The Nexus between Solid Mineral Development and Economic Growth in Nigeria

Nwogwugwu, Uche Collins[1]; Nwokoye, Ebele Stella[2]; and Ebenebe, Onyeka Ernest[3]

[1,2,3]Nnamdi Azikiwe University, Awka

Abstract: *As the need to achieve sustainable and high economic growth has continued to gain currency in Nigeria, researchers and policymaker are constantly advocating for diversification of Nigerian economy. Monocultural economies are said to be highly vulnerable to macroeconomic shocks and the only viable remedy is having an economy being supported by economic activities from broad-based sectors. It is against this backdrop, that we investigated the role of solid mineral sector in driving economic growth in Nigeria. Using time series from 1980 to 2020, we estimated a CCR (canonical cointegrating regression) model of solid mineral – economic growth nexus in Nigeria. The results obtained from CCR estimation show that solid mineral production exerts a significant positive effect on economic growth. Increase in solid mineral production translates into increase in investment in intermediate and capital goods which in turn raises the aggregate demand. If this incremental change persists and more than off sets upward prices, it will translate to economic growth. The result also shows that solid mineral export is critical for economic growth. On the other hand, the result shows that solid mineral depletion could retard economic growth. This effect could be transmitted through confidence channel. As the depletion rate increases, the business confidence of economic agents on further economic outlooks may be dampened thereby leading to decline in current economic activities. The study therefore recommended that government should increase funding and support for research and technological development that will on one hand optimize the production of solid mineral and the other hand, engender development of renewal resources.*

I. INTRODUCTION

Economists and policy makers are also interested in understanding the impacts of economic activities and realities on economic growth. In Nigeria, the events of recent past, especially; the economic recession orchestrated by oil price shock has renewed interest in search of alternative economic sectors that could sufficiently drive the growth process in Nigeria. One of such sectors that could be a veritable growth driver is the solid mineral sector (Ajie, Okoh & Ojiya, 2019; Edeme, Onoja & Damulak, 2018). Nigeria is blessed with a huge endowment of solid minerals widely distributed across the different parts of the country. According to Steyn (2009), the geology of Nigeria is comparable to the geology of some other African countries where world class minerals deposits have been found and many geoscientists believe that major deposits are yet to be discovered in Nigeria. Presently there are deposit of tin, limestone, coal, columbite, iron, pottery clays, gild, lead, zinc, oil gas Marbles etc in various parts of the country. Mining of minerals resources in Nigeria is, however, dated far back beyond the amalgamation of Nigeria in 1914.

However, the contribution of solid mineral to GDP in Nigeria has not been impressive. Solid mineral output according to CBN (2018) fell from ₦67.14 billion in 1981 to ₦29.09 billion in 1990. It further fell to ₦21.31 billion in 2000. However, it has risen since 2003: from ₦23.20 billion in 2003 to ₦51.88 billion and ₦96.60 billion in 2010 and 2018 respectively. However, when viewed in terms of percentage contribution, CBN (2018) reports that the contribution solid mineral to GDP has been declining over time. It declined from 0.44% in 1981 to 0.15%, 0.089% and 0.093% in 1990, 2000 and 2010 respectively. Although percentage contribution rose slightly in subsequent years (eg 0.103% in 2011 and 0.138% in 2018), it is still far below the level recorded in the 1980s.In the same vein, economic growth exhibits profound features. The economy rose from recession in the early 1980s to high growth of as much as 6.4% (in 1989) in late 1980s. It however, slowed done to average of 2.6% between 1990 and 1999. The growth rate of the economy rose to average of 7.9% between 2000 and 2014 with highest value of 33% recorded in 2004. Since 2015, economic growth has remained low: fell from 6.3% in 2014 to 2.65% and -1.62% in 2015 and 2016 respectively. Although the 2016 recession was adjudged to have ended in 2017 with growth rate of 0.81%, the growth rate improved slowly as 2018 recorded 1.92% growth.

Moreso, Nigerian growth rate has been relatively low. According to WDI (2018), economic growth in sub-Saharan Africa was 2.30% and 3.01% in 2017 and 2018 respectively. In the same period, economic growth was 0.83% and 1.92% in Nigeria. The report also noted that the average growth rate of low-income countries between 1980 and 2018 was 3.9% against 2.32% recorded in Nigeria. The problem is that low economic growth is not desirable, especially for a developing economy. Thus, economists and policy makers are constantly worried about growth drivers: understanding growth drivers could tantamount to getting an economy into the desired growth trajectory. One of the identified growth drivers in economic literature is solid mineral development. Although there is no consensus on the nexus between solid mineral development and economic growth, the growing need to diversify the Nigerian economy has reengineered a reassessment of the role of solid mineral in economic growth in Nigeria.

