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Statistical Analysis of Population and Economic Growth in Ghana.

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Abstract.

Purpose: The relationship between population and economic growth has been a subject of extensive research and debate for decades. Population of a country is driven by factors such as fertility rate, mortality rate and migration. Rapid population growth can strain resources, infrastructure, and social services, potentially hampering economic development. However, it can also create a demographic dividend when the working age population surpasses dependent age group, leading to increased productivity and economic growth.

Methodology: The researchers performed statistical analysis on population and economic growth using Time Series. The study revealed that Ghana's age profile is much concentrated at the youthful age, which is also the most fertile part of the age distribution.

Findings: The Percentage Change of Population (PCPOP), Per Capita Gross Domestic Product (PCGDP) and Exchange Rate (EXCR) are statistically significant. Also Population and the economic growth in Ghana are inversely proportional to each other.

Unique contributor to theory, policy and practice: Furthermore, the future values of the population of the country is relatively high for the next ten years and there is a negative correlation between the population and economic growth hence the future population is likely to face poverty. Stakeholders and policy makers are to ensure that future policies are directed towards Entrepreneurship and Skills Training to enable income generation in the Country.

Keywords: *Population, Economic Growth, Gross Domestic Product, Fertility rate, Mortality.*

1.0 Introduction.

Population refers to the total number of people living in a specified geographical area in a period of time. The concern of population and economic growth since ages is as older as economics itself. Only few economists have been considering the impact of the population and its demographic process when dealing with issues concerning economic growth (WHO,2023).

Economic growth, can influence population growth through improved standard of living, healthcare and education. As economies grow, they often experience demographic transitions characterized by declining birth and death rates, resulting in a more balanced age distribution. The research aimed at performing statistical analysis on population and economic growth and other factors influencing the economy in Ghana and as well forecast the population growth in the country.

The economists Bloom et al., (2001) explored the effect of demographic process on economic growth. The economists raised an argument that it is possible that the interaction of economic growth with population dynamics can result in poverty trap. Their argument shows that there is a strong relationship between population and economic growth and must be dealt us such. The knowledge about their argument aids in the understanding that, high population corresponds to a proportional economic growth and income levels.

Malthus (1798) also claimed that there is a tendency for the population growth rate to surpass the production growth rate because population increases at a geometrical rate while production increases at an arithmetic rate. Thus, an unconcerned impact of population on a country's economy can lead to a slow decline and poverty.

Many analysts believe that economic growth in high income countries is likely to be relatively slow in the coming years in part because population growth in these countries is predicted to slow considerably (Baker et al., 2005). This is due to the reduction in the work force as the aged in these countries are likely to be out working potentials and therefore there will be reduction of laborers in the labor or working force. When there is reduction in the labor force there is going to be low flow of money in the system thereby declining the economic growth.

Ghana has a population of about 33,107,275 with a population growth rate of 2.23% and a population density of 143.05 people per kilometer square which has attained an increase of about 1.93% since 2022 as recorded by the Population and Housing Census in 2022. (Ghana Statistical Service, 2022). Ultimately, the interaction between population and economic growth is a critical aspect of sustainable development, which requires research and informed policy making to strike a harmonious balance between demographic trends and economic prosperity. Population growth on the other hand has a lot of impact on certain phenomena such as economic inequality, age structure, migration and the work force of the country.

Yoo (1994) developed three models to examine the impact of this increase in population growth on U.S. economic growth. His research revealed that the large increase in the number of children

slowed growth as resources were transferred from more productive activities to education and health care for this large cohort.

Bloom and Williamson (1998) performed an empirical study on population and economic growth. The two aimed at showing the role of demographic factors in explaining the boom growth rates in East Asia during the period of 1965 to 1990. In their pursuit, they realized that demographic dividend in east Asia was made possible due to effective social, economic and political institutions and policies.

Carvalho and Rodriguez-Wong (2004) performed some studies on the age structure transition and its emerging challenges in Brazil. According to the two, due to the age structure transition, some improvement related to the health nutrition and education among children and adolescent were achieved.

Mason and Westley (2002) pointed out that six Asian countries, viz. Japan, South Korea, Taiwan, Singapore, Thailand and Indonesia achieved unparalleled economic development during the period from 1960 to 1990. Deaton and Paxson (1999) studied the relationship between demographic structure, economic growth and savings using Time Series.

1.1 Methodology.

The analysis on the population and economic growth is obtained using the Gross Domestic Product of the country from 1960-2021.

