BUSINESS AND ECONOMICS RESEARCH JOURNAL
ISSN: 2619-9491
www.berjournal.com
Business and Economics Research Journal Vol. 16, No.2, 2025 pp. 125-136 doi: 10.20409/berj.2025.460

Exploring the Role of Financial Development on Energy Consumption in Turkiye

Pınar Karahan-Dursun[1]

Abstract: *This study investigates the impact of financial development on energy consumption in Turkiye from 1985 to 2019. To this end, the study employs Bound test, ARDL model and VECM-based causality test. In the empirical analysis, economic growth and foreign direct investment are included in the estimated model. The results of the Bound test indicate that there is cointegration between the series. The results of the estimated ARDL model show that financial development contributes to the increase in energy consumption both in the long run and in the short run. The results of the long-run ARDL model show that a 1% increase in financial development leads to an increase in energy consumption by 0.36%. The study also concludes that economic growth is a driver of energy use, while human capital negatively affects energy consumption in the long-run. The results of the causality test in the VECM framework reveal that there is a causal relationship from financial development to energy consumption in the short run, and all explanatory variables together are Granger causes of energy consumption in the long run.*

Keywords: Financial Development, Energy Consumption, Economic Growth, ARDL, VECM Causality Test

JEL: O16, O13, C32

Received : 02 January 2025
Revised : 20 February 2025
Accepted : 19 April 2025

Type : Research

1. Introduction

Energy plays a crucial role in promoting economic development, since the production of goods and services in any country depends on the availability and use of energy resources (Furuoka, 2015). Identifying the determinants of energy consumption has become an important research topic in the last decade. Understanding the factors that influence energy demand is crucial to reducing countries' energy dependence and minimizing the environmental impact of energy consumption. In this context, financial development is considered as one of the most important drivers of energy demand (Destek, 2018). Financial development has an important impact on energy consumption, which can be positive or negative (Chiu & Lee, 2020).

As stated by Sadorsky (2010), financial development has three effects that increase energy consumption. First, the direct effect asserts that financial development increases the economic efficiency of a country's financial system which enables consumers to easily borrow money to purchase more energy-intensive goods like automobile and appliances. Consequently, this increases energy consumption. Second, the business effect suggests that businesses also benefit from an improved financial system, and have the opportunity to expand, build new facilities and purchase more equipment by accessing easier and less costly access to financial capital. Thus, this contributes to an increase in energy demand for business activities. Third, the wealth effect indicates that an increase in stock market activity boosts consumer and business

Cite this article as: Karahan-Dursun, P. (2025). Exploring the role of financial development on energy consumption in Turkiye. *Business and Economics Research Journal, 16*(2), 125-136. http://dx.doi.org/10.20409/berj.2025.460

[1] Asst. Prof., PhD., Mudanya University, Faculty of Arts and Social Sciences, Department of Economics and Finance, Bursa, Turkiye, pinarkarahan.dursun@mudanya.edu.tr

confidence and increased economic confidence lifts demand for energy-intensive goods (Sadorsky, 2010). Conversely, the effect of financial development on energy consumption is not always positive. The technology effect implies that financial development decreases energy consumption by enabling firms to easily find funds for investing in advanced and efficient technology. In addition, financial development reduces energy consumption by driving the technology innovation of energy industry. Because of these theoretical effects, financial development has a significant impact on energy consumption, and this impact can be either positive or negative (Chiu & Lee, 2020; Shahbaz et al., 2018; Xu et al., 2023).

According to the International Energy Acency (IEA), Turkiye's total final consumption increased by approximately 93.4% between 2000 and 2022. During this period, total final consumption increased by 474% in commercial and public services, 156% in transport services, and 68% in industry services. In 2022, 37% of energy consumption is oil products, 26% is natural gas and 22% is electricity. Accordingly, it is crucial to investigate the factors affecting energy consumption in the Turkish economy. Over the past two decades, the link between financial development and energy consumption has been of great interest to researchers (Pata et al., 2022). However, studies examining the nexus between energy consumption and financial development in Turkiye remain limited. This study investigates the effect of financial development on energy consumption in Turkiye over the period from 1985 to 2019.

This study differs from other studies in Turkiye by including foreign direct investment (FDI) and human capital in the analysis within the financial development-energy consumption nexus. In Turkiye, there remains a research gap regarding the role of FDI and human capital on energy consumption. The impact of FDI on energy consumption is explained by three effects. First, the scale effect states that FDI increases energy consumption due to increased economic activity. Second, the technology effect suggests that FDI reduces energy consumption since foreign investors improve energy efficiency and disseminate knowledge in the host country. Third, the composition effect suggests that the impact of FDI on energy consumption is uncertain, depending on the sectoral distribution of FDI and the level of economic development in the host country (Salim et al., 2017). Regarding human capital, the income effect and the technology effect determine the direction of the human capital effect on energy consumption. The income effect claims that better educated individuals will earn higher incomes, which will increase energy consumption. On the other hand, the technology effect argues that human capital accumulation contributes to higher levels of national income, which in turn facilitates the adoption of more efficient technologies and reduces energy consumption (Churchill et al., 2023). Furthermore, this study applies the bound test, the ARDL model and VECM-based causality test and differentiates from the relevant literature for Turkiye in terms of testing the long-run and the short-run causal relationship between foreign direct investment, human capital, and energy consumption in the context of financial development-energy consumption nexus. As pointed out by Danish and Ulucak (2021), the study also uses a comprehensive proxy for financial development developed by the International Monetary Fund, which provides detailed insights into financial development.

