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Impact of Brain Drain on the Manufacturing Sector Output in Nigeria (1990-2023)

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ABSTRACT
This study investigated the impact of brain drain on Nigeria's manufacturing sector output from 1990 to 2023. Brain drain, the emigration of skilled professionals seeking better opportunities abroad, poses significant challenges for developing economies, particularly in Africa. Nigeria's manufacturing sector, a critical driver of economic growth, has suffered due to the outflow of human capital, contributing to reduced productivity, underutilization of resources, and increased unemployment. Using secondary data from the World Bank and Nigeria's National Bureau of Statistics, the study employs the Autoregressive Distributed Lag (ARDL) model to examine the effects of net migration rate, per capita income, and unemployment on manufacturing output. Findings reveal that while net migration rate negatively affects the manufacturing sector in the short run, it contributes positively in the long run, suggesting that initial disruptions may stabilize over time. Per capita income demonstrates a significant positive impact on manufacturing output in both short- and long-term analyses, emphasizing its role in economic expansion. However, unemployment showed no statistically significant effect on the manufacturing sector. The results underscore the need for income-enhancing policies, economic diversification, and strategies to mitigate the adverse effects of skilled labor emigration. Policy recommendations include investment in human capital, promotion of innovation, and labor market reforms to boost industrial growth and economic stability.

Keywords: Manufacturing sector output, Brain drain, Net migration rates, Per capita income, Unemployment rate and ARDL
JEL Classifications: L60, F22, J61, O15, J64, and C51

I.INTRODUCTION

"Brain Drain" refers to the migration of individuals, particularly highly educated and skilled professionals, from their home countries to pursue higher education or better employment opportunities abroad. This phenomenon, often driven by factors such as political instability, economic difficulties, and undervaluation of skills, has a pronounced impact on developing nations (Mishra, Ghimire & Aithal, 2023). Commonly termed "human capital flight," it affects regions such as Caribbean Island nations, former African colonies, and Eastern Germany. Historically, brain drain gained attention in the 1960s when a notable exodus of scientists and engineers occurred from the United Kingdom to the United States (Docquier& Rapoport, 2008, as cited in Docquier, F., Lowell, B. L., &Marfouk, A., 2009). Initially less pronounced before the mid-20th century, the phenomenon intensified with migrations to Western nations like West Germany and North America. Today, brain drain remains a global issue, transcending regional boundaries as individuals seek improved prospects overseas.

Factors such as the desire for improved living standards and access to higher education motivate young individuals to leave their countries for education abroad. In 2000, around 175 million people, or 2.9% of the global population, lived outside their country of birth for over a year (Dodani& LaPorte, 2005). The number of international migrants increased from 75 million to 190 million between 1960 and 2005.Developed countries, facing a shortage of specialized human resources, often recruit and retain skilled individuals from across the globe. This movement of skilled labor has significant implications for the welfare and growth of sending economies. This reallocation of skilled labor was seen as detrimental to sending economies because it reduced the productivity of those left behind and had negative fiscal consequences (Groizard& Llull, 2007). A considerable portion of brain drain involves skilled

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migration. Docquier and Marfouk (2006) define a country's brain drain rate for a particular education level as the percentage of individuals aged 25 and over with that education level who were born in that country but now live abroad. In their data, they find that the brain drain rate for tertiaryeducated individuals is significantly higher than for those with primary or secondary education.

Brain drain is much more detrimental to the growth and development of African nations. The ongoing emigration of skilled workers could cause a financial loss in the area because of the lack of capital. There is need for close attention to the issue of brain drain in Africa, World Bank (2019). It is especially alarming that Nigeria is losing qualified people. Because the economy is marked by socioeconomic challenges such rising poverty, income inequality, and poor educational quality. One of Africa's most mobile populations, Nigerians were said to reside on almost every continent (Adeagbo and Ayandibu, 2014). In Nigeria, for instance, emigration has outpaced immigration for the past thirty years, maintaining a negative figure. More worrisome is the fact that the negative number has gotten worse over time. The net emigration rate decreased from -0.2 in 1990 to -0.3 in 2018. 2019 (World Bank). This demonstrates how desperate Nigerians are to leave their country. Remittances from abroad are a key justification for migration. According to the World Bank, Nigeria is the fifth-largest recipient of remittances globally and the top recipient in Africa (World Bank 2016; 2019).

