriser:** Enterpriser is the backbone on which Schumpeter built his theory of economic growth. Enterpriser is innovative and able to initiate innovative actions that serve the production process. The Enterpriser intends to direct the factors of production to new channels that achieve high profits (Croitoru, 2012).

These theories have significantly developed in the last century as Keynesian thought appeared on the ruins of classical thought in the aftermath of the Great Depression in 1929. As a result, new models of economic growth emerged from its supporters. At the top of the models is the "Harrod-Domer" model. Harrod independently developed in 1939 and Domar in 1946. According to this model, economic growth is determined by the saving rate and the capital-output ratio (Sengupta, 2011; Lakhera, 2016).

These models were followed by the appearance of new models in the 1950s. the Robert Solow model is the most important model that appeared in that period. He developed two models that showed how economic growth would take place. In his first model in 1956, he neglected technological progress and showed that economic growth's primary determinant is the labor force and capital stock (Solow, 1956; Bartelsman et al., 2013; Jones, 2014). As for his second model in 1957, he presented new ideas in the field

of economic growth. The rate of growth in GDP can be attributed to factors other than capital and labor, so he stressed the importance of technological progress as a factor through which growth can be explained in the long term and assumed that the technological level is determined outside the framework of the model and determined independently of all other factors (Solow, 1957; Snowdon & Vane, 2005; Lakhera, 2016).

The 1960s and 1970s saw the emergence of many models similar to previous models based either on the classical theory or on the Solow model. Therefore, there was no new evolution in the theories and then the models that adopted them except in the 1980s of the last century, when new growth theories appeared, known as the endogenous growth theory, which searched for growth as an internal variable.

Although the modern growth theory (endogenous growth) agrees with the Solow model that technological progress is the most important determinant of economic growth, it differs in that technological progress is not determined exogenously by the model. Besides, it interpreted how to achieve such progress, as it showed that it results from investment in both human and intellectual capital (Howitt, 2010; Sengupta, 2011).

Many models have emerged from this theory. The model developed by (Romero, 1986) focused on the importance of research and development and its role in achieving economic growth. While the model developed by (Lucas, 1988) clarified the role of human capital in economic growth and showed that it generates Self (or internal) economic growth based on human capital. It is sufficient that the marginal revenue of human capital (designated for formation and preparation) is fixed, but if it decreases, then there is no long-term growth. While if it is increasing, there is explosive growth. The models developed by (Rebelo, 1991; Aghion & Howitt, 1992; 1998) followed the same Schumpeter's approach and showed the role of innovation as a determinant of economic growth. Moreover, the model adopted by (Romer, 1990; Grossman & Helpman, 1991) demonstrated the role of knowledge creation as a determinant of economic growth (creation of new knowledge as a source of growth). The following equation summarizes the determining factors of economic growth according to the proponents of Endogenous Growth Theory:

$$\boldsymbol{Y = \alpha\, f(K, H, L)} \quad \textbf{(1)}$$

Where

α : innovation, K: Capital, H: human capital L: Labour

Literature review

Based on the continuous and renewed interest in knowing the determinants of economic growth, many applied studies have been conducted to explain the determinants of economic growth in all countries, and these studies have varied in determining the determinants of economic growth as follows:

Some studies have suggested that the main determinant of economic growth is saving. (Masih & Peters, 2010) concluded that saving is the main determinant of Mexico's GDP in the long term. The study also followed the same direction (Tang& tan, 2014; Najarzadeh et al., 2014; Bari, 2020; Sloboda, 2020), which showed that saving is the main determinant of economic growth in the long and short term. These studies explained that increasing saving provides the necessary funds to finance investment and thus enhance economic growth.

Other studies have emphasized that the determinant of economic growth is technological progress. (Licheng, 2011) concluded that technological progress is one of the essential factors that increases the economic growth rates in three economic regions in China. Therefore, the study showed that the Yangtze River Delta region has the most significant contribution of science and technology to achieving high economic growth rates in China, followed by the central Bohai area, followed by the Pearl River Delta region. Moreover, (Adak, 2015; Fan et al., 2017) showed that innovation is the determinant of economic growth in China. These studies justified this by the fact that technological progress contributes directly to increase the total productivity of the factors of production, which encourages economic growth. In addition to that, this contributes to improve the competitive advantage of the state's goods, leading to an increase in exports and stimulating economic growth.

Most of the studies in the recent period have shown that the primary determinant of economic growth is human capital. (Lee & Hong, 2010; Zhang & Zhuang, 2011; Hanushek, 2013; Mariana, 2015; Pelinescu, 2015; Teixeira & Queiros, 2016; Ogundari & Awokuse, 2018; Saksiriruthai, 2021). This showed that the determinant of economic growth in many developing and developed countries is human capital, especially in the long term. These studies have shown that investing in human capital through education, training, and health contributes directly or indirectly to increased productivity, which leads to improved economic growth, as well as increasing the labor force's efficiency in its ability to handle modern technology and improve its ability to innovate and gain experience from other countries.

(Amann, 2005; Power, 2010) found that the determinant of economic growth in the Brazilian economy from 1994 to 2014 is political stability, The transitions towards democracy and economic reform. Moreover, (Bosworth et al., 2007; Sardana, 2010; Li, 2017) showed that the determinant of economic growth in India during the period of openness from 1991 to 2014 are the democratic transformation , openness to the world, and the encouragement of foreign direct investment. Also, (Bekaert et al., 2005; Kose, 2005; Tang et al., 2008; Doucouliagos et al., 2010) showed that financial openness associated with increased FDI inflows is one of the main determinants of economic growth. In the same context, (Simionescu et al., 2017) showed that foreign direct investment encouraged economic growth in Hungary, Poland, and the Czech Republic. According to these studies, Political stability contributes to attract foreign direct investment filling the technological gap, transferring advanced administrative skills, and integrating with domestic investments. Therefore, achieving better investment allocation that supports economic growth.