1.2 Ordinary Least Square (OLS).

Ordinary least square is a statistical method used in econometrics and data analysis. It's used for linear regression, where it is aimed at best fitting linear relationship between a dependent variable and one or more independent variables by minimizing the sum of square differences between observed and predicted values. It is also used to find coefficients of a linear equation that minimizes the sum of the squared residuals.

The OLS minimizes the sum of squares residuals, often represented as

$$\text{Min}_{a,b} \sum Y_i - (a + bX_i)^2 \quad (1.0)$$

Where Y_i is the observed value of the dependent variable for observation i .

X_i is the observed value of the independent variable for observation i , a and b are the intercept and slope respectively.

1.3 Econometrics.

Econometrics deals with application of statistical methods to economic data in order to give empirical evidence or content to economic relationships. It provides the quantitative analysis to real economic phenomena. Now some basic tools for the econometric is the multiple linear

regression model. It relates the dependent variables to the independent variables and gives some vivid explanation to how exogenous variables influence the independent variable.

1.3.1 The model specification.

$$GDP_t = \beta_0 + \beta_1 PCGDP_t + \beta_2 FR_t + \beta_3 PCPOP_t + \beta_4 pcGDP_t + \beta_5 EXCR_t + \varepsilon_t \quad (1.1)$$

The β_0 is the intercept of the regression model and also the constant term of the estimated regression line. Furthermore, the intercept (β_0) actually represent the mean of the model when all the endogenous variables are equal to zero.

The $\beta_1 \dots \beta_5$ represent the coefficients of their respective endogenous variables that influence the exogenous variable (economic growth) of the regression model. They also represent the change in the mean response attached to the particular term anytime the other variables are held constant. Hence the β talks about the means associated to the model in different perspectives but in the same model.

The error term ε accounts for the uncertainty in the model. As econometric models are stochastic in nature, they always make room for errors. The error term also makes room for some imperfections of the independent variables compared to real life.

The expectation of the model is to determine whether the endogenous variables are significant to the dependent variable.

1.4 Time series Analysis.

The model obtained below is a linear time series analysis obtained from the time series trend data about the population.

The trend analysis of the form and formula to be used in this chapter is the linear trend.

Hence the linear trend takes the form:

$$Y_t = \beta_0 + \beta_1 t + \varepsilon_t \quad (1.2)$$

Where β_0 is the constant, β_1 is the change from one period to the other, t is the value of the time unit, and ε_t is the error term.

1.4.2 Quadratic trend model.

The quadratic model accounts for simple curvature in the data.

If the series shows a parabola shape, then it exhibits a quadratic trend represented as

$$Y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_t. \quad (1.3)$$

If $\beta_2 < 0$, then a plot of the series eventually turns to negative. But if $\beta_2 > 0$, then a plot of the series sky-rockets up

Where β_0 is the constant, β_1 is the average change from one period to the next, t is the value of the time unit, and e_t is the error term.

1.4.3 The S-curve model.

$$Y_t = \frac{10^a}{\beta_0 + \beta_1 \beta_2^t} \quad (1.4)$$

1.4.4 Mean Absolute percentage error (MAPE).

The mean absolute percentage error measures the accuracy of fitted time series values. The formula or the MAPE is given as

$$\text{MAPE} = \frac{\sum |(y_t - \hat{y}) / y_t|}{n} \times 100\%, (y_t \neq 0) \quad (1.5)$$

where y_t is the actual value at time t , \hat{y} is the fitted value, n is the number of observations

1.4.5 Mean Absolute Deviation (MAD).

The Mean Absolute Deviation measures the accuracy of the fitted time series values. MAD expresses the accuracy in the same units as the data. Hence the formula below

$$\text{MAD} = \frac{\sum_{t=1}^n |y_t - \hat{y}|}{n} \quad (1.6)$$

Table 1 The model diagnostics.

Residual error	standard	Degree of freedom	R-squared	Adjusted R-squared	F-statistic	p-value	Significant level.
0.7341		55	0.99	0.987	10570	22×10^{-16}	5%

The coefficient of determination also known as the R-squared (R^2) is the proportion of the variation in the dependent variable that is predictable from the dependent variable.

It provides a measure of how well the observed outcomes are replicated by the model, based on the proportion of the total variation of outcomes explained by the model. With an R-squared of 0.99 means 99.0% of the variability of the dependent variable has been accounted for, and 5% of the variability is still unaccounted for. Therefore, considering the data to be a better fit for the model.

