FACTORS AFFECT ECONOMIC GROWTH EMPIRICAL EVIDENCE FROM SUDAN ECONOMY

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Abstract

This paper aims to identify factors affecting the pattern of real GDP growth of Sudan. Secondary data for the period 1960-2009 are used via two classification methods i.e. discriminant analysis and Neural Network Analysis (NNA) in addition to Baxter-King frequency filter for depicting business cycles. Based mainly on growth models Okun's law and Harrod-Domar model results showed that growth has been affecting by labor productivity; terms of trade; investment and saving ratio to GDP, growth of unemployment; terms of trade; import duty to ratio GDP; general price growth. Both estimation methods reached the same results. NNA outperformed discriminant analysis.

Key words: Harrod-Domar, Okun's law, business cycle, classification

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1. Introduction

Business cycle refers to fluctuations in aggregate production, trade and activity over several months or years in a market economy. In economic recession is a business cycle contraction (periods of relative stagnation or decline) it is a general slowdown in economic activity, generally does not last longer than one year. The type and shape of recessions are distinctive V-shaped: short-and-sharp contractions followed by rapid and sustained recovery; U-shaped (prolonged slump); L-shaped eight consecutive quarters of decline. An economic expansion is an increase in the level of economic activity, and of the goods and services available. It is a period of economic growth as measured by a rise in real GDP (Burns and Mitchell (1946) Wikipedia). There are various factors affecting economic growth of which supply and demand, technology, weather, political stability and economic policies. Each government seeks increasing real gross domestic product (GDP) in order to increase the standard of living. The growth rate is measured in percentage change in real GDP valuated at constant prices (e.g. 1982 for Sudan) Sudan has been formulating short, medium, and long term economic plans since the early sixties of nineteen century. The common feature of these plans is the targeting of growth rate of the economy by six per cent. However the mean growth rate during 1960 - 2009 was 3.9; the maximum was 14.2 percent and the minimum was -7.7 per cent. The economy was expanding during the period 1960-1965. Almost the economy has been in recession taking the V-shaped lasted for two years four times during half of the period 1966 – 1992. Recession in the remaining period is almost U-shaped. The aforesaid period had witnessed political instability, inappropriate economic policies e.g. devaluation of the Sudanese pound and excessive levies of custom duties; in addition to internal and external shocks such as drought and desertification, surge in international oil prices and economic sanction.

Discriminant analysis has been used extensively for classification, but many studies proved the superiority of Artificial Neural Network Analysis (ANN) over discriminant analysis. The objective of this paper is twofold: First is to identify factors affect the real growth and to assess their contribution in classifying the episodes of recession and expansion. Second add to applications of (ANN). To my knowledge no one has attempted to use ANN to classify growth of Sudan economy.

2. Literature Review

Assessing the contribution of GDP determinants via ANN opened the space for various multivariate models to contain as many variables as 19 as is the case for New Zealand model by Easton (2014) which consists of change in (log) per capita GDP, change in (log) employment; change in (log) quantity of capital; inflation; savings ratio; change in (log) relative unit labor costs; change in (log) terms of trade; two dummy variables for the oil shocks in the 1970s; real exchange rate; share of government consumption in GDP; the highest marginal individual and corporate tax rates; openness; time trend and an adjustment for the business cycle; and distance. Another nineteen variable is the Indonesian model by Mansyah *etal* (2011) includes capital expenditure; prices of rubber, Brent oil copper, Aluminum, Jakarta Stock Price Index, and Nickel; import of raw material and consumer goods; and import and export growth rate; US and Korea GDP (main trading partners); consumer and business tendency index; Central Bank interest rate, motorcycle sales, and Hard Sandwood. A smaller model relative to the above models has been constructed by Önder, etal (2013) and Gonzalez (2000). The first model contains eight macroeconomic indicators i.e. GDP, gross national savings, inflation, population, total investment, unemployment rate, volume of exports of goods and services, and volume of imports of goods and services. And the second one was for Canada contains only six variables leading indicator of economic activity, employment growth current and one lag, consumer confidence index, first difference of real interest rate and federal budgetary balance as a share of GDP, and four dummy variables to control outliers. Tkacz & Hu (1999) chose their dependent variables to be the 1-quarter and 4-quarter cumulative growth rate of real GDP; and long-short interest rate spread, real 90-day commercial paper and real long-term bond rates, the growth rates of narrow (real M1) and broad (real M2) monetary aggregates, and the growth rate of the real TSE 300 index as explanatory variables.

The role of unemployment on growth has been studied by Ball, *etal* (2014), Andrei and Vasile (2009), Atsalakis *etal* (2007), Marattin & Salotti (2009) and Pirayoff (2004). The first study provided an assessment of the consistency of unemployment and output forecasts. It showed that, consistent with Okun's Law, forecasts of real GDP growth and the change in unemployment are negatively correlated. The Second emphasized the link between real GDP growth and unemployment, as described by Okun's law. The empirical analysis showed that a rise of one percentage point of unemployment is associated with a decline of roughly half percentage point

of real GDP growth. The third presented a new technique in the field of unemployment modeling in order to forecast unemployment index. They combined Artificial Neural Networks and fuzzy logic has been combined to generate a neuro-fuzzy model. The input is a time series. Classical statistics measures are calculated in order to assess the model performance. Further the results are compared with an ARMA and an AR model. The forth study applied both time series and panel cointegration techniques on data on 19 OECD countries; it failed to reject the hypothesis of absence of a long run common stochastic trend among productivity and full utilization of employment in the period 1980-2005. Furthermore, it applied a simple decomposition of GDP growth into five variables, productivity, employment, the activity rates, and a demographic ratio. The last study reached an inverse relationship between aggregate expenditures and unemployment. The more people spend, the fewer people are unemployed; the less people spend, the more people are unemployed.