This study consists of five sections. Section 2 reviews the literature on the connection between energy consumption and financial development. Section 3 outlines the data, model, and methodology. Section 4 presents empirical findings, and section 5 offers the conclusion.

2. Literature Review

In the literature on the financial development-energy consumption nexus, the studies were generally conducted using country groups rather than country specific. The studies examining the relationship between energy consumption and financial development can be categorized into three main groups as panel data studies, time series studies, and nonlinear studies.

Firstly, from panel data studies, Furuoka (2015) examines the relationship between financial development and energy consumption for 12 Asian countries by using heterogeneous panel causality test over the period 1980-2012. The panel causality test results show that there is a unidirectional causality from energy consumption to financial development. The results of the analysis also detect the causality from economic growth to energy consumption. Chang (2015) examines the effects of financial development on energy consumption for a sample of 53 countries covering the period from 1999 to 2008. The study divides the countries into high-income and non-high income countries and brings about that financial development increases energy consumption in non-high income countries. Destek (2018) investigates the impact of financial development on energy consumption for 17 emerging economies for the period 1991-2015 and concludes that financial development negatively affects energy consumption. Ma and Fu (2020) find the positive impact of financial development on energy consumption in 120 countries during 1991-2014. Their analysis also includes the development of financial institutions and the financial market and reveals the similar effects on energy consumption. During the period 1997-2017, Wang et al. (2021) find that the financial development has a significantly negative influence on renewable energy consumption for China as a whole and western China. Shahbaz et al. (2021) test the impact of financial development on renewable energy consumption in 34 upper-income developing countries. They employ the FMOLS approach for spanning from 1994 to 2015 and conclude that financial development positively affects renewable energy consumption. Usman et al. (2023) affirm that financial development lifts energy consumption in the developing Asian countries from 1991 to 2019. Xu et al. (2023) examine the role of financial development on energy consumption for the panel data of 30 provinces in China for the period 2010-2019. The findings show that financial development increases energy consumption through the channel of poverty alleviation efficiency. Yıldırım and Şenol (2024) detect the unidirectional causality from renewable energy consumption to financial development in 14 EU countries and Turkiye from 2004 to 2019.

Secondly, from time series studies, Tang and Tan (2014) detect that financial development positively affects energy consumption in Malaysia over the period 1972-2009. Kakar (2016) examines the causality between financial development and energy consumption in Pakistan and Malaysia for the period 1980-2010. The results indicate that the causality runs from financial development to energy consumption in Pakistan, while the causality is bidirectional in Malaysia. Mahalik et al. (2017) find the positive influence of financial development on energy consumption in Saudi Arabia from 1971 to 2011. The results also reveal that there is a unidirectional causal relationship from financial development to energy demand. Farhani and Solerin (2017) detect that financial development has a negative impact on energy consumption in the United States over the period 1973q1-2014q4. Kahouli (2017) find a negative impact of financial development on energy consumption for Egypt while financial development is insignificant linked to Algeria and Lebanon. In Azerbaijan, Mukhtarov et al. (2018) expose that the financial development exerts significantly positive impact on energy consumption for the period 1992-2015. In France, Shahbaz et al. (2018) conclude that financial development and foreign direct investment decrease energy consumption during the period 1955-2016. Danish and Ulucak (2021) conclude that financial development increases energy consumption in Pakistan between 1980-2017. Pata et al. (2022) examine the influence of financial development on renewable energy consumption for the USA from 1980 to 2019. They use a total of six sub-indicators, three for financial market development and three for the financial institution's development. The results of the study show that the dept and access to financial markets play a crucial role in fostering renewable energy consumption in the USA.

Thirdly, from non-linear studies, Baloch et al. (2019) explore the nonlinear relationship between financial development and energy consumption, and economic growth and energy consumption for 25 OECD countries between 1980-2016. The study captures the presence of an inverted U-shaped link between financial development and energy consumption. The finding also reveals that urbanization increases energy use while FDI is found to be insignificant and detects the bidirectional causal relationship between financial development and energy use, and between economic growth and energy use, and between urbanization and energy use. Yue et al. (2019) use five different financial development indicators for 21 transitional countries covering the period from 2006 to 2015. Their analysis reveals that financial development has a significant nonlinear effects on energy consumption, and financial development affects energy consumption differently in the sample countries based on the financial development indicators used. Chiu and Lee (2020) investigate the effects of country risks on the linkages between financial development and energy use for OECD and non-OECD countries from 1984 to 2015. The results of the analysis show that banking sector indicators have more influences on energy consumption than stock market development indicators. The study also captures the inverted U-shaped relationship between stock market development and energy consumption for the non-

OECD countries, and banking sector indicators affect these countries differently according to their risk environment. Thebuho et al. (2022) test the symmetric and asymmetric relationship between energy consumption and financial development for 21 sub-Saharan Africa countries. They apply a panel NARDL approach over the period 1990-2016 and conclude that the negative shocks in financial development have a stronger effect on energy consumption than the positive shocks in financial development. The results also show that FDI decreases energy consumption in the long-run. McFarlane et al. (2023) employ NARDL model to reveal asymmetric impacts of financial development on energy consumption in Jamaica from 1980 to 2018. The long-term results indicate that positive movements in financial development have no impact on energy consumption, while a decline in financial development is causally linked to an increase in energy consumption.

