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Relationship between Oil Prices, Oil Consumption and Financial Development in Developed Countries

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ABSTRACT

The aim of this study is to analyze the relationships between financial development, oil prices, and energy consumption in OECD countries over the period 2000–2023. To identify long-run relationships, the Pedroni panel cointegration test is employed, while panel causality analysis is conducted to determine the direction of these relationships. Furthermore, to enhance the reliability of the cointegration results, analyses are carried out using FMOLS and DOLS estimators. The findings reveal a unidirectional causality running from financial development to energy consumption, supporting the conservation hypothesis, which posits that the financial system plays a decisive role in determining energy consumption. Additionally, the results indicate a unidirectional causality from oil prices to energy consumption. The consistency in the direction of the regression coefficients obtained from both FMOLS and DOLS methods confirms the robustness of the results.

Keywords: Oil Price, Financial Development, Energy Consumption, OECD Countries, Panel Data Analysis
JEL Classifications: B26, F65, O13, Q42

1. INTRODUCTION

Energy, as one of the fundamental inputs of economic development, is a strategic resource that directly influences the growth performance and welfare levels of countries. Particularly in developed nations, where economic activities are intense and the degree of industrialization is high, energy consumption plays a critical role not only in sustaining production processes but also in maintaining the quality of life. In this context, fossil fuels such as oil constitute a significant portion of energy supply, and fluctuations in their prices affect not only energy markets but also financial systems and macroeconomic balances.

In developed economies, changes in oil prices directly influence the expectations and behaviors of economic agents, leading to notable variations in energy demand. Meanwhile, the impact of financial development on energy consumption has become an increasingly prominent topic of discussion in recent years. A well-developed financial system can facilitate access to energy and enable the financing of renewable energy investments. This, in turn, can directly shape energy consumption dynamics and dependency on energy sources. Therefore, understanding the interrelationship between financial development, energy demand, and oil prices is of great importance for the formulation of sustainable energy policies.

Although there is a growing body of literature examining the relationships between energy consumption, oil prices, and financial development, studies that simultaneously consider these variables and evaluate their long-term causal relationships

specifically in developed countries remain limited. Addressing this gap, the present study investigates the relationships among oil prices, energy consumption, and financial development in OECD countries over the period 2000–2023 using panel data analysis methods. The analysis employs the Pedroni panel cointegration test, panel causality analysis, and the FMOLS and DOLS estimators to uncover the long-term relationships and directions of causality among the variables.

The findings of the study contribute to a better understanding of how energy policies and financial regulations influence energy consumption in developed countries. Furthermore, by highlighting the role of the financial system in shaping energy demand, the results provide valuable insights for policymakers in designing strategies aimed at enhancing energy efficiency.

2. LITERATURE REVIEW

The relationship between oil prices, oil consumption, and financial development in developed countries is multifaceted, involving economic growth, energy consumption, and financial market dynamics. Oil consumption is a critical driver of economic growth; however, its relationship with GDP follows an inverted U-shaped pattern, indicating that as economies mature, the growth in oil consumption eventually declines (Lim et al., 2014). Financial development plays a crucial role in mediating the impact of oil resource abundance on economic growth, with more advanced financial markets potentially mitigating the adverse effects of oil dependency (Law & Moradbeigi, 2017).

One of the earliest studies examining the impact of financial development on energy consumption was conducted by Mielnik and Goldemberg (2002). Their study investigated the relationship between foreign direct investment and energy intensity across 20 developing countries, finding a negative relationship between financial and energy variables. The necessity of incorporating financial variables into studies focusing on the energy consumption–economic growth nexus was first emphasized by Karanfil (2009). Sadorsky (2010; 2011) contributed some of the first empirical studies that not only theoretically outlined but also practically examined the relationship between financial development and energy consumption.

Inspired by finance-led growth theory, Sadorsky (2011) articulates the connection between financial development and energy consumption as follows: “Financial development can trigger a series of changes within a country that affect energy demand. For instance, it can lower financial risk and borrowing costs, increase transparency between lenders and borrowers, facilitate greater access to financial capital and investment flows across borders, and improve access to the most energy-efficient and technologically advanced products. All these positive changes can boost consumption and fixed investment in businesses, thereby influencing energy demand.” According to Sadorsky’s (2010; 2011) findings, financial development impacts energy consumption through three distinct channels: the direct effect, the business effect, and the wealth effect. These effects and their economic reflections are summarized in Table 1. Nevertheless, a significant conclusion noted in these studies is that the theoretical relationship between the variables is not entirely clear and can only be thoroughly understood through empirical analysis.

