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The Effect of Natural Resources on Economic Growth in West Africa: The Mediating Role of Human Capital Disaggregation

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Abstract: The purpose of this paper is to examine the conditional impacts of natural resources on economic growth through human capital development. This study employs Dynamic Ordinary Least Squares (DOLS) and Vector Error Correction Model (VECM) methodologies in a panel dynamic analysis. The research demonstrates that natural resources and trade openness are the key contributors to lower economic growth. On the other hand, labour force, physical capital, and human capital development measures are effective in boosting growth. Furthermore, the estimates are much higher in the model of tertiary school enrolment (TSE) than in the model of secondary school enrolment (SSE). This means that TSE performs better than SSE in terms of augmenting natural resources to improve growth. From a policy aspect, governments in such nations should devise policies that will improve human capital. The emphasis must be on improving tertiary education quality.

Keywords: *Economic growth, Resource curse, Secondary education enrolment, Tertiary education enrolment, Natural resource endowments, Panel dynamic analysis.*
JEL Classification: *Q00; F43; Q32; E24; C10*

1. Introduction

Ever since the ground-breaking works of Karl (1997); Sachs and Warner (1997) and Auty (1993) on the natural-resource curse, geography has always played a critical part in stimulating debates concerning economic growth. These authors observe that there was low economic growth in countries with an abundance of natural resources relative to countries with little or no natural resources.

Ever since, the literature has continuously investigated the reasons that explain such a phenomenon. Therefore, a range of factors relating to economics, politics, and institutions have been assembled to clarify this perception (Di John, 2011; Robinson, Torvik, & Verdier, 2006). Lederman and Maloney (2007) and Gylfason (2001) are the first sets of research papers that demonstrate that natural resources help countries whose human capital levels are high. A second set of authors think that the influence of natural resources on economic growth depends on institutional quality (Mehlum, Moene, & Torvik, 2006; Sala-i-Martin & Subramanian, 2008). Nevertheless, a third group thinks that neither human capital nor institutions have a particular responsibility for the resource curse (Arezki & Van Der Ploeg, 2007; Sachs & Warner, 1997). Moreover, there is no agreement on the influence of natural resource abundance on economic growth and the method that causes the influence. Actually, considering 43 meta-analyses, Havranek, Horvath, and Zeynalov (2016) establish that around 40% of empirical papers discover a negative effect, 40% find no influence, and 20% detect a positive outcome. Our present study indicates that natural resources (NR) impact growth negatively in both models (the model with secondary school enrolment (SSE) as human capital development and the model with tertiary school enrolment (TSE) as human capital development). Our results also demonstrate that when natural resources interact with human capital (SSE and TSE),

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these interacting variables (interaction of natural resources with secondary school enrolment and interaction of natural resources with tertiary school enrolment) improve economic growth, unlike when natural resources affect growth negatively when they stand alone. Our current study also reveals that the interaction term between tertiary school enrolment and natural resources yields more robust results than the interaction term between secondary school enrolment and natural resources. This could be attributed to the idea that education at the tertiary level is more significant for innovation and technology diffusion (Aghion & Howitt, 1998). As buttressed by Wilson and Vellinga (2022), innovation has the capacity to counterbalance the negative effect of the resource curse on economic growth. Also, as stated by Pradhan, Arvin, Nair, and Bennett (2020), empirical evidence demonstrates that research and development (R&D) as well as various new innovations provide new goods, services, procedures, product enhancements, and innovative business strategies that promote economic growth. Notwithstanding this, policymakers and proponents of economic growth in West Africa have limited awareness and knowledge of which type of human capital development indicator contributes the most to augmenting natural resources in order to improve economic growth and prosperity.

In view of the aforementioned, the research asks the following questions for policy: First, do natural resources affect economic growth positively or negatively in West Africa? Second, what are the impacts of natural resources on economic growth? Third, what are the contributions of human capital development by source to making natural resources a blessing rather than a burden to economic growth and, by extension, economic development? To address these concerns, the paper explores whether natural resources have a positive or negative impact on economic growth. It also estimates the direct effect of human capital development by source on economic growth. Lastly, the research attempts to find whether human capital development by source makes natural resources a blessing and which type of human capital development contributes more.

Nevertheless, the economic literature largely classifies two categories of natural resource influence on economic growth: direct and indirect influence. Actually, the indirect influence would generally function via human capital development and institutional quality. However, we concentrate on the indirect channel of human capital in this research. Conversely, it should be noted that the various mechanisms used for indirect influence only looked at the aggregated human capital development variable. As a result, from the standpoint of endogenous growth theory, it is only natural to investigate the impact of natural resources on economic growth via the human capital development channel by incorporating the disaggregated human capital development variables (SSE and TSE) into the same model. This study, therefore, investigates the conditional influence of natural resources on economic growth through human capital in West Africa. To do this, we use a panel dynamic ordinary least squares (DOLS) model, which enables us to mutually examine the direct and indirect impact of natural resources on the growth of the economies of 15 West African countries from 1990–2020.

However, our present research centers on the breakdown of human capital development by source. In brief, this work complements the prevailing body of literature concerning resource-human capital-growth. First, the bulk of prior studies focused on the aggregated measure of human capital development and therefore could not differentiate which of the human capital development indicators did better in relation to the significant role played by human capital in economic growth and wealth. The present study disaggregated the human capital development indicators into two groupings: models with SSE as human capital development and models with TSE as human capital development. This division reveals the impact of each human capital indicator and, subsequently, suggests policy implications on the type of human capital development a country must concentrate on in terms of improving economic growth.

Second, the existing literature indicates that the influence of natural resources on the growth of the economy is contingent on the human capital abilities of countries that have an abundance of natural resources. Consequently, we included human capital development in the model. In addition to the individual contributions, we include disaggregated interaction variables of human capital in the model to derive the conditional influence of natural resources on economic growth via human capital development.

