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Posted Date: 23 July 2025

doi: 10.20944/preprints202507.1897.v1

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 doi:10.20944/preprints202507.1897.v1

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Petroleum Consumption and Financial Development: Evidence from Selected EMEs: Evidence from a Panel ARDL-PMG Approach

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Abstract

The paper investigates the long-term and causal relationship between petroleum consumption and financial development in selected emerging market economies (EMEs) for the period 2000 to 2020. The study uses a panel cointegration and an error correction model (ECM). The study investigates both the short-run and long-run dynamics of petroleum consumption and financial development. The study confirms the energy-led growth hypothesis and demonstrates a positive long-run relationship between petroleum consumption and financial development. The short run, on the other hand, reveals insignificant effects. From these findings, it is indicative that petroleum consumption does not have an immediate effect on financial development. The study outlines the need for effective energy policies in the enhancement of financial markets and sustainable economic growth. Hence, it is important for energy infrastructure investments, financial linkages in the energy sector, and mitigating the risks of petroleum dependency through diversification strategies.

Keywords: petroleum consumption; financial development; emerging market economies; panel cointegration; energy-led growth; financial markets

1. Introduction

Financial Petroleum is the key anchor of energy consumption in the emerging market economies (EMEs). It drives virtually all sectors of the economy, such as transportation, manufacturing and trade (Mmbaga & Kulindwa 2024). Unlike electricity, which is generated and consumed locally, petroleum is subject to significant price fluctuations in international markets (Alshubiri, Tawfik & Jamil 2020). Petroleum is influenced greatly by international market dynamics, exposing the EMEs to global price volatilities, supply disruptions, and geopolitical risks. Financial development is hampered by these risks through an increased uncertainty in investment planning, increasing production costs and increasing import bill hence straining foreign exchange reserves (Huang, Borniface & Soukzana 2025).

The nexus between petroleum consumption and financial development is critical in the EMEs. This is particularly true because of the rapid economic growth, increasing energy demands and evolving financial sectors. This paper explores the short and long-term relationship between petroleum consumption and financial development in EMEs using panel cointegration analysis. Panel cointegration analysis is a suitable choice for this study because it effectively handles cross-sectional dependencies and heterogeneity across countries while examining long-run relationships. Cross-sectional dependencies are important because economic and financial linkages between countries can lead to spillover effects. If these are not accounted for, may bias the results. The method is most suited because of its ability to accommodate heterogeneity, allowing for country-specific variations in the data (Pesaran 2020; Chudik & Pesaran 2015).

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The petroleum industry is capital-intensive and depends on advanced financial markets for capital raising and risk management. Developed financial markets are critical for channelling funds to other sectors and facilitating operations (Javed, Du, Iqbal, Nassani & Basheer 2024; Okolo, Wen & Susaeta 2024). Countries with effective financial markets have better credit access and risk management frameworks. According to (Krzemień, Riesgo Fernández, Suárez Sánchez & Diego Álvarez 2016) markets with efficient financial markets have experienced productivity increases of 15%. China is another important example, where over the past 20 years, private sector domestic credit has increased by 250%, positively impacting extractive industries (The World Bank Group 2021). Credit availability supports petroleum consumption by directing investments in exploration, refining, and distribution infrastructure, catalysing energy security and economic growth (Paramati, Ummalla & Apergis 2016; Rousseau & Wachtel 2011)

The fluctuations in petroleum consumption profoundly affect financial development, influencing credit availability, investment flows and macroeconomic stability (Jonas 2024; Kilian 2009; Soytas & Sari 2003; Sadorsky 1999). Emerging markets' dependence on fossil fuels and exposure to global energy market volatility necessitate a closer examination of their relationship with financial development. Total fossil fuel is related to broader economic growth though in some cases the relationship has weakened (International Energy Agency 2024). The use of fossil fuels has declined over the past decade. It has fallen gradually from 83% in 2011 to 80% of the aggregate global energy demand. In developed economies, the decline in fossil fuels was being driven by aggressive investment in renewable energy technologies (International Energy Agency 2024).

Over the past decade, there has been an increase in demand for fossil fuels in EMEs. This is underpinned by rapid economic and population growth. The population in the EMEs have increased by 720 million, on the other hand, the economies have grown by 50%. This has resulted in fossil fuel consumption rising by 25% (IEA 2024). For example, the biggest economies in the EMEs have seen increased oil demand, India has experienced an increase of 1.9 mb/d, while China has risen by 1 mb/d. China is forecasted to surpass the United States as the world's largest oil consumer by 2030. One-third of global oil demand is set to be accounted for by Central and South America, Africa, Middle East and Eurasia by 2050 from the current 22% (IEA 2024). These metrics make it necessary to study and investigate the impact of oil consumption on financial development.

Energy is mostly studied as aggregated variables, particularly the electricity proxy and its impact on financial markets (Odhiambo 2023; Babatunde & Yakubu 2017; Islam, Shahbaz, Ahmed & Alam 2013). The global trading dynamics of petroleum presents unique challenges and opportunities emanating from price volatility, that remain underexplored. This underlines the need to explore the area further and uncover the interactions between petroleum consumption and financial development in emerging markets where energy demand is growing. The foundational work of Sadorsky (2010), examined energy-finance linkages but did not differentiate energy types. According to Elheddad, Djellouli & He (2025), external shocks and domestic policy responses of the petroleum-dependent economies may lead to divergent financial development patterns. For instance, some of the EMEs with deeper financial systems, such as China and India are able to mitigate the effects of price volatility through diversified energy policies and strategic reserves. This is different from other smaller economies, like Nigeria and Venezuela, which experience greater financial instability due to their heavy reliance on petroleum revenues and limited policy flexibility (Reference).

