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MODELING THE IMPACT OF MAJOR ECONOMIC INDICATORS ON STUDENTS' PERFORMANCE IN MATHEMATICS

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ABSTRACT

In this paper, a linear model that relate students' performance in mathematics at West African Secondary School Certificate Examination (WASSCE) and major economic indicators was designed as by way of continuation of an earlier study of the students' performance in the Basic Education Certificate Examination (BECE) in Ghana [Adamoah and Acquah].Quantitative analysis subject to the hypothesis testing is carried out. The results indicate that students' performance and major economic indicators are positively correlated at significance level $\alpha = 0.01$. Educational spending and Gross Domestic Product (GDP) per capita are leading factors among others. Statistically, higher GDP contributes to the educational sector, more especially at the senior high school level, and this leads to higher educational spending which, in turn, better students' performance in mathematics. This positive outcome will translate to reinforce economic strength.

KEYWORDS: Modeling, Students' Performance (SP), Gross Domestic Product per capita (GDP), Economic Indicators, West African Secondary School Certificate Examination (WASSCE), Linear Multiple Regression models.

1.1 INTRODUCTION

Mathematics education is key to national development. This is true because Science, Technology, and Engineering are rotated on Mathematics and the success in each field is based on how the principles and methods of Mathematics are properly applied to solve real-life problems. In other related articles, it turns out that mathematics is a unique distinguishing factor between developed and developing countries in the economic performance (Mehmet and Sevgi, 2014).This is therefore, a major indication that the scientific and technology strength in developed countries (like USA, Singapore, UK, Japan, etc) is as a result of the priority given to the use of mathematics by those nations (Zachariah et al., 2012).The educational level is one of the main reasons for economic performance (economic strength) between developed and developing countries. Many developed countries have more priority to the study of mathematics and so their Science, Technology and Engineering are strong and have advanced in many other fields as well. In addressing the main issue of poor performance of students, many others have identified first the causes, and these include the misconception of both learners and some teachers about the subject (mathematics) as difficult one and so end up bringing in fear and anxiety in students which at end affect their general performance (Tata et al., 2014). "Students' beliefs and attitudes towards mathematics teaching and learning play an important role in mathematics education" (Peter and Araña, 2010). There are other several factors that contribute to students' poor performance and so any factor identified should be given the

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necessary attention to address the situation. Ghana as a developing country, needs to address the situation of students' poor performance in Mathematics considering the current WASSCE mathematics results. The increase in labor productivity as the level of education increases impacts the competitiveness of countries positively and facilitates openness.

The more mathematically literate students who are capable of passing WASSCE mathematics at credit level on their own we have in the nation, the more would be the chances of the candidates having access to tertiary institutions, and the more the country would have human capital development in different fields of human endeavor, especially in the science related fields (Musah and Dauda, 2014).

"Education can promote economic growth if it reflects positively on individual income and economic productivity" (Marius-Cristian and Cosmin, 2012). Mathematics education in Ghana, therefore, must be given that same priority to ensure economic development. Mathematics forms the basis of all our educational curriculum and as such, much attention should be drawn to the teaching and learning of Mathematics. Many students begin to develop a phobia for Mathematics right from the basic level, especially where it is not made fun with more mathematical activities. Mathematics is considered by many students as too abstract just because many Mathematics teachers fail to relate it to real life through some practical activities. This will not only make Mathematics more fun to students but will also make the teaching very easy and stress-free for teachers. In so doing, we move from teacher-teaching to student-learning and this makes students more creative and they solve problems through learning. Mathematics, therefore, helps students to develop their mental faculties through problem-solving. Mathematics is gradually losing its value at the lower levels of education in Ghana and that is posting very serious impact on the Senior High schools. Many students after Senior High School will always want to pursue courses at tertiary institutions that have little or no Mathematics because of the mindset that Mathematics is difficult.

After a successful completion of the Senior high school, students then proceed to the tertiary institution for which they have a variety of choices to make (Universities, Polytechnics, Teacher training Colleges and other areas based on one's interest). In order to be admitted into any program at any Ghanaian tertiary institution, candidates must in principle have obtained a credit (grade A1 to C6) in at least three of the compulsory subjects, Mathematics, English and Science in the West African Senior School Certificate Examination (WASSCE).

"Many writers have described academic performance as a scholastic standing of a student at a given moment" (Adeyemi., 2011). The issue of the falling standard of students' performance in Mathematics at the West African Secondary School Certificate Examination (WASSCE) in Ghana is quite alarming. This project seeks to design comparative analysis in terms of the relationship between the Ghanaian economic strength and students' academic performance in Mathematics.

