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Oil price shocks and human capital channels in Nigeria

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ABSTRACT

Nigeria faces persistent challenges of high unemployment and poverty, worsened by its over-reliance on the oil sector. While many studies have investigated the relationship between oil price volatility and human capital development, few have examined how this relationship impacts both basic and advanced human capital channels in developing economies; this study addresses that gap by using a Structural Vector Auto Regression (SVAR) approach to investigate how oil price shocks influence human capital channels. Co-integration tests reveal significant long-term relationships among the variables. For the basic channel, oil price shocks are negatively associated with secondary school enrollment but positively linked to primary school enrollment. In the advanced channel, oil price has a positive effect on government expenditure on tertiary education but negatively affects tertiary institution enrollment. The impulse response function confirms that oil price fluctuations significantly affect both basic and advanced channels of human capital. The findings show the detrimental impact of oil price shocks on Nigeria's human capital development, which may negatively affect sustainable development. The study emphasises the urgent need for economic diversification to reduce the economy's vulnerability to oil shocks and promote long-term growth and human capital development.

Introduction

Oil price shocks have long been one of the leading causes of economic debate. Numerous studies have documented their significant impact on macroeconomic variables, such as trade balance, inflation, currency stability, economic activity, and overall growth [1–5]. These effects have raised concerns about their potential to derail progress towards global development targets set by the United Nations. Despite extensive research on the economic repercussions of oil price shocks, little attention has been paid to their effects on human capital development pathways; this gap is crucial because sudden declines in oil prices can reduce government revenue in

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oil-exporting nations, leading to cuts in education and health expenditures critical for human capital growth [6,7]. Conversely, increases in oil prices may temporarily boost export earnings. Still, they could also inflate government spending, potentially reducing investment priorities away from human capital towards infrastructure and subsidies, thereby affecting overall development outcomes.

In Nigeria, where oil dominates trade and serves as the primary revenue source for the government [8], such effects are particularly pertinent. Despite substantial oil revenues, which constitute about 75 % of total government income [9–11], the country faces persistent challenges, including high unemployment, widespread poverty, and low per capita income [12–15]. Notably, Nigeria struggles with one of the lowest human capital indices globally [16], which may be related to the vulnerability of human capital development to oil price fluctuations.

This study is motivated by three key factors that address significant gaps in the literature and contribute to the ongoing empirical research. First, the identified gap, inconsistencies and mixed results in existing studies emphasise the need for more exploration of oil price fluctuations and their economic effects, particularly in resource-dependent nations like Nigeria. Second, Nigeria's substantial reliance on oil revenues makes it especially vulnerable to oil price volatility, which can profoundly impact various sectors, including human capital development. Finally, this study is essential for understanding the relationship between oil price fluctuations and achieving the United Nations Sustainable Development Goals, particularly in promoting economic resilience, enhancing educational performance, and reducing poverty.

First, despite extensive research on the economic impacts of oil price shocks and human capital development [1–5,17,18], few studies or no study to the best of our knowledge have examined its effect the distinct channels of human capital namely, the basic and advanced channels. The basic channel of human capital, as stated by Scott-Clayton [19], Lucas [6], Mankiw et al. [20], and Lerner [21], focuses on elementary education, which boosts productivity directly through human capital input. In contrast, the advanced channel, emphasised by Nelson & Phelps [22], Romer [7], and Abramovitz [23], involves higher education, research and development (R&D), and the capacity to absorb and apply new technologies, thus influencing total factor productivity. Likewise, previous studies have shown mixed results regarding the relationship between human capital and productivity, with some attributing this to sectoral shocks and varying human capital levels across countries [24]. However, the specific ways oil price shocks affect human capital development mainly through these basic and advanced channels remain largely unexplored in oil-dependent economies like Nigeria.

Second, given Nigeria's heavy reliance on oil revenues, which account for a significant portion of government income [9–11], fluctuations in oil prices can significantly affect government expenditure on key sectors such as education and healthcare, which are crucial for human capital development. Although empirical studies such as those by Asaleye et al. [25], Jarrett, Mohaddes, and Mohtadi [26], and Olopade et al. [27] have examined the effects of oil shocks on various macroeconomic factors, the specific influence on human capital channels remains underexplored; this is further supported by studies such by Aderemi et al. [28] and Ogunjobi et al. [29].

Finally, this study plays a crucial role in advancing the United Nations' Sustainable Development Goals (SDGs), particularly those focused on quality education (SDG 4), decent work and economic growth (SDG 8), and reducing inequalities (SDG 10). Given that human capital hrough investments in education, healthcare, and innovation is essential for achieving sustainable and inclusive economic growth, understanding the impact of oil price volatility is critical for long-term planning and development. Nigeria's reliance on oil revenues, which accounts for a significant portion of government funding, means that fluctuations in oil prices can have far-reaching consequences for sectors vital to human capital development, such as education and health. The study's findings could inform policy recommendations to mitigate the negative impacts of oil price fluctuations on human capital development, thereby supporting Nigeria's efforts to meet the UN's development goals; this research offers practical solutions for ensuring that oil wealth translates into sustainable human development and economic progress in line with the UN's global vision.

