

Modeling and Forecasting Africa's GDP with Time Series Models

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Abstract- Forecasting economic growth for developing countries is a problematic task, peculiarly because of particularities they face. The model identification process in this paper yielded a random walk model for the Gross Domestic Product (GDP) series. We applied ARIMA models to get empirical results and bring to a close that the models obtained are suitable for forecasting the economic output of Africa. The adequate models were used for each of 20 Africa's largest economies to forecast future time series values. Based on the estimation results, we concluded that from 1990 looking forward to 2030, there will be an increasing GDP growth where the average speed of the economy of Africa will be of 5.52%, and the GDP could achieve \$2185.21 billion to \$10186.18 billion.

Keywords: Africa, ARIMA Model, Economic Growth, Forecasting.

growing economy behind South Asia. In 2013, Africa was the world's fastest-growing continent at 5.6% a year. Estimated to have strengthened from 1.3% in 2016 to 2.4% in 2017, the GDP growth in the region is mainly led by the largest economies: Nigeria, South Africa, and Angola. Where, According to African Development Bank, Nigeria and South Africa account for the largest share of Africa's GDP with 29% and 19%, respectively (Bank 2017). In this paper, we made a projection of the GDP growth for fourteen years ahead that is from 2016 to 2030. This paper also points out the largest region in the continent and the largest country's economic growth. According to the result obtained, we suggest that each Country must have its focal point on comprehensive development of economic growth. The Government of a Country must know how to adjust to low oil prices, depressed revenues, and rising debt levels, each Country should increase its infrastructure investment. Each Country should increase the public investment and each Country must ensure its Political stability.

I. INTRODUCTION

While the rest of the world's economy grew at an annual rate of close to 2% from 1960 to 2002, growth performance in Africa has been hopeless. From 1974 through the mid-1990s, growth was negative, reaching negative 1.5 percent in 1990-4. As a consequence, hundreds of millions of African citizens have become poor: one half of the African continent lives below the poverty line. According to the 2012 Africa Millennium Development Goals (MDGs) report, Africa has made a huge progress. The report states that between 1990 and 2008, the number of Africans living under US\$1.25 per day decreased from 56.5% to 47.5%, and the number of poor people fell from 394.9 million to 386 million. Africa is the world's second-fastest

II. OBJECTIVES OF THE STUDY

The main objective of this study is to model and forecast the Gross Domestic Product of Africa using Time Series models. In the study, we present the largest economy of Africa by regions and give a macro number upon which many African businesses and governments could base their decisions with respect to investment, hiring, and spending.

III. DATA AND METHODOLOGY

From the World Bank database, we collected GDP data for 26 years from 1990 to 2016, analyzed and forecasted them for 14 years ahead. The sample is composed of twenty biggest economies in terms of the size of GDP: Equatorial Guinea, Gabon, Zambia, Uganda, Cameroon, Ivory Coast, Democratic Republic of Congo, Tanzania, Tunisia, Ghana, Ethiopia, Kenya, Sudan, Libya, Morocco, Angola, Algeria, and Egypt. In this study, E-views 9 have been used for statistical analysis.

A. ARIMA model

An Autoregressive Integrated Moving Average (ARIMA) model is a generalization of an Autoregressive Moving Average (ARMA) used in statistics and econometrics. ARIMA models are of a great significance in the Box-Jenkins approach to time-series model and the most general class of models for forecasting a time series which can be stationary by transformations such as differencing and logging (Lu and He 2009).

The paper adopts ARIMA (p, d, q) models where p is the number of autoregressive terms, d is the number of non-seasonal

differences and q is the number of moving average lags. Let us assume the series y_t which can be stationary after d times of differentiating, i.e. $y_t \sim I(d)$ then, $u_t = \Delta^d - y_t = (1 - B)^d y_t$ where u_t is stationary series, i.e. $u_t \sim I(0)$ and in this case the ARIMA (p, q) model will be as follow:

$$\text{ARIMA}(p, q): (1 - L)^d \varphi^*(L)y_t = c + \theta(L)e_t$$

Where φ^*L is defined in $\varphi(L) = (1 - L)\varphi^*(L)$, with $\varphi^* \neq 0$ for all $|z| \leq 1$ and $\theta(L)$ is defined in $\theta(z) \neq 0$ for all $|z| \leq 1$. Hamilton and Samuel stated that ARIMA models are always used in situations where time series show evidence of non-stationary by using an initial differencing step to remove the non-stationary(Hamilton and Susmel 1994).

