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REVIEW ARTICLE

BUSINESS CYCLE AND ENERGY INTENSITY IN NIGERIA: THE ROLE OF FOREIGN DIRECT INVESTMENT

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ABSTRACT

The study investigates how Nigeria's economic fluctuations shape energy consumption patterns, focusing on the interplay between business cycles, foreign direct investment (FDI), and energy intensity. Key questions include: how business cycles influence energy use, whether FDI exhibits cyclical behavior with the economy, and the extent to which FDI mediates the business cycle–energy intensity relationship. Using annual data from the World Development Indicators (1971–2022) on GDP per capita, urbanization, ecological footprint, and energy intensity, the analysis applies unit root tests, ARDL bounds testing, and post-estimation diagnostics. Results reveal that the business cycle has a negative effect on energy consumption, while FDI tends to amplify business cycles. However, FDI's moderating effect on the business cycle–energy intensity link is insignificant. Urbanization and trade openness significantly influence energy intensity. The findings suggest a counter-cyclical link between business cycles and energy use, a pro-cyclical connection between FDI and economic cycles, and limited combined effects of FDI and business cycles on energy intensity. Policy recommendations include strengthening early detection and monitoring of business cycles to tailor energy policies to different economic phases and ensuring that FDI inflows do not exacerbate environmental degradation. Nigeria is urged to avoid sacrificing environmental quality for economic gains when leveraging foreign investment.

KEYWORDS

Business Cycle, FDI, Energy Intensity, GDP, and ARDL.

1. INTRODUCTION

1.1 Background to the Study

Economic fluctuations remain a critical concern for policymakers in emerging markets and globally, as economies naturally experience cycles of expansion and contraction. These business cycles, defined as recurring upward and downward movements in economic indicators like output, prices, interest rates, and employment, require understanding of their underlying causes rather than merely the concept itself (Neumeyer and Perri, 2004). Recent studies, such, emphasize that economic fluctuations in emerging economies are influenced by policy shocks, market failures, and productivity shocks as explained by the neoclassical model (Garcia-Cicco, et al., 2006). Additionally, frequent interest rate changes in such economies significantly influence these fluctuations.

Energy intensity, a measure of a country's energy efficiency, is calculated as the share of GDP derived from energy consumption, reflecting dependence on energy resources. Rising global energy use, driven by economic growth, contributes to environmental concerns like global warming. Reducing energy intensity not only increases output per unit of energy consumed but also mitigates pollutant emissions (Wang et al., 2013). Addressing this challenge is vital for sustainable development and climate change mitigation.

The relationship between business cycles and energy intensity varies across economic phases. During booms, energy-intensive industries expand production, increasing demand for energy; in recessions, many such firms exit the market, reducing demand (Mahmood and Ahmad, 2018). In Nigeria, historical periods of boom, such as the oil-driven growth of the 1970s, were followed by sharp declines during revenue shortfalls, with corresponding drops in energy intensity, worsening living standards, rising debt, and GDP contraction.

Foreign direct investment (FDI) plays a dual role in this nexus. The "pollution halo" hypothesis suggests that FDI transfers advanced, energy-efficient technologies to host countries, improving efficiency (Amoroso and Muller, 2018). Conversely, the "pollution haven" hypothesis argues that multinational corporations relocate polluting industries to countries with lax environmental standards, increasing energy intensity (Millimet and Roy, 2016). Given increasing global economic interdependence—via trade, financial flows, and production networks—FDI has expanded rapidly, with foreign affiliates now accounting for about 11% of world output (UNCTAD, 2002).

1.2 Statement of Problem

Economic fluctuations stem from numerous external economic conditions, each capable of altering the course of economic activity. When these changes are substantial and persistent, they can trigger prolonged disruptions, resulting in an economic crisis. Unlike minor, daily variations in the economy, these larger swings represent significant shifts in scale. Historical observations reveal a regular pattern in economic cycles that cannot be fully explained by random external shocks, prompting the search for underlying causes. One such cause is the scarcity of capital, which hinders the continuation of lengthy production processes. Elevated interest rates further limit production by making capital more expensive, forcing less competitive entrepreneurs to halt operations. This cessation releases capital goods and labor into the market, often depressing their prices. However, labor wages may not fall quickly—especially without price controls—leading to persistent unemployment. A reduced capital supply also limits resources available for sustaining long production cycles.

In Nigeria, business cycle trends have been closely tied to key economic events. Between 1970 and 1980, the economy surged, peaking in 1980 due to the oil boom. This was followed by a sharp downturn after the oil price

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collapse and political transition, bottoming out in 1984. Similar recessions occurred in 2001 and 2016, with GDP contracting for consecutive quarters. Consumption and investment have generally moved in tandem with business cycles, while the trade balance to GDP ratio has often shown an inverse relationship. Despite its abundant resources and large market, Nigeria's FDI inflows remain modest relative to potential, partly due to the instability of its business cycles. Although past studies have explored the link between FDI and economic growth, little is known about how FDI interacts with business cycles in Nigeria. This study therefore investigates the relationship between business cycles and energy intensity, incorporating FDI inflows as a mediating factor.

1.3 Research Questions

Arising from the identified problems, this research seeks to address the following key questions:

- What is the nature of the cyclical relationship between the business cycle and energy intensity in Nigeria?
- How does the business cycle relate cyclically to foreign direct investment in Nigeria?
- What role does foreign direct investment play in the cyclical relationship between the business cycle and the energy intensity cycle?

1.4 Research Objectives

The main aim of this study is to investigate the relationship between business cycles and energy intensity in Nigeria. The specific objectives are to:

- Analyze the cyclical linkage between the business cycle and energy intensity in Nigeria.
- Assess the cyclical relationship between the business cycle and foreign direct investment in Nigeria.
- Explore the role of foreign direct investment in the cyclical interaction between the business cycle and energy intensity.

1.5 Justification for the Study

The justification for this study rests on several points. Foremost, it is the first to investigate the relationship between business cycles and energy intensity specifically in Nigeria, as prior research on this subject has focused on other countries and largely employed panel data approaches. For example, explored this connection for certain emerging economies but did not account for the influence of foreign direct investment (FDI), while analyzed the business cycle–energy intensity link in Algeria in the context of energy conservation policy (Adom, 2015; Li et al., 2022). To date, no existing study has examined the mediating role of FDI inflows within this nexus, making this research the first to address this gap and contribute new insights to the literature. Additionally, the study applies the Hodrick–Prescott filter to isolate the business cycle component from per capita GDP, offering a more precise measure of cyclical trends. Previous works often relied on GDP growth or unemployment growth rates, which are less reliable indicators for capturing cyclical movements (Adebimpe et al., 2007; Ahmad, 2005).

1.6 Scope of the study

In line with the study's objectives, annual data will be utilized for Gross Domestic Product per capita (GDP per capita), foreign direct investment inflows (FDI), energy intensity (ENG), urban population (URB), and trade openness (TRADE) covering the period from 1980 to 2021, comprising 41 observations. All data will be sourced from the 2023 edition of the World Development Indicators (WDI).