Numerous studies emphasized that no developed nation has achieved economic growth and development without capitalizing on its manufacturing and industrial sectors (Adofu, Taiga, & Tijani, 2015). Research by Ekpo and Umoh (2014), Jide (2017), and Joshua, Happy, and Dankumo (2016) underscores the pivotal role of the manufacturing sector in driving sustainable economic development. The "manufacturing sector" encompasses all business entities involved in the production, processing, and distribution of goods, as well as activities that add value (Adebayo, 2010). In industrialized nations, this sector constitutes a significant part of the industrial economy. Manufactured goods can be sold directly to consumers as finished products or used as intermediate inputs in further production processes. The sector plays a crucial role in economic growth by enhancing productivity through import substitution, boosting export capacity, generating foreign exchange, creating jobs, and increasing per capita income (Dickson, 2010; Loto, 2012).

In Nigeria, the discovery of crude oil in 1956 at Oloibiri shifted the nation's focus from manufacturing to oil production (Adugna, 2014). This reliance on oil has led to poor performance in the manufacturing sector, accompanied by rising unemployment. Despite being the largest economy in Africa, Nigeria's manufacturing sector remains underdeveloped due to resource underutilization, insufficient investment, and widespread corruption. These challenges have contributed to escalating human capital flight, unemployment rates, high poverty levels, and a low standard of living (Awad, 2010; Eze &Ogiji, 2013).

According to the National Bureau of Statistics (2021), the manufacturing sector contributed only about 9% to the country's GDP in 2020. This low contribution is partly due to the lack of skilled labor, which hinders the sector's ability to operate efficiently and compete globally. The emigration of skilled professionals further exacerbates this challenge, as it reduces the availability of qualified personnel needed to drive industrial growth and development (National Bureau of Statistics, 2021).It is against this backdrop that the current study endeavours to investigate the impact of brain drain on the manufacturing sector output in Nigeria between 1990and 2023.The study achieved the following specific objectives, which includes to:

i. examines the impact of net migration rate on manufacturing sector output in Nigeria
ii. investigates the effect of per capita income on manufacturing sector output in Nigeria
iii. analyze the effect of unemployment rate on manufacturing sector output in Nigeria

The following formulated hypotheses guided the study:

H_{01}: Net migration rate has no significant impact on manufacturing sector output in Nigeria
H_{02}: Percapita income has no significant effect on manufacturing sector output in Nigeria
H_{03}: Unemployment rate has no significant effect on manufacturing sector output in Nigeria

The rest of the paper was structured as follows. The next is section two which explains the conceptual framework, as well as the review of empirical findings and theoretical basis. Section three describes the methodology of this paper including data issues and preliminary analyses. Section four presents and discusses the results; while section five concludes the paper with policy recommendations.

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II.LITERATURE REVIEW

Conceptual Review

Brain drains also known as a human capital flight is the movement of people especially the most skilled and competent individuals or manpower from the less developed countries to developed countries where they believed the returns of their human capital is appreciated (Adeyemi *et al,* 2018). Goga (2020) explained that brain drain is the movement (emigration) of high skilled workers from a developing country to a developed country. The concept of "Brain Drain" according to Alem (2016) was created by the British Royal Society to refer to the exodus of engineers, professionals, physicians, and scientists, via emigration from the United Kingdom to the United States of America. Walter Adams cited in Alem (2016) described the term brain drain"The flight of technical, scientific, managerial and administrative personnel from less developed countries to North America and Europe or from the semi-advanced nations to the advanced countries". Cambridge Dictionary (2016) defined the term as "the situation in which large numbers of educated and very skilled people leave their own country to live and work in another country where pay and conditions are better". According to Chimanikire (2005) brain drain is the movement of a specialized set of people such as medical doctors, engineers, scientists, academics and among others from one nation to another, commonly for higher wages or for the quality standard of living. In Nigeria, brain drain syndrome is popularly known or nicknamed 'JAPA' (a Yoruba word which means to run or to flee) according to Nnoruga and Osigwe (2023): it is the exodus of middle- class and highly skilled Nigerians to other countries of the world.

On the other hand, the manufacturing sector output refers to the total value of goods and products produced within the manufacturing sector over a specific period. This sector includes industries engaged in the transformation of raw materials, components, or sub-assemblies into finished goods that meet consumer or business needs. The manufacturing sector is a cornerstone of economic development and contributes significantly to GDP, employment, and technological innovation the manufacturing sector encompasses industries that involve the transformation of raw materials into finished goods through mechanical, physical, or chemical processes. It is a critical component of industrial development and economic growth, as it contributes to employment generation, export earnings, and technological advancement (Federal Ministry of Industry, Trade and Investment, 2020). In Nigeria, the manufacturing sector has been identified as a key driver of economic diversification and industrialization. However, the sector faces numerous challenges, including inadequate infrastructure, inconsistent power supply, and a shortage of skilled labor, exacerbated by the brain drain phenomenon (Adenikinju, 2020). The decline in manufacturing output has significant implications for the economy, including reduced export earnings and increased unemployment.

