Empirical assessment of manufacturing sub-sector's performance

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As noted in prior works, the manufacturing sub-sector remains one of the essential pivots of the industrial sector. The foregoing underscores enviable role of the manufacturing sub-sector within the broader Ghanaian economy. However, manufacturing activities thrive on the availability of raw materials from the agricultural sector to meet growing needs of various factories operating across the country. As a result, it was deemed imperative to examine how the activities of agribusiness could be effectively harnessed to provide the requisite raw materials to feed the manufacturing sub-sector to improve on its performance (prior series of this publication addressed the foregoing phenomenon). Further, it was considered necessary to scientifically measure contribution of the manufacturing sub-sector to growth of the Ghanaian economy within a stated time frame. The following section presents useful information on the method of data collection analysis.

Methodology

The quantitative approach to scientific inquiry was applied to the assessment. Specifically, a cross-sectional design, an example of survey design, was adapted and used in the assessment. This facilitated gathering of relevant assessment data over a specific period of time (Ashley, Takyi & Obeng, 2016; Creswell, 2009; Frankfort-Nachmias and Nachmias, 2008).

Data required for the assessment were obtained mainly from secondary sources including text books, peer-reviewed articles published in journals, research papers, newspaper publications; Google Search Engine, financial websites such as The Global Economy.com; electronic databases of the Bank of Ghana (BoG) and Ghana Statistical Service (GSS); and database of the World Bank, among others.

Annual data on Ghana's total gross domestic products (GDPs) and manufacturing sub-sector values denominated in Ghana Cedis (GH¢) for the period 2000 through 2018; and data on the world's and Ghana's total manufacturing values denominated in United States Dollars (US$) from 1997 through 2016 were used in the assessment.

Analytical Tools

Regression models and descriptive statistics were used to describe the research variables; and to evaluate their behaviour over the stated time frame within the Ghanaian and global economies. Measures such as the range and standard deviation were employed to describe the extent of dispersion about the central tendency (Ashley et al., 2016; Creswell, 2009; Frankfort-Nachmias & Nachmias, 2008). These measures were used to describe trends in Ghana's and the world's manufacturing performance for selected time periods.

Variables

The ***independent*** research variable was ***manufacturing*** while the ***dependent*** research variables were ***Ghana's industrial sector***, ***Ghana's GDP***, and the ***world's total manufacturing values***.

Regression Model

Regression statistical model was adapted to measure the effect and level of interaction of manufacturing on Ghana's industrial sector, total GDP; and the world's total manufacturing values over the research period. The Microsoft Excel analytical software was adapted and used in the research. Diagrams and tables were derived from Microsoft Excel to explain the research data.

Hypotheses

The assessment tested causal relationship between manufacturing and the industrial sector; between manufacturing and gross domestic product; and between manufacturing and global manufacturing values using the following null and research or alternative hypotheses:

Hypothesis One

Ho: $\mu_1 = \mu_2$; this implies manufacturing has no strong effect on Ghana's industrial sector

H$_1$: $\mu_1 \neq \mu_2$; this implies manufacturing has strong effect on Ghana's industrial sector

Hypothesis Two

Ho: $\mu_1 = \mu_2$; this implies manufacturing has no significant influence on Ghana's GDP

H$_1$: $\mu_1 \neq \mu_2$; this implies manufacturing has significant influence on Ghana's GDP

Hypothesis Three

Ho: $\mu_1 = \mu_2$; this implies manufacturing has no strong impact on the world's total manufacturing values

H$_1$: $\mu_1 \neq \mu_2$; this implies manufacturing has strong impact on the world's total manufacturing values

Descriptive Statistics

Descriptive statistical test was conducted to ascertain magnitude of Ghana's total manufacturing values during the period – 2000 through 2018. Manufacturing data in Tables 1 and 4 were useful for the analysis in this section. Table 1 appeared in the first series of this publication. Table 3 provides a statistical description for measures of central tendency such as the mean, median, and mode; and measures of dispersion such as the range, minimum, maximum; and standard deviation (Ashley et al.; Frankfort-Nachmias and Nachmias, 2008) for Ghana's total manufacturing values during the assessment period.

Table 3: Ghana's Manufacturing Values – 2000 To 2018

Mean	7851.2
Standard Error	2466.619482
Median	1868
Mode	#N/A
Standard Deviation	10751.74505
Sample Variance	115600021.7
Kurtosis	-0.2392549
Skewness	1.156182173
Range	31393.8
Minimum	47.2
Maximum	31441
Sum	149172.8
Count	19
Largest(1)	31441
Smallest(1)	47.2

The respective highest manufacturing value (GH¢31.441 billion) and the lowest value (GH¢47.2 billion) were recorded during fiscal years 2018 and 2000. The statistical distribution depicts the *range* of total manufacturing values during the period as 31393.8 (GH¢31.3938 billion). This represents the difference between the highest and lowest manufacturing values during the period. Results in Table 3 depict respective *mean* and *median* of 7851.2 and 1868;

and standard deviation of 10751.74505. These tell us the extent to which the observations were dispersed around the central tendency. The *mode* explains the variable with the highest frequency in the data. Table 3 affirms no absolute value for the mode (#N/A). This implies no manufacturing value was repeated during the period.

Respective *Kurtosis* and *standard error* values of -0.2392549 and 2466.619482 are included in the output in Table 3. The standard error value (2466.619482) indicates the extent to which the coefficients are significantly different from zero; whereas the extent to which the tails of the distribution in Table 3 differ from the tails of a normal distribution is indicated by the Kurtosis value (-0.2392549). S*kewness* of the distribution is 1.156182173. This value explains distortion or asymmetry of the random variable around the mean. Data in the table depict *sample variance* of 115600021.7, which is indicative of the expectation of squared deviation of the research random variable from its mean. Again, analysis in the following section would help determine the significance or otherwise of the manufacturing values relative to the industrial sector, Ghana's GDP and global manufacturing values.

RESULTS

The underlying objective of this assessment was to test three major hypotheses. That is, measure the extent to which the manufacturing sub-sector's performance significantly influences the industrial sector; Ghana's gross domestic product; and manufacturing values at the global level. Statistics in column 2 in Table 4 depict the manufacturing values for Ghana from 2000 through 2018.

