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RESEARCH ARTICLE

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Energy sector competitiveness in E-7 countries: Evidence from panel data analysis

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ABSTRACT

This study uses the Balassa Revealed Comparative Advantage (RCA) index and the Net Export Index (NEI) to examine the export competitiveness of energy sub-product groups in the E-7 countries (Brazil, Russia, India, China, Indonesia, Mexico and Türkiye) over the period 2005–2024. According to the Balassa index, Russia demonstrates very strong specialisation in crude oil and natural gas, while Brazil, Mexico and Indonesia demonstrate strong specialisation in crude oil. Panel data analysis reveals that energy prices, per capita GDP, per capita energy consumption and renewable energy consumption positively and statistically significantly affect energy exports, whereas real exchange rate appreciation has a negative impact on energy exports. The findings highlight significant polarisation within the E-7 group and emphasize the importance of diversifying energy exports towards renewable technologies and green hydrogen. This study makes a valuable contribution to the existing literature by providing a long-panel, product-level analysis and robust econometric evidence on the factors that influence the performance of energy exports in major emerging economies.

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1. Introduction

In an increasingly globalized and digitalized world, the importance of countries having high export competitiveness, particularly in the energy sector, is growing all the time. In this context, it is crucial for countries to identify the product groups in which they have a competitive advantage or disadvantage. This study focuses on the E-7 countries (Brazil, Russia, India, China, Indonesia, Mexico, and Türkiye), a group of major emerging economies that play an increasingly important role in global energy markets.

Energy has become one of the top priorities for economies around the world. While some countries are concerned about environmental problems stemming from high energy consumption, others are hindered by energy scarcity. Some countries also face international political pressure regarding their energy resources. This shows that energy is not just an economic factor, but also has political and social implications. Regardless of the reason, energy is a fundamental production factor that must be used sustainably by all countries. This compels governments to utilize existing energy resources as efficiently as possible and to develop rational energy policies for the future (Kusat 2018). Throughout human history, energy has been essential for sustaining life. Today, it has become an indispensable input for the economic development of developing countries and the growth of developed countries. In this context, the production, transmission and distribution of electrical energy has been a priority for all countries worldwide since the beginning of the 19th century (Karacor and Guvenek 2010). Today, however, maintaining competitiveness hinges on the transition to green energy and the integration of digitalization into energy management. Recent literature highlights the economic and technological challenges of zero-emission strategies for energy companies (Borowski 2025). Furthermore, modern energy sectors are increasingly relying on digitization, digital twins, blockchain and Industry 4.0 as fundamental elements of enterprise management in order to optimize efficiency and sustainability (Borowski 2021). Recognizing these factors is essential for evaluating long-term export performance.

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There are many studies in the literature on determining export competitiveness at both the sector and country levels. However, the number of studies on the market power analysis of the energy sector is limited. The few studies that have addressed the Turkish energy sector have done so only superficially. For instance, in her study, Aktas Cimen (2024) examined Türkiye's competitiveness in selected sectors using the Revealed Comparative Advantage (RCA) method, but did not address the energy sector comprehensively. No comparison was made with E-7 countries in the energy sector and its sub-product groups were not examined. This study contributes to the existing literature in three important ways. First, it provides a comprehensive 20-year panel analysis of energy sub-product groups at the SITC 4-digit level. Second, it compares all seven E-7 countries simultaneously. Third, it identifies the determinants of energy exports using robust panel econometric techniques (Azam 2020; Azam and Haseeb 2021). Unlike most previous studies that focus on the energy-growth or energy-environment nexus (Ahmed and Azam 2016; Gul et al. 2015; Raza, Azam, and Bakhtyar 2025), this paper examines export competitiveness and trade specialization in the energy sector. The findings are expected to inform E-7 countries long-term energy export strategy as it transitions towards renewable energy technologies and green hydrogen.

While the Balassa, RCA and NEI indices offer detailed assessments of export specialization patterns at a product level across energy sub-products, subsequent panel data analysis identifies the key macroeconomic and energy-related drivers of aggregate energy exports in the E-7 countries, complementing these descriptive findings. Together, these two empirical approaches offer a granular view of specialization and a systematic understanding of the factors shaping overall export performance.

The remainder of the paper is organized as follows: Section 2 presents the theoretical background and literature review; Section 3 outlines the conceptual framework; Section 4 explains the methodology; Section 5 reports the empirical findings; Section 6 discusses the results; and concludes by presenting policy implications, limitations, and suggestions for future research.