The adjusted R-squared is a modified R-squared that accounts for the predictors that are not significant in the regression model. It provides a more precise view of that correlation by also taking into account how many independent variables are added to a particular model. This is done because the addition of independent variables usually increases the reliability of the model. The adjusted R-squared give a more realistic of the model fit and this as shown to be 0.987 which is

almost or approximately equal to the R-squared. This value hence confirm that the model estimated is correctly done and fits our data values.

The F-statistic also known as the F value provides us with a way for globally testing whether any of the independent variables have any relationship with the outcome GDP. The F-statistic always come with the p-value for proper interpretation.

If the p-value associated with the F-statistic is greater than 0.5 then there is no relationship between the independent variable and the outcome variable.

On the other hand, if the p-value is less than 0.5, then it can be interpreted that at least one of the independent variables is related to the outcome variable. One important characteristic of the F value is that it adjusts the number of the independent variables. This is to prevent biasedness when we have more than one independent variable. It also helps in assessing the significance of the entire regression model. The F-statistics is found to be 10570.0, which is statistically significant at 5% level of significance.

This implies that all our model coefficients are jointly statistically significant. The model diagnostics confirms that the estimated model is accepted and therefore can be used to do interpretations and predictions intended.

Table 2 Descriptive Statistics of the variables used in the model.

Variables	GDP (Billions of US dollars)	Annual % change (GDP)	Fertility rate	Exchange rate	Percentage change (population)	Per capita GDP
Minimum value	1.217	-12.432	3.795	0.000071	2.090	176.1
Maximum value	77.594	14.047	6.951	5.805700	3.310	2363.3
Mean value	15.829	3.689	5.619	0.858170	2.620	668.8
Median	5.380	4.406	5.720	0.034689	2.535	354.4
First quartile	2.831	2.856	4.546	0.000115	2.440	265.2
Third quartile	18.017	5.628	6.754	0.912632	2.790	783.1

Table 2 indicates the descriptive statistics of the variables used in the model. The mean shows the averages of the figures with respect to each variable. The maximum and minimum value shows the highest and smallest value in the data with respect to each variable. The median shows the middle value after categorically arranging the data. And the first quartile shows value for which

25% of the data value is found when the values are arranged in ascending order. The third quartile also known as the upper quartile shows the value under which 75% of the data values are found when the data is arranged in ascending order.

Table 3 The result of the estimates obtained from the econometric model.

Variables	Estimates	Standard error	T value	Pr(> t)
Intercept	1.8886122	1.4162071	1.334	0.01878
PCGDP	0.0030447	0.0257140	0.118	0.9062
FR	0.0828417	0.1510165	0.549	0.5855
PCPOP	-1.0189558	0.4286248	-2.377	0.0209
PcGDP	0.0256599	0.0004195	61.170	<2e-16
EXCR	3.1773926	0.1769763	17.954	<2e-16

The result in table 3 represents the results from the ordinary least square regression model. The model diagnostics shows that, the estimated model are actually correctly formulated and the data fits the model correctly. So the model diagnostics are the residual standard error, degrees of freedom, R-squared, adjusted R-squared, F-statistics and the p-value.

The residual standard error is the standard deviation of the residuals. Smaller values for the residual error means the predictions are better. It measures how well a linear model fits the data. It is the average amount of the real value of the Gross Domestic Product (GDP) that differs from the predictions provided by the regression line. So the endogenous variable accurately predicts the GDP with about 0.7341 average error. This means that 68% of the predicted GDP values will be within 0.7341 average error of the real value. The degrees of freedom is the number of independent pieces of information used to calculate a statistic before random constraints can be put into place. Hence the degrees of freedom at 55 means that 55 pieces of the independent information was used to calculate a statistic.

From the model estimates in table 3, it can be seen that the constant term or the intercept of the model is having a value of 1.8886122 which is also statistically significant at the five percent level of significance. The intercept represents the mean of the economic growth when all the endogenous or independent variables are equal to zero. In other words, the intercept represents the value of the exogenous variable when all the endogenous variables are jointly zero.

The coefficients in the model explain the average increase in the response variable associated with a one-unit increase in the predictor variable, assuming all other predictor variables are held constant.

The standard error in the model estimation is also the measure of uncertainty in our estimation of the coefficients. For instance, the error in the Percentage change in Gross Domestic Product (PCGDP) is 0.0257140, meaning we are ready to risk an error of this value between the actual value and the values estimated by the model.

The main understanding of the significance of the variables involved in the model comes from the p-value attached to the coefficient of the independent variables. When the p-value is less than the chosen level of significance, then there is a conclusion that there is non-zero correlation between the dependent and independent variable.

Furthermore, if the p-value is greater than the significant level then there is no enough evidence to reject the null hypothesis that, there is a zero correlation between the dependent and independent variable.