Following the global economic recession of the 1980s and early 1990s and the fluctuations of the global oil prices in recent time, the Federal Government of Nigeria made several attempts to diversify the nation's economic base from oil to the non-oil sectors. This led to the creation of the Ministry of Solid Minerals Development in 1995 (Iduh, 2012; Ayodele et al., 2013). Efforts had earlier been made by various government dispensation towards the development of the solid mineral sector which include the enactment of Minerals and Mining Act of 2007 and the Minerals and Mining Regulations of 2011, the establishment of the Presidential Retreat on Solid Minerals in August 2013 and National Council for Mining and Mineral Resources Development (NCMMRD) in 2017(Omoh, 2015; Foramfera, 2016; Olofin & Odeleye, 2017). The policies and programs of government notwithstanding, available evidence indicates that share of solid mineral output to national output has not been impressive.

Although there is handful of studies on the role of solid mineral on economic growth, there is hardly any study, at least, in Nigeria on the role of solid mineral export and solid mineral depletion on economic growth. In this study, we decomposed solid mineral development into solid mineral production, solid mineral export and solid mineral depletion. Many studies on solid mineral and economic growth used contribution of solid mineral sector to GDP as a measure of solid mineral development and GDP as a measure of economic growth (see Ayodele et al, 2013; Edeme et al, 2018; Ajie, 2019). However, there are some econometric concerns that are raised by the procedure of such empirical methods. First, GDP is a measure of the size of the economy rather than a measure of economic growth (Grossman & Helpman, 2016). Second, solid mineral GDP is a measure of aggregate GDP and inclusion of both series in an econometric estimation may undermine critical classical regression robustness assumptions such as multi-collinearity and linear independency assumptions. In line with Grossman and Helpman (2016), we utilized annualized percentage changes in real output as measure of economic growth. Also, as proposed by Chambers and Guo (2013), we utilized solid mineral net output as a measure of solid mineral production. Chambers and Guo (2013) argue that gross production as indicated by solid mineral GDP does not account for the offsetting effect of high government spending in the development of solid mineral sector. Thus, they advocate that the spending and rent associated with solid mineral production should be netted off the total production to ascertain the actual or true output of mineral resources.

II. REVIEW OF RELATED LITERATURE

The impact of natural resources on economic growth has become topical among economists and policymakers, especially those dealing with the resource economy. Adesoji and Sotubo (2013) focused on the effect of non-oil exports (solid mineral and agriculture) on economic growth over the period 1981 to 2010. Applying the OLS, the findings conclude that non-oil exports have negatively impacted economic growth in Nigeria. Ayodele, Akongwale and Udefuna (2013) in their analysis on the role of solid minerals on economic diversification in Nigeria using descriptive analysis, shows that the solid mineral sector in Nigeria has the potential to contribute immensely to the economy of Nigeria. Specifically, it reveals that the development of the solid mineral sector could help to combat poverty in Nigeria via job creation; especially, given its forward linkage with other sectors of the economy. Most importantly, it could help alleviate some of the problems associated with "enclave" nature of the Nigerian economy that has for too long being vulnerable to fluctuations in global oil prices. Maduaka (2014) analyzed the impact of solid minerals on economic growth in Nigeria from 1970 to 2012. Utilizing VAR, the study reported that solid minerals are positively related to Nigeria's economic growth. Udoka and Duke (2017) investigated the impact of three sectors (solid mineral, tourism and agriculture) on Nigeria economic growth. The study utilized time series data from 1981 to 2014. Utilizing OLS, the study found that solid mineral have a positive significant impact on the Nigeria's economic growth. In a related study, Damulak (2018) Linear Growth Regression model on a time series data spanning from 1960 to 2015 and found that solid minerals has a positive and significant impact on economic growth. Edeme, Onoja and Damulak (2018) examined the role of solid mineral in economic growth of Nigeria during the period 1960 to 2015. Using time series such as GDP per capita as proxy for economic growth which is the dependent variable, the study employed OLS technique. The explanatory variables include solid minerals output, foreign trade balance, domestic interest rate, inflation, and gross domestic savings. The linear growth regression model estimated with OLS indicates that solid minerals positively impact on sustainable growth and is statistically significant. The study also found that solid mineral is highly significant but negatively related with foreign exchange due largely to illegal migration of mineral commodities across the borders of the country.