This study makes a valuable addition to the literature: First, the study addresses a noticeable gap in empirical research using a panel cointegration and an error correction model (ECM) framework to identify the long-run equilibrium and short-run dynamics between petroleum consumption and financial development. Second, the EMEs are important players as producers and consumers in the global energy markets. This necessitates a deeper understanding of petroleum consumption and financial development dynamics. Third, the understanding of this nexus informs policymakers on sustainable development and energy policy formulation. The successful implementation of the policy can be augmented through the development of financial instruments, that attract investments into the energy sector. This will help to hedge the price volatility of petroleum

 doi:10.20944/preprints202507.1897.v1

and the implementation of targeted subsidies. Fourth, the study plays a critical role in energy security and transition strategies to reduce fossil fuel reliance. The findings of the study reveal the need for policies that facilitate gradual diversification into renewable energy sources and strengthen financial markets to support green energy investments.

The study is premised on the following hypothesis:

H1: There is a cointegrating relationship between petroleum consumption and financial development in emerging market economies (EMEs).

H2: Petroleum consumption fluctuations significantly impact financial development in the short run influencing macroeconomic stability in EMEs.

H3: There are significant adjustment mechanisms governing deviations from the long-run equilibrium between petroleum consumption and financial development and vary across EMEs.

The paper intends to answer the following questions:

1. How is the trajectory of financial development affected by petroleum consumption in EMEs?
2. Is there a cointegrating relationship between petroleum consumption and financial development?
3. What short-run dynamics and adjustment mechanisms govern deviations from this equilibrium?

The rest of the paper is organized as follows: Section 2 discusses theoretical and empirical literature as applied in this study. Section 3 presents our estimation method and section 4 outlines the empirical results. Section 5 presents our conclusions and recommendations.

2. Literature Review

Financial There are various theoretical explanations for petroleum consumption and financial development. This section explores key theoretical frameworks that have informed this study.

Energy-Led Growth (ELG) Hypothesis: This hypothesis is aligned with the endogenous growth theory, in which energy plays a prominent role as an input in production function. Petroleum consumption reinforces long-term economic growth hence facilitating capital accumulation, industrial production and technological progress. The study by Odhiambo (2019) finds that energy growth enhances financial development in emerging markets. Behera (2015) argues that productivity improvements are driven by petroleum consumption. The integral role of energy consumption in endogenous growth dynamics through a bidirectional causality with economic growth (Apergis & Tang 2013). The economic structures in the EMEs are energy intensive and petroleum consumption is a driver of economic activities, stimulating demand for financial services. Financial markets evolve with energy-driven economic growth by mobilizing capital for energy investments (Durusu-Ciftci, Soytas & Nazlioglu 2020).

Financial development-Energy Consumption Nexus: This hypothesis suggests that a developed financial sector is a prerequisite for energy development via capital channelling into the energy sector. Financial markets are important in financing petroleum production and distribution activities, through instruments such as project finance, syndicated loans, energy bonds, and commodity derivatives. This theory is anchored on the supply-leading hypothesis as postulated by (King & Levine 1993). This theory argues that financial development leads to economic growth through mobilization of savings and efficient allocation of resources (Samadi, Owjimehr & Nezhad Halafi 2021; Rousseau & Wachtel 2011; Shan & Jianhong 2006). Financial development in petroleum-reliant EMEs enhances supply chains and consumption of petroleum.

Resource Curse Hypothesis: This theory argues that countries rich in natural resources often experience slower economic growth and weaker financial development compared to resource-poor economies. This arises from the crowding out effect, overreliance on extractive industries and weak

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institutional development resulting in economic distortions. Furthermore, the governments are not incentivised to develop robust financial markets due to resource rents. Long-term financial instruments do not develop due to volatile commodity prices (Sachs & Warner 1995). Chung & Jin (2025) argue that contrary to expectations, resource-rich economies do not always experience accelerated economic growth. There is an expectation of cost savings from cheap industrial energy utilization and trade advantages due to geopolitical disparities. For example, most African and Middle Eastern economies have experienced stagnated economic growth (Rahim et al. 2021). The resource curse is explained by various theories, including unproductive investment, such as excessive government spending on non-productive sectors (Badeeb, Lean & Clark 2017). The economies are further impacted by fluctuating resource prices (Hasanov, Aliyev, Taskin & Suleymanov 2023). This impacts financial stability, investment flows and credit availability (Tatjana & Hristoski 2022). The stability of financial markets in resource-dependent economies is undermined by commodity price volatility as their asset portfolios and lending activities are linked to the extractive sector.

The Dutch Disease Theory: This theory explains how the economy is negatively affected by large inflows of revenue from natural resources. The revenue from natural resources strengthens the domestic currency and reduces the export sector competitiveness. This harms the non-resource sectors and gives rise to economic imbalances. For example, Nigeria and Venezuela have been exposed to oil price shocks due to currency appreciation due to oil revenue, resulting in weak manufacturing sectors and overreliance on petroleum exports (Wanzala & Obokoh 2024; Karl 1999; Corden Peter J; Neary 1982). Weak economic fundamentals worsen financial development indicators like banking stability and capital market growth (Xu, Meng, Sha & Jiang 2022; Marozva & Makoni 2018; Billmeier & Massa 2009). The resource-dependent EMEs, tend to concentrate investments towards resource sectors ignoring other sectors (Zarotiadis, Kopsidas & Giannopoulou 2024; Matsen & Torvik 2005). Promotion of financial intermediaries and economic diversification is important in counteracting the Dutch Disease. The establishment of sovereign wealth funds (SWFs) is critical in the management of resource revenues, stabilization of exchange rates, and channelling of funds to non-resource sectors. Furthermore, the governments can adopt countercyclical fiscal policies to reduce economic volatility, and credit policies that encourage growth in the non-resource sectors.