From the model estimated above, the p-values associated with the variable in comparison with the 5% significant level shows that, Per Capita Gross Domestic Product (PCGDP) and Fertility Ratio (FR) are not statistically significant. Meaning these two variables have no influence on the dependent variables (GDP) according to the data used. It can also be shown that, Percentage Change of Population (PCPOP), Per Capita Gross Domestic Product (PCGDP) and Exchange Rate (EXCR) are statistically significant. They have some influence on the dependent variable.

The value of the coefficient of the PCPOP is -1.0189558 which is also statistically significant at 5% level of significance. The negative coefficient means that there is an opposite status between the dependent and independent variables. In other words, as there is an increase in percentage change in population, the GDP also tend to decrease. This means that, every unit percentage increase in the population, retards the economy by 1.01896%. This means that the population of the country is having a negative impact on the GDP of the country and as such have a significant negative effect on economic growth in the country. This may be due to many reasons, and it is very important to research on that. This may seem to answer the question as whether the high population of a country tends to increase or decrease the economic growth.

China is a country with one of the highest populations in the world, but with a high GDP as compared to Ghana.

A country's economic growth depends on its management and government interventions and not the population status. It was also seen that per capita GDP and Exchange rate are statistically significant and also positive. This means that, they have a positive effect of the economic growth of the country and also important to the economy of Ghana.

Foreign exchange rates contribution to Ghana's economy is rational. This is because Ghana produce a lot of goods that can be exported. Minerals contribute to about 5% of the country's GDP and about 37% of the minerals are exported. Agriculture also contribute to about 54% of the country's GDP and about 40% of it is accounted as export earnings. This products and others in the international exchange market makes the exchange rate an important aspect of the country's economic growth.

The data used has a trend pattern and it exhibits no seasonality.

The linear trend equation.

$$Y_t = 3699258 + 426195t \tag{1.8}$$

The quadratic equation

$$Y_t = 6955287 + 125638t + 4696.2t^2 \tag{1.9}$$

The S-curve Trend equation

$$Y_t = \frac{10^9}{8.021+143.857(0.97046^t)} \tag{1.10}$$

From the above trend equation, the equation that best fit the data can be derived from the measure of accuracy (Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD)) for the equations.

Table 4 The Measures of accuracy for the Trend analysis.

	Linear equation	trend	Quadratic equation	trend	S-curve equation	trend
MAPE	8.57669		0.838511		0.709906	
MAD	1.20523 x 10 ⁶		1.27443 x 10 ⁵		1.06877 x 10 ⁵	
MSD	1.95262 x 10 ¹²		2.49445 x 10 ¹⁰		1.67809 x 10 ¹⁰	

To find which equation best fit the data for analysis and for correct forecasting we need to do comparison to see which of the measures have the smallest accuracy measures. From the table above, the S-curve has the smallest accuracy measures and therefore has the best fits for the analysis and best fits our data for correct predictions. All the other plots for the other equations can be seen at the appendix.

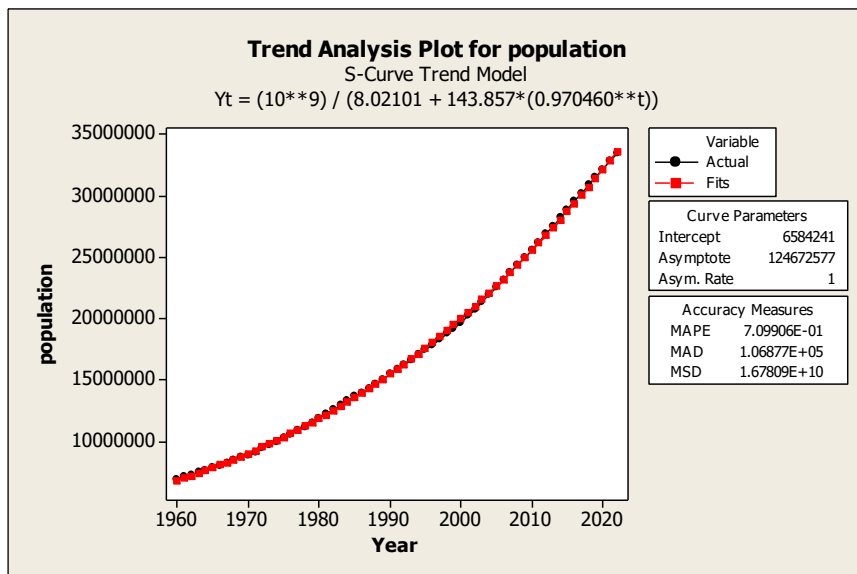


Fig 1 The S-curve Trend Model for Population.