The literature on the relationship between energy consumption and financial development for Turkiye is quite scarce, and it can be observed that these studies have been growing in recent years. The relevant empirical literature mostly examines the causality between energy consumption and financial development. Some of them, Çetin et al. (2015) employ ARDL model and Granger causality based on vector error correction model (VECM) for the period 1960-2011. The results of the analysis display that financial development positively affects energy consumption, and there is unidirectional causality from financial development to energy consumption in Turkiye for the period 1960-2011. Çetin (2018) conclude that the financial development increases energy consumption, and there is one-way causality from financial develop to energy consumption in Turkiye. The study applies the DOLS approach and annual data from 1980 to 2015. Kızılkaya and Gökçe (2021) conclude that there is unidirectional causality from financial development to energy consumption in Turkiye in the period from 1965 to 2019. Covering the period 1980-2015, Tarla and Bayat (2021) reveal that increase in energy consumption causes a decrease in financial development according to the Hatemi J-Roca (2014) asymmetric causality test. They also use Balcılar et al. (2010) rolling window causality test and conclude that it is more observes the causality running from energy consumption to financial development for the analyzed period.

Moreover, some of the studies analyze the relationship between energy consumption and financial development considering the type of energy consumed. One of them, Çağlar and Kubar (2017) use Fourier Toda Yamamoto causality test from 1969 to 2014 and detect the presence of a unidirectional causal relationship from financial development to fossil fuel energy consumption in Turkiye. The empirical results also show that there is no causality between renewable energy consumption and financial development. Mukhtarov et al. (2022) examines the effects of financial development, economic growth, and consumer price index (CPI) on renewable energy consumption in Turkiye for the period 1980-2019. Using the VECM and ARDL approaches, they conclude that financial development triggers renewable energy. Şahin (2023) captures the negative effect of financial development on renewable energy consumption on for the results of the short-term ARDL model, over the period from 1990 to 2000.

Eyüpoğlu and Eyüpoğlu (2023) investigates the effects of financial development, economic growth, and trade openness on financial development in Turkiye from 1980 to 2020. The results of the ARDL model display that there is an inverted U-shaped relationship between energy consumption and financial development. In addition, economic growth increases energy consumption while trade openness negatively affects energy consumption.

On the other hand, some studies find to fail long-run relationship between energy consumption and financial development for Turkiye. Some of them, Keskingöz and İnançlı (2016) conclude that there is no cointegration relationship between energy consumption and financial development in Turkiye for the period 1960-2011. Their analysis reveals the bidirectional causality between financial development and energy consumption. The other study, Kibritçioğlu (2023) state that there is no long-term relationship between energy consumption and financial development in Turkiye over the period 1980-2022. However, the findings demonstrate that energy consumption Granger-causes financial development in the short-run. Şahin (2023) reveal the no-cointegration between renewable energy consumption and financial development in Turkiye over the period 1980-2022.

The empirical studies examining the link between energy consumption and financial development in Turkiye employs various financial development indicators as proxies for measuring financial development. These are financial development index (Eyüpoğlu & Eyüpoğlu, 2023; Şahin, 2023; Tarla & Bayat, 2021), domestic credit to private sector (Çetin, 2018; Kızılkaya & Gökçe, 2021), and total values of stocks traded as a % of GDP (Mukhtarov et al., 2022). Furthermore, some studies including Çetin et al. (2015), Çağlar and Kubar (2017), and Kibritçioğlu (2023) utilize various indicators of financial development.

3. Data and Method

The aim of the study is to investigate the impact of financial development on energy consumption considering the economic growth, foreign direct investment, and human capital in Turkiye. The study covers the period from 1985 to 2019. This period is based on the availability of data for the variables of financial development and human capital.

This study uses the financial development index as a proxy for financial development in line with Tarla and Bayat (2021), Eyüpoğlu and Eyüpoğlu (2023), and Şahin (2023). The Financial Development Index has been developed by the International Monetary Fund (IMF) to provide a more comprehensive assessment of financial development. This index captures the extent to which financial institutions and financial markets are developed in terms of depth (size and liquidity), access (the ability of individuals and firms to access financial services), and efficiency (the provision of services at low cost with sustainable revenues, and the level of activity of capital markets) (Svirydzenka, 2016). The model of this study is expressed in equation (1).

$$LEC_t = \alpha_0 + \beta_1 LFD_t + \beta_2 LGDP_t + \beta_3 LFDI_t + \beta_4 LHC_t + \varepsilon_t \quad (1)$$

In equation (1), EC denotes the primary energy consumption per capita, FD signifies the financial development index, GDP indicates real GDP per capita (constant 2015 USD) as a proxy for economic growth, FDI shows foreign direct investment net inflows (% of GDP), and HC represents the human capital index, based on years of schooling, and returns to education. All variables in the analysis are measures of their natural logarithms to obtain the elasticity value of the coefficients, and L demonstrates natural logarithm. $\beta1$, $\beta2$, $\beta3$, and $\beta4$ are the long-run elasticities of the EC with regards to FD, GDP, FDI, and HC, respectively. EC is obtained from the BP' Statistical Review of World Energy, and FD is retrieved from the IMF' Financial Development Index Database. GDP and FDI extracted from World Bank' World Development Indicators (WDI). HC is obtained from the Penn World Table (PWT 10.01).