2. Theoretical background and literature review

2.1. Theoretical background

This study is based on classical trade theories and contemporary literature examining the relationship between energy and growth. According to Ricardian and Heckscher-Ohlin theories, countries tend to specialize in and export goods that make intensive use of their relatively abundant production factors. In the context of the energy sector, this implies that countries with abundant energy resources or favorable technological conditions should prioritize exporting energy products.

However, modern empirical literature emphasizes that energy is not only a production factor, but also a strategic determinant of competitiveness. Recent studies have shown that energy consumption, energy prices and the transition to renewable energy play a vital role in determining export performance and long-term economic growth in emerging economies (Azam 2020; Azam and Haseeb 2021; Raza, Azam, and Bakhtyar 2025). Furthermore, the relationship between research and development, financial development, energy use and environmental sustainability has been well-documented (Ahmed and Azam 2016; Gul et al. 2015). These theoretical foundations justify including energy prices, per capita GDP, per capita energy use, renewable energy consumption and the real exchange rate as key explanatory variables in the present panel data model.

This study uses the Balassa Revealed Comparative Advantage Index and the Net Export Index to measure export specialization. Although the RCA index measures trade specialization rather than broader notions of competitiveness, such as productivity or technological capability, it remains the most widely used tool for identifying patterns of comparative advantage in international trade (Balassa 1965; Laursen 2015; Vollrath 1991).

2.2. Literature review

A substantial body of literature has examined export competitiveness using Revealed Comparative Advantage indices. However, studies specifically focusing on the energy sector competitiveness of E-7 or similar emerging economies remain relatively limited. Early studies largely focused on Türkiye's

traditional manufacturing and agricultural sectors. For instance, Aynagoz Cakmak (2005) analyzed the textile and ready-made clothing industry; Gurpınar and Barca (2007) evaluated the furniture sector; and Ozdamar and Albeni (2011) investigated the automotive industry. Subsequent studies by Akyuz (2019), Demir (2022); Erkan (2012, Erkan (2016), Saricoban, Kösekahyaoğlu, and Erkan (2017) and Binboga and Demirbas (2025) have broadened the scope of analysis to encompass various product groups, including comparisons with Syria, seafood, paper products, hazelnuts and almonds, vegetables (Yalcin 2023) and cereals (Yalcin 2024a).

While these studies provide valuable insights into Türkiye's export structure, they offer limited analysis of the energy sector. In recent years, research attention has shifted towards energy and resource-based competitiveness. Azam (2020), Azam and Haseeb (2021), Gul et al. (2015) and Raza, Azam, and Bakhtyar (2025) have examined the relationship between energy consumption, economic growth and export performance in Malaysia, the BRICS countries and other developing Asian economies. Comparative studies on export competitiveness have also been conducted for other major emerging economy groups such as BRICS and MIST (Yalcin 2020, 2024b). Chaturvedi et al. (2024) analyzed the competitiveness of Indian rice in the global market. However, there is a lack of empirical studies that specifically examine energy sub-product groups at the SITC 4-digit level across the E-7 countries using panel data methods. This study aims to address this shortcoming by providing a comprehensive, long-panel, product-level analysis of energy export competitiveness within the E-7 group.

In addition to traditional energy sources, recent theoretical and empirical literature highlights the increasing economic importance of renewable energy and green materials in various economic sectors. As global zero-emission strategies present new economic and technological challenges, countries are focusing more and more on green energy and sustainable processes in order to maintain their market power. Recent studies emphasize that integrating digitalization and green technologies is no longer optional, but a fundamental requirement for competitiveness in the energy sector (Wang et al. 2025; Zheng and Zhang 2025). This theoretical shift necessitates a re-evaluation of energy exports in terms not just of volume, but also of technological adaptation and environmental sustainability.

3. Conceptual framework

The measurement of competitive strength is based on important works such as David Ricardo's 'Theory of Comparative Advantage' and Hecksher-Ohlin's 'Factor Endowment Theory' from classical economists. According to these theories, countries can specialize in foreign trade thanks to the cost advantages they possess in different products. However, these theories do not provide a direct measure of a country's competitive strength. Therefore, RCA coefficients have been developed to determine countries' comparative advantages. These coefficients are calculated based on countries' foreign trade data (Demir 2001; Saricoban 2022).

Although revealed comparative advantages are one of the cornerstones of international trade theory, they are quite difficult to measure with concrete data. This is because the concept is based on prices that are valid in a situation where countries are assumed to be self-sufficient, and these prices cannot be observed in the real world. Therefore, to investigate comparative advantages, it is necessary to conduct analyzes based on data generated by trade (Veeramani 2006).