The S-curve trend model showed in figure 1 is the graphical representation of how the trend evolves over time. Two lines can be seen in the chart, the black one representing the actual trend of the data and the red one shows the line of fit. The curve ascend as the years goes by. This shows how the population of the country increase with respect to the years. The line of fit of the S-curve lies almost to the actual data plot. This shows that almost all the data points are in line with the increasing trend pattern. Very few data points can be seen outside the fitted line but also very close to the line.

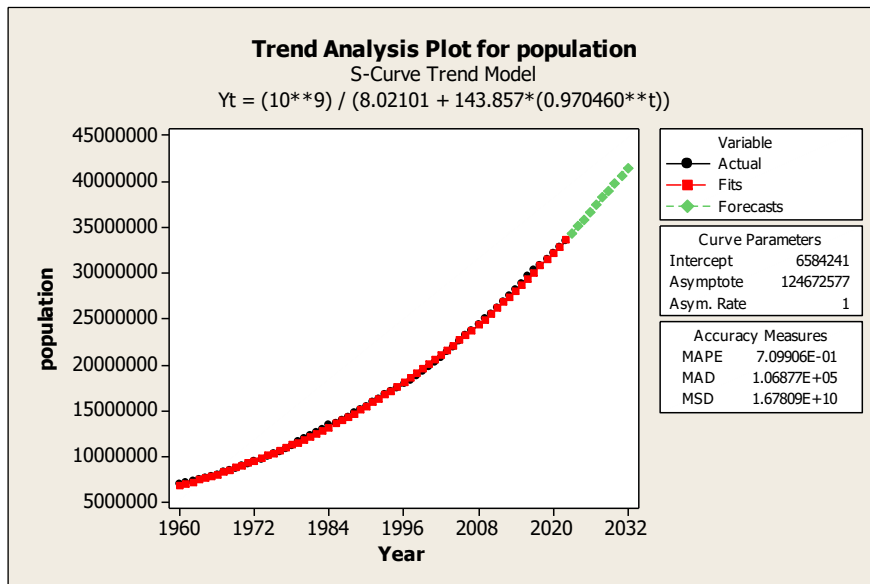


Fig 2 Forecast values for the S-Curve.

The trend model and the predicted values are showed in figure 2. The trend model derived from the population data of the country is predicted as follows:

Table 5 The predicted Population for the period of 2023 to 2032

Years	Predicted population
2023	34327743
2024	35078661
2025	35839488
2026	36610074
2027	37390255
2028	38179853
2029	38978680
2030	39786532
2031	40603194
2032	41428437

The population exhibits an increasing trend. This may be due to a lot of factors. When demographers attempt to forecast the increase in population, they focus on four main factors: fertility rate, death rate, initial age profile and migration of a country.

Another important factor that influences the population status is the age profile. The age profile helps us to know where much of the country's population is concentrated with respect to the age divisions. It helps us to know whether the country has an old age (46 and above) profile, young age or youthful (18 to 45) profile and under age (17 and below). (Ghana Statistical Service,2022)

Ghana's age profile is much concentrated at the youthful age, which is also the most fertile part of the age distribution. Hence the population with the great increase in this aspect also.

Lastly, one major factor to be considered is migration. Migration can be explained in two aspects,ie. Emigration and immigration. Immigration increase the population of a country. The immigration of a country is actually the number of people who come into the country either citizens or foreigners. (UNDESA,2020)

Immigration can also increase the population of a country since some of the immigrants come and settle. These factors are factors that explain the trend of the population increment.

4.3 Conclusion.

Population and the economic growth in Ghana are inversely proportional to each other. This confirms the results obtained by Bloom and Williamson (1998) which suggests a strong relationship between population and economic growth. This is an important sector that may help in the development of the country's economic growth include an increase in the exchange rate at the international exchange market and the per capita Gross Domestic Product.

Furthermore, the future values of the population of the country is relatively high for the next ten years and there is a negative correlation between the population and economic growth hence the future population is likely to face poverty.

4.4 Recommendations.

Therefore, stakeholders and policy makers are to ensure that future policies are directed towards Entrepreneurship and Skills Training that will enable income generation in the Country.

Also, Government, Non-Governmental Organizations, private groups and other benevolent individuals can help in the creation of jobs for the citizens in the country. The creation of employment for individuals in the country generate income for the citizens and also increase their standard of living, thereby contributing to Economic growth.

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