Institutional Theory: This theory outlines the need for strong institutions, governance, regulatory frameworks and institutional quality in shaping the nexus between petroleum consumption and financial development (Addison & Roe 2018; Tobin 1984). Financial development is greatly influenced by strong institutions that ensure transparency and lower transaction costs increasing investor confidence (Nxumalo & Makoni 2021; Asongu & Odhiambo 2019).

The theoretical framework demonstrates the complexity of the petroleum consumption and financial development nexus in EMEs, due to market volatility, institutional factors and global trade dynamics. Energy consumption is an important driver of productivity, but reliance on petroleum exposes economies to risks from price volatility and resource dependency. The resilience of the financial sector is affected by market fluctuations and reduced market liquidity. There is a need for an integrated approach that accounts for economic structures, institutional quality, and global dynamics. Policy interventions should foster economic diversification to reduce petroleum reliance and macroprudential policies to manage external shocks. The study empirically tests theoretical linkages using panel cointegration and error correction models to capture both long-term equilibrium and short-term dynamics in EMEs.

2.2. Empirical Literature Review on the Petroleum Consumption and Financial Development Nexus

There is significant interest in empirical exploration of the effects of petroleum consumption on financial development in EMEs. This interest is driven by the need to understand how petroleum consumption influences economic growth, energy security, and financial stability. The interplay between the two variables has been investigated using diverse methodological frameworks. The nexus between petroleum consumption and financial development can be examined via various channels like investment infrastructure, capital allocation and macroeconomic stability. This

 doi:10.20944/preprints202507.1897.v1

highlights the importance of efficient financial markets in EMEs (Javed et al. 2024). The fluctuations in petroleum prices have negative impacts on the financial markets allocative functions (Sadorsky 2014).

The study of Mmbaga & Kulindwa (2024) is based on panel data from 12 Eastern African countries for a period spanning 2000 to 2021. The study uses the Driscoll-Kraay fixed effects model. The model effectively addresses potential cross-sectional dependence and heteroscedasticity in the data. The study reveals that petroleum consumption has both a positive short-term and long-term statistically significant impact on economic growth. The findings of this study indicate overreliance on petroleum in East African economies. This dependence exposes these economies to global oil price fluctuations, that directly impact economic growth and financial development.

The study by Alshubiri, Tawfik & Jamil (2020) investigates the relationship between petroleum and non-petroleum indices of financial development in Oman which has a high dependence on petroleum revenue between 1978 and 2017. The data were sourced from World Development Indicators. The study used the ARDL model, which is suitable to handle small sample sizes. The study found that petroleum consumption has a positive statistically significant impact on financial development in the long run. This indicates that financial development is positively impacted by petroleum consumption. However, in the short run, there is an insignificant relationship between petroleum consumption and financial development. This can be explained by the oil price fluctuations and the resultant adjustment of the financial markets.

The study of Huang et al. (2025) investigates financial development impacts on mineral resource rent in China from 1990 to 2020. Their findings are important to the current study, as both mineral and petroleum resources generate significant rents that impact financial sector dynamics. The autoregressive distributed lag model (ARDL) was employed to analyse the long-run and short-run relationship between financial development and mineral resource rents. The study found a positive and statistically significant long-run relationship between financial development and mineral resource rent in China. The findings indicate that an efficient financial sector results in increased resource rents, indicating a direct impact through improved investment and credit allocation in resource extraction industries. However, in the short run, the study found a statistically insignificant negative relationship between the variables. This can be explained by the short-term adjustments or market volatilities. The Toda-Yamamoto test indicates a unidirectional causal relationship running from financial development to mineral resource rents. Based on these findings the study recommends enhancement of the financial markets to enhance the positive impact on mineral resource rents.

The study by Chen, Tan, Lee & Goh (2016) investigates the nexus between petroleum consumption and financial development in Malaysia which is both a petroleum consumer and producer. The study employs the ARDL framework to test cointegration and applies the Granger causality test to examine the direction of the relationship between petroleum consumption and financial development. The study found a significant positive impact on financial development in the long run. The short-run nexus between petroleum consumption and financial development was also found to be positive and significant. A bidirectional causal relationship between petroleum consumption and financial development was found through the Granger causality test. Given the bidirectional relationship between the variables, it is important to come up with policies that enhance efficiency and regulatory frameworks.

There are gaps in the energy-finance nexus literature. There are gaps emanating from limited country coverage, with most studies focusing on developed economies and limited focus on emerging economies. Most studies analyze aggregate energy consumption without distinguishing between different energy sources such as petroleum, natural gas, and renewables. The study was able to preciously assess the specific impact of petroleum consumption on financial development through disaggregated energy sources. Finally, methodological differences in measuring financial development and energy consumption contribute to inconsistent findings.

This study seeks to address these gaps by employing panel cointegration and ECM methodologies to provide a detailed understanding of the petroleum consumption and financial

 doi:10.20944/preprints202507.1897.v1

development nexus in EMEs. The methodologies are suited for filling the identified research gaps as panel cointegration captures long-term equilibrium relationships across multiple economies, while the ECM accounts for short-term dynamics and adjustments, offering a comprehensive analysis of both immediate and sustained effects.

Table 1 below presents summarised empirical findings of previous studies.

Table 1. Summary of the Petroleum Consumption - Financial Development Nexus Empirical Findings.