It is important to note that Revealed Comparative Advantage indices measure trade specialization rather than broader competitiveness in terms of productivity, technological capability, or market power. Consequently, high RCA values suggest significant export specialization rather than comprehensive competitiveness.

4. Methodology

4.1. Data

Data on exports and imports for the E-7 countries from 2005 to 2024 were obtained from the WITS (World Integrated Trade Solution) database. The data used for the panel data analysis were obtained from the BIS (Bank for International Settlements) Data Portal and the World Bank. This part of the study looks

at five sub-product groups in the energy sector of the E-7 countries. Analyzes were carried out using export and import figures (in US dollars) for these countries between 2005 and 2024.

This study used the Balassa Index and Net Export Index to analyze energy sector sub-product groups. These indices were calculated using export and import data for five energy commodity groups at the four-digit level of the SITC Rev. 3 classification. The codes for these five energy groups are shown in Table 1.

4.2. Revealed comparative advantage

The concept of comparative advantage is fundamentally based on the principle of specialization. Just as individuals specialize in certain areas, countries demonstrate specialization by focusing their production on specific goods and services. This occurs in areas where countries excel, i.e. where they have a comparative advantage. This approach is accepted as a fundamental principle in both classical and modern foreign trade theory (Utkulu 2005).

Although comparative advantages are a frequently used economic concept for determining competitive advantages, they are difficult to measure directly due to a lack of factor cost data. Indirect methods, such as the Revealed Comparative Advantage (RCA) index, which analyzes countries' past trade data, are therefore used (Prasad 2004).

In the Revealed Comparative Advantage (RCA) approach, a country's export basket reveals its competitive advantages, while its import basket shows its competitive disadvantages. The RCA approach enables cost differences between countries to be measured based on the structure of the goods they produce and export (Cizmeci 2010).

4.2.1. Balassa index

The RCA index, popularized by Balassa (1965), is actually a concept whose foundation was laid by (Liesner 1958) pioneering work. Liesner (1958) proposed a simple RCA measurement based on the ratio of a country's exports of a particular product to the total exports of all other countries exporting that product. Balassa (1965), however, made this measurement more comprehensive and advanced, creating the most widely used RCA index today (Utkulu and Seymen 2004). Among countries with similar RCA coefficients, the likelihood of a high level of trade intensity, excluding intra-industry trade, is low. The level of specialization of country i in product j is generally measured by the ratio of the share of that product in the country's total exports to its share in the global trade of the same product (Gurpınar and Barca 2007).

$$RCA_{ij} = (X_{ij}/X_{it}) / (X_{wj}/X_{wt}) \quad (1)$$

In the formula, X_{ij} represents country i's exports of product j, X_{wj} represents world exports of product j, X_{it} represents country i's total exports, and X_{wt} represents world total exports. If the resulting ratio is below 1, the country has a relatively smaller share of the world market for product j and is at a disadvantage in terms of comparative advantage. If the ratio is above 1, the country has a larger share of the world market for product j and has achieved a comparative advantage (Balassa 1965). For a more detailed interpretation of these coefficients, the results can be considered in 4 categories (Hinloopen and Marrewijk 2001):

1. Category → If $0 < RCA \leq 1$, the country does not have a competitive advantage (Disadvantage).
In the case of Category 2 → $1 < RCA \leq 2$, the country has weak competitiveness,
In the case of Category 3 → $2 < RCA \leq 4$, the country has moderate competitiveness,
In the case of Category 4 → $4 < RCA$, the country has high (strong) competitiveness.

Table 1. SITC rev. 3 classification 4-digit energy product codes.

3330	Petrol./bitum. oil, crude
3354	Petrol. bitumen/coke/etc
3432	Natural gas, gaseous
3449	Petroleum gases, gaseous
3510	Electrical energy

Source: (World Integrated Trade Solution, 2025).

4.2.2. Net export index (NEI)

The Net Export Index is obtained by dividing the net exports of a particular sector by the total of exports and imports (Balassa and Noland 1989).

$$\mathrm{NEI_{jkt}} = \frac{X_{kt}^{j} - M_{kt}^{j}}{X_{kt}^{j} + M_{kt}^{j}} \tag{2}$$

The Net Export Index (NEI) takes different values between -1 and +1 (Amighini 2004). When this value is positive, the country has a comparative advantage in the good in question, while when it is negative, it has a comparative disadvantage. Furthermore, an index value of -1 indicates full imports, 1 indicates full exports, and 0 indicates balanced trade (Donges and Riedel 1976; Erkan 2009; Saricoban and Kaya 2021).