1.7 Structure of the Paper

The structure of this paper is organized into five main sections. Following the introduction in Section 1, Section 2 presents a comprehensive literature review, which encompasses the conceptual, theoretical, and empirical foundations related to business cycles, energy intensity, and foreign direct investment. Section 3 details the methodological approach of the study, including the research design, data sources, model specification, estimation techniques, and analytical framework. Section 4 focuses on the presentation and discussion of empirical results, covering pre-estimation tests, model estimations, and interpretation of findings. Finally, Section 5 provides the summary, conclusion, and policy recommendations derived from the study's outcomes.

2. Literature Review

Numerous empirical studies have explored the extent to which business cycles and other macroeconomic indicators influence energy intensity. This growing interest stems from the increasing significance of business cycle–related issues in recent years, as well as the profound impact that environmental quality policies have on a nation's sustainable development. Over time, previous research has examined diverse theories, hypotheses, geographical scopes, and econometric approaches, resulting in a variety of conclusions and insights. This chapter provides a review of relevant theories on energy consumption and business cycles, alongside an examination of the methodological and empirical approaches adopted in existing literature.

2.1 Conceptual Review

2.1.1 Concept of Business Cycle

A business cycle is a cycle of fluctuations in the Gross Domestic Product (GDP) around The long-term natural growth rate reflects the pattern of expansion and contraction in economic activity that occurs over time. A business cycle is considered complete when the economy passes through one phase of boom followed by one phase of contraction. The duration required to complete this sequence is referred to as the length of the business cycle. A boom represents a phase of rapid economic growth, while a recession denotes a period of comparatively stagnant growth. These phases are typically measured using the growth rate of real GDP, adjusted for inflation (Lamey et al., 2007).

2.1.1.1 Stages of the Business Cycle

Business Expansion: The business cycle begins with the expansion phase, marked by rising positive economic indicators such as employment, income, output, wages, profits, and both the demand and supply of goods and services (Zarnowitz, 1984). Debt repayments are timely, the money supply circulates rapidly, and investment levels are high. This upward trend persists as long as economic conditions remain favorable.

Business Peak: Following expansion, the economy reaches its peak or saturation point (Matutinovic, 2005). At this stage, growth hits its maximum limit, with economic indicators at their highest and prices peaking. No further growth occurs, and this stage signals a turning point in economic trends. Consumers often adjust their spending patterns at this time (Hasen, 2013).

Business Recession: After the peak comes the recession phase, where demand for goods and services declines steadily. Producers, slow to react, continue production, leading to excess supply. Prices begin to drop, and key indicators like income, wages, and output fall (Whittemore, 2022).

Depression and Trough: As the slowdown deepens, unemployment rises, and economic growth dips below its steady rate, signaling a depression (Papadimitriou et al., 2013). The trough marks the lowest point, where prices, demand, and supply hit their minimum, and national income and expenditure are heavily depleted (Smith et al., 2009).

Recovery: After the trough, the recovery phase begins. Low prices stimulate demand, encouraging increased supply, investment, and production. Employment improves, lending activity grows, and worn-out capital is replaced, driving new investments. This stage continues until the economy regains steady growth levels (Goldfeld et al., 1976).

2.1.2 Energy Intensity

Energy intensity is a commonly used indicator for evaluating an economy's energy efficiency (Tanaka, 2008). It is typically calculated as the ratio of energy consumption (or supply) to gross domestic product (GDP), reflecting how effectively an economy converts energy into monetary output. The metric is often expressed in joules (or Btu) per US dollar, though other equivalent units are also used. A lower energy intensity ratio indicates greater efficiency (Stern, 2004). In the early stages of a nation's development, it is expected that energy intensity will rise, as GDP and energy consumption are closely linked. This is due to the energy-intensive nature of early industrial and infrastructure growth, which involves producing large quantities of cement, steel, and other materials for roads, buildings, vehicles, appliances, and communication systems (York, 2007). As industries mature, energy intensity typically declines as cost-saving measures and efficiency improvements are adopted (Whitley, 1992).

Reducing energy intensity can be achieved through various strategies, including adopting advanced energy extraction and conversion technologies, improving material production efficiency, or outsourcing manufacturing to other countries (Vikhorev et al., 2013). These approaches enable higher GDP with equal or reduced energy consumption, thereby lowering energy intensity. Historical trends show a global decline in energy intensity during the latter half of the 20th century, driven by improved efficiency and a shift toward less energy-intensive economic activities—a trend expected to continue (Abdul-Majid et al., 2010).

2.1.3 Foreign Direct Investment

In its broadest sense, foreign direct investment (FDI) encompasses mergers and acquisitions, the establishment of new facilities, reinvestment of earnings from overseas operations, and intra-company loans. Narrowly defined, FDI refers specifically to the creation of new facilities and the acquisition of a lasting management interest—typically 10 percent or more of voting stock—in an enterprise located in an economy different from that of the investor (World Bank, 2012). It consists of equity capital, long-term capital, and short-term capital as recorded in the balance of payments (Singh, 2003). FDI often involves managerial participation, joint ventures, technology transfer, and specialized expertise. The stock of FDI represents the net cumulative total (outward minus inward) for a given period, excluding investments where less than 10 percent of a company's shares are acquired (CIA, 2017).

FDI, a subset of international factor movements, entails controlling ownership of a business in one country by an entity from another. Unlike foreign portfolio investment, which passively involves securities such as stocks and bonds, FDI carries an element of control (Dauda et al., 2019). While the standard benchmark for control is 10 percent of voting shares, smaller holdings can also yield control, particularly in widely held companies, and control may also be exercised via technology, management, or key resources (FTL, 2014). From the investor's perspective, FDI can be horizontal (replicating home-country production in the host country), vertical (backward—acquiring resource suppliers, or forward—securing distribution outlets), or conglomerate (a mix of both) (Moosa and Imad, 2002). From the host country's perspective, it can be import-substituting, export-enhancing, or government-initiated. Platform FDI refers to investments made in a host country with the aim of exporting to a third market.

2.2 Theoretical Review

2.2.1 The Pollution Halo Hypothesis

The pollution halo hypothesis, first introduced by Edward L. Thorndike in 1920, suggests that multinational corporations, through foreign direct investment (FDI), transfer environmentally friendly technologies to host countries. Such technology transfers may include pollution control systems, renewable energy technologies, and advanced energy-efficient innovations that reduce reliance on conventional energy sources. This hypothesis posits that FDI provides recipient countries with superior technologies, thereby contributing to a reduction in carbon emissions.