Furthermore, (Bond et al., 2010) demonstrated that a concern for physical capital by investing in infrastructure, machinery, and equipment is a determinant of economic growth, especially in the early stages of development, since providing infrastructure encourages and increased investment in general, as well as achieving external economies of scale that contribute to increasing production and thus increasing economic growth.

In addition to the above, (Barro, 1996; Aghion et al., 2007; Durlauf & Blume, 2016; Sloboda, 2020) have shown that the quality of institutions and governance through the rule of law is the determinant of economic growth because it stimulates innovation, increases the degree of competition and contributes to attracting investments. Thus, all of them provide a general ecosystem encouraging economic growth.

(Loayza & Otlawara, 2010) have found that government expenditure is one of the main determinants of economic growth. This is because government spending on infrastructure contributes to the realization of private investment for external economies of scale that promotes and increases investment and stimulates economic growth. Government spending on health and education also leads to increased economic growth, both directly and indirectly.

Also, it is essential to remember that inflation is one of the main determinants of economic growth, according to (Barro, 1996; Sloboda, 2020). This is justified because keeping inflation low and not increasing contributes to creating an attractive environment for investment and enhancing economic growth. Moreover, High inflation rates lead to raises production costs, increases uncertainty, and negatively affects saving, which negatively affects economic growth, especially in the long run.

2. Method

We use the artificial neural network model, to explore the determinants of economic growth in developing countries.

An Artificial Neural Network (ANN) is a model that attempts to simulate the biological nervous system in the human body for processing information by constructing a new structural system. This connects and organizes many of the processing elements, which are neurons (Neurons) linked together and worked in harmony to solve the phenomenon under the study by (Evans et al., 2013; Zou et al., 2007). Figure 1 illustrates a simple model for the neural network.

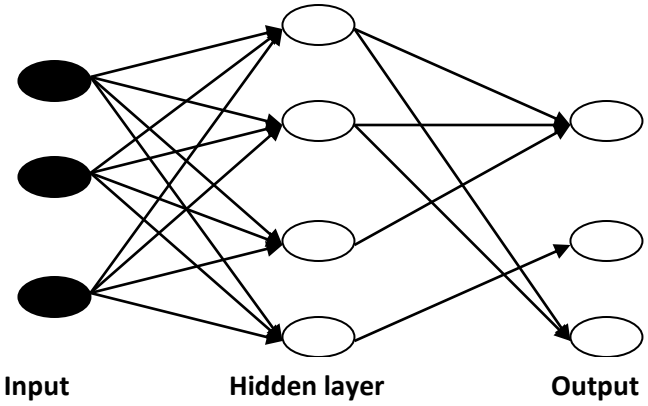

Figure No. (1): A simple artificial neural network architecture.
Source:(Ibiwoye et al., 2012)

A neural network consists of a set of neurons connected to its successor through weighted connections expressed by arrows and takes the symbol Wij (i: represents neuron node source, j: represents neuron node source). The j takes the interval value θ and receives the inner signals of $X = [X_1, \dots, X_n]$ from the units (cells/nodes) attached to them from the previous layer. Each signal is associated with a specific weight $W_j = \lfloor W_{1j}, \dots, W_{nj} \rfloor$(Alabbasi, 2013).

These neurons are organized into Layers. The network begins with the Input Layer, in which each node corresponds to an independent variable. Each node in the input layer is connected to all the hidden layer

nodes, and there may be more than one hidden layer in the network. The layers end with an Output Layer, which is a node (or more) representing the dependent variable (or dependent variables).

The Wij weight is calculated by the sum of the product of multiplying the node weights from which it emits in the node values (independent variables).

Weights in the neural network express adjustable coefficients in response to signals traveling in the network according to an appropriate learning algorithm and threshold (also known as bias) similar to the intersection limit in the regression model.

The input signals, their weights, and the interval value for each cell are studied by combination function. For each cell, the combination function produces one value called potential (or net input). The activation function converts the potential into out signal.

The combination function is usually linear, so the potential Pj is the sum of the deviations of the previous cell values Xi weighted by the weights coming out of them Wij from the interval value θ. Equation No. (2) expresses this (Alabbasi, 2013) :

$$p_j = \sum_{i=1}^{n} (x_i w_{ij} - \theta_j) \quad (2)$$

The signal out of cell j (yj) can be obtained by applying the activation function to the potential p_j to give the following equation(Alabbasi, 2013):

$$y_j = f(\mathbf{p_j}) = f\left(\sum_{i=0}^{n} x_i w_{ij}\right) \quad (3)$$

There are many ways to activate cells in the neural network. Among the most famous are the linear method, the piecewise method, the Sigmoidal method, and the Softmax method. The sigmoidal method is the most popular method used in empirical studies, and It is an S-shaped curve. It has two common functions, the hyperbolic function, and the logistic function, and this function produces a positive value only in the interval [0, 1]. It is defined by the following equation (Alabbasi, 2013):

$$f(p_j) = \frac{1}{1+e^{-p_j}} (4)$$

Neural networks are used because, unlike other methods, they do not require preconditions or assumptions, and they are distinguished from others by their high flexibility and capacity to find acceptable the ability to provide appropriate solutions. It was used in this study because it arranges the independent variables according to the importance of their effect on the dependent variable, which is what the researcher wants in order to know the determinants of economic growth.