In the empirical analysis, bound test is utilized for the cointegration analysis. The bound test is applicable regardless of the degree of stationarity of the variables (Narayan & Narayan, 2005). For bound test analysis, the unrestricted error correction model (UECM) specification constituted for this study is presented in equation (2).

$$\begin{aligned}\Delta \mathrm{LEC}_t = {} & a_0 + a_{1t+} \sum_{i=1}^{m} a_{2i} \Delta \mathrm{LEC}_{t-i} + \sum_{i=0}^{m} a_{3i}\, \Delta \mathrm{LFD}_{t-i} + \sum_{i=0}^{m} a_{4i}\, \Delta \mathrm{LGDP}_{t-i} \\ & + \sum_{i=0}^{m} a_{5i}\, \Delta \mathrm{LFDI}_{t-i} + \sum_{i=0}^{m} a_{6i}\, \Delta \mathrm{LHC}_{t-i} + a_7 LEC_{t-1} + a_8 L\mathrm{FD}_{t-1} + a_9 L\mathrm{GDP}_{t-1} \\ & + a_{10} L\mathrm{FDI}_{t-1} + a_{11} L\mathrm{HC}_{t-1} + \varepsilon_t \end{aligned} \quad (2)$$

In equation 2, "m" and "t" stand for the lag and trend variable, respectively. The null hypothesis of the Bound test, is that there is no long-run relationship between the series, is constructed as Ho: $\alpha7 = \alpha8 = \alpha9 = \alpha10 = \alpha11 = 0$, for this study. The null hypothesis is evaluated by comparing the calculated F-statistic with the critical values provided by Pesaran et al. (2001). If the calculated F-statistic exceeds the upper critical bound, the null hypothesis is rejected. Conversely, if the F-statistic falls below the lower critical bound, the null hypothesis cannot be rejected (Narayan & Narayan, 2005; Pesaran et al., 2001).

After identifying the cointegration relationship, the study uses the ARDL (Autoregressive Distribution Lag) model to examine the long-run and short-run relationship between the variables. The ARDL method allows simultaneous analysis of both short-run and long-run effects of independent variables on the dependent variable. It is also especially powerful for small sample analyses compared to other techniques (Narayan & Narayan, 2005; Seker et al., 2015). Therefore, the specifications of the long-run and short-run ARDL models are given in equations (3) and (4), respectively.

$$\mathrm{LEC}_t = a_0 + \sum_{i=1}^{p} a_{1i}\mathrm{LEC}_{2t-i} + \sum_{i=0}^{q} a_{2i}\,\mathrm{LFD}_{t-i} + \sum_{i=0}^{r} a_{3i}\,\mathrm{LGDP}_{t-i} + \sum_{i=0}^{s} a_{4i}\,\mathrm{LFDI}_{t-i} + \sum_{i=0}^{s} a_{5i}\,\mathrm{LHC}_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta\mathrm{LEC}_t = a_0 + a_1\mathrm{ECT}_{t-1} + \sum_{i=1}^{m} a_{2i}\Delta\mathrm{LEC}_{t-i} + \sum_{i=0}^{n} a_{3i}\,\Delta\mathrm{LFD}_{t-i} + \sum_{i=0}^{n} a_{4i}\,\Delta\mathrm{LGDP}_{t-i} + \sum_{i=0}^{n} a_{5i}\,\Delta\mathrm{LFDI}_{t-i} + \sum_{i=0}^{s} a_{6i}\,\mathrm{LHC}_{t-i} + \varepsilon_t \quad (4)$$

The error correction term, ECT, in equation (4), represents the speed of adjustment of the variables to the long-run equilibrium. The estimated coefficient of the error correction term is expected to be negative and statistically significant.

The final step was to implement the Granger causality test based on the vector error correction model (VECM). The VECM is a useful method for identifying long-run and short-run causality when variables are cointegrated. The study uses VECM-based Granger causality to detect causal relationships, especially from the independent variables to energy consumption both in the short-run and the long-run. In equation (4), the null hypothesis is constructed as H_0: $\alpha_{3i}=0$, $\alpha_{4i}=0$, $\alpha_{5i}=0$, $\alpha_{6i}=0$ meaning that there is no causality from LFD, LGDP, LFDI, and LHC to LEC in the short-run. To examine whether short-run causal relationships exist, the joint significance of the coefficients for each explanatory variable is evaluated using the Wald test's F-statistic. If the F-statistic of the variable is significant, it indicates the presence of short-run causality from that variable to the dependent variable. In the long run, the causality from the independent variables to energy consumption is examined by testing whether α_1, the coefficient of ECT(-1), is zero or not. If the coefficient of the error correction term is statistically significant, there is a causality from the explanatory variables to the dependent variable in the long run (Gülmez et al., 2020; Şeker et al., 2015).

3. Empirical Results

The bound test presumes that the variables are either I(0) or I(1). Therefore, this study examines the stationarity of the variables to verify that none of the variables are integrated of order two (I(2)) or beyond (Frimpong & Oteng-Abayie, 2006). For the stationary analysis, the study uses augmented Dickey–Fuller (ADF) test and Phillips Perron (PP) test. The results of the ADF and PP test are presented in Table 1.

Table 1. Unit Root Test Results

	ADF Test	PP Test
LEC	-1.283	-1.408
LFD	-4.254*	-4.254*
LGDP	-0.005	0.087
LFDI	-2.285	-2.184
LHC	3.554**	3.080**
ΔLEC	-6.892*	-7.700*
ΔLGDP	-6.009*	-6.032*
ΔLFDI	-6.502*	-9.234*

*, and ** denotes 1%, and 5% significant level, respectively.

The ADF and PP tests have a null hypothesis that the series are not stationary. Table 1 shows that the LFD and LHC do not contain unit root, while LEC, LFDI, and LGDP become stationary after taking their first differences. Thus, the results of the ADF and PP tests indicate that LFD and LHC are integrated of order 0 (I(0)), whereas LEC, LGDP and LFDI are integrated of order 1, I(1).

Following that neither of the variables are integrated in two and beyond, the study employs the Bound test for cointegration analysis. The result of the cointegration test is presented in Table 2.

