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THE ROLE OF RESEARCH & DEVELOPMENT (R&D) INVESTMENT ON ECONOMIC TRANSFORMATION IN NIGERIA

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Abstract

This paper investigates the role of Research and Development (R&D) investment (expenditure) in Nigeria's economic transformation process in the 32-year period from 1990 to 2021, using the ARDL modeling technique, where variables may have a long-term relationship but may also exhibit short-term dynamics. The study finds that R&D expenditures have a positive relationship with the export diversification index (EDI), which is a trade-based measure of economic transformation, although the impact is not statistically significant, thus indicating a weak relationship between R&D expenditure and economic transformation. It also reveals that the control variables: ALR (adult literacy rate - used to proxy human capital development) has a positive relationship with the EDI in the second lagged period, and CRP (credit to the private sector as a percentage of GDP), and FDI (foreign direct investment stock as a percentage of GDP) have positive relationships with the EDI in the current and second lagged periods, thus implying positive impacts on economic transformation. Thus, increasing spending on R&D can drive economic transformation in Nigeria, but it should be accompanied by other measures, including measures to improve literacy, credit to the private sector, and FDI inflows into the

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country, as these can help to enhance the impact of R&D expenditures on economic transformation in Nigeria. The paper concludes that the Nigerian government would need to be better committed to R&D efforts in order to boost its rate of economic transformation. It recommends, among other measures, a need for Nigeria to rapidly increase public funding for R&D, improve the efficiency of this increased R&D funding through a more targeted approach and create an environment that encourages R&D, especially for the private sector.
Keywords: Research and Development Expenditure, Economic Transformation, Science, Technology, Innovation

INTRODUCTION

The importance of Research and Development (R&D) to the economic progress of countries has been relatively well recognized. Science, Technology, and Innovation (STI) are essential for the economic transformation of any society. Recent research shows that more than 50 percent of the wealth created in developed countries is due to technology, which is often a product of R&D activities (Ozor, 2020). High-level R&D activities and the resulting innovation have contributed significantly to the transformation of top economies such as the United States, China, France, United Kingdom, India, and South Korea (Alizada, 2019; Ozor, 2020; Shrestha et al., 2019). R&D is a major source of technical change, leading to the creation of new goods, processes, and knowledge, as well as the absorption of existing technology, which reduces production costs and improves product quality (Boţoroga et al., 2022; Sezgin, 2020). R&D also helps with achieving well-designed and efficient production techniques in production processes and the creation of new and improved products. There is sufficient evidence that countries with more R&D expenditure benefit from higher productivity which has a direct impact on the economic transformation path of any given country. R&D expands the boundaries of knowledge and thus expands human capacities for innovation. As of 2018, Nigeria's investment in R&D was relatively low compared to other countries, with its share as a percentage of GDP at only 0.22 percent, according to data from the World Bank. Estimates for 2021 put this figure at 0.31 percent, which is below the African Union's target of 1 percent of GDP to be invested in research and development by African countries.

To transform its economy and achieve its national agenda of becoming one of the top 20 economies in the world, Nigeria would need to build strong technological infrastructure, increase its STI capabilities, and implement effective R&D funding mechanisms and policies. Through R&D and other controlling macro-economic variables, an economy can progress towards the production and export of more sophisticated products, which is a hallmark of economic

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transformation. Indeed, economic transformation has been referred to as the continuous process of moving labor and other economic resources from lower to higher-productivity sectors; and raising within-sector productivity growth (e.g., from low-productivity subsistence farming to high-value crops within sophisticated value chains). Within-sector productivity growth entails the adoption of new and modern technologies and management practices that increase production efficiency (McMillan et al., 2017). Economic transformation is thus measured either through production-based indices (e.g., sectoral shares of output or employment) or trade-based indices (e.g., export diversification index). Economic transformation, either through output sophistication or export sophistication and diversification, in turn, contributes to economic development which entails growth with structural transformation. Besides, export diversification allows a government to achieve some of its macroeconomic objectives, which includes sustainable economic growth, a satisfactory balance of payments situation, employment and redistribution of income, leading to economic transformation (Sharda, 2022.; Streimikiene & Kyriakopoulos, 2022).