Empirical Review

Akinola and Adekile (2024) analyzed the impact of brain drain and unemployment on Nigeria's economic growth. Using GDP growth as the dependent variable and factors like skilled labor emigration rates and unemployment as key independent variables, they conducted regression analysis with data from government and international sources. The study found that both brain drain and unemployment negatively affect economic growth by reducing human capital and underutilizing the workforce. Policy recommendations included addressing these issues to improve economic performance. However, the study did not explore long-term effects of brain drain, such as its impact on innovation or sector-specific challenges, nor did it consider potential benefits like remittances or the return of skilled labor.

Asongu and Odhiambo (2024) examined the relationship between capital flight, foreign aid, and unemployment in sub-Saharan Africa. Using panel data, they found that capital flight worsens unemployment by deteriorating economic conditions. However, foreign aid can mitigate this impact, provided governance and institutional quality are strong. The study highlighted the importance of proper management and allocation of foreign aid to effectively address unemployment linked to capital flight.

Omotola et al. (2023) analyzed the long-term effects of net migration rates and remittances on Nigeria's economic growth using Real GDP growth, migration rates, remittances, school enrollment, and unemployment as variables. Employing a Fractional Cointegration Framework, the study found no evidence of a long-term relationship between human capital flight, remittances, and economic growth. Despite rising trends in migration and remittances, their impact on growth is minimal if not directed toward productive investments. The study called for further research on the sector-specific effects of brain drain to inform targeted policy measures.

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Eze (2021) investigated the macroeconomic determinants of human capital flight and the effect on Nigeria's industrial output. The study adopted the panel data regression analysis and found that human capital flight, particularly among professionals, is significantly influenced by high unemployment and low GDP growth, leading to a decline in industrial output.

Okon (2020) analyzed labour market dynamics, brain drain, and industrial growth in Nigeria: A macroeconomic assessment. The variables used were labor force participation, unemployment rate, skilled migration and industrial sector productivity. The study adopted Vector autoregression (VAR) and found that brain drain resulting from labor market inefficiencies significantly reduces the industrial sector's overall productivity.

Adeyemi et al. (2019) examined the economic consequences of brain drain in developing economies: a focus on Nigeria's industrial sector. The study utilized econometric analysis and suggested that brain drain driven by macroeconomic instability, including high inflation and low government investment, adversely affects industrial productivity.

Adetunji et al. (2019) examined the impact of fiscal and monetary policies on brain drain and industrial decline in Nigeria. The study utilized econometric modelling and suggested that Unstable fiscal and monetary policies are key drivers of brain drain, leading to a decline in Nigeria's industrial competitiveness.

Imafidon (2018) examined the impact of the brain drain on Nigeria's health care system from the perspective of Nigerian medical doctors in the United States (US) versus Nigerian medical doctors who remained in Nigeria. The social ecological model was used as a framework to examine push factors out of Nigeria and pull factors into host countries such as the US. The method adopted was a thematic analysis of qualitative data (key-informant interviews) obtained from a convenience and snowball sample of 17 medical doctors residing in Nigeria and the US.

Abdelhamid (2018) investigated a geo-economic approach to brain drain in Morocco. He explained through empirical analysis that the migration of skilled labor from a country can play a potential role in the pace of development of the latter and can be a source of positive externalities through two channels. The first is related to the acquisition of additional skills and the increase in the ex-ante level of education. The second is related to the "brain gain" thanks to compensation in terms of migrants' return and the technology transfer that ensues.

Chand (2018) investigated the immigration of people born in Africa to the U.S. It analyzed their backgrounds, the reasons for their move, and the activities they engaged in while engaging with their countries of origin. It used the theoretical lens of brain drain and brain circulation to analyze how these take place in the context of recent African immigration to the U.S. It proposed some ways in which African countries can best engage with their diasporas in the U.S. in a manner that is beneficial to all three parties involved the country of origin, the U.S., and the Diaspora itself.

Mago (2018) examined if the benefits of migration are realized by Ethiopian migrants with respect to their livelihood. Using primary data and descriptive analysis, interesting findings were gotten from the migrants based largely in South Africa. A large number of respondents opined that migration had reduced unemployment, enhanced migrants' standard of living and increased the likelihood of sending remittances back to their home countries. Findings also show that, similar to previous studies, a large part of remittances was spent on consumption purposes; however, some other recipients invested remittances in business-oriented activities. The study further recommends implementing a framework that will enhance the inflow of remittances into Ethiopia.

Shah and Muhammed (2018) examined the effects of brain drain on the Pakistani economy, some empirical influences of remittances, political instability and unemployment on the brain drain phenomenon in Pakistan by employing the Johanson co-integration technique. Annual time series data is used over the period of 1980–2013. Their empirical results show that all independent variables have a positive and long-term relationship with the brain drain phenomenon.