Table 2. Bound Test Results

k	F statistics	Critical values at 5% significant	
		Lower Bound	Upper Bound
4	4.07	3.05	3.97

k is the number of independent variables in Equation (2).
Critical values are obtained from Table CI(iv) at Pesaran et al. (2001: 301).

Table 2 shows that the estimated F-statistic is greater than the upper bound of the critical values. Accordingly, the study rejects the null hypothesis of the bound test and detects the long-run relationship between energy consumption and the independent variables, including financial development, GDP per capita, foreign direct investment, and human capital.

Following the identification of a cointegration relationship among the series, the study examines long-run and short-run relationships using the ARDL model. The results of the estimated ARDL (4,3,4,4,0) model are presented in Table 3. Optimal lengths are determined using the Akaike Information Criterion (AIC).

Table 3. ARDL (4,3,4,4,0) Model Results

Long-run Estimation		
Variables	Coefficient	T-statistics
LFD	0.342	8.705*
LGDP	0.858	7.265*
LFDI	0.000	-0.036
LHC	-0.863	-2.481**
C	-4.250	-4.833*
Short-run Estimation		
Variables	Coefficient	T-statistics
D(LEC(-1))	0.542	3.454*
D(LEC(-2))	-0.037	-0.35
D(LEC(-3))	0.293	2.938**
D(LFD)	0.184	4.276*
D(LFD(-1))	-0.204	-3.005**
D(LFD(-2))	-0.270	-4.419*
D(LGDP)	0.703	9.348*
D(LGDP(-1))	-0.516	-3.619*
D(LGDP(-2))	-0.290	-2.312**
D(LGDP(-3))	-0.391	-3.587**
D(LFDI)	-0.022	-2.577**
D(LFDI(-1))	0.030	3.227*
D(LFDI(-2))	-0.019	-2.482**
D(LFDI(-3))	0.011	1.75
D(LHC)	-1.052	-1.959***
ECT(-1)	-1.162	-5.979*

Table 3. ARDL (4,3,4,4,0) Model Results (Continue)

Diagnostic Tests	
Serial Correlation LM test (Breusch-Godfrey)	2.819 [0.127]
Heteroscedasticity test (ARCH)	0.05 [0.825]
Ramsey Reset Test	0.430 [0.676]
Jargue-Bera Normality test	1.074 [0.584]

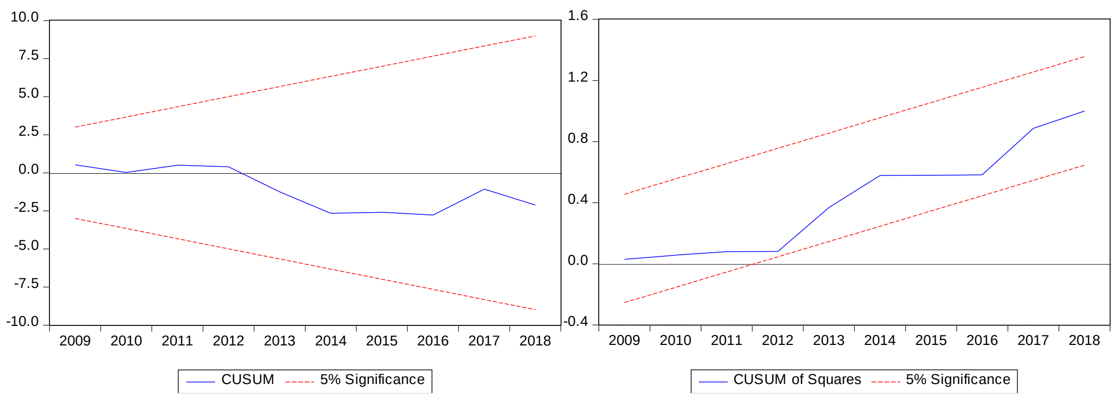
*, **, and *** denotes 1%, 5%, and 10% significant level, respectively.
p values in parentheses.

The diagnostic results in Table 3 show that the estimated ARDL model is free from the serial correlation, heteroscedasticity, misspecification, and normality problems. Besides, the results of CUSUM and CUSUM-squared tests in Figure 1 reveal that the estimated coefficients in the model are stable.

The long-run estimation results reveal that the estimated coefficients of financial development, GDP, and human capital are found to be statistically significant. The results show that financial development and GDP positively affect energy consumption while human capital has a negative impact on energy use. The coefficient of LFD suggests that a 1% increase in financial development leads to a 0.34% rise in energy consumption in the long run, indicating that financial development contributes positively to energy demand. This result is in line with the results of Çetin (2018), Kızılkaya and Gökçe (2021), and Eyüpoğlu and Eyüpoğlu (2023) for Turkiye. Similarly, the coefficient of LGDP shows that a 1% increase in economic growth results in a 0.86% increase in energy consumption. This result confirms that economic growth is a significant driver of energy demand. This result is consistent with the results of Yue et al. (2019), Balonch et al. (2019), and Wang et al. (2021). On the other hand, the coefficient of LFDI is found to be insignificant in the long-run. The long-run findings also indicate that a 1% increase in human capital decreases a 0.86% energy consumption in the long-run. This result is in line with the results of Yao et al (2019), Churchill et al. (2023), and Pegkas (2024).

The results of the short-run ARDL model reveal that all estimated coefficients are statistically significant. The signs of LFD, LGDP, LFDI, and LHC are found to be positive, positive, negative, and negative respectively. In line with the long-run ARDL model results, the short-run results show that financial development and economic growth significantly affect energy consumption. LFDI negatively affects energy consumption, and this impact is estimated approximately -0.02. This result supports the technical effect of foreign direct investment in the short-run. The findings show that human capital has a strong negative impact on energy consumption in the short-run, as it is in the long-run. The results of the short-run ARDL model also indicate that lagged energy consumption has a positive influence on energy consumption.