From the foregoing, despite the vast literature on oil price shocks, there has been relatively little focus on their impact on human capital development; this is critical, as human capital is a key driver of economic growth [6,7]. Education is central to human capital development and is categorised into basic and advanced channels [30–32]. The basic channel, which represents human capital as an input to production [32], plays a role in factor accumulation, while the advanced channel stimulates total factor productivity through research and development. Given Nigeria's dependence on oil revenues and its largely unskilled workforce [33], investment in human capital is crucial for economic growth. However, the country's reliance on oil revenues means that consistent oil price shocks could undermine efforts to improve education and human capital development, thereby threatening long-term economic stability. This study addresses this gap by investigating how oil price shocks affect both the basic and advanced channels of human capital in Nigeria using Structural Vector Auto Regression (SVAR), revealing a negative impact on secondary school enrollment (basic channel) and a mixed effect on tertiary education (advanced channel), thus contributing to the discourse on sustainable development. The rest of the paper is outlined as follows: Section 2 presents the materials and methods. Section 3 reveals empirical results. While Section 4 discusses the empirical results, section 5 concludes the study.

Materials and Method

Theoretical framework

The theoretical framework specified in the model is the augmented Solow model, which explains the justification for adding human capital to the growth theory; this is because skills and quality education are important in the determination of the aggregate output of a nation. The model also supports the opinion in the production process that physical labour and capital are insufficient without human capital inclusion. The production function is, therefore, specified as:

$$OUPT_t = A_t KP_t HM_t LB_t \quad (1)$$

In Eq. (1), *OUPT* is the output level; A is the level of total factor productivity;*KP*is physical capital stock; *HM* is human capital level; *LB* is labour. Further explanation of the theoretical framework can be found in appendix 1. From equation A.10 (see appendix 2) 'N' represents the advanced channel, it can be deduced that productivity channel is sustained and effective only when there is a growth in the level of human capital, not merely when the basic channel expresses an increase in output level. In this study, primary school and secondary school enrollments are the indicators for the basic channel, while tertiary enrollment and government expenditure in higher education represent advanced channel indicators. Different determinants have been identified in the literatures that affect the economy in the presence of oil shock and adequate investment in human capital, such as an increase in population growth, mismanagement of resources, and instability, among others [34,35]. However, these factors are not included in the model, so to be able to determine the extent to which oil price shock affects the basic and advanced channels of human capital in Nigeria.

Model specification and estimation techniques

In line with the theoretical framework adopted in this study, equations A.5 and A.10 (see appendix 1) was used to capture the basic channel and advanced channel respectively as follows:

Basic channel

To measure the effect of oil price on basic human capital, equation A.5 (see appendix 1) is modified with the inclusion of basic channel indicators and expressed in Eq. (2).

$$\Delta In(OILP_t) = \theta_0 + \theta_1 \Delta In(PSE_t) + \theta_2 \Delta(SSE_t) + \theta_3 \Delta In(LB_t) + \theta_4 \Delta In(KP_t) + \theta_5 \Delta In(GDP_t) + \varepsilon_t \quad (2)$$

Two main channels were reported in both theoretical and empirical literature in which human capital can affect the economy [7,22, 32]. The first is the advanced channel; this involves the role of research and development in spurring innovation to increase aggregate productivity. The next is referred to as the 'basic channel', with attention on how human capital formation can augment in boosting aggregate output [6,19,21,36,37]. Popoola *et al.* [32] considered two basic channel indicators, that is primary and secondary school enrollment. In equation (12), PSE is primary school enrollment, SSE is secondary school enrollment, KP is capital, LB is labour, and OILP is the oil price.

Advanced channel

For the effect of the advanced channel of human capital on oil price, equation A.1 (see appendix 1) is modified by the inclusion of the advanced channel indicators and expressed in Eq. (3) below:

$$\Delta In(OILP_t) = \alpha_0 + \alpha_1 \Delta In(GEXD_t) + \alpha_2 \Delta(UNIE_t) + \alpha_3 \Delta In(LB_t) + \alpha_4 \Delta In(KP_t) + \alpha_5 \Delta In(GDP_t) + \varepsilon_t \quad (3)$$

Likewise, two indicators are used to proxy the advanced channels, that is, government expenditure and enrolment at the university [32]. Therefore, in Eq. (3), GEXD is the indicator for government expenditure on higher education, and UNIE is university education enrolment. Eqs. (2) and (3) will be estimated through a vector auto regression procedure, which allows all variables to be considered as both independent and dependent variables. The long-run equation will be established by normalising the human capital indicators; this will allow the objectives of the study to be actualised, that is, the impact of oil prices on human capital channels in Nigeria. The Nigerian economy is significantly impacted by changes in oil prices . Nigeria depends on crude oil as the major source of revenue generation in the country. Studies on the connection between oil prices and human capital are still growing. However, an increase in oil prices in the international market may increase Nigerian government revenue, which can promote aggregate investment in education, infrastructure, and improved access for students. Also, a decrease in oil prices may reduce government revenue; this can result in budget cuts across various sectors, including education. Due to decrease in oil prices, which will result in less funding, the Nigerian government may face difficulties in providing educational infrastructure and also reduce school enrolment.