Regression techniques have been used to estimate factors effect on growth. Kira (2013) showed that Tanzanian GDP growth is influenced by total Consumption, exports, Investment and problems such as increase in oil prices, power shortages and political instabilities are a distinctive source of GDP. Saymeh & Orabi (2013) investigated the effect of interest rate, inflation rate, and GDP on real economic growth in Jordan over the period 2000-2010. Regression was conducted to test growth rate with interest rate which showed that current interest rate has an influence power on growth rate. Also, regression used to test growth rate with inflation rate; it showed that inflation rate has influence power on growth rate. Finally regression used to test GDP, interest rate, and inflation rate together; results have shown that current GDP and one lag GDP have influence power to growth rate. Swain, *etal* (2012) focused on IRIS plant classification using Neural Network, which has been successfully applied. Hameed & Ume (2011) proved that the interest rate has minor relationship with GDP but the Growth in Money Supply greatly affects the GDP of an economy. Hamberg & Vesistanding (2009) estimated logistic model containing six variables: real GDP, changes in stock price, oil price, confidence indicator, European GDP, spread between long-term and short-term interest rate, and residential building start. Rahimi & Shahabadi (2010) investigated the effect of trade liberalization on economic growth in Iranian economy using a Cobb–Douglas production function, which is expanded to take into account political instability and trade liberalization. The empirical results show that in the long run the real export and import duty have positive effect on GDP, while the

Labor force and education causes to decrease the GDP. Finally Fox & Kohli (1997) assessed the contribution of major factors explaining Australian nominal GDP i.e. technological Change, movement in terms of trade, increases in endowments of labor and capital and changes in domestic output prices.

The use of ANN for classification is done by Zekic (*2008.*) into three main groups of problems: first group consists of predicting stock performance by classifying stocks into the classes such as: stocks with either positive or negative returns, and stocks that perform well, neutrally, or poorly. Second NNs for stock price predictions. The third is concerned with modeling stock performance and forecasting.

3. Model Specification

The proposed model consists of GDP growth rate (G) classified into two groups: recession versus expansion, in addition to nine independent variables that is saving ratio to GDP (SR), terms of trade (TOT), productivity of labor growth rate (LPGR), unemployment growth rate (UGR), investment ratio to GDP (INVR), real money growth rate (M2GR), real exchange rate (RER), import duty ratio to GDP (IDR), and general price growth rate (PGR). The selection of explanatory variables is based on economic theory, absence of multi-collinearity among them and long-run relationship via cointegration analysis (see annex).

Savings Ratio

Saving has been treated by development theories as an essential ingredient. Harrod-Domar introduced the concept of the warranted rate of growth, which is the rate of growth of total output consistent with equilibrium in both input and output markets. This output growth rate equals the ratio i.e. saving rate divided by the constant capital–output ratio. Thus, an increase in the savings rate, which allows a higher level of investment and capital goods creation, will increase the growth rate of the economy other things remain the same (Sengupta 2011). The exogenous growth model by Solow-Swan model is an economic model of long-run economic growth explains long-run economic growth by looking at capital accumulation, labor or population growth. Labor productivity is a function of capital per worker. Since Individuals consume whatever they do not save, all output is either allocated to consumption or investment. The later is the product of the saving ratio time labor productivity. Population increase (n) decreases the amount of capital per worker (k) so does depreciation (δ) the rate at which capital wears out. These two factors combined are eating away at capital per worker on a regular basis. To avoid

this situation investment should create new capital to offset the wear out over time. Thus, to maintain a "steady state" where capital per worker is constant over time, change in capital equal investment in new capital minus loss in capital,$\Delta k = sf(k) - (\delta + n)k = 0 \rightarrow sf(k^*) = (\delta + n)k^*$, * indicates steady state values. Harrod-Domar model helps to explain how growth has occurred and how it may occur again in the future. It states that the rate of growth of GDP is determined by the savings ratio in the economy and the capital output ratio (σ) (Sanders 2008).

Terms of Trade

The accounting relationship between the measure of real GDP and the terms of trade a measure of the strength of the home economy incorporates these changes is real gross domestic income (Zhang, Gourley & Soriano 2006). An improvement in terms of trade is realized by an increase in export price index relative to import price index thus has positive impact on GDP growth; or a decrease in import price index relative to export price increases the volume of import affecting adversely home production of similar goods, and on the other hand increases the imports of raw material thus increase production for home consumption and export offsetting decline in production. Kehoe & Ruhl (2007) stated when real GDP is measured at base period prices and domestic factors of production are held fixed, the effect of terms of trade shock on real GDP is determined by the current terms of trade relative to the base period terms of trade. If the current import price is the same as the base period price, then the shock has no effect. If the current price is higher than the base period price, the effect is negative, and, conversely, if the current price is lower, the effect is positive. With base period price weighting, a change in the terms of trade can have a first-order effect on GDP, but this result follows from an artifact of the deflation method and not from an underlying structural relationship.