Ajie, Okoh and Ojiya (2019) empirically tried to expose the potentiality in solid mineral resources as viable alternative to the petroleum sector. Using various econometric tools, such as augmented Dicker-Fuller test of unit root, Johansen cointegration test and ordinary least technique, they evaluated the impact of solid mineral on economic growth in Nigeria. Gross domestic product (GDP) was used as a proxy for economic growth while contribution of solid mineral sector to GDP was used as a proxy for solid mineral sector. Major findings from the OLS output showed that, a billion naira increase in solid minerals development e.g. quarrying, bauxite, metal ores, iron ore, coal etc will contribute 0.26 billion naira to the GDP of Nigeria. Mbah, Mgbemena and Mbah (2019) employed VAR to assess the linkages between investment, solid minerals and economic growth in Nigeria over the period 1981 to 2016. The study established that domestic investment does not significantly drive solid mineral development in Nigeria while foreign direct investment is positively related to solid mineral development; it has not significantly driven solid mineral development within the period under study. On the other hand, foreign portfolio investment exerts a negative impact on solid mineral development in Nigeria. Finally, the authors reported that solid mineral is a key growth driver in Nigeria.

Salifu, Oladejo and Adetunde (2013) focused on the relationship between gold production and economic growth in Ghana. The main variables the study utilized are real gross domestic product, labour, capital and gold production. Using OLS, the study found that gold production significantly influence Ghana's economic growth. Dejene (2015) investigated the contribution of exports of some mineral resources to Ethiopia's economy. The study used annual data of Ethiopia, and the variables included in their analysis were gross domestic product (GDP), export of gold, tantalum and opal (X) and exchange rate. The Granger causality test had indicated that in the short-run there was no causality among variables, but in the long-run, there was bi-directional causality among the five variables, namely, GDP, export of opal, export of tantalum, export of gold and exchange rate. The study concludes that export of major minerals had positively and significantly affected economic growth in Ethiopia, and this growth had stimulated the export of minerals in the long-run. Zayone, Henneberry and Radmehr (2020) investigated the effects of Angola's agricultural, manufacturing, and mineral exports on the country's economic growth using data from 1980 to 2017. An Autoregressive Distributed Lag (ARDL) model is employed to estimate the effect of sectoral exports on economic growth. The estimation results showed that while exports from all three sectors (manufacturing, mineral, and non-mineral) have driven Angola's economic growth in the long-run; only non-manufacturing (agricultural and mineral) exports have led its growth in the short-run. Moreover, growth in non-export GDP was driven by mineral exports in the long-run and agricultural exports in the short-run. Overall, this study extends the frontier of knowledge by investigation the impact of solid mineral export on economic growth. Furthermore, the scope of existing studies does not include the impact of the rate of solid mineral depletion on economic growth. Thus, another novelty exhibited by this study is the investigation of the impact of the rate of solid mineral depletion on economic growth. In all respects, it is clear that this study is not only pertinent but also expedient.

III. EMPIRICAL STRATEGY

3.1 Theoretical Framework

The theoretical framework is anchored on neoclassical growth theory as utilized by Chambers and Guo (2013) and Cavalcanti, et al (2018). Solow (1956) set out an aggregative, competitive general equilibrium perfect foresight growth model built around three equations: a constant returns to scale production function with smooth substitution and diminishing returns to capital and labor, an equation describing capital accumulation on the assumption of a constant rate of savings (investment) as a fraction of output, and a labor supply function in which labor grows at an exogenously given rate. The model economy has a single produced good ("output") whose production per unit time is Y(t). The available technology allows output to be produced from current inputs of labor, L(t), and the services of a stock of "capital" that consists of previously accumulated and partially depreciated quantities of the good itself. Suppose we assume that technological progress is "purely labour-augmenting" so that the extensive production function can be written in the form

$$Y(t) = F(K(t), A(t)L(t)). \qquad 3.1$$

Where the quantity A(t)L(t) referred to as "labour in efficiency units" is exponential function of time.

Chambers and Guo (2013) demonstrated that natural resources can be introduced into the neoclassical model. Let us consider the simple case of renewable resources. Sources of natural resources can be thought of as providing a technology for converting capital and labor (and a small amount of materials) into usable energy. Suppose $y(t)$ is now redefined as $Y(t)/A(t)L(t) = Y(t)/e^{gt}e^{nt} = Y(t)e^{(g+n)t}$ and R is the input of a renewable natural resource (assumed constant at a sustainable level), then,

$$Y = F(K, R, e^{(g+n)t}) \qquad 3.2$$

If a constant fraction of gross output is saved and invested, the full-utilization dynamics are

$$K' = sF(K, R, e^{(g+n)t}) - dK \qquad 3.3$$

Where R is remembered to be constant.