Liew, Mansor and Puah (2016) carried out an empirical investigation on the macroeconomic causes of capital flight in the Malaysian economy between the period 1980-2010. Using the autoregressive distributed lag (ARDL) model, the study found that political risk and financial crisis positively and significantly influence capital flight in the long-run.

Kim and Lee (2016) examined the effect of human capital flight on the home economy, focusing on 19 sub-Saharan countries between 1990 and 2013. The study found a negative effect of high-skilled migration and foreign direct investment in the dynamic panel model with system generalized methods of moments estimators. The study also

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found a negative effect of high-skilled migration and foreign direct investment in the latter estimation technique used.

Sulaiman, Umar, Bulama, Salisu and Ibrahim (2015) investigated the impact of human capital and technological growth on economic output in Nigeria between 1975 and 2010. Using the applied autoregressive distributed lag approach to examine the link between human capital and technological growth and output, it was shown that human capital has a positive impact on economic output in Nigeria. This shows the importance of human capital in growth and development in Nigeria.

Theoretical Review

The theoretical framework for this study is built on Lucas model.Human capital enters the production function in the Lucas model in the same way that technology does in the Solow model, that is, in a labour-augmenting form (which would seem like a rather natural way to conceptualize things). The economy is made up of identical individuals (or representative agents) who seek to maximize their lifetime utility. The degree of consumption and the allocation of time between labour and skill learning are two variables over which agents have influence. The first variable influences an agent's future production, whereas the second affects the accumulation of physical capital. Lucas proposes the following method of production:

$Yt = AK_t^{\beta} H_t^{\beta} (UthtLt)^{1-\beta} h_{at}^{r}$ (1)

where Y, A, K, and L are output, technology, capital, and labor, respectively, and u is the fraction of an individual's time dedicated to work, h is the representative agent's skill level or human capital, and ha is the economy's average human capital. The technological level, A, is believed to be constant (so that it could in principle be dropped from the expression or subsumed within the capital term). Exogenous population growth is assumed. The most significant assumption of the model involves the law of motion according to which the human capital variable evolves with time, leaving aside the last term on the right-hand side for the time being. Lucas The ARDL form of the model is as follows:

believes that investing in education produces human capital, which is the most important factor in the growth process. He distinguishes between internal impacts of human capital, which raise the productivity of the particular worker undergoing training, and external effects, which increase the productivity of capital and other workers in the economy. Rather than physical capital, investments in human capital have spillover effects that raise the degree of technology.

III.METHODOLOGY

The paper employed secondary data sourced from World Bank Indicators data andNational Bureau of Statistics (NBS). It covers the period of 33 years (1990–2023). It adopted the ARDL-ECM approach in order to investigate the impact of brain drain on the manufacturing sector output in Nigeria. The first step was to test the stationarity of the series to avoid spurious regression results. Estimation was conducted using the econometric computer software package, E-Views 12.

Model specification

The model used for this investigation is the adaption and modification of the work of Oluwaseyi et al (2020) NMR = f (LE, IM, PGR, UNEMPR) where: NMR = net migration rate; LE = life expectancy; IMR = infant mortality rate; PGR = population growth rate; and UNEMPR = unemployment rate.

Themodel is modified and specified to follow the study objectives and hypotheses. It is therefore stated as follows;

MSO = *f* (NMR, PCI, UNEMP) (2)

Where; MSO = Manufacturing Sector Output, NMR = Net Migration Rate, PCI = Per Capita Income and UNEMP = Unemployment Rate

It is expressed explicitly as

$MSO_t = \beta_o + \beta_1 NMR_t + \beta_2 PCI_t + \beta_3 UNEMP_t + \mu_t$ (3)

Where;

β_0:Intercept term

β_1—β_4:Coefficients of the independent variables

μ_t : Error term

$$MSO = \beta_0 + \sum_{g=1}^{l} \beta_1 MSO_{t-1} + \sum_{h=1}^{m} \beta_2 NMR_{t-i} + \sum_{i=1}^{n} \beta_3 PCI_{t-i} + \sum_{j=0}^{o} \beta_4 UNEMP_{t-i} + \sum_{g=1}^{l} \beta_5 \Delta MSO_{t-1} + \sum_{h=1}^{m} \beta_6 \Delta NMR_{t-i} + \sum_{i=1}^{n} \beta_7 \Delta PCI_{t-i} + \sum_{j=0}^{o} \beta_8 \Delta UNEMP_{t-i} + +\varepsilon_t \quad (4)$$

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Where;
Δ is the difference operator and
β_1 – β_4 are the short run dynamics of the independent variables.
The empirical error correction model (ECM) is stated as;

$$\Delta \text{MSO} = \beta_0 + \sum_{g=1}^{l} \beta_1 \Delta MSO_{t-1} + \sum_{h=1}^{m} \beta_2 \Delta NMR_{t-i} + \sum_{i=1}^{n} \beta_3 \Delta PCI_{t-i} + \sum_{j=0}^{o} \beta_4 \Delta UNEMP_{t-i} + \lambda ECM_{t-1} + \varepsilon_t (5)$$

where the ECM_{t-1} is expected to be negative and shows the speed of adjustment of the net migration rate to equilibrium in the long run after a disequilibrium occurs due to change in the explanatory variables.

