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A Statistical Examination of Major Global Determining Factors for Achieving Robust Life Expectancy by the Year 2030

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ABSTRACT

For Nigeria to attain the goal of becoming one of the twenty (20) largest economies by the year 2030, the life expectancy of her citizens must be robust. This study reveals the relationship that exists between Global Life Expectancies (GLE) and some of its major predictors such as Gross Domestic Products (GDP) per capita, Electricity Consumption (ECM) per capita, and Access to Safe Water (ASW), Infant Mortality Rate (IMR), Maternal Mortality Rate (MMR) and Acquired Immune Deficiency Syndrome (AIDS) reported cases with the aim of formulating an appropriate model for measuring such relationship. Using the Ordinary Least Squares regression analysis, it is observed that the determinants contribute most significantly to the growth of life expectancies. The multiple regression analysis reveals highly significant and negatively linear relationship between life expectancy and maternal mortality rate with a significant and positive association with Gross Domestic Product per capita and access to safe water.

Keywords: Life expectancy; Determining factors; Gross domestic products; Infant mortality rate; Vision 2030.

Introduction

Life expectancy at birth measured in years is the number of years newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life over the population of each individual country (Glasen, 2015). It reflects social factors such as health care, disease control, immunization, overall living conditions, and nutrition. In the last several decades, life expectancy has increased in all regions for both men and women. In high-income countries, women tend to outlive men by six to eight years. In developing countries, the difference between male and female life expectancy is much less- about two to three years (WHO, 2017).

A good economic environment having the necessities of life normally should lead to a robust life expectancy. Life expectancies of nations are therefore determined by certain factors, among such factors that have been investigated and identified in the past by researchers are Gross Domestic Product (GDP) and Electricity Consumption (EC) (Nwankwo et al., 2007). Other recognisable factors are Infant Mortality Rate (IMR) and Maternal Mortality Rate (MMR) (Ogunmolasuyi, 2009; Cornia and Menchini, 2006; United Nations, 2017).

In this paper, the effect of Gross Domestic Products (GDP), Electricity Consumption (EC), Infant Mortality Rate (IMR), Maternal Mortality Rate (MMR), Access to safe water (AW) and Acquired Immune Deficiency Syndrome (AIDS) on life expectancies of some notable nations of the world in comparison with that of Nigeria is examined. This is to proffer possible solutions to the low life expectancy in the country in order to make vision 2030 a reality, using the 2008 global data provided by the United States Census Bureau; International database.

For the purpose of analysis, only the countries having data on the six (6) determining factors are considered, and having satisfied this assumption, the Multiple Linear Regression was employed as the method of analysis.

Infant Mortality Rate (IMR) and Maternal Mortality Rate (MMR)

The infant mortality rate indicates the number of children, per 1000 live births, who die before they reach their first birthday. The rate reflects the probability of dying between birth and exactly one year of age. An infant mortality rate above 50 per 1000 live births reflects socioeconomic problems such as malnutrition, poverty, relatively widespread childhood infectious diseases, and lack of affordable health care, prenatal care, and immunizations. (United States Census Bureau, International Programs Center; International database, 2008). The maternal mortality rate measures the number of women who die due to pregnancy and childbirth complications, per 100000 live births. It provides an indicator of the overall quality of health care available to women within a country. Higher numbers, representing more deaths, may indicate limited access to basic health care and may have negative effect on life expectancy of people (United Nations Children's Fund (UNICEF) database, 2004).

Electricity Consumption per Capita

Electricity consumption per capita is the average annual electric energy usage per person, measured in kilowatt-hours. It is calculated by dividing a country's total electricity consumption by its population. Electricity is a versatile energy form that is easily stored and transmitted; it can provide heat, light, and mechanical power on demand. Expressing electricity use per person is useful for comparisons between countries because the figures compensate for differences in population among countries. The larger the number, the greater the annual use of electricity per person in a country (United States Energy Information Administration (EIA); International Energy Annual database, 2004). Research works have proved that any country with low electricity per capita stands the risk of having low life expectancy.