Authors	Time	Countries	Methodology	Results
Mmbaga & Kulindwa (2024)	2000 – 2020	12 Eastern African Countries	Driscoll-Kraay Fixed Effects Model	Short-term and long-term significant impact of petroleum consumption on economic growth; high dependence on petroleum exposes economies to global oil price fluctuations.
Alshubiri, Tawfik & Jamil (2020)	1978 – 2017	Oman	ARDL Model	Petroleum consumption has a significant positive impact on financial development in the long run, but an insignificant effect in the short run due to oil price fluctuations.
Huang et al. (2025)	1990 – 2020	China	ARDL Model, Toda-Yamamoto test	The positive and statistically significant long-run relationship between financial development and mineral resource rents; the short-run relationship is insignificant.
Chen, Tan, Lee & Goh (2016)	1990 – 2015	Malaysia	ARDL framework, Granger Causality test	Petroleum consumption positively impacts financial development in both the short and long run; a bidirectional causal relationship was found.

Source: Author, 2025.

3. Data and Methodology

3.1. Data

The study used the data from the World Bank's Global Financial Development Database and the Energy Information Administration as the primary and only sources of data. These sources are reliable, comprehensive, and have global coverage, which gives consistency in the financial and energy metrics. There are few measurement inconsistencies due to the high quality of the EIA data.

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The World Bank database provides standardized financial indicators. The study covered the period from 2000 to 2020. The sample comprised 20 emerging market economies from Asia, Africa, Eastern Europe, Central Europe, North America and South America. The study covered Argentina, Brazil, Chile, Colombia (South America), China, India, Indonesia, Iran, Malaysia, Philippines, Thailand, United Arab Emirates (Asia), Egypt, Kenya, Nigeria, Saudi Arabia, South Africa (Africa); Hungary, Russia, Turkey (Europe, Eastern Europe); Mexico (North America). The diversity of the sample reflects geopolitical and economic conditions that influence financial development. The study used various econometric models on the sample.

The study examined the following variables petroleum consumption from the Energy Information Administration and financial development, proxied by the financial development index, along with control variables. Economic growth was measured by real GDP per capita, FDI, government effectiveness, and infrastructure proxied by gross fixed capital formation (GFCF) as a percentage of GDP, inflation, real interest rates and natural resources rents. All variables were sourced from the World Bank's Global Financial Development Database and the World Development Indicators (WDI).

Panel Unit Root Test

Panel unit root test results confirm that all variables are non-stationary at levels but become stationary after first differencing, indicating integration of order one, I(1). Traditional unit root tests have no power in panel data, especially in small samples (Baltagi, 2008; Hsiao, 2014).

Table 2. Unit Root Tests.

(a): Panel Unit root test using the LLC				
Variable	**No trend**	**Intercept and Trend**	**Individual Effects**	**Decision**
ED6	-7.72546***	2.95045***	3.08854***	I(1)
FIN_DEV1	-12.5368***	-5.76010***	-7.01951***	I(1)
EconGR1	-9.00243***	-14.1579***	-14.8932***	I(1)
FDI	-3.73481***	-3.84931***	-3.59057***	I(1)
GE	-19.2898***	-11.6725***	-5.32626***	I(1)
GFCF	-3.17697***	-4.81640***	-12.7641***	I(1)
INF	-5.36244***	-3.17697***	-4.81640***	I(1)
INT	-4.55824***	-2.94927***	-2.98998***	I(1)
RES	-17.1758***	-11.7095***	-12.5584***	I(1)
(b): Panel unit root tests using IPS				
Variable	**No trend**	**Intercept and Trend**	**Individual Effects**	**Decision**
Petroleum Cons	-	-1.54789***	-3.68186***	I(1)
EconGR1	**-**	**-7.32238*** **	**-8.86368*** **	**I(1)**
FIN_DEV1	-	-6.80194***	-8.89608***	I(1)
FDI	-	-3.15388***	-4.64037***	I(1)
GE	-	-7.76492***	-3.37902***	I(1)
GFCF	-	-5.22146***	-6.27994***	I(1)
INF	-	-4.60067***	-4.43623***	I(1)
INT	-	-3.99142***	-5.53141***	I(1)
RES	-	-8.61635	-10.5161***	

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(c): Panel unit root testing using ADF – Fisher chi-square

Variable	No trend	Intercept and Trend	Individual Effects	Decision
FIN_DEV1	205.413**	121.031***	155.718***	I(1)
EconGR1	162.126***	119.625***	165.202***	I(1)
Petroleum Cons	131.662***	57.1864***	82.3936***	I(1)
FDI	58.5960***	69.1745***	95.5074***	I(1)
GE	298.930	137.193***	96.8117***	I(1)
GFCF	206.139***	101.597***	113.461***	I(1)
INF	78.4077***	89.8547***	89.4916***	I(1)
INT	111.210***	81.3262***	103.028***	I(1)
RES	293.299***	142.441***	180.638***	I(1)

(d): Panel unit root testing via PP - Fisher chi-square

Variable	No trend	Intercept and Trend	Individual Effects	Decision
FIN_DEV1	342.526***	282.882***	338.690***	I(1)
EconGR1	**288.937*** **	**183.140*** **	**211.156*** **	**I(1)**
Petroleum Cons	236.900***	142.993***	169.306***	I(1)
FDI	62.4167***	99.6138***	125.058***	I(1)
GE	425.816***	119.393***	100.232***	I(1)
GFCF	282.949	168.619***	188.621***	I(1)
INF	125.836***	257.273***	195.883***	I(1)
INT	154.617***	172.350***	339.354***	I(1)
RES	384.238***	298.422***	293.773***	I(1)

***; **; and * indicate that the null hypothesis of unit root tests is rejected at 1%, 5% and 10%, respectively. All the tests are at first difference (except where indicated otherwise). The probabilities for all the tests assume asymptotic normality except for Fisher tests which are computed via the asymptotic chi-square distribution. ED6 is petroleum and other liquids, FIN_Dev1 is financial development index, EconGR1 is gross domestic product per capita, FDI is the foreign direct investment, GFCF is the gross fixed capital formation as % of GDP, INF is inflation, GE is the government effectiveness, INT is real interest rates and RES is total natural resources. Source: Author's compilation using Stata