Equation No. (5) shows the ANN model used in the study, as it takes the following form (Zou et al., 2007):

$$Y_t = F\,[H_1 X_{t-1}, H_2 X_{t-2}, \ldots, H_N X_{T-N})] + U \quad (5)$$

Yt: output layer and represents the dependent variable, expressing economic growth.

X1,…, XN: input layer and represents explanatory variables or independent variables.

F, H: function of neural network

H: represents Hidden Layer Activation Function

F: represents the output of Hidden Activation Function

U: Error Term.

Table No. (1) displays a word about measuring the variables and the data used. Following the standard practice in the literature, We measured the dependent variable (economic growth) by gross domestic product (GDP) denoted in the rest of the paper by **(EG)**. Fifteen variables are used as a determinant of economic growth (independent variables).

Table No. (1): independent variables

Variable	symbol	Source
The governance and institution quality.	**GQ**	The Global economy database
Technology	**TECH**	The Global economy database and UNCTAD database.
Political stability index.	**PS**	The Global economy database
Trade openness	**OPPON**	The Global economy database
economic freedom	**EF**	The Global economy database
Saving	**S**	The Global economy database
Human resources	**HR**	The Global economy database
Population Growth rate	**PG**	The Global economy database
Capital	**CAPITAL**	UNCTAD database
Consumption	**C**	UNCTAD database
Foreign direct investment	**FDI**	The Global economy database.
Government expenditure	**G**	The Global economy database.
Inflation	**INF**	The Global economy database.
Human development	**HD**	The Global economy database.

Source: The author

Each of these variables was calculated as a composite index for each group of developing countries. Where the countries under study were classified and divided as shown in (Table 2). Also, the used data cover the period from 2000 until 2018.

(Table 2): Categories of developing countries.

Low- income developing economies	Middle- income developing economies	high- income developing economies
Ethiopia	Algeria	Argentina
	Egypt	Brazil
Uganda	Ghana	Chile
Mali	Jordan	Colombia
Niger	Jamaica	Gabon
Rwanda	Kenya	Mexico
Benin	Morocco	Peru
Burkina Faso	Philippines	South Africa
Burundi	Tunisia	Turkey
Nepal	Indonesia	

Source: the author depends upon the classification of world bank

According to the multilayer perception method, a single output layer representing the dependent variable (economic growth) will be used and will use one hidden layer. This layer is connected to the input layers (independent variables). In addition, the hyperbolic tangent function will be used because the exponential function of range (0, 1) is often used to activate neural networks with binary output values. Inputs represent the data of the independent variables, and outputs represent the values of the dependent variable yt. In the case of outputs, the identity function will be used as a stimulus function. The training was done by supervised training, which involves providing a sequence of training vectors as inputs along with the target output vector. The network will also be trained several times until the lowest error is obtained and the weights are thus estimated.

According to the supervised training method, forecasting is as follows:

a) The data are divided into Inputs and outputs.
b) There is a target output vector for both the inputs and outputs
c) Initial weights are specified for all input elements, as these weights transfer data from layer to layer within the network affecting the output values.

A learning function is used to adjust the weights. After that, a comparison is made between the current output values of the network and the target values, and the weights are adjusted until the lowest possible error is achieved. The error-back propagation algorithm is used to learn in three phases:

1) **Forward Phase**: The difference between the actual and expected values is estimated and equals the error for each input. Each X_t layer collects the entry signal, which is then sent to the hidden layer units based on their number. Each hidden layer collects the values and its weighted entry signal using the equation No. (6) (Alabbasi, 2013; Saad, 2016):

$$Z - in_k = W_{Ok} + \sum_{i=1}^{n} Z_j W_{ik} \quad (6)$$

Where

$$Z_j = f(Z - inj)$$

$$Z - in_j = V_{Oj} + \sum_{i=1}^{n} X_i V_{ij}$$

Where

Z_j: represents subunit j.

$Z - in_j$: refers to total input for unit Z_J.

V_{Oj}: denotes the Bias limit of the subunit j.

X_i: refers to I input.

W_{ik}: express the weights of the output layer.

2) **Backward Phase**: After the values are transferred to the output layer, whose value was determined via the previous steps, a comparison is done between the calculated values and the desired values (calculating the error) through the difference among the values of those outputs. Equation (7) shows how to calculate the error and minimize it to the lowest possible value (Alabbasi, 2013):

$$E = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{k}\left(x_{ij} - y_{ij}\right)^2, i = 1,2,\dots,n, j = 1,2,\dots,k \quad (7)$$

Where:

n: indicates the sample size.

k:represents the number of samples.

x: represents the target or desired output from the network.

All error signals from layers are grouped as follows (Alabbasi, 2013; Saad, 2016):

$$\Delta_j = \sum_{k=1}^{m} E_k f(y - in_k) W_{\text{jk}} \quad (8)$$

3) **Adaptation of weight phase**: The error is reduced to the lowest value. The weight is corrected and adjusted through the learning process on the network (Haykins, 1999; Alabbasi, 2013; Saad, 2016).

Concerning each unit of the output layer, its weights are adjusted according to Equation No. (9) (Haykins, 1999; Alabbasi, 2013; Saad, 2016):

$$W_{jk}(\text{ new }) = W_{jk}(old) + \alpha \cdot \beta \cdot W_{JK} \quad (9)$$

α expresses the learning rate that is placed at the lowest level of learning. While β expresses the difference between the calculated value and the desired value to calculate the error, it is called the backward phase. These steps are repeated in the network for several times with a forward step, and a backward step called an epoch.