In order to achieve long-term economic transformation, R&D investments play a crucial role. R&D is an important driver of innovation, which ultimately increases productivity and leads to economic transformation (Sehleanu et al., 2021). Theoretically, R&D expenditures are expected to have a positive and persistent effect on economic transformation. However, determining this effect empirically could be complicated due to direct and indirect effects of different types of R&D. Nonetheless, some empirical studies have been conducted to investigate the relationship between R&D expenditures and economic transformation. These studies vary in terms of the level of aggregation (firms, industries, or countries), sources of data (time periods, countries), and measurements of key variables (stocks, flows, or differences). Despite these differences, the overall findings of these studies generally support the theoretical assumptions. For instance, studies conducted by (Matyushok et al., 2020; Zafar et al., 2019) in Taiwan found that R&D expenditures have a significant positive effect on economic transformation. Similarly, a study by (Kim, 2019) in Germany also confirmed the positive relationship between R&D expenditures and economic transformation. Moreover, a meta-analysis of 45 studies conducted by (Ali et al., 2020) found that R&D expenditures have a positive and significant effect on economic transformation. Finally, a more recent study by Ghazouani and (Kim, 2019; Lee et al., 2020) in Turkey also confirmed the positive relationship between R&D expenditures and economic transformation. Therefore, despite the methodological differences among studies, the overall empirical evidence suggests that R&D investments are crucial for achieving long-term economic transformation.

There have also been a couple of studies examining the relationship between research and development (R&D) expenditures and economic transformation using panel data analysis.

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However, results vary depending on the panel, time period, variables, and econometric methods used. (Guo et al., 2020) conducted a literature review of aggregate-level effects of R&D and found that public R&D had a neutral effect on growth, neither stimulating nor crowding out private R&D. Furthermore, total R&D in Central and Eastern European Countries (CEECs) did not appear to be statistically significant in any specification between 2008 and 2018. (Ullah et al., 2022) conducted a panel data regression analysis for 26 selected European Union (EU) countries between 1999 and 2011. Their findings suggested a positive impact of R&D expenditures on economic transformation when considering a two-year lag, but a negative effect in the current year. These results are consistent with a study by Chen, Chen, and Chen (2018) in Taiwan, which found that R&D expenditures have a positive impact on economic transformation but with a lag effect. In contrast, a study by (Visconte, 2020) in Turkey found a significant and positive effect of R&D expenditures on economic transformation without any lag effect. Therefore, the findings on the relationship between R&D expenditures and economic transformation are not consistent across different studies, and the results may depend on the context and the methodological approach used as seen the studies of (Alghazali et al., 2022; Bohloolvand & Shemshadi, 2022; Olaoye et al., 2021, 2021; Prasetyo et al., 2022).

Popa (2020) conducted an analysis of the contribution of research and development (R&D) expenditure to economic transformation, comparing developed and developing countries. He found that R&D expenditure has a positive and significant effect on economic transformation in the long run for all countries. However, the effect was weak in the short run for developing countries but strong in the long run. The authors considered all European Union (EU) countries to be developed in their analysis. These findings are consistent with a meta-analysis of 45 studies conducted by (Kadir et al., 2020), which found that R&D expenditures have a positive and significant effect on economic transformation across different countries and regions. Moreover, a more recent study by (Ismayilov et al., 2021) in Turkey also confirmed the positive relationship between R&D expenditures and economic transformation. Therefore, the overall empirical evidence suggests that R&D investments are important for achieving long-term economic transformation in both developed and developing countries.

Based on the literature review, there is still a pending question about the total effects of research and development (R&D) expenditure on economic transformation in Nigeria. From previous studies, we expect that there is a statistically significant and positive impact on economic transformation, at least in recent years. However, with respect to regional convergence speed in Nigeria, R&D expenditure could have a more significant effect. To our knowledge, there are limited timeseries data studies for Nigeria where dynamic results (short-run and long-run effect estimates in ARDL) are obtained. Therefore, further research is needed

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to explore the relationship between R&D expenditure and economic transformation in Nigeria. Thus, the goal of this paper is to investigate the role of research and development expenditures in the economic transformation process of Nigeria while examining the controlling effects of Nigeria's adult literacy rate (as another proxy for human capital development), credit to private sector (which is expected to boost firms' ability to spend on R&D) and foreign direct investment (expected to contribute to increased productivity, innovation and technology transfer) with the application of time series data in an econometric model.

METHODOLOGY

Research design

In the study, we adopted a non-experimental quantitative research design, specifically an ex-post facto research design, as it allowed for the collection of data without interfering with the natural setting of the research. This type of design is commonly used in econometrics research when it is not feasible or ethical to manipulate the independent variable (see Rodriguez et al., 2022; Waleed & Siddiqui, 2021); Díaz-Lanchas et al., 2021).