Techniques of estimation

Stationarity and unit root tests and johansen Co-integration method

It is crucial to test the time series using the unit root test before applying the Johansen co-integration method. Different studies have been advanced in the testing unit root [38,39]. However, the Phillips-Perron and Augmented Dickey-Fuller (ADF) are still relevant and are employed in this study. In the scenario that the unit root test has been carried out on the time series and all the time series are integrated of the same order, then we can conduct a Johansen co-integration test. This is a maximum likelihood method that helps identify the number of vectors that are cointegrated in a non-stationary time series. Johansen [40] defines two statistical tests for co-integration: the maximum Eigen value test and the trace test. The maximum Eigen value test carries out a separate test on each eigenvalue, while the trace test is a joint test that tests for the null hypothesis of no cointegrating relationship $H_0 : r = 0,$ against the alternative hypothesis of a cointegrating relationship $H_0 : r > 0$. The Eigen value also tests the null hypothesis that the number of vectors that are cointegrated is equal to r against the alternative hypothesis of r+1 cointegrating vectors [41].

As part of our methodology, to determine the effect of oil price shock on basic and advanced human capital, we normalised the resulting cointegrating relationship on the indicators of the channels. In this study, two cointegrating vectors are established in the models of basic and advanced channels. Hence, we normalised PSE and SSE in equation 12. Likewise, on GEXD and UNIE in equation

13, the coefficients of the variables are equal to 1. These two variables are chosen because they give results that are more interpretable to fit the objective of the study.

Structural vector auto regression (SVAR) analysis

The study examined the effect of oil price shocks on the basic and advanced human capital in Nigeria using the structural VAR approach. This model, which was proposed by AB-model of Amisano and Giannini [42], is adopted to check for the possibility of oil price shock on human capital channels. The benefit of SVAR over simple, unrestricted vector autoregressive (VAR) is the ability to be able to make use of theoretical assumptions in their empirical model by ensuring that there is an imposition of explicit restrictions for the structural relationships. Assuming: $\Sigma = E(\mu_t \mu_t)$ is the residual covariance matrix. This means that for the structural analysis, the reduced form model can be stated as:

$$A\mu_t = Be_t \tag{4}$$

where μ_t is the disturbance vector in its reduced form, while e_t is the structural innovation vector that is not observed, both with length j. Therefore, the reduced form disturbances are related to the underlying shocks in Eq. 1. Some restrictions for C and D matrices with dimension jxj are to be added in the SVAR analysis. The covariance matrix from the structural innovations is $E(e_t e_t) = U$ where U represent the identity matrix where e_t imposes the restrictions below on C and D: $C \sum C = DD$. Specifically, for CD model identification, at least the restrictions $J^2 + \frac{j(j-1)}{2} = \frac{j(3j-1)}{2}$ are needed. Over-identification of the model will facilitate the report of the likelihood ratio (LR) value. The study adopted the short-run restrictions to recognise the concurrent relationship between the variables. The traditional vector autoregressive (VAR) system is stated without any explicit contemporaneous connection among the variables. SVAR restrictions are divided into short-run and long-run restrictions. Still, this study will adopt only the short-run restrictions to determine the contemporaneous relationship between the parameters for both the basic and the advanced channels. The SVARs for this study are given as:

Oil price shock on basic channel

$$\begin{pmatrix} \mu_t^{OILP} \\ \mu_t^{SSE} \\ \mu_t^{PSE} \\ \mu_t^{LAB} \\ \mu_t^{GCF} \\ \mu_t^{GDP} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_t^{OILP} \\ \varepsilon_t^{SSE} \\ \varepsilon_t^{PSE} \\ \varepsilon_t^{LAB} \\ \varepsilon_t^{GCF} \\ \varepsilon_t^{GDP} \end{pmatrix} \tag{5}$$

In Eq. (5), μ_t^{OILP} represent the oil price shock; μ_t^{SSE} depict the secondary school enrollment shock; μ_t^{PSE} depict the primary school enrollment shock; μ_t^{LB} represent the labour shock; and μ_t^{KP} depict the capital stock shock. There are 15 parameters to be estimated in the matrix, which satisfy the ordering requirement.

Table 1
Data description and measurement.

Variables	Identifier	Description	Source	Measurement
Oil Price (OILP	OILP	This is the reference price for buyers and sellers of crude oil, as well as the spot price of a barrel of benchmark crude oil.	World Development Indicator	A measure of oil price/ supply shock
Secondary School Enrollment	SSE	This is the sum of students enrolled in secondary education in Nigeria.	World Development Indicator	A measure for basic human capital
Primary School Enrolment (PSE)	PSE	This is the total number of pupils enrolled in primary school in Nigeria	World Development Indicator	A measure for basic human capital
UNIE University Enrollment	UNIE	This is the total number of students that are enrolled for university education/postgraduate study in Nigeria.	Federal Ministry of Education, Lagos	A measure for advanced human capital
Government Expenditure on Education	GEXD	This is the total amount spent by the government on education in Nigeria.	CBN Bulletin	A measure for advanced human capital
Labour	LAB	This is the group of people who are now employed in the economy and are working between the ages of 16 and 64.	UNCTAD	Measure of workforce
Gross Capital Formation	GCF	This is the net growth of physical assets during a certain time period (investment less disposals).	CBN Bulletin	Capital growth rate
Gross Domestic Product	GDP	The total value of all the goods and services produced by a country in a specific year	CBN Bulletin	Measure of economic growth and development

Source: Authors Computation.