3. Findings and Discussions

(1) low- income developing countries

A program SPSS ver. (22) was used to determine the neural network architecture and know the determinants of economic growth for low-income developing countries. The neural network architecture in Figure No. (2) consists of three layers. The first layer is the input layer that represents the independent variables. The second layer is the hidden layer, consisting of eight neurons. The third layer is the output layer, represented by the dependent variable, which is economic growth (EG).

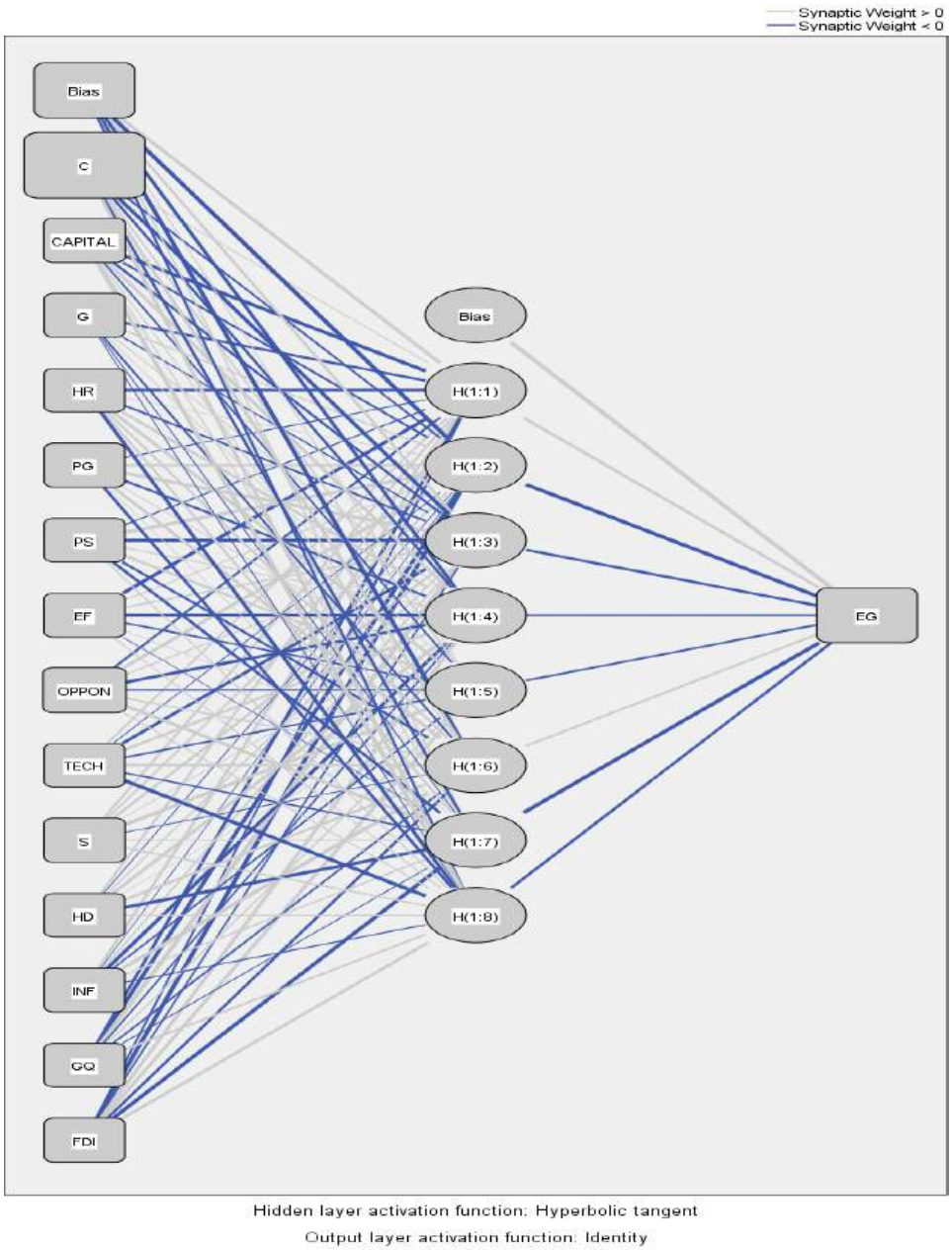

Figure No. (2): Neural network architecture
Source: Spss v.22 output

It is clear from Tables No. (3) and No. (4) that the number of periods in the network training phase is (16) at a rate of (84%) of the total data. It is also clear from the Tables That the sum of squares of error in the training phase is (0.675) and the relative error (0.09), while in the testing phase, the sum of squares of error is (0.171) and the relative error (0.083), using multilayer perceptron (MLP). There is no doubt that the low value of the relative error indicates the accuracy and quality of the model**.**

Table NO. (3): Case Processing Summary

		N	Percent
Sample	Trainig	16	84.2%
	Testing	3	15.8%
Valid		19	100.0%
Excluded		0	
Total		19	

Source: Spss v.22 output

Table No. (4): Model Summary

Training	Sum of Squares Error	.675
	Relative Error	.090
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	00:00:00.013
Testing	Sum of Squares Error	.171
	Relative Error	.083

Dependent Variable: EG

a. Error computations are based on the testing sample.

Source: Spss v.22 output

Table No. (5) and Figure No. (3) show the relative importance of the independent variables in the neural network model. It is clear from Table No. (6) that increasing the relative importance of consumption reaches (0.877) with a standard value of 100%. As a result, we find that economic growth in low-income developing countries depends mainly on consumption in these countries, meaning that the engine of economic growth in these countries is consumption. These results show the opposite of what has been proven by modern economic growth theories. This may be due to the nature of these countries from the low level of income and then directing the majority, if not all, towards consumption. Therefore, if the sum of all the factors determining economic growth in these countries is true, we find that the share of consumption is 0.877, while the rest of the factors are 0.133. This means that the rest of the other factors play only a small role in determining economic growth in these countries.