Gross Domestic Product (GDP) Per Capita

Gross Domestic Product (GDP) measures the value of all economic activity within a nation's borders. It is equal to the market value of all goods and services that are exchanged for money or traded in a market system. Gross Domestic Product at purchaser values (market prices) is the sum of gross value added by all resident and non-resident producers in the economy, plus any taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.

The 20 ranked countries in the world measured by Human Development Index (HDI) show that countries with high quality of life and Life Expectancy Index have a high GDP per capita (Pozzi and Farinas, 2015; Zaman, 2017).

The GDP is an important economic indicator because it measures the value of everything produced in a given country (World Bank, 2006). A robust life expectancy may be impossible in a nation with too low GDP per capita, it's a vital determinant. Applications of real GDP per capita as a measure of economic development have a global documentation (Ediev, 2011; Mpofu, 2013; Lutz and Kebede, 2018).

Access to Safe Water

Access to safe water for the total population refers to both urban and rural areas. As defined by the World Health Organization (WHO), in rural areas access to safe water/means that a family need not spend a disproportionate part

of the day fetching water. In urban areas, it means access to piped water or a public standpipe within 200 meters (219 yards) of a dwelling or housing unit. Safe drinking water includes treated surface water and untreated water from protected springs, boreholes, and sanitary wells. The definition of what constitutes 'access' to safe water varies from country to country. Generally, walking distance or time from household to water source is the principal criterion, particularly in rural areas. Access to safe water is essential in preventing waterborne diseases, and it is a minimum requirement for human health and well-being(United Nations Children's Fund, 2008). A high life expectancy may be a mirage in a land where inhabitants have no or less access to safe water, as most diseases come up as a result of consumption of unsafe water.

Acquired Immune Deficiency Syndrome (AIDS) Reported Cases

Acquired immune deficiency syndrome (AIDS) is the late stage of infection by the Human immunodeficiency virus (HIV), which results in the suppression of the body's immune response. AIDS is a usually fatal disease that is transmitted sexually, through infected blood or blood products, in uterus, during birth, or through breast-feeding. The system of reporting AIDS cases vary greatly among countries. Most of the industrialized countries report almost all AIDS cases; while others report vary few cases. Overall, the cumulative number of AIDS cases reported is less than 15 percent of the total estimated number of AIDS cases. This results from under-diagnosis, incomplete reporting, and reporting delay.

Most countries report confirmed AIDS cases to the World Health Organization (WHO). The reported number of AIDS cases is presumed to be lower than the estimated number, due to under-diagnosis, under-reporting, and delays in reporting. Data have been compiled and estimated by the WHO from official national reports and special studies (WHO, 2003). This of course lowers the life expectancy of a country having high number of AIDS cases.

Methodology

Data Collection

The data were collected from various organizations, among which are: United States Census Bureau, International Programs Center; International database, United Nations Children's Fund (UNICEF database), World Bank database and Organization for Economic Co-operation and Development (OECD), World Health Organization (WHO). Out of the more than 190 countries of the world, only 177 having the six predicting variables were used in the analysis.

Multiple Linear Regression

This is applicable when the data are multivariate. A multiple linear regression model relates a response variable Y to more than one explanatory variable.

The main purpose of the multiple regression analysis is to find which explanatory variables contribute to the variation of the response variable. We are usually looking for the 'best' subset of the explanatory variables.

The Model

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki} + \varepsilon_i, \qquad i = 1,2,...n,$$

where k is the number of explanatory variables,

β_0 , $\beta_1, \cdots \beta_k$ are the parameters of the model,
ε_i is a random error term.

$H_0 : \beta_1 = \beta_2 = \cdots = \beta_k = 0$ (y does not depend on x's)
$H_1 : at\ least\ one\ of\ the\ \beta_i \neq 0$

Test Statistic, $F = \dfrac{MS(regression)}{MS(residual)}$

Reject H_0 if observed $F > F_{k,n-k,\alpha}$ and conclude that y does depend on x.

Residual Analysis to Validate the Assumptions of the Model

The residuals are given by $e_i = y_i - \hat{y}_i$

The assumptions are:

(i) Errors are independent;

(ii) Mean zero, constant variance;

(iii) Normally distributed.