Suppose we take F to be Cobb-Douglas with elasticities a,b and 1-a-b for K, R and L respectively. optimization of equation … shows that the only possible exponential path for K and Y has been growing at the rate $h = (1-a-b)(g+n)/(1-a)$. If intensive variables are defined by $y = Ye^{-ht}$ and $k = Ke^{-ht}$, then the neoclassical model is stable in its steady state. In other words, natural resource exploration will engender economic progress. Similarly, the model also implies that output person in natural units is growing at the rate $h-n=[(1-a-b)g-bn]/(1-a)$

But, solid mineral resource is nonrenewable. In this case, $R \geq 0$ is the rate of depletion of a fixed initial stock S_0 given at t = 0. In this case, the stock remaining at any time t > 0 is

$$S(t)=\int_t^{\infty} R(u)du \qquad 3.4$$

Assuming eventual exhaustion at t > 0, then

$$R(t)=-S'(t) \qquad 3.5$$

This implies that although solid mineral development could drive economic growth, the depletion of the available stock could undermine economic growth process. However, the extent of the negative effect of resource depletion on economic growth will depend on rate of technological progress in the economy.

Recall that the basic neoclassical production function as shown in Equation 3.1 is expressed in terms of K and L. differentiating Equation 3.1 and dividing by Y will therefore yield:

$$\frac{\dot{Y}}{Y}=\frac{\partial f}{dK}\frac{\dot{K}}{Y}+\frac{\partial f}{\partial L}\frac{\dot{L}}{Y} \qquad 3.6$$

Since $w_K=\frac{\partial f}{dK}\frac{K}{Y}$ represents the relative share of capital and $w_L=\frac{\partial f}{\partial L}\frac{L}{Y}$ is the relative share of labour, then we can write the above equation as follows:

$$\frac{\dot{Y}}{Y}=w_K\frac{\dot{K}}{K}+w_L\frac{\dot{L}}{L} \qquad 3.7$$

In this model, it is assumed that factors are paid their marginal products, w_K and w_L.

The neoclassical model assumes that changes in the factors of production results from investment, capital accumulation and labour growth (Acemoglou, 2014). This implies that investments in the solid mineral sector measured as solid mineral produced or exported could engender substantial changes in the growth rate of the economy.

3.2. Model Specification

Following Acemoglou (2014), Helpman (2016) and Cavalcanti et al (2018), the model specification proceeds as follows. Suppose $\frac{\dot{Y}}{Y}=ECOG, A=TEC, \frac{\dot{K}}{K}=CAP, \frac{\dot{L}}{L}=LAB$. Combining equation 3.5 7 will yield:

$$ECOG_t=\Omega_1 TEC_t+\Omega_2 CAP_t+\Omega_3 LAB_t+\Omega_4 R_t \qquad 3.18$$

Where ECOG refers to economic growth, TEC refers to technological change, CAP refers to growth rate of capital, LAB refers to growth rate of labour, and R refers to solid mineral resource.

Helpman (2016) noted that changes in the production factor occur as a result of change in investment and population growth. Suppose we assume further that population growth is negligible and R consists of solid mineral production (SOMP), solid mineral export (SOME) and solid mineral depletion rate (SOMD). Suppose we further assume that the only sector of the economy is the solid mineral sector. Then, all investments in the economy could be approximated by solid mineral production (SOMP), solid mineral export (SOME) and solid mineral depletion rate (SOMD). Then, by the prediction of the neoclassical model, SOMP, SOME and SOMD could have substantial implication for ECOG. Thus, Equation 3.8 would yield:

$$ECOG_t=\Omega_1 TEC_t+\Omega_2 CAP_t+\Omega_3 LAB_t+\Omega_4 R_t+\Omega_5 SOMP_t+\Omega_6 SOME_t+\Omega_7 SOMD_t \qquad 3.9$$

We employed Fully Modified OLS (FMOLS) in estimating Equation 3.9. FMOLS is considered efficient in estimating a long-term cointegrated function. It produces consistent, unbiased and efficient estimates even when the data are multicollinear or serially correlated. This efficiency is achieved through asymptotical transformations that eliminate the endogeneity caused by the long run correlation of the cointegrating equation errors and the stochastic innovations. Thus, this study employed FMOLS. To estimate Equation 3.9, it is redefined in the context of FMOLS as follows:

$$\begin{aligned}ECOG_t&=\alpha_0+\alpha_1 t+\alpha_2 t^2+\Omega_1 TEC_t+\Omega_2 CAP_t+\Omega_3 LAB_t+\Omega_4 R_t+\Omega_5 SOMP_t\\&+\Omega_6 SOME_t+\Omega_7 SOMD_t+\Omega_8 OILR_t+\varepsilon_t\end{aligned} \qquad 3.10$$

Where α_0 and Ω_i are intercept and slope parameters to be estimated, ε is the identically independent stochastic error term. $\alpha_1 t, \alpha_2 t^2$ are linear and quadratic trend components of the model. $OILR$ refers to oil revenue which enters the model as a control variable. The inclusion of OILR is based on Nwokoye, Igbanugo, Mgbemena and Dimnwobi (2019) conclusion that oil revenue is a key variable in economic growth processes and cyclical conditions in Nigeria.