From this, it can be concluded that economic growth theories were created for developed countries, and that apply them to developing countries would be inappropriate due to the different nature of the environment in which they grew up.

Table No. (5): Independent Variable Importance for low-income developing countries.

	Importance	Normalized Importance
C	.877	100.0%
CAPITAL	.022	2.5%
G	.006	.6%
HR	.001	.2%
PG	.003	.3%
PS	.002	.3%
EF	.011	1.3%
OPPON	.056	6.4%
TECH	.000	.1%
S	.013	1.5%
HD	000	.0%
INF	.002	.2%
GQ	.001	.1%
FDI	.005	.6%

Source: Spss v.22 output

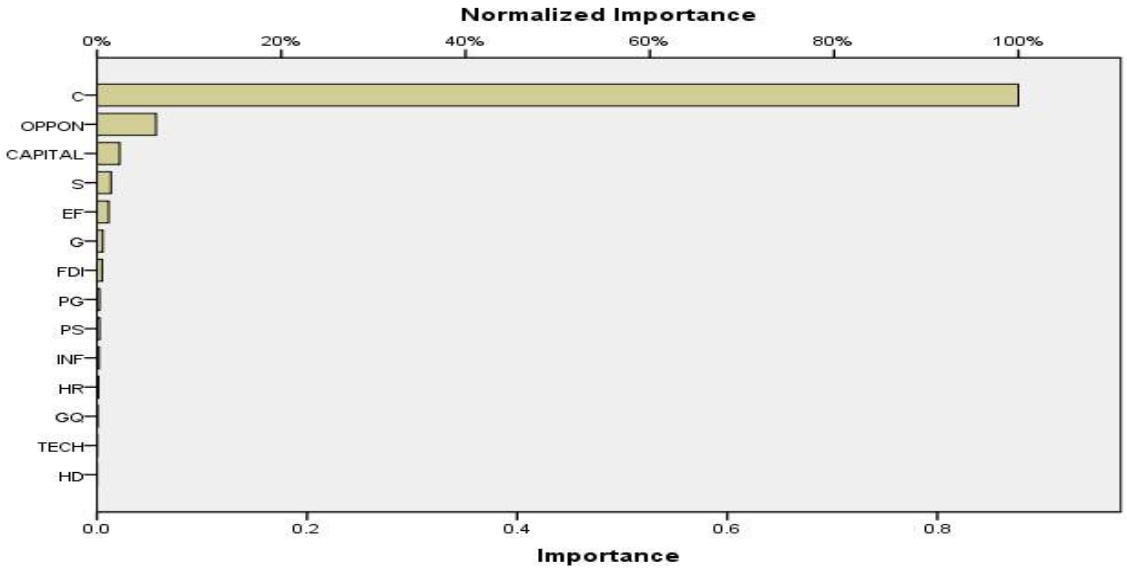

Figure No. (3): Independent Variable Importance
Source: Spss v.22 output

(2) Middle-income developing countries

A program SPSS ver. (22) was used to determine the neural network architecture and know the determinants of economic growth for Middle-income developing countries. The Neural network Architecture in Figure No. (4) consists of three layers. The first layer is the input layer, representing the independent variables. The second layer is the hidden layer, consisting of seven neurons. The third layer is the output layer, represented by the dependent variable, which is economic growth (EG).