Plot of Residuals Fitted Values

The plots should be randomly scattered about zero with fairly constant 'spread' if assumption of independence and homogeneity are valid. If the model fitted is inadequate, this can also be noticed from a distinctive pattern to this plot

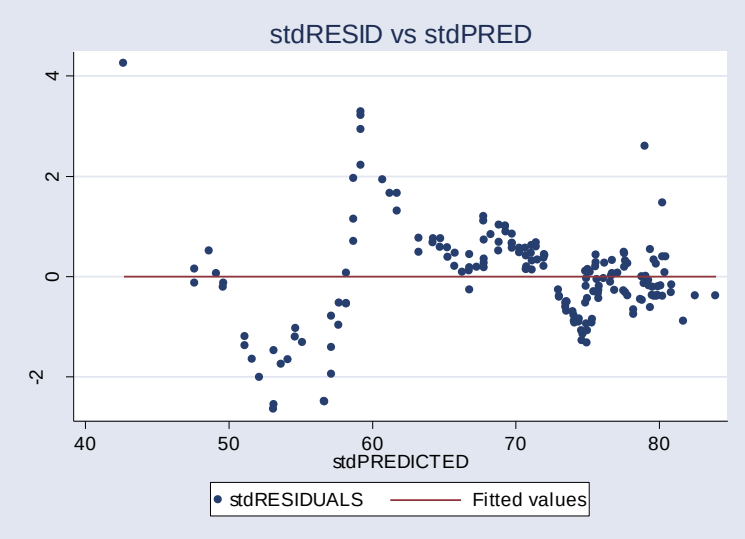

Figure 1. Plot of Residuals versus Fitted Values

Comments: There is a definite pattern to the residual plots by fitted values. The observations may not be independent and also the linear fit in the model may be inadequate.

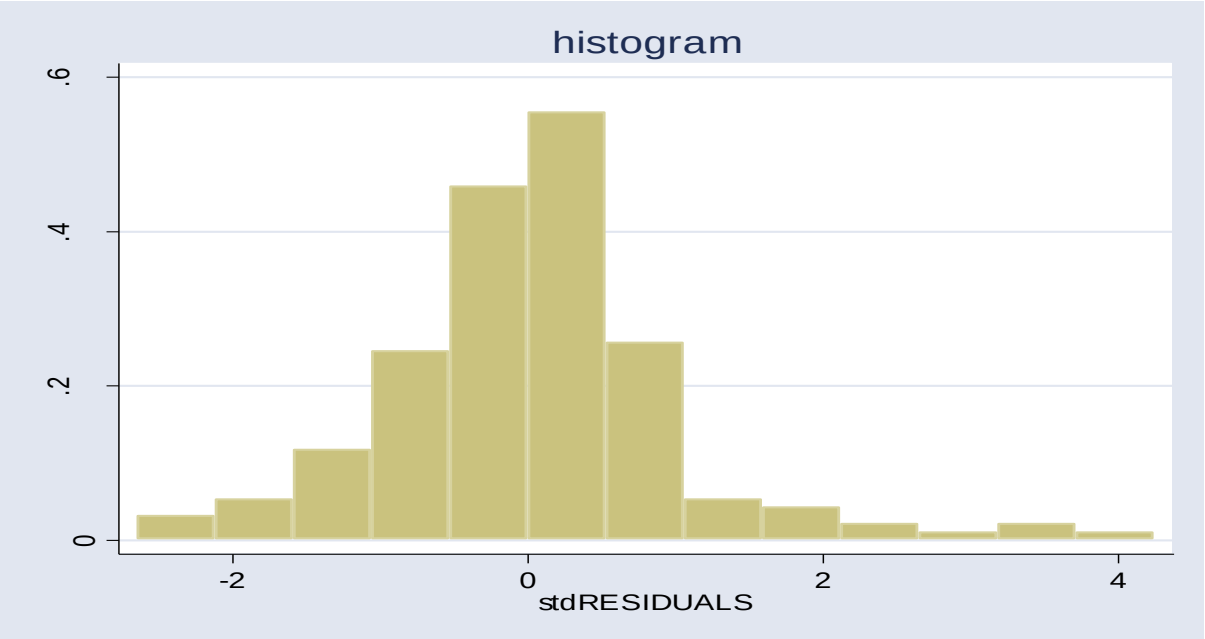

Figure 2. Histogram

The Histogram should be symmetric about zero and bell-shaped if the normality assumption is valid. Thus, the Histogram looks relatively symmetric.

