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Is the relationship between foreign direct investment and energy consumption asymmetric? Empirical evidence from Türkiye

Czy relacja między bezpośrednimi inwestycjami zagranicznymi a zużyciem energii jest asymetryczna? Badania empiryczne na przykładzie Turcji

Abstract

Developing countries need foreign direct investment (FDI) to close capital and investment gaps. At the same time, however, these countries want to improve their export performance through greater openness. This paper examines whether the relationship between FDI, openness, and energy consumption are asymmetric in Türkiye. A nonlinear ARDL analysis of 38 years of data collected between 1984 and 2021 was performed for this purpose. The results show an asymmetric relationship between FDI and energy consumption in the short and long-run. The relationship between openness and energy consumption is shown to be asymmetric in the long-run, but symmetrical in the short-run. Finally, the results show that positive and negative changes in FDI and energy consumption in the same direction. These results indicate that FDI contributes to energy consumption in Türkiye. Given Türkiye's foreign dependence on energy, it would be a strategic move to increase renewable energy consumption with economic growth.

Keywords: energy consumption, openness, Foreign direct investment (FDI), Nonlinear ARDL.

JEL: 013, 016, Q43

Streszczenie

Kraje rozwijające się potrzebują bezpośrednich inwestycji zagranicznych (BIZ), aby zlikwidować luki kapitałowe i inwestycyjne. Jednocześnie jednak kraje te dążą do poprawy swojej efektywności eksportowej dzięki większej otwartości. Niniejszy artykuł bada, czy relacja między BIZ, otwartością kraju a zużyciem energii w Turcji jest asymetryczna. W tym celu przeprowadzono nieliniową analizę ARDL na podstawie danych zebranych w latach 1984–2021. Wyniki wskazują na asymetryczną relację między BIZ a zużyciem energii zarówno w krótkim, jak i długim okresie. Relacja między otwartością kraju a zużyciem energii okazała się asymetryczna w długiej, ale symetryczna w krótkiej perspektywie czasowej. Ostatecznie wyniki dowodzą, że pozytywne i negatywne zmiany BIZ i zużycia energii podążają w tym samym kierunku. Rezultaty te sugerują, że BIZ przyczynia się do wzrostu zużycia energii w Turcji. Biorąc pod uwagę zależność Turcji od importowanej energii, strategicznym posunięciem byłoby zwiększenie zużycia energii odnawialnej w miarę wzrostu gospodarczego.

Słowa kluczowe: zużycie energii, otwartość, bezpośrednie inwestycje zagraniczne (BIZ), nieliniowy ARDL.

JEL: 013, 016, Q43

1. Introduction

That energy plays a critical role in production is common knowledge, as is the fact that energy is indispensable to production. This crucial role of energy has prompted several studies on the determinants of energy consumption. Increased energy consumption is a natural consequence of global economic growth and population increase. The increase in the demand for energy is greater in developing economies such as Türkiye than in developed countries. This increase in global energy demand has introduced such problems as harmful emissions and global warming. Renewable energy and energy-efficient technologies are therefore extremely topical.

The gradual reduction in the barriers to capital in the globalizing world economy has led to fund transfers from developed countries to developing countries with high return potential. These transfers can be realized in various ways. From the perspective of developing countries, the sustainability of their economic growth performance depends on the funds they need to remain in their countries in a long--term, stable manner. For this reason, FDIs are considered long-run investments in the countries in which they are implemented and countries in need of capital are their preferred destinations. Moreover, as FDIs involve technology and knowledge transfer in addition to the capital they provide, they not only support economic growth; they are crucial to economic development. FDIs, which alter the structure of production and improve production technologies in their destination countries, also affect the quantity, quality, and efficiency of energy consumption.

Identifying and examining the causes and restrictions of energy consumption have occupied a substantial section of contemporary theoretical and empirical research, given energy's critical role in economic growth and development. Among the various factors highlighted, FDI flows are particularly noteworthy (Gakpa and Kouadio, 2022).