Figure 1. CUSUM and CUSUM of Squares Test Results



The sign and magnitude of the coefficient of the error correction term (ECT) are important for our understanding of the adjustment process in the short run. In Table 3, the value of the ECT (-1.16) is between -1 and -2 with the correct sign. The ECT coefficient between these values implies that the error correction process oscillates damping around the long-run value before converging relatively quickly to the equilibrium path, instead of monotonically converging directly to the equilibrium path (Alam & Quazi, 2003).

In the empirical analysis, the study lastly investigates the causality from financial development, foreign direct investment, economic growth, and human capital to energy consumption both in the short-run and the long-run. Table 4 presents the results of the Granger causality tests within the VECM framework.

Table 4. The results of the VECM based Granger Causality Test

Dependent Variable	Short-term Causality					Long-term Causality
	ΔLEC	ΔLFD	ΔLFDI	ΔLGDP	ΔLHC	ECT(-1)
ΔLEC	-	10.714*	6.065**	48.857*	3.812***	21.962*
		(0.0011)	(0.0138)	(0.0000)	(0.0509)	(0.0000)

*, **, and *** represent 1%, 5%, and 10% significant level, respectively.
p values in parentheses.

As seen in Table 4, there exists causal relationship from each independent variable to energy consumption in the short-run. Namely, the study detects causality in the short run from financial development, foreign direct investment, economic growth, and human capital to energy consumption. The long-run causality test results also reveal that financial development, foreign direct investment, economic growth, and human capital are together the Granger causes of energy consumption in the long-run.

5. Conclusion

This study examines the effect of financial development on energy consumption in Turkiye for the period 1985-2019. In addition, the study considers the role of economic growth, foreign direct investment, and human capital for the financial development-energy consumption nexus. In the empirical analysis, the Bound test is used for cointegration analysis while ARDL model is applied for the long-run and short-run static relationship between energy consumption and the explanatory variables. Finally, the study employs the Granger causality test based on VECM to investigate the long-run and short-run causality from the explanatory variables to energy consumption.

The results of the bound test show that the series are cointegrated. The results of the long-run ARDL model indicate that financial development has a positive impact on energy consumption, i.e., a 1% increase in financial development leads to a 0.36% increase in energy consumption. These results affirm the direct effect, the business effect, and the wealth effect of financial development on energy consumption in the theoretical frame. The estimated long-run ARDL model results show that economic growth is found to be a significant determinant of energy consumption, while human capital has a negative effect on energy consumption. On the other hand, foreign direct investment is found to be insignificant in the long-run. The short-run ARDL model results show that financial development and economic growth promote energy consumption, while human capital and FDI negatively affect energy consumption. Accordingly, the negative impact of human capital and FDI on energy consumption confirms the validity of the technology effect. As for the results of the causality test based on VECM, there is a causal relationship from financial development to energy consumption, economic growth to energy consumption, FDI to energy consumption, and human capital to energy consumption in the short run. The results also indicate that financial development, FDI, economic growth, and human capital are jointly the Granger causes of energy consumption in the long run.

The findings of the study provide important policy recommendations. Firstly, regulations should be strengthened to ensure that financial institutions provide credit incentives for sustainable projects that invest in energy efficient technologies. In this sense, financial incentives and long-term financing opportunities should be provided to encourage the private sector to invest more in renewable energy. It should be encouraged the promotion of green investment products by providing tax incentives and subsidies for green bonds and sustainable investment funds, to ensure that these instruments gain a larger market share. The inability to account for the promoting impact of financial development on energy demand may prevent energy conservation policies from achieving their intended goals. Secondly, sectoral strategies and targets should be set to increase FDI in specific sectors (e.g., renewable energy, energy efficiency technologies). This could contribute to an increase in investments that reduce energy consumption in the long term. Thirdly, energy efficiency and sustainability issues should be included in the curriculum for all levels of education. Besides, the awareness raising activities on energy efficiency should be carried out in schools and universities. In this respect, energy consumption stimulated by economic growth could be offset by increased investment in human capital.

In future studies, the impact of financial development index components such as financial development index and financial market index on energy consumption can be analyzed separately. Moreover, energy consumption can be considered separately in terms of fossil fuel and renewable energy consumption to investigate in detail how different types of financial development affect energy use. Moreover, the impact of human capital on energy consumption may be examined in more detail by considering fossil fuel and renewable energy consumption or by considering different levels of education.

Declarations and Disclosures

Ethical Responsibilities of Authors: The author of this article confirms that her work complies with the principles of research and publication ethics.

Conflicts of Interest: No potential conflict of interest was reported by the author.

Funding: The author received no financial support for the preparation and/or publication of this article.

Author Contributions: The author confirms sole responsibility for conceptualization and design, data collection, analysis of data and interpretation of results, writing the first draft of the manuscript, and review and editing.

Plagiarism Checking: This article was screened for potential plagiarism using a plagiarism screening program.

References

Alam, I., & Quazi, R. (2003). Determinants of capital flight: An econometric case study of Bangladesh. *International Review of Applied Economics*, *17*(1), 85-103, https://doi.org/10.1080/713673164

Baloch, M. A., Danish, & Meng, F. (2019). Modeling the non-linear relationship between financial development and energy consumption: Statistical experience from OECD countries. *Environmental Science and Pollution Research*, 26, 8838-8846. https://doi.org/10.1007/s11356-019-04317-9

BP. (2024). Energy economics. https://www.bp.com/en/global/corporate/energy-economics.html (Access Date: 15.12.2024).