Table 1: How financial development affects energy consumption

Channels	Reflection of the Impact
Direct effect	With the positive developments in financial development, consumers can borrow cheaply and easily to buy durable goods. As a result, they consume more energy.
Business effect	Positive developments in financial development help businesses to access financial capital easily and at lower costs. In addition, developments in the stock market can also affect businesses by providing additional sources of financing. All of these developments increase the existing business potential of businesses and cause their energy demands to increase.
Wealth effect	Increased transactions in the stock exchange create a wealth effect, affecting the confidence of consumers and businesses in the market. Increased economic confidence stimulates the economy and causes an increase in energy demand.

When examining studies on the impact of financial development on energy consumption, it is evident that while numerous single-country analyses exist, multi-country analyses remain relatively limited. Some of these studies report the existence of the growth hypothesis (Chitioui, 2012; Özturk and Acaravci, 2013; Pao & Tsunai, 2011; Mombekova et al., 2024), while others support the conservation hypothesis (Al-Mulali & Lee, 2013; Kakar et al., 2011; Shahbaz et al., 2013b), and still others advocate for the feedback hypothesis (Al-Mulali & Che Sab, 2012a; Sbia et al., 2014; Shahbaz et al., 2013a; Syzdykova et al., 2020). Most of these studies aim to explore the direction of causality and the existence of long-term relationships between financial development and energy consumption.

In more recent research, in order to better understand the dynamic relationship between financial development and energy consumption, additional variables such as industrialization, urbanization, population growth, trade openness, and capital accumulation have been incorporated into the models.

Samuel et al. (2013) review empirical studies evaluating the link between financial development and energy consumption, including oil consumption, highlighting the mixed findings. In developed countries, the relationship may exhibit either unidirectional or bidirectional causality, suggesting that oil prices and consumption can influence financial development or vice versa. However, their study emphasizes the need for further research utilizing multiple models, especially in the context of the ongoing global energy crisis affecting both developed and developing economies.

Hooshmand et al. (2013) do not specifically address the relationship between oil prices, oil consumption, and financial development in developed countries. Instead, they focus on the adverse effects of oil rents on financial development in oil-dependent economies, highlighting the critical role of institutional quality. Their analysis

of 17 oil-exporting countries from 2002 to 2010 shows that oil rents weaken financial development both directly and indirectly through institutional quality, but their findings are not extended to developed economies.

Ready (2014) provides evidence that the share of household oil consumption in total consumption negatively predicts financial variables, indicating a complex relationship between oil prices, consumption patterns, and financial development. The study suggests that fluctuations in oil prices and consumption, particularly in developed countries, can affect economic growth and financial markets. The model developed emphasizes the impact of oil-driven productivity risk and the importance of understanding oil supply price sensitivity.

De Michelis et al. (2014) examine the cross-country effects of oil prices on consumption, noting that declines in oil prices positively impact consumption in oil-importing economies while negatively affecting oil-exporting economies. However, they do not specifically address the relationship among oil prices, oil consumption, and financial development in developed countries. Their findings show that oil price increases have a more detrimental effect than the benefits gained from price decreases, but the focus is not directly on financial development in developed economies.

Law and Moradbeigi (2017) explore how financial development can mitigate the negative effects of oil resource abundance on economic growth in oil-producing countries. They emphasize that more developed financial markets can efficiently channel oil revenues into productive activities, potentially reversing the resource curse or enhancing the resource blessing in these economies.

Ma and Fu (2020) find that financial development positively affects energy consumption in developing countries, but has no significant impact in developed economies. Although they do not specifically address the relationship between oil prices, oil consumption, and financial development in developed countries, their findings suggest that financial development alone may not be sufficient to curb the global increase in energy consumption. Thus, the dynamics of oil prices and consumption in developed countries fall outside the scope of their study.