Data in column 2 show steady increase in manufacturing sub-sector's performance from 2000 through 2018, save 2007 when there was a decline in performance relative to the previous year (2006). Columns 3 and 4 present the respective values for Ghana's industrial sector and GDP during the period. Values for data in Table 4 are in *billions of Ghana Cedis (GH¢)*. Data used in this section were obtained from the databases of the Bank of Ghana and Ghana Statistical Service.

Table 4: Contribution of Manufacturing to Industry and GDP – 2000 To 2018

Year	Manufacturing	Industry	GDP*
2018	31,441.00	94,770.30	300,596.10
2017	26,860.00	78,015.00	256,671.00
2016	23,922.00	60,709.00	215,077.00
2015	20,506.00	57,155.00	180,399.00
2014	17,605.00	53,767.00	155,433.00
2013	14,523.00	43,104.00	123,650.00
2012	2,437.00	7,659.00	30,099.00
2011	2,242.00	7,132.00	27,742.00
2010	1,984.00	5,053.00	24,187.00
2009	1,844.00	4,725.00	22,454.00
2008	1,868.00	4,521.90	21,592.20
2007	1,801.30	3,929.60	19,913.40
2006	1,823.50	3,704.30	18,705.10
2005	58.9	165.50	658.90
2004	56.1	153.80	622.40
2003	53.6	146.70	589.50
2002	51.3	139.60	560.10

2001	48.9	133.30	535.70
2000	47.2	129.50	514.20

Sources: Bank of Ghana & Ghana Statistical Service

Data in Table 4 helped in testing significance of the relationship between the manufacturing sub-sector and the industrial sector; and between the manufacturing sub-sector and Ghana's GDP. Table 5 and Figure 3 present relevant data on total manufacturing values for Ghana and the world's economy spanning over a twenty-year period. That is, from 1997 through 2016. The world's and Ghana's manufacturing values presented in Table 5; and in Figure 3 are in *trillions of United States Dollars (US$)*.

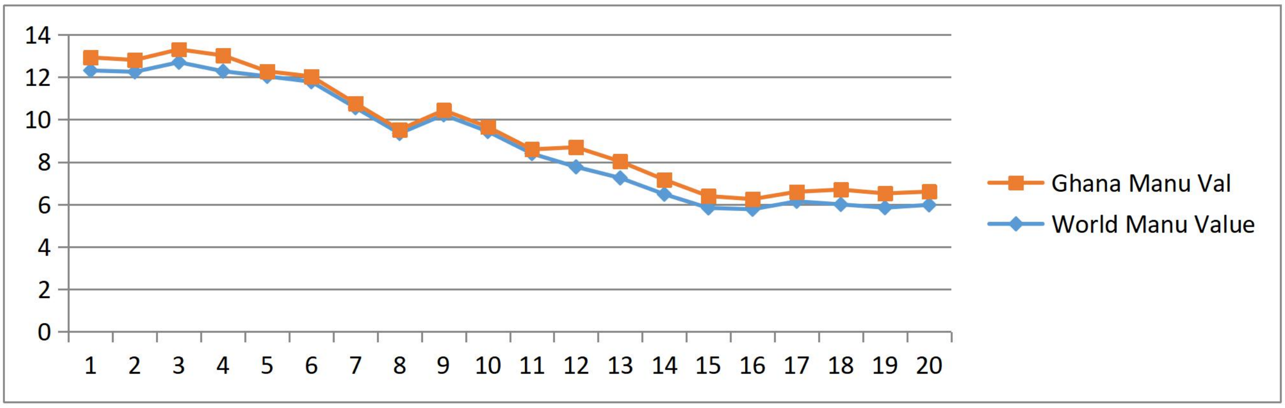
Table 5: Manufacturing Values for the World and Ghana – 1997 To 2016

Year	World's Manufacturing Value	Ghana's Manufacturing Value
2016	12.313	0.611842624
2015	12.248	0.559051972
2014	12.699	0.607117815
2013	12.276	0.743193108
2012	12.034	0.237403464
2011	11.781	0.254164598
2010	10.557	0.205553641
2009	9.343	0.17592434
2008	10.221	0.215210237
2007	9.436	0.212836837
2006	8.393	0.198961626
2005	7.765	0.928864614
2004	7.245	0.776409116
2003	6.478	0.685048454
2002	5.83	0.556650681
2001	5.768	0.478500628
2000	6.143	0.4493118
1999	5.997	0.696624156
1998	5.842	0.672361592
1997	5.975	0.623779297

***Manufacturing values in Trillions of United States Dollars (US$)**
Sources: The Global Economy.com & World Bank

Data in Table 5 and Figure 3 proved useful to measurement of the significance of Ghana's manufacturing sub-sector's contribution to the world's total manufacturing values during the assessment period. Data in the table and figure were obtained from the database of the World Bank; and The Global Economy.com. Available data on Ghana's total manufacturing values at the World Bank spanned from 1965 through 2016.

Figure 3: Manufacturing Values for the World and Ghana – 1997 To 2016



The foregoing was emphasised because recent empirical study (during 2019) on pensions revealed Ghana had no reliable data on pension fund assets at the World Bank; albeit policies and programmes related to pensions had been formulated and implemented prior to independence, immediately after independence; and till date. Results from tests of the research hypotheses are presented in the following section.

Test of Hypothesis One

The alternative hypothesis under the first hypothesis sought to test whether or not manufacturing has strong effect on performance of the industrial sector within the Ghanaian economy. Output from the statistical analysis on research hypothesis one is outlined in the ensuing section.

Model Summary

Regression analysis outputs on the first hypothesis are presented in Tables 6 through 9; and in Figures 4 and 5. Summary constitutes an important aspect of a regression model. To this end, Table 6 presents an overall description of the regression model. Values for R (0.996987922), R^2 (0.993984917) and adjusted R^2 (0.993631089) are displayed in Table 6. Value for the multiple correlation coefficients between the independent variable (manufacturing) and the dependent variable (industrial sector) is presented in the R row.