Definition and Measurement of variables

S/N	Variable	Definition and Measurement	Source
1	Solid Mineral Production (SOMP)	Refers to the production of all solid and inorganic naturally occurring substances derived from the earth's crust and are valuable to humanity. The proxy for solid mineral production in this study is the mineral rent. Mineral rents are the difference between the value of production for a stock of minerals at world prices and their total costs of production.	WDI (2020)
2	Economic Growth (ECOG)	This is proxied using the growth of the real GDP which is computed as $rgdpr = (\frac{rgdp_t - rgdp_{t-1}}{rgdp_{t-1}})*100$. It is the annualized percentage change in RGDP which is used as a proxy for economic growth.	WDI (2020)
3	Capital stock (CAP)	This is proxied using annual rate of change in gross fixed capital formation. Gross capital formation (GCF) refers to the net increase in physical assets (investment minus disposals) within one year.	WDI (2020)
4	Solid Mineral Export (SOME)	This refers to the export of solid mineral. It is measured as the share of solid mineral export in the total export. It is an explanatory variable and on apriori, it is expected that it is positively related with ECOG.	WDI (2020)
5	Solid Mineral Depletion Rate (SOMD)	This is the rate at which the solid mineral deposit depletes. Solid mineral depletion is the consumption of a solid mineral resource faster than it can be replenished.	WDI (2020)
	Oil Revenue (OILR)	This is the revenue obtained from the exploration and sale of crude oil, including production sharing profit and petroleum profit tax.	WDI (2020)
6	Technological Change (TEC)	TEC refers to the collection of techniques, skills, methods, and processes used in the production of goods or services. Economic complexity index is used to proxy TEC in this study. Economic complexity index is a measure of the relative knowledge intensity of an economy or a product (Morrison & Berndt, 2011).	WEO (2020)

Source: Compiled by the Researchers

IV. DISCUSSION OF RESULTS

4.1 Data Presentation

Although the raw data utilized in this study are not presented here, the underlying patterns in the data are x-rayed using descriptive statistics and correlational analysis.

Table 4.1: Summary of Descriptive Statistics

	TEC	OILR	SOMP	SOMD	SOME	LAB	GFCF	ECOG
Mean	-2.008299	2348.605	0.015271	0.011933	0.152664	55.27434	12.73689	3.410747
Median	-2.021340	977.6350	0.004732	0.003675	0.037003	55.10000	12.25764	3.614657
Maximum	-1.600880	8878.970	0.084822	0.063357	1.081501	56.89100	34.02084	33.73578
Minimum	-2.764250	7.250000	6.05E-05	0.000206	0.001289	54.09800	5.467015	-13.12788

Std. Dev.	0.256732	2711.057	0.022804	0.017456	0.224609	0.544913	5.897982	7.421099
Skewness	-0.626206	0.858719	0.003387	0.049967	0.292229	0.122923	0.814376	0.290468
Kurtosis	2.646401	2.438048	2.800162	2.987805	3.024194	2.426661	3.060364	3.176409
Jarque-Bera	3.145081	5.170186	3.507260	2.651450	0.737920	11.20871	46.95279	70.94800
Probability	0.207517	0.075389	0.200008	0.389003	2.076340	0.003682	0.000000	0.000000
Sum	-76.31538	89246.98	0.580314	0.453463	5.801234	2100.425	484.0018	129.6084
Sum Sq. Dev.	2.438714	2.72E+08	0.019241	0.011275	1.866623	10.98640	1287.089	2037.690
Observations	38	38	38	38	38	38	38	38