Third, as indicated by Horváth and Zeynalov (2016) the majority of earlier studies concentrate on data that are cross-sectional in nature. Nonetheless, Rajan and Subramanian (2011) and Van Der Ploeg (2011) emphasise the importance of using panel data because cross-sectional data is prone to the bias of omitted variables, which stem from the initial productivity level and initial income level. This study builds on this submission by using regressions on panel data for West African countries.

This study is split into five sections: Section one discusses the introduction; Section Two looks at a short literature review; and Section Three deliberates on the methodology, which includes model specification and estimation techniques. Section four presents and discusses the findings, while the conclusion and policy recommendations are discussed in section five.

2. Brief Literature Review

According to the literature, it has been observed that the interaction of natural resources with human capital development affects growth rates. Actually, economic growth is negatively affected by natural resources only in countries where human capital development is very low.

From a theoretical paradigm wherein a rise in the abundance of natural resources in a country stimulates a re-allocation of human capital development from the sector of industries to the sector of natural resources, Bravo-Ortega and De-Gregorio (2007) demonstrate that the marginal effect of the abundance of natural resources is positive for economic growth in countries with high levels and quality of human capital development. Considering this viewpoint, Lederman and Maloney (2007) state that wealthy countries that have effectively developed their natural resources, such as Australia and Norway, have high and quality levels of human capital development. This high quality level of human capital is essential for innovation and economic growth. According to Wilson and Vellinga (2022), innovation increases productivity, strengthens an economy's efficiency, and aids in the development of knowledge-based nations. The importance of innovation efficiency, particularly at the aggregate level, and how it may impact economic development and competitiveness, is a vital topic that is clearly important to resource-rich countries (Wilson & Vellinga, 2022). Consequently, natural resources impede economic growth only when human capital levels are low.

Nevertheless, Gylfason (2001) claims that plenty of natural resources have a habit of crowding out other types of capital, specifically physical capital, social capital, and human capital. Thus, countries that do not improve their human capital development would have problems in trying to reduce their reliance on primary products. Therefore, these countries will face insufficient diversification within their economies. Furthermore, the experience of Finland's and South Korea's industrial development demonstrates that there is an intense relationship between the ability of human capital and the ability of a country to change from a country that is dependent on commodities to an economy reliant on manufacturing exports. These are the two countries that are frequently mentioned amongst the countries with educational systems that are effective in the world. Also, Gylfason and Zoega (2006) establish that natural resource abundance has an indirect and positive influence on the growth of the economy via human capital development. Furthermore, Zallé (2019) investigates the indirect impacts of natural resource dependence on growth through human capital and institutional quality. The paper examines the interactions between natural resources and human capital on the one hand, and natural resources and institutional quality on the other. An Autoregressive Distributed Lag model was applied to a panel of 29 nations with an average dependency rate of 19.53 percent from 2000 to 2015. Zallé (2019) uses corruption as a proxy for institutions. The findings indicate that the combination of human capital and the fight against corruption is an effective mechanism for leveraging natural resources in African nations. These findings suggest that African countries should increase their investments in human capital while simultaneously battling corruption in order to turn the curse of natural resources into a gift.

Several studies, however, have discovered an inverse relationship between resource dependence and factors thought to be directly related to growth performance. This larger group of impact factors includes human capital development (Blanco & Grier, 2012; Gylfason, 2001; Shao & Yang, 2014; Stijns, 2006), schooling, and openness (Papyrakis & Gerlagh, 2007). The majority of these findings show that natural

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resource abundance or dependency on the factors of interest has an adverse effect. Empirical research, for example, demonstrates that school enrolment at all levels is negatively associated with natural resource dependence (Gylfason, Herbertsson, & Zoega, 1999). Additionally, Pelle, Baskaran, and Bigsten (2020) investigate the effect of gold mining on educational attainment in Ghana. Using the Afro barometer survey dataset and a geocoded dataset on the discovery and closure dates of gold mines, Pelle et al. (2020) show that people who grew up in an area containing gold mines had significantly lower educational attainment as adults. Moreover, their findings show that small-scale and artisanal mining (which is popular but not limited to gold extraction) is not an economic occupation that can supply disadvantaged households with long-term revenue. They discover that this impact is not caused by endogenous migration, an increase in the frequency of disputes, or a lack of school availability in mining regions. As a result of this, we find that the negative effect of natural resource dependency or (potentially) abundance on growth is most likely due to their detrimental influence on relevant variables that promote long-term economic growth.

According to our present study, the interaction of human capital with natural resources explains the disparities in economic development results among countries.

3. Methodology

3.1. Model Specification

The traditional Solow growth model describes growth differences among countries in the world via a production function that is assumed to have a return to scale that is constant. However, Mankiw, Romer, and Weil (1992) upgraded this basic model by introducing human capital. Therefore, this upgraded solo model states that growth output is a function of technology, labour, and physical and human capital. This growth model may be expressed using the Cobb-Douglass production function as follows:

$$Y = AL^{\alpha}PK^{\beta}HC^{\mu}\varepsilon_{it} \quad (1)$$

Taking natural logarithms of Equation 1 gives the following:

$$lnY_{it} = A + \alpha lnL_{it} + \beta lnPK_{it} + \mu lnHC_{it} + \varepsilon_{it} \quad (2)$$

Where L, PK, and HC represent labour and physical and human capital, A signifies constant. Y represents real GDP per capita, which is used as a proxy for growth. The changes of L, PK, and HC with respect to Y are explained by α, β *and* μ, respectively, whereas ε_{it} indicates the error term. Each country in the group is denoted by i = 1, …, N whereas the period of time series is denoted by t = 1, …, N.