2.2.2 The Porter's Theory

The relevance of Porter's theory lies in its provision of strategies for comparing firms' competitiveness at both domestic and international levels, with the goal of enhancing a nation's competitive advantage. The theory emphasizes that for a country to successfully integrate into the global economy, it must be capable of addressing the drawbacks associated with environmental globalization. In this context, any negative impacts of globalization are more likely to manifest in the host country rather than the home country. Rooted in a system of determinants—such as a nation's natural resource endowments and other factors of production—these elements interact and are significantly shaped by political influences like government policies. Porter further asserts that a country's success depends largely on its economic priorities in relation to its resource base, and that the complexity and dynamism of its economic environment can lead to the failure of firms that do not effectively align their capital utilization with these conditions. He classifies production inputs into four categories: natural resources, human resources, knowledge resources, and capital resources (including infrastructure). Ultimately, this theory establishes a modern framework for shaping industrial and commercial policies.

2.2.3 Environmental Kuznets Curve Theory (EKC)

During the 1990s, rising public concern over severe environmental degradation led researchers to investigate the key factors driving such deterioration (Dinda, 2004). Much of the debate revolved around whether rapid economic growth could coexist with environmental improvement, as many feared that development would inevitably worsen environmental quality. In response to these concerns, the Environmental Kuznets Curve (EKC) concept emerged, inspired earlier work linking income inequality and economic development (Simon Kuznets', 1955). Grossman and Krueger later adapted this idea to environmental economics, showing that environmental quality often declines in the early stages of a nation's economic growth but improves after a certain income threshold is reached. This inverted U-shaped relationship suggested that economic expansion could eventually lead to environmental restoration, contradicting the belief that growth inherently worsens environmental conditions (Allen and Webber, 2010; Stern, 2004).

The simplicity and intuitive appeal of the EKC framework inspired extensive theoretical and empirical research aimed at validating the "grow first, clean later" perspective. Proponents argued that as nations transition from low-income, agrarian economies to industrialized and post-industrial states, environmental degradation in the early stages is an inevitable byproduct of industrialization. Increased production, resource consumption, pollutant emissions, and inefficient technologies initially harm the environment. However, they maintained that once a country achieves higher economic stability, it acquires both the financial means and public will to invest in cleaner technologies, implement stricter environmental regulations, and adopt conservation measures. Rising public demand for better quality of life would push governments toward policies that integrate environmental protection into economic planning (Munasinghe, 1999; Al-Mulali and Ozturk, 2015).

Despite its influence, the EKC theory has faced significant criticism. Kuznets himself cautioned about the fragility of the data underpinning his hypothesis. Critics argue that the curve's inverted U-shape may reflect historical differences between countries in the dataset rather than a universal developmental path. Because Kuznets' data relied heavily on Latin American countries—known for high income inequality—the findings may not generalize globally. When controlling for such disparities, the curve's shape becomes less pronounced. Moreover, more recent economic growth experiences have not always followed the predicted EKC pattern, prompting alternative theories that incorporate additional variables and multidimensional approaches to better explain the complex relationship between economic growth and environmental quality.

2.2.4 The Pollution Haven Hypothesis

The pollution haven hypothesis, introduced, suggests that when large industrialized nations establish factories or offices abroad, they often choose locations that provide low-cost resources and labor, along with the necessary land and material access (Copeland and Taylor, 1994). However, such choices frequently come at the expense of environmentally responsible practices. Developing countries, which typically offer cheaper labor and resources, often have weaker or less strictly enforced environmental regulations. In contrast, countries with more stringent environmental standards tend to be costlier for businesses due to the expenses involved in meeting compliance requirements. As a result, companies seeking to invest abroad are inclined to (re)locate to nations with the lowest environmental standards or weakest enforcement. The costs of pollution control play a role in influencing investment and trade decisions, particularly at the margins where they can significantly affect competitiveness. In some cases, countries may deliberately set their environmental regulations below socially optimal levels to attract foreign investment or boost export performance.

2.3 Empirical Review

As investigate the connection between business cycles, energy intensity, and foreign direct investment (FDI) in sixteen emerging economies from 1990 to 2014 (Li et al., 2021). Their findings show that during economic expansions, business cycles tend to reduce energy intensity, while during recessions, energy intensity increases. They also explore the moderating role of FDI and discover that FDI reduces energy intensity in economies with high development levels but raises it in less developed economies. Additionally, they identify a nonlinear relationship between business cycles and energy intensity, making their work the only study closely aligned with the present research focus.

Similarly, analyze the energy intensity of 206 major Chinese cities between 2005 and 2008, examining the influence of foreign firm locations (Elliot et al., 2013). Their results reveal an inverted U-shaped relationship between city-level income per capita and energy intensity, with most cities positioned on the downward slope. FDI inflows are found to significantly reduce energy intensity, though the effect varies geographically due to differences in absorptive capacity. The modest economic effect of FDI is partly explained by foreign investments targeting energy-intensive industries and China's capital-intensive growth strategy.

As expand this discussion by applying panel regression and panel smooth transition regression (PSTR) models to assess the FDI–energy intensity link in BRICS and non-BRICS emerging economies from 1990 to 2014 (Cao et al., 2020). They find FDI's overall impact on energy intensity to be statistically insignificant but highlight its heterogeneous effects across country groups. Innovation capacity plays a moderating role, and industrial structure serves as a transition variable in the nonlinear mechanism connecting FDI and energy intensity. These findings emphasize that the relationship depends on structural and innovation-related factors.

Focus on 81 countries from 1990 to 2014, using advanced econometric techniques to eliminate previous methodological flaws (Petrovic and Lobanov, 2022). Their results confirm that each additional billion-dollar inflow of FDI reduces energy intensity by 0.23% on average, with stronger effects in technologically advanced economies. The study highlights that higher absorptive capacity enables better utilization of FDI-driven technological spillovers. Likewise, , using OECD country data from 1987 to 2013, uncover an R&D threshold effect—FDI to non-primary sectors increases energy intensity when R&D levels are below the threshold, but reduces it when R&D is above the threshold (Vita et al., 2021).

Other related works, for Sub-Saharan Africa and for Nigeria, identify economic growth, industrial output, and population as primary drivers of energy intensity, with FDI and trade openness generally reducing intensity under certain structural conditions (Adom, 2015; Keho, 2016). Studies for China and for Indonesia show that technology-intensive outward FDI and spatial spillovers shape energy intensity outcomes like (Sun et al., 2022; Saraswati et al., 2022). Finally, provide evidence that foreign investment patterns themselves are influenced by business cycle developments, as German outward FDI responds positively to economic upturns abroad (Buch and Lipponer, 2005).

2.4 Methodological Review

To address the various questions surrounding how business cycles influence energy intensity in Nigeria, academic research has expanded its scope to explore the interactions among these variables. This section reviews different methodological approaches employed in the literature to derive conclusions. While some studies focus on the direct impact of business cycles on energy intensity, others investigate the nexus between energy intensity and foreign direct investment (FDI).