Table 6: Summary Output

Regression Statistics	
Multiple R	0.996987922
R Square	0.993984917
Adjusted R Square	0.993631089
Standard Error	2485.835557
Observations	19

The R^2 value (0.993984917) in Table 6 tells us the extent to which variability in the dependent variable is accounted for by the independent variable. The R^2 value implies manufacturing accounts for about 99.40% (0.993984917 x 100% = 99.3985% = 99.40%) of the variation in industrial sector's performance. The results suggest less than 1% (100% - 99.40% = 0.60%) of the outcome is explained by external random factors, including other industrial sector components such as mining and quarrying; electricity; water and sewerage; and construction.

One of the measures that determine generalisability of the regression model is the adjusted R^2. Generally, an ideal adjusted R^2 value is closer to zero or the R^2 value. The adjusted R^2 value (0.993631089) in Table 6 is not significantly different from the observed value of R^2 (0.993984917). This implies cross-validity of the regression model is good; the model may accurately predict the same dependent variable from the given independent variable in a different group of participants (Field, 2009). The R^2 significance was computed using an F-ratio to cross-validate the F-value (2809.229) in Table 7. The ideal F-ratio formula for measuring R^2 significance is:

$$F = \frac{(N - k - 1)\ R^2}{k\ (1 - R^2)}$$

Where:

R^2 = Unadjusted value
N = Number of cases or participants in the study
k = Number of independent variables in the regression model

Value for the F-ratio was determined as follows:

$$F = \frac{(19 - 1 - 1)\ 0.993984917}{1\ (1 - 0.993984917)}$$

$$= \frac{16.897743589}{0.006015083}$$

$$= \mathbf{2809.22867}$$

Our computations revealed the change in the amount of variance that can be explained gives rise to an F-ratio of 2809.22867, which is equivalent to the F-value (2809.229) in Table 7. This F-ratio shows a non-significant value ($p = 0.676503$, $p > 0.05$) as presented in Table 8.

ANOVA
The ANOVA helps to determine whether or not regression analysis provides better and significant prediction on the outcome than the mean. Data in Table 7 show degree of freedom (between) of 1 (2 - 1 = 1); degrees of freedom (within) of 17 (19 - 2 = 17); total degrees of freedom (df) of 18 (19 - 1 = 18); and an F-value of 2809.229.

Table 7: ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.74E+10	1.74E+10	2809.229	2.54131E-20
Residual	17	1.05E+08	6179378		
Total	18	1.75E+10			

Further, statistical distribution in Table 7 depict the model sum of squares (SSM) value, represented by *Regression*; the residual sum of squares (SSR) value, represented by *Residual*; the total sum of squares (SST) value, represented by *Total*; and the degrees of freedom (df) for each group of squares.
The degree of freedom for the SSM is 1, comprising the only independent variable (manufacturing) in the assessment. The sum of squares divided by the degrees of freedom gives us the mean squares (MS). That is, 1.74E+10 (17359287014.1961) ÷ 1 = 1.74E+10; and 1.05E+08 (105049433.073346) ÷ 17 = 6179378.

Model Parameters
Table 8 presents results on the parameters of the regression model. Data in the table show the coefficients, standard error, test statistic (t Stat or t-test), significance; and confidence intervals for the coefficients. The coefficients in Table 8 hint us on the contribution of the independent variable (manufacturing) to the regression model. Generally, a positive coefficient connotes a

positive relationship between the independent variable and the dependent variable; whereas a negative value symbolises a negative relationship between the two variables.

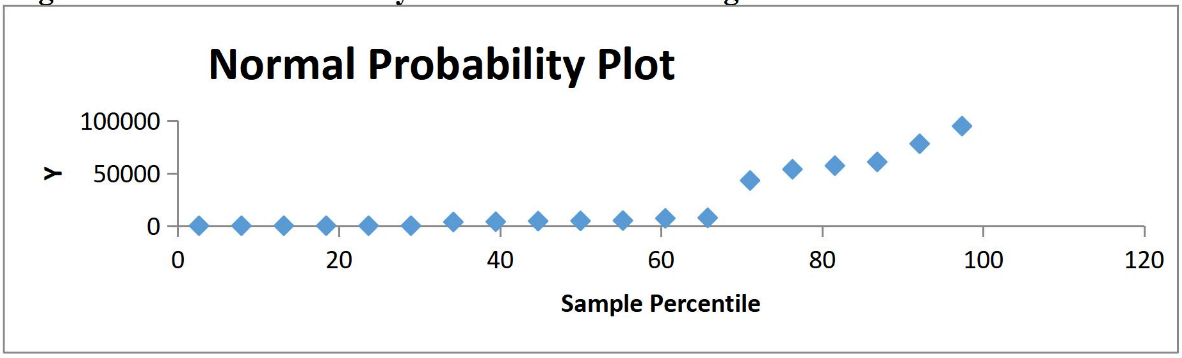
Results from the statistical analysis in Table 8 affirm a positive coefficient value (2.888356073). This means there is a positive relationship between the manufacturing sub-sector and industrial sector of the Ghanaian economy. However, relationship between the two variables is not significant ($p = 0.676503$, $p > 0.05$). The results suggest manufacturing has no significant influence on industrial sector's performance. The statistical outcomes undermine authenticity of the high annual data churned out by key stakeholders for the manufacturing sub-sector.

Table 8: Model Parameters

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-302.6664641	712.9428	-0.42453	0.676503	-1806.844356	1201.51143
X Variable 1	2.888356073	0.054495	53.00216	2.54E-20	2.773381534	3.00333061

A normal probability plot on the relationship between manufacturing and industrial sector's values is presented in Figure 4. The figure depicts a steady rise in comparative values over a six-year period, that is, from fiscal period 2013 through 2018. This steep rise is preceded by relatively flat distribution of comparative values over the preceding thirteen-year period; ranging from fiscal year 2000 through 2012. The relatively flat distribution is observed from the 2.63rd percentile (during 2000) through 34.2nd percentile (during 2006) to the 65.79th percentile (during 2012). However, the steep rise in values is observed from the 71.05th percentile (during 2013) through the 86.84th percentile (during 2016) to the 97.37th percentile (during 2018) in the distribution.