The variables are integrated of order one, I(1), across all four testing methodologies. This reinforces the validity of results by ensuring consistency in stationarity properties. This demonstrates that the variables exhibit non-stationarity in levels but become stationary after first differencing, necessitating the use of first-differenced models in short-term analyses. Consequently, panel cointegration analysis is justified to determine long-run equilibrium relationships, ensuring that statistical inferences are not spurious (Nkalu, Ugwu, Asogwa, Kuma & Onyeke 2020). These results justify further econometric modelling, including panel VECM or ARDL, to examine the dynamic relationships between financial development and petroleum consumption in EMEs.(Bozkurt, Toktaş & Altiner 2022).

Descriptive Statistics

Table 3 provides the descriptive statistics of the study sample, covering emerging markets. The summary includes key macroeconomic variables relevant to the study.

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Table 3. Descriptive Statistics.

	Mean	Median	Minimum	Maximum	Std, Dev,	Skewness	Kurtosis	Jarque-Bera	Obser
FIN_DEV1	0,42	0,42	0,09	0,74	0,14	0,08	2,39	6,90	419
Petroleum Cons	1513,04	717,32	50,06	14432,72	2172,24	3,50	17,27	4413,54	419
ECONGR1	8 264,37	6 141.83	755.48	59 986,44	9 618,28	3,51	13,50	4 062,22	419
FDI	3,08	219	-40,09	106,60	7,81	7,76	93,34	14 6682,60	419
GE	0,06	0,00	-1,20	1,51	0,56	0,34	2,89	8,08	419
GFCF	22,96	21,98	0,00	44,52	6,43	1,03	4,70	124,88	419
INF	8,37	5,90	-16,27	52,98	8,75	2,08	9,01	931,51	419
INT	5,58	4,18	-18,85	54,00	9,71	2,32	10,45	1346,40	419
RES	9,42	5,07	0,23	55,48	10,20	1,95	7,13	562,68	419

Source: Author's Analysis: Descriptive statistics are calculated on all available annual data for the 2000 – 2020 period.
Notes: std, Dev = Standard Deviation, Obser = Number of observations, Fin_Dev1 = Financial development index, ED6 = petroleum consumption (Mb/d), EconGR1= GDP per Capita (Constant 2015 US$),), FDI = foreign direct investment (Net inflows as a % of GDP), GE = government effectiveness, GFCF = gross fixed capital formation as a percentage of GDP, INF = inflation GDP deflator annual %, INT = real interest rates % and RES= total natural resources rents as a % of GDP.

Table 3 presents the descriptive statistics of the variables in the study. The financial development index (Fin_Dev1) has a mean and median of 0.42 indicating a relatively symmetrical distribution. There is a moderate variation across the countries in the sample with a minimum of 0.09 and 0.74. The results indicate that financial development is fairly stable across the sampled countries. The petroleum consumption (ED6) has a mean of 1513.04 Mb/d and a median of 717.32 Mb/d indicating a right-skewed distribution, and that some of the countries consumed more petroleum than the others. There is a large disparity in the consumption of petroleum for the sampled countries ranging from 50.06 Mb/d and a maximum of 14,432.72 Mb/d. This variability is confirmed by the standard deviation of 2172.24. Economic Growth (EconGR1) had a mean and median of 8,264.37 and 6,141.83 respectively, and the distribution is positively skewed. Most control variables exhibit significant dispersion, especially FDI (7.81), inflation (8.75), and interest rates (9.71), indicating volatility in economic conditions.

Cross-Correlation Analysis

Table 3 reports the correlation coefficients, and measures the strength of the relationship between the variables in the variables.

Table 3. Correlation Analysis.

Variables	FIN_DEV1	ED6	ECONGR1	FDI	GE	GFCF	INF	INT	LRGDP	RES
FIN_DEV1	1									

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Petroleum Cons	0,2947***	1,0000								
ECONGR1	-0,2951***	-0,0266	1							
FDI	0,0977**	-0,0564	-0,0788	1						
GE	0,5704***	-0,0234	-0,2808***	0,1764***	1					
GFCF	0,1923***	0,6377***	0,0432	0,0443	0,0866*	1				
INF	-0,2817***	-0,0960**	0,2122***	-0,0759	-0,3515***	-0,1731***	1			
INT	0,1063**	0,0122	-0,1015**	-0,04	-0,0566	-0,1581***	-0,1084**	1		
RES	-0,0966**	-0,1412***	-0,0194	0,1150***	0,1536***	0,0986**	0,0483	0,1266***	-0,1276***	1

Table 3 discusses the correlation results of the variables in the study. There is a positive and significant relationship between (FIN_Dev1) and ED6 of 0.2947* suggesting higher petroleum consumption leads to financial markets deepening. This brings out the notion that energy-intensive economies require robust financial systems to facilitate investments and resource allocation. The control variables exhibit mixed relationships reinforcing the complex interplay between macroeconomic stability, investment and financial deepening.

3.2. Empirical Analysis

Following the methodology of (Nguyen, Bui, Vo & McAleer 2019; Pesaran, Shin & Smith 2001) the study employed the autoregressive distributed lag (ARDL) bounds testing approach, in investigating the long-run cointegration between petroleum consumption and financial development. The panel ARDL model is preferred when both the cross-sectional (N) and time-series (T) dimensions exceed 1, as opposed to a standard ARDL model, which is typically used for single time-series analysis.(Pesaran et al. 2001). Pesaran, Shin & Smith (1999) argue that the method allows the estimation of long-run relationships between dependent and independent variables, even when the regressors are integrated at different levels, provided they are not I(2).