Regarding the energy intensity–business cycle relationship, and apply the panel Autoregressive Distributed Lag (ARDL) model to analyze how business cycles affect energy intensity (Li et al., 2021; Buch et al., 2005). Similarly, employ the same estimation technique to examine the link between FDI and energy intensity in China and across 81 economies, respectively (Sun et al., 2022; Elliot et al., 2013). The strength of the panel ARDL lies in its ability to handle variables with mixed integration orders (excluding second differences), its suitability for heterogeneous panel groups, and its application in cases where the time dimension (T) exceeds the cross-sectional dimension (N). However, its limitation emerges when working with relatively small datasets, as the model's assumptions become less reliable.

To overcome this drawback, more robust estimation techniques such as the Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) have been introduced. As employs these methods to assess the effect of FDI on Nigeria's energy intensity (Adom, 2015). Meanwhile, uses the time series ARDL method for a country-specific analysis (Keho, 2016). Unlike the panel ARDL, the time series ARDL does not account for cross-sectional variations among multiple groups, making it suitable only for single-country studies.

Furthermore, to account for different regimes in variable interactions, apply Threshold Regression Analysis to identify asymmetric effects (Vita et al., 2021). This approach is particularly valuable for determining how varying levels or "regimes" of independent variables influence the long-run effects on the dependent variable, thereby offering deeper insights into the dynamics of these relationships.

2.5 Literature Gap

A review of existing literature on the nexus between business cycles, energy intensity, and foreign direct investment (FDI) reveals that prior studies have primarily focused on how FDI influences energy intensity (see Elliot et al., 2013; Cao et al., 2020; Vita et al., 2021; Keho, 2016; Adom, 2015; Saraswati et al., 2022). However, there is no evidence of research specifically examining how business cycles affect energy intensity in Nigeria. Moreover, the potential mediating role of FDI in this relationship remains unexplored within the Nigerian context. The only related work addressing this mediating effect is a panel study on emerging economies by (Li et al., 2021).

This study seeks to fill that gap by investigating the influence of business cycles on energy intensity in Nigeria, while also assessing the mediating role of FDI. Unlike, who employed a panel ARDL approach, this research adopts a time series ARDL methodology (Li et al., 2021). This deviation is intentional, as it allows for a country-specific analysis that more accurately captures Nigeria's unique economic and structural dynamics in the business cycle–energy intensity relationship.

2.6 Literature Appraisal

From a methodological perspective, employ the ARDL technique to investigate the nexus between business cycles and energy intensity (Li et al., 2021; Elliot et al., 2013; Petrovic and Lebanov, 2022; Keho, 2016; Sun et al., 2022; and Buch and Lipponer, 2005). In the case of Nigeria, utilizes the Fully Modified Ordinary Least Squares (FMOLS) approach (Adom, 2015).

On the theoretical front, applies the pollution haven hypothesis to explain this relationship, while examine the pollution halo effect within BRICS and non-BRICS economies (Cao et al., 2020; Adom, 2015). Building on these foundations, the present study adopts the ARDL method to analyze the business cycle–energy intensity relationship for Nigeria and incorporates the Environmental Kuznets Curve (EKC) hypothesis as a framework for interpreting the findings.

2.7 Literature Map

Table 1: Literature Map on Business Cycles and Energy Intensity in Nigeria: The Roles of Foreign Direct Investment (FDI)

Authors	Countries	Scope	Methodology	Findings
Li et al., (2021)	Emerging economies	1990-2014	PARDL	BIZ^{+} (-) → ENG BIZ^{-} (+) → ENG
Elliot et al., (2013)	Chinese City	2005 to 2008	PARDL	FDI (-) → ENG
Cao et al., (2020)	BRICS and Non-BRICS	1990-2014	PSTR	FDI ≠ ENG
Petrovic and Lobanov (2022)	81 Economies	1990-2014	PMG	FDI (-) → ENG
Vita et al., (2021)	34 OECD	1987-2013	Threshold Regression	FDI (-) → ENG
Keho (2016)	6 Sub-Saharan African Countries	1970-2011	ARDL	FDI (-) → ENG
Adom (2015)	Nigeria	1989-2013	FMOLS	FDI (-) → ENG
Sun et al., (2022)	China	2006-2015	PARDL	OFDI(-) → ENG
Saraswati et al., (2022)	Indonesia	2008-2015	SDM	FDI (+) → ENG
Buch and Lipponer (2005)	Germany	1989-2002	PARDL	BIZ^{+} (-) → ENG

Note: AMG: Augmented Mean Group; ARDL: Autoregressive Distributed Lag technique; ARDL: Autoregressive Distributed Lags Model; FMOLS: Fully Modified Ordinary Least Square; PSTR: Panel Smooth Transition Regression; SDM: Spatial Durbin Model.

3. Theoretical Framework and Methodology

This chapter presents the theoretical framework and methodology employed to explore the relationship between energy intensity and the business cycle in Nigeria. It is organized into several sections. The first section outlines the research design, while the second focuses on the sources and methods of data collection. The third section discusses the theoretical framework, followed by the fourth section, which states the research hypotheses and the model specification. Subsequently, the estimation techniques are described, and the chapter concludes with the presentation of the data.

3.1 Research Design

The research design serves as the overall strategy for conducting the study, providing a clear and systematic approach to addressing the predefined research questions through the collection, interpretation, analysis, and presentation of data. This study adopts an ex-post facto research design, which involves comparing groups with preexisting characteristics on a dependent variable. As a quasi-experimental approach, it examines how an independent variable that existed prior to the study influences a dependent variable. In this case, the cyclicality of GDP is employed as a proxy for the business cycle, energy intensity is represented by kilojoules per capita, and foreign direct investment inflow is proxied by FDI as a percentage of GDP (see Saud et al., 2019).

3.2 Sources and Method of Data Collection

Annual data on GDP, urban population as a share of total population (URBAN), foreign direct investment inflows as a percentage of GDP (FDI), trade openness (TRADE), and oil rent as a percentage of GDP (OIL) are obtained from the World Development Indicators (WDI, 2023). The study relies on secondary data sources for its data collection.

3.3 Theoretical Framework

The central premise of this study is grounded in the Environmental Kuznets Curve (EKC) theoretical model, which posits that environmental pollution initially increases with economic activity until a certain income threshold is reached. Beyond this critical level, environmental quality improves, and pollution begins to decline, forming an inverted U-shaped pattern. The EKC framework illustrates a quadratic relationship between carbon emissions and economic growth. At higher stages of economic growth, the composition effect enhances environmental quality as the economic structure transitions from agriculture and heavy manufacturing to cleaner industries and the service sector. In the early phases of development, pollution levels rise due to reliance on polluting industries, but in the later phase—when the economy shifts towards services and light manufacturing—pollution decreases. This progression reflects the transformation from a developing economy characterized by highly polluting production methods to a developed economy with cleaner, less-polluting production patterns (Hettige et al., 1998). In other words, the composition effect refers to developing economies' transitions from capital-intensive industrial sectors to service sectors. Hence, the EKC model is written below;

$$\mathrm{CO2} = \mathrm{f}(\mathrm{GDP}, \mathrm{GDP}^2) \quad (1)$$

Where CO2 represents the environmental quality and GDP represents the level of economic activities. The quadratic form of GDP accounts for the nonlinearity of GDP to account for the EKC hypothesis.