In this study, RCA coefficients were examined over two periods. The first period was defined as 2005-2014, and the second period as 2015-2024. Moreover, average values were calculated for the 2005-2024 period. The appropriate mean is defined as the average calculated by removing abnormal or outliers from the data. The appropriate mean is defined as the statistical method that best summarizes the central tendency of the data (Türkiye Cumhuriyet Merkez Bankası (TCMB) 2025).

4.3. Panel data analysis

In financial econometrics studies, panel data analysis is the method that makes it possible to analyze cross-sectional and time series components simultaneously (Yildiz 2021). This method offers a comprehensive analysis by considering the time and cross-sectional dimensions together when examining relationships between variables. It provides more reliable results by expanding the data set, increasing the degrees of freedom and reducing the problem of multicollinearity (Ilgun 2016).

Panel data is formed by observing cross-sectional or individual data over time. There are several advantages to using panel data. These can be listed as follows (Gujarati and Porter 2014):

- Firstly, it significantly increases the sample size.
- Secondly, the dynamics of change are better understood through the analysis of repeated cross-sectional observations.
- Thirdly, it allows for the examination of more complex models.

A panel data analysis was conducted to examine the factors influencing energy exports in all E-7 countries. The analysis utilizes a random effects model in which the total export values of the energy sector for each country are defined as the dependent variable and the energy sector explanatory variables (real exchange rate, energy price, per capita gross domestic product, per capita energy use and renewable energy consumption) are defined as the independent variables. The model variable abbreviations are included in Table 2 to avoid confusion.

The research dataset comprises energy sector export values and explanatory variables for the period between 2005 and 2024. The model assumes that energy sector export values are a function of the real exchange rate, energy price, per capita gross domestic product, energy use and renewable energy consumption.

$$\mathrm{EEXP} = \mathrm{f(RER, EP, PCGDP, PCEU, REC)} \tag{3}$$

This study used the panel data method to analyze the factors affecting EEXP values. A panel regression model was constructed as follows:

Table 2. Model variables.

Variables	Abbreviations	Sources
Energy Export	EEXP	WITS (2025)
Real Exchange Rate	RER	BIS Data Portal (2025)
Energy Price	EP	World Bank Commodity Price (2025)
Per Capita Gross Domestic Product	PCGDP	World Bank (2025a)
Per Capita Energy Use	PCEU	World Bank (2025b)
Renewable Energy Consumption	REC	World Bank (2025c)

$$\text{LogEEXP} = \beta 0 + \beta 1\text{RER}_{it} + \beta 2\text{EP}_{it} + \beta 3\text{PCGDP}_{it} + \beta 4\text{PCEU}_{it} + \beta 5\text{REC}_{it} + \varepsilon i \quad (4)$$

When expressed logarithmically, the EEXP can be modeled as the sum of the constant term (β0) and the effects of the independent variables (RER, EP, PCGDP, PCEU and REC) at different rates. Here, 'i' represents different countries or firms, 'ε_i' represents the error term and 't' represents time.

The empirical model is theoretically grounded in the energy-growth and energy-trade literature. The model includes energy price because increases in global energy prices raise export revenues and strengthen export performance in energy-exporting economies (Azam 2020; Azam and Haseeb 2021). Per capita GDP and per capita energy use represent economic development and production capacity respectively, both of which are expected to enhance energy export performance by expanding industrial output and energy supply capacity (Azam and Haseeb 2021; Gul et al. 2015). Renewable energy consumption is incorporated to capture the transition to sustainable energy systems, a development that recent empirical studies have linked to improved economic performance and export capacity in developing economies (Ahmed and Azam 2016; Raza, Azam, and Bakhtyar 2025).

5. Findings

5.1. Analysis of energy sector sub-product groups using the balassa index

In this section of the study, the Balassa Index was used to determine countries' trade performance.

The Balassa Index was used to evaluate export values across five different sub-product categories covering the energy exports of the E-7 countries, and the results are presented in Table 3. In the energy sector sub-product groups, countries with strong competitiveness are indicated as 'SC', those with moderate competitiveness as 'MC', those with weak competitiveness as 'WC', and those at a disadvantage as 'D'. Analysis of Table 3 reveals that Brazil, Russia, Indonesia and Mexico have achieved a significant competitive advantage and strong superiority through specialization in the category "3330 Petroleum oils and oils from bituminous minerals (crude oil)". In contrast, India, China and Türkiye are found to be at a disadvantage in this product group. No countries have shown any specialization in the sub-product category "3449 Other gaseous hydrocarbons". Furthermore, only Indonesia has a moderate competitive

Table 3. Analysis of energy sector sub-product groups using the balassa index.