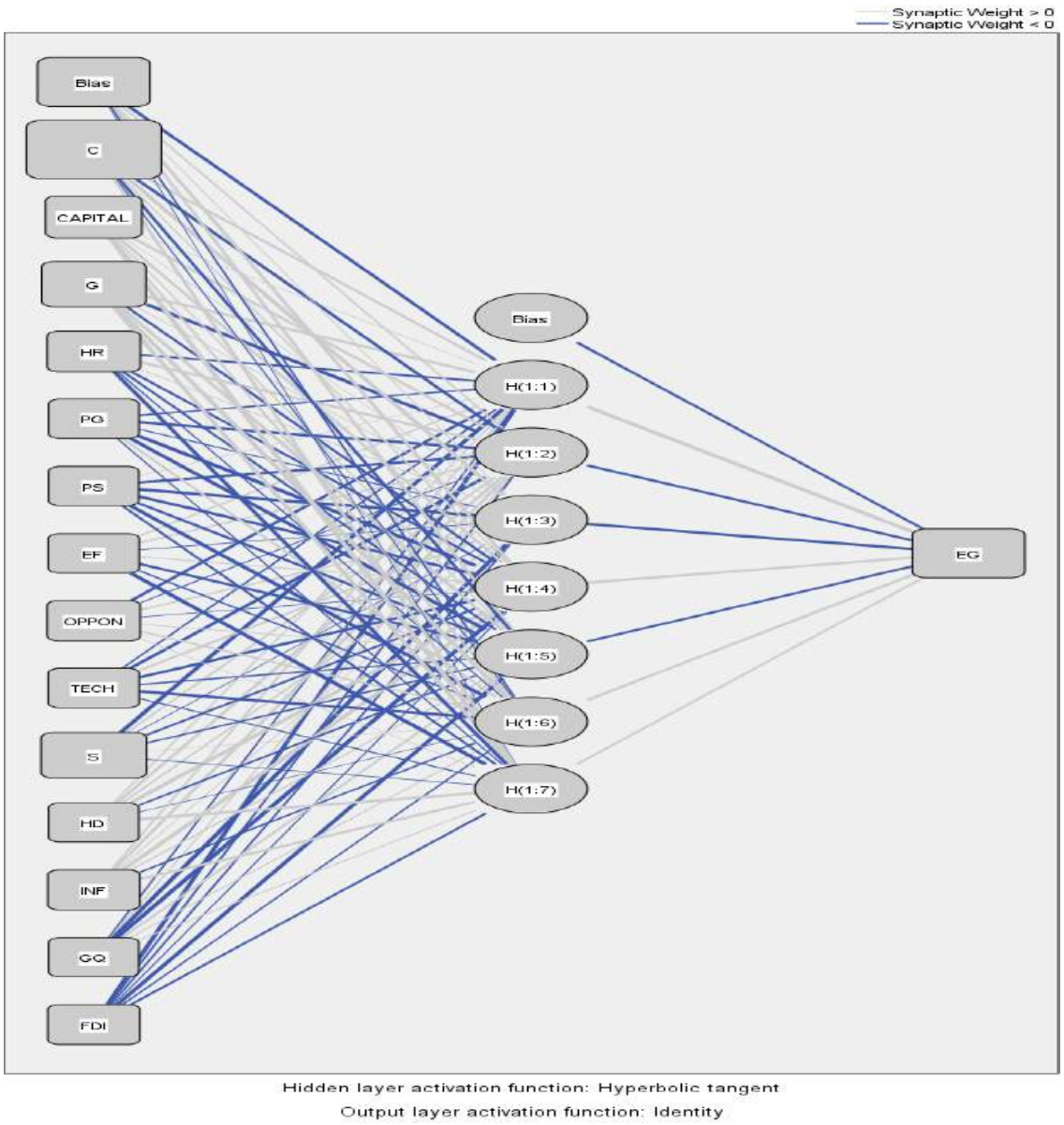

Figure No. (4): Neural network Architecture for income-middle developing countries.
Source: Spss v.22 output

It is clear from Tables No. (6) and No. (7) that the number of periods in the network training phase is (14) at a rate of (73.7%) of the total data. It is also clear from the Tables that the sum of squares of error in the training phase is (0.459) and the relative error (0.071). While in the testing phase, the sum of squares of error is (0.036), and the relative error is (0.016), using multilayer perceptron (MLP). There is no doubt that the low value of the relative error indicates the accuracy and quality of the model.

Table No. (6): Case Processing Summary

		N	Percent
Sample	Training	14	73.7%
	Testing	5	26.3%
Valid		19	100.0%
Excluded		0	
Total		19	

Source: Spss v.22 output

Table No. (7): Model Summary

Training	Sum of Squares Error	.459
	Relative Error	.071
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	00:00:00.003
Testing	Sum of Squares Error	.036
	Relative Error	.016

Dependent Variable: EG

a. Error computations are based on the testing sample.

Source: Spss v.22 output

The relative importance of the independent variables in the neural networks model for middle-income developing countries is shown in Table No. (8) and Figure No. (5). The Table clearly shows that the following are the main determinants of economic growth in these countries:

1) As its relative importance in influencing economic growth, consumption reached about (0.482) with a standard value of 100%.
2) Government expenditure and saving their relative importance in affecting economic growth were reaches (0.318).

Without a doubt, Table No. (8) and Figure No. (5) demonstrates that consumption, savings, and government spending are the main determinants of economic growth in these countries. The rest of the factors have a minor impact on economic growth.

In contrast to low-income developing countries, the state plays a role in middle-income developing countries. The relatively high income in these countries compared to low-income developing countries has resulted in the state's ability to collect taxes and direct them toward spending and stimulating economic growth on the one hand, and to direct part of the income toward saving and use it in financing economic growth on the other hand.

Table No. (8): Independent Variable Importance

	Importance	Normalized Importance
C	.482	100.0%
CAPITAL	.069	14.4%
G	.153	31.7%
HR	.035	7.3%
PG	.002	.5%
PS	.000	.1%
EF	.010	2.0%
OPPON	.031	6.4%
TECH	.008	1.8%
S	.165	34.3%
HD	.000	.1%
INF	.022	4.5%
GQ	.000	.0%
FDI	.022	4.5%