Figure 4: Normal Probability Plot for Manufacturing and Industrial Sector

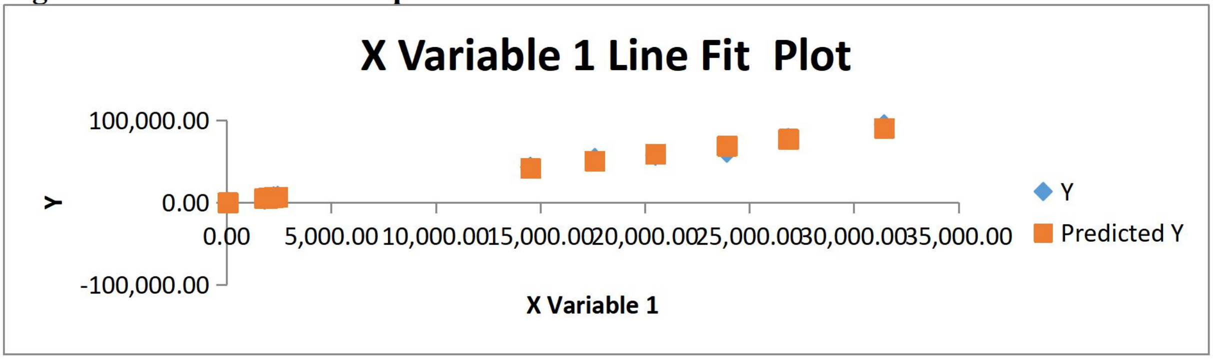


The magnitude of the t-test ($p = 0.676503$, $p > 0.05$) in Table 8 tells us the independent variable (manufacturing) has no strong impact on the dependent variable (industrial sector). A standard error is identified with the coefficients in the table. The standard error shows the extent to which the coefficients would vary in different research samples (Field, 2009). The probability that a parameter would fall between a pair of values around the mean is measured by the confidence interval. Stated differently, confidence interval values affirm the extent or level of uncertainty; or certainty in a method of sampling (Hayes, 2021). Statistics in Table 8 depict the respective upper 95% confidence interval values for the *Intercept* and *X Variable 1* as 1201.51142742426 and 3.00333061185457.

Test of Assumptions

Statistical tests were conducted to determine linearity of the relationship between the independent variable (manufacturing) and the dependent variable (industrial sector); and to measure the variance in residual values. The statistical outputs are presented in Figure 5 and Table 9. The scatter plots in Figure 5 are on a straight line. This affirms the identified relationship between the independent variable and dependent variable is linear; it implies the model fits the analysis.

Figure 5: Linear Relationship between X and Y Variables



The *residual* values in Table 9 allow us to test the *homoscedasticity* of the model. That is, to be able to determine whether or not the residual values at each level of the independent variable depict constant variance. Residuals in Table 9 show constant variance values. This implies the assumption of homoscedasticity is met. Further, data in Figure 5 indicate relationship between the X and Y variables were measured at the interval level and beyond; while variability of the dependent variable (industrial sector) was not constrained. The foregoing analysis indicates most of the assumptions have been met. This renders the regression model fit and appropriate for the research.

Table 9: Predicted Y Values and Residual Values for Variable X

Predicted Y	*Residuals*	*Standard Residuals*
90510.13683	4260.163	1.763460067
77278.57766	736.4223	0.304836068
68792.58752	-8083.59	-3.346135632
58925.96317	-1770.96	-0.733075872
50546.8422	3220.158	1.33295826
41644.92879	1459.071	0.603970721
6736.257286	922.7427	0.381961879
6173.027852	958.9721	0.39695876
5427.831985	-374.832	-0.155158667
5023.462135	-298.462	-0.123545985
5092.78268	-570.883	-0.236312265
4900.12933	-970.529	-0.401742762
4964.250835	-1259.95	-0.521546451
-132.5422914	298.0423	0.123372194
-140.6296884	294.4297	0.121876787
-147.8505785	294.5506	0.121926828
-154.4937975	294.0938	0.121737747
-161.4258521	294.7259	0.121999381
-166.3360574	295.8361	0.122458942

Report on P -Value and Confidence Interval

Table 8 depicts *P* value of 0.676503 and positive coefficient value of 2.888356073. These values are not significant at Alpha level $\alpha = 0.05$. The table further shows a confidence interval of 2.77338153429046 and 3.00333061185457. The Alpha level, a priori, for this study is $\alpha = 0.05$. The foregoing suggests there is 5 per cent probability that we would be wrong. Further, there is 5 per cent likelihood the population mean would not fall within the interval (Ashley et al.; Bowerman & O'Connell, 1990; Frankfort-Nachmias and Nachmias, 2008). However, we are 95% certain our conclusions would be right. Again, the Microsoft Excel output in Table 7 shows degree of freedom (between) of 1 (2 - 1 = 1); degrees of freedom (within) of 17 (19 - 2 = 17); total degrees of freedom (df) of 18 (19 - 1 = 18); and an F-ratio of 2809.229. These values could be interpreted as:

$$F\ (1,\ 17) = 2809.229,\ p > 0.05,\ \textit{two-tailed.}$$

Interpretation and Rejection of Alternative Hypothesis

The foregoing results indicate manufacturing has no strong influence on Ghana's industrial sector. Therefore, we reject the alternative hypothesis (H_1: $\mu_1 \neq \mu_2$); and accept the null hypothesis (H_o: $\mu_1 = \mu_2$) which states, the manufacturing sub-sector has no strong effect on Ghana's industrial sector.

Test of Hypothesis Two

The alternative hypothesis under the second hypothesis was formulated to test whether or not manufacturing has significant influence on Ghana's gross domestic product. Results from the statistical analysis on research hypothesis two are presented below.

Model Summary

Results from the regression analysis are presented in Tables 10 through 13; and in Figures 6 and 7. As noted earlier, Summary constitutes an important aspect of a regression model; and therefore, an overall description of the regression model is presented in Table 10. Similarly, values for R (0.998226311), R^2 (0.996455768) and adjusted R^2 (0.996247284) are displayed in Table 10. The R row in the table shows the value of the multiple correlation coefficients between the independent variable (manufacturing) and the dependent variable (Ghana's GDP).