The advantages of the ARIMA models are not only to speculate the influence of systematic factors such as continual advancement of technology, and sustainable growth of workforce, continual improvement of educational level, continual formation of capital, continual improvement of total factor productivity, but also includes many unobservable factors such as change of system, change of climate, etc.(Wang 2016).

IV. ANALYSIS AND FINDINGS

For the analysis, we adopted different calculating method and refer to the methodology used by Wang for Shenzhen GDP Forecasting (Wang 2016), Ince and Molodtova for rationality and forecasting accuracy (Ince and Molodtova 2017) and Oluwatayo and Ojo for economic growth and poverty in Africa (Oluwatayo and Ojo 2018).

To reach the objective, we made the following Hypothesis:

H_0 : An increasing trend will appear for African economic growth for the 14 upcoming years

H_1 : An increasing trend will not appear for African economic growth for the 14 upcoming years

The steps taken to analyze and test the above hypothesis are

Step-1 To plot the data as time series

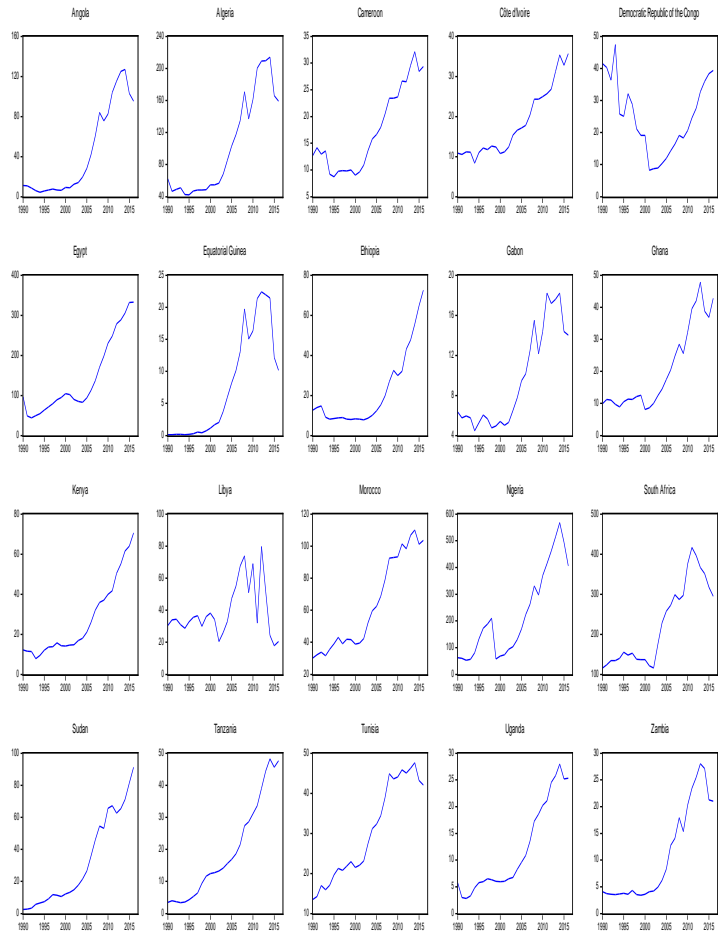
Step-2 To perform the first and second difference to make the data stationary

Step-3 To plot ACF and PACF to identify potential AR and MA model

Step-4 Identification of best fit ARIMA model

Step-5 Forecast the GDP using the best fit ARIMA model

Step-6 Plot the ACF and PACF for residuals



the data are not stationary and then we proceed for differentiation. After the first difference of the data, the GDP data of Algeria, Cameroon, Ivory Coast, DRC, Egypt, Equatorial Guinea, Ethiopia, Ghana, Libya, Morocco, Tunisia, Uganda, and Zambia become stationary.

The first difference of the data is not stationary for Angola, Gabon, Kenya, Nigeria, South Africa, Sudan and Tanzania. Therefore, we perform the second difference and the second difference render the data stationary. Since all the data are now stationary, we can apply Box –Jenkins methodology and select the best fit model. The ARIMA models established using B-J method are obtained in the following table.