However, our current study modifies this model by inserting into it more factors such as natural resources and making changes to HC by disaggregating it into SSE and TSE. Therefore, the modified model of our current study is defined as follows:

$$lnY_{it} = A + \gamma lnNR_{it} + \varphi lnTO_{it} + \alpha lnL_{it} + \beta lnPK_{it} + \delta lnSEE_{it} + \mu lnTEE_{it} + \varepsilon_{it} \quad (3)$$

Where:

Y_{it} = Real GDP per capita at market prices. Aggregates are based on constant 2010 U.S. dollars.
NR_{it} = natural resources export as a share of GDP.
TO_{it} = trade openness (Import + Export)/GDP.
L_{it} = labourr force participation rate.
PK_{it} = gross fixed capital formation as a proxy for physical capital.
SSE_{it} = secondary school enrolment rate as a proxy for human capital.
TSE_{it} = tertiary school enrolment rate as a proxy for human capital.
$\gamma, \varphi, \alpha, \beta, \delta$ *and* $\mu > 0$.

The examined data came from the CD-ROM of the World Bank Database (World Development Indicators) (2021) and covered a period of 31 years from 1990 to 2020. We collected the data for a sample of 15 West African countries. Appendix 1 presents the list of the 15 countries involved in the panel data.

3.2. Panel Non-Stationarity Test

Considering the situation of time-series data, it could also be probable that the time-series characteristics of cross-sectional data would have a significant effect on how to specify the econometric model when approximating panel data. It is, therefore, important to carry out a stationarity test for panel data. Owing to the fact that panel data involves an intricate process in working with them, the traditional ADF and PP unit root tests could lead to outcomes that are erratic. We therefore carried out first and second generation stationarity tests for the panel data. The basic model of the Levine, Lin, and Chu (LLC) approach, which is the first generation of unit root tests for panel data, is specified below:

$$y_{it} = \partial_i y_{i,t-I} + Q'_{it}K + \varepsilon_{it,} \quad \text{I} = 1, 2, \ldots\ldots, \text{N: t} = 1, 2, \ldots.., \text{T}, \tag{4}$$

Where Q specifies the deterministic component, which could be 0, 1, ε_{it} represents the error term, fixed effects, and a time trend t. If $\partial = 1$, it shows the existence of a unit root. Levin, Lin, and Chu (2002) assume that $\partial_i = \partial$, $\forall_i$ denoting that there are persistent parameters occurring throughout the cross-sectional data or the panel has autoregressive parameters that are the same. Owing to this hypothesis, a new equation is specified as follows:

$$\Delta y_{it} = \vartheta y_{i,t-I} + Q'_{it}K + \varepsilon_{it,} \quad \text{I} = 1, 2, \ldots\ldots, \text{N: t} = 1, 2, \ldots.., \text{T}, \tag{5}$$

Where Δ is the first difference's operator. $\vartheta = \partial$-I. At this point, the null hypothesis of ∂ = I is equal to $\vartheta = 0$. With the added lag of the dependent variable, the modified model of Levin et al. (2002) can be defined as follows:

$$\Delta Y_{it} = \vartheta y_{i,t-I} + Q'_{it}K + \sum_{j=1}^{p} \alpha_{ij} \Delta Y_{it-j} + \varepsilon_{it} \tag{6}$$

Where ϑ denotes the maximum lags. The test of LLC is built on testing the null hypothesis of H_0: $\vartheta = 0$, against the alternative hypothesis of H_1: $\vartheta < 0$. The bias-adjusted t-statistics for ϑ is used to test for the null hypothesis of unit root. This test assumes that there are cross-sectional independent individual processes. The disadvantage of the panel unit root test of LLC is that it takes ϑ to be the same across the panel. Nonetheless, such a hypothesis is disputed in practice. On the other hand, Im, Pesaran, and Shin (2003) loosen up such assumptions by considering the null hypothesis that all cross-sectional entities contain unit roots against the alternative hypothesis that some (but not all) entities are stationary. Equation 7 presents the Im et al. (2003) panel unit root test:

$$\Delta Y_{it} = \vartheta_i y_{i,t-I} + Q'_{it}K + \sum_{j=1}^{p_i} \alpha_{ij} \Delta Y_{it-j} + \varepsilon_{it} \tag{7}$$

Contrasting the test of LLC, the null hypothesis here (IPS test) is specified as H_0: $\vartheta_i = 0$ $\forall_i$ against the alternative hypothesis of $H_1 : \vartheta_i < 0$ for i = 1, 2,…, N_1 and $\vartheta_i = 0$ for i = N_1 + 1, 2,…, N with $0 < N_1 \leq N$. The unit root test of IPS is centered on the Augmented Dickey-Fuller (ADF) statistics, taking a simple average across groups. The null hypothesis of country i unit root is tested via Equation 8.

$$\bar{t}_{NT} = \frac{1}{N} \sum_{i=1}^{N} t_{iT}(\delta_i, \alpha_i) \tag{8}$$

Where $t_{iT}(\delta_i, \alpha_i)$ with $\alpha_i = (\alpha_i, 1, \ldots.\ \alpha_i,\ \delta_i)$ denote the ADF t-statistic. They then standardized the statistics and showed that the standardized t-bar statistics converge to a normal distribution as N and T tend to infinity. According to Im et al. (2003), the t-bar test performs well when the sample is small.

3.3. Panel Co-Integration Test

There are numerous co-integration tests for panel data in the literature, and the advent of a test for panel co-integration from time series investigation is a new development. We, therefore, employed seven different test statistics of Pedroni for testing for the existence of co-integration between the variables in the heterogeneous panels (Pedroni, 1999). Nevertheless, this examination is adjusted to reduce the possibility of biasness generated by the possible endogenous series in the model. When using the test for co-integration by Pedroni (1999), we first estimated the panel co-integration regression model and saved the residual. Equation 9 shows the panel co-integration regression model:

$$X_{it} = \gamma_{0i} + \vartheta_{it} + \mu_{1i}Y_{1it} + \mu_{ni}Y_{nit} + \epsilon_{it} \tag{9}$$

We continued with the previous test in a bid to find the first difference in our dataset for the 15 countries in the panel and estimated the residuals of the first difference regression as stated by Equation 10:

$$\Delta X_{it} = \mu_{1i}\Delta Y_{1it} + \mu_{ni}\Delta Y_{nit} + \varepsilon_{it} \tag{10}$$

The test of the third sequence was to analyze the variance of the residual and long run employing the equation of the regression established following the approximation of our first difference. The following step involves the estimation of a suitable autoregressive model employing the residuals from the equation of the panel co-integration regression. The subsequent phase is to estimate the seven-panel statistics established by Pedroni (1999) by employing the averages and a modification of the variance. The null hypothesis for both tests indicates no co-integration, while the alternative hypothesis for the two tests indicates the existence of co-integration.