Table 10: Model Summary

Regression Statistics	
Multiple R	0.998226311
R Square	0.996455768
Adjusted R Square	0.996247284
Standard Error	6045.612222
Observations	19

The R^2 value (0.996455768) in Table 10 depicts the extent to which variability in the dependent variable (Ghana's GDP) is accounted for by the independent variable (manufacturing). The R^2 value implies manufacturing accounts for about 99.65% (0.996455768 x 100% = 99.6456% = 99.65%) of the variation in Ghana's GDP. The results suggest less than 1% (100% - 99.65% = 0.35%) of the outcome is explained by external random factors, including all other components of the industrial sector; all components of the agricultural sector; and all components of the services sector.

As affirmed in the preceding section, the adjusted R^2 remains one of the measures that facilitate our determination of generalisability of the regression model. An ideal adjusted R^2 value is closer to zero or the R^2 value. The adjusted R^2 value (0.996247284) is not significantly different from the observed value of R^2 (0.996455768); implying the cross-validity of the regression model is high; it suggests the model may predict with accuracy the same dependent variable from the given independent variable in a different group of participants. Consistent with the test of hypothesis one, the R^2 significance was computed using an F-ratio to cross-validate the F-value (4779.526) in Table 11. Again, the ideal F-ratio formula adapted to measure the R^2 significance under hypothesis two is:

$$F = \frac{(N - k - 1)\ R^2}{k\ (1 - R^2)}$$

Where:

R^2 = Unadjusted value
N = Number of cases or participants in the study
k = Number of independent variables in the regression model

Value for the F-ratio was determined as follows:

$$F = \frac{(19 - 1 - 1)\ 0.996455768}{1\ (1 - 0.996455768)}$$

$$= \frac{16.939748056}{0.003544232}$$

$$= \mathbf{4779.52574}$$

Results from our computations showed the change in the amount of variance that can be explained gives rise to an F-ratio of 4779.52574, which is equivalent to the F-value (4779.526) in Table 11. This F-ratio depicts a non-significant value ($p = 0.327796$, $p > 0.05$) as presented in Table 12.

ANOVA

Statistical data on the ANOVA in Table 11 helps to determine whether or not regression analysis provides better and significant prediction for the outcome than the mean. Figures in Table 11 depict degree of freedom (between) of 1 (2 - 1 = 1); degrees of freedom (within) of 17 (19 - 2 = 17); total degrees of freedom (df) of 18 (19 - 1 = 18); and an F-value of 4779.526.

Table 11: ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	*1*	*1.75E+11*	*1.75E+11*	*4779.526*	*2.83113E-22*
Residual	*17*	*6.21E+08*	*36549427*		
Total	*18*	*1.75E+11*			

Table 11 outlines the model sum of squares (SSM) value, represented by *Regression*; the residual sum of squares (SSR) value, represented by *Residual*; the total sum of squares (SST) value, represented by *Total*; and the degrees of freedom (df) for each group of squares. The degree of freedom for the SSM is 1, comprising the one independent variable (manufacturing). As noted earlier, the sum of squares divided by the degrees of freedom gives us the mean squares (MS). That is, 1.75E+11 (174688939590.042) ÷ 1 = 1.75E+11; and 6.21E+08 (621340261.456054) ÷ 17 = 36549427.

Model Parameters

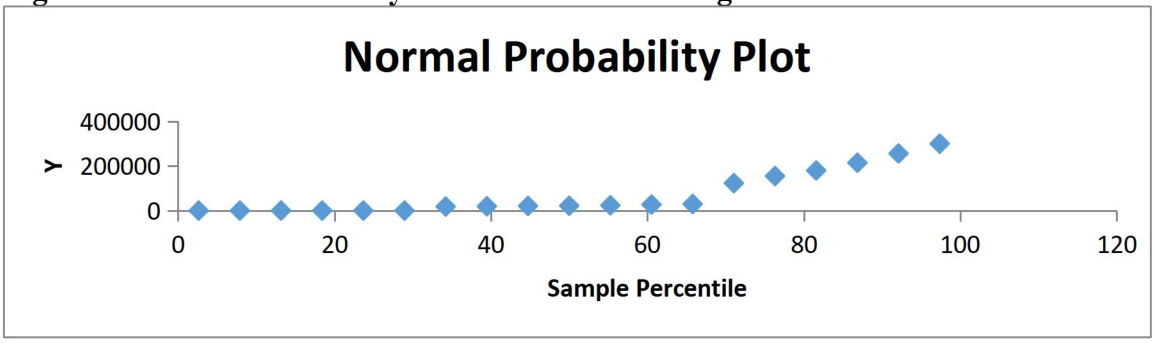
Results on the parameters of the regression model are presented in Table 12. Data in the table depict the test statistic, significance, coefficients, standard error; and confidence intervals for the coefficients. The coefficients in Table 12 reveal contribution of the independent variable (manufacturing) to the regression model. Conventionally, a positive coefficient generally connotes a positive relationship between the independent variable and the dependent variable; while a negative value is indicative of a negative relationship between the two variables.

Table 12: Model Parameters

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1746.988694	1733.894	1.007552	0.327796	-1911.208334	5405.18572
X Variable 1	9.162573973	0.132533	69.13412	2.83E-22	8.882953113	9.44219483

Data in Table 12 depict a positive coefficient value (9.162573973). This affirms the existence of a positive relationship between manufacturing and Ghana's GDP. However, relationship between the two variables is not significant ($p = 0.327796$, $p > 0.05$). The results suggest manufacturing has no significant influence on Ghana's GDP. Again, the statistical analysis raises some concerns about veracity of the relatively high annual data presented by key stakeholders for the manufacturing sub-sector.