Sample frame

The research used publicly available secondary data from various sources, including the International Monetary Fund (IMF) and the World Bank's World Development Indicators. The data covered a 32-year period from 1990 to 2021 and were downloaded from the public websites of these institutions. The choice of 1990 as the start period was due to data constraints for Nigeria prior to then, while the end year of 2021 was due to the unavailability of 2022 data for most of the variables.

Model Specification

The model used in this study was built based on an adapted endogenous growth equation model. Domestic RDE was included as a form of human capital in explaining economic transformation (as against growth in the standard endogenous growth model). The Export Diversification Index (EDI) – a trade-based measure of economic transformation – is the dependent variable, while ALR, CRP and FDI play a controlling effect role in the relationship between RDE and EDI, as shown in equation 1:

$$\ln EDI_{i,t} = \beta_0 \ln EDI_{i,t-1} + \beta_1 \ln RDE_{i,t} + \beta_2 \ln \mathrm{ALR}_{i,t} + +\beta_3 \ln \mathrm{CRP}_{i,t} + \beta_4 \ln FDI_{i,t} + \varepsilon_{i,t} \quad \ldots 1$$

Where: *EDI* is export diversification index, *RDE* is R&D expenditure in percentage of GDP, *ALR* is the adult literacy rate used to proxy human capital development. *CRP* is credit to private

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sector as a percentage of GDP, and *FDI* is foreign direct investment stock as a percentage of GDP (detailed description of the variables and data sources are presented in Table I), and thus represents the set of control variables; $\mathcal{E}_{i,t}$ is an error term assumed to be homoscedastic and with no serial correlation.

Estimation (Modeling) Technique

The estimation technique applied by this study to analyze the role that Research and Development (R&D) play in Nigeria's economic transformation is the Autoregressive Distributed Lag (ARDL) technique through Bounds testing approach and Error Correction Model (ECM) to examine the existence of long-run and short-run relationships among the variables. The ARDL methodology was first published by Sargan (1964) where it was described as a major workhouse in a dynamic single equation regression. It was further popularized by Hendry (1967) and extended by the duo of Pesaran and Shin (1999) and Pesaran et al. (2001) in (Olaoye et al., 2021; Onsay, 2021).

ARDL models are often used to analyze dynamic relationships with time series data in a single-equation framework. The current value of the dependent variable is allowed to depend on its own past values – the autoregressive part – as well as current and past values of additional explanatory variables – the distributed lag part. The variables can be stationary, non-stationary, or a mixture of both. In its equilibrium correction (EC) representation, the ARDL model can be used to separate the long-run and short-run effects, and to test for cointegration or, more generally, for the existence of a long- run relationship among the variables of interest.

A general form of an ARDL model is as follows:

$$Y_t = \mu_0 + \sum_{i=1}^{k} \beta_{0i} X_{ti} + \beta_{1i} X_{(t-1)i} + \ldots + \beta_{pi} X_{(t-pt)i} + \gamma_1 Y_{t-1} + \ldots + \gamma_q Y_{t-q} + e_t$$

Where:

μ_0 is the constant.

Y_t and X_{ti} are respectively dependent ith independent series;

pi is the lag order of i^{th} independent series;

q is the autoregressive order of the model; and

e_t is the (white noise) error term.

The parameters, $\beta_{(0i,1i,\ldots,pi)}$ function as short-run multipliers, while the $\gamma_{i \ldots 1}$, for i=1, …, q parameters function as the long-run dynamic coefficients of the underlying ARDL model.

Furthermore, time plots, descriptive statistics, test for normality, unit root test, Optimal Lag Length determination, and other model diagnostics like; Autocorrelation Test,

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Heteroscedasticity Test, Normality Test for Residuals (Histogram and Jarque-Bera Test), and the Parameter Stability Test (CUSUM Chart) is computed using EVIEWS 12 econometric package, for robust conclusion on the study objectives.