Table 1: ARIMA models

Country	ARIMA model
Algeria	(1,1,6)
Angola	(3,2,1)
Cameroon	(1,1,2)
DRC	(1,1,3)
Egypt	(1,1,1)
Equatorial Guinea	(1,1,6)
Ethiopia	(1,1,1)
Gabon	(3,2,1)
Ghana	(5,1,1)
Ivory Coast	(1,1,0)
Kenya	(1,2,2)

Figure 1: Time plot of Annual GDP series (1990-2016)

Libya	(1,1,1)
Morocco	(1,1,5)
Nigeria	(1,2,0)
South Africa	(1,2,1)
Sudan	(1,1,1)
Tanzania	(1,1,1)
Tunisia	(1,1,1)
Uganda	(1,1,0)
Zambia	(1,1,0)

The observed forecasted values are shown in table 2 and the actual numerical values are used to compute errors. The data demonstrate that the predicted values are much closer to actual values, and average prediction errors are calculated as 1.5%, approximating to 2 % points, which shows a good fitting effect and higher prediction precision of the model. Therefore this model can be used to predict the actual GDP of Africa.

Table 2: Forecasted values

	Algeria	Angola	Cameroon	DRC	Egypt	Eq. G.
2017	162.78	99.96	29.97	40.44	333.00	10.57
2018	166.52	101.75	30.61	40.83	333.95	10.95
2019	170.26	103.51	31.25	40.48	335.13	11.34
2020	173.99	105.24	31.89	39.42	336.49	11.72
2021	177.73	106.94	32.53	37.70	338.00	12.11
2022	181.47	108.61	33.17	35.39	339.61	12.50
2023	185.20	110.26	33.81	32.61	341.31	12.88
2024	188.94	111.89	34.45	29.50	343.08	13.27
2025	192.68	113.49	35.09	26.20	344.90	13.66
2026	196.41	115.07	35.73	22.88	346.76	14.04
2027	200.15	116.63	36.37	19.70	348.65	14.43
2028	203.89	118.16	37.01	16.80	350.57	14.82
2029	207.62	119.68	37.65	14.34	352.51	15.20
2030	211.36	121.18	38.29	12.43	354.47	15.59

	Ethiopia	Gabon	Ghana	Iv. Co	Kenya	Libya
2017	94.90	15.15	44.04	37.35	75.46	36.88
2018	124.50	13.38	45.30	39.10	80.73	41.41
2019	161.95	13.00	46.56	40.94	86.37	39.35
2020	213.36	14.01	47.82	42.86	92.40	39.35
2021	284.71	13.32	49.09	44.87	98.86	39.35
2022	384.78	13.01	50.35	46.98	105.77	39.35
2023	526.71	13.76	51.61	49.18	113.16	39.35
2024	730.24	13.61	52.87	51.49	121.07	39.35
2025	1025.41	13.41	54.13	53.91	129.53	39.35
2026	1458.37	13.93	55.39	56.44	138.58	39.35
2027	2100.77	14.02	56.65	59.09	148.27	39.35
2028	3064.98	13.94	57.92	61.87	158.63	39.35
2029	4529.15	14.30	59.18	64.77	169.71	39.35
2030	6778.66	14.49	60.44	67.81	181.57	39.35

	Morocco	Nigeria	S.	Sudan	Tanzania	Tunisia
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			Africa			
2017	106.43	418.64	296.42	117.22	55.16	43.17
2018	109.26	431.85	303.12	156.88	67.32	44.27
2019	112.08	445.05	309.82	196.95	82.43	45.37
2020	114.90	458.25	316.53	246.27	98.03	46.47
2021	117.73	471.46	323.23	303.90	112.12	47.57
2022	120.55	484.66	329.93	343.80	124.21	48.67
2023	123.38	497.86	336.64	365.65	135.42	49.77
2024	126.20	511.07	343.34	383.80	147.55	50.87
2025	129.02	524.27	350.04	395.51	162.27	51.97
2026	131.85	537.47	356.75	408.00	180.67	53.07
2027	134.67	550.67	363.45	441.90	203.14	54.17
2028	137.50	563.88	370.15	507.13	229.52	55.27
2029	140.32	577.08	376.86	609.90	259.34	56.37
2030	143.14	590.28	383.56	768.00	292.16	57.47

	Uganda	Zambia
2017	24.58	17.27
2018	26.59	16.90
2019	26.21	17.31
2020	27.69	17.73
2021	27.72	18.15
2022	28.88	18.56
2023	29.17	18.98
2024	30.13	19.40
2025	30.57	19.81
2026	31.41	20.23
2027	31.94	20.65
2028	32.72	21.06
2029	33.30	21.48
2030	34.03	21.90

From table 2, we can state that the economic growth of Africa has an increasing trend and accept the Null hypothesis” An increasing trend will appear for African economic growth for the 14 upcoming years”.