3.4. Granger Cause-Effect Analysis

If the variables are co-integrated, a VECM can be employed to do a cause-effect analysis (Pesaran, Shin, & Smith, 1999). In a bid to obtain the error terms, a co-integrating regression, in a two-step method, needs to be employed (Granger, 1987). The F-statistic denotes the causality of the short-run whereas μ_i, the ECT_{t-1} coefficient, denotes the causality of the long-run. If μ_i, the coefficient of ECT_{t-1} is statistically significant, it thus implies a long-run causal link between the variables. After that, the next step is to investigate the causality trend by applying the ECT obtained by the VECM in the long run. To perform this task, we specified a VECM framework as performed by Iorember, Goshit, and Dabwor (2020) as follows:

$$\begin{bmatrix} \Delta\ln Y_{it} \\ \Delta\ln NR_{it} \\ \Delta\ln TO_{it} \\ \Delta\ln L_{it} \\ \Delta\ln PK_{it} \\ \Delta\ln SEE_{it} \\ \Delta\ln TEE_{it} \end{bmatrix} = \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \\ \delta_7 \end{bmatrix} + \begin{bmatrix} \eta_{11i}\eta_{12i}\eta_{13i}\eta_{14i}\eta_{15i}\eta_{16i}\eta_{17i} \\ \eta_{21i}\eta_{22i}\eta_{23i}\eta_{24i}\eta_{25i}\eta_{26i}\eta_{27i} \\ \eta_{31i}\eta_{32i}\eta_{33i}\eta_{34i}\eta_{35i}\eta_{36i}\eta_{37i} \\ \eta_{41i}\eta_{42i}\eta_{43i}\eta_{44i}\eta_{45i}\eta_{46i}\eta_{47i} \\ \eta_{51i}\eta_{52i}\eta_{53i}\eta_{54i}\eta_{55i}\eta_{56i}\eta_{57i} \\ \eta_{61i}\eta_{62i}\eta_{63i}\eta_{64i}\eta_{65i}\eta_{66i}\eta_{67i} \\ \eta_{71i}\eta_{72i}\eta_{73i}\eta_{74i}\eta_{75i}\eta_{76i}\eta_{77i} \end{bmatrix} \times \begin{bmatrix} \Delta\ln Y_{it} \\ \Delta\ln NR_{it} \\ \Delta\ln TO_{it} \\ \Delta\ln L_{it} \\ \Delta\ln PK_{it} \\ \Delta\ln SEE_{it} \\ \Delta\ln TEE_{it} \end{bmatrix} + \ldots + \begin{bmatrix} \eta_{11i}\eta_{12i}\eta_{13i}\eta_{14i}\eta_{15i}\eta_{16i}\eta_{17i} \\ \eta_{21i}\eta_{22i}\eta_{23i}\eta_{24i}\eta_{25i}\eta_{26i}\eta_{27i} \\ \eta_{31i}\eta_{32i}\eta_{33i}\eta_{34i}\eta_{35i}\eta_{36i}\eta_{37i} \\ \eta_{41i}\eta_{42i}\eta_{43i}\eta_{44i}\eta_{45i}\eta_{46i}\eta_{47i} \\ \eta_{51i}\eta_{52i}\eta_{53i}\eta_{54i}\eta_{55i}\eta_{56i}\eta_{57i} \\ \eta_{61i}\eta_{62i}\eta_{63i}\eta_{64i}\eta_{65i}\eta_{66i}\eta_{67i} \\ \eta_{71i}\eta_{72i}\eta_{73i}\eta_{74i}\eta_{75i}\eta_{76i}\eta_{77i} \end{bmatrix} \times \begin{bmatrix} \Delta\ln Y_{it} \\ \Delta\ln NR_{it} \\ \Delta\ln TO_{it} \\ \Delta\ln L_{it} \\ \Delta\ln PK_{it} \\ \Delta\ln SEE_{it} \\ \Delta\ln TEE_{it} \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \\ \mu_6 \\ \mu_7 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \\ \varepsilon_{6,t} \\ \varepsilon_{7,t} \end{bmatrix} \tag{11}$$

Where $\varepsilon_{1,t}$ $\varepsilon_{2,t}$ $\varepsilon_{3,t}$ $\varepsilon_{4,t}$ $\varepsilon_{5,t}$ $\varepsilon_{6,t}$ and $\varepsilon_{7,t}$ are the residual terms, consistently presumed to have zero mean and normally distributed; and η_I signifies the elasticity parameters of the short-run (Equation 11).

Table 1.
Panel Unit root test results.

Variable	LLC	IPS	ADF	PP
lnY	-28.900 (00)	-28.400 (00)	639.900 (00)	675.600 (00)
lnNR	-24.600 (00)	-28.000 (00)	603.700 (00)	683.500 (00)
lnTO	-32.800 (00)	-25.800 (00)	507.600 (00)	572.000 (00)
lnL	-23.200 (00)	-23.100 (00)	527.500 (00)	602.100 (00)
lnPK	-29.400 (00)	-32.900 (00)	723.600 (00)	822.800 (00)
lnSSE	-23.400 (00)	-21.400 (00)	482.400 (00)	508.600 (00)
lnTSE	-21.200 (00)	-24.000 (00)	496.900 (00)	585.000 (00)

Note: Probabilities for Fisher tests are calculated using asymptotic Chi-square distribution. All other tests assume asymptotic normality. The probability values for the tests are in parentheses.