IV.RESULTS AND DISCUSSION

Descriptive Analysis

Table 1: Descriptive Analysis

	MSO	NMR	PCI	UNEMP
Mean	15819.42	-0.28171	313999.2	14.85806
Median	8441.760	-0.289	233832.4	14.20000
Std. Dev.	19431.34	0.076151	297927.8	9.748496
Skewness	1.689350	0.117240	0.842310	0.445226
Kurtosis	5.201362	1.685469	2.711109	2.482390
Jarque-Bera	21.00457	2.303005	3.773479	1.370234
Probability	0.000027	0.316161	0.151565	0.504031
Observations	31	31	31	31

Source: *Researcher's Computation Using EViews-12 (2025)*

The descriptive statistics table provides an overview of four economic indicators: Manufacturing Sector Output (MSO), Net Migration Rate (NMR), Per Capita Income (PCI), and Unemployment Rate (UNEMP). The mean values indicate the central tendency of each variable, with MSO averaging 15,819.42, NMR at -0.28171, PCI at 313,999.2, and UNEMP at 14.86. The median values suggest a skewed distribution, particularly for MSO and PCI, where the median is significantly lower than the mean, indicating potential right-skewness.

The standard deviation values demonstrate the dispersion of data around the mean, with PCI exhibiting the highest variability (297,927.8), followed by MSO (19,431.34). The relatively low standard deviation for NMR (0.076151) suggests minimal fluctuations in this variable.

Skewness measures the asymmetry of the data distribution. MSO (1.689350) and PCI (0.842310) are positively skewed, indicating a longer right tail, while UNEMP (0.445226) and NMR (0.117240) show relatively symmetrical distributions. Kurtosis further assesses the shape of the distribution, with MSO (5.201362) exhibiting leptokurtic characteristics (indicating heavier tails and potential outliers). In contrast, NMR (1.685469) displays a platykurtic distribution, suggesting lighter tails than a normal distribution.

The Jarque-Bera test assesses the normality of each variable. MSO has a significant Jarque-Bera statistic (21.00457) with a probability value of 0.000027, rejecting the null hypothesis of normality. PCI also demonstrates some deviation from normality, while NMR and UNEMP have higher probability values, suggesting they may approximate normal distributions.

Finally, all variables are based on 31 observations, ensuring a consistent sample size across the dataset. These statistical measures provide insights into the distributional characteristics of economic indicators, which can influence econometric modelling and policy analysis.

Stationary Tests (Unit Root Tests)

The Augmented Dickey-Fuller (ADF) test results presented in the table provide an assessment

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of the stationarity properties of the four economic variables: MSO, NMR, PCI, and UNEMP. Stationarity is a critical assumption in time series econometrics, as non-stationary variables can lead to spurious regression results and unreliable statistical inferences.

The ADF test statistic is compared against the 5% critical value to determine the presence of a unit root. If the test statistic is more negative than the critical value, the null hypothesis of a unit root (non-stationarity) is rejected, indicating that the variable is stationary.

Table 2: Unit Root test

Variable	Augmented Dickey-Fuller (ADF) Test		
	ADF	@ 5%	Status
MSO	- 5.403022	-1.953858	1(0)
NMR	-2.171419	-1.951687	1(1)
PCI	- 2.268773	-1.952910	1(1)
UNEMP	-5.655532	-2.971853	1(1)

Source: *Author's Computation Using EViews-12 (2025)*

According to the results, MSO exhibits an ADF test statistic of -5.403022, which is significantly lower than the 5% critical value of -1.953858. This suggests that MSO is stationary at level, denoted as I(0), meaning that it does not require differencing to achieve stationarity. Similarly, UNEMP has an ADF test statistic of -5.655532, which is lower than its corresponding critical value (-2.971853), indicating that it is also stationary at level, or I(0).

Conversely, NMR and PCI exhibit test statistics of -2.171419 and -2.268773, respectively, which are not sufficiently negative to reject the null hypothesis at the 5% significance level (-1.951687 for NMR and -1.952910 for PCI). This suggests that both variables are non-stationary at levels and require first differencing to achieve stationarity. Consequently, NMR and PCI are integrated of order one, denoted as I(1).