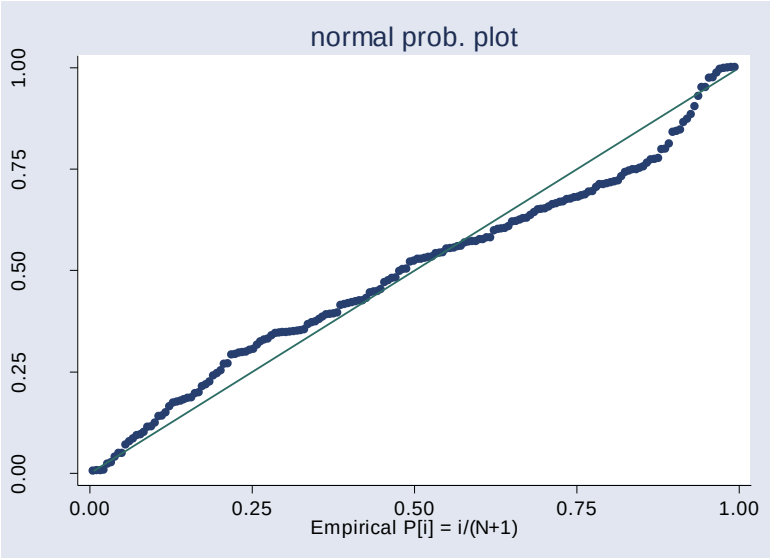

Figure 3. Normal Probability Plot

Normal probability plot looks like a straight line. Hence, Normality assumption looks valid.

Shapiro-Wilk Tests for Normality

Hypothesis:

H_o: The data are normal

H_1: The data are not normal

Reject H_o if $P < \alpha$ ($\alpha = 0.05$

Table 1. Shapiro-Wilk W test for 3-parameter lognormal data

Variable	Observation	W	V	z	Prob >
Life Exp	177	0.8991	13.5400	-0.6980	0.7573

Since P (0.7573) is not less than α (0.05), there is no sufficient reason to reject the null hypothesis, hence it is concluded that normality is significant.

Results

All analyses were done using STATA 14.0 SE and MICROSOFT- EXCEL.

Table 2. Some of the Countries with Life Expectancy and notable determinants

COUNTRIES	LEXP Estimated. in years	MMR Deaths Per 100,000	IMR Deaths Per 1000	GDP US$ Per capita	ECM KWH Per capita	ASW in Percentage	AIDS Reported cases
Japan	82.1	6	2.8	34,194	7,413	100	2,548
Singapore	81.9	14	2.3	29,474	7,267	100	100
France	80.9	8	3.4	36,700	7,205	100	57,772
Sweden	80.7	3	2.8	42,251	14,838	100	1,923
Spain	79.9	4	4.3	27,757	5,631	100	67,466
Israel	79.7	4	6.6	19,927	6,170	100	945
U. Kingdom	78.8	8	4.9	39,257	5,841	100	20,440
U. States	78.1	11	6.3	43,968	12,574	100	806,157
Libya	77.1	97	21.9	8,333	2,412	72	74
Saudi Arabia	76.1	18	12	14,745	5,572	95	327
Algeria	73.8	180	27.7	3,440	783	85	501
Russia	65.9	28	10.8	6,926	5,665	97	467
Ghana	59.5	560	52.3	561	243	75	14,449
Haiti	57.6	670	62.3	527	61	54	0
Kenya	56.6	560	56	623	132	61	81,492
Nigeria	47.8	1,100	93.9	797	117	48	60,564
Niger	44.3	1,800	115.4	172	22	46	5,598
Zambia	38.9	830	101	133	533	58	44,942
Swaziland	32	390	69.6	104	1,075	62	4,787
Sierra Leone	40.9	2,100	156.2	175	49	57	317