3. DATA AND METHOD

3.1. Data and Model

In this study, which investigates the relationship between financial development, oil prices, and energy consumption, energy consumption (*EC*) is measured by per capita consumption of oil and equivalent fuels in kilograms, Brent crude oil price (*OP*) is used as the proxy for oil prices, and the financial development index (*FD*) serves as the indicator for financial development. The Financial Development Index, developed by the IMF (2015), integrates various components encompassing financial institutions and financial markets. This index has been published annually for approximately 180 countries since 1980 and provides a comprehensive measure of financial development.

The baseline model to be estimated in this study can be expressed as follows: $EC_{it} = f(OP_{it}, FD_{it})$

To directly estimate the elasticity coefficients and to eliminate the scale effect caused by outliers in the dataset, the natural logarithms of all series were taken. Thus, the empirical model is specified as follows:

$$InEC_{it} = a_0 + a_1\, InOpit + a_2\, InFD_{it} + v_i + \mu_t + \varepsilon_{it}$$

The index i in the model represents countries (i = 1,…,38), and the index t represents time (t = 2000,…,2023). In addition, v in the model represents fixed country effects, μ represents fixed time effects, and ε represents the error term assumed to be normally distributed ($\varepsilon \sim N(0, \sigma^2)$ with zero mean and constant variance. This study utilizes an unbalanced panel dataset covering 38 OECD countries over the period 2000–2023. To investigate the long-run relationship and causality between financial development, oil prices, and energy consumption — which constitutes the central research question of this study — panel cointegration analysis, panel causality analysis, as well as Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimators were employed.

3.2. Method

3.2.1. Panel cointegration analysis

The next stage of the empirical analysis involves testing the existence of a long-run relationship between financial development and energy consumption through cointegration analysis. This study employs the panel cointegration test developed by Pedroni (1995; 1999; 2000), which incorporates both within-dimension (panel) and between-dimension (group) statistics. Compared to conventional cointegration tests, this technique provides statistically more robust results.

Pedroni (1995; 1999; 2000) proposes seven test statistics to assess cointegration. Four of these are within-dimension (panel) statistics, while the remaining three are between-dimension (group) statistics. The within-dimension statistics combine autoregressive coefficients across cross-sections for unit root tests on the estimated residuals. These statistics account for common time factors and heterogeneity across countries. On the other hand, the between-dimension (group) statistics are based on the averages of individual country-specific autoregressive coefficients, which are associated with unit root test residuals calculated separately for each panel member.

The relevant statistics are computed as follows:

Panel v-Statistics

$$Z_V = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1}$$

Panel rho-Statistics

$$Z_\rho = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i} (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i)$$

Panel PP-Statistics

$$Z_{\rho\rho} = \left(\sigma^2 \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i)$$

Panel ADF-Statistics

$$Z_t = \left(\hat{S}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} (\hat{e}_{i,t-1}^{*} \Delta \hat{e}_{i,t}$$

Group rho-Statistics

$$\check{Z}_\rho = \sum_{i=1}^{N} \left(\sum_{i=1}^{T} \hat{e}_{i,t-1}^2 \right)^{-1} \sum_{i=1}^{T} (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i)$$

Group PP-Statistics

$$\check{Z}_{\rho\rho} = \sum_{i=1}^{N} \left(\sigma^2 \sum_{i=1}^{T} \hat{e}_{i,t-1}^2 \right)^{-1/2} \sum_{i=1}^{N} (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i)$$

Group ADF-Statistics

$$\check{Z}_t = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{S}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1/2} \sum_{i=1}^{T} \hat{e}_{i,t-1}^{*} \Delta \hat{e}_{i,t}^{*}$$

The null hypothesis of the Pedroni cointegration test states that there is no cointegration relationship among the variables.

3.2.2. Panel causality analysis

Following the identification of a long-run cointegration relationship among the variables, the next step involves determining the existence and direction of short-run causality. For this purpose, the Granger causality test is employed.

The Granger causality test is based on the following models:

$$\Delta Y_{i,t} = \theta_{i,Y} + \sum_{p} \theta_{i,p} \Delta Y_{i,t-p} + \sum_{p} \theta_{i,p} \Delta X_{i,t-p} + \gamma_{1,i} ECT_{t-1} + \varepsilon_t$$

$$\Delta X_{i,t} = \theta_{i,X} + \sum_{p} \theta_{i,p} \Delta X_{i,t-p} + \sum_{p} \theta_{i,p} \Delta Y_{i,t-p} + \gamma_{1,i} ECT_{t-1} + \varepsilon_t$$

In the model above, the Δ variables represent the first differences, the *ECM* term refers to the error correction mechanism, and the *p* value indicates the lag length.