The remainder of this paper is organized as follows: Section 2 discusses the theoretical background; Section 3 reviews the literature; Section 4 explains the data and the methodology; Section 5 lists the empirical findings and includes a discussion; and finally, Section 6 contains the conclusions and discusses the policy implications.

2. Theoretical Background

The impact of FDI on energy consumption varies with such factors as economic development, technological advances, and the energy consumption structure of the host country. Grossman and Krueger (1995) classify the influence of FDI on energy consumption into three categories: the scale effect, the technical effect, and the decomposition effect. Scale refers to the increased energy used in increased economic activity. By contrast, technology effect illustrates the inverse correlation between FDI flows and energy consumption on the part of those foreign investors who not only enhance energy efficiency in their own operations, but extend it to the broader society. Finally, the decomposition effect remains ambiguous, as it is

contingent on both the sectoral allocation of FDI and the economic development level of the host nation. This study predicts that evaluating these effects for Türkiye will reveal an asymmetry between the scale effect and the technical effect. This is because although energy consumption increases due to the scale effect, it is here posited that it can be suppressed by the technical effect. Scale and technological impact may also separate into positive and negative directions. This study predicts that the scale effect may be dominant since FDI in Türkiye is more oriented towards production, e.g. manufacturing.

FDI can introduce advanced technology to recipient countries. This is essential for transferring knowledge, enhancing energy efficiency, and reducing energy consumption. An increase in FDI can significantly boost advances sustainable energy practices and result in positive outcomes (Dong et al., 2019). On the other hand, by stimulating economic growth and industrial progress in the host country, it can also increase energy consumption. Higher economic growth leads to higher FDI inflows, which in turn contribute to an overall increase in energy usage (Pan et al., 2020). Generally, the impact of FDI on energy consumption is not uniform and can vary depending on economic development, technological advances, and energy usage patterns (Mielnik and Goldemberg, 2002). Considering these variables is essential when analyzing the correlation between FDI and energy consumption in different countries or regions (Amri, 2016). While some studies suggest that encouraging renewable energy consumption can lead to energy savings, others suggest it can contribute to increased energy consumption, especially in economic growth scenarios (Huang, 2018).

As a result, the impact of FDI on energy consumption varies. This difference creates a nonlinear (asymmetric) relationship. Several factors can cause asymmetric relationships between variables; one of them involves the complexity of the economic system and the mechanisms that generate the variables under study. This complexity can trigger multiple channels through which one variable affects another (Shahbaz et al. 2017). The primary distinction between the present study and previous research is the asymmetric nature of the NARDL technique, which gives rise to divergent perspectives on the influence of FDI on energy consumption in emerging economies like Türkiye. This method was used to separate changes in FDI into positive and negative directions, and their effects on energy consumption were examined separately.

Trade liberalization and energy consumption are commonly thought to be linked. Heckscher-Ohlin Trade Theory states that developing countries increase their production and use of natural resources when trade is liberalized. Research, however, shows that openness can have different effects on energy consumption. One view has it that economic activity and energy consumption increase as trade becomes more open (Shahbaz et al., 2014). But another maintains that importing more technology while opening up trade can reduce energy consumption by increasing energy intensity (Nasreen and Anwar, 2014). Like FDI, Trade openness affects energy consumption through the combination of the scale effect and the technical effect (Shahbaz et al., 2014). This study examines FDI and openness, which affect energy consumption through similar channels.

3. Literature Review

Academic studies examining the relationship between FDI and energy consumption have produced differing results. The literature on the relationship between FDI and energy consumption is considerably diverse in regards to countries, regions, periods, variables, and methodologies. Therefore, it can be said that there is an asymmetry in the literature regarding the results of the studies. These studies fall into three broad groups that can be studied separately.