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Over the past few years, there has been a drastic change in students' performance in Mathematics at the West African Secondary School Certificate Examination (WASSCE) in the country. From 2007 to 2017, students' performance rates in Mathematics had followed a certain pattern and that generates much interest to investigate what major economic and non – economic factors influence the change and in what direction (positive or negative). This helps policymakers to know they will put in all the necessary measures to ensure that students' poor performance in Mathematics is properly addressed.

Table 1.1 Students' Performance in Mathematics (2007 – 2017)

Year	2007	2008	2009	2011	2012	2013	2014	2015	2016	2017
Value (%)	25.0	26.1	28.2	43.6	49.9	36.8	31.3	25.3	32.8	42.7

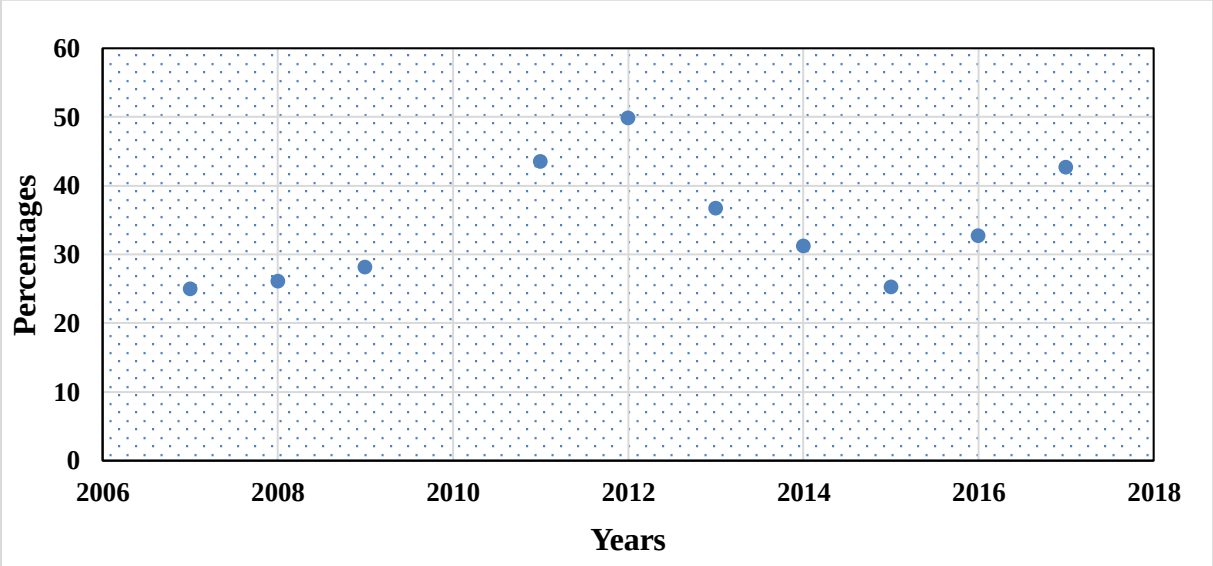

Figure 1.1: Trend of Students' Performance (Source: Authors' construct, May 2018)

It worth stated that due to the change in the educational system at the Senior High School level from 3 years to 4 years, there was no batch of students in 2010 rather the next WASSCE in Ghana after 2009 was 2011. This project therefore identified and statistically analyzed some economic and non-economic factors that have partial effect that contribute to the performance of students in Mathematics in Ghana. A holistic statistical model was designed to identify the correlation between students' performance and those factors. Students' Performance serves in the model as the independent variable whilst the rest of the factors Gross Domestic Product Per capita, Gross Domestic Product growth rate, Educational Spending and Students Teacher Ratio were acting as dependent variables in the model.

2.1 Study Area

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Ghana has ten (10) political regions and these include; Greater Accra, Ashanti region, Eastern region, Western region, Central region, Volta region, Brong-Ahafo region, Northern region, Upper East region and Upper West region. Most people in Ghana are citizens of the urban cities namely; Ashanti region and greater Accra regions.

The Republic of Ghana is located on the west coast of Africa, surrounded by the countries Ivory Coast, Burkina Faso and Togo, on the Gulf of Guinea. Ghana gained independence from Britain in 1957 and thus became the first independent majority-ruled nation in sub-Saharan Africa and one of the strongest democratic country in the world. Ghana's climate can be described as tropical because Ghana is only a few degrees north of the Equator. Ghana's seasons can be divided into two different categories. The cold or the wet season and the hot or the dry season. The rainy season begins in the north part of Ghana in around March and prevails until the end of the month of November. The southern part of Ghana experiences the wet season from the start of the month of April until the middle of the month of November. For Ghana's latitude, its tropical climate can be considered fairly mild. From the month of December through the month of March, dry wind blows in northeastern Ghana, which pretty much lessens the humidity in the climate, as well as making the days hot and the nights cool in the northern part of Ghana. Ghana has a total land area of approximately total 238 540km^2(Ghana Statistical Service., 2013a).