Table 1 Description of variables

Variable	Description	Source
ln*EDIi,t*	Natural logarithm of Export diversification index	International Monetary Fund
lnRDE*i,t*	Natural logarithm of R&D expenditure (in % of GDP)	World Bank
ln*ALRi,t*	Natural logarithm of Adult literacy rate (proxy of human capital formation)	World Bank: Literacy rate, adult total (% of people ages 15 and above)
ln*CRPsi,t*	Natural logarithm of Credit to private sector (proxy of access to credit) as a percentage of GDP	World Bank
ln*FDIi,t*	Natural logarithm of foreign direct investment (% of GDP)	World Bank

RESULTS

Descriptive Statistics of Study Variables

Table 2 Descriptive Statistics and Test of Normality of Study Variables

Statistics	EDI	FDI	RDE	ALR	CRP
Mean	5.753969	1.634469	0.431906	56.06703	10.20338
Median	5.834	1.501	0.3015	55.209	9.395
Maximum	6.077	5.791	1.813	70.198	19.626
Minimum	5.253	0.195	0.04	49.813	4.958
Std. Dev.	0.241197	1.19657	0.382146	4.909184	3.494397
Skewness	-0.616057	1.86378	1.811998	1.512509	0.889336
Kurtosis	2.13217	6.879634	6.598794	5.137031	3.576356
Jarque-Bera	3.028312	38.59501	34.77956	18.29017	4.66115
Probability	0.219994	0	0	0.000107	0.09724
Observations	32	32	32	32	32

EDI is export diversification index,
RDE is R&D expenditure in percentage of GDP,
ALR is the adult literacy rate used for proxy human capital development.
CRP is credit to private sector as proxy for access to credit in percentage of GDP,
FDI is foreign direct investment stock as percentage of GDP

The mean EDI value is 5.753969, while the median value of 5.834 is close to the mean, indicating that the data is not skewed. The minimum and maximum EDI values are 5.253 and 6.077, respectively. The standard deviation of 0.241197 is relatively small, suggesting that the

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data points are close to the mean value. The skewness of -0.616057 indicates that the data is slightly negatively skewed, meaning that more observations have higher EDI values than lower ones. The kurtosis value of 2.13217 is greater than 3, which indicates that the data is slightly more peaked than a normal distribution. Also, the Jarque-Bera test result of 3.028312 with a probability of 0.219994 suggests that the data is normally distributed, as the p-value is above the common significance level of 0.05.

The mean FDI value is 1.634469. The median value of 1.501 is lower than the mean, indicating that the data is positively skewed. The minimum and maximum FDI values of 0.195 and 5.791, respectively. The standard deviation of 1.19657 is relatively large, suggesting that the data points are more spread out from the mean value. The skewness of 1.86378 indicates that the data is significantly positively skewed, meaning that more observations have lower FDI values than higher ones. The kurtosis value of 6.879634 is much greater than 3, which indicates that the data is much more peaked than a normal distribution. The Jarque-Bera test result of 38.59501 with a probability of 0.000 suggests that the data is not normally distributed. The low probability indicates that the data significantly deviates from normality. Therefore, the variable will be transformed by taking natural log to correct the effect of this non normality as a prerequisite for application of ARDL model.

The mean RDE value is 0.431906. The median value of 0.3015 is lower than the mean, indicating that the data is positively skewed. The minimum and maximum RDE values of 0.04 and 1.813, respectively. The standard deviation of 0.382146 is relatively large, suggesting that the data points are more spread out from the mean value. The skewness of 1.811998 indicates that the data is significantly positively skewed, meaning that more observations have lower RDE values than higher ones. The kurtosis value of 6.598794 is much greater than 3, which indicates that the data is much more peaked than a normal distribution. The Jarque-Bera test result of 34.77956 with a probability of 0 suggests that the data is not normally distributed. The low probability indicates that the data significantly deviates from normality.

The mean ALR value is 56.06703, meaning that the country has relatively low levels of adult literacy, even when compared to other African countries like Ghana, Kenya, and South Africa. The minimum and maximum values of 49.813 and 70.198, respectively. The standard deviation of 4.909184 is relatively low compared to the range of values, indicating that the data is relatively clustered around the mean value. The median value of 55.209 is lower than the mean, which indicates that the data is positively skewed. The skewness of 1.512509 indicates that the data is significantly positively skewed, meaning that more observations have lower ALR values than higher ones. The kurtosis value of 5.137031 is greater than 3, indicating that the data is more peaked than a normal distribution. The Jarque-Bera test result of 18.29017 with a

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probability of 0.000107 indicates that the data is not normally distributed. The low probability indicates that the data significantly deviates from normality, and therefore, the techniques that assume normality should be used with caution.