The first group of studies claim that there is a direct relationship between FDI and energy consumption. They attribute this to the increase in production capacity that FDI brings about and the increase in the scale of production that results from the boost given to other sectors and companies. These studies show a positive relationship between FDI and economic growth, although its direction varies depending on the study. These studies have found a positive relationship between FDI and energy consumption due to the increase in economic scale. They include Behket and Othman (2011), Bento (2011), Kuo et al. (2012), Alam (2013), Tang and Tan (2014), Dalia (2015), and Lin and Benjamin (2018). Some studies additionally identify a causal relationship between FDI and energy consumption. For example, Amri (2016) discovered a link between FDI and energy consumption. Similarly, Koç and Saidmurodov (2018) conducted a causality analysis on selected Central Asian countries and found that FDI increases energy consumption growth and fosters economic development. Destek (2015) examined energy consumption, economic growth, openness to foreign trade, and financial development data in Türkiye and found bidirectional causality between economic growth and energy consumption. In a study of Türkiye between 1980 and 2015, Uzar and Eyüboğlu (2019), by employing Fourier ADL analysis, determined that FDI, trade openness, and economic growth affected energy consumption.

As with the first group of studies, the second group establishes a positive relationship between FDI and energy consumption. However, they maintain that this relationship is based on the transfers of obsolete technology that accompany FDI. In developed countries, the use of obsolete technology is restricted by stringent statutes and regulations on e.g. carbon emissions. These production methods are redirected to developing countries with few if any restrictions on the form of FDI or on energy consumption levels (Wang et al., 2021; Baek, 2016).

The third group of studies indicate an inverse relationship between FDI and energy consumption. These studies conclude that host countries reduce their energy consumption as a result of the technologies and energy-efficient technology that FDI introduces. FDI is thought to increase renewable energy resources and reduce carbon emissions (Lee, 2013). Salim et al. (2017) conclude that increased FDI investment leads to a long-run decline in energy consumption. Hubler (2009) examined the impact of FDI on energy-efficient technology using CGE modeling and determined that it has the potential to improve energy-saving technology and reduce energy consumption. Similarly, Mielnik and Goldemberg (2002) found that increasing FDI reduces energy usage by raising productivity.

One group of studies examined the relationship between FDI and renewable energy, and concluded that investments in renewable energy reduced the con-

sumption of fossil energy resources. Doytch and Narayan (2016) found that FDI in renewable and non-renewable energy sources affects energy consumption. This study revealed that FDI in sectors using renewable energy resources increases energy consumption, while FDI in sectors using non-renewable energy resources reduces it. By employing the bootstrap causality test, Arı (2021) found that FDI had no effect on renewable energy consumption.

Similarly with the literature examining the relationship between FDI and energy consumption, that which examines the relationship between trade openness and energy consumption is focused on the scale effect and the technical effect. Some studies have found that trade openness or trade liberalisation has a positive effect on energy consumption, e.g. Cole (2006), Ghani (2012), Kyophilavong et al. (2015), Arif et al. (2017), Koengkan (2018), Cetin and Ecevit (2018) can be given as examples. Others, however, have found that imports and exports have a positive effect on energy consumption, e.g. Sadorsky (2011) and Dedeoğlu and Kaya (2013). Hossain (2012) found no causal relationship between exports and energy consumption. Shahbaz et al. (2017) found a cointegration relationship between trade openness and energy consumption. However, they only detected a causal relationship in some of the countries in the sample. Hubler (2009) can be given as an example of studies predicting that trade openness can reduce energy consumption through technology transfer.

4. Data and Methodology

The model used in the present study was designed on the basis of studies by Alam (2013), Salim et al. (2017), Amoako and Insaidoo (2021), and others.

$$LNEN_t = f\,(LNFDI_t,\ LNOPEN_t,\ LNENP_t,\ GR_t) \tag{1}$$

Where $LNEN_t$ is energy consumption, $LNFDI_t$ is FDI, $LNOPEN_t$ is trade openness, $LNENP_t$ is energy prices, and GR_t is a proxy for GDP growth.

Annual data for 1984–2021 were used. EN and ENP were obtained from the BP - Statistical Review of World Energy (2023) report. Crude oil prices (USD per barrel) were used to represent energy prices. This was the control variable. FDI (million USD) was obtained from the Central Bank of the Republic of Türkiye (CBRT). Openness and GDP growth were sourced from the World Bank's World Development Indicators (World Bank, 2023). Openness is defined here as the ratio of the sum of imports and exports to GDP. Energy consumption, FDI, openness, and energy price series were entered into the model in logarithmic form.