Figure 6: Normal Probability Plot for Manufacturing and Ghana's GDP



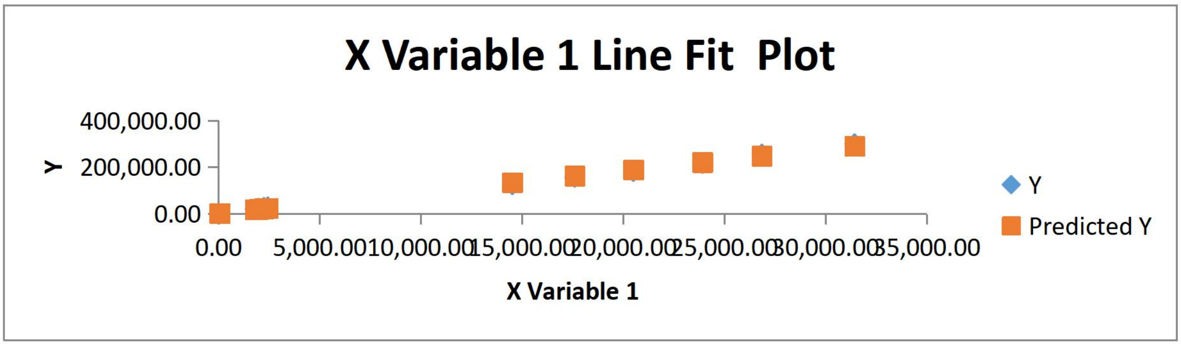
A normal probability plot on the relationship between the manufacturing sub-sector and Ghana's total GDP is presented in Figure 6. Data in the figure depict relatively flat distribution of percentile values during the preceding thirteen-year period; and steady rise in comparative values over the last six-year period. Specifically, Figure 6 depicts fairly flat distribution of values from the 2.63rd percentile through the 34.21st percentile to the 65.79th percentile; and steep rise in values from the 71.05th percentile through the 81.58th percentile to the 97.37th percentile.

A standard error is identified with the coefficients in Table 12. The standard error value is indicative of the extent to which the coefficients would vary in different research samples (Field, 2009). Table 12 shows respective upper and lower 95% confidence interval values for the *Intercept* (5405.1857216262 and -1911.208334); and *X Variable 1* (9.44219483364362 and 8.882953113).

Test of Assumptions

Statistical tests were conducted to determine linearity of the relationship between the independent variable (manufacturing) and the dependent variable (Ghana's GDP); and to measure the variance in residual values. The statistical outputs are presented in Figure 7 and Table 13. The scatter plots in Figure 7 are on a straight line. This means the relationship between the independent variable and dependent variable is linear; it implies the model fits the analysis.

Figure 7: Linear Relationship between X and Y Variables



The *residual* values in Table 13 allow us to test the *homoscedasticity* of the model. That is, it facilitates our determination of whether or not the residual values at each level of the independent variable depict constant variance. Residuals in Table 13 show constant variance values; this implies the assumption of homoscedasticity is met. Moreover, data in Figure 7 indicate relationship between the X and Y variables were measured at the interval level and beyond; while variability of the dependent variable (Ghana's GDP) was not constrained. The foregoing analysis indicates most of the assumptions have been met. This renders the regression model fit and appropriate for the research.

Table 13: Predicted Y Values and Residual Values for Variable X

Predicted Y	*Residuals*	*Standard Residuals*
289827.477	10768.62301	1.832870064
247853.7256	8817.274381	1.50074139
220934.0833	-5857.083285	-0.996903003
189634.7306	-9235.730592	-1.571964596
163054.1035	-7621.103495	-1.297147503
134815.0505	-11165.05051	-1.900343881
24076.18147	6022.818533	1.025111918
22289.47954	5452.520458	0.928044515
19925.53546	4261.464543	0.725321221
18642.7751	3811.224899	0.648688325
18862.67688	2729.523124	0.464577618
18251.53319	1661.866808	0.282857513
18454.94233	250.1576656	0.042578006
2286.664301	-1627.764301	-0.277053107
2261.009094	-1638.609094	-0.278898941
2238.102659	-1648.602659	-0.280599893
2217.028739	-1656.928739	-0.28201703
2195.038561	-1659.338561	-0.282427194
2179.462186	-1665.262186	-0.283435422

Report on P -Value and Confidence Interval

Data in Table 12 show *P* value of 0.327796 and positive coefficient value of 9.162573973. These values are not significant at Alpha level $\alpha = 0.05$. The table further shows a confidence interval of 8.88295311309066 and 9.44219483364362. The Alpha level, a priori, for this study is $\alpha = 0.05$. The implication is there is 5 per cent probability that we would be wrong; and there is 5 per cent likelihood that the population mean would not fall within the interval (Ashley et al.; Bowerman & O'Connell, 1990; Frankfort-Nachmias and Nachmias, 2008). However, we remain 95% certain our conclusions would be right. Again, the Microsoft Excel output in Table 12 depicts degree of freedom (between) of 1 (2 - 1 = 1); degrees of freedom (within) of 17 (19 - 2 = 17); total degrees of freedom (df) of 18 (19 - 1 = 18); and an F-ratio of 4779.526. These values could be interpreted as:

$$F\ (1,\ 17) = 4779.526,\ p > 0.05,\ \text{two-tailed.}$$

Interpretation and Rejection of Alternative Hypothesis

Results from the analysis indicate the manufacturing sub-sector has no strong influence on Ghana's GDP. Therefore, we reject the alternative hypothesis (H_1: $\mu_1 \neq \mu_2$); and accept the null hypothesis (H_o: $\mu_1 = \mu_2$) which states, manufacturing has no significant influence on Ghana's GDP.

Test of Hypothesis Three

The alternative hypothesis under the third hypothesis sought to test whether or not the contribution of Ghana's manufacturing value has strong impact on the world's total manufacturing values. Results from the statistical analysis on research hypothesis three are presented in the following section.

Model Summary

Data derived from the regression analysis on hypothesis three are presented in Tables 14 through 17; and in Figures 8 and 9. One of the important components of a regression model is its Summary. Table 14 presents an overall description of the regression model. Values for R (0.298667081), R^2 (0.089202026) and adjusted R^2 (0.038602138) are displayed in Table 14. Value for the multiple correlation coefficients between the independent variable and the dependent variable is presented in the R row.

Table 14: Model Summary

Regression Statistics	
Multiple R	0.298667081
R Square	0.089202026
Adjusted R Square	0.038602138
Standard Error	2.614564128
Observations	20

The R^2 value (0.089202026) in Table 14 reveals the extent to which variability in the dependent variable (world's total manufacturing values) is accounted for by the independent variable (Ghana's manufacturing value). The R^2 value reveals Ghana's manufacturing value accounts for only about 8.92% (0.089202026 x 100% = 8.92%) of the variation in the world's total manufacturing values. The results suggest about 91.08% (100% - 8.92% = 91.08%) of the outcome is explained by external random factors.