The mean CRP value of 10.20338. The minimum and maximum values of 4.958 and 19.626, respectively, suggest a wide range of CRP values. The standard deviation of 3.494397 is relatively high compared to the mean, indicating that the data is widely spread out. The median value of 9.395 is lower than the mean, indicating that the data is positively skewed. The skewness value of 0.889336 confirms this and indicates that more observations have lower CRP values than higher ones. The kurtosis value of 3.576356 is also greater than 3, suggesting that the data is more peaked than a normal distribution. The Jarque-Bera test result of 4.66115 with a probability of 0.09724 indicates that the data is approximately normally distributed. While the probability is greater than the conventional threshold of 0.05, indicating a non-significant deviation from normality, it should be noted that the skewness and kurtosis values suggest a non-normal distribution.

Figure 1 The time plot at level for the export diversification index, research and development expenditure and other control variables for period 1990-2021 (E-VIEWS 12 Output)

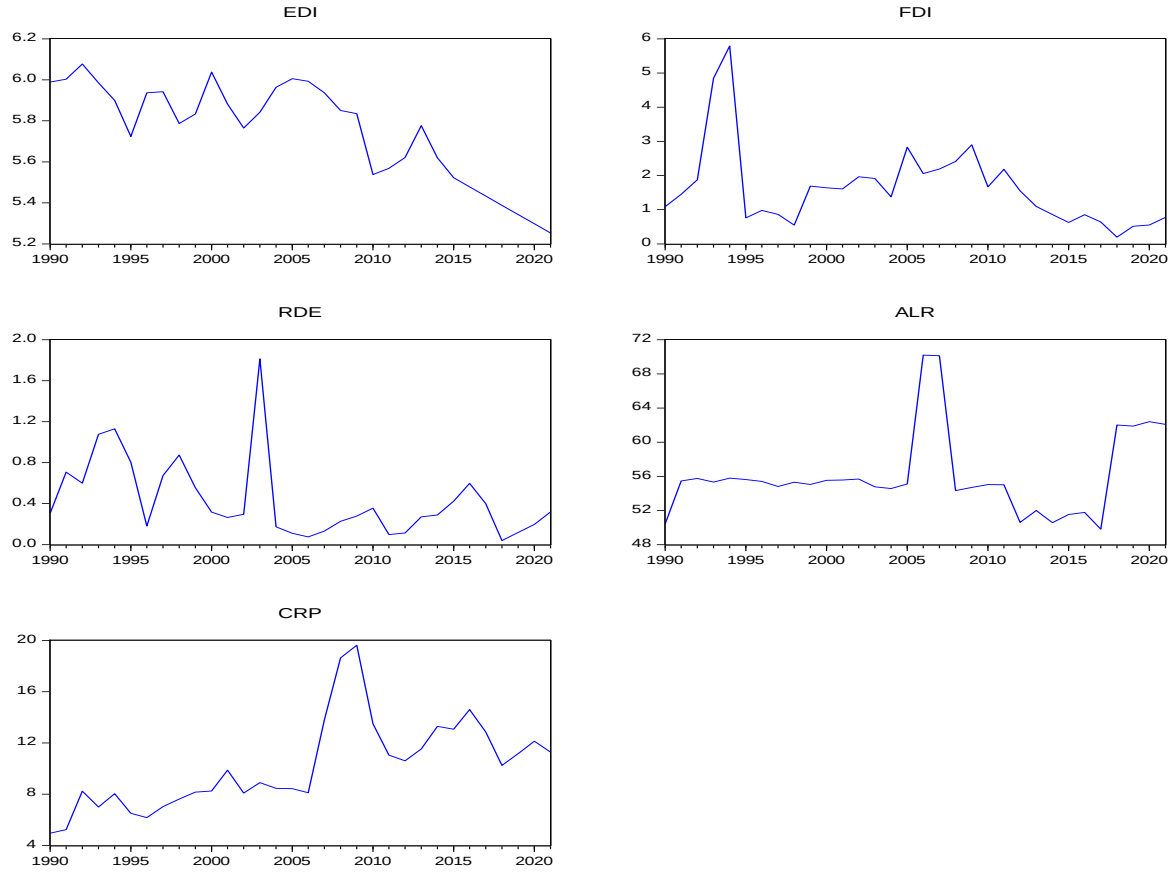

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Figure 1 presents the trend analysis of the yearly data on all variables selected for the study from the period 1990 to 2021. From the trend plots, we can observe that, FDI (Foreign Direct Investment) had a steady increase until around 2003, followed by a period of fluctuation. After 2010, FDI decreased and has remained relatively low. RDE (Research and Development Expenditures) had a similar pattern to FDI, but the fluctuations were more pronounced. There was a large increase in RDE in 2013, but it quickly decreased the following year. ALR (Adult Literacy Rate) has been steadily increasing over the years, with a minor dip in the mid-2000s. EDI has also been steadily increasing, with a more noticeable increase after 2010. While, CRP has been fluctuating over the years, with a notable spike in 2008 followed by a steady decrease until 2015, when it began to increase again. The credit to private sector (CRP) has fluctuated over the years, with a notable increase in 2008.