The effect of FDI on energy consumption was examined using the nonlinear autoregressive distributed lag (NARDL) method developed by Shin et al. (2014). The NARDL method is a version of the ARDL method developed by Pesaran et al. (2001) that is expanded to include short- and long-run asymmetric relationships. The nonlinear ARDL model has significant advantages: (i) it allows effective estimation in small samples (Mujtaba and Jena, 2021); (ii) it shows the possible positive and negative effects of independent variables on the dependent variable in the short and long term (Akhtar et al., 2023); and (iii) it ena-

bles analyses between series with different degrees of integration (except I(2)) (Pesaran & Pesaran, 1997). The NARDL model was used on account of these advantages and because of possible asymmetric effects in the relationship between FDI and energy consumption.

The NARDL model used in the present study to examine the asymmetric effect of FDI on energy consumption can be described as follows:

$$LNEN_t = \alpha_0 + \alpha_1 LNFDI_t^+ + \alpha_2 LNFDI_t^- + \alpha_3 LNOPEN_t^+ + \alpha_4 LNOPEN_t^- + \alpha_5 LNENP_t^+ + \alpha_6 LNENP_t^- + \alpha_7 GR_t + \varepsilon_t \quad (2)$$

Moreover, in equation (2), $LNFDI_t^+$, $LNFDI_t^-$, $LNOPEN_t^+$, $LNOPEN_t^-$, $LNENP_t^+$ and $LNENP_t^-$ are the partial sums of the positive and negative changes in FDI, openness, and energy prices, respectively. This can be shown as follows:

$$LNFDI_t^+ = \sum_{j=1}^{t} \Delta LNFDI_j^+ = \sum_{j=1}^{t} \max\left(\Delta LNFDI_j, 0\right), LNFDI_t^- = \sum_{j=1}^{t} \Delta LNFDI_j^- = \sum_{j=1}^{t} \min\left(\Delta LNFDI_j, 0\right) \quad (3)$$

$$LNOPEN_t^+ = \sum_{j=1}^{t} \Delta LNOPEN_j^+ = \sum_{j=1}^{t} \max\left(\Delta LNOPEN_j, 0\right), LNOPEN_t^- = \sum_{j=1}^{t} \Delta LNOPEN_j^- = \sum_{j=1}^{t} \min\left(\Delta LNOPEN_j, 0\right) \quad (4)$$

$$LNENP_t^+ = \sum_{j=1}^{t} \Delta LNENP_j^+ = \sum_{j=1}^{t} \max\left(\Delta LNENP_j, 0\right), LNENP_t^- = \sum_{j=1}^{t} \Delta LNENP_j^- = \sum_{j=1}^{t} \min\left(\Delta LNENP_j, 0\right) \quad (5)$$

This NARDL model can explain both positive and negative modifications in FDI, openness, and energy prices with another control variable as follows:

$$\Delta LNEN_t = \alpha_0 + \alpha_1 LNEN_{t-1} + \alpha_2^+ LNFDI_{t-1}^+ + \alpha_3^- LNFDI?_{t-1}^- + \alpha_4^+ LNOPEN_{t-1}^+ + \alpha_5^- LNOPEN_{t-1}^- + \alpha_6^+ LNENP_{t-1}^+ + \alpha_7^- LNENP_{t-1}^- + \alpha_8 GR_{t-1} + \sum_{i=1}^{k} \beta_{0i} \Delta LNEN_{t-i} + \sum_{i=0}^{l} (\beta_1^+ \Delta LNFDI_{t-i}^+ + \beta_1^- \Delta LNFDI_{t-i}^-) + \sum_{i=0}^{m} (\beta_2^+ \Delta LNOPEN_{t-i}^+ + \beta_2^- \Delta LNOPEN_{t-i}^-) + \sum_{i=0}^{n} (\beta_3^+ LN\Delta ENP_{t-i}^+ + \beta_3^- LN\Delta ENP_{t-i}^-) + u_t \quad (6)$$

where k, l, m, and n are the lag orders.