Again, the adjusted R^2 has been identified as one of the measures that determine generalisability of the regression model. An ideal adjusted R^2 value is generally closer to zero or the R^2 value. The adjusted R^2 value (0.038602138) is significantly different from the observed value of R^2 (0.089202026); implying cross-validity of the regression model is low; the model may not accurately predict the same dependent variable from the given independent variable in a different group of participants (Field, 2009, p. 221). We computed the R^2 significance using an F-ratio to cross-validate the F-value (1.7628898) in Table 15. The ideal F-ratio formula adapted and used in measuring the R^2 significance is:

$$F = \frac{(N - k - 1)\ R^2}{k\ (1 - R^2)}$$

Where:

R^2 = Unadjusted value
N = Number of cases or participants in the study
k = Number of independent variables in the regression model

Value for the F-ratio was determined as follows:

$$F = \frac{(20 - 1 - 1)\ 0.089202026}{1\ (1 - 0.089202026)}$$

$$= \frac{1.605636468}{0.910797974}$$

= **1.7628898**

Results from the computations revealed the change in the amount of variance that can be explained gives rise to an F-ratio of 1.7628898, which is equivalent to the F-value (1.7628898) in Table 15. This F-ratio is non-significant ($p = 0.201$, $p > 0.05$) as shown in Tables 15 and 16.

ANOVA

In order to determine whether or not the regression analysis provides better and significant prediction on the outcome than the mean, the ANOVA was applied. Data in Table 15 show degree of freedom (between) of 1 (2 - 1 = 1); degrees of freedom (within) of 18 (20 - 2 = 18); total degrees of freedom (df) of 19 (20 - 1 = 19); and an F-value of 1.7628898.

Table 15: ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	*1*	*12.05101874*	*12.0510187*	*1.7628898*	*0.200857659*
Residual	*18*	*123.0470205*	*6.83594558*		
Total	*19*	*135.0980392*			

The model sum of squares (SSM) value, represented by *Regression*; the residual sum of squares (SSR) value, represented by *Residual*; the total sum of squares (SST) value, represented by *Total*; and the degrees of freedom (df) for each group of squares are outlined in Table 15. The degree of freedom for the SSM is 1, which comprises the one independent variable (Ghana's manufacturing value). The mean squares (MS) value in Table 15 equals the sum of squares divided by the degrees of freedom. That is, 12.05101874 ÷ 1 = 12.0510187; while 123.0470205 ÷ 18 = 6.83594558.

Model Parameters

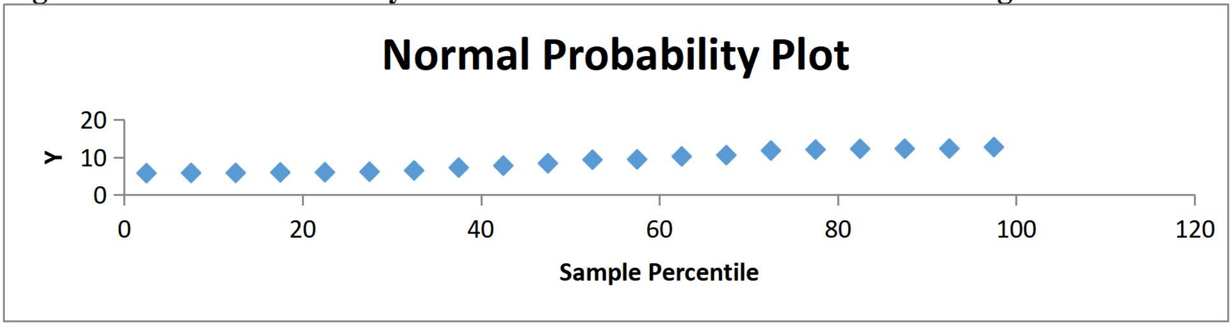
Table 16 presents results on parameters of the regression model. Data in the table show the test statistic, significance, coefficients, standard error; and confidence intervals for the coefficients. The coefficients in Table 16 indicate contribution of the independent variable (Ghana's manufacturing value) to the regression model. Generally, a positive coefficient suggests a positive relationship between the independent variable and the dependent variable; a negative value is indicative of a negative relationship between the two variables.

Table 16: Model Parameters

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	10.59562055	1.392765572	7.60761234	4.9782E-07	7.669528666	13.52171243
X Variable 1	-3.394585286	2.556666859	-1.3277386	0.20085766	-8.765943032	1.976772459

Statistical results in Table 16 depict a negative coefficient value (-3.394585286). This means there is a negative relationship between Ghana's manufacturing value and the world's total manufacturing values. The results suggest Ghana's manufacturing value has no positive and significant influence on the world's total manufacturing values. A standard error is identified with the coefficients in the table. The standard error shows the extent to which the coefficients would vary in different research samples (Field, 2009). The respective upper 95% confidence interval values for the *Intercept* and *X Variable 1* in Table 16 are 13.5217124308647 and 1.97677245945489.