These findings imply that while MSO and UNEMP can be used directly in econometric modelling without differencing, NMR and PCI must be differenced once to achieve stationarity. The integration properties of these variables are crucial in determining the appropriate econometric techniques, such as cointegration analysis and vector autoregression (VAR) modelling, to ensure robust empirical results.

Co-integration of ARDL-Bounds Test

The cointegration test results presented in table 3 assess the existence of a long-run equilibrium relationship among the economic variables under consideration. The null hypothesis states that no long-run relationship exists between the variables, while the alternative hypothesis suggests the presence of cointegration.

Table 3: ARDL-Bound Testing

Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	K
F-statistic	5.961051	3
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10%	3.47	4.45
5%	4.01	5.07
2.5%	4.52	5.62
1%	5.17	6.36

Source: *Researcher's Computation Using EViews-12 (2025)*

The test statistic, represented by the F-statistic, is compared against the critical value bounds at various significance levels (10%, 5%, 2.5%, and 1%). The bounds test includes an I(0) bound, which corresponds to the lower bound assuming all variables are stationary at level, and an I(1) bound, which represents the upper bound assuming all variables are integrated of order one. If the computed F-statistic exceeds the upper bound, the null hypothesis of no cointegration is rejected, indicating a long-run relationship. Conversely, if the F-statistic falls below the lower bound, the null

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hypothesis cannot be rejected. If the F-statistic lies between the bounds, the result is inconclusive.

In this case, the computed F-statistic is 5.961051, which exceeds the I(1) bound at the 5% significance level (5.07) and is also above the critical values at 10% and 2.5% levels. This suggests strong evidence against the null hypothesis, indicating that the variables are cointegrated and share a stable long-run equilibrium relationship.

The presence of cointegration implies that despite short-term fluctuations, the economic variables move together over time, suggesting underlying economic linkages. This finding has important implications for econometric modelling, as it justifies the use of an error correction model (ECM) to capture both short-term dynamics and long-term equilibrium adjustments. Additionally, it reinforces the need to consider long-run dependencies when formulating economic policies based on these variables.

ARDL Regression Result

The Autoregressive Distributed Lag (ARDL)-ECM and long-run estimates presented here provide significant insights into how macroeconomic variables affect mortality rate in Nigeria over short and long term.

Table 4: ARDL-ECM and Long Run Estimates

Dependent Variable: MSO

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
MSO(-1)	0.563802	0.161907	3.482268	0.0025
MSO(-2)	-0.03429	0.144019	-0.2381	0.8144
NMR	-42339.5	19398.77	-2.18259	0.0418
NMR(-1)	62410.38	25906.99	2.409017	0.0263
PCI	0.167246	0.024482	6.831307	0
PCI(-1)	-0.12674	0.024687	-5.13387	0.0001
UNEMP	68.9807	62.54381	1.102918	0.2838
C	4786.634	1418.004	3.375613	0.0032
@TREND	-505.8	210.3594	-2.40446	0.0266
CointEq(-1)*	-0.47049	0.097177	-4.84156	0.0001
R-squared	0.913335			
Adjusted R-squared	0.893639			
F-statistic	46.37032			
Prob(F-statistic)	0.00000			
Durbin-Watson stat	2.372187			
LONG-RUN ESTIMATION				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
NMR	42659.7	15386.55	2.772531	0.0121
PCI	0.086093	0.012419	6.932327	0
UNEMP	146.6153	124.2359	1.180136	0.2525

Source: *Author's Computation Using EViews-12 (2025)*

The **error correction term (CointEq(-1))** is highly significant **(p = 0.0001)** and negative (**-0.47049**), confirming the existence of a long-run equilibrium relationship. The coefficient value

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suggests that approximately **47% of any deviation from the long-run equilibrium is corrected in each period**, indicating a moderate speed of adjustment.

The R-squared value (0.9133) and adjusted R-squared (0.8936) indicate a strong explanatory power of the model, with approximately 91.3% of the variation in MSO being explained by the independent variables. The F-statistic (46.37032, p = 0.0000) further confirms the overall significance of the model.

The Durbin-Watson statistic (2.3722) suggests no severe autocorrelation issues, supporting the robustness of the results.

The ARDL model findings confirm the existence of both short-run and long-run relationships between MSO and its determinants. While NMR exerts a negative influence in the short run, it contributes positively in the long run, highlighting the importance of time horizons in economic analysis. PCI consistently demonstrates a significant positive effect on MSO, suggesting that income growth is a key driver of MSO expansion. The absence of a significant effect of UNEMP in both timeframes implies that employment fluctuations do not play a crucial role in explaining MSO behaviour.