(*SOURCE:* Encarta, 2009)

Table 3. Model or Regression Statistics

Multiple R	0.9926
R Square	0.9854
Adjusted R Square	0.9849
Standard Error	1.1342
Observations	177

Table 4. Analysis of Variance

	DF	***SS***	***MS***	***F***	***Significance F***
Regression	6	14791.5972	2465.2662	1916.2623	2.8523E-153
Residual	170	218.7045	1.2864		
Total	176	15010.3018			

Table 5. Parameter Estimates

	Coefficients	***Standard Error***	***t Stat***	***P-value***
Intercept	28.0841	0.6207	45.2434	1.004E-96
MMR	-0.00901	0.0036	-2.4507	0.0152
IMR	0.01006	0.0365	0.2749	0.7837
GDP	0.0003	0.00005	5.4893	1.45E-07
ECM	0.0001	0.0001	0.535	0.5933
ASW	0.4992	0.01284	38.8762	1.64E-86
AIDS	-1.50E-04	2.51E-06	-0.6002	0.5491

Response Variable: Life Expectancy at Birth (LEXP)

The appropriate model is:

LEXP = 28.0841 - 0.0090 MMR + 0.0101 IMR + 0.0003 GDP + 0.0001 ECM + 0.4992 ASW – 0.00002 AIDS

Discussion of Results

Validation of normality assumptions is presented in Figures 1-3 and Table 1. The importance of this cannot be over-emphasised in any statistical analysis, neglect of which has brought questionable results in the world of statistics.

It can be seen in Table 2 that Japan has the second to the highest life exp (83.5 years) in the world by virtue of its MMR and IMR are very low but high value in GDP, ECM and ASW. Nigeria's life expectancy ranks 175th position

in table with a value of 47.8 years simply because she does not have good values in some favourable predictors, the country ranks 10th among the countries with highest MMR and AIDS reported cases and 14th in IMR. An African nation, Swaziland has the lowest life expectancy on the globe of 32 years. MMR and IMR in Nigeria are 1,100 and 93.9 respectively compared with Sweden with less population has MMR and IMR of 3 and 2.8 respectively. Despite her abundant rivers, Access to safe water in Nigeria is 48% while it is 97% in Saudi Arabia where vast of the land is desert.

With Regression Statistics presented in Table 3, Coefficient of Multiple Determination R^2 of 98% and deviance of 1.13, it shows that the model (regression equation) is efficient and it adequately fit the data. It also means that the predictors can affect life expectancy by 98%.

Table 4 shows the Analysis of variance, which confirms a generalized high significant linear relationship with P-value of 2.85E-153 between life expectancy and the predictors.

From the significant determinants in Table 5, Access to Safe Water (ASW) has the highest value, 1.64E-86. This of course is a major determinant of a robust life expectancy and it is also enough evidence to show its inevitability for any nation having a goal of becoming great.

Conclusion

Based on the results from the tables, it can be concluded that MMR, GDP per capita and ASW are significantly associated with life expectancy. Nigeria and some other African countries are in the rear, with low life expectancies which is the aftermath of low GDP per capita, Electricity consumption (ECM) per capita, and Access to Safe Water (ASW). The negative relationship between life expectancy, MMR and AIDS reported cases is normal; increase in either MMR or AIDS means decrease in life expectancy and vice versa.

Recommendation

For Nigeria to achieve the goal of vision 2030, her life expectancy must significantly improve, 47.8 years life span is too low for a country with such a goal. The government should provide adequate healthcare facilities in order to reduce MMR, IMR and AIDS cases; this will go a long way in bringing these variables on a perpetual negative side. Despite the huge population, the Electricity consumption (ECM) per capita is about 117kwh. This is too small if compared with Israel, which has 6,170kwh per capita with population of just over 6.5 million people. Future researchers should look into the effect of standard of living, quality of leaders, system of government, debt service and poor infrastructures such as roads on life expectancy in Nigeria.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this research study.

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