The null hypothesis of no cointegration (H_0: $\alpha = \cdots = \alpha_8$) in Eq. (6) is tested against the alternative hypothesis (H_1: $\alpha_1 \neq \cdots \neq \alpha_8$) using the F-test with critical values. Pesaran et al. (2001) listed two different sets of asymptotic critical values (lower and upper bounds) for the I(0) and I(1) variables. The calculated F statistic is greater than the upper bound critical value, indicating cointegration. Based on the estimation of Eq. (6), a Wald test was conducted to determine the short-run ($\beta_1^+ = \beta_1^-$) and long-run ($\alpha_2^+ = \alpha_2^-$) asymmetric effects of FDI on energy consumption. Moreover, the asymmetric cumulative dynamic multiplier effect of the negative and positive changes at FDI on energy consumption can be calculated as follows:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial EN_{t+j}}{\partial FDI_t^+} = \sum_{i=0}^{h} \lambda_j^+, \; m_h^- = \sum_{j=0}^{h} \frac{\partial EN_{t+j}}{\partial FDI_t^-} = \sum_{j=0}^{h} \lambda_j^-, \; h = 0,1,2,\ldots \quad (7)$$

5. Empirical Findings and Discussion

The PP unit root test, developed by Philips and Perron (1988), and the ADF unit root test, developed by Dickey and Fuller (1981), were used to determine the stationary of the series. Table 1 shows the results of the ADF and PP unit root tests. These results show that all variables are stationary at the level or first difference. In order to apply the NARDL method to time series, variables must not be second-order stationary.

Table 1.
Unit Root Test Findings

Variables	ADF			PP		
	Cons.	Cons.&Trend	First dif.	Cons.	Cons.&Trend	First dif.
LNEN	-1.80 (0.37)	-3.49 (0.06)*	-7.11 (0.00)***	-2.34 (0.16)	-3.42 (0.06)*	-7.34 (0.00)***
LNFDI	-1.55 (0.49)	-2.00 (0.57)	-5.99 (0.00)***	-1.56 (0.49)	-2.07 (0.54)	-6.13 (0.00)***
LNOPEN	-0.83 (0.79)	-3.84 (0.02)**	-5.51 (0.00)***	-0.25 (0.92)	-3.11 (0.11)	-7.01 (0.00)***
LNENP	-1.74 (0.40)	-2.59 (0.28)	-5.41 (0.00)***	-1.76 (0.39)	-2.59 (0.28)	-5.82 (0.00)***
GR	-6.32 (0.00)***	-6.23 (0.00)***	-9.69 (0.00)***	-7.08 (0.00)***	-7.08 (0.00)***	-19.18 (0.00)***

NoteB: values in parentheses include probability values. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Source: the author's computation based on CBRT and World Bank datasets.

Table 2 shows the cointegration test results applied to test the long-run relationships between the variables. Cointegration exists when the F statistic exceeds the critical values in the table. These results show a cointegration relationship between energy consumption, FDI, openness, energy prices, and growth.

Table 2.
Bounds Test for Cointegration

F-stat.	*Signif.*	*Lower Bound*	*Upper Bound*
14.19963	% 10	2.03	3.13
	% 5	2.32	3.5
	% 1	2.96	4.26

NoteB: Critical values for the bound test are adapted from Pesaran, Shin, and Smith (2001).

Source: the author's computation based on CBRT and World Bank datasets.

This study primarily aims to empirically confirm the impact of FDI on energy consumption in developing countries such as Türkiye. Table 3 shows the estimation results produced by the NARDL method. These have been organised into four groups. The first group consists of short-run coefficients. The first part of the table only shows those

coefficients whose probability values are significant. These findings show that the coefficients of FDI and openness are significant, although they are subject to different lags. Error Correction Term (ECT) is the coefficient at the bottom of the first section of Table 1. The ECT is negative and statistically significant, which indicates that the error correction mechanism is working. According to ECT, short-run deviations from equilibrium revert to equilibrium in the long-run. The error correction mechanism asserts that a deviation in energy consumption returns to long-run equilibrium very quickly, at 91% per year.