4. Results and Discussion

4.1. Panel Unit Root Test Results

The panel unit root test summary of the outcomes obtained is presented in Table 1. The outcomes in Table 1 illustrate that real GDP per capita (Y), natural resources export (NR), trade openness (TO), labour (L), physical capital (PK), secondary school enrolment (SSE) and tertiary school enrolment (SSE) are all integrated of order 1, denoted by I(1), meaning all the variables are stationary at first difference.

4.2. Panel Co-Integration Test Results

One unique challenge posed by long-run estimates is the differentiation process of the series, which can be fixed by applying co-integration. The use of co-integration gives understanding and awareness about the long-run information of unit root series. The following step is to ascertain the presence of long-run interaction among the variables after identifying that the variables comprise a panel unit root and are of first difference. In order to investigate the existence of co-integration among the variables, there is a need to apply the panel long-run tests carried out by Pedroni (1999) and Pedroni (2004). The outcomes of Predoni co-integration are presented in Table 2.

Table 2.
Pedroni co-integration test results.

Model	Statistic	P-Value
Within-Dimension		
Panel v-Statistic	-0.247	0.597
Panel rho-Statistic	2.842	0.997
Panel PP-Statistic	-3.290	0.000*
Panel ADF-Statistic	-2.456	0.007*
Between-Dimension		
Group rho-Statistic	4.450	1.000
Group PP-Statistic	-3.453	0.000*
Group ADF-Statistic	-2.827	0.002*

Note: * indicate significance at 1%.

The results of the investigation in Table 2 show that the hypothesis of no co-integration is rejected at the levels of 1% and 5% significance because most of the test statistic substantiate the rejection of the null hypothesis.

Thus, the entire proof from the co-integration tests of Pedroni (1999) and Pedroni (2004) indicates that a long-run relationship occurs between the explained and the explanatory variables in the panel of 15 West African countries.

4.3. Results of Panel Long Run Analysis

Since we have established the presence of co-integration among the variables, the next step is to estimate the long-run coefficients of the regressors. One advantage of co-integration analysis is that once its existence is established, the values of the independent variable(s) in relation to the dependent variable turn out to be economically and statistically meaningful. Nevertheless, the problem remains with the kind of long-run estimator to be implemented, given that there are different kinds of estimators. The OLS is the most popular and frequently used estimator in an extensive variety of econometric literature. Narayan and Smyth (2007) and Lee (2007) state that the FMOLS (Fully Modified Ordinary Least Squares) and the DOLS (Dynamic Ordinary Least Squares) have lately been accepted and favoured over the OLS since they are relatively efficient when it comes to fixing the problem of endogeneity of the independent variables and the problem of residual autocorrelations, thus allowing the variables to be asymptotic (Pedroni, 2004). Although the estimator of the FMOLS uses a non-parametric method to resolve the endogeneity drawback and autocorrelation (serial correlation), the estimator of the DOLS, in contrast, uses a

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parametric method to remove the fundamental problem in the estimate. As a result of this, the estimator of the DOLS works better and gives more effective estimations, particularly in small samples, than the FMOLS and OLS (Fei, Dong, Xue, Liang, & Yang, 2011; Kao & Chiang, 1999; Narayan & Smyth, 2007). Additionally, Pedroni (2001) argues that the generated coefficients from the estimator of the DOLS are consistent and unbiased. Herrerias, Joyeux, and Girardin (2013) maintain that the absence of cross-sectional independence among panel series is better controlled by the use of the DOLS estimator. As a result of the above-mentioned advantages, the current paper employs the estimator of the DOLS in order to estimate long-run structural coefficients in a bid to permit for the fundamental heterogeneity in the variances of the long run (Mark & Sul, 2003).

4.3.1. Analysis of the Sample without Interaction Terms

Table 3 shows the results of the estimated two models, one with SSE as human capital development and one with TSE as human capital development, using the DOLS estimators. We start our analysis with the model of SSE (Table 3, model 1) as human capital development for the long-run DOLS estimates. The result presented in Table 3 shows that the coefficient of natural resources is negative and significant at the 10% level. This indicates that there is an inverse correlation between natural resources and growth. The coefficient of natural resources is 0.5116, implying that a 1% increase in natural resources reduces economic growth by approximately 0.5%. Given West Africa's abundance of natural resources, this study adds credence to the resource curse theory. A large number of scholars have come to the same conclusion that economies with ample natural resources tend to grow more slowly than countries with fewer resources (Auty, 2001; Boschini, Pettersson, & Roine, 2007; Jalloh, 2013; Rainis, 1991; Sachs & Warner, 1997; Sachs & Warner, 2001). Another possible explanation for the negative effect of the abundance of natural resources on growth can be attributed to the fact that resource-rich countries have a very high tendency for civil conflict, which can be detrimental to growth and development (Collier & Hoeffler, 2006). This is not surprising given that many of the countries in question have experienced long civil wars or civil unrest sparked by natural resources.

Table 3.
Panel Estimation Results of the Dynamic Ordinary Least Squares (DOLS) - without interaction terms.

Variables	Dependent Variable = lnY	
	Dynamic Ordinary Least Squares (DOLS) model	
	Model 1	**Model 2**
lnNR	-0.511 (-1.940)***	-0.720 (-17.800)*
lnTO	-0.193 (-4.250)*	-0.189 (-3.710)*
lnL	1.884 (7.290)*	2.382 (4.770)*
lnPK	2.030 (7.810)*	3.332 (4.860)*
lnSSE	3.446 (6.080)*	----------
lnTSE	----------	3.558 (6.340)*
C	4.142 (2.250)**	2.222 (1.870)***
Diagnostic checking		
R^2	0.639	0.712
Adj. R^2	0.595	0.591
LM	6.092 [0.636]	6.662 [0.672]
RESET	0.604 [0.726]	1.397 [0.213]
HET(ARCH)	1.126 [0.345]	1.607 [0.186]

Note: *, ** and *** represent 1%, 5% and 10% significance levels, respectively. t-statistic values are reported in parenthesis while probability values are represented by [ ]. LM is the Lagrange multiplier test for serial correlation. RESET is the misspecification test. HET is White's heteroscedasticity test.