Labor Productivity

Cobb-Douglas function is a particular functional form to represent the technological relationship of two or more inputs particularly physical capital K (the real value of all machinery, equipment, and buildings); labor L (total number of person-hours worked in a year) and A (the total factor productivity) and the amount of output (real value of goods produced in a year) Y produced those inputs. In most standard form the production function: $Y = AK^{\beta}L^{1-\beta}$. The production function was widely used. Rapid productivity growth will virtually has its implications for both the evolution of aggregate supply, as well as the growth of real income and the types of macroeconomic and structural policies needed to sustain and enhance economic welfare. Rapid

growth is associated with high saving, well-educated work forces, and the ability to tap the technology of the leading countries. Export orientation, low government spending, and stable political systems are also often linked with good performance. Human capital, mainly measured by the growth or level of education (Shigehara 1992)

Unemployment

There are three types of unemployment: frictional when workers are either searching for jobs or waiting to take jobs; structural unemployment: any worker who becomes unemployed due to a lack of skill with a new technology introduced by his or her employer; normal fluctuations of the business cycle. There is a positive rate of unemployment that the economic system would tend to i.e. natural rate of unemployment. Okun's Law defines an inverse relationship between unemployment rate and the growth rate of output, unemployment is a social problem the society loses output the amount of loss equals the difference between actual GDP and what it could be under the condition of full employment. Philips Curve found changes in money wage rate to be inversely related to unemployment rate, the derivation of the equations commences with equating the product of output by prices on the left hand to the product of mark-up times nominal wages times employment level and with some mathematical manipulation the relation between changes in prices is set to depend on changes in mark-up, changes in wages, and changes in real GDP minus change in the employment level (Sengupta 2011). Higher employment among skilled workers means higher aggregate income, hence higher saving rate, rise in the return to capital, more capital accumulation. On the other hand higher employment among low skilled worker encourages investment in human capital mainly through learning by doing and on job training.

Investment

The role of investment as the addition to the stock of physical capital and technological progress is emphasized by the classical economists since aggregate production depends on labor, physical capital and technology. Endogenous growth theory did not find physical capital accumulation to be dominant factor in spurring economic growth. The AK model assumes that income is a linear function of combined stock of human, physical and knowledge capital. Harrod-Domar used capital accumulation as central to economic growth. Solow assumed standard neoclassical production function where saving and population growth are exogenous (Sengupta 2011).

Monetary Policy

An increase in money supply will lower the interest rate and, therefore, increase investment and income. The higher amount of income will raise the demand for both domestic and foreign goods and services thus, causing a current account deficit. Further, a decline in the rate of interest would cause an outflow of capital. All in all, there is a higher demand for foreign currency and a lower supply of it. But now the price of foreign currency, namely the exchange rate, is flexible. It will rise, meaning the domestic currency is depreciated. The depreciation continues until the external equilibrium is restored and supply of and demand for foreign currency are equal. But the depreciation also cuts the amount of imports because foreign goods and services have become more expensive, and increases the amount of exports because domestic goods and services are cheaper for foreigners. The increase in exports also boosts income. Thus, the final equilibrium is reached at a higher level of income and a lower rate of interest; monetary policy is effective (Dadkhah 2009). Money Supply (M2) would affect real GDP positively because an increase in real quantity of money causes the nominal interest rate to decline and real output to rise (Hameed & Ume 2011).

Real Exchange Rate

The tradable sector of a country's economy is made up of the industry sectors whose output in terms of goods or services are traded internationally, or could be traded internationally given a plausible variation in relative prices. Most commonly, the tradable sector consists largely of sectors of the manufacturing industry, while the non-tradable sector consists of services, including health, education, retail and construction(Wikipedia) Nontradable goods, can only be consumed in the economy in which they are produced; they cannot be exported or imported. Balassa-Samuelson effect, asserts that in the process of growth real cost reduction comes faster in the tradables goods than in nontradables. Inflow of capital in the country if spent on nontradables i.e. dump the dollars in the local foreign exchange market, they cause the exchange rate to fall (or cause an expansion of the money supply and a consequent rise in the internal price level)., hence prices of tradables tend to fall relative to nontradables, which implies that the real price of the dollar will also tend to fall through time. Outflows of capital will similarly work to raise the real exchange price of the dollar. a rise in the world price of an export product, by adding to the supply of dollars, will lead to a fall in the real price of the dollar. Reduction of real cost of production lead to a fall in real price of the dollar opposite to the reduction of real cost of nontradables goods.

Custom duty and taxes reduce the demand and supply of foreign currency respectively (Harberger 2003). The real exchange rate is calculated as the nominal exchange rate multiplies ratio of consumer price index (CPI) divided by the world consumer price index (WCPI), which is available from the IMF data base. An increase in real exchange rate is caused by one or more the following: an increase in the nominal exchange rate and or WCPI, or a decrease in CPI.

Import Duty (Openness)

Custom duty (CD) is imposed to protect domestic industry—typically infant industries— from aggressive foreign competition. A high or low customs duty structure has an impact on revenue and fostering comfortable or tense international economic relations. Keynesian economists believe that low tariffs cause trade deficit. In a conventional neoclassical growth model, trade does not affect the equilibrium or steady state rate of output growth because, by assumption, growth is determined by exogenously given technological progress. Trade policy affects the allocation of resources between sectors. The effect of lowering rates on total revenue will be negative if the growing manufacturing sector is significantly dependent on imported capital and intermediate goods and enjoying exemptions from import duties, if the drawback systems tend to be based for administrative convenience, if there are discretionary measures, and finally the use artificial exchange rates for import duty valuation purposes which further reduce potential revenue. The reduction of revenue will lower public expenditure for development purposes. The abolition of trade restrictions (tariffs and quotas) is often seen as a necessary condition for growth. The idea is to widen markets and thus allow of scale in exporting industries (Goff 2003).