	Brazil				Russia			
	2005–2014 ave.	2015–2024 ave.	Ave.		2005–2014 ave.	2015–2021 ave.	Ave.	
3330	52.15	83.96	**61.34**	SC	261.49	210.37	**242.60**	SC
3354	0.25	0.40	**0.30**	D	0.21	0.49	**0.29**	D
3432	0.00	0.00	**0.00**	D	31.42	4.41	**20.29**	SC
3449	0.00	0.00	**0.00**	D	0.00	0.00	**0.00**	D
3510	1.05	0.27	**0.41**	D	1.79	1.71	**1.76**	WC
	India				China			
	2005–2014 ave.	2015–2024 ave.	Ave.		2005–2014 ave.	2015–2024 ave.	Ave.	
3330	0.11	0.00	**0.03**	D	1.31	0.34	**0.74**	D
3354	0.38	0.26	**0.31**	D	0.17	0.13	**0.14**	D
3432	0.00	0.00	**0.00**	D	0.09	0.11	**0.10**	D
3449	0.04	0.00	**0.02**	D	0.00	0.00	**0.00**	D
3510	0.00	1.09	**0.36**	D	0.63	0.46	**0.52**	D
	Indonesia				Mexico			
	2005–2014 ave.	2015–2024 ave.	Ave.		2005–2014 ave.	2015–2024 ave.	Ave.	
3330	58.18	15.65	**35.95**	SC	101.93	39.41	**68.33**	SC
3354	4.26	1.57	**2.72**	MC	0.01	0.00	**0.00**	D
3432	3.32	3.25	**3.16**	MC	0.10	0.00	**0.04**	D
3449	0.05	0.00	**0.01**	D	0.00	0.00	**0.00**	D
3510	0.00	0.00	**0.00**	D	0.82	0.31	**0.47**	D

	Türkiye			
	2005–2014 ave.	2015–2024 ave.	Ave.	
3330	0.01	0.00	**0.00**	D
3354	0.02	0.40	**0.15**	D
3432	0.03	0.00	**0.01**	D
3449	0.00	0.02	**0.00**	D
3510	0.98	0.56	**0.73**	D

advantage in the product group "3354 Other parts of oils from petrocoke-bitumen-oils", while other countries remain at a disadvantage.

In the "3432 Natural gas - in gaseous form" subgroup, it was determined that Russia has a strong competitive advantage and Indonesia has a moderate competitive advantage. Other countries are at a disadvantage due to their inability to specialize. In subgroup "3510 Electrical energy", it was found that only Russia has a weak competitive advantage, while other countries are at a disadvantage due to their inability to demonstrate specialization in this category.

5.2. Analysis of energy sector sub-product groups using net export index

In this section of the study, the Net Export Index (NEI) was used to determine countries' national trade performance solely within their own borders, and the results are presented in the Table 4 below. Negative index results indicate that the country has gained a competitive advantage in importing the examined good and prioritizes imports, while positive values indicate that a competitive advantage has been achieved in exporting the relevant good and that exports are given more importance (Donges and Riedel 1976; Saricoban and Kaya 2017). An NEI value of "1" indicates that a country is purely an exporter in that product group, while a value of "−1" indicates that it is purely an importer (Erkan 2009).

In Table 4, product groups in which countries have export specialization are indicated with 'S', and product groups in which they do not specialize are indicated with 'NS'. The analyzes shown in the table indicate that Brazil, Russia and Mexico are specialized (S: specialization exists) in exporting product category 3330, "Petroleum oils and oils obtained from bituminous minerals (crude oil)". Specifically, Russia and Mexico achieving a value of 1 in this product group indicates that both countries are absolute net exporters.

Furthermore, it is understood that Russia (for 3432, during the 2005-2014 period) and Indonesia have specialized in the export of product groups coded 3432, "Other parts of oils obtained from petroleum coke-bitumen-oils" and 3354, "Natural gas - in gaseous form". In the category coded 3449, "Other gaseous hydrocarbons," India and China demonstrate export expertise. Finally, in the category coded 3510,

Table 4. Analysis of energy sector sub-product groups using net export index.