The second part of Table 3 contains the long-run coefficients. The long-run results show that positive and negative changes in FDI and openness are statistically significant. The impact of both positive and negative shocks on energy consumption is identifiable. Similar results were obtained in studies conducted by Omri and Kahouli (2014) for low-middle and high-income country groups, and Leitao (2015) for Portugal. LNFDI+ and LNFDI- are statistically significant, and their coefficients are positive. Both positive and negative changes affect energy consumption in the same direction. When FDI increases by 1%, energy consumption rises by 0.09%. When FDI decreases by 1%, energy consumption decreases by 0.09%. Similarly, LOPEN+ and LNOPEN- are statistically significant, and their coefficients are positive. A 1% increase in openness increases energy consumption by 0.39%, and a 1% decrease in openness reduces energy consumption by 0.29%. The theoretical section explains that FDI and openness affect energy consumption through similar channels. This explanation is corroborated by the empirical results.

Table 3.
Long-run and short-run estimations of the NARDL model

NARDL Model (3, 3, 2, 3, 0, 3, 3, 3)			
1) Short-run estimates			
	Coefficients	*t-statistics*	*p-values*
C	0.296095***	6.109174	0.0009
LNEN(-1)	-0.909955***	-6.148216	0.0008
LNFDI+ (-1)	0.085399***	7.241262	0.0004
LNFDI- (-1)	0.086319**	2.554738	0.0432
LNOPEN+ (-1)	0.361956***	5.762966	0.0012
LNOPEN-	0.268739**	3.629866	0.0110
LNENP- (-1)	-0.181958***	-5.067996	0.0023
GR(-1)	0.016448***	6.423497	0.0007
D(LNFDI+)	-0.054666**	-3.453183	0.0136
D(LNFDI+ (-1))	-0.037244**	-2.495128	0.0468
D(LNFDI+ (-2))	-0.059333***	-4.544960	0.0039
D(LNFDI-)	0.077393**	3.299290	0.0164
D(LNENP+ (-1))	0.137322***	3.798246	0.0090
D(LNENP-)	-0.150029***	-5.325067	0.0018
D(LNENP- (-2))	-0.147452***	-5.619301	0.0014
D(GR)	0.006091***	6.427832	0.0007
D(GR(-1))	-0.005868***	-3.802502	0.0089

NARDL Model (3, 3, 2, 3, 0, 3, 3, 3)			
ECT(-1)	-0.909955***	-15.68843	0.0000
2) Long-run estimates			
	Coefficients	*t-statistics*	*p-values*
LNFDI+	0.093850	6.143788	0.0009
LNFDI-	0.094861	2.815372	0.0305
LNOPEN+	0.397774	7.002988	0.0004
LNOPEN-	0.295332	3.048735	0.0225
LNENP+	-0.013792	-0.312384	0.7653
LNENP-	-0.199964	-8.674268	0.0001
GR	0.018075	5.818601	0.0011
3) Asymmetry Tests			
	WLR	*WSR*	
LNFDI	2.676** (0.0190)	-6.896***(0.000)	
LNOPEN	3.006** (0.0101)	-	
LNENP	3.737*** (0.0025)	9.105*** (0.000)	
4) Diagnostic tests			
		F-statistic	*p-values*
Breusch-Godfrey Serial Correlation LM Test		3.079	0.406
Jarque–Bera Normality Test		0.309	0.856
ARCH Heteroscedasticity Test		32.293	0.221
Ramsey Reset Test		1.810	0.236
R2	0.998	*Adj. R2*	0.999
F-statistic	1423.451***(0.00)	*DW*	3.413

NoteB: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The values in parentheses are probability values. + and – indicate positive and negative changes in the relevant variable. WLR and WSR indicate Wald tests for asymmetry in the long and short-run, respectively. The Akaike information criterion (AIC) was used to determine the appropriate number of lags for the NARDL model.