Source: Researchers' estimations using Eview 10

From the result shown on Table 4.1, the mean value of SOMP (SOMP is production output of solid mineral expressed as a percentage of the GDP) is 0.015% with median value of 0.0047%. The maximum value of 0.084 indicates that the highest annual production of solid mineral was 0.084%: this value was achieved in 2017. Similarly, solid mineral export (SOME), expressed as percentage of total export, records an annual average of 0.153% and a median value of 0.037%. The minimum value of the distribution is 0.0013% while the maximum value is 1.08%. In the same vein, the distribution for solid mineral depletion is 0.0119%, 0.0037%, 00634%, and 0.000206% for mean, median, maximum and minimum values respectively. Another important statistics reported on Table 4.1 is skewness. Skewness indicates the direction and relative magnitude of a distribution's deviation from the normal distribution. It is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. A distribution with an asymmetric tail extending out to the right is referred to as "positively skewed" or "skewed to the right", while a distribution with an asymmetric tail extending out to the left is referred to as "negatively skewed" or "skewed to the left". The range of skewness is from minus infinity (-∞) to positive infinity (+∞). Symmetrical distribution or fairly skewed (skewness between -0.5 and 0.5) and moderately skewed (skewness is between -1 and -0.5 or between 0.5 and 1) distribution may not raise a serious concern in statistical analysis. However, highly skewed distribution (skewness less than -1 or greater than 1) are said to pose serious constraint to statistical inference. With pronounced skewness, standard statistical inference procedures such as a confidence interval for a mean will be not only be incorrect, in the sense that the true coverage level will differ from the nominal (e.g., 95%) level, but they will also result in unequal error probabilities on each side (Kothari, 2004). The result obtained show that the skewness for SOMP, SOMD and SOME are 0.003387, 0.049967, 0.292229 respectively. This suggests that the data does not pose a serious challenge to statistical inference.

The summary of descriptive statistics also shows that the mean value of economic growth (ECOG) is 3.41% with median value 3.61%. The maximum growth rate of 33.73% was recorded in 2004 while the minimum ECOG of -13.128% was recorded in 1981. The standard deviation of 7.421 which is greater than mean growth indicates that there is high dispersion or vagaries in the growth pattern. In addition, skewness and kurtosis are 0.290468 and 3.176409 respectively. Other variables include TEC, OILR, LAB and CAP. The mean values are -2.008299, 2348.605, 55.27434 and 12.73689 respectively. The skewness and kurtosis also show that the distributions are free from any serious statistical limitations.

Table 4.2 also presents the results of correlational analysis. Correlation analysis is a statistical method used to evaluate the strength of relationship between two quantitative variables. A high correlation means that two or more variables have a strong relationship with each other, while a weak correlation means that the variables are hardly related. In terms of the strength of relationship, the value of the correlation coefficient varies between +1 and -1. A value of ± 1 indicates a perfect degree of association between the two variables. As the correlation coefficient value goes towards 0, the relationship between the two variables will be weaker. The direction of the relationship is indicated by the sign of the coefficient; a + sign indicates a positive relationship and a – sign indicates a negative relationship (Kothari, 2004; Stephens, 2015). Woodridge (2001) also notes that correlational analysis has practical relevance in econometrics. It is an indicator of dependence between variables. He predicted that variables that are linearly dependent will have correlational coefficient in excess of 0.70. While this kind of linear dependence is expected between dependent and independent variables, it could indicate presence of multicollinearity among explanatory variables. In other words, correlational coefficient greater than 0.70 between two explanatory variables is a prima facie evidence of existence of multicollinearity.

Table 4.2: Summary of Correlation Coefficient

	TEC	OILR	SOMP	SOMD	SOME	LAB	CAP
OILR	0.104824 (0.632428) [0.5311]						

SOMP	0.445791 (2.988083) [0.0050]	-0.008406 (-0.050437) [0.9601]					
SOMD	0.434003 (2.890429) [0.0065]	-0.149193 (-0.905293) [0.3713]	-0.045030 (-0.270457) [0.7884]				
SOME	0.279235 (1.744814) [0.0895]	-0.241057 (-1.490287) [0.1449]	0.308351 (1.944875) [0.0596]	0.497939 (3.445097) [0.0015]			
LAB	0.099943 (0.602678) [0.5505]	-0.308689 (-1.947228) [0.0593]	-0.102151 (-0.616128) [0.5417]	-0.144791 (-0.877998) [0.3858]	-0.086393 (-0.520306) [0.6060]		
CAP	0.273544 (1.706345) [0.0966]	-0.041052 (-0.246519) [0.8067]	0.239174 (1.477935) [0.1481]	0.192238 (1.175349) [0.2476]	0.295394 (1.855150) [0.0718]	0.204698 (1.254760) [0.2177]	
ECOG	0.652637 (5.168238) [0.0000]	0.540388 (3.853418) [0.0005]	0.783321 (12.43863) [0.0000]	-0.583449 (-4.310406) [0.0001]	0.607481 (3.651640) [0.7171]	0.574057 (4.206491) [0.0002]	0.745604 (3.074579) [0.0040]

(…) and […] indicate t-statistics and probabilities respectively
Source: Researchers' estimations using E View 10

The result presented indicates that there are no correlational coefficients between two explanatory variables that is greater than 70%. In fact, the highest coefficient between two explanatory variables is 0.49 which is the coefficient of the correlation between SOME and SOMD. However, the coefficients of correlation between the dependent variables (ECOG) and the explanatory variables indicate that there is linear reationships (whether negative or positive) between ECOG and the explanatory variables (SOME, SOMD, SOMP, TEC, CAP, OILR and LAB).