As stated by Collier and Hoeffler (2006), the chance of civil conflict in nations with limited natural resource wealth is 0.5 percent, but 23 percent in states where natural resources account for 26% of GDP. They said that the abundance of natural resources, such as mineral or oil riches, had not been successfully transformed into economic and social well-being for the majority of the people in most of these countries, including Iraq, Zambia, Nigeria, Venezuela, Sierra Leone, and others. As has already been observed in the region of West Africa, the abundance of natural resources could well have contributed to civil strife in nations such as Côte d'Ivoire, Liberia, Nigeria, and Sierra Leone. For instance, the ten-year civil war in Sierra Leone was attributed in part to a scramble for the nation's diamonds (the so-called Blood Diamond War). As a result, the inverse relationship between natural resources and growth could be justified in part by the civil conflict that has decimated the economy of Sierra Leone over the past 30 years. While it is impossible to cease mining for natural resources, which is a key contributor to West Africa's economic growth, this research indicates that the region may increase its contribution to growth by implementing tougher rules.

Regarding the effect of trade openness on economic growth, Table 3 further reveals that there is a negative correlation between trade openness and economic growth. The coefficient of trade is -0.1934, implying a 1% increase in the share of trade reduces growth by 0.19%. Certainly, this study does not confirm the premise that more open economies are expected to develop better than others. The outcomes dispute earlier results found by Gnangnon (2016), Hye and Lau (2015), and Musila and Yiheyis (2015) for developing countries. The outcomes of our study back up the findings of Huchet-Bourdon (2013), which submit that trade openness might have a negative influence on economic growth when countries, such as those in West Africa, have focused on low-quality goods. They discovered that trade openness definitely boosts growth when countries focus on high-quality goods. They confirm that the more developed the quality of the export basket, the greater the effect of the export ratio on growth. Similarly, the present study gives support to Feenstra (2010) and Feenstra and Kee (2008) suggesting that low levels of export variety could reduce economic growth. When it comes to labour, the variable has a predicted positive and significant coefficient, indicating that there is a positive relationship between labour and economic growth. A probable justification of this finding is that the involvement of more of the labour force in the economy is likely to increase economic growth, which is a significant input in any growth matrix. Generally, the labour force rate enters the growth equation with a positive sign and a 1% significant level for the whole panel of West African countries, suggesting that a 1% increase in the rate of labour force will stimulate economic growth by 1.88%. Furthermore, the findings show that investment in physical capital is positive and statistically significant in inducing growth as expected. This is in line with the conventional growth theory that physical capital investment is required for increased growth. A related outcome was found by Ghazanchyan and Stotsky (2013). This means that an increase in physical capital investment would increase growth by 2.03%. Equally, human capital investment (represented here by SSE) also indicates a positive sign and is highly meaningful to growth, consistent with the endogenous growth theory. The outcomes suggest that human capital investments are vital for economic growth. The coefficient of the human capital variable implies that a 1% increase in SEE increases economic growth by approximately 3.45%.

Turning to the model with TSE as human capital development (Table 3, model 2), using the DOLS model, the outcomes of the DOLS long-run estimates are likewise presented in Table 3. The results show that natural resources have a negative and statistically significant influence on economic growth. The coefficient of resource export shows that a 1% rise in natural resources decreases growth by reducing economic growth by 0.72%. Likewise, there is an inverse and statistically significant association between trade openness and economic growth. A 1% increase in trade openness, according to the findings, reduces growth by about 0.19%

Concerning labour, the estimates show that it has a positive and statistically significant impact on growth. The coefficient of labour is 2.3823, inferring that a 1% increase in the labour force in West Africa increases economic growth by 2.38%. The results also indicate that investment in physical capital is positive and statistically significant in influencing growth as predicted. The coefficient of physical capital

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is 3.3321, implying that when investment in physical capital in West Africa increases by 1%, economic growth increases by 3.33%. Furthermore, the human capital variable (represented here by TSE) has a positive and robust relationship with economic growth. The coefficient of this variable is 3.5582. This implies that there will be a 3.56% increase in growth when human capital (TSE) increases by 1%. This clearly shows how tertiary education is so vital to economic growth and development, as stated by Aghion and Howitt (1998) that tertiary education is more relevant for technology innovation and diffusion.

However, it is worth noting that the impact of TSE on growth (3.5582) is higher than the impact of SSE (which is about 3.4461), emphasizing the importance of the former over the latter on growth. Considering the DOLS estimates for both models (SSE and TSE as human capital development), the policy implication of these results lies in the encouragement of more investment in human capital by developing and implementing strategies that will continue to increase both forms of human capital. However, more emphasis must be placed on tertiary education, as observed from our findings.

4.3.2. Analysis of the Sample with Interaction Terms

Table 4 shows the results when the human capital variables (SSE and TSE) were gradually incorporated into the models as interaction factors.

Table 4.
Panel Estimation Results of the Dynamic Ordinary Least Squares (DOLS) - with interaction terms.