Figure 8: Normal Probability Plot for Ghana and World's Manufacturing Data

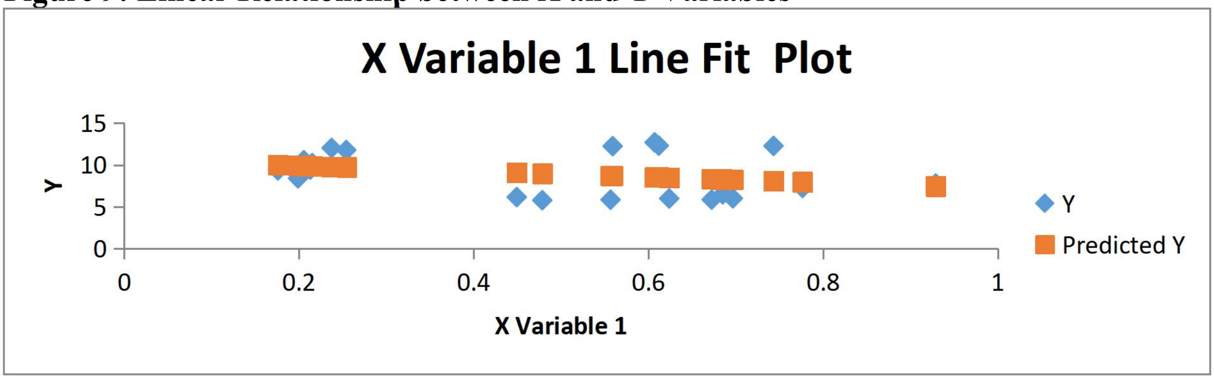


A normal probability plot on the relationship between Ghana and world's manufacturing values is presented in Figure 8. Data in the figure depict a steady rise in comparative values over the twenty-year period. Specifically, we observe marginal increase in percentile values during the preceding ten-year period. That is, from the 2.5th percentile through the 22.5th percentile to the 47.5th percentile; and sharp increase in comparative values during the eleventh-year through the twentieth-year, that is, from the 52.5th percentile through the 77.5th percentile to the 97.5th percentile.

Test of Assumptions

Consistent with hypotheses one and two, statistical tests were conducted to determine linearity of the relationship between the independent variable (Ghana's manufacturing value) and the dependent variable (world's total manufacturing values); and to measure the variance in residual values. The statistical outputs are presented in Figure 9 and Table 17. The scatter plots in Figure 9 are on a straight line. This affirms relationship between the independent variable and dependent variable is linear; it implies the model fits the analysis.

Figure 9: Linear Relationship between X and Y Variables



The *residual* values in Table 17 allow us to test the *homoscedasticity* of the model. That is, to test whether or not the residual values at each level of the independent variable depict constant variance. Residuals in Table 17 show constant variance values. This implies the assumption of homoscedasticity is met. Data in Figure 9 indicate relationship between the X and Y variables were measured at the interval level and beyond; while variability of the dependent variable (world's total manufacturing values) was not constrained. The foregoing analysis indicates most of the assumptions have been met. This renders the regression model fit and appropriate for the research.

Table 17: Predicted Y Values and Residual Values for Variable X

Predicted Y	*Residuals*	*Standard Residuals*
8.51866858	3.79433142	1.490996114
8.697870948	3.550129052	1.39503592
8.534707345	4.164292655	1.636373706
8.072788159	4.203211841	1.651667139
9.789734244	2.244265756	0.881892263
9.732837142	2.048162858	0.804832927
9.897851184	0.659148816	0.259014887
9.998430373	-0.655430373	-0.257553711
9.865071044	0.355928956	0.139863558
9.873127753	-0.437127753	-0.171770915
9.920228341	-1.527228341	-0.600129844
7.442510395	0.322489605	0.126723445
7.960033586	-0.715033586	-0.280975007
8.270165146	-1.792165146	-0.70423771
8.706022335	-2.876022335	-1.130143272
8.971309356	-3.203309356	-1.258751879
9.070393322	-2.927393322	-1.150329685
8.230870438	-2.233870438	-0.877807385
8.313231782	-2.471231782	-0.971079375
8.478148525	-2.503148525	-0.983621174

Report on P -Value and Confidence Interval

Statistical values in Table 15 depict *P* value of 0.20085766 and negative coefficient value of -3.394585286. These values are not significant at Alpha level $\alpha = 0.05$. The table further shows a confidence interval of -8.7659430323792 and 1.97677245945489. The Alpha level, a priori, for this study is $\alpha = 0.05$. The inference is there is 5 per cent probability that we would be wrong; and there is 5 per cent likelihood the population mean would not fall within the interval (Ashley et al.; Bowerman & O'Connell, 1990; Frankfort-Nachmias and Nachmias, 2008). However, we are 95% certain our conclusions would be right. Again, the Microsoft Excel output in Table 15 shows degree of freedom (between) of 1 (2 - 1 = 1); degrees of freedom (within) of 18 (20 - 2 = 18); total degrees of freedom (df) of 19 (20 - 1 = 19); and an F-ratio of 1.7628898. These values could be interpreted as:

$$F\ (1,\ 18) = 1.7628898,\ p > 0.05,\ \text{two-tailed.}$$

Interpretation and Rejection of Alternative Hypothesis

The analytical outcomes indicate Ghana's total manufacturing value has no positive and significant influence on the world's total manufacturing values. Therefore, we reject the alternative hypothesis (H_1: $\mu_1 \neq \mu_2$); and accept the null hypothesis (H_o: $\mu_1 = \mu_2$) which states, Ghana's total manufacturing value has no strong impact on the world's total manufacturing values.

Conclusion

Results from the statistical analysis of hypothesis one affirmed the existence of positive, but non-significant relationship between the manufacturing sub-sector and industrial sector of the

Ghanaian economy. Similarly, analytical outcomes from test of hypothesis two indicated positive, but non-significant relationship between the manufacturing sub-sector and Ghana's GDP. The foregoing notwithstanding, annual figures released by key stakeholders for the manufacturing sub-sector are not only impressive, but also appear significant to both the industrial sector and national GDP. Given the size of Ghana's economy (GDP of about US$67.34 billion during 2020) comparative to the global economy (GDP of about US$84.97 trillion during 2020) (World Bank, 2021), it was not surprising to observe non-positive and non-significant effect of Ghana's annual manufacturing values on the world's annual manufacturing values; as affirmed by the test of hypothesis three.

The statistical analysis revealed, annual data presented for manufacturing activities within the Ghanaian economy are not true reflection of the sub-sector's performance. Stated in different terms, the data are not representative of actual performance of the manufacturing sub-sector and its related activities. Further, the statistical outcomes revealed weaknesses inherent in national supervision and regulatory measures pertaining to the manufacturing sub-sector. To address this pertinent impasse, it is incumbent on elected governments through the sector-ministry to ensure key stakeholders in the formal manufacturing sub-sector are discouraged from publishing reports that are not representative of the sub-sector's actual performance. Recommended measures for strategic transformation of the manufacturing sub-sector were outlined in earlier series of this publication.

Author's Note

The above write-up was extracted from an earlier publication on "Role of Agribusiness in the Development of Robust Manufacturing Sub-Sector" by Ashley and Gyekye (2021) in the *International Journal of Business and Management*.

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