Analysis of Results on Impact of Solid Mineral Development on Economic Growth

The model of the impact of solid mineral was estimated using canonical cointegrating regression (CCR) framework after testing for unit root and cointegration. The CCR was estimated with Bartlett kernel and Newey-West fixed bandwidth of 4.0. The $R^2$of the estimated model is 0.88. R^2 of 0.88 indicates that 88% of changes in ECOG are explained by the independent variables of the model.

Table 4.5: Summary of Longrun estimates of the impact of solid mineral development on economic growth

Dependent Variable	Economic growth (ECOG)			
Variable	Symbols	Coefficient	Std. Error	t-Statistic
Technology	TEC	0.274197	0.044933	6.102399
Capital	CAP	-0.309894	0.094928	-3.264501
Labour	LAB	0.325891	0.059562	5.471480
Solid mineral depletion	SOMD	-0.006501	0.001862	-3.491863
Solid mineral export	SOME	0.223376	0.090433	2.470075
Solid mineral production	SOMP	0.423566	0.056645	7.477589
Oil revenue	OILR	0.001202	0.000646	1.859312
Intercept	C	-0.431840	1.620054	-0.266559
	@TREND	1.546606	0.859222	1.800007
	@TREND^2	-0.032577	0.013397	-2.431621
R-squared	0.878328			
Adjusted R-squared	0.810524			
Obs	38			

Source: Researchers' estimations using Eview 10

The result presented on Table 4.5 shows that TEC, CAP, LAB, SOME, SOMP, OIL could exert positive impact on ECO while SOMD could exert negative impact on ECOG. The coefficient of TEC is 0.274. This suggests that increasing TEC by one unit will lead to 0.274 unit increase in ECOG. Similarly, the coefficients of LAB and CAP are 0.326 and 0.3099 respectively. This indicates that one unit decline in LAB and CAP could lead to 0.326 unit and 0.3099 unit decline in ECOG respectively. In the same manner, OILR entered the model with a coefficient of 0.0012. This indicates that raising oil revenue by one unit could raise ECOG by 0.0012 units.

The indicators of solid mineral development, namely, SOMD, SOME and SOMP entered the model with the prescribed signs. The coefficient of SOMD is -0.0065 indicating that increasing SOMD by one unit could lead to decline in ECOG by -0.0065 unit. However, the coefficients for SOME and SOMP are 0.2234 and 0.4236 respectively. This shows that raising SOME and SOMP by one unit could raise ECOG by 0.2234 units and 0.4236 units respectively. Generally, the findings indicate that solid mineral development is a critical driver of economic growth. This finding corroborates Edeme et al (2018). In essence, this is even more important for the Nigerian economy that is believed to be one of the mostly endowed economies in Africa. Solid minerals resources, no doubt, play an important role in boosting economic development of a country. The solid minerals can provide gainful employment. They are also capable of raising national income and foreign exchange earnings. In addition, they can provide funds for investment in other sectors of the economy and most importantly, provide locally, raw materials for the building and construction industries while widening the productive base of the national economy and bringing infrastructural facilities to otherwise rural areas. A lot of opportunities exist in solid mineral development for both the domestic and export markets.

Specifically, solid mineral production was found to exert significant positive effect on economic growth. Solid mineral production could drive economic growth through various channels. First, as production of solid mineral increases, the contribution of the sector to gross domestic product increases. Put differently, the aggregate demand increases through increase in investment demand in the solid mineral sector. Investment demand especially in intermediate input and machineries raises the productive capacity of the sector in particular and the economy in general by increasing the stock of capital. Standard growth models show that investment demand in any sector of the economy can increase the growth rateof output permanently (Lucas, 1988; Scott, 2016). For example, R&D by a firm in the solid mineral sector produces knowledge that can be used simultaneously by more than one firm (it is said to be non-rivalrous). Thus, an increase in the level of R&D would lead to a rise in the flow of knowledge and the rate of growth of technical change. Moreover, to the extent that new production possibilities are embodied in new capital, investment makes further R&D possible. If these effects are large enough, an increase in net investment of the solid mineral sector could be sustained indefinitely because the marginal product of capital would not diminish with capital deepening. Overall, economic growth would be raised with sustained increase in solid mineral production.