Figure 2: East Africa GDP forecast

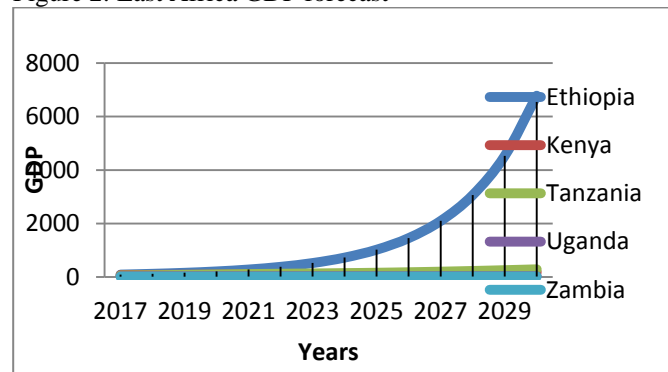


Figure 3: West Africa GDP forecast

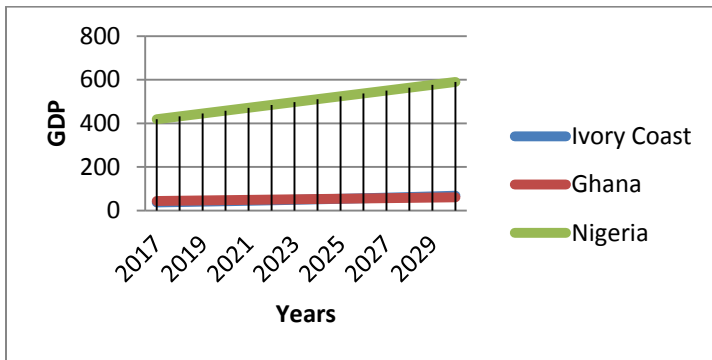


Figure 4: North Africa GDP forecast

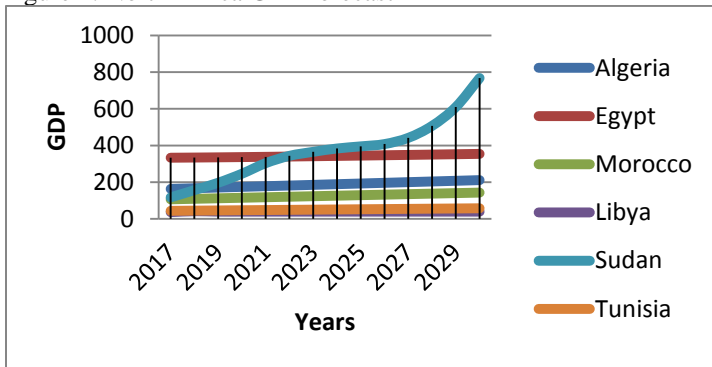


Figure 5: Central Africa GDP forecast

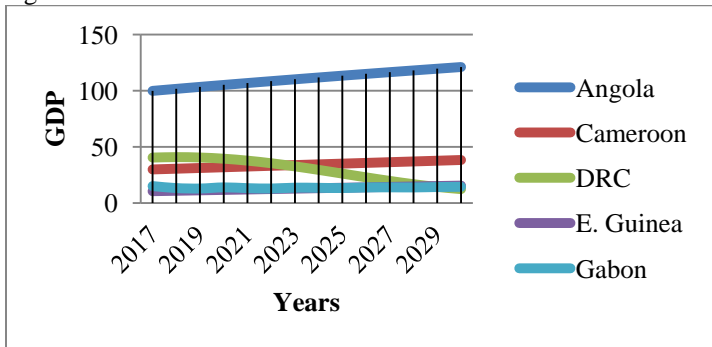
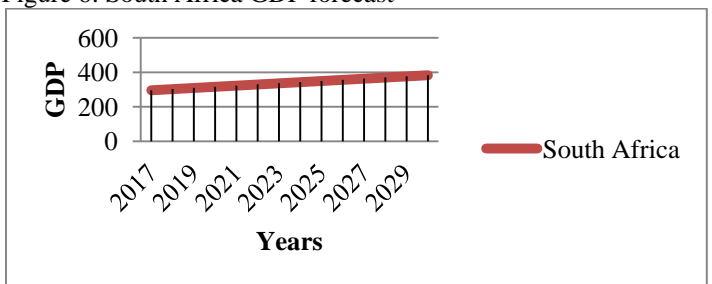
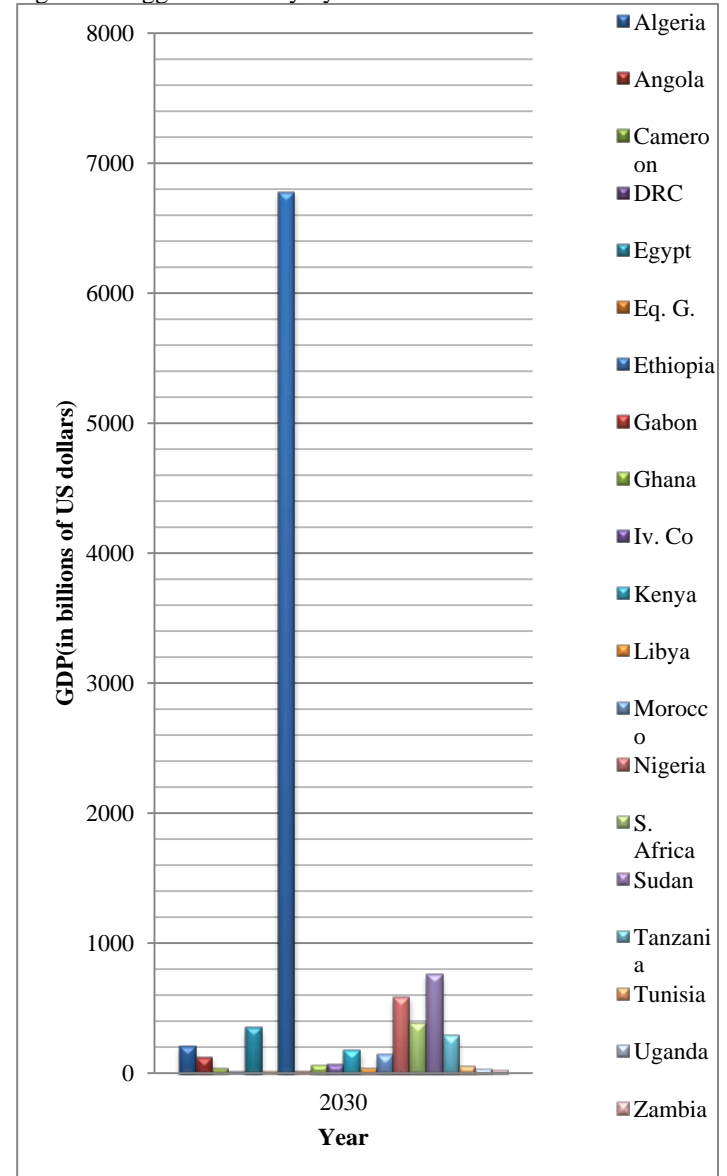


Figure 6: South Africa GDP forecast



The economic growth in Northern Africa has a changing magnitude over the course of the coming 14 years. However, growth prospects remain weak in the Central African Economic and Monetary Community (CEMAC) countries. East Africa Community (EAC) countries continue to be the fastest growing economy while Southern Africa is projected to see a down slope. When comparing the GDP of all the twenty countries, we find that by 2030, Ethiopia will be the biggest economy.

Figure 7: Biggest economy by 2030



For testing the forecast accuracy, we especially consider the aspect of Theil Inequality Coefficient which is the systematic error given by:

$$TIC = \frac{\sqrt{\frac{1}{1+f} \sum_{t=T}^{T+f} (\sigma_t^2 - \sigma_{t.T}^2)^2}}{\sqrt{\frac{1}{1+f} \sum_{t=T}^{T+f} (\sigma_t^2) + \sqrt{\frac{1}{1+f} \sum_{t=T}^{T+f} (\sigma_{t.T}^2)^2}}}$$

Where f represents the forecast horizons. For the values of Theil Inequality Coefficient, if equals to zero then we have a perfect fit meaning that the actual and forecasted variable is same and there is no error, therefore the predictive power is perfect. If equals to 1, then the predictive power is the worst and if between zero and 1 then the predictive power is the best.