Çağlar, A. E., & Kubar, Y. (2017). Finansal gelişme enerji tüketimini destekler mi? *Süleyman Demirel Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, (27), 96-121.

Çetin, M. (2018). Türkiye'de finansal gelişme ve enerji tüketimi ilişkisi: Bir zaman serisi kanıtı. *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *13*(3), 69-88.

Çetin, M., Ecevit, E., Seker, F., & Günaydin, D. (2015). Financial development and energy consumption in Turkey: Empirical evidence from cointegration and causality tests. In: Handbook of Research on Behavioral Finance and İnvestment Strategies: Decision Making in The Financial Industry (pp. 297-314). IGI Global.

Chang, S. C. (2015). Effects of financial developments and income on energy consumption. *International Review of Economics & Finance,* 35, 28-44. https://doi.org/10.1016/j.iref.2014.08.011

Chiu, Y. B., & Lee, C. C. (2020). Effects of financial development on energy consumption: The role of country risks. *Energy Economics*, 90, 104833. https://doi.org/10.1016/j.eneco.2020.104833

Churchill, S. A., Inekwe, J., Ivanovski, K., & Smyth, R. (2023). Human capital and energy consumption: Six centuries of evidence from the United Kingdom. *Energy Economics*, 117, 106465. https://doi.org/10.1016/j.eneco.2022.106465

Danish, & Ulucak, R. (2021). A revisit to the relationship between financial development and energy consumption: Is globalization paramount? *Energy*, 227, 120337. https://doi.org/10.1016/j.energy.2021.120337

Destek, M. A. (2018). Financial development and energy consumption nexus in emerging economies. *Energy Sources, Part B: Economics, Planning, and Policy*, *13*(1), 76-81. https://doi.org/10.1080/15567249.2017.1405106

Eyüboğlu, K., & Eyüboğlu, S. (2023). Finansal gelişme-enerji tüketimi ilişkisi: Türkiye örneği. *Karadeniz Teknik Üniversitesi Sosyal Bilimler Enstitüsü Sosyal Bilimler Dergisi*, *13*(26), 339-352.

Farhani, S., & Solarin, S. A. (2017). Financial development and energy demand in the United States: New evidence from combined cointegration and asymmetric causality tests. *Energy*, *134*, 1029-1037. https://doi.org/10.1016/j.energy.2017.06.121

Frimpong, J. M., & Oteng-Abayie, E. F. (2006). Bounds testing approach: An examination of foreign direct investment, trade, and growth relationships. MPRA Munich Personal RePEc Archive, 352(10), 1-19.

Furuoka, F. (2015). Financial development and energy consumption: Evidence from a heterogeneous panel of Asian countries. *Renewable and Sustainable Energy Reviews,* 52, 430-444. http://dx.doi.org/10.1016/j.rser.2015.07.120

Groningen Growth and Development Centre. (2025). Penn World Table. https://www.rug.nl/ggdc/productivity/pwt/ (Access Date: 25.02.2025).

Gülmez, A., Altıntaş, N., & Kahraman, Ü. O. (2020). A puzzle over ecological footprint, energy consumption and economic growth: The case of Turkey. *Environmental and Ecological Statistics*, 27, 753-768. https://doi.org/10.1007/s10651-020-00465-1

International Monetary Fund (IMF). (2024). IMF Data. https://data.imf.org/?sk=f8032e80-b36c-43b1-ac26-493c5b1cd33b (Access Date: 15.12.2024).

Kahouli, B. (2017). The short and long run causality relationship among economic growth, energy consumption and financial development: Evidence from South Mediterranean Countries (SMCs). *Energy economics*, 68, 19-30. https://doi.org/10.1016/j.eneco.2017.09.013

Kakar, Z. K. (2016). Financial development and energy consumption: Evidence from Pakistan and Malaysia. *Energy Sources, Part B: Economics, Planning, and Policy*, 11(9), 868-873. https://doi.org/10.1080/15567249.2011.603020

Keskingöz, H., & İnançlı, S. (2016). Türkiye'de finansal gelişme ve enerji tüketimi arasında nedensellik ilişkisi: 1960-2011 dönemi. *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *11*(3), 101-114.

Kibritcioglu, A. (2023). Financial development and energy consumption dynamics in Turkey. *Journal of Energy and Environmental Policy Options*, *6*(2), 1-8.

Kızılkaya, F., & Gökçe, E. C. (2021). Türkiye'de finansal gelişme ve enerji tüketimi ilişkisi: Fourier yaklaşımı. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi*, *9*(5), 1279-1290.

Ma, X., & Fu, Q. (2020). The influence of financial development on energy consumption: Worldwide evidence. *International Journal of Environmental Research and Public Health*, *17*(4), 1428, 11-15. https://doi.org/10.3390/ijerph17041428

Mahalik, M. K., Babu, M. S., Loganathan, N., & Shahbaz, M. (2017). Does financial development intensify energy consumption in Saudi Arabia? *Renewable and Sustainable Energy Reviews*, *75*, 1022-1034. https://doi.org/10.1016/j.rser.2016.11.081

McFarlane, A., Brown, L., Campbell, K., & Das, A. (2023). Is the impact of financial development on energy consumption in Jamaica asymmetric? *International Journal of Energy Sector Management*, *17*(4), 677-692. https://doi.org/10.1108/IJESM-02-2022-0004