Source: Spss v.22 output

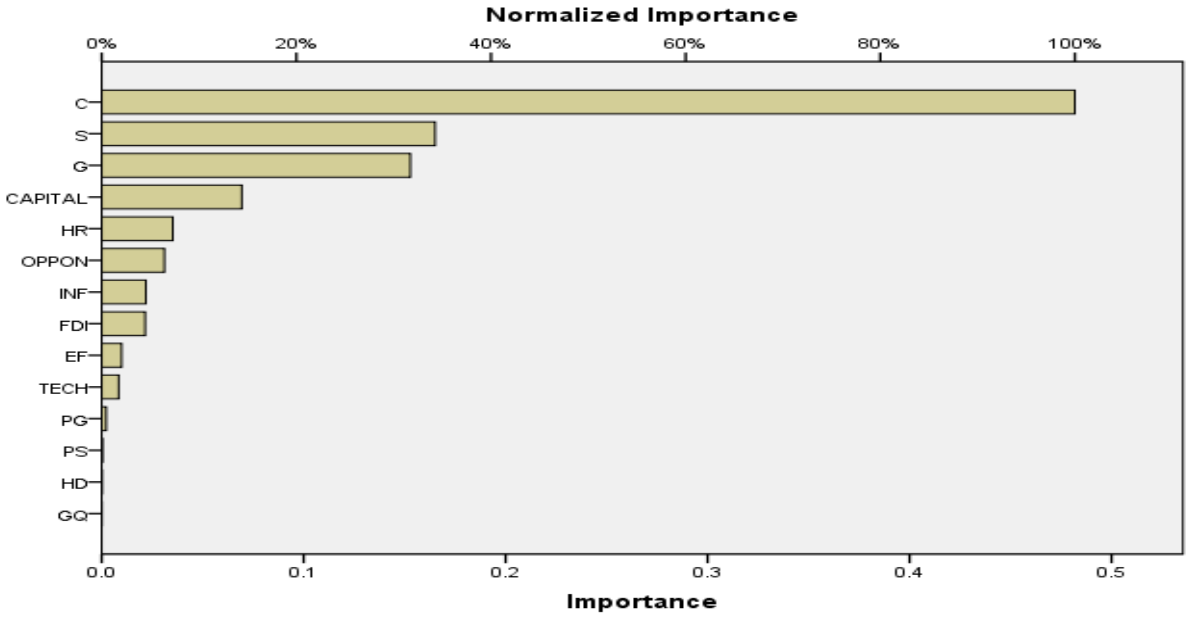

Figure No. (5): Independent Variable Importance for income-middle developing countries
Source: Spss v.22 output

(3)high- income developing countries

A program SPSS ver. (22) was used to determine the neural network architecture and know the determinants of economic growth for high-income developing countries. The neural network Architecture in Figure No. (6) consists of three layers. The first layer is the input layer representing the independent. The second layer is the hidden layer, consisting of seven neurons. The third layer is the output layer, represented by the dependent variable, which is economic growth (EG).

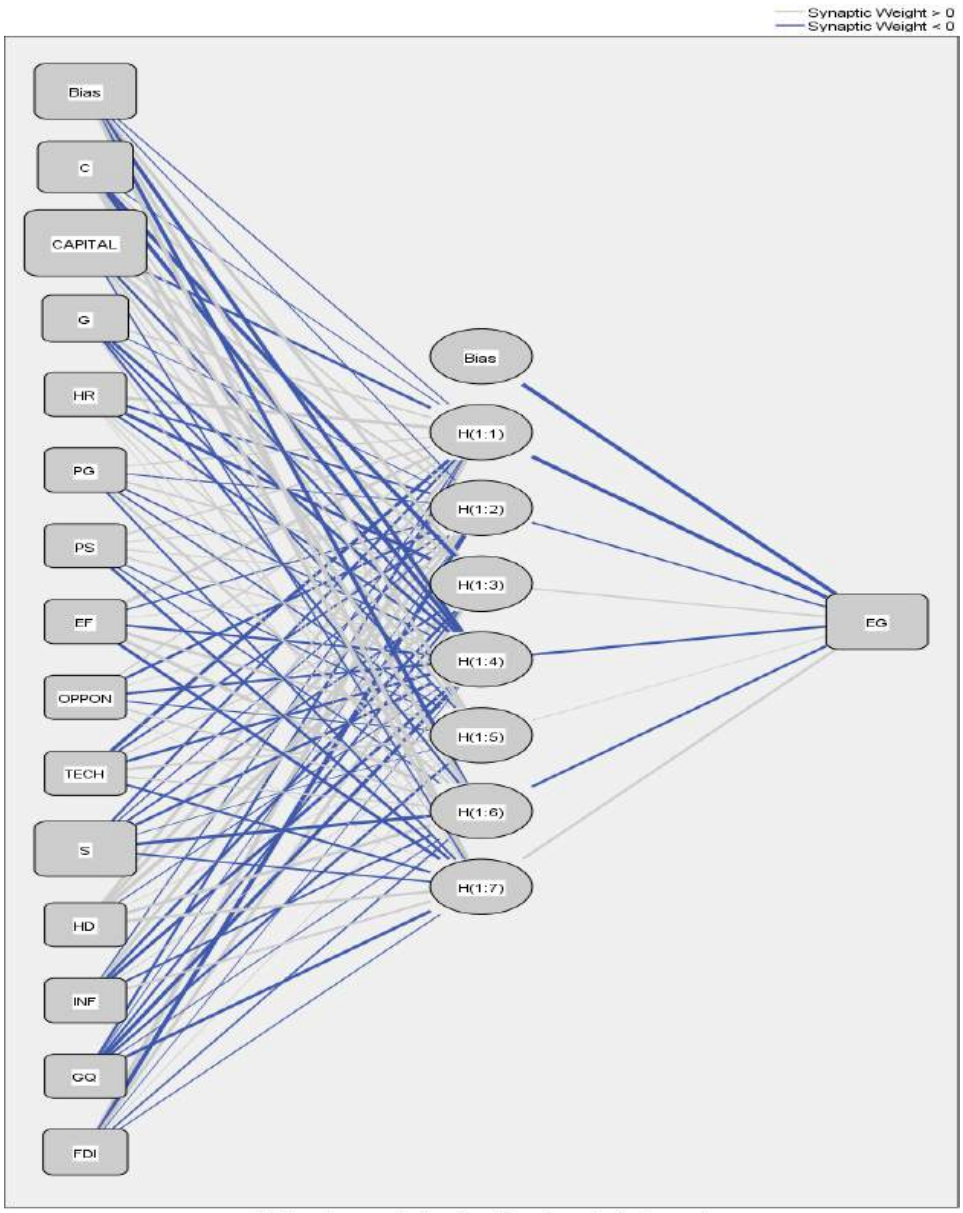

Figure No. (6): Neural network Architecture for income-middle developing countries.
Source: Spss v.22 output

It is clear from Tables No. (9) and No. (10) that the number of periods in the network training phase is (15) at a rate of (78.9%) of the total data. It is also clear from the Tables that the sum of squares of error in the training phase is (2.028) and the relative error is (0.290), while in the testing phase, the sum of squares of error is (0.205) and the relative error is (0.238), using multilayer perceptron (MLP).