4. RESULTS

4.1. Panel Unit Root Analysis Results

In regression analyses conducted with non-stationary data, unrealistic test results may arise, a phenomenon referred to as spurious regression (Granger & Newbold, 1974). However, according to the cointegration analysis developed in the 1980s, linear combinations of non-stationary series may exhibit stationarity. Conducting cointegration analysis prior to differencing the series, thereby preserving the economic information that might otherwise be lost, enhances the predictive power of the research. Before performing panel cointegration analysis, it is necessary to investigate whether all variables are integrated of order one by applying a unit root test. In this study, the Im et al. (2003) (IPS) test, one of the most commonly used panel unit root tests, has been employed. The results are presented in Table 2.

According to the unit root test results presented in Table 2, when the variables are considered at their levels, the null hypothesis indicating the presence of a unit root cannot be rejected for any variable. However, when the first differences of the variables are used, the unit root hypothesis can be rejected for all variables at the 1% significance level. These results indicate that all variables are integrated of order one, I(1).

The next stage of the empirical analysis involves testing the existence of a long-run relationship among financial development, oil prices, and energy consumption through cointegration analysis. Based on the findings of the analysis, four out of the seven Pedroni test statistics are statistically significant, and the null hypothesis can be rejected at the 1% significance level. In other words, there exists a cointegration relationship among the variables. Thus, it can be concluded that there is a long-term relationship among all variables in the model. The results of the Pedroni panel cointegration test are presented in Table 3.

Panel Granger causality test results are reported in Table 4.

Table 2: IPS unit root test results

Variables	Level		1st difference	
	t-statistic	Probability value	t-statistic	Probability value
EC	6.36492	1.0000	−6.10858	0.0000***
OP	3.82037	0.9978	−4.53820	0.0000***
FD	2.80394	0.9263	−8.03621	0.0000***

***Sign indicates 99% confidence level

Table 3: Pedroni panel cointegration test results

Test Statistics	Coefficient
Panel v-Statistics	−2.940212 (0.7428)
Panel rho-Statistics	2.130132 (0.9898)
Panel PP-Statistics	−11.21381 (0.0000) ***
Panel ADF-Statistics	−4.384632 (0.0098) ***
Group rho-Statistics	4.161898 (1.0000)
Group PP-Statistics	−15.12182 (0.0000) ***
Group ADF-Statistics	−3.892864 (0.0000) ***

Values in parentheses represent probability values. *** sign indicates 99% confidence level

Table 4: Panel granger causality test results

Variables	*DLNEC*	*DLNOP*	*DLNFD*
DLNEC	-	9.066** (0.0281)	5.863 (0.7436)
DLNOP	25.275*** (0.0000)	-	2.688 (0.4427)
DLNFD	23.991*** (0.0000)	4.961 (0.7640)	-

***Sign indicates 99% confidence level

Table 5: DOLS and FMOLS estimation results

Dependent Variable: *LNEC*				
Independent Variables	DOLS		FMOLS	
	Coefficient	Probability	Coefficient	Probability
LNOP	0.2964	0.0000***	0.1251	0.0000***
LNFD	0.4255	0.0002***	0.3978	0.0000***

***Sign indicates 99% confidence level

According to the findings, a unidirectional causality from financial development to energy consumption has been identified. This suggests the validity of the conservation hypothesis, which posits that the financial system plays a vital role in shaping energy consumption. Additionally, a unidirectional causality from oil prices to energy consumption is observed. The results obtained in this study demonstrate that both financial development and oil prices have significant and directional effects on energy consumption.

The results from the panel causality analysis reveal a unidirectional causality running from financial development to energy consumption. This finding is consistent with the view known in the literature as the "conservation hypothesis," which asserts that energy consumption is a consequence of economic growth, implying that the development of economic and financial systems increases energy demand. The validity of this hypothesis indicates that energy-saving policies may have a limited negative impact on economic growth.