Source: the author's computation based on CBRT and World Bank datasets.

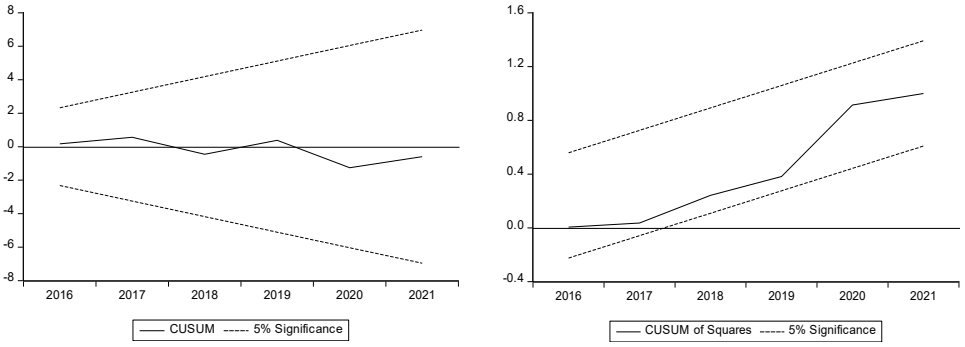
Energy consumption, which moves in the same direction as FDI and openness, can be explained by the increase in economic activity. Grossman and Krueger (1995) label this the scale effect. Increases and decreases in FDI and openness affect energy consumption by activating other areas of the economy. It is safe to say the scale effect is the dominant channel in the effect of FDI and openness on energy consumption.

The third part of the table shows the results of the asymmetry test. This was used in conjunction with the Wald test to determine whether there was a long--run or short-run asymmetric relationship. According to the Wald test results, the relationship between FDI and energy consumption is asymmetrical in both the short and long-run. It can be argued that the effects of positive and negative developments in FDI on energy consumption are differentiated. This adds to the positive relationship between FDI and energy consumption obtained by Amoako and Insaidoo (2021). This relationship is valid for both positive and negative changes, and is asymmetric. Demir (2022) states that there is a causal relation-

ship between FDI and energy consumption. The present study additionally states that the relationship between FDI and energy consumption is asymmetric.

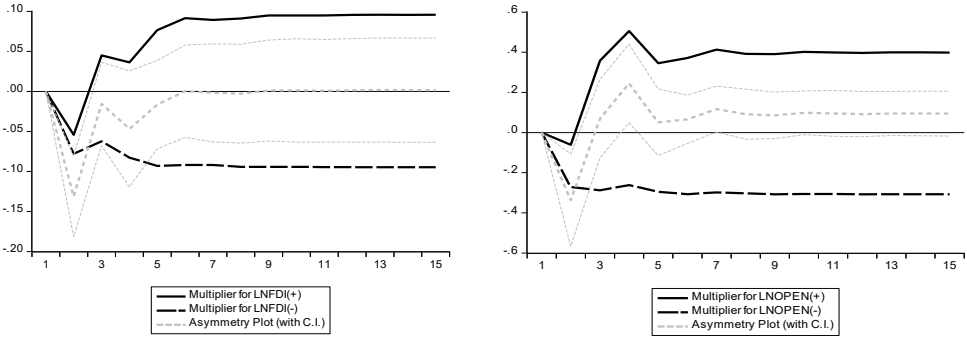
A long-run asymmetric relationship and a short-run symmetric relationship was observed between openness and energy consumption. The relationship between energy prices and energy consumption is asymmetrical in both the short and long--run. These results were in line with expectations. Various diagnostic statistical tests were used to verify the adequacy of the dynamic model. The fourth section of Table 3 contains the Diagnostic tests results. It was verified that the residual of the estimated NARDL model was free from serial autocorrelation, nonnormality, heteroscedasticity, and misspecification. Finally, the CUSUM and CUSUMQ tests were used to determine whether the coefficients of the NARDL model were stable or nonstable. Figure 1 graphically illustrates the CUSUM and CUSUMQ test results.