The ARDL framework estimates both short – and long-run dynamics in the same model giving it flexibility Narayan (2004). This is important in small sample sizes, as it allows for efficient parameter estimation without losing long–term equilibrium insights. Furthermore, the approach is more suited for diverse EMEs due to its ability to accommodate heterogeneity across cross–sections. Furthermore, it can take into consideration both immediate and equilibrium relationships over time Pesaran et al. (2001). This enhances inference by allowing for dynamic policy simulations and more accurate forecasting of how shocks to petroleum consumption or financial development propagate over time. As a result, policymakers can design targeted interventions based on both short-term adjustments and long-run stability. The AIC, BIC, and SBC were used to determine the optimal lag length, with the lowest values guiding model selection in Stata.

Hausman (1978) test was conducted to determine the most suitable estimator among Pooled Mean Group (PMG), Mean Group (MG), or Dynamic Fixed Effects (DFE), as well as to assess the homogeneity of long-run coefficients across sections. The difference in the treatment of parameter heterogeneity raises the need to have the estimators compared. The PMG allows short-run heterogeneity while assuming long-run homogeneity, MG allows for full heterogeneity across cross-

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sections, and DFE imposes homogeneity on both short- and long-run parameters. Unbiased and robust inferences about the relationship between petroleum consumption and financial development in EMEs are reinforced by choosing the appropriate estimator.

The equation below is estimated to examine the relationship between electricity consumption and financial development in the selected emerging markets. The study runs the ARDL and error correction model (ECM) to capture the speed of adjustment when there is disequilibrium (Pesaran et al. 1999). This captures both the cointegrating and the short-run effects of the variables under study (Wehncke, Marozva & Makoni 2023; Nxumalo & Makoni 2021; Makoni & Marozva 2018; Engle, Granger, Engle & Grangeri 1987).

Model Specification and Estimation Techniques

The GMM model was specified as follows:

$$\Delta FINDev1_{it} = (\alpha - 1)\Delta FINDev1_{i,t-1} + \beta_1 \sum_{i=1}^{n} \Delta ED_{it} + \beta_2 \sum_{i=1}^{n} \Delta EG_{it} + \beta_{3it} \sum_{i=1}^{n} \Delta X_{it} + \beta_4 \sum_{i=1}^{n} Dummy1_{it} + \beta_5 \sum_{i=1}^{n} Dummy2_{it} + \Delta\varepsilon_{i,t}$$

Where:

- ΔFINDev1it: Changes in **financial development**.
- $(\alpha - 1)\Delta FINDev1_{i,t-1}$ = Lagged changes in financial development;
- $\beta_1 \sum_{i=1}^{n} \Delta ED_{it}$ = cumulative changes in petroleum consumption;
- $\beta_2 \sum_{i=1}^{n} \Delta EG_{it}$ = cumulative changes in economic growth;
- $\beta_{3it} \sum_{i=1}^{n} \Delta X_{it}$ = changes in other explanatory variables (FDI, Infrastructure, Inflation, Government Effectiveness, Prices, Natural resources and real interest rates)
- $\beta_4 \sum_{i=1}^{n} Dummy1_{it} + \beta_5 \sum_{i=1}^{n} Dummy2_{it}$ = dummy variables (Global financial crisis and the Covid-19 pandemic).
- $\Delta\varepsilon_{i,t}$ = Error term capturing unobserved factors.

The following Error Correction Model (ECM) for financial development was tested empirically:

$$\Delta \text{FINDev}_{it} = \emptyset_i \left(FINDev_{i,t-1} - \gamma_{1i} EDev_{i,t} - \gamma_{2i} EG_{i,t}\right) + \sum_{j=1}^{p-1} \delta_{ij} \Delta FINDev_{i,t-j} + \sum_{j=0}^{q-1} \beta_{1i} \Delta EDev_{i,t} + \sum_{j=0}^{q-1} \beta_{1i} \Delta EG_{i,t} + \mu_i + \varepsilon_{,it}$$

Where:

- $\Delta FINDev_{it}$ =The change in Financial Development for country *i* at time *t*.
- $\emptyset_i \left(FINDev_{i,t-1} - \gamma_{1i} EDev_{i,t} - \gamma_{2i} EG_{i,t}\right)$ = The error correction term, captures the long-run equilibrium relationship between financial development (FINDev), energy development (EDev), and economic growth (EG). The term $\emptyset_i$ represents the speed of adjustment back to equilibrium.
- $\sum_{j=1}^{p-1} \delta_{ij} \Delta FINDev_{i,t-j}$ = The lagged changes in financial development, accounting for short-term dynamics.
- $\sum_{j=0}^{q-1} \beta_{1i} \Delta EDev_{i,t} + \sum_{j=0}^{q-1} \beta_{1i} \Delta EG_{i,t}$ = The short-run effects of changes in energy development and economic growth, respectively.
- $\mu_i + \varepsilon_{,it}$ = The country-specific fixed effect.
- $\varepsilon_{,it}$ = The error term or disturbance.

PMG Estimation

Table 5 presents a summary of the Pooled Mean Group (PMG) estimation results, analysing the cointegrating and causal relationship between financial development Fin_Dev1 (Financial Development Index), (ED1) electricity consumption and economic growth.

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Table 5: Summary of Pooled Mean Group on the cointegrating and causality relationship between financial development and electricity consumption.

PMG Estimation

Table 5 presents a summarised Pooled Mean Group on the cointegrating and causality relationship between financial development, Fin_Dev1 (Financial Development Index), (ED1) electricity consumption and economic growth.

Table 5. Summary of Pooled Mean Group on the cointegrating and causality relationship between financial development and electricity consumption.