Mukhtarov, S., Mikayilov, J. I., Mammadov, J.& Mammadov, E. (2018). The impact of financial development on energy consumption: Evidence from an oil-rich economy. *Energies*, *11*(1536), 2-14. https://doi.org/10.3390/en11061536

Mukhtarov, S., Yüksel, S., & Dinçer, H. (2022). The impact of financial development on renewable energy consumption: Evidence from Turkey. *Renewable Energy*, 187, 169-176. https://doi.org/10.1016/j.renene.2022.01.061

Narayan, P. K., & Narayan, S. (2005). Estimating income and price elasticities of imports for Fiji in a cointegration framework. *Economic Modelling*, 22, 423-438. https://doi.org/10.1016/j.econmod.2004.06.004

Pata, U. K., Yilanci, V., Zhang, Q., & Shah, S. A. R. (2022). Does financial development promote renewable energy consumption in the USA? Evidence from the Fourier-wavelet quantile causality test. *Renewable Energy*, 196, 432-443. https://doi.org/10.1016/j.renene.2022.07.008

Pegkas, P. (2024). Energy consumption and human capital: Does human capital stimulate renewable energy? The case of Greece. *Journal of the Knowledge Economy*, 17256-17283. https://doi.org/10.1007/s13132-024-01770-x

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, 289-326. https://doi.org/10.1002/jae.616

Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy Policy*, *38*(5), 2528-2535. http://dx.doi.org/10.1016/j.enpol.2009.12.048

Şahin, C. (2023). Finansal gelişme ve yenilenebilir enerji arasında ilişki var mıdır? Türkiye için uygulama. *Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, (43), 379-407. https://doi.org/10.14520/adyusbd.1229257

Salim, R., Yao, Y., Chen, G., & Zhang, L. (2017). Can foreign direct investment harness energy consumption in China? A time series investigation. *Energy Economics*, 66, 43-53. https://doi.org/10.1016/j.eneco.2017.05.026

Şeker, F., Ertuğrul, H. M., & Cetin, M. (2015). The impact of foreign direct investment on environmental quality: A bounds testing and causality analysis for Türkiye. *Renewable and Sustainable Energy Reviews*, 52, 347-356. http://dx.doi.org/10.1016/j.rser.2015.07.118

Shahbaz, M., Nasir, M. A., & Roubaud, D. (2018). Environmental degradation in France: The effects of FDI, financial development, and energy innovations. *Energy Economics*, 74, 843-857. https://doi.org/10.1016/j.eneco.2018.07.020

Shahbaz, M., Topcu, B. A., Sarıgül, S. S., & Vo, X. V. (2021). The effect of financial development on renewable energy demand: The case of developing countries. *Renewable Energy*, 178, 1370-1380. https://doi.org/10.1016/j.renene.2021.06.121

Svirydzenka, K. (2016). *Introducing a new broad-based index of financial development*. IMF Working Paper, WP/16/5, 1-42.

Tang, C. F., & Tan, B. W. The linkages among energy consumption, economic growth, relative price, foreign direct investment, and financial development in Malaysia. *Quality & Quantity, 48*(2014), 781-797. https://doi.org/10.1007/s11135-012-9802-4

Tarla, E. G., & Bayat, T. (2021). Türkiye ekonomisinde finansal gelişme ve enerji tüketimi ilişkisinin asimetrik ve kayan pencere nedensellik testleri ile analizi. *Erciyes Akademi*, *35*(1), 34-43.

The International Energy Agency (IEA). (2024). Energy system of Türkiye. https://www.iea.org/countries/turkiye (Access Date: 01.12.2024).

The International Energy Agency (IEA). (2024). How is energy used in Türkiye? https://www.iea.org/countries/turkiye/energy-mix#how-is-energy-used-in-turkiye (Access Date: 01.12.2024).

Thebuho, W., Opperman, P., & Steenkamp, L. A. (2022). The asymmetric effect of financial development on energy consumption in sub-Saharan Africa. *Cogent Economics & Finance*, 10, 2095770. https://doi.org/10.1080/23322039.2022.209577

Usman, M., Rasheed, K., Mahmood, F., Riaz, A., & Bashir, M. (2023). Impact of financial development and economic growth on energy consumption in developing countries of Asia. *International Journal of Energy Economics and Policy*, *13*(3), 512-523. https://doi.org/10.32479/ijeep.14233

Wang, J., Zhang, S., Zhang, Q. (2021). The relationship of renewable energy consumption to financial development and economic growth in China. *Renewable Energy*, 170, 897-904. https://doi.org/10.1016/j.renene.2021.02.038

Xu, J., Weng, J., & Yuan, R. (2023). Impacts of financial development on the energy consumption in China from the perspective of poverty alleviation efficiency. *Environmental Science and Pollution Research*, 30, 63647-63660. https://doi.org/10.1007/s11356-023-26759-y

Yao, Y., Ivanovski, K., Inekwe, J., & Smyth, R. (2019). Human capital and energy consumption: Evidence from OECD countries. *Energy Economics*, *84*, 104534, 1-14. https://doi.org/10.1016/j.eneco.2019.104534

Yıldırım, E. B., & Şenol, Z. (2024). Finansal gelişme ile yenilenebilir enerji tüketimi arasındaki ilişki. *Uluslararası Ekonomi Siyaset İnsan ve Toplum Bilimleri Dergisi*, *7*(1), 12-29. https://doi.org/10.59445/ijephss.1375840

Yue, S., Lu, R., Shen, Y., & Chen, H. (2019). How does financial development affect energy consumption? Evidence from 21 transitional countries. *Energy Policy*, 130, 253-262. https://doi.org/10.1016/j.enpol.2019.03.029