Post-Estimation Checks (ARDL Diagnostic Test)

The post-estimation diagnostic tests presented in the table assess key statistical properties of the estimated autoregressive distributed lag (ARDL) model, specifically evaluating the presence of heteroskedasticity and serial correlation in the regression residuals. Ensuring that these econometric assumptions hold is critical for the validity and reliability of the estimated coefficients and statistical inferences.

Table 5: Post-Estimation Diagnostic Tests

Test type	F-Statistic	Prob
Heteroskedasticity Test	1.030393	0.4478
Breusch-Godfrey Serial Correlation LM	1.441740	0.2640

Source: *Author's Computation Using EViews-12 (2025)*

The heteroskedasticity test yields an F-statistic of 1.0304 with an associated probability value of 0.4478. The null hypothesis for this test assumes that the variance of the residuals remains constant over different levels of the independent variables (homoskedasticity). Given that the probability value exceeds the conventional significance thresholds (e.g., 5% or 10%), the null hypothesis cannot be rejected. This result suggests that heteroskedasticity is not a concern in the model, implying that the variance of the errors is stable, and the estimated standard errors are reliable. Consequently, no corrective measures, such as robust standard errors or generalized least squares (GLS), are necessary.

The Breusch-Godfrey test assesses the presence of serial correlation (autocorrelation) in the residuals, which can arise when error terms from different time periods are correlated. Serial correlation can lead to inefficient estimates and misleading statistical inference. The test yields an F-statistic of 1.4417 with a probability value of 0.2640, indicating that the null hypothesis of no serial correlation cannot be rejected. This suggests that the residuals are not systematically correlated across periods, confirming that the model is correctly specified in terms of dynamic structure

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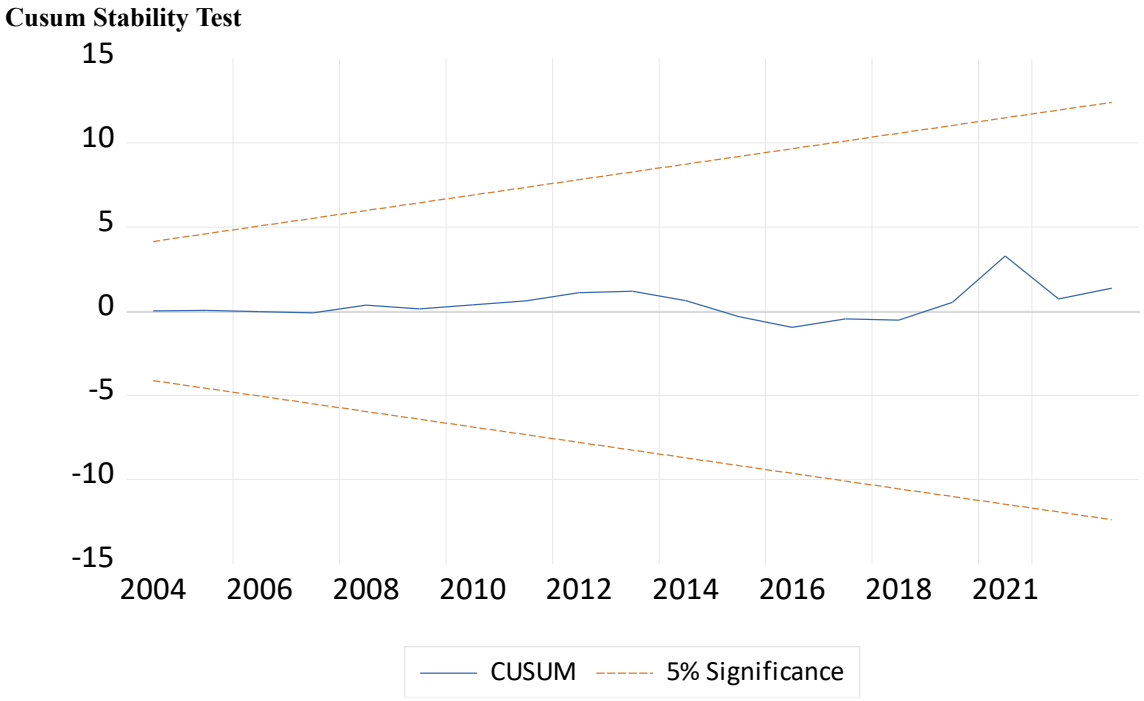

Source: Author's computation using EVIEWS 12.0, 2025.

Figure 1: Cusum Stability test

From the plot, the CUSUM line remains well within the 5% significance boundaries for most of the period under analysis (2004–2023), indicating that the estimated model is structurally stable over time. Although a slight upward movement is observed around 2020–2021, the CUSUM statistic does not exceed the critical bounds, suggesting that no significant structural break has occurred.