Oil price shock on advance channel

$$\begin{pmatrix} \mu_t^{OILP} \\ \mu_t^{GEXD} \\ \mu_t^{UNIE} \\ \mu_t^{LAB} \\ \mu_t^{GCF} \\ \mu_t^{GDP} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ f_{21} & 1 & 0 & 0 & 0 & 0 \\ f_{31} & f_{32} & 1 & 0 & 0 & 0 \\ f_{41} & f_{42} & f_{43} & 1 & 0 & 0 \\ f_{51} & f_{52} & f_{53} & f_{54} & 1 & 0 \\ f_{61} & f_{62} & f_{63} & f_{64} & f_{65} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_t^{OILP} \\ \varepsilon_t^{GEXD} \\ \varepsilon_t^{UNIE} \\ \varepsilon_t^{LAB} \\ \varepsilon_t^{GCF} \\ \varepsilon_t^{GDP} \end{pmatrix} \tag{6}$$

The matrix for the advance channel in Eq. (6) has 16 parameters to be estimated: μ_t^{OILP} depict the oil price shock; μ_t^{GEXD} represent government expenditure on higher education shock; μ_t^{UNIE} depict the university enrollment shock; μ_t^{LB} depict the labour shock; and μ_t^{KP} depict the capital stock shock. The shocks identified in the two matrices contemporaneously affect the corresponding variables. The oil price is the independent shock that affects other variables.

Source of data

Table 1 presents the information about the data used in this study. Due to data availability, the time series yearly data from 1980 to 2022 was collected and used for this study. The variables in the model were sourced from World Development Indicators (WDI) and the Central Bank of Nigeria statistical bulletin.

Presentation of results

Preliminary analysis

To establish the reliability of the data obtained, Table 2 shows the result of the unit root test in both level and first difference forms. The ADF and the PP results show that all the variables were not stationary at level, but are all stationary at first differencing since the absolute value of ADF and PP statistics exceed the critical value at 5 per cent significance level. In accordance with the result of the test, the number of cointegrating vectors is determined. The co-integration result for the basic channel is presented in Table 3; both the maximum Eigen value and the trace reject the null hypothesis, which states that there are no cointegrating vectors among the series at the 5 % level of significance. Three cointegrating vectors are shown by the trace statistics, while the maximum Eigen value shows two cointegrating vectors.

Table 3 shows the co-integration results of the unrestricted co-integration rank tests (trace and maximum Eigen value) for both basic and advanced channels. Evidence from the basic channel indicates 3 cointegrating equations at a 5 per cent significance level for Trace and 2 cointegrating equations for maximum Eigen value. Based on the maximum Eigen value result, the study normalised on the two indicators of the basic channels of human capital to establish two equations. Likewise, evidence from the advanced channel result indicates 3 cointegrating equations at a 5 per cent significance level for Trace and 2 cointegrating equations for Maximum Eigen value. Based on the maximum Eigen value result, the study normalised on the two indicators of the advanced channels of human capital to establish two equations.

Main analysis

The normalised cointegrating result of the basic and advance channels are shown in Table 4. The indications are interpreted in a reverted way as a result of the normalising process. With primary school enrollment (PSE) as the explained variable, it has a positive

Table 2
ADF and PP unit root test results.

Variables	ADF Results		PP Results		Order of Integration
	Level	First Diff.	Level	First Diff.	
lnOILP	-1.4957	-4.8221*	-0.9742	-5.9835*	I(1)
lnGEXD	-1.6424	-5.0773*	-0.1.1604	-11.3812*	I(1)
lnPSE	-1.5779	-5.7646*	-1.6631	-5.8253*	I(1)
lnSSE	-1.4837	-5.1139*	-1.4753	-5.1039*	I(1)
lnUNIE	-2.4128	-5.6527*	-2.5403	-5.6521*	I(1)
lnLAB	1.1968	-4.4739*	1.2185	-4.4739*	I(1)
lnGCF	0.5702	-4.2679*	0.4634	-4.5988*	I(1)
lnGDP	-0.0067	-5.5502*	-0.0424	-5.5520*	I(1)

Notes:
* Indicate significant at 10 % significance level.
Source: Authors' Computation.

Table 3
Johansen co-integration test for basic & advance channels.