General Price Inflation

Inflation variable is measured as growth in the CPI its relevance (e.g. general price level). Typically, caused by many things of which are increase in total spending (demand pull inflation); abrupt increases in the costs of production, such as raw materials and power inputs (cost push). High prices indicate that more of certain things are wanted or are hard to get. Low prices indicate that the things to which they are attached are in surplus or have a low priority. Unanticipated inflation hurts fixed-income recipients, savers, and creditors (Pirayoff 2004). Inflationary effects associated with wages, mark-up, and/or tax pressures depend on the way monetary authorities will pass them on effective demand. For cost pressures come with the high demand for transaction money, inflation can develop if the central bank satisfies the additional demand for money (Arestis, Hein, & Heron 2006). Inflation has devastating effects on incomes do not rise

proportionally with general price level; injures low-income groups, results in unfulfilled implied promises. When people lose confidence in the value of money, they change their savings habits; harms business decision making; and creates a balance of payments problem by reducing our exports and stimulating our imports.

4. Methodology

4.1 Baxter-King Frequency Filter

Band-pass (frequency) filters) are used to isolate the cyclical component of a time series by specifying a range for its duration. Roughly speaking, the band-pass filter is a linear filter that takes a two-sided weighted moving average of the data where cycles in a "band", given by a specified lower and upper bound, are "passed" through, or extracted, and the remaining cycles are "filtered" out (EViews 7.1).

4.2 Discriminant Analysis

Rencher (2002) stated that there are two major objectives in separation of groups: (1) description of group separation, in which linear functions of the variables (discriminant functions) are used to describe or elucidate the differences between two or more groups i.e. identifying the relative contribution of the *p* variables to separation of the groups and finding the optimal plane on which the points can be projected to best illustrate the configuration of the groups. (2) Prediction or allocation of observations to groups, in which linear or quadratic functions of the variables classification functions) are employed to assign an individual sampling unit to one of the groups. The discriminant function is the linear combination of these p variables that maximizes the distance between the two (transformed) group mean vectors. A linear combination $z = a'y$ transforms each observation vector to a scalar:

$$z_{1i} = a'y_{1i} = a_1y_{1i1} + a_2y_{1i2} + \cdots + a_py_{1ip}; i = 1,2,\cdots,n_1 \ (1)$$

$$z_{2i} = a'y_{2i} = a_1y_{2i1} + a_2y_{2i2} + \cdots + a_py_{2ip}; i = 1,2,\cdots,n_2 \ (2)$$

The means are: $\bar{z}_1 = \sum_{i=1}^{n_1} z_{1i}/n_1 = a'\bar{y}_1; \bar{z}_1 = \sum_{i=1}^{n_2} z_{2i}/n_2 = a'\bar{y}_2$ (3)

Then find the vector a that maximizes the standardized squared difference as follows:

$$\frac{(\bar{z}_1 - \bar{z}_2)^2}{S_z^2} = \frac{[a'(\bar{y}_1 - \bar{y}_2)]^2}{a'S_{p1}a} \ (4)$$

The maximum of a occurs when $a = S_{p1}^{-1}(\bar{y}_1 - \bar{y}_2)$. For k groups H matrix from MANOVA in place of $(\bar{y}_1 - \bar{y}_2)(\bar{y}_1 - \bar{y}_2)'$ and E in place of S_{p1} to obtain: $\lambda = \frac{a'Ha}{a'Ea} = \frac{SSH(z)}{SSE(z)}$ where SSH*(z)* and SSE*(z)* are the between and within sums of squares for *z*. The relative importance of each discriminant function $z_i$can be assessed by considering its Eigen value as a proportion of the total: $\frac{\lambda_i}{\sum_{j=1}^{s}\lambda_j}$

4.3 Neural Network Analysis

Artificial Neural Network ANN is a group of neurons which communicate with each other. Artificial neural networks can detect basic functions within a set of data and perform tasks such as pattern identification, classification, assessment, modeling, forecasting, and control. The most commonly used is Multi-Layer Preceptors MLP network consists of three layers, the input layer and hidden layer, with each layer are one or more neurons, and output layer. In addition, the biased neurons (error) are linked by hidden layers and output. Due to its simple network structure and learning speeds Radial Basis Function RBF networks are used. It's kind of a forward feed NN consists of three layers, inputs layer, hidden, and the output layer. Weights Link distance between neurons in the hidden layer with the input of weigh vector a_p , multiplied by the threshold I_i . Back propagation (BP) algorithm is the most widely used training algorithm for ANN. They store the captured knowledge and make it available for future use. ANN has the capability to adapt the network parameters to the changes in the studied system (Simon and Raoot 2012). Two-layer feed forward neural network with an identity activation function is identical to a linear regression model. One of the inputs called the **bias** is equal to 1 for all observations. The various weights are equivalent to estimated regression coefficients, and the bias is the intercept (**Gonzalez 2000)**. If a variable that contain negative value has to be forecasted it is better to use the hyperbolic tangent as an activation function: $\frac{e^x - e^{-x}}{e^x + e^{-x}}$. If the dependent variable is binary the output would be the same as binary logistic probability model: $Y_t = f(a_0 + a_1X_{1t} + a_2X_{2t}) = \frac{1}{1+e^{(a_0+a_1X_{1t}+a_2X_{2t})}}$. If the dependent variable is not bounded, unbounded nonlinear activation function as $f(X) = X^3$. In the real world of application structure includes one or more hidden layer:

$$H_1 = f(a_{01} + a_{11}X_1 + a_{21}X_2) = \frac{1}{1 + e^{(a_{01}+a_{11}X_1+a_{21}X_2)}} \quad (5)$$

$$H_2 = f(a_{02} + a_{12}X_1 + a_{22}X_2) = \frac{1}{1 + e^{(a_{02}+a_{12}X_1+a_{22}X_2)}} \quad (6)$$

If the dependent variable is not bounded, the output put is identity activation function i.e. the output will be equal to weighted sum of hidden unit values weighted by the b_j coefficients. This yields continuous nonlinear unbounded output expresses as follows:

$$Y = b_0 + b_1H_1 + b_2H_2 = b_0 + \frac{b_1}{1 + e^{(a_{01}+a_{11}X_1+a_{21}X_2)}} + \frac{b_2}{1 + e^{(a_{02}+a_{12}X_1+a_{22}X_2)}} \quad (7)$$

If the dependent variable is bounded

$$Y = f(b_0 + b_1H_1 + b_2H_2) = b_0 + \frac{1}{1 + e^{(b_0+b_1H_1+b_2H_2)}} \quad (8)$$

$$Y = -\left(b_0 + \frac{b_1}{1 + e^{(a_{01}+a_{11}X_1+a_{21}X_2)}} + \frac{b_2}{1 + e^{(a_{02}+a_{12}X_1+a_{22}X_2)}}\right) \quad (9)$$

5. Results and Discussion

5.1 Data Description

The data used for investigating the determinant of GR in the Sudan economy during the period 1960 - 2009 are taken from different sources. Data symbols, description and sources are displayed in Table (1)

Table (1) Variables included, their description and sources 1960-2009

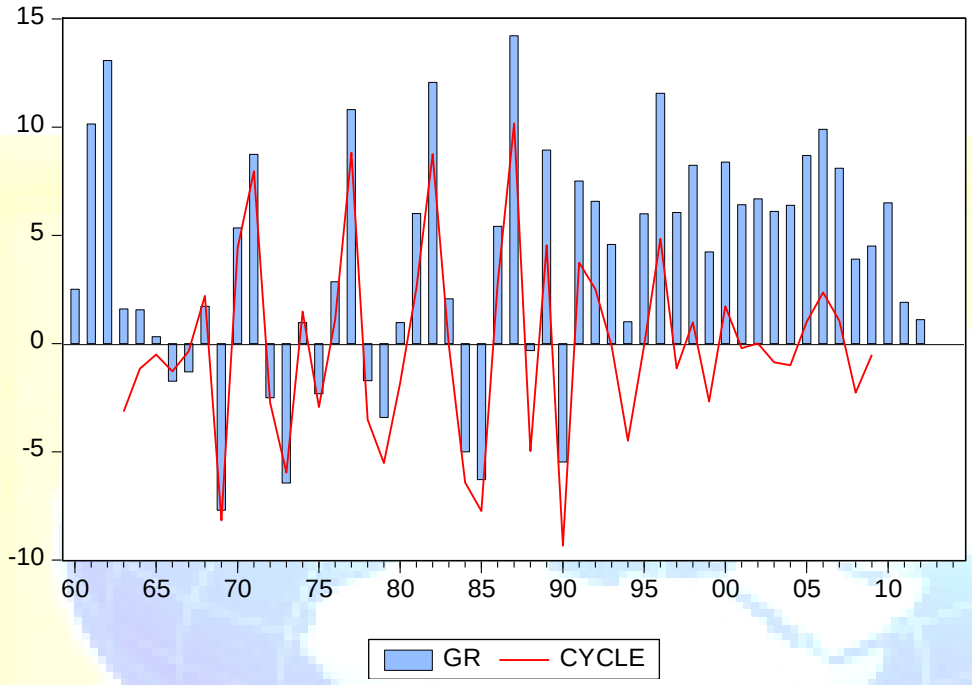
Variable	Symbol	Description	Source
Real GDP Growth Rate	GR	Percentage	Central Bureau of Statistics
Saving Ratio	SR	Ratio to GDP	Central Bureau of Statistics
Terms of Trade	TOT	Percentage	Central Bureau of Statistics
Labor Productivity Growth	LPGR	Percentage	Central Bureau of Statistics
Unemployment Growth rate	UGR	Million Persons	Central Bureau of Statistics
Investment ratio to GDP	INVR	Ratio to GDP	Central Bureau of Statistics
General Price Inflation	PGR	Percentage	Central Bank of Sudan
Real Growth Rate of Money	M2GR	Ratio to GDP	Central Bank of Sudan
Import Duty Ratio to Import	IDR	Ratio to Import	Central Bureau of Statistics
Real Exchange Rate	RER	Percentage	Central Bank of Sudan/IMF

Real growth of GDP (GR) turned to dummy variable $G = \begin{cases} 1\ if\ GR > 0, expansion \\ 0, otherwise, recession \end{cases}$

5.2 Results

Below are the results of three methods. Baxter-King filter to identify cycle, discriminant analysis and ANN to classify growth into two group recession and expansion.