The results of the CUSUM test suggest that the estimated model exhibits parameter stability, implying that the relationships among the independent and dependent variables remain consistent over time. This reinforces the robustness of the model for forecasting and policy analysis, as structural instability could otherwise lead to misleading inferences and unreliable predictions.

V. Discussion of Findings

The short-run results indicate that MSO (-1) has a statistically significant positive coefficient (0.5638, p = 0.0025), suggesting that past values of MSO have a strong influence on its current level. However, the second lag MSO (-2) is insignificant, implying that the impact weakens over time.This aligns with studies on market persistence and path dependence in economic and business cycles (Dosi et al., 2017).

The coefficient for NMR is negative and statistically significant (-42,339.5, p = 0.0418), suggesting that a contemporaneous increase in NMR negatively affects MSO in the short run. However, the lagged value NMR (-1) has a positive and significant effect (62,410.38, p = 0.0263), indicating a potential reversal effect, where past values of NMR positively contribute to MSO in subsequent periods.Empirical studies on migration and economic growth, such as Borjas (2001), indicate that large short-term migration shocks can disrupt local economies due to increased competition or transitional unemployment.This finding also parallels studies by Clemens (2011) on migration-induced economic dynamism, where long-term impacts are generally favorable despite short-run frictions.

The variable PCI has a strong and significant positive effect in the short run (0.1672, p = 0.0000), reinforcing the notion that an increase in per capita income directly stimulates MSO. However, its lagged value PCI (-1) is negative and highly significant (-0.1267, p = 0.0001), implying some degree of adjustment in response to prior movements.This aligns with classical and Keynesian economic theories, which propose that rising income levels lead to greater consumer spending and business expansion (Keynes, 1936). Research by Deaton & Paxson (1994) also supports this, showing that higher income translates into increased market participation and demand growth.

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The variable UNEMP does not exhibit a statistically significant effect in the short run (p = 0.2838), suggesting that short-term fluctuations in unemployment do not substantially impact MSO.The findings align with research indicating that consumer behavior may not always be highly sensitive to unemployment changes (Carroll et al., 2011).

The long-run coefficients provide insights into the sustained relationships between the dependent and independent variables. NMR exhibits a positive and significant long-run effect on MSO (42,659.7, p = 0.0121), suggesting that, over time, increases in NMR contribute positively to MSO. This is in contrast to the short-run negative effect, indicating potential lagged adjustments in economic relationships. Similarly, PCI maintains a strong and highly significant positive impact on MSO (0.0861, p = 0.0000), reinforcing the notion that higher income levels support MSO growth in the long run. On the other hand, UNEMP is statistically insignificant in the long run (p = 0.2525), implying that unemployment does not exert a persistent influence on MSO, aligning with its short-run results.

VI.CONCLUSION AND RECOMMENDATIONS

This paper examined the Impact of brain drain on the manufacturing sector output in Nigeria (1990-2023) using ARDL results. The findings of this study provide robust evidence of both short-run and long-run relationships between MSO and its key determinants, namely NMR, PCI, and UNEMP. The Autoregressive Distributed Lag (ARDL) model reveals that while NMR exerts a negative short-run effect, it positively contributes to MSO in the long run, suggesting that initial disruptions in NMR may subside, leading to more favourable long-term outcomes. The results further highlight the significant and persistent positive impact of per capita income (PCI) on MSO, reinforcing the role of economic growth in driving MSO expansion. In contrast, unemployment (UNEMP) does not exhibit a statistically significant effect in either the short or long run, implying that employment fluctuations do not play a decisive role in shaping MSO trends within the observed period.

Based on the empirical findings, the following policy recommendations are proposed to enhance MSO performance and ensure long-term economic stability:

i. Given the strong positive influence of PCI on MSO in both the short and long run, the federal government, state government and private stakeholders should prioritize income-enhancing policies such as wage growth strategies, investment in human capital, and productivity-driven economic expansion. Strengthening sectors that contribute to per capita income will support sustained MSO growth.
ii. The negative short-run effect but positive long-run impact of NMR suggests that immigration office should adopt countercyclical policies to mitigate short-term adverse effects while ensuring that long-run benefits materialize. This may include targeted fiscal interventions, trade diversification, and financial market stabilization measures to cushion short-term disruptions. Also to enhance MSO resilience, governments should focus on economic diversification strategies that reduce dependency on volatile sectors. Encouraging innovation, technology adoption, and industrial expansion can create a more stable economic environment, reducing the short-run volatility observed in NMR.
iii. While unemployment does not exhibit a direct impact on MSO, ensuring a stable labour market remains critical for broader economic stability. Policymakers should invest in workforce retraining programs, labour market reforms, and skills development initiatives to enhance employment opportunities and economic productivity.

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