This study adapts this model to account for the business cycle-energy intensity relation; since foreign direct investment inflow (FDI) affects the level of business activities and energy consumption. The current study includes the moderating roles of FDI in the nexus.

3.4 Model Specification

Following the specification of Li et al., (2021) of the business cycle-energy intensity model, this study then adapts mathematically below to account for other environmental and macroeconomic indicators:

$$EI_t = \beta_0 + \beta_1 BC_t + \beta_2 VAR_t + \varepsilon_t \quad (2)$$

Where EI is the energy intensity and BC is the business cycles, while VAR is the vector of the control variables.

Following this specification, this study introduces other variables that affects energy intensity. These are then modeled below to show the study's model;

$$EI = f(BC, FDI, TRADE, URBAN) \quad (3)$$

Mathematically, this is modelled below;

$$EI_t^{cyc} = \beta_0 + \beta_1 BC_t + \beta_2 TRADE_t + \beta_3 URBAN_t + \varepsilon_t \quad (4)$$

To achieve the second objective, the model takes the below form;

$$BC_t^{cyc} = \beta_0 + \beta_1 FDI_t + \beta_2 TRADE_t + \beta_3 URBAN_t + \varepsilon_t \quad (5)$$

For the third objective, we have;

$$EI_t^{cyc} = \beta_0 + \beta_1 (BC * FDI)_t + \beta_2 TRADE_t + \beta_3 URBAN_t + \varepsilon_t \quad (6)$$

3.5 Estimation Techniques

To empirically achieve the objectives of this study, four testing procedures were undertaken. First, unit root tests were conducted to assess the stationarity of the variables, using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Second, the long-run cointegration relationship among the variables was examined through the Autoregressive Distributed Lag (ARDL) Bounds testing approach. Following the establishment of cointegration, the ARDL model was applied to estimate both the short-run (dynamic) and long-run (static) relationships. Prior to these estimations, essential pre-tests were performed to evaluate the stability properties of the data series and confirm their long-run behavior, particularly for otherwise unstable series. These preliminary assessments included unit root testing, which identifies the level of stability of each variable, and cointegration testing, which determines whether variables with unit roots converge in the long run. This process is critical, as unstable series cannot provide reliable forecasts.

3.6 Unit Root Tests

To prevent spurious results caused by the instability of certain variables in the analysis, this study employed the Augmented Dickey-Fuller (ADF) unit root test. The choice of the ADF test is justified by its improved formulation over the standard Dickey-Fuller test, making it more suitable for handling large datasets such as those used in this study. In conducting the unit root tests, multiple model specifications were considered, including equations with intercepts, equations with intercepts and trends, and equations without intercepts or trends. These different specifications for the ADF test take the following forms:

$$\Delta\gamma_t = \alpha_* + \alpha_{**}\gamma_{t-1} + \sum_{i=1}^{k} \beta_* \Delta\gamma_{t-1} + \eta_t \quad (7)$$

3.7 Cointegration Test

The cointegration test is essential for verifying the long-run convergence of the mixed-order series within the model. This is because the instability of an individual series in the short run does not necessarily imply the absence of long-run convergence with other series in the model. In this study, the ARDL bounds testing approach is employed for this purpose. To confirm the existence of a long-run relationship, the F-statistic from the bounds test must exceed the upper bound at the chosen significance level. If it does not, there is no evidence of convergence among the series, and only a short-run relationship exists. When the F-statistic falls between the lower and upper bounds, the convergence is weak, making it inconclusive whether a long-run relationship is present.

The ARDL model specification is presented as follows:

$$\Delta Y_t = \rho_0 + \pi T + \sum_{i=1}^{pq} \varphi_i \Delta Y_{t-i} + \sum_{j=1}^{mn} \varphi_j \Delta X_{t-j} + \delta_1 Y_{t-1} + \delta_2 X_{t-1} + \mu_t \quad (8)$$

Where Y represents the dependent variables as defined above, X represent the regressor. Δ represents the first difference operator, ρ_0 is the drift, μ_t is the error term, T is the trend of the model and i=1…pq lag periods. In the ARDL model, an error correction mechanism existed by which changes in the dependent variables were modeled as a function of the level of the disequilibrium in the cointegrating relationship, captured by the error-correction term (ECT), as well as changes in the other explanatory variables to capture all short-term relations among variables.

Accrodingly, equation (13) is further re-specified to capture the error correction mechanism as developed by Pesaran et al., (2001). Thus, we have;

$$\Delta \mathrm{Y_t} = \rho_0 + \pi\mathrm{T} + \sum_{i=1}^{pq} \varphi_i \Delta \mathrm{Y}_{t-i} + \sum_{j=1}^{mn} \varphi_j \Delta \mathrm{X}_{t-j} + \delta_1 \mathrm{Y}_{t-1} + \delta_2 \mathrm{X}_{t-1} + \Omega \mathrm{ECM}_{t-i} + \mu_t \quad (9)$$

Here, ECM_{t-i} is the lagged error correction term calculated as $\mathrm{ECM}_{t-i} = \mathrm{Y}_{t-1} - \hat{\rho} - \widehat{\delta_2}\mathrm{X}_{t-1}$

3.8 Model Evaluation

For the Autoregressive Distributed Lag (ARDL) analysis to be reliable, both the short-run and long-run coefficients are assessed at critical probability levels, with decisions made according to the conventional null hypothesis rule. The final stage of the process involves validating the estimated models to ensure that key assumptions have not been violated. Post-estimation diagnostic tests are conducted, including the Ramsey RESET test to check for model linearity, the Jarque-Bera test to assess the normality of the residuals, the ARCH LM test to detect heteroscedasticity, and the Breusch-Godfrey test to identify the presence of serial correlation in the model.

4. Presentation and Discussion of Results

This chapter presents the empirical results derived from the models discussed earlier, accompanied by a critical analysis and evaluation of the findings. The discussion is organized into three main sections: an introduction, estimation, and evaluation of the estimates. In the pre-estimation stage, the statistical characteristics of the variables are outlined, followed by formal preliminary tests—such as the unit root and cointegration tests—to determine whether the series are stationary and whether a long-run relationship exists among the variables. The subsequent section focuses on the estimation process using the Auto-Regressive Distributed Lags (ARDL) model, chosen for its ability to accommodate first-difference series. The final section assesses whether the estimated results satisfy classical econometric assumptions.

4.1 Pre-estimation

4.1.1 Descriptive Statistics

Table 2 shows that energy intensity (ENG), economic growth (GDP), foreign direct investment (FDI), trade openness (TRADE), and urbanization (URBAN) have average values of 731.27 kilojoules of energy, $1,998.54 per capita in Nigeria, 1.23% of GDP, 12.45% of GDP, and 37.79% of the total population, respectively. The maximum values recorded for these variables are 735.69 kilojoules, $2,088.61 per capita, 0.85% of GDP, 12.96% of GDP, and 39.79% of the total population over the study period.