Variables	Dependent Variable = lnY	
	Dynamic Ordinary Least Squares (DOLS) model	
	Model 1	Model 2
lnNR	-0.303 (-3.760)*	-0.276 (-3.830)*
lnTO	-0.192 (-8.090)*	-0.166 (-4.640)*
lnL	1.931 (7.460)*	3.480 (6.250)*
lnPK	1.913 (7.350)*	3.505 (6.350)*
ln(SSE*NR)	3.480 (6.240)*	----------
ln(TSE*NR)	----------	4.142 (2.250)**
C	3.552 (6.300)*	3.446 (6.080)*
Diagnostic checking		
R^2	0.628	0.645
Adj. R^2	0.595	0.629
LM	9.267 [0.863]	10.048 [0.967]
RESET	1.720 [0.113]	1.459 [0.178]
HET(ARCH)	1.426 [0.241]	1.535 [0.163]

Note: *, and ** represent 1%, and 5% significance levels, respectively. t-statistic values are reported in parenthesis while probability values are represented by [ ]. LM is the Lagrange multiplier test for serial correlation. RESET is the misspecification test. HET is White's heteroscedasticity test.

The inclusion of the interaction terms (see Table 4) does not alter the results with regard to the signs and statistical significance of the control variables. In line with Table 3, the impacts of natural resources and trade openness on growth are still negative and statistically significant.

Interestingly, the interaction of natural resources with human capital (SSE*NR) was able to generate positive effects on growth. The DOLS regression result reveals that the coefficient of this variable has a positive sign and is statistically significant at the 1% level (see Model 1 in Table 4). The coefficient of this interacting variable is 3.4808, meaning a 1% increase in this variable will lead to approximately a 3.48% increase in economic growth. Similarly, the interplay of natural resources and human capital (TSE*NR) has a strong and favourable impact on growth. Also, the DOLS regression results reveal that the coefficient of this variable has a positive sign and is statistically significant at the 5% level (see Model 2 in Table 4). The coefficient of this interacting variable is 4.1429, meaning a 1% increase in this variable leads to a 4.14% increase in economic growth. This implies that, unlike the negative contributions of natural resources to economic growth when it stands alone, the interactions between natural resources and human capital (both TSE and SSE) have a positive effect on growth. This outcome is similar to the results of several studies on the role of human capital in augmenting the performance of natural resources in growth (Bah, 2021; Bravo-Ortega & De-Gregorio, 2007; Zallé, 2019). These researchers believe that natural resources could be beneficial in countries with a high level and quality of human capital. This shows that improving the region's human capital can positively and strongly affect growth. This lends credence to the idea that human capital is complementary to natural resources in improving growth. This highlights the point that human capital is very important as a growth-enhancement mechanism. Developing it works as an excellent strategy to improve growth.

Nevertheless, it is critical to draw the following conclusions from the research results:

- The model using TSE as human capital outperforms the model with SSE as human capital (see table 3).
- When natural resources combine with human capital (for both SSE and TSE), the factors contribute favorably to economic growth (see Table 4); but, when natural resources stand alone, they contribute negatively to growth. One of the most noteworthy outcomes of the study supports the concept that natural resources have a positive impact on growth due to human capital development. Any marginal improvement in human capital quality via advanced education and training could have a substantial influence on economic growth. The reason being, there is a huge stockpile of untapped growth-related skills in these economies, such that any marginal increase in the use of suitable technologies via higher education and training could trigger an increase in the average productivity of the workers. Thus, by adding to the stock of workers' quality owing to extra training, the development of human capital can boost total productivity at a faster rate and, thus, speed up economic growth in the region. This finding is in harmony with the results of Sarkar, Sadeka, and Sikdar (2012) who argue that the improvement of human capital can influence growth considerably if only complemented with the necessary education, training, and advancement of technology.
- Also, it is worth noting that the interaction term between tertiary school enrolment and natural resources (see model 2 in Table 4) produces more robust results than the interaction term between secondary school enrolment and natural resources (see model 1 in Table 4). This might be due to the notion that tertiary education is more important for innovation and technology spread (Aghion & Howitt, 1998).

4.4. Diagnostic Tests

The R^2s of the DOLS estimates for both models (secondary education enrolment model and tertiary education enrolment model) of economic growth relating to the independent variables of natural resources, trade openness, labour force, physical capital, and human capital development are 63.93% and 71.23% (Table 3), respectively.

Generally, the ARCH and Ramsey Reset tests show that the models are free from heteroscedasticity and specification bias. Furthermore, there are no serially correlated errors in the panel DOLS models since the null hypotheses of the Breush-Godfrey Serial Correlation LM Tests are accepted. Thus, the carefully chosen panel DOLS models are suitable for the estimation.

4.5. Panel Granger Causality Results

The causality outcomes are presented in Table 5. The table shows the short-run alongside the long-run causal relationship of the panel. The results indicate that, in the short-run, there is a one-way causality from tertiary school enrolment to trade openness, endorsing the growth hypothesis. Nevertheless, a two-way (bi-directional) causation is identified between natural resources, trade openness, labour, physical capital, secondary school enrollment, tertiary school enrolment, and economic growth, confirming the feedback hypothesis. An identical feedback effect is also identified between labour, tertiary education enrollment, physical capital, secondary education enrolment, and natural resources, respectively, and labour and tertiary education enrollment. The consequences of the two-way causality outcomes of these examinations, particularly between economic growth and natural resources, show that whereas a rise in economic growth encourages natural resource development, this natural resource development in turn improves economic growth. Furthermore, the substantial influence of both economic growth and the disaggregated human capital development variables (TSE and SSE) in developing natural resources can be established. On the one hand, the increase in economic growth, which is one of the primary contributors to economic growth, could allow policymakers the capability to devise policies meant to increase growth by adopting mechanisms for monitoring and controlling the activities of natural resources. This disaggregated human capital development, represented by tertiary school and secondary school enrolment, alternatively assists these economies to seize the opportunity of their significance in turning natural resources into blessings.

Table 5.
Results of VECM Granger -causality test.