5.2.1 Figure (1) Baxter-King Frequency Filter



5.2.2 ANN and Discriminant Analysis

Discriminant analysis and NNA were used to classify growth rates into two groups' Recession and Expansion.

Linear Method for Response: G; Predictors: SR, TOT, LPGR, UGR, INVR, M2GR, RER, IDR, and PGR

Table (2) Classification by ANN and Discriminant Analysis

	ANN			**Discriminant**		
	Recession	Expansion	Overall	Recession	Expansion	**Overall**
Recession	10	1	11	11	6	17
Expansion	1	24	25	1	32	33
True N	11	25	36	12	38	50
N Correct	10	24	34	11	32	43
Proportion	0.909	0.96	**0.944**	0.917	0.842	**0.860**

Recession	1	0	1	10	9	
Expansion	0	12	12	2	29	
cross N	1	12	11	12	38	
N Correct	1	12	11	10	29	39
Proportion	0.100	0.100	**0.100**	0.883	0.763	**0.780**

Source: Author's calculation

5.3 Discussion

The Baxter-King frequency filter depicted in Figure (1) showed that the real growth rate has been oscillating between expansion and recession which in most times lasting for two years. Artificial Neural Network (ANN) results outperform discriminant analysis.

Saving-Investment gap has not been bridged. The minimum and maximum of savings and investment ratio to GDP are -4.4% 5.9%; and 13.7%, 47.5% respectively, the period 1983-1986 witnessed negative saving ratio due to drought, start of civil war, and change of government by military coup. The years 1996 and 1997 showed negative share was direct result of inappropriate economic policies i.e. liberalization of the economy adopted in Feb. 1992. Generally the rise of the dependency ratio from 69 in 1992 to 85 in 2008 has an impact on saving as has been stated by life cycle hypothesis and being proven by empirical research. The Investment ratio reached the highest at 47.5% and the bottom was 5.9%. The gap ought to be bridged by foreign saving i.e. current account surplus which was realized only in three years 1970, 1973, and 2000. Hence the only way-out was to resort to foreign borrowing.

Labor Productivity –Unemployment: Sudan is endowed with labor abundant recourses. Most of labor force engages in primary production (agriculture and handicrafts) which depends on traditional tools and obsolete technology (this means inefficiency of technology is not responsible for translating skills, learning on the job and educational achievement into productivity gains.), and production is affected by weather conditions. The growth of labor productivity has similar pattern to real growth rate, except the decline lasts for longer periods that is three to five years. The education revaluation which began in early 1990's resulted in huge increase of enrolment at the general and higher education. The expansion has been biased towards academic education and ignoring to a great extent the technical and vocational training led to shortage of skilled labor. The schooling years per individual (educational achievement) increased from 0.48 in 1960 to 3.04 in 2005. Despite the rising number of labor force labor

productivity is declining due to the phenomenon of disguised unemployment resulted mainly from politicization of civil work. Unemployment of all types is growing steadily. The rise is caused by declining real wage rate as a result of continuous rise in prices, labor market rigidities, and the discourage caused by labor market policies do to job seeking and human capital formation especially among university graduates where nepotism has been widely spread. The rise in the cost of production and shortage of raw material especially fuel Leeds to continuous shutdown of factories and hence loss of jobs Unemployed graduates compose the bulk of unemployed and the number is rising annually by the addition of new graduates. Graduates suffer from skill-shortage vacancies due to the lack of experience or qualification, and internal skill gap where the existing staff is not fully proficient.

Terms of Trade, Real Exchange Rate and Import Duty variables relate Sudan to the external world. They showed significance effects in the process of classification which means the country is vulnerable to foreign shocks result from unfavorable terms of trade, real exchange rate and custom duty whereas Sudan exports are mainly primary products. There has been favorite term of trade during periods 1960-1974 and 2000-2009. Real exchange rate has downward trend during the period 1969-1990. The continuous increase in the consumer price index and relative stable world price were the main causes of downward trend. Devaluation of the exchange rate was supposed to make export more competitive and import expensive. The Marshal-Lerner condition has not been met for the elasticity of demand for imports and exports have not been achieved. Empirical results do not support existence of J-curve (Arabi & Abdalla 20114). Import duty has been one of the main sources of revenue. Its mean ratio to GDP and import of goods is 5% and 34.4% respectively. The manufacturing sector depends largely on imported raw material; this puts the public policy into a dilemma i.e. how to balance the collection revenue by levying custom duty on imported goods in the one hand and to exempt or lower custom duty to encourage and defend local industries. Nontradable sectors comprise most development projects meaning that foreign currency on these sectors leading to the expansion in money supply and rising inflation.

Monetary (Policy) growth rate is the main tool of the monetary authorities. The Sudan abolished the use of interest rate since the introduction of Islamic laws in 1983 and replaces it with Islamic modes of finance. The major Islamic mode of finance is the sharing of profits and losses (Participation) usually in trade activities and not real production. The increase in nominal money

supply leads to price rise and depreciation of the exchange rate. Real demand for money is calculated by dividing the quantity of money by the consumer price index. The real growth of money was negative during the period 1992-1996 where inflation reached 129%. Real demand form money (M2) affects real GDP positively because an increase in real quantity of money causes the returns of Islamic modes of finance rate to decline and real output to rise due to direction of loans toward agricultural and industrial production. The potential GDP exceeds real GDP during the period 1978-1996 so there is inflationary gap. The increase in the quantity of money lowers the cost of capital. The lower cost of capital increases investment. The increase in investment leads to a multiplier effect that decreases aggregate demand, thereby lowering the price level and decreasing real GDP so it equals potential GDP and avoiding recession.