Map of Ghana showing all the ten (10) political regions (Source: Ghana Statistical Service., 2013)

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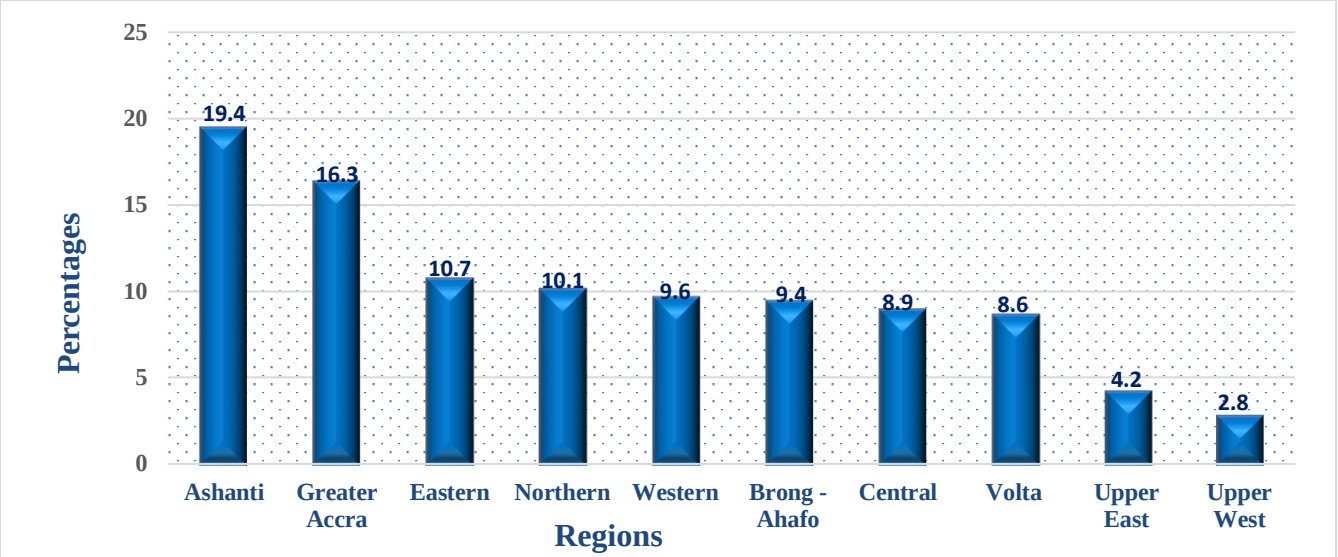
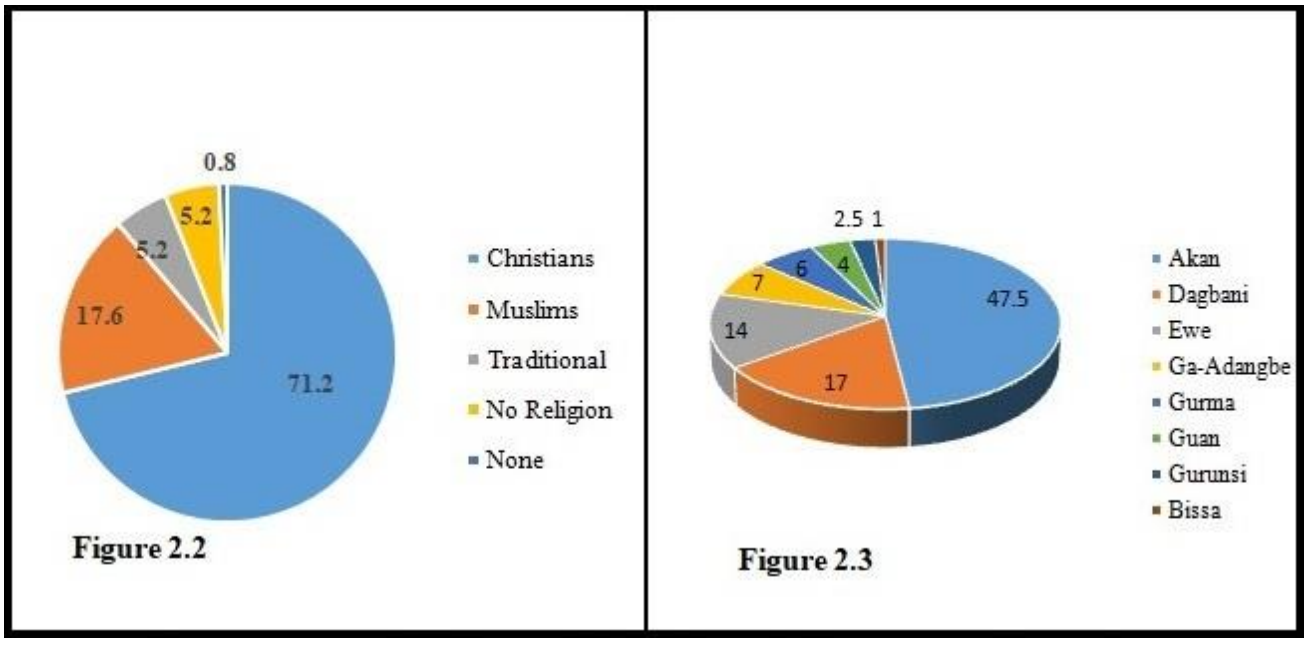