Variables	Short-run causal relationship							Long run
Dep. variable	ΔLnY_{t-1}	$\Delta lnNR_{t-1}$	$\Delta lnTO_{t-1}$	ΔlnL_{t-1}	$\Delta lnPK_{t-1}$	$\Delta lnSSE_{t-1}$	$\Delta lnTSE_{t-1}$	$ECT_{(t-1)}$
ΔLnY_t	-	0.324** (0.042)	5.417* (0.000)	0.469* (0.001)	0.218* (0.000)	0.317* (0.000)	10.032* (0.000)	-0.380* [-20.322]
$\Delta lnNR_t$	0.098* (0.004)	-	0.780 (0.484)	0.482* (0.000)	0.322* (0.000)	0.019*** (0.063)	6.608* (0.000)	-0.271* [-6.103]
$\Delta lnTO_t$	4.083* (0.000)	1.768 (0.166)	-	0.780 (0.484)	0.149 (0.150)	0.414 (0.335)	4.142** (0.026)	-0.250** [-2.318]
ΔlnL_t	1.931* (0.000)	6.051* (0.000)	0.001 (0.980)	-	0.149 (0.150)	0.190 (0.114)	5.415* (0.000)	-0.041* [-2.757]
$\Delta lnPK_t$	0.093* (0.000)	0.041* (0.000)	0.274 (0.185)	0.610 (0.283)	-	0.162 (0.126)	0.644 (0.137)	-0.061** [-2.483]
$\Delta lnSSE_t$	1.888* (0.000)	6.207* (0.000)	0.191 (0.121)	2.281 (0.998)	0.807 (0.527)	-	0.044 (0.330)	-0.178** [-2.451]
$\Delta lnTSE_t$	8.046* (0.000)	10.719* (0.000)	0.054 (0.235)	0.127** (0.019)	0.232 (0.683)	2.465 (0.999)	-	-0.433* [-3.601]

Note: *, **, and *** denote rejection of the null hypothesis at 1%, 5%, and 10% significant levels respectively, P-values are listed in parentheses, t –values are reported in [ ].

Considering the long-run causality, the outcomes indicate that the coefficients of ECT_{t-1} are negative and significant for all the equations in the VECMs. Additionally, the consistency of the ECT_{t-1} confirms that should there be deviations in the short term, the system regulates and balances itself for the long term at a rate of -0.3800 for economic growth, -0.2718 for natural resources, -0.2506 for trade openness, -0.1786 for secondary education enrolment and -0.4339 for tertiary school enrolment relative to the adjustment speed of -0.0617 for physical capital and -0.0416 for labour VECMs.

5. Conclusion and Implication for Policy

There is an ongoing debate on the nexus between natural resources and economic growth. Some studies indicate that natural resources contribute negatively to growth, referring to this scenario as the "resource curse," while other findings come to the conclusion that natural resources contribute positively to economic growth. Researchers have not reached a conclusion on this very thought-provoking topic. This paper, thus, employs the methods of co-integration, DOLS, and VECM to examine the elasticity of economic growth on natural resources, trade openness, labour force, physical capital, and human capital development in a panel dynamic study. The relationship between the short and long-run causality among the variables of natural resources, human capital indicators (SSE and TSE), and economic growth is also analyzed, considering trade openness, labour force, and physical capital as other factors of growth apart from natural resources. The study employs panel data for 15 West African countries, comprising lower middle income countries (LMIC) and low income countries (LIC), for a 31-year period, from 1990 to 2020. The panel unit root test results disclose that the variables are stationary at the first difference, whereas the Pedroni co-integration results show a long-run relationship among the variables. Secondary and tertiary school enrolment (SSE and TSE) were used as key indicators of human capital.

The analysis shows that natural resources and trade openness are the major contributing factors to reducing economic growth, though natural resources possess the biggest elasticities. In contrast, the labour force, physical capital, and indicators of human capital development are efficient in improving growth. Furthermore, the long-run elasticities of economic growth in the DOLS with regard to labour force, physical capital, and human capital development variables are significantly larger in the model of tertiary school enrolment (TSE) than in the model of secondary school enrolment (SSE). The findings also disclose that when human capital variables were incorporated into the models as interacting terms, these interacting variables (secondary school enrolment with natural resources and tertiary school enrolment with natural resources) ended up improving growth. However, the findings indicate that the interaction of tertiary school enrolment with natural resources adds more to economic growth than the interaction of secondary school enrolment with natural resources (see Table 4). This implies that tertiary school enrolment performs better in making natural resources add more to growth than secondary education enrolment. The findings of this study add to the empirical and theoretical knowledge of the prevailing literature. The disclosure of the performance of disaggregated human capital development in secondary school and tertiary school enrolment suggests that in order to strategies for economic growth, countries ought to develop their human capital by considering the human capital influence of both secondary and tertiary education, respectively. The study also reveals the sort of human capital development that has the greatest impact on enhancing economic growth and also augmenting natural resources to improve economic growth. This study could assist in creating policy frameworks, especially for developing natural resource countries, in drafting their national policies and regulations in a bid to improve growth. The findings also give policymakers an understanding of the combination of natural resources with human capital development for economic growth and development. Since our findings have provided evidence that human capital development and natural resources are complementary in terms of improving growth, the policy standpoint should be that governments of such countries must improve and device policies that will improve primary, secondary, and tertiary education enrolment through more educational institutions and continue to give financial support to students. The focus must be on enhancing the quality of tertiary education. According to Aghion and Howitt (1998) tertiary education is more important for innovation and technological dissemination.

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Both authors contributed equally to the conception and design of the study.

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Appendix 1.
List of countries in the panel.

No.	Country	Abbreviation	Panel data id
1	Benin	BEN	1
2	Burkina Faso	BFA	2
3	Cape Verde	CPV	3
4	Cote d'Ivoire	CIV	4
5	Gambia	GMB	5
6	Ghana	GHA	6
7	Guinea	GIN	7
8	Guinea-Bissau	GNB	8
9	Liberia	LBR	9
10	Mali	MLI	10
11	Niger	NER	11
12	Nigeria	NGA	12
13	Senegal	SEN	13
14	Sierra Leone	SLE	14
15	Togo	TGO	15