GDP and ENG exhibit relatively high standard deviations compared to the other variables. Specifically, the standard deviations are 37.95 kilojoules for ENG, $456.21 per capita for GDP, 1.22% of GDP for FDI, 5.86% of GDP for TRADE, and 10.678% for URBAN. While ENG and GDP are negatively skewed, the other variables show positive skewness. Based on skewness statistics, only FDI fails to meet the normality assumption.

In terms of kurtosis, TRADE displays a mesokurtic distribution, indicating normality, whereas the other variables have flatter (platykurtic) peaks over time. The Jarque-Bera (JB) test, considered a more reliable measure of normality, indicates that all variables except FDI and GDP follow a normal distribution pattern.

Table 2: Descriptive Statistics

	ENG	GDP	FDI	TRADE	URBAN
Mean	731.2680	1998.536	1.2328	12.4570	39.7934
Maximum	735.6947	2088.605	0.8534	12.9591	39.9430
Minimum	669.7432	1408.209	-1.1508	1.5067	21.9700
Std. Dev.	37.9475	456.2117	1.2241	5.8614	10.6780
Skewness	-0.0596	-0.0223	1.7753	0.1429	0.0298
Kurtosis	1.4632	1.3415	7.4758	2.6673	1.8335
Jarque-Bera (Prob.)	4.0589 (0.1314)	4.7027 (0.0952)	55.7605 (0.0000)	0.3286 (0.8485)	2.3307 (0.3118)

Sources: Author's Computation (2023) from Eviews 9.

4.1.2 Unit Root Test

It is essential to determine the stationarity properties of the series, as is standard practice in time series analysis. This step helps in selecting the most appropriate estimation method. Ignoring the stationarity characteristics of the variables can lead to the use of unsuitable techniques, biased estimates, and ultimately flawed policy recommendations.

As shown in Table 3, the unit root test results reveal mixed orders of integration. Energy intensity (ENG) is stationary at level, whereas the remaining variables attain stationarity only after first differencing at the 1% significance level. Given this outcome, it becomes necessary to conduct a co-integration test to verify the presence of a long-run relationship and to avoid misleading regression results. Consequently, the ARDL Bounds co-integration test is employed to assess the co-integration properties of each model.

Table 3: Augmented Dickey Fuller Unit Root Test

	Augmented Dickey-Fuller						
Variables	**Levels**			**First Difference**			
	Intercepts	**Trend and Intercepts**	**None**	**Intercepts**	**Trend and Intercepts**	**None**	**I(d)**
ENG	-0.6105	-0.0586	-0.8420	-7.0164***	-7.8204***	-7.0831***	**I(1)**
GDP	-1.2350	-1.8752	-0.1076	-2.5848	-2.9299	-1.9580**	**I(1)**
FDI	-1.9737	-2.0417	0.8398	-6.8787***	-6.6445***	-6.8102***	**I(1)**
TRADE	-1.9736	-2.0417	0.8398	-6.8787***	-6.6445***	-6.8102***	**I(1)**
URBAN	-2.3333	-2.6311	0.8044	-6.6830***	-6.7076***	-6.6443***	**I(1)**

Source: Author's computation, 2023.

Note: ***, ** and * indicates significance at 1%, 5% and 10% critical levels respectively.

4.1.3 Co-integration Test

The ARDL Bounds co-integration test is considered the most appropriate method for determining whether a long-run relationship exists among the variables, given their first-order integration properties identified in the unit root analysis. This approach is suitable for variables that are not endogenous in nature. The test provides two critical values, which are compared with the calculated F-statistic to decide whether to reject the null hypothesis of no co-integration among the series. If the F-statistic exceeds the upper critical bound, or I(1) bound, at the chosen significance level, the null hypothesis is rejected. Conversely, if the F-statistic is below the lower critical bound, or I(0) bound, the null hypothesis is not rejected. When the F-statistic lies between the I(0) and I(1) bounds, the result is deemed inconclusive.

As presented in Table 4, the bounds test results show that Models 1 and 2 reject the null hypothesis of no co-integration, while Model 3 fails to reject it, as its F-statistic of 2.58 falls below the lower bound at the 10% significance level. These findings from both the unit root and bounds tests justify the application of the ARDL long-run model for Models 1 and 2, while for Model 3 and the others, only short-run ARDL estimates are employed to address the study's objectives.

Table 4: ARDL Bounds Cointegration Tests

	Model 1 ARDL(1,0)Trend	**Model 2 ARDL(1,0)Cons**	**Model 3 ARDL (2,1)Trend**

Table 4 (cont): ARDL Bounds Cointegration Tests						
	F-Statistic = 3.96		**F-Statistic = 6.09**		**F-Statistic = 2.58**	
	I(0)	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
10%	2.45	3.52	2.72	3.77	3.03	4.06
5%	3.47	4.57	3.23	4.35	3.47	4.57
2.5%	3.89	5.07	3.69	4.89	3.89	5.07
1%	4.4	5.72	4.29	5.61	4.4	5.72

Author's computation, 2023.

4.2 Interpretation of Results

4.2.1 Model 1: Objective 1

Based on the findings from the unit root and co-integration tests, which show that the variables in this study have mixed orders of integration and that two out of the three models exhibit long-run relationships, the short-run estimations are conducted using the Autoregressive Distributed Lag (ARDL) technique. This method is particularly suitable as it can accommodate variables with different integration orders. The short-run results for the baseline and interactive models are presented in Table 5.

In Model 1, the results indicate a counter-cyclical relationship between the business cycle and energy intensity in Nigeria in both the short and long run, as interpreted from the sign of the coefficients. Specifically, a 1% expansion in the business cycle leads to a 0.00042% decrease in energy intensity. Furthermore, foreign direct investment (FDI) reduces energy intensity, while trade openness increases it. In the short run, a 1% rise in FDI and trade openness changes energy intensity by approximately –0.00093% and +0.0015%, respectively. In the long run, a 1% increase in FDI and trade openness changes energy intensity by about –0.000076% and –0.00093%, respectively.

Lastly, the error correction term indicates that approximately 55.8% of any shocks to the system are corrected each year, ensuring the model's gradual convergence to long-run equilibrium.

Table 5: ARDL Results			
Model 1 (Objective 1)			
Short-Run Estimates (ARDL 1,0 Trend)			
Variables	***Coefficients***	***Standard Errors***	***T-Statistics***
D(Biz_Cycle)	-0.00042**	2.5511	2.2701
DFDI)	-0.0052**	0.1711	-2.2130
D(TRADE)	0.0009*	0.1678	2.0568
ECT	-0.5582***	0.0933	-5.1170
Long-Run Estimates (ARDL 1,0 Trend)			
Biz_Cycle	-0.000076**	5.3792	2.2570
FDI	-0.00093**	0.3611	-2.1967
TRADE	0.0015**	0.3343	2.1638
URB	-0.0005***	0.0199	-6.2380
Constant	0.0150**	20.4316	-2.3971

Source: Author's computation, 2023.