Figure 2.1: Percentage Share of Population on by Regions (Source: Ghana Statistical Service., 2013)

The 2010 Population and Housing Census showed that the resident population of Ghana was 24,658,823 made up of 12,024,845 males (48.8%) and 12,633,978 females (51.2%). Major ethnic groups in Ghana include: Akan (47.5%), Dagbani (17%), Ewe (14%), Ga-Adangbe (7%), Gurma (6%), Guan (4%), Gurunsi (2.5%), and Bissa (1%). In terms of religions: Christian 71.2% (Pentecostal/Charismatic 28.3%, Protestant 18.4%, Catholic 13.1%, other 11.4%), Muslim 17.6%, traditional 5.2%, other 0.8%, none 5.3% (Ghana Statistical Service., 2013b).



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Religions and ethnic groups in Ghana in Figure 2.2 and 2.3 respectively (Source: Ghana statistical service. 2013)

2.2 Educational system in Ghana

Senior high School education in Ghana consists of a junior phase and a senior phase, each lasting 3 years. The junior high school phase concludes the compulsory-school-age years. Children are then usually 15 years old. During the junior high school phase, pupils are taught subjects such as English, mathematics, social studies, and integrated science in addition to basic design and technology, religious and moral education, French and ICT. At the end of the junior phase, pupils sit examinations to obtain the Basic Education Certificate. During senior secondary education, pupils are taught English, mathematics, social studies, and integrated science. In addition to these subjects, they can choose from a number of electives. These electives are followed in the specializations of agriculture, business, technology, and trade, as well as general education (arts or sciences). Senior secondary education is concluded with examinations for the West African Senior School Certificate Examination (WASSCE), which has since 2007 replaced the Senior Secondary School Certificate Examination (SSSCE).These examinations are held by the West African Examinations Council (WAEC), Ghana National Office. To obtain the West African Senior Secondary School Certificate pupils take exams in four compulsory subjects, namely English, mathematics, social studies, and integrated science. In addition, they must sit examinations in three or four electives (in the specializations listed above). Pupils are usually 18 years old on completing senior high school education (Ghana Education Service., 2015a).

Ghana's education system is characterized in principle by a binary structure, with universities on the one hand and polytechnics on the other hand. Since the reforms introduced in 1987, the education system has had a 6+3+3+4 structure. This means 6 years of primary education, followed by two 3-year stages of High school education (Junior High and Senior High) and 4 years of higher education (bachelor's degree programs). Master's degree programs have a nominal duration of 1 or 2 years (Ghana Education Service., 2015b)

The Ministry of Education (MOE) oversees all the affairs regarding education Ghana and head office in all the ten (10) regions in Ghana as well as district and metropolitan offices. The Ministry of Education has an implementing body called The Ghana Education Service which is solely responsible for implementing policies in respect of primary and secondary (general and vocational) education, as formulated by the Ministry of Education. These district offices are responsible for the local implementation of the national educational policies across the country.

3.1 Methodology

This chapter deals with various sources and methods of gathering the data and how the data were analyzed. This chapter also takes into consideration the type of data and data size, research design and the nature of the model(s) achieved after proper analysis of the data collected for this research.