Unit Root Test Results

Table 3 Augmented Dickey-Fuller test statistic

Variable		Level		1st Difference		2nd Difference	
		t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*
EDI	export diversification index	-1.816	0.369	-7.303	0.000	NA	NA
RDE	research and development expenditure in percentage of GDP,	0.446	0.983	-5.517	0.000	NA	NA
ALR	adult literacy rate used for proxy human capital development	-0.995	0.749	-12.986	0.000	NA	NA
CRP	credit to private sector as proxy for access to credit in percentage of GDP	-1.365	0.592	-6.778	0.000	NA	NA
FDI	foreign direct investment stock as percentage of GDP	3.183	1	-7.251	0.000	NA	NA
NA = test is not required since stationarity is obtained							

The table shows the results of calculating the first difference for five variables: EDI (export diversification index), RDE (research and development expenditure in percentage of GDP), ALR (adult literacy rate used for proxy human capital development), CRP (credit to private sector as proxy for access to credit in percentage of GDP), and FDI (foreign direct investment stock as percentage of GDP).

The table presents the probability of observing the t-statistic for each variable, both before and after taking the first difference. The p-values in the "1st Difference" column are all very small (less than 0.001), indicating that the first difference has reduced the serial correlation and made the data stationary, making it easier to identify trends and relationships in the data.

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Additionally, all the t-statistics are negative, indicating that the changes in the variables over time are statistically significant.

Determination of Lag Length

Table 4 VAR Lag Order Selection Criteria

Endogenous variables: EDI

Exogenous variables: C RDE ALR CRP FDI

Sample: 1990 2021

Lag	LogL	LR	FPE	AIC	SC	HQ
0	8.213925	NA	0.047406	-0.214262	0.019271	-0.139553
1	25.65533	27.90625*	0.015879*	-1.310355*	-1.030116*	-1.220704*
2	25.69860	0.066350	0.016980	-1.246573	-0.919627	-1.141981

As observed from Table 4, the Vector Autoregressive Lag order is one (1) based on the Akaike Information Criterion (AIC). Hence, the lag of order-1 will be used in the model specification.

Bounds Cointegration Test

Table 5 F-Bounds Test

Null Hypothesis:
No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic : n=1000	
F-statistic	0.858856	10%	2.2	3.09
k	4	**5%**	**2.56**	**3.49**
		2.5%	2.88	3.87
		1%	3.29	4.37

The F-statistic test (0.8589) which is less than the critical value upper bound (2.56) indicates the no presence of cointegrating among the variables, denoting the acceptance of the

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null hypothesis of no cointegrating equation between the export diversification index and economic transformation variables at 5 per cent level of significance. The non-existence of a cointegrating equation indicates the presence of short-run relationships between the variables and hence, the ARDL model is employed to study the short-run effect of the independent variables on the dependent variable.

Model Estimation

Table 6 Estimated ARDL (2,2,2,2,2) (E-Views 12 output)

Method: ARDL				
Sample (adjusted): 1992 2021				
Included observations: 30 after adjustments				
Dependent lags: 2 (Fixed)				
Dynamic regressors (2 lags, fixed): RDE ALR CRP FDI				
Fixed regressors: C				
Dependent Variable: EDI				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
EDI(-1)	0.816227	0.235143	3.47119	0.0034
EDI(-2)	0.04173	0.238153	0.175222	0.8632
RDE	0.061901	0.069145	0.895238	0.3848
RDE(-1)	0.048343	0.06747	0.71651	0.4847
RDE(-2)	0.025223	0.069305	0.363947	0.721
ALR	-0.000403	0.005698	-0.070789	0.9445
ALR(-1)	-0.010815	0.006613	-1.635584	0.1227
ALR(-2)	0.012337	0.006422	1.921125	0.0739
CRP	0.016107	0.014104	1.141952	0.2714
CRP(-1)	-0.047705	0.017701	-2.694985	0.0166
CRP(-2)	0.016238	0.015225	1.066495	0.3031
FDI	0.017021	0.024473	0.695493	0.4974
FDI(-1)	-0.029584	0.025003	-1.183238	0.2551
FDI(-2)	0.011971	0.025626	0.467144	0.6471
C	0.889588	1.184618	0.750949	0.4643
R-squared			0.903132	
Adjusted R-squared			0.812722	
F-statistic			9.989261	
Prob(F-statistic)			0.000033	
Durbin-Watson stat			2.234786	