	Brazil				Russia			
	2005–2014 ave.	2015–2024 ave.	Ave.		2005–2014 ave.	2015–2021 ave.	Ave.	
3330	−0.02	0.62	**0.31**	S	0.99	1.00	**1.00**	S
3354	−0.66	−0.18	**−0.42**	NS	0.04	0.42	**0.18**	S
3432	−1.00	−1.00	**−1.00**	NS	0.99	–	–	–
3449	−0.96	−0.87	**−0.94**	NS	−0.71	−0.85	**−0.83**	NS
3510	−0.79	−0.86	**−0.85**	NS	0.76	0.80	**0.79**	S
	India				China			
	2005–2014 ave.	2015–2024 ave.	Ave.		2005–2014 ave.	2015–2024 ave.	Ave.	
3330	−1.00	−1.00	**−1.00**	NS	−0.96	−0.99	**−0.98**	NS
3354	−0.45	−0.81	**−0.70**	NS	−0.60	−0.71	**−0.66**	NS
3432	–	–	–	–	0.17	−0.81	**−0.36**	NS
3449	0.35	0.01	**0.19**	S	0.30	0.10	**0.21**	S
3510	–	–	–	–	0.56	0.73	**0.64**	S
	Indonesia				Mexico			
	2005–2014 ave.	2015–2024 ave.	Ave.		2005–2014 ave.	2015–2024 ave.	Ave.	
3330	0.02	−0.42	**−0.18**	NS	1.00	1.00	**1.00**	S
3354	0.45	0.28	**0.39**	S	−0.96	−0.99	**−0.98**	NS
3432	0.79	1.00	**0.94**	S	−0.89	−1.00	**−0.96**	NS
3449	−0.31	−0.94	**−0.69**	NS	−0.91	−0.90	**−0.95**	NS
3510	−0.60	−1.00	**−0.89**	NS	0.74	0.28	**0.54**	S

	Türkiye			
	2005–2014 ave.	2015–2024 ave.	Ave.	
3330	–	–	–	–
3354	−0.96	−0.49	**−0.74**	NS
3432	–	–	–	–
3449	−0.62	−0.67	**−0.72**	NS
3510	0.31	−0.05	**0.15**	S

Note: Countries and/or years with missing data are indicated with a "–" symbol throughout the study.

"Electrical energy," Russia, China, Mexico, and Türkiye exhibit export expertise, while the remaining countries have not specialized in this area (NS: no specialization). In light of these findings, it can be concluded that countries that achieve positive values and possess export expertise have foreign sales exceeding their imports in the relevant product groups, thus gaining a competitive advantage in exports in these categories.

5.3. Determinants of energy exports: Panel regression results

Building on the patterns of specialization identified in previous sections, this part of the study uses panel data techniques to investigate the determinants of total energy exports. According to the Im-Pesaran-Shin (2003) panel unit root test, which was performed on the level values, it was found that some variables contained unit roots. Therefore, the test was repeated using the first differences of these variables. The logarithmic model (Δln) with first differences was then used to examine the short-term relationships of the panel data model. Taking the first differences caused the p-values of the variables to fall below the 0.05 significance level and made the series stationary. This approach ensured econometric consistency by eliminating the risk of spurious relationships between the series.

The Hausman (1978) test for the logarithmic model yielded a chi-squared value of 1.5887 and a p-value of 0.9026. As the p-value is greater than the 0.05 significance level, the null hypothesis was not rejected. This suggests that the random effects model provides consistent and reliable estimates. Therefore, using the random effects model to estimate the log-log model was deemed appropriate.

To test the validity of the model's basic assumptions, tests for heteroskedasticity, autocorrelation and cross-sectional dependence were performed, and the results are presented in Table 5.

First, the Breusch-Pagan test (Breusch and Pagan 1979) was applied to determine whether the variance of the error terms was constant. The test statistic was found to be BP = 2.6208 and p = 0.7582. As the p-value is greater than 0.05, there is no evidence of heteroskedasticity in the model. In other words, the variance of the error terms is constant and there is no heteroskedasticity problem in the model.

Secondly, Breusch (1978) Godfrey (1978) and Wooldridge (2002) autocorrelation tests were conducted to investigate the presence of serial correlation between the error terms. The result, $\chi^2 = 67.517$ and $p = 0.0000$, indicates the presence of an autocorrelation problem in the model. This shows that the error terms are related to each other over time, meaning that standard errors may become biased.

Finally, the Pesaran (2004) CD test was applied to determine whether there is a relationship between the error terms across countries. With $z = -0.4692$ and $p = 0.639$, however, there is no cross-sectional dependence. The E-7 countries are acting independently of each other and there is no relationship between their error terms.