Unrestricted co-integration rank test (Trace)				
Basic Channel Co-integration Test				
Hypothesised No. of CE (s)	Eigenvalue	Trace statistic	0.05 Critical value	Prob.
None*	0.9526	199.9444	103.8473	0.0000
At most 1*	0.7529	102.3671	76.9727	0.0002
At most 2*	0.5447	57.6217	54.0790	0.0233
At most 3	0.4294	32.4438	35.1927	0.0961
At most 4	0.2331	14.4864	20.2618	0.2573
At most 5	0.1707	5.9910	9.1645	0.1914
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level				
Unrestricted co-integration rank test (Maximum Eigenvalue)				
Hypothesised No. of CE (s)	Eigenvalue	Max-Eigen Statistics	0.05 Critical value	Prob.
None*	0.9526	97.577	40.9568	0.0000
At most 1*	0.7529	44.7453	34.8058	0.0024
At most 2	0.5447	25.1779	28.5880	0.1284
At most 3	0.4294	17.9573	22.2996	0.1812
At most 4	0.2331	8.4953	15.8921	0.4898
At most 5	0.1707	5.9910	9.1645	0.1914
Eigen test indicates 2 cointegrating eqn(s) at the 0.05 level				
Advanced Channel Co-integration Test				
Hypothesised No. of CE (s)	Eigen value	Trace statistic	0.05 Critical value	Prob.
None*	0.8216	162.2337	103.8473	0.0000
At most 1*	0.6820	100.1635	76.9727	0.0003
At most 2*	0.5122	58.9127	54.0790	0.0174
At most 3	0.3301	33.0647	35.1927	0.0833
At most 4	0.2880	18.6413	20.2618	0.0823
At most 5	0.1631	6.4128	9.1645	0.1612
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level				
Unrestricted co-integration rank test (Maximum Eigenvalue)				
Hypothesised No. of CE (s)	Eigen value	Max-Eigen Statistic	0.05 Critical value	Prob.
None*	0.8216	62.0701	40.9568	0.0001
At most 1*	0.6820	41.2508	34.8058	0.0074
At most 2	0.5122	25.8480	28.5880	0.1076
At most 3	0.3301	14.4233	22.2996	0.4240
At most 4	0.2880	12.2285	15.8921	0.1731
At most 5	0.1631	6.4128	9.1645	0.1612
Eigen test indicates 2 cointegrating eqn. (s) at the 0.05 level				

Notes:
* shows significance at 5 per cent.
Source: Authors' Computation.

Table 4
Normalised cointegrating coefficients for the basic & advance channels.

Normalised Cointegrating Coefficients for Basic Channel					
lnPSE	**lnOILP**	**lnSSE**	**lnGCF**	**lnGDP**	**lnLAB**
1.0000	-0.8013	-2.5312	1.1154	-2.5161	-3.1380
	(0.1174)	(0.5267)	(0.1295)	(0.3163)	(0.8765)
lnSSE	**lnOILP**	**lnPSE**	**lnGCF**	**lnGDP**	**lnLAB**
1.0000	-0.3165	-	0.4406	0.9940	-1.2397
	(0.0484)	-	(0.0442)	(0.0987)	(0.3459)
Normalised Cointegrating Coefficients for Advance Channel					
lnTIER	**lnOILP**	**lnGEXD**	**lnGCF**	**lnGDP**	**lnLAB**
1.000000	0.2382	0.8454	-0.2954	0.4055	-1.2327
	(0.0985)	(0.0916)	(0.0678)	(0.1775)	(0.5740)
lnGEXD	**lnOILP**	**lnTIER**	**lnGCF**	**lnGDP**	**lnLAB**
	-0.2817	-	0.34945	-0.4797	1.4581
	(0.1708)	-	(0.0969)	(0.2001)	(0.6502)

Notes: The values in parentheses below the coefficients are the standard errors
Source: Authors' Computation

association with OILP, SSE, LAB, and GDP and has a negative association with GCF. This finding implies that increasing oil prices contribute positively to primary school enrollment in Nigeria.

A percentage change in OILP leads to about 0.80 per cent increase in PSE in Nigeria. In another vein, primary school enrollment responds negatively to GCF. A percentage change in GCF brings about 1.11 per cent decrease in primary school enrollment. Also, using secondary school enrollment as an explained variable, it has a negative association with GCF and GDP and a positive relationship with; OILP and LAB. This result implies that a percentage change in OILP and LAB leads to 0.32 and 1.23 per cent in secondary school enrollments, respectively. This is unfavorable to the economy as Nigeria is an oil-dependent country, whereas the increasing oil price only has a positive association with secondary school enrollment and does not culminate in increasing GDP in Nigeria. The implication of this on the economy is that the labour force might lack adequate knowledge to spur innovation, as stressed in the new growth theory.

For the advance channel, the co-integration test in Table 3 indicates that there are three cointegrating vectors for the trace test and two cointegrating vectors for the maximum Eigenvalue test. The result of the normalised cointegrating is shown in Table 4. The interpretation of the indications is reversible as a result of the normalising process. Using tertiary institution enrollment (TIER) as an explained variable, it has a negative association with OILP, GEXD, and GDP and has a positive association with GCF and LAB. The result implies that OILP contributes inversely to tertiary institution enrollment in Nigeria, as a percentage increase in OILP leads to about 0.24 per cent fall in TIER in Nigeria. All the *t*-tests are statistically significant. In another vein, TIER price responds positively to GCF and LAB. A percentage increase in LAB and GCF brings about 0.29 per cent, and 1.23 per cent increase in oil TIER, respectively. Taking government expenditure on tertiary education as an explained variable, it has a positive connection with OILP and GDP and a negative connection with LAB and GCF. This result implies that a percentage change in oil price will bring about 0.28 per cent increase in GEXD. While a percentage change in GCF and LAB will lead to 0.34 per cent and 1.46 per cent fall in GEXD, respectively.