In the given model in Table 6 above, the coefficients and p-values for each variable are reported as follows:

The study examines the relationship between the export diversification index (EDI) – a proxy for economic transformation – and research and development expenditure (RDE), while

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controlling for other variables (ALR, CRP and FDI). The ARDL model shows that research and development expenditure (RDE) has a positive effect on the export diversification index (EDI) in the current period, as indicated by the coefficient of 0.061901. However, the p-value of 0.3848 suggests that this relationship is not statistically significant. The lagged values of RDE (-1 and -2 periods ago) are also not found to be significant predictors of EDI, as indicated by their respective coefficients and p-values, although they are also positively related to EDI. Therefore, there is insufficient evidence to suggest that RDE is a significant predictor of current EDI. The findings therefore negate the studies of (Ali et al., 2020; Matyushok et al., 2020; Sehleanu et al., 2021; Zafar et al., 2019) that report positive and significant relationship between research and development and economic transformation.

The adult literacy rate (ALR) was analyzed as a predictor of the export diversification index (EDI) in three time periods: current, lagged by one period, and lagged by two periods. The coefficient for ALR in the current period was -0.000403, indicating that a one-unit increase in ALR in the current period is associated with a very small decline in EDI. Furthermore, the p-value of 0.9445 suggests that this relationship is not statistically significant. Similarly, the coefficient for the lagged ALR in the first period was -0.010815, but the p-value of 0.1227 indicates insufficient evidence to suggest that this lagged variable is a significant predictor of current EDI. The coefficient for the lagged ALR in the second period was 0.012337, indicating that a one-unit increase in ALR two periods ago is associated with a small expected increase in EDI. The p-value of 0.0739 suggests that this relationship is not statistically significant at conventional levels, but it is significant at the 10% level. This finding corroborates the submission of (Alizada, 2019; Boţoroga et al., 2022; Ozor, 2020; Streimikiene & Kyriakopoulos, 2022).

The export diversification index (EDI) is analyzed in relation to credit to the private sector (CRP) in the lagged ARDL model. The coefficient for CRP in the current period is positive at 0.016107, indicating that an increase in CRP is associated with an expected increase in EDI, holding all other variables constant. However, the p-value of 0.2714 suggests that this relationship is not statistically significant. The coefficient for the lagged value of CRP in the immediate previous period is negative at -0.047705, implying that an increase in CRP in the previous period is associated with a decrease in EDI in the current period, but this coefficient is statistically significant at the 5% level. The coefficient for the lagged value of CRP two periods ago is positive at 0.016238, but it is not statistically significant at conventional levels, indicating insufficient evidence to suggest that the lagged value of CRP two periods ago is a significant predictor of current EDI. Thus negating the findings of (Guo et al., 2020; LEE et al., 2020; Ullah et al., 2022; Visconte, 2020).

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Furthermore, foreign direct investment (FDI) and the export diversification index (EDI) relationship was explored. The results show that a one-unit increase in FDI is associated with an expected 0.017021 increase in EDI in the current period, indicating a positive effect on EDI. However, the p-value of 0.4974 suggests that this relationship is not statistically significant at conventional levels, indicating insufficient evidence to suggest that FDI is a significant predictor of current EDI. The lagged values of FDI (-1 and -2 periods) also show no statistically significant relationship with current EDI. Lastly, the constant term in the regression equation is represented by the coefficient C, which is equal to 0.889588. This coefficient reflects the expected value of the export diversification index (EDI) when all other variables in the equation are set to zero. Similarly, this finds does not totally support reviewed works of literature (Alizada, 2019; OZOR, 2020; Shrestha et al., 2019) in Nigeria context.

Summarily, the ARDL model suggests that the lagged value of EDI and the lagged value of CRP(-1) are the only significant predictors of current EDI among the dynamic regressors included in the model. However, CRP(-1) is of the wrong sign. The coefficients for the other dynamic regressors are either statistically insignificant or only marginally significant.