5.3.1. Random effects log-log panel model findings (Driscoll-Kraay)

Due to the presence of autocorrelation (as indicated by the Breusch-Godfrey test) and the requirement for robust standard errors in panel data that may exhibit cross-sectional dependence, the Driscoll and Kraay (1998) estimator was chosen as the primary method. Although the Pesaran CD test did not indicate statistically significant cross-sectional dependence, the Driscoll and Kraay (1998) estimator was preferred because it provides robust standard errors in the presence of heteroskedasticity and autocorrelation, which were identified as issues in the diagnostic tests. This estimator is widely recommended for use in panel data applications involving potential temporal and spatial dependence, as it ensures more reliable inference even when cross-sectional dependence is not clearly evident. As a robustness check, cluster-robust standard errors based on the Arellano (1987), Froot (1989), Rogers (1993) method were also applied.

Table 5. Diagnostic test results.

Test	Hypothesis	Test Statistics	p-Value	Result
Breusch-Pagan Heteroscedasticity Test	(H0) There is no heteroscedasticity.	BP = 2.6208	0.7582	(H0) could not be rejected.
Breusch-Godfrey/Wooldridge Autocorrelation Test	(H0) There is autocorrelation.	$\chi^2 = 67.517$	0.0000	(H0) was rejected.
Pesaran CD Cross-Sectional Dependence Test	(H0) There is no horizontal section dependence.	$z = -0.4692$	0.639	(H0) could not be rejected.

As the model is in log-log form, the coefficients represent the elasticity of energy exports with respect to the independent variables. The log-log specification was favored because it enables the coefficients to be interpreted directly as elasticities and mitigates the heteroskedasticity that is often evident in trade data. The results of the Driscoll-Kraay random effects estimation are summarized in Table 6.

According to the model results, all the explanatory variables were found to be statistically significant. The variables with the strongest effects on energy exports (ln_eexp) were energy price, per capita energy use and real exchange rate.

The energy price (ln_ep) coefficient is 1.018, which is positive and significant at the 1% level. This indicates that a 1% increase in energy prices leads to an average increase in energy exports of 1.018%. This finding reveals that price increases in the energy market directly and strongly affect export revenues. When global energy prices rise, the international market value of oil, natural gas and other energy products also increases. This can increase export revenues and create an expansionary effect on export volumes in energy-exporting countries.

The coefficient for GDP per capita (ln_pcgdp) is 0.563, which is positive and significant. This indicates that a 1% increase in GDP per capita leads to an average increase in energy exports of 0.563%. Economic growth supports energy exports by boosting energy production and export capacity.

The per capita energy use (ln_pceu) coefficient was found to be positive and significant at a level of 1.270. This result indicates that increases in total energy consumption stimulate energy exports by expanding production capacity. Increased energy use may indicate an expansion of energy supply and production capacity, as well as accelerated economic growth. Increased industrialization and production capacity contribute to creating a larger production base for energy products for both domestic demand and export. Therefore, energy use, as a representative variable of energy supply capacity, can have a positive effect on the export of energy products.

The renewable energy consumption (ln_rec) variable was found to be positive and significant at the 5% level, with a coefficient of 0.473. This finding shows that developing renewable energy technologies supports the energy supply and contributes to total energy exports. The increased use of renewable energy sources leads to lower production costs in the long term, greater energy supply security and the provision of environmentally compliant products in international markets. These factors can enhance the competitiveness of energy products and have a positive impact on total energy exports.

The real exchange rate (ln_rer) coefficient is −0.770, which is negative and significant at the 1% level. This indicates that an increase in the value of the local currency reduces energy exports. Real appreciation of the domestic currency increases the relative price of export goods in foreign currencies, which has a negative impact on external demand and thus reduces energy exports.

R^2 (0.709): The independent variables explain approximately 71% of the variation in energy exports. This is a fairly strong explanatory power for social sciences and economics. F Statistic (275.683***): The model as a whole is statistically significant at the 1% significance level. That is, the selected variables have a non-random power to explain energy exports.

Although energy prices are treated as exogenous in the model, reverse causality may still be a factor, particularly in major energy-exporting countries such as Russia. Therefore, within the adopted modeling framework, the estimated coefficients should primarily be interpreted as empirical associations rather than strict causal effects. To mitigate possible endogeneity concerns, the Driscoll-Kraay estimator was employed as the main estimation method, as it is robust to serial correlation and cross-sectional dependence. However, this issue could be addressed more rigorously in future research by adopting instrumental

Table 6. Results of the Driscoll-Kraay random effects estimation.