General Price Inflation decline for two consecutive years was materialized five times over the period 1966 -1984. The growth rate started rising since 1990 to reach the peak of 132% in 1996. The main reason was the economic policies adopted in 1992. The surge of oil prices in the early 1972's affects negatively growth. Inflation has devastating effects on incomes do not rise proportionally with general price level; injures low-income groups the official announcement about the ratio of people under the poverty line is 47% while independent researchers found about 85%. The continuous rise of prices resulted in the dollarization of the economy, capital flight and aggravated a balance of payments problem by reducing our exports and stimulating our imports

6. Conclusion

In this article, we have resorted to two classification techniques: discriminant analysis and artificial neural networks (ANN). The performance of the two above techniques is contrasted with each other, ANN outperform discriminant analysis. The model identified nine factors that played a major role in influencing GDP growth. Duration of recession and expansion for two consecutive years appeared four times. The problem of unemployment rate should have the appropriate attention. The government should activate its policies toward graduate employment by offering opportunities to run small scale projects. The balance between technicians and academics should be strutted by revising educational and human capital formation policies. Investment in physical and human capital should be accompanied by structural reforms and revision of the current economic policies. The role of fiscal policy is necessary in increasing income and employment by an increase in government expenditure or a tax cut. Increase in the

spending on infrastructure and new technology reduces cost of production. Prices ought to be controlled by tide monetary policy, and to direct Islamic financing mode towards production rather than trade. The mobilization of saving is a necessity to bridge the gap with investment. The priority of custom duty is to protect infant industries.

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Annex (1) Descriptive Statistics

	GR	SR	TOT	LPGR	UGR	INVR	M2GR	RER	IDR
Mean	3.686792	4.648946	1.083391	1.184235	1.175057	21.27621	5.672932	1.325873	18.07443
Median	4.574514	4.847953	1.019608	1.555512	1.040119	20.09878	6.795016	1.293091	12.51552
Maximum	14.22088	13.67054	2.830334	14.22088	1.738123	47.52305	34.63610	2.151376	61.72558
Minimum	-7.703950	-9.507065	0.577593	-16.48708	0.949668	5.870246	-30.38946	0.328019	0.000000
Std. Dev.	5.566397	5.467763	0.388942	6.793098	0.273593	9.775154	13.99403	0.463236	19.40060
Skewness	-0.209436	-0.486290	2.152599	-0.297636	1.318097	0.976942	-0.559929	-0.026949	0.874243
Kurtosis	2.231768	2.706323	10.03616	2.577367	2.870560	3.511902	3.443335	2.028231	2.447162
Jarque-Bera	1.499367	2.021307	133.2493	1.043727	13.64229	7.989424	2.840809	1.855011	6.585552
Probability	0.472516	0.363981	0.000000	0.593414	0.001090	0.018413	0.241616	0.395539	0.037151

Annex (2) Growth Rate Frequency Distribution

Date: 10/25/14 Time: 06:01

Sample (adjusted): 1960 2010

Number of categories: 5

Value	Count	Percent
[-10, -5)	5	9.80
[-5, 0)	7	13.73
[0, 5)	12	23.53
[5, 10)	21	41.18
[10, 15)	6	11.76
Total	51	100.00

Annex (3) Pairwise Granger Causality Tests

Date: 10/25/14 Time: 22:32

Sample: 1960 2014

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
SR does not Granger Cause GR	51	1.01453	0.3705
GR does not Granger Cause SR		0.74467	0.4805
TOT does not Granger Cause GR	51	0.13990	0.8698
GR does not Granger Cause TOT		0.18433	0.8323
LPGR does not Granger Cause GR	50	0.11190	0.8944
GR does not Granger Cause LPGR		3.65093	0.0339
UGR does not Granger Cause GR	50	2.62012	0.0839

GR does not Granger Cause UGR		0.33539	0.7168
INVR does not Granger Cause GR	49	5.20022	0.0094
GR does not Granger Cause INVR		0.81000	0.4514
M2GR does not Granger Cause GR	50	0.01960	0.9806
GR does not Granger Cause M2GR		0.88525	0.4197
RER does not Granger Cause GR	47	1.02256	0.3685
GR does not Granger Cause RER		2.22330	0.1208
IDR does not Granger Cause GR	48	0.39600	0.6754
GR does not Granger Cause IDR		0.25953	0.7726

Annex (4) Variance Inflation Factors

Date: 11/01/14 Time: 11:37

Sample: 1960 2009

Included observations: 48

	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
TOTGR	0.000324	1.282769	1.264373
UGR	8.595667	54.70426	2.963776
PGR	0.000760	6.089831	3.366748
SR	0.018308	3.883842	2.254734
INVR	0.007216	16.79386	2.817211
IDR	0.002425	16.90625	3.990302
LPGR	0.006389	1.260341	1.215515
M2GR	0.002306	2.152898	1.845281
RER	2.377115	19.56804	2.190464