Table 5 presents the variance decomposition of oil price shock for the basic and advance human capital channels. Variance decomposition relates the variation in one variable to systemic innovation. In variance decomposition analysis using VECM, time horizons are typically classified into short-term (periods 1–3), medium-term (periods 4–7), and long-term (periods 8–10) to understand dynamic effects. Short-term reflects immediate impacts [43], medium-term captures intermediate effects where other variables' influence becomes prominent [44], and long-term shows stabilisation and enduring relationships [45]. This classification for interpreting dynamic changes is used in this study.

The result shown under decomposition of oil price (OILP) refers to the response of oil price level to own shocks, shocks in gross capital formation (GCF), shocks in gross domestic products (GDP), shocks in labour (LAB), shocks in secondary school enrollment (SSE), and shocks in primary school enrollment (PSE). It can be observed that oil price response to shocks in itself causes 64 % fluctuations in the short run, dropping to 43.84 per cent fluctuations in the long run in Nigeria. Shocks in gross capital formation caused 17 per cent and 13.5 per cent variation to oil price in the short and long run respectively, while shocks in secondary school enrollment contributed 2.4 per cent fluctuations in the short run and 10.81 per cent in the long run. In the short run, shocks in primary school enrollment cause 0.31 percent fluctuations to oil price but increased to fluctuations of 2.54 per cent in the long run. This implies that secondary school enrollment has more impact on oil price shock than primary school enrollment, both in the short and long term.

Table 5
Variance decomposition for basic and advance channels.

Basic Channel: Variance Decomposition						
Period	LNOILP	LNGCF	INSSE	INPSE	LNLAB	LNGDP
1	81.1032	16.9875	0.0000	0.0000	0.0000	1.9092
2	79.4672	14.5814	2.3707	0.0170	2.1132	1.4503
3	71.7159	12.6140	7.3911	0.2480	6.5784	1.4525
4	64.0071	12.8119	10.7301	0.3170	10.6730	1.4607
5	57.2645	13.9718	11.9545	1.0764	13.9847	1.7478
6	52.1832	14.7259	11.9324	1.7556	16.8294	2.5731
7	48.6906	14.8310	11.4216	2.1913	19.1660	3.6991
8	46.3858	14.5016	10.8138	2.5388	20.9226	4.8370
9	44.8591	13.9833	10.2793	2.8631	22.2201	5.7949
10	43.8390	13.4590	9.8422	3.1913	23.2157	6.4525
Advance Channel: Variance Decomposition						
Period	LNOILP	LNGDP	LNGCF	INGEXD	INUNIE	LNLAB
1	78.1551	0.9096	20.9352	0.0000	0.0000	0.0000
2	71.2488	0.5998	24.6037	1.2649	0.3688	1.9138
3	68.5397	0.6079	23.4687	4.4936	0.3461	2.5436
4	68.7521	1.2782	21.9978	4.9428	0.3286	2.7003
5	66.6483	3.1465	20.7138	4.9565	0.3174	4.2173
6	63.3169	5.3855	19.5438	5.0507	0.3175	6.3853
7	60.2775	7.6754	18.4154	5.1616	0.4928	7.9771
8	57.5373	10.0623	17.3070	5.0191	0.8811	9.1929
9	54.75857	12.3621	16.2608	4.7347	1.3528	10.5308
10	52.1077	14.2010	15.3317	4.4619	1.8680	12.0294

Notes: *Values in this table are expressed in percentage*
Source: Authors' Computation

Furthermore, shocks in labour caused 2.1 per cent and 23.2 per cent variation to oil price in the short run and long run, respectively. Lastly, shocks in gross domestic product contributed 1.91 per cent fluctuations to oil price in the short run but increased to 6.5 per cent fluctuations in the long run; this implies that the nation's GDP has more impact on the oil price in the long run. The result revealed that forecasting error shocks to primary and secondary school enrollments could influence oil prices. However, the price of oil is significantly impacted by shocks in secondary school enrollment compared to that of primary school enrollment at any given period.

For the advance channel, the result shown under decomposition of oil price refers to the response of oil price to own shocks, shocks in gross capital formation (GCF), shocks in gross domestic product (GDP), shocks in labour (LAB), shocks in government expenditure on higher education (GEXD), and shocks in university enrollment (UNIE). 71.2 per cent and 54.75 per cent of the variations in oil price are explained by oil price itself in the short run and long run, respectively. Shocks in gross capital formation caused 20.9 percent fluctuations to oil price in the short run, dropping to 15.3 per cent in the long run. Additionally, shocks in gross domestic product play a crucial role in explaining oil price, contributing 1.28 and 14.2 per cent fluctuations to oil price in the short run and long run respectively, indicating that Nigeria's GDP is a determinant of oil price.