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Data collected for this purpose was secondary data and contained all the necessary information for this study. Data were obtained from the West African Examination Council (WAEC) which include WASSCE May/June results in Mathematics from 2007 to 2017. The source of the other data was World Bank data – Knoema, Alden Library, Ohio University, and Ghana Statistical Service Department which include the economic indicators of the country such as the Gross Domestic Product (GDP) per capita and its corresponding Gross Domestic Product (GDP) growth rate. Non – economic indicators such as Educational spending on the portion of the GDP and Student – teacher ratio are also considered in order to build a holistic model to that enable the government of Ghana and stakeholders identify the level at which each of these factors plays as far students' performance is concerned.

3.2 Regression Analysis and Model

Relationships that exist in real life are best described by the extent to which one party either partially or totally depends on the other. In statistics, the concept of determination of the relationship between one variable (called dependent variable) and one or more other variables (called independent variable) is termed Regression. This article will make use of both simple and multiple linear regression models in the analysis of the sample data. The statistical analysis of the data and fitting an appropriate model that best describes a given data set assists in interpretation of the general results.

In this model, we determine the correlation and the extend of effect each factor has on Students' performance in mathematics. A multiple linear regression model is designed as an extension of the simple linear regression model that describes a linear relationship between one response variable and at least two predictor variables. Students' performance is acting as the dependent variable and GDP per capita, GDP growth rate, Educational expenditure and Student – teacher ratio as independent variables. This model is validated by selected statistical methods by using first the original data and by employing bootstrapping to resample the original data size to 100 and 1000 to build two additional models out of the same data. Significant factors among the economic indicators are identified and further correlation analysis is performed on students' performance with on those factors. Further various useful regression statistics are identified from the analysis of the data in R program; a statistical tool.

Hypothesis testing was carried out on the model with the null hypothesis that all the parameters of the linear multiple regression model are statistically insignificant at 1%versus the alternate hypothesis that all the parameters of the linear multiple regression model are statistically significant at 1%.

Correlation Analysis

Correlation analysis attempts to measure the strength of relationships between two or more variables. This can be done through the following commonly known methods: Pearson correlation (Parametric correlation), Kendall tau and Spearman rho (Non – parametric correlation). A correlation coefficient

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is used in statistics to measure how positive strong (+1), negative strong (-1) or none in the relationship between two variables. The correlation coefficients and other related regression analysis information from the data are obtained from the statistical package (R software).

4.1 Discussion of Results

Results were obtained with the help of R programming. A statistical model was fitted with four economic indicators as the dependent variables and Students' Performance as the independent variable. The parameters were coded as follows; Students' Performance (SP), as the response variable, Gross Domestic Product per capita (GDP per capita), Gross Domestic Product growth rate (GDP growth rate), Educational Spending (Edu. S) of the portion of GDP and Student - teacher Ratio (STR).

The multiple linear regression model: $V_5 = \beta_0 + \beta_1 V_1 + \beta_2 V_2 + \beta_3 V_3 + \beta_4 V_4$ where

V_5= Students' Performance

V_1= GDP Per Capita

V_2= GDP Growth Rate

V_3= Educational Spending

V_4= Student Teacher Ratio

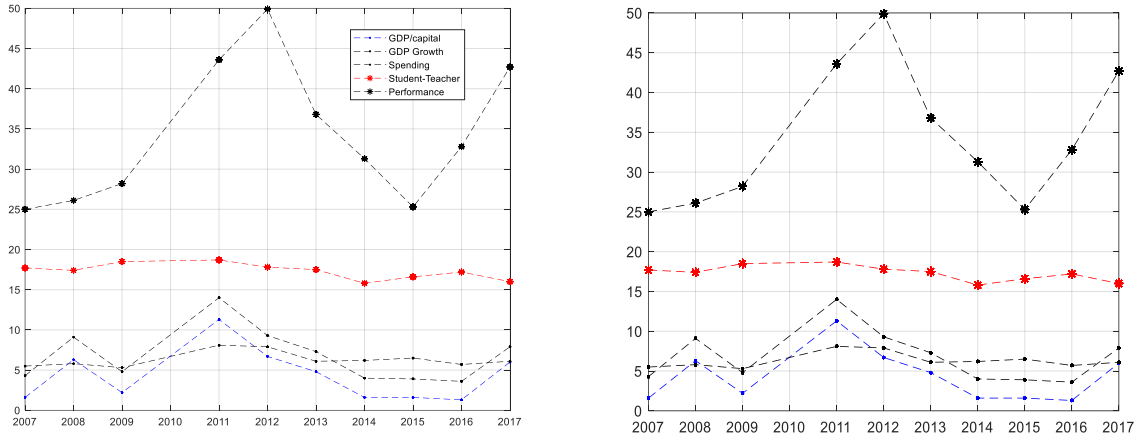

Figure 4.1: The resample data sets. Left: sample size=100, Right: sample size=1000(Source: Authors' construct, May 2018)

Figure 1.1 indicates the original data set and Figure 4.1 indicates the resampled data sets graphical representation. The educational spending on the part of the GDP between 2009 and 2013 is relatively higher than all the other years. The results therefore clearly show that students' performance within those years is better than all the other years. This is, therefore, a strong indication that the higher the educational spending on the part of the GDP, then the better students' performance.