Summary of Model Performance

The model's R-squared value of 0.903132 suggests that a large portion of the variation in the dependent variable, export diversification index (EDI), is explained by the included independent variables. This indicates that the model captures approximately 90% of the variability in EDI. The adjusted R-squared value of 0.812722, which considers the number of independent variables in the model, is only slightly lower than the R-squared value, suggesting that including irrelevant variables did not significantly impact the model's performance. The F-statistic of 9.989261, with a very low p-value of 0.000033, confirms that the model is statistically significant, meaning that at least one of the independent variables has a significant impact on EDI. The Durbin-Watson statistic of 2.234786, which falls within an acceptable range of 1.5 to 2.5, indicates that there is no significant correlation in the residuals of the model, further supporting its suitability for the data.

CONCLUSION

The economic transformation of developed nations such as China, South Korea, and Singapore has been attributed to their focus on technological development (Boţoroga et al., 2022; Streimikiene & Kyriakopoulos, 2022). The Nigerian government has also recognized the importance of technological development and innovation in achieving economic transformation but is yet to accord due attention to research and development (R&D) which is able to drive

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technological development and innovation. This is evident from the significantly low annual expenditure (public and private) on R&D which has consistently been less than 1 percent of GDP over the past 3 decades. This study examined the impact of R&D expenditures on Nigeria's economic transformation between 1990 and 2021, taking into account the country's adult literacy rate as a contributor to economic transformation, credit to the private sector, and foreign direct investment as other contributors to the economic transformation process.

The study finds that while gross expenditure on research and development (RDE) plays an insignificant role in economic transformation, a positive relationship between both variables is observed. The study also reveals that the control variables; ALR (adult literacy rate used for proxy human capital development), CRP (credit to private sector as proxy for access to credit in percentage of GDP), and FDI (foreign direct investment stock as percentage of GDP) have a positive relationship (except the 1st lag of ALR, CRP and FDI) with the export diversification index (EDI), thus implying a positive impact on economic transformation. Therefore, increasing spending on RDE can drive economic transformation in Nigeria, but it must be accompanied by other measures, including measures to improve literacy, credit to the private sector, and FDI inflows into the country, as these can also help to enhance the impact of R&D expenditures on economic transformation in Nigeria.

Indeed, increased expenditure on R&D expenditures can have both direct and indirect impacts on Nigeria’s export diversification index, which is a proxy for economic transformation. Direct impacts include the creation of new jobs in R&D expenditure-related fields, while indirect impacts may include increased productivity and efficiency in the secondary and tertiary sectors of the economy.

RECOMMENDATIONS

To maximize the impact of R&D expenditures on Nigeria's economic transformation, this paper recommends that Nigeria places a stronger focus on R&D, and this can be done in a variety of ways. Firstly, there is a need to rapidly increase public funding for R&D. A more significant amount of the federal and subnational budgets should be allocated to R&D. Secondly, the efficiency of the increased R&D expenditure should be improved. To this end, a more targeted approach by the Nigerian government will be crucial. For example, it is established that the manufacturing sector in Nigeria is particularly poorly developed, and it constitutes less than 10 percent of national output and employment. But since the manufacturing sector plays a special role in the process of economic transformation, and evidence suggests that manufacturing tends to be more productive than many other sectors - traditionally supporting large-scale job generation, this study recommends that the government

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of Nigeria's R&D efforts targeted at the enhancement of industrial and manufacturing capabilities. As manufacturing has now become more capital-intensive, it will be increasingly important to be more strategic about this sector.

Thirdly, to encourage and enhance private sector capacities and participation in R&D, Nigeria should create an environment that encourages R&D. For example, research funding agencies could also be established. and research infrastructure, such as laboratories and research centers should be provided. Tax incentives could also be offered to companies that invest more in R&D. Fourthly, Nigeria should encourage collaboration between universities, research institutions, and the private sector. This can be achieved through joint research projects, partnerships, and knowledge sharing. In addition, Science education at all levels (primary secondary and tertiary) should be promoted to help create a pool of skilled researchers and innovators who can contribute to the country's R&D efforts. Lastly, Nigeria would do well to develop a national innovation policy that specifies its goals and objectives for R&D. The policy should also provide a framework for the implementation of all R&D initiatives.

By implementing these measures, Nigeria can improve its R&D investments, and progress more rapidly on its economic transformation journey, in addition to positioning itself as a leader in innovation on the African continent.

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