The short-term predictive capacity of labour explains a 2.5 percent variation in oil price, which steadily increased to 12.03 per cent in the long run; this suggests a growing influence of labour shocks on oil price over time. The forecast error shock revealed that government expenditure on higher education causes 1.3 per cent and 5.01 per cent fluctuations to oil price in the short run and long run, respectively. Lastly, in the short run, shocks in university enrollment caused 0.37 per cent variation to oil price but increased to fluctuations of 1.86 per cent in the long run. In conclusion, the results indicate that government expenditure on education and university enrollment significantly affect oil prices, with a more pronounced impact from government expenditure for both short and long terms; this shows the dependency of oil revenue on education investment, underlining the economic implication of human capital development on oil prices in Nigeria.

Inverse roots of AR characteristic polynomial

The models' stability test employing the inverse roots of the AR characteristics polynomial is shown in Figures A.1 and A.2 (see appendix 2). The fact that the dots are visible to be inside the circles indicates that the stability requirement is met.

Basic channel: Impulse response function

The impulse response function of the basic channel of human capital is depicted in Figure A.3 (see appendix 2). Although a total of 36 shock responses were estimated due to the six-variable structural VAR employed in the study, we simply examine two of them that are pertinent to the study. The graphs in Figure A.3 revealed that a one standard deviation shock (innovation) on oil price has an initial positive impact, though not significant, on primary school enrollment up to year 2. These responses, nonetheless, started to decline significantly, which became negative after year 2 and remained so until year 7, when it significantly and positively increased. This implies that oil price shocks and primary school enrollment are not significantly linked in the short run, whereas in the medium term, oil price shocks worsen primary school enrollment but become mitigated in the long run. Additionally, a one standard deviation shock on oil price has a persistent positive impact, though less significant, on secondary school enrollment both in the short run and long run. This implies that the forecast error shock of oil price shows more response variation in primary school enrollment than in secondary school enrollment. This finding is in line with the study of Abdul-Mumuni et al. [46], who investigated the effect of crude oil price changes on human development in Ghana.

Advanced channel: Impulse response function

For the advanced channel, the impulse response function (IRF) in Figure A.4 (see appendix 2) revealed that one standard deviation shock (innovation) on oil price has a negative impact on university enrollment from year one to year three. Afterward, the response started to increase and became positive from the fourth year and never declined again. This implies that shocks to oil price have a negative impact on university enrollment in the short run and a positive impact in the long run, though statistically not significant. This finding is similar to that of Ahmad [47], who examined the effect of increasing oil revenue on education in Saudi Arabia. The IRF results also indicate that one standard deviation shock on oil price has positive and significant impact on government expenditure in

Table 6
Diagnostic checks.

Diagnostic Check: Basic Channels	Probability	Hypothesis Testing
Histogram Normality Test (Jarque-Bera Value)	0.8498	Reject H_0
Serial Correlation Test	0.3022	Accept H_0
Heteroskedasticity Test	0.2602	Accept H_0
Diagnostic Check: Advance Channels		
Histogram Normality Test (Jarque-Bera Value)	0.5488	Reject H_0
Serial Correlation Test	0.3529	Accept H_0
Heteroskedasticity Test	0.2509	Accept H_0

Source: Authors' Computation.

education (GEXD) from year 1 to 6. Although, after the sixth-year oil price has no significant impact on GEXD. The result also implies that oil price shocks have a significant positive impact on government expenditure on education only in the short and medium term. This finding corroborates that of Edeh *et al.* [48], who found that any significant increase in oil price encourages investment by increasing government expenditure.

Diagnostic analysis

The diagnostic checks in Table 6 were employed to determine if the models were appropriately specified. According to the Jarque-Bera value, which was adopted for the normality test, the residual is normally distributed since the Jarque-Bera statistic is more than 5 %. Hence the null hypothesis that the residuals are not normally distributed is rejected. The serial correlation test reveals that there is no serial correlation in the model because the probability value is greater than 5 %. The Chi-square probability value for the heteroskedasticity test indicates that there is no ARCH effect because the likelihood value is more than 5 %. Hence, for both basic and advanced channels, the variables are normally distributed, homoscedastic, and devoid of serial correlation because the probability of the three tests indicated above is greater than 0.05.

Discussion of findings

The impact of the oil price shock on human capital channels was investigated in this study. To ascertain the time series properties, the Philip-Perron and Augmented Dickey-Fuller tests were used. The result showed that while none of the series are stationary at level, they all become stationary at first differencing. The Johansen co-integration was tested to show the number of cointegrating vectors. For the basic channels, the trace test indicates three cointegrating relationships, while the maximum Eigen value indicates two cointegrating relationships. Similarly, the result of the advanced channel revealed that the trace test shows three cointegrating relationships and the maximum Eigen test indicates two cointegrating vectors. The long-run equation for the basic channel, using primary school enrollment as an explanatory variable, has a direct relationship with the oil price, secondary school enrollment, employment, and aggregate output, whereas primary school enrollment exerts an inverse association with gross fixed capital formation. When secondary enrollment is used as a dependent variable, it has a negative relationship with gross fixed capital formation and aggregate output, while it exerts a negative association with the oil price and employment.