Annex (5) Cointegration Results

Date: 10/04/14 Time: 15:25

Sample (adjusted): 1962 2006

Included observations: 45 after adjustments

Trend assumption: Linear deterministic trend

Series: GR S/GDP TOT LPGR UGR INVR M2GR RER IDR

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**

None *	0.786853	207.1832	197.3709	0.0148
At most 1	0.586760	137.6234	159.5297	0.4078
At most 2	0.449028	97.85573	125.6154	0.6682
At most 3	0.393833	71.03253	95.75366	0.6875
At most 4	0.340907	48.50553	69.81889	0.7012
At most 5	0.258368	29.74546	47.85613	0.7319
At most 6	0.211381	16.29484	29.79707	0.6914
At most 7	0.090424	5.608594	15.49471	0.7412
At most 8	0.029417	1.343641	3.841466	0.2464
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Annex (6) Linear Discriminant Function for Two Group

	Recession	Expansion
Constant	-12.109	-11.188
SR	-0.318	-0.144
TOT	1.450	1.374
LPGR	-0.185	0.105
UGR	0.855	0.883
INVR	0.391	0.381
M2GR	0.135	0.168
RER	1.017	3.282
IDR	0.208	0.181
PGR	0.003	0.030

Source: Authors calculation

Annex (7) ANN Results : Case Processing Summary

		Two Groups	
		N	Percent
Sample	Training	36	73.5%
	Testing	13	25.5%
Valid		49	100.0%
Excluded		4	
Total		51	

Figure (2)

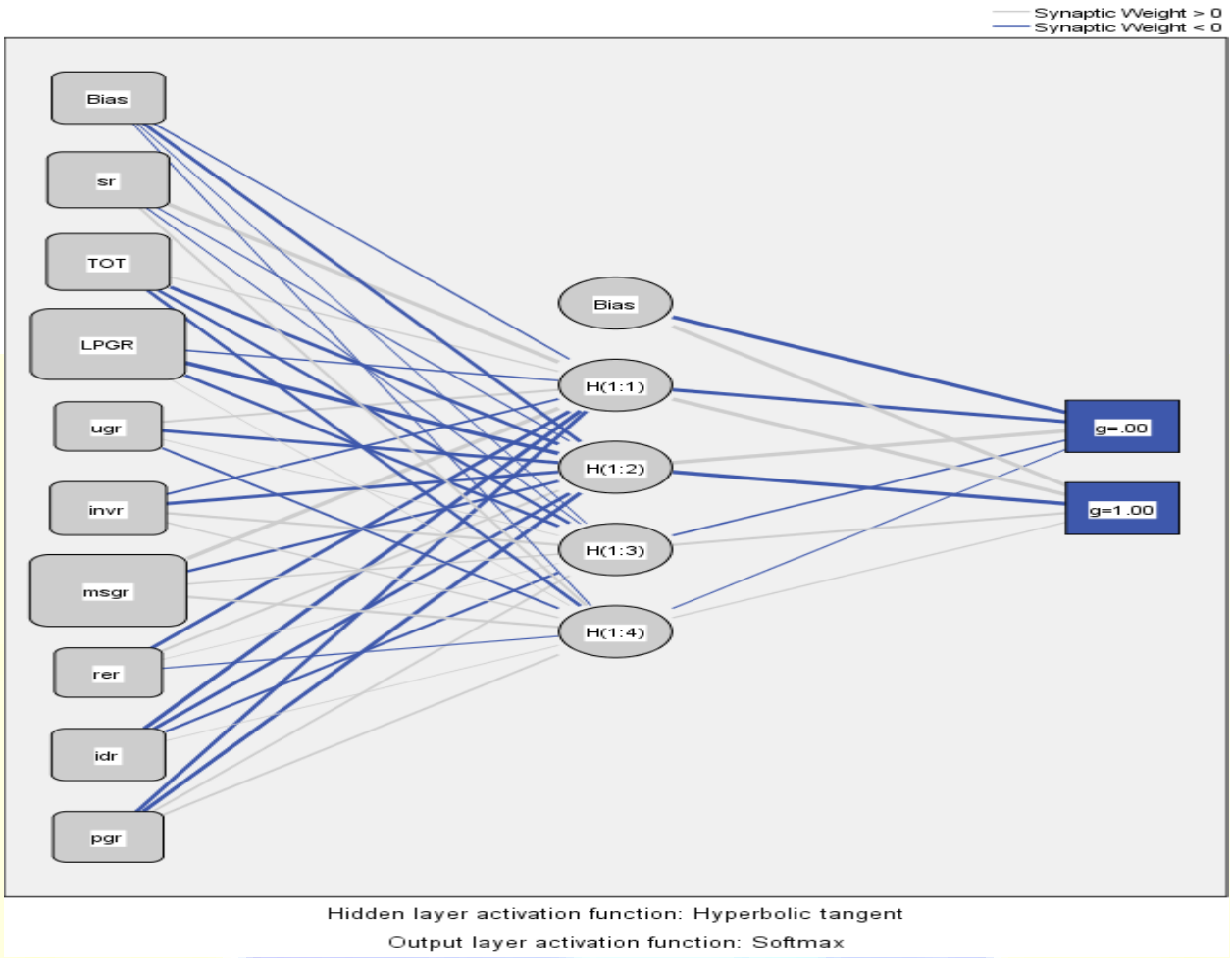

Figure (3) Normalized Importance