Figure 1.
CUSUM and CUSUMQ



Source: the author's computation based on CBRT and World Bank datasets.

Figure 2.
The multipliers for FDI and OPENNESS



Source: the author's computation based on CBRT and World Bank datasets.

Figure 2 shows the adjustments made to the new equilibrium equation. These were necessitated by previous negative and positive shocks, as shown by the NARDL multipliers on the explanatory variables. The black dashed and solid black lines show the asymmetry of energy adjustment for negative and positive shocks, respectively. By contrast, the thick and thin grey dashed lines show the asymmetric mode and critical boundary, respectively. The stage pattern in Figure 2 confirms the asymmetric relationship between FDI, openness, and energy consumption.

6. Conclusions and Policy Implications

The present study examined the asymmetric effect of FDI and openness (OPEN) on energy consumption (EN) in Türkiye using the NARDL method. The empirical results confirm both a short and long-run asymmetric relationship between FDI and energy consumption. An asymmetric relationship between openness and energy consumption was only confirmed in the long-run. An asymmetric relationship between energy prices (as a control variable) and energy consumption was proven in both the short and long-run.

Existing studies on this subject fall into two main groups. The first argues that FDI increases energy consumption. This direct relationship occurs through two channels: (i) increased FDI induces economic growth and higher energy consumption; and (ii) carbon emission restrictions in developed countries lead to the transfer of obsolete technologies to developing countries. This technology transfer directly increases energy consumption in developing countries. Some of the studies examined in the literature, however, show that FDI reduces energy consumption. These studies claim that FDI transfers energy-efficient technology and helps reduce energy consumption.

Türkiye is a developing country that imports energy. At the same time, it has a significant current account deficit and needs FDI to finance it. FDI increases energy consumption in Türkiye through production channels. The results of the present study support this conclusion.

Moreover, energy consumption increases in tandem with economic growth and income. Meeting this increase in energy demand by importing fossil fuels increases the current account deficit. This leads to a catch-22 situation for in Türkiye. The present study used the NARDL method to prove that there is an asymmetric relationship between FDI and energy consumption. This result shows that the relationship between FDI and energy consumption needs to be considered separately, positively and negatively. Energy consumption increases and decreases together with FDI. At first glance, these results may indicate that Türkiye should accept less FDI in order to import less energy. However, Türkiye is a developing country that is dependent on foreign energy and which has a savings gap. For this reason, Türkiye needs both FDI and more energy resources. While Türkiye economic growth is increasing through FDI, it needs to meet its increasing energy consumption with domestic and renewable resources.

The relationship between openness and energy consumption parallels the relationship between FDI and energy consumption. Countries that receive more FDI are more open to the outside world. Increasing FDI increases exports through the production channel. In Türkiye, exports depend on imports, and imports increase as exports increase. Therefore, energy consumption also increases with FDI. The present study proves this relationship. The relationship between openness and energy consumption is asymmetric in the long-run and symmetric in the short-run.

The clear policy recommendations for Türkiye are to: (i) design more energy-saving policies to reduce household energy consumption; (ii) invest more investment in energy efficiency technologies; (iii) implement more liberalization and deregulation policies to encourage renewable energy technologies; (iv) implement policies designed to attract FDI to the domestic and renewable energy sector; and (v) devise strategies to evaluate alternative energy sources.

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Appendix

Table A1.
Descriptive Statistics

	LNEN	LNFDI	LNOPEN	LNENP	GR
Mean	1.200340	7.795177	-0.802826	3.956231	4.789928
Median	1.161238	7.685781	-0.748323	3.851659	5.923846
Maximum	1.920923	10.00093	-0.344818	4.852099	11.35350
Minimum	0.252884	4.595120	-1.223684	3.005182	-5.750007
Std. Dev.	0.477889	1.711694	0.225134	0.494182	4.383426
Skewness	-0.184209	-0.289386	-0.233920	0.262952	-0.838707
Kurtosis	2.010655	1.811930	2.219145	2.043526	3.050550
Observations	38	38	38	38	38

Source: the author's computation based on CBRT and World Bank datasets.