The long-run equation for the advanced channel; using tertiary institution enrollment as the explained variable, it has a negative association with the oil price; this finding aligns with the study of Almutairi [49]. In addition, government expenditure and aggregate output have negative relationship with oil price, this is line with the study of Zakaria et al [50] and Mrabet et al. [51]. However, oil price has positive relationship with gross fixed capital formation and employment; the outcome aligns with the study of Opadeji et al [52]. In addition, when government expenditure on tertiary education is used as a dependent variable, it has a positive relationship with the oil price and total output, with a negative connection with employment and gross fixed capital formation. The impulse response function for basic channels revealed that oil price shows more variation in primary school enrollment than other variables. For the advance channels, the result revealed that oil price has a negative impact on university enrollment in the short run and a positive impact on university enrollment and government expenditure in the long run.

The findings in this study revealed that over-dependence on oil sector had not helped boost sustainable gross domestic product (GDP) over time; even though it has a positive effect on primary school enrollment, and employment in Nigeria but the ability to spur research and development in the advanced channels is limited as stressed in the studies by Popoola *et al.* [32], Lee and Lee [31] and, Escosura, and Roses, [30]. This study contradicts the study of Kim [53], who documented that the contribution of natural resources improves education. But in line with studies that documented that a negative effect on oil price will have an adverse effect on the economy [54–56]. Variation in oil shock affects human capital (both the basic and advanced channels); this finding is in line with Eyden *et al.* [1] on oil price shock and economic growth.

Conclusion and recommendations

This study examines how the oil shock affected human capital channels. The long-run equation was established using the normalised equation.The human capital channels were categorised into the basic and the advanced channels. In the basic channel, using primary school enrollment as an explained variable, it has a positive association with the oil price, secondary school enrollment, employment, and aggregate output. While primary school enrollment exerts a negative connection with gross fixed capital formation. When secondary enrollment is used as an explained variable, it has a negative association with gross fixed capital formation and aggregate output, while it exerts a positive association with employment and oil prices. Although the basic channels of human capital tend to increase employment in the long run, they are limited to transforming the economy through research and innovation that can improve aggregate welfare. Likewise, the basic channel indicators are elastic to changes in oil price; by this, an adverse effect on the oil price could result in negative outcomes on the basic channel indicators and employment in the long run.

For the advanced channel, using tertiary institution enrollment as an explained variable, it has a negative association with the oil price, government expenditure, and aggregate output, with a positive association with gross fixed capital formation and employment. In addition, when government expenditure on tertiary education is used as an explained variable, it has a positive connection with the oil price and aggregate output, with a negative association with employment and gross fixed capital formation. Even though Nigeria's economy is based solely on the oil industry, making it a monoproduct nation. However, the benefit from the oil sector has not promoted enrollment in tertiary institutions as observed in the results, despite the positive connection between government expenditure on

education and oil prices.

The findings of this study underline the urgent need for policy implementation to address the negative effects of oil price shocks on human capital development in Nigeria. The country's heavy reliance on oil revenues has worsened vulnerabilities in education and economic resilience. To counteract these issues, diversification of the Nigerian economy is essential; this approach will help close the gap between declining oil revenues and rising expenditures, positively impacting human capital channels. The government should prioritise policies that enhance tertiary education enrollment and boost funding for research and development, either through direct investment or by encouraging private sector participation. Additionally, promoting linkages between industrialisation and higher education, and integrating entrepreneurship training at all educational levels, will support the development of both basic and advanced human capital channels.

These recommendations are aligned with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth), and contribute to Africa's Union Agenda 2063; by providing insights for economic diversification and human capital development, which are essential for achieving sustainable economic growth and reducing vulnerabilities in oil-dependent economies. The study emphasis on the need to address these policy needs, which may help build economic resilience and improve educational outcomes, extending more comprehensive framework for effective policy development and national economic planning.

CRediT authorship contribution statement

Olabisi Rasheedat Oladipo: Conceptualization, Formal analysis, Funding acquisition, Methodology, Software, Supervision, Writing – original draft, Writing – review & editing. **Abiola John Asaleye:** Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Ademola Andrew Onabote:** Project administration, Visualization, Writing – original draft, Writing – review & editing. **Damilola Felix Eluyela:** Resources, Validation, Writing – review & editing. **Rotimi Ayoade Ogunjumo:** Conceptualization, Writing – original draft, Writing – review & editing. **Joseph Olufemi Ogunjobi:** Data curation, Resources. **Olufemi Adebayo Oladipo:** Data curation, Project administration, Software, Validation, Visualization. **Stephen Adesina Ibitowa:** Visualization, Writing – review & editing.

Declaration of competing interest

We have read and understood the policies on declaration of interest of your reputable journal (Scientific African), and we declare that we have no conflict of interest.

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Supplementary materials

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