On the other hand, the downward trend from 2013 to 2015 from the results could be as a result of drastically decrease in the GDP per capita within those years. This is also very clear from 2016 and 2017 with an increased in GDP which eventually turned to better the performance of students in those years.

Hypothesis Testing

- H_0: All the parameters of the Linear Multiple Regression Model are statistically insignificant at 1%
- H_1: Some of the parameters of the Linear Multiple Regression Model are statistically significant at 1%

Models and results

The following models and results were obtained by using R programming to perform the statistical analysis

Original data (10) $V_5 = 3.856 + 18.121\,V_1 - 17.294\,V_2 + 4.955\,V_3 + 2.211\,V_4$

Resample data (100) $V_5 = -1.408 + 18.721V_1 - 18.343V_2 + 6.522V_3 + 2.251V_4$

Resample data (1000) $V_5 = 4.041 + 18.366V_1 - 17.555V_2 + 5.007V_3 + 2.224V_4$

Table 4.1 Regression Statistics

	Original data (10)	Resample data (100)	Resample data (1000)
R Square	0.7533	0.8180	0.7580
Adjusted R Square	0.556	0.8104	0.7571
Standard Error	5.833	3.715	4.057
F-statistic	5.817	106.8	779.3
P-value	0.08114	< 2.2e-16	< 2.2e-16

(Source: Authors' Construct, May 2018)

The R square value is was better in the resample with the sample size 100 which has a value of 0.8180 and this indicates that there are socio-economic and other factors that trigger students' performance. In all, these four (4) variables together can explain 81.8% of the students' performance and the rest of 18.2% is explained by other factors not mentioned in this regression model .The p-value was 2.2e-16 which is less than α = 0.01; which indicates that the regression explained by the model is significant. It was also observed that the F-statistic was greater than the p-value which indicates that there is strong evidence against the null hypothesis H_0.

4.1 Identification and analysis of statistical significant indicators in the model

Various further statistical procedures have been employed in this process and the results obtained are indicated on Table 4.2 and Table 4.3.

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Table 4.2 Correlation of V5 with V1, V2, V3 and V4

N	(V1, V5)	(V2, V5)	(V3, V5)	(V4, V5)
10	0.6820	0.6512	0.7536	0.1258
100	0.6159	0.5805	0.7953	0.1265
1000	0.6701	0.6368	0.7456	0.1013
Average	0.6560	0.6228	0.7648	0.1179
Weights	0.30368752	0.273726	0.412777	0.00981

(Source: Authors' Construct, May 2018)

Table 4.3 Correlation of V1 with V2, V3 and V4

N	(V1, V2)	(V1, V3)	(V1, V4)
10	0.9970	0.7373	0.4129
100	0.9967	0.7167	0.4391
1000	0.9968	0.72268	0.3950
Average	0.9968	0.7256	0.4157

(Source: Authors' Construct, May 2018)

From Table 4.2, we observed that educational spending has the greatest influence on student' performance with a numerical value of 76% followed by GDP per Capita with 66%, GDP Growth rate with 62% and Student teacher ratio with 18%. Generally, all the indicators are positively correlated to students' performance. These results are further confirmed by respective weights (Table 4.2) of each indicator on the general model for Students' performance (V5). Table 4.3 is further validation of the results in Table 4.2 concerning the effect GDP per capita has on each other economic indicators on students' performance in mathematics. It is, therefore, a clear indication from both results that the level of impact educational spending has on students' performance depends on the GDP per capita of the economy. This could be said that the higher the portion of the GDP per capita is distributed to the educational sector, then the better students' performance. The student-teacher ratio with 18% is a true reflection of the behavior of the data to students' performance which shows that at the Senior High School level for over the past 10 years, great efforts have been made to have a quite fairly distribution of mathematics teachers (efforts of about 82% fairly distribution).

4.2 Statistical Significant variables models

From Table 4.2, the GDP per capita is correlated with students' performance and educational spending is also correlated with students' performance. Model 1 and model 2 are built to determine which of the two have a greater impact on students' performance.