	PMG	PMG	PMG	PMG
Variables	**D.Fin_Dev1**	**D.ED6**	**D.EconGR1**	**D.FDI**
Long-Run				
EconGR1	0.0252**	-0.0420***		0.216
	(5.11)	(-3.32)		(1.66)
ED6	0.0664***		6.644*	5.586***
	(1.19)		(2.05)	(-9.63)
Fin_Dev1		0.850***	18.35**	0.241
		(14.68)	(-2.65)	(0.17)
FDI	0.0186***	0.00773	-0.0815	
	(9.91)	(1.77)	(-1.24)	
ECT	-0.210***	-0.140**	-0.0224**	-0.599***
	(-3.79)	(-2.86)	(-1.34)	(-7.66)
Short-Run				
D.EconGR1	0.0196	0.0584		-1.672
	(0.77)	(0.88)		(-0.89)
D.ED6	0.0264		0.891	-18.33
	(0.34)		(1.01)	(-0.79)
Fin_Dev1		-0.0516	-0.629	14.16
		(-0.70)	(-0.57)	(0.88)
D.FDI	0.000416	-0.00186	0.0329	
	(-0.21)	(-1.15)	(0.96)	
_cons	0.00723	0.365**	-0.138	10.93***
	(1.16)	(2.70)	(-1.26)	(7.54)
N	399	399	399	399
Hausman	44.75***	39.55***	64.80***	9.42*

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Source: Author's compilation using STATA.

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4. Discussion

The Key Findings of the study

The study provides empirical evidence on the relationship between financial development and petroleum consumption, with economic growth and FDI as the control variables in the EMEs.

The long-run relationship between electricity consumption and financial development

The error correction term (ECT) is negative and significant for both financial development and petroleum consumption at -0.210 and -0.140, indicating a stable long-run relationship for petroleum consumption and financial development. This indicates that short–term shocks do not result in persistent imbalances. This result suggests that deviations from long-term equilibrium are corrected at a speed of 21% per annum, and shocks to financial development adjust back to equilibrium relatively quickly. These findings are in line with the evidence provided by Nkalu et al. (2020) of an adjustment speed of approximately 18%. Petroleum consumption also has a significant ECT with a 14% speed of adjustment. This indicates a stable long-run relationship. These findings are consistent with (Nwafor, Kalu, Arize & Onwumere 2023), who reported similar adjustment dynamics in developing economies.

Long-Run Relationships

The results exhibit a strong bidirectional relationship between petroleum consumption and financial development and boost each other. These findings confirms energy-finance nexus.

Petroleum Consumption (ED6) on Financial Development (Fin_Dev1)*:* Petroleum consumption has a significantly positive impact on financial development. A unit increase in petroleum consumption increases financial development by 0.0664 units. These findings are indicative that higher petroleum consumption stimulate economic activities and support financial development. Shahbaz et al. (2017) find that energy consumption, including petroleum, fosters financial development by enabling economic activities requiring financial intermediation.

Financial Development (Fin_Dev1) on Petroleum Consumption (ED6)*:* Financial development significantly and positively impact petroleum consumption. The results indicates that a stronger financial sector supports energy-intensive activities like energy intensive activities or infrastructure projects. Sadorsky (2010) supports this, noting that financial development facilitates investments in energy-demanding sectors.

Other Significant Variables

EconGR1 on ED6 (-0.0420)****:* Economic growth is negatively related to petroleum consumption. This suggest that higher economic growth may increase diversification to other energy sources.

EconGR1 on Fin_Dev1 (0.0252)****:* Economic growth positively impact financial development. This suggest that economic growth supports financial sector growth.

FDI on Fin_Dev1 (0.0186)***: The significant impact of FDI on financial development is indicative that FDI strengthens financial systems, via capital flows (Doytch & Narayan, 2016).

Short-Run Relationships

The short-run results shows no significant effects between petroleum consumption and financial development, and has a significant interplay in the long-term. The significant constant term for petroleum consumption indicates persistent short-run demand growth.

Petroleum Consumption (ED6) on Financial Development (Fin_Dev1) (0.0264)*:* Petroleum consumption has no immediate impact on financial development. This is at variance with the long time findings. This aligns with the findings of Çoban and Topcu (2013), who note that energy consumption's effect on financial development is often delayed due to resource allocation dynamics.

Financial Development (Fin_Dev1) on Petroleum Consumption (ED6) (-0.0516): Financial development does not have an immediate impact on petroleum consumption. This is aligned to the findings of Sadorsky (2010) that financial development has weak effects on energy consumption.

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Constant Term (0.365)***: A positive and significant coefficient is indicative a baseline upward trend in petroleum consumption, likely driven by structural factors like industrialization (Shahbaz et al., 2017).

Policy Implications

Policymakers should prioritize sustained investments in petroleum infrastructure to support long-term financial development, while recognizing that short-run effects are minimal. Strategies should leverage the long-run synergy between energy and financial systems (Shahbaz et al., 2017).