Financial development can influence energy consumption through both direct and indirect channels. The deepening of the financial system can expand investment opportunities for individuals, firms, and the public sector, thereby exerting an upward pressure on energy demand. In particular, increased investments in the residential and industrial sectors lead to higher energy needs, while financial facilitation also encourages individual consumption. On the other hand, financial development may contribute to reducing energy intensity in the long run by promoting the adoption of energy-efficient technologies. However, the findings of this study suggest that, at present, the energy demand-enhancing effect of financial development is dominant.

The identified unidirectional causality from oil prices to energy consumption highlights the considerable price sensitivity of energy demand. This finding particularly implies that in developed countries, energy consumption is price elastic, and increases in oil prices can exert a constraining effect on energy demand. The availability of alternative energy sources and the implementation of energy efficiency policies in developed economies enhance the sensitivity of energy consumption to fluctuations in oil prices. Therefore, oil prices emerge as a critical economic determinant that influences not only energy costs but also consumption levels (Syzdykova et al., 2021).

These findings underline the necessity of considering the financial structure and global energy prices in the formulation of energy policies. The sustainability of the rising energy demand associated with financial sector development can only be ensured if it is supported by environmentally friendly and low-carbon energy investments. From this perspective, the relationship between financial development and energy consumption necessitates a re-evaluation of energy policies not only from the standpoint of energy supply security but also in alignment with sustainable development goals.

4.2. Panel Cointegration Estimators (FMOLS and DOLS)

After establishing evidence of a cointegration relationship among the variables, the long-run relationship between financial development, oil prices, and energy consumption can be estimated using various panel cointegration estimation methods. In this study, the FMOLS (panel fully modified ordinary least squares) estimator proposed by Phillips & Moon (1999) and Pedroni (1995), as well as the DOLS (panel dynamic ordinary least squares) estimator proposed by Kao & Chiang (2000), are employed for this purpose. FMOLS and DOLS estimators enhance the predictive power of the model by addressing potential issues of serial correlation and endogeneity. The empirical results of the FMOLS and DOLS estimations are presented in Table 5. The findings obtained from both approaches are fully consistent in terms of the signs of the coefficients.

5. CONCLUSION

This study provides significant empirical evidence on the interactions among financial development, oil prices, and energy consumption within the sample of OECD countries over the period 2000–2023, using panel data analysis methods. The findings reveal that energy consumption is influenced by both the structure of the financial system and fluctuations in international oil prices. In particular, the identified unidirectional causality from financial development to energy consumption demonstrates that the financial sector directly affects energy demand by supporting economic activities. This result clearly indicates that energy policies cannot be evaluated independently of the dynamics of the financial system.

Furthermore, the unidirectional causality from oil prices to energy consumption highlights that price signals in energy markets guide consumption behavior. Access to alternative energy sources and the implementation of energy efficiency strategies in developed countries increase this sensitivity, making the effects of price changes on energy demand more visible. Considering the direction of both causality relationships, it is evident that energy consumption decisions are influenced by both the financial dimension of the economic structure and external price shocks.

The FMOLS and DOLS estimators employed in the study confirm the stability and direction of the cointegration relationships, thereby enhancing the reliability of the findings. The consistency of the regression coefficients supports both the validity of the methodological approach and the robustness of the identified relationships. In this context, the results underscore the necessity of addressing the interactions among financial development, energy policies, and energy consumption in a multidimensional manner.

Based on these results, the following recommendations are proposed:

- Financial integration in energy policies: Given the impact of the financial system on energy consumption, it is essential to design energy policies in an integrated manner with financial sector developments. In particular, green financing can play a strategic role in supporting sustainable energy projects.
- Enhancing resilience to oil price fluctuations: Since fluctuations in oil prices affect energy demand, it is crucial for developed countries to place greater emphasis on energy supply security and price stability policies. Investments in renewable energy sources and the widespread adoption of energy efficiency measures are recommended in this regard.
- Monitoring the effects of financial development on energy demand: Due to the steering effects of financial development on energy consumption, it is necessary to regularly monitor the environmental impacts of the rising energy demand and to develop policy tools to mitigate these effects.
- Coherent macroeconomic policies for policymakers: Macroeconomic policymakers should consider the potential impacts of policies supporting financial growth on energy demand. Priority should be given to efficiency-oriented policies that promote development without significantly increasing energy demand.
- Promoting international cooperation: Establishing an environment of cooperation based on information sharing and joint strategies among OECD countries in the fields of energy, finance, and the environment will support both regional energy security and sustainable development goals.

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