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Model 1. $V_5 = 1.787V_1 + 26.421$ **Model 2.** $V_5 = 6.89V_3 - 9.28$

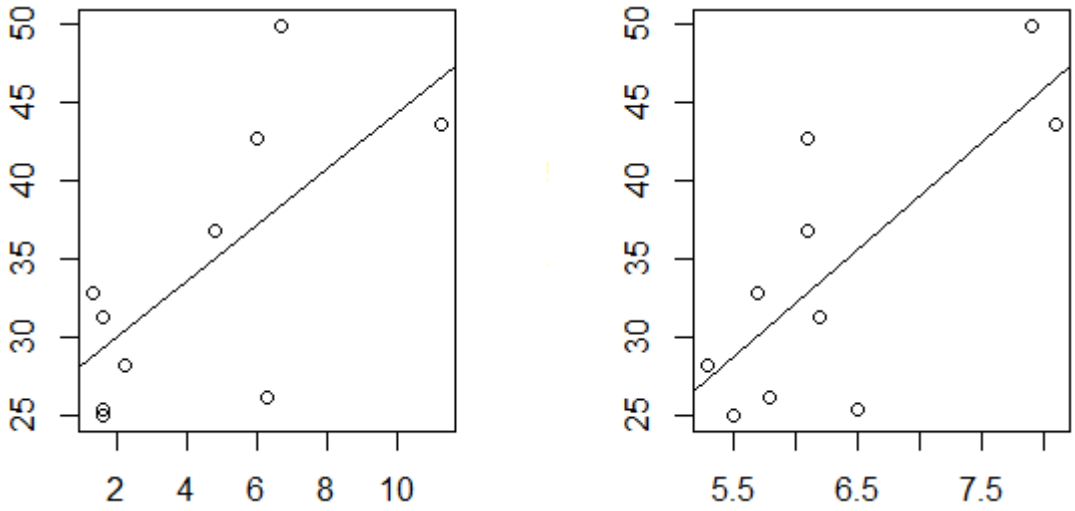

Figure 4.2 Model 1: Students' Performance Vs GDP per capita and Model 2: Students' Performance Vs GDP per capita(Source: Authors' Construct, May 2018)

These two simple linear models give their respective residuals and it is observed that model 2 returned smaller residuals than Model 1. This is a clear reflection of the fact that the economic indicator of educational spending is strongly correlated to student performance (Table 4.2, two variables are STRONGLY correlated if the correlation coefficient is > 0.7).

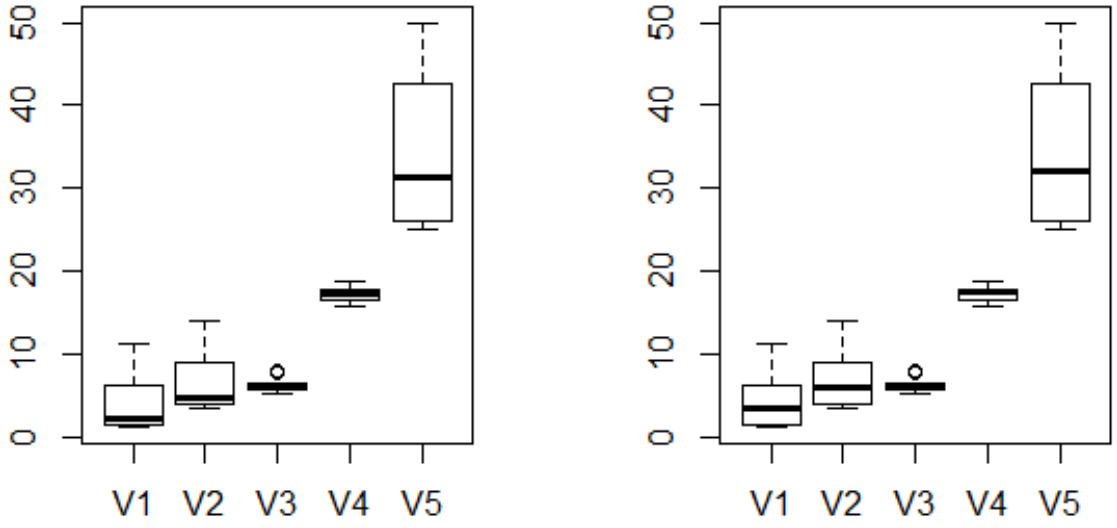

Figure 4.3 Boxplots of original data and resample data (Source: Authors' Construct, May 2018)