Note: ***, ** and * indicates significance at 1%, 5% and 10% critical levels respectively.

4.2.2 Model 2: Objective 2

Model 2 demonstrates a pro-cyclical relationship between the FDI cycle and the business cycle, indicating that the business cycle increases by 0.91% and 0.72% in the short run, and by 0.72% and 0.89% in the long run, for every 1% rise in the business cycle. Therefore, the null hypothesis of no significant relationship is rejected. Both trade openness and urbanization exert a positive influence on the business cycle in Nigeria. Specifically, a 1% increase in trade openness and urbanization raises the business cycle by 0.0758% and 0.1470% in the short run, respectively. This positive relationship also holds in the long run, where the same 1% increase in trade openness and urbanization results in a 0.089% and 0.218% rise in the business cycle, respectively. The error correction term suggests that approximately 76.8% of shocks are corrected each year, enabling the model to converge to its long-run equilibrium.

Table 6: ARDL Results			
Model 2 (Objective 2)			
Short-Run Estimates ARDL(2,1)Cons			
D(FDI)	0.9091***	0.0752	12.0946
D(TRADE)	0.07582	1.2375	0.0613
D(URB)	0.1470**	0.0647	2.2719
ECT	-0.7684***	2.0055	-0.8818
Long-Run Estimates (ARDL 1,0 Constant)			
FDI	0.7234***	0.0752	12.0946
TRADE	0.0885*	1.2375	0.0613
URB	0.2185**	0.0647	2.2719
Constant	-0.7256***	2.0055	-0.8818

Source: Author's computation, 2023.

Note: ***, ** and * indicates significance at 1%, 5% and 10% critical levels respectively.

4.2.3 Model 3: Objective 3

In Model 3, the interaction between the business cycle and foreign direct investment has an insignificant impact on energy intensity in Nigeria, as its probability exceeds the 10% significance threshold. Furthermore, trade openness is the only variable that positively influences the business cycle in the country, with a 1% increase in trade openness leading to an approximate 0.0724% rise in the business cycle.

Model 3 (Objective 3)			
Short-Run Estimates (2,1)Trend			
$\mathbf{D}(\boldsymbol{ENG}(-\mathbf{1}))$	0.7928***	0.0811	9.7787
$\boldsymbol{BC\_FDI}$	0.0210	0.2220	0.1948
$\boldsymbol{TRADE}$	0.0724**	0.0292	2.4821
Constant	-1.0047	1.3821	-0.7269

Source: Author's computation, 2023.

Note: ***, ** and * indicates significance at 1%, 5% and 10% critical levels respectively.

4.3 Discussion of Findings

4.3.1 Objective 1

Model 1 shows a counter-cyclical link between the business cycle and energy intensity in Nigeria in both the short and long run. A 1% expansion in the business cycle leads to a 0.00042% reduction in energy intensity. During economic booms, energy demand is high, and in some cases, energy shortages may occur. Increased consumer energy use during peak growth periods further fuels demand. However, when growth begins to fluctuate due to internal constraints, energy demand decreases, leading to lower energy intensity.

In times of recession, energy demand declines, excess capacity emerges, and reduced consumer purchasing power causes an overall drop in production and domestic energy use. When growth starts to recover, aided by investment multipliers, the economy gradually strengthens, and energy demand rises again. As a result, fluctuations in the business cycle during recessions tend to increase energy intensity.

These findings align, who reported similar patterns for emerging economies with (Li et al., 2020).

4.3.2 Objective 2

Model 2, which demonstrates a pro-cyclical relationship between the FDI cycle and the business cycle, shows that a 1% increase in FDI cycle leads to a 0.91% and 0.72% rise in the business cycle in the short and long run, respectively. Therefore, the null hypothesis of no significant relationship is rejected.

This implies that because foreign direct investment inflows stimulate economic growth by boosting output, their cyclical fluctuations are likely to drive economic booms in Nigeria—especially given the country's heavy reliance on imports. These results are consistent with Haque et al., (2019), who found similar evidence for BRICS economies.

4.3.3 Objective 3

In Model 3, the interaction between the business cycle and foreign direct investment (FDI) has an insignificant effect on energy intensity in Nigeria, with its probability exceeding the 10% significance level. Based on this result, the null hypothesis of no moderating relationship between the two variables cannot be rejected.

During periods of economic expansion, FDI brings substantial capital into the host country and tends to increase energy consumption, which weakens the negative effect of business cycles on energy intensity.

Conversely, during an economic downturn, heightened uncertainty causes many high-energy-consuming enterprises to exit the market, leading to a rapid decline in energy consumption. At the same time, governments often implement measures to attract FDI to stimulate recovery. The new technologies introduced through FDI can contribute to reducing energy use, thereby strengthening the negative effect of business cycles on energy intensity during recessions.

4.3.4 Control Variables

Across all models, both urbanization and trade openness exert a positive influence on energy intensity and business cycles in Nigeria. A higher share of manufacturing in the economy is associated with greater energy intensity, indicating that the industrial structure positively impacts energy use. Similarly, improvements in the energy structure do not necessarily lead to lower energy consumption, suggesting that the energy mix also has a positive effect on energy intensity. However, the evidence linking trade openness directly to energy intensity remains inconclusive.

In contrast, urban population growth tends to foster innovation, which can lead to improvements in energy efficiency. The adjusted R-squared values across the models indicate substantial variations between the dependent and independent variables, while the Durbin–Watson statistics confirm the absence of serial correlation. Furthermore, the F-statistics affirm the joint significance of the variables in all the models.

4.3 Post Estimation Tests

4.3.1 Model 1

Table 7 presents the results of the post-estimation tests, offering additional evidence of the reliability of the estimated findings. In Model 1, the Jarque–Bera statistic rejects the null hypothesis, confirming that the model satisfies the assumption of normality. The Breusch–Godfrey LM test is applied to check for serial correlation in the residuals, and the results across all models indicate that the null hypothesis of no serial correlation cannot be rejected.

Similarly, adopting the null hypothesis of no heteroscedasticity suggests that the residuals have constant variance over time, indicating that the model is homoscedastic. The Ramsey RESET test is also conducted to verify the correctness of the model's functional form. The results confirm that all models are correctly specified in a linear form. Overall, these outcomes demonstrate that the results are consistent, robust, and suitable for reliable forecasting, in line with the expectations of the classical linear regression model.

Table 7: Post Estimation Test for Model 1

Post Estimation Test Results		
	F-Statistics	**Probability**
Serial Correlation	0.6197	0.5431
Heteroskedasticity (ARCH)	0.5960	0.4426
Normality	5.3864	0.0677
Linearity (RAMSEY)	0.1177	0.7332

4.3.2 Model 2

Table 8 presents the post-estimation test results, offering further confirmation of the reliability of the estimated outcomes. In Model 2, the Jarque–Bera statistic rejects the null hypothesis, indicating that the model satisfies the assumption of normality. The Breusch–Godfrey LM test is applied to check for the presence of serial correlation in the residuals, and the results across all models suggest that the null hypothesis of no serial correlation cannot be rejected.