Second, increase in solid mineral production could lead to economic growth through labour absorption. As the sectoral activities expand, more labour is absorbed. This not only reduces unemployment but also increases the demand capacity of the private households through increased earning. A large proportion of the earnings by the new hires (depending on the marginal propensity to consume) would be used to finance private consumption spending which in turn raises the aggregate demand. As aggregate demand rises, economic growth also increases. Similarly, the findings indicate that solid mineral export has significant positive impact on economic growth. Solid mineral export can impact economic growth through foreign exchange, reduction in external vulnerability, employment generation and revenue generation. For example, increase in solid mineral exports may loosen a foreign exchange constraint which makes it easier to import inputs to meet domestic demand and so allow for output expansion. The foreign exchange made available by export growth allows the importation of capital goods, which, in turn, increase the production potential of an economy (Ramos, 2015). From the foregoing discussion, it is obvious that promotion of a country's export provides a foreign exchange cover necessary to fund critical raw materials, packaging materials, component materials and parts, intermediate products, and installations, required to produce exportable products.

In addition, solid mineral exports provide revenue to Nigerian government. The contribution of exports to Nigerian revenue stream has been attested to by different authors and sources. According to United Nations Industrial Development Organization (UNIDO) (2002) since the 1970s, the largest sources of revenue to developing economies has come through mining activity which became dominant in terms of government revenue and export earnings. As government revenue increase, it is expected that government spending, which is a component of aggregate demand, will also increase thereby generating growth gains. Solid mineral exports can also drive economic growth through the creation of new jobs and expansion of the existing ones in export-related industries. More importantly, solid mineral export engenders the kind of export diversification that could reduce vulnerability to shock. Note that, as observed by Hausman and Fernandis (2017), dependence on a single export commodity increases a countries vulnerability to external shocks. However, as the economy diversifies away from crude oil and to solid mineral, a buffer effect is created.

Although solid mineral production and export is expected to drive economic growth, the findings indicate that increase in solid mineral depletion rate is expected to slow down the growth potentials of the economy. As solid mineral resources are depleted, the quantity available in subsequent period reduces. In other words, in the long run, depletion can engender declining effect on growth. Similarly, the resource curse hypothesis opines that Natural resource abundance lends itself easily to rent seeking and corruption by governments and elites (Wick and Bulte, 2006), which have significant knock-on effects throughout the economy, impeding growth and development. Also, analysis by Sachs and Warner (2017) has shown that natural resources may crowd out manufacturing, which is vital to economic growth. As the revenue from natural resources tends to accrue to small elites who are already among the wealthiest class, the incentive to productively invest these monies is low. Instead, the revenues are more likely to be spent on high consumption lifestyles, which in turn may put upward pressure on the prices of goods and services, including labour, thereby depressing the competitiveness of existing manufacturers in export markets by raising the costs of their inputs.

V. CONCLUSION AND RECOMMENDATION

The main through of this study was to evaluate the impact of solid mineral development on economic growth in Nigeria. The study employed CCR technique estimated with time series spanning from 1981 to 2018. From the results obtained, we conclude as follows:

- Solid mineral production is a veritable source of economic growth
- Solid mineral export exerts significant positive effect on economic growth
- Solid mineral depletion is a growth retarding factor.

Contingent of the findings of this study, we recommend as follows:

Research Funding: Although, solid mineral development was found to drive growth, the impact is still very low. This suggests that government needs to invest in researches focusing of the development of the solid mineral sector. The federal government has an appropriate, clear, and necessary role to play in funding research and development on mining technologies. The government should have a particularly strong interest in what is sometimes referred to as high-risk, “far-out,” “off-the-path,” or “blue-sky” research. A portion of the federal funding for basic research and long-term development should be devoted to achieving revolutionary advances with potential to provide substantial benefits to both the mining industry and the public.

Fundamental Technology Development: In other to enhance the implementation of research findings in the development of the solid mineral sector, there is need to set up fundamental technology departments that will be tasked with developing prototypes; using research findings to develop practical applications, etc. Because it may be difficult for a single federal agency to coordinate the transfer of research results and technology to the mining sector, a coordinating body or bodies should be established to facilitate transfer of appropriate federally funded technology to the mining sector.

Private sector funding policy: A private sector funding policy initiative needs to be worked on immediately. This should be targeted at encouraging commercial banks and other private sector fund providers invest in the mining sector while being deliberate in managing their risks especially from exploration. Necessary incentives should be made available for commercial banks to embed this within their corporate strategy and achieve set levels of implementation.

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