Table No. (9): Case Processing Summary

		N	Percent
Sample	Training	15	78.9%
	Testing	4	21.1%
Valid		19	100.0%
Excluded		0	
Total		19	

Source: Spss v.22 output

Table No. (10): Model Summary

Training	Sum of Squares Error	2.028
	Relative Error	.290
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	00:00:00.013
Testing	Sum of Squares Error	.205
	Relative Error	.238

EG: Dependent Variable

a. Error computations are based on the testing sample.

Source: Spss v.22 output

The relative importance of the independent variables in the neural networks model for high-income developing countries is shown in Table No. (11) and Figure No. (7). The Table clearly shows that the following are the main determinants of economic growth in these countries:

1) As its relative importance in influencing economic growth, capital accumulation reached about (0.487) with a standard value of 100%.
2) Saving and consumption their relative importance in affecting economic growth reached (0.411).

The relative importance shows that the determinants of economic growth in these countries are capital accumulation, saving, and consumption. The rest of the factors have a minor impact on economic growth, with a combined effect of around 0.102.

The high levels of income in these countries, compared to their counterparts in other emerging countries, can be argued to be the fundamental reason for their economic growth relying on savings, capital accumulation, and consumption.

Table No. (11): Independent Variable Importance for high-income developing countries

	Importance	Normalized Importance
C	.167	34.2%
CAPITAL	.487	100.0%
G	.056	11.6%
HR	.004	.7%
PG	000	.0%
PS	000	.0%
EF	.000	.1%
OPPON	.002	.4%
TECH	.001	.2%
S	.244	50.1%
HD	000	.0%
INF	.003	.6%
GQ	000	.0%
FDI	.037	7.5%

Source: Spss v.22 output

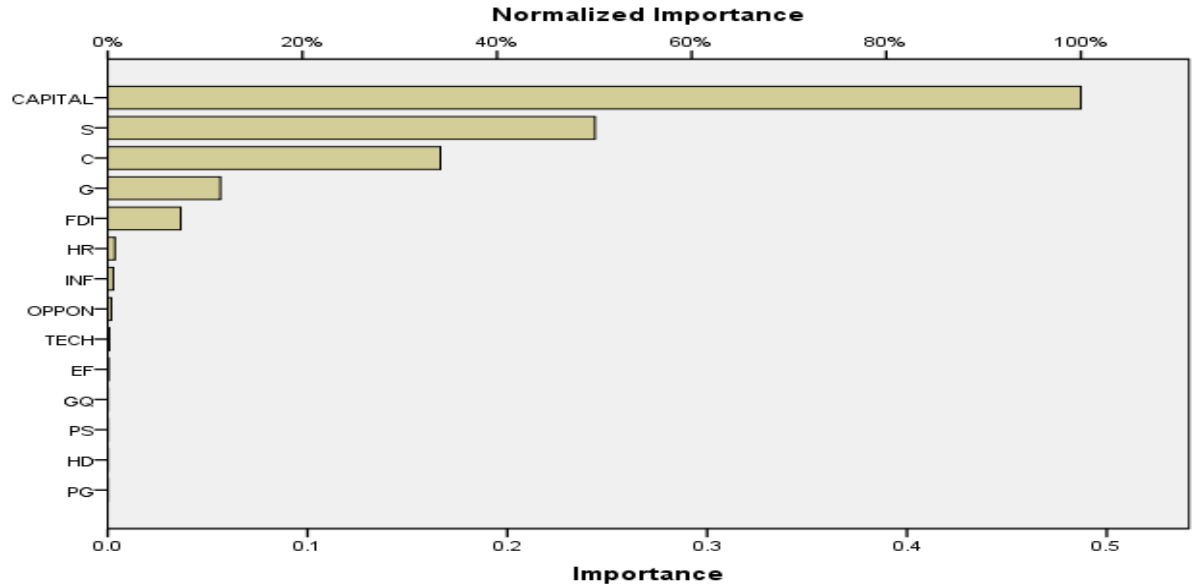

figure No. (7): Independent Variable Importance for high-income developing countries
Source: Spss v.22 output

After reviewing the three classifications of developing countries, it can be said that the determinants of economic growth for developing countries are consumption, saving, and capital accumulation, followed by government spending. As for the other factors that modern theories of economic growth talked about such as political stability, economic freedom, human development, governance, quality of institutions, and technological progress, do not affect economic growth. This is because these countries still do not care about these factors to advance their economies due to the limited income and the difficulty of directing a large part of it towards paying attention to these factors.

4. Conclusion

All countries, without exception, are interested in raising the rate of economic growth. In order to achieve this, it sets all appropriate policies for this goal. For this purpose, many studies have searched for the main determinants that raise economic growth.

This study is one of the first studies that used neural networks in economic research, which had never been studied before. Its use is because it arranges the independent variables according to the importance of their impact on the dependent variable, which is what the researcher needs to show the determinants of economic growth in developing countries.

The study revealed that consumption is the main determinant of economic growth in developing countries, and this is because in these countries, in light of the low level of income, consumption is the main determinant of demand and then economic growth due to the high marginal propensity to consume.

From here, it can be said that the determinants of economic growth for developing countries are consumption, savings, and capital accumulation, followed by government spending. As for the other factors that modern theories of economic growth talked about, such as political stability, economic freedom, human development, governance, quality of institutions, and technological progress, do not affect economic growth. This is because these countries still do not care about these factors to advance their economies due to the limited income and the difficulty of directing a large part of it towards paying attention to these factors.

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