Moreover, accepting the null hypothesis of no heteroscedasticity implies that the residuals maintain constant variance over time, confirming that the model is homoscedastic. The Ramsey RESET test is also performed to assess the correctness of the model's functional form. The results confirm that the model is correctly specified in a linear form. Overall, these findings demonstrate that the estimates are consistent, robust, and suitable for reliable forecasting, aligning with the assumptions of the classical linear regression framework.

Table 8: Post Estimation Test for Model 2		
Post Estimation Test Results		
	F-Statistics	***Probability***
Serial Correlation	0.1906	0.8272
Heteroskedasticity (ARCH)	1.2853	0.2627
Normality	2.8677	0.2384
Linearity (RAMSEY)	0.0007	0.9792

4.3.3 Model 3

Table 9 presents the results of the post-estimation tests, offering additional evidence of the reliability of the estimated outcomes. In Model 3, the Jarque–Bera statistic rejects the null hypothesis, confirming that the model meets the normality assumption. The Breusch–Godfrey LM test is applied to detect serial correlation in the residuals, and the findings across all models indicate that the null hypothesis of no serial correlation cannot be rejected.

Furthermore, accepting the null hypothesis of no heteroscedasticity implies that the residuals maintain constant variance over time, confirming the model's homoscedasticity. The Ramsey RESET test is also performed to verify the correctness of the model's functional form. The results affirm that the model is correctly specified in a linear form. Overall, these outcomes suggest that the estimates are consistent, robust, and suitable for accurate forecasting, in line with the principles of the classical linear regression model.

Table 9: Post Estimation Test for Model 3		
Post Estimation Test Results		
	F-Statistics	**Probability**
Serial Correlation	0.6174	0.5446
Heteroskedasticity (ARCH)	1.6316	0.2078
Normality	2.7350	0.2547
Linearity (RAMSEY)	0.3033	0.5849

5. Summary, Conclusion and Policy Recommendation

This section provides a summary of the key findings from the preceding results, followed by the conclusion and recommendations. It proposes practical economic policies aimed at improving energy intensity in Nigeria and offers business cycle–based solutions for policymakers.

5.1 Summary of the Study

Similar to trends in the global economy, policymakers in developing countries remain concerned about fluctuations in economic activity, as business cycles are a natural response to economic variations. Numerous theories have been developed to explain these cycles, which are characterized by shifts in production, price levels, interest rates, and employment, as described by (Neumeyer and Perri, 2004). However, rather than focusing solely on the concept of business cycles, this study emphasizes the underlying macroeconomic drivers, as identifying these drivers is essential for effective cycle management.

The primary aim of this research is to examine how economic fluctuations in Nigeria influence energy consumption patterns. Specifically, it seeks to answer the following questions: How does Nigeria's business cycle impact energy usage? To what degree does foreign direct investment (FDI) in Nigeria exhibit cyclical patterns alongside the economic cycle? Is there a link between the business cycle and energy intensity, and if so, what role does FDI play in this relationship? To address these questions, the study relies on annual data from the World Development Indicators (WDI) covering the period 1971–2022, which includes variables such as GDP per capita, urbanization, ecological footprints, and energy intensity.

To determine the most appropriate estimation techniques and understand the properties of the variables, the study employs several procedures, from unit root tests to post-estimation diagnostics. The Augmented Dickey-Fuller test is used to check stationarity, revealing that while some variables are stable at level, others achieve stability only after first differencing. This necessitates assessing the long-run relationships among the variables using the ARDL bounds test, which shows that while some models possess long-run characteristics, others do not—leading to the estimation of both short- and long-run effects for some models, and only short-run effects for others.

Empirical results indicate that the business cycle negatively affects energy consumption in Nigeria, while FDI positively drives the business cycle. However, the interaction between FDI and the business cycle does not significantly influence energy intensity. Additionally, urbanization and trade openness are found to have notable effects on energy intensity.

To ensure the robustness of these findings, post-estimation diagnostics—including tests for normality, linearity, serial correlation, and heteroscedasticity—confirm that all models are well-specified, with residuals that are normally distributed, free from serial correlation and heteroscedasticity, and linearly stated. Consequently, the estimated results are deemed reliable for policy implications.

5.2 Conclusion of the Study

After conducting a series of econometric analyses to address the study's objectives, the following conclusions are reached:

First, the business cycle exerts a negative impact on energy consumption in Nigeria. This indicates that fluctuations in economic activity significantly influence the country's energy use—energy consumption tends to decline during periods of economic expansion and rise during recessions.

Second, foreign direct investment (FDI) has a positive effect on the business cycle in Nigeria, suggesting that inflows of FDI play an important role in driving economic fluctuations.

Lastly, the interaction between FDI and the business cycle does not produce a significant effect on energy intensity in Nigeria.

5.3 Policy Recommendations

Drawing from the above findings, several key policy recommendations are proposed for Nigerian policymakers.

First, it is crucial to enhance the monitoring and early detection of business cycle fluctuations and implement targeted energy policies tailored to each phase of the cycle. This approach will support informed decision-making in the energy sector, help curb excessive growth in energy intensity, and potentially reduce it over time.

Second, given Nigeria's relatively low level of economic development, it is important to remain vigilant about environmental pollution when attracting foreign direct investment (FDI), ensuring that economic growth is not pursued at the expense of environmental sustainability.

Third, the results suggest that low levels of FDI can encourage the relocation of pollution-intensive industries to the host country, making emerging economies potential havens for such industries. However, as FDI increases, business cycles tend to have a negative effect on energy intensity. This is because FDI can raise the host country's technological capacity through technology spillovers, improving energy efficiency and lowering energy intensity.

Therefore, Nigeria should prioritize the integration of advanced technologies when introducing FDI to strengthen its technological base. Additionally, comprehensive environmental assessments should be conducted for all FDI projects to safeguard against environmental degradation.

5.4 Suggestions for Further Studies

This study does not differentiate between the components of renewable and non-renewable energy consumption in relation to business cycles, nor does it examine how each interacts with energy intensity. Disaggregating these energy types could provide a clearer understanding of the specific impacts that different energy sources have on economic fluctuations. Such an approach would also help to identify whether renewable energy consumption responds differently to business cycle phases compared to non-renewable energy, which could have significant implications for energy policy and sustainability strategies in Nigeria.

Therefore, it is recommended that future research explore this relationship by analyzing renewable and non-renewable energy consumption separately, while also considering their moderating effects on energy intensity. This would provide a more detailed picture of the energy–economy nexus and help policymakers design targeted interventions that encourage cleaner energy use, improve efficiency, and support sustainable economic growth.

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