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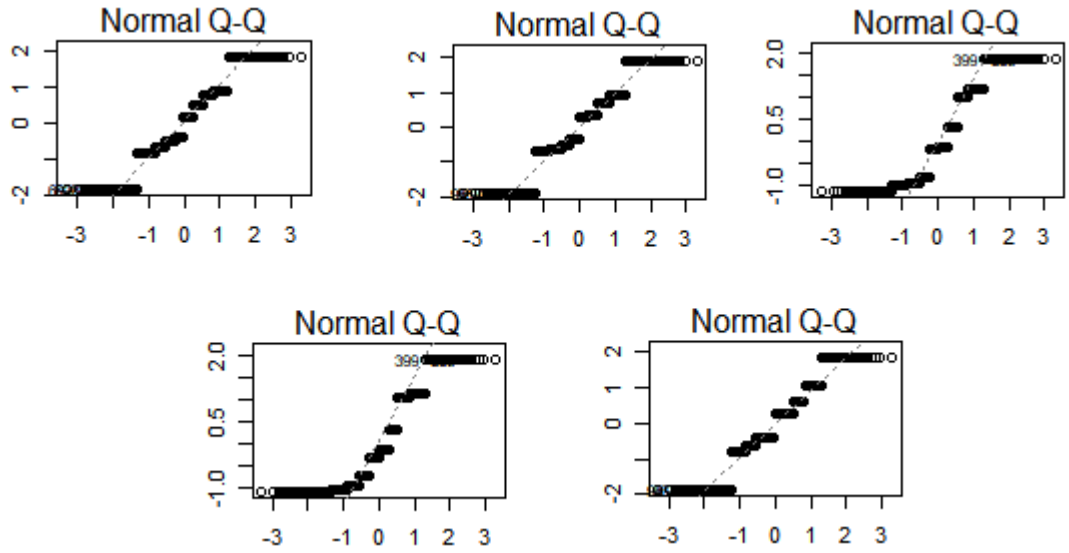

Figure 4.4normal Q-Q plots of data. (Source: Authors' Construct, May 2018)

Table 4.4 Summary for the original data

	V1	V2	V3	V4	V5
1st Quartile	1.3	3.6	5.3	15.8	25
Minimum	1.6	4	5.7	16.6	26.1
Mean	3.5	6.05	6.1	17.45	32.05
3rd Quartile	6.3	9.1	6.5	17.8	42.7
Maximum	11.3	14	8.1	18.7	49.9

(Source: Authors' Construct, May 2018)

Table 4.5 Summary for the original data

	V1	V2	V3	V4	V5
1st Quartile	1.3	3.6	5.3	15.8	25
Minimum	1.6	4	5.7	16	26.1
Mean	4.8	4.8	6.1	17.5	32.8
3rd Quartile	6.3	9.1	6.5	17.8	42.7
Maximum	11.3	14	8.1	18.7	49.9

(Source: Authors' Construct, May 2018)

The boxplot of the original and resample data indicates outliers in educational spending and this could be due to fluctuation in the distribution of the GDP per capita to the educational sector in Ghana each year for the past ten (10) years of consideration in this study. The points of the normal Q-Q plot of the resample data follow a weakly nonlinear pattern, suggesting that the errors do not

deviate much from the straight line. The offset between the line and the points suggests that the mean of the data is not zero (0) and hence there is enough evidence to reject the null hypothesis H_0and this further confirmed the final decision on the hypothesis testing for the model. This summary results indicate that there are similar values for both original data and the resample and this also validates the Bootstrap method used in generating the resample data.

Observations, Conclusions, and Recommendations

Various statistical methods were used to thoroughly analyze the collected data to identify the best significant economic indicator(s) that influences students' performance in mathematics at WASSCE. Also, data and model validation methods were used to ensure the quality of the final results. It has also been observed that, the government of Ghana for the past ten (10) years has made great efforts in dealing with students' teacher ratio (82% efforts in fairly distribution) and finally it was observed that all the indicators were positively correlated with students' performance which means each of these indicators has some amount of influence on students' performance.

The goal of this research has been achieved with results indicating that the GDP per capita and Educational spending significantly influence students' performance in mathematics. The relationship between these two indicators in terms of their influence on students' performance is that students turn to do well at WASSCE mathematics when a greater portion of the GDP per capita is allocated to the educational sector. Overall these are satisfactory results that are clearly in line with the hypothesis for this research work. The government of Ghana therefore needs to put more resourses to the educational sector especially at the Senior High School level in order to improve students' performance in mathematics.

However, it appeared there are several factors to consider when predicting students' performance at a particular time since some of these factors could be based on economic or demographic conditions. This makes it very complex and therefore demands more statistical tools for further statistical analysis. Therefore, for future extensive research analysis, both economic and demographic factors should consider in order to better understand the correlation and statistical significance of the regression models. Finally, in future research in this area of study, only one of the variable GDP per capita or variable GDP growth rate should be used in the regression model.

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