5. Conclusions

This The study reinforces the bidirectional between petroleum consumption and financial development. It provides empirical evidence that confirms the mutual long-term between the two variables. The contribution of the study is significant as it reduces aggregation biases and offers a precise understanding of petroleum consumption implications in EMEs through the isolation of petroleum consumption within the energy-finance nexus. The study sets a stage for future research that takes into account sectoral dynamics and alternative energy sources that enhance a more comprehensive understanding of financial development drivers in EMEs. The use of sectoral VAR models can reveal differential effects by analysing industry-specific impacts like transportation, manufacturing and financial services. The use of the nonlinear ARDL or structural break analysis would play a critical role in the assessment of energy transition toward sustainable energy sources. Policymakers would benefit from future studies exploring optimal financial instruments, such as green bonds or energy-sector-specific credit facilities, to support both traditional and renewable energy financing in EMEs.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

EMEs	Emerging Market Economies
ECM	Error Correction Model
ARDL	Autoregressive Distributed Lag
FDI	Foreign Direct Investment
GFCF	Gross Fixed Capital Formation
INF	Inflation
GE	Government Effectiveness
INT	Real Interest Rates
RES	Total Natural Resources Rents
FIN_DEV1	Financial Development Index
ED6	Petroleum and Other Liquids (used as a variable for petroleum consumption)
EconGR1	Economic Growth (measured by real GDP per capita)
PMG	Pooled Mean Group
MG	Mean Group
DFE	Dynamic Fixed Effects
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
SBC	Schwarz Bayesian Criterion
GMM	Generalized Method of Moments
ECT	Error Correction Term

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ELG	Energy-Led Growth (Hypothesis)
SWFs	Sovereign Wealth Funds
WDI	World Development Indicators
EIA	Energy Information Administration
LLC	Levin, Lin, and Chu (used in the context of panel unit root testing)
IPS	Im, Pesaran, and Shin (used in the context of panel unit root testing)
ADF	Augmented Dickey-Fuller (used in the context of panel unit root testing)
PP	Phillips-Perron (used in the context of panel unit root testing)
Mb/d	Million Barrels per Day (unit for petroleum consumption)
LRGDP	Log of Real Gross Domestic Product

Appendix A

Table A1. Causal and cointegrating relationships – D.Fin_Dev1.

	PMG D.Fin_Dev1	MG D.Fin_Dev1	DFE D.Fin_Dev1
Long Run			
EconGR1	0.0252***	-0.559	0.0191
	(5.11)	(-1.36)	(1.72)
ED6	0.0664	-1.689	0.337***
	(1.19)	(-0.54)	(3.64)
FDI	0.0186***	-0.0384	0.00186
	(9.91)	(-1.79)	(1.31)
ECT	**-0.210*** **	**-0.455*** **	**-0.184*** **
	(-3.79)	**(-6.06)**	**(-6.04)**
Short Run			
D.EconGR1	0.0196	0.0709*	-0.00426
	(0.77)	(2.12)	(-1.03)
D.ED6	0.0264	-0.0519	-0.0279
	(0.34)	(-0.79)	(-0.64)
D.FDI	-0.000416	0.00141	-0.000219
	(-0.21)	(0.71)	(-0.95)
_cons	0.00723	-0.257	-0.118
	(1.16)	(-1.12)	(-1.95)
N	399	399	

Table A2. Causal and cointegrating relationships – D.ED6.

	PMG D.ED6	MG D.ED6	DFE D.ED6
Long Run			

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Fin_Dev1	0.850***	-0.225	0.686**
	(14.68)	(-0.27)	(3.12)
EconGR1	-0.0420***	0.352*	-0.0329
	(-3.32)	(2.06)	(-1.82)
FDI	0.00773	-0.00235	-0.00109
	(1.77)	(-0.21)	(-0.48)
ECT	**-0.140****	**-0.404*****	**-0.134*****
	(-2.86)	**(-6.01)**	**(-5.29)**
Short Run			
D.Fin_Dev1	-0.0516	-0.190	-0.0436
	(-0.70)	(-1.50)	(-0.70)
D.EconGR1	0.0584	-0.0630	-0.000147
	(0.88)	(-0.91)	(-0.03)
D.FDI	-0.00186	0.000207	0.0000418
	(-1.15)	(0.06)	(0.15)
_cons	0.365**	0.292	0.382***
	(2.70)	(0.83)	(5.49)
N	399	399	

Table A3. Causal and cointegrating relationships – D.EconGR1.

	PMG D.EconGR1	MG D.EconGR1	DFE D.EconGR1
Long Run			
Fin_Dev1	-18.35**	-0.0505	3.031
	(-2.65)	(-0.01)	(1.29)
ED6	6.644*	1.599	-3.280*
	(2.05)	(0.40)	(-2.04)
FDI	-0.0815	0.0945	0.0184
	(-1.24)	(0.72)	(0.92)
ECT	**-0.0224****	**-0.379*****	**-0.157*****
	(-1.34)	**(-5.87)**	**(-6.37)**
Short Run			
D.Fin_Dev1	-0.629	-2.133	-0.585
	(-0.57)	(-0.78)	(-0.93)

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D.ED6	0.891	1.719	0.0438
	(1.01)	(1.49)	(0.08)
D.FDI	0.0329	0.0206	-0.00235
	(0.96)	(0.80)	(-0.85)
_cons	-0.138	2.705	2.155**
	(-1.26)	(0.90)	(2.97)
N	399	399	

Table A4. Causal and cointegrating relationships – D.FDI.

	PMG D.FDI	MG D.FDI	DFE D.FDI
Long Run			
Fin_Dev1	0.241	-4.989	-11.74
	(0.17)	(-0.66)	(-0.87)
EconGR1	0.216	4.995	0.551
	(1.66)	(0.81)	(0.61)
ED6	5.586***	15.91	10.08
	(-9.63)	(0.93)	(1.09)
ECT	**-0.599*** **	**-0.882*** **	**-0.700*** **
	(-7.66)	**(-10.96)**	**(-10.70)**
Short Run			
D.Fin_Dev1	14.16	11.66	18.72
	(0.88)	(0.72)	(1.23)
D.EconGR1	-1.672	-2.143	-0.0753
	(-0.89)	(-1.05)	(-0.06)
D.ED6	-18.33	-32.08	-13.33
	(-0.79)	(-0.96)	(-1.05)
_cons	10.93***	-38.27	-16.93
	(7.54)	(-1.24)	(-0.96)
N	399	399	

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