Table 2: Theil Inequality Coefficient Forecasting accuracy

Country	Theil Inequality	Bias Proportion
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	Coefficient	
Algeria	0.07	2%
Angola	0.11	13%
Cameroon	0.05	9%
DRC	0.1	1%
Egypt	0.04	6%
Equatorial Guinea	0.11	4%
Ethiopia	0.06	11%
Gabon	0.08	20%
Ghana	0.13	48%
Ivory Coast	0.05	13%
Kenya	0.04	29%
Libya	0.17	1%
Morocco	0.03	14%
Nigeria	0.09	8%
South Africa	0.04	6%
Sudan	0.05	23%
Tanzania	0.04	29%
Tunisia	0.03	15%
Uganda	0.05	12%
Zambia	0.08	9%

V. DISCUSSION

Based on the findings, we can see that GDP data are non-stationary series as shown in figure 1. Therefore, the Dickey-Fuller test was performed to confirm the stationarity. The ARIMA model that fits best for the 20 continent's largest economies is presented in table 1. From figure 2 to 6, we can see that the growth rate shows a rising tendency for Algeria, Angola, Cameroon, Ivory Coast, Equatorial Guinea, Ghana, Kenya, Morocco, Nigeria, South Africa, Sudan, Tanzania, Tunisia, and Zambia while for Gabon and Uganda the economic growth rate goes up and down. Libya has an increasing then a decreasing then a constant tendency. A slight raising economic growth tendency is observed for Egypt and a gradually raising for Ethiopia. A falling tendency for the Democratic Republic of Congo with an average growth rate around 1.8%, 1.3%, 1.7%, -13.3%, 0.6%, 2.6%, 49.7%, 1.3%, 2.1%, 4.7%, 7.0%, 0.0%, 2.0%, 2.3%, 1.8%, 25.9%, 12.7%, 2.0%, 2.2%, and 2.0% for Algeria, Angola, Cameroon, Ivory Coast, Equatorial Guinea, Ghana, Kenya, Morocco, Nigeria, South Africa, Sudan, Tanzania, Tunisia, and Zambia respectively.

The result in figure 7 means that among twenty largest economies, Ethiopia comes on top with a GDP amount of 6778.66 billion US Dollars. The result in table 2 means that a significant forecast ability is obtained for all countries and the Bias Proportion or the systematic error shows that the gap between the actual variable and the predicted variable is small.

VI. CONCLUSION

The present study tries to forecast the economic growth of Africa in 14 years ahead. The study shows that the economic growth of Africa has an increasing trend and there is a high economic growth trend of about 5.52% and GDP can achieve \$2185.21 billion to \$10186.18 billion by 2030.

Based on regions, the first, second, third, fourth and fifth top are respectively East, North, West, South, and Central Africa. Our findings are in line with that of Rodrik, Fedderke, and Oluwatayo (Rodrik 2016), (Fedderke and Mengisteab 2017), (Oluwatayo and Ojo 2018). Each country forecasted GDP value of the year 2030 is 211.36 billions of dollars, 121.18 billions of dollars, 38.29 billions of dollars, 12.43 billions of dollars, 354.47 billions of dollars, 15.59 billions of dollars, 6778.66 billions of dollars, 14.49 billions of dollars, 60.44 billions of dollars, 67.81 billions of dollars, 181.57 billions of dollars, 39.35 billions of dollars, 143.14 billions of dollars, 590.28 billions of dollars, 383.56 billions of dollars, 768.00 billions of dollars, 292.16 billions of dollars, 57.47 billions of dollars, 34.03 billions of dollars and 21.90 billions of dollars respectively for Algeria, Angola, Cameroon, Democratic Republic of Congo, Egypt, Equatorial Guinea, Ethiopia, Gabon, Ghana, Ivory Coast, Kenya, Libya, Morocco, Nigeria, South Africa, Sudan, Tanzania, Tunisia, Uganda, and Zambia.

Among countries, Ethiopia comes first with a GDP amount of 6778.66 billion US Dollars and Democratic Republic of Congo (DRC) is the last with an average growth rate of -13.3% that is, 12.43 billion US dollars. Our findings show that the ten largest economies by 2030 will be: Ethiopia, Sudan, Nigeria, South Africa, Egypt, Tanzania, Algeria, Kenya, Morocco and Angola.

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