Variables	Coefficient	Std. Error	t-Value	*p*-Value
ln(Real Exchange Rate)	−0.7703***	0.1281	−6.014	0.0000
ln(Energy Price)	1.0179***	0.0508	20.037	0.0000
ln(Per Capita Gross Domestic Product)	0.5631***	0.0900	6.258	0.0000
ln(Per Capita Energy Use)	1.2698***	0.3689	3.442	0.0008
ln(Renewable Energy Consumption)	0.4730**	0.2037	2.322	0.0220
Constant	0.8858	2.9444	0.301	0.764
$R^2 = 0.709$		F statistic = 275.683***		
Adjusted $R^2 = 0.696$				

Note: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$ The results were obtained using the R program.

variable techniques or dynamic panel data models, such as the system GMM estimator. Multicollinearity was assessed using variance inflation factors.

5.3.2. Random effects log-log panel model findings (Arellano-Froot-Rogers robust standard errors)

Although the Driscoll and Kraay (1998) robust standard error estimator is effective in considering cross-sectional dependence and serial correlation, cluster-robust standard error estimators developed by Arellano (1987), Froot (1989) and Rogers (1993) were also employed as an alternative method to verify the robustness of the findings. This approach produces standard errors that are robust to heteroskedasticity and serial correlation within panel units. The results of the random effects log-log model with Arellano-Froot-Rogers robust standard errors are presented in Table 7.

The results obtained using the robust Arellano-Froot-Rogers standard error estimator are largely consistent with the Driscoll-Kraay estimation results in terms of sign, magnitude and statistical significance. All the main explanatory variables have the expected signs and remain statistically significant. This suggests that the model's outcomes are robust to different robust standard error approximations and that the findings are reliable. The consistency of the findings obtained using both the Driscoll and Kraay (1998) and the Arellano (1987), Froot (1989) and Rogers (1993) robust standard error estimators reveals that the model is robust against potential violations, such as heteroskedasticity, serial correlation and dependence within panel units.

6. Discussion and conclusion

6.1. Discussion

The empirical results reveal a clear polarization in the competitiveness of energy exports among the E-7 countries. Russia's dominant position in crude oil and natural gas is consistent with its resource endowment and export-oriented energy policy. Brazil, Mexico and Indonesia also demonstrate strong specialization in crude oil, supporting classical comparative advantage theory. By contrast, Türkiye, China and India remain at a disadvantage in traditional fossil fuel categories.

The panel data analysis reveals that the strongest positive drivers of energy exports are energy prices, per capita energy consumption, and per capita GDP. These findings are consistent with the conclusions of recent studies on the energy-growth nexus in BRICS and other developing Asian economies (Azam 2020; Azam and Haseeb 2021; Raza, Azam, and Bakhtyar 2025). Notably, the positive and significant coefficient of renewable energy consumption suggests that the green energy transition can support export performance while also serving environmental goals. The negative effect of real exchange rate appreciation is theoretically expected and empirically robust. However, the potential endogeneity between energy prices and export volumes in major exporters such as Russia requires further consideration. Robustness checks using two different standard error estimators confirm that the main findings are not sensitive to the estimation method used.

These findings largely align with those of previous studies on the energy-growth nexus in emerging economies. The strong positive effect of energy prices is in line with the work of Azam (2020) and Azam and Haseeb (2021), and the positive impact of renewable energy consumption supports the idea that the green transition can improve rather than hinder a developing country's export performance (Raza, Azam, and Bakhtyar 2025). The negative impact of real exchange rate appreciation is also consistent with the

Table 7. Results of the Arellano-Froot-Rogers random effects estimation.

Variables	Coefficient	Robust Std. Error
ln(Real Exchange Rate)	-0.770*	(0.436)
ln(Energy Price)	1.018***	(0.123)
ln(Per Capita Gross Domestic Product)	0.563**	(0.246)
ln(Per Capita Energy Use)	1.270**	(0.566)
ln(Renewable Energy Consumption)	0.473**	(0.193)
Constant	0.886	(3.718)
$R^2 = 0.709$		F statistic = 275.683***
Adjusted: $R^2 = 0.696$		

Note: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$ The results were obtained using the R program.

wider body of literature on trade. Unlike many earlier studies, however, which focused primarily on fossil fuel dominance, the present analysis highlights the emerging role of renewable energy in export competitiveness, thereby extending the literature on the energy transition within the E-7 group.

Our empirical findings take on greater significance when considered within the broader theoretical framework of energy digitalization and global zero-emission targets, and beyond these macroeconomic factors. The positive impact of renewable energy consumption on export competitiveness indicates that E-7 countries that invest in green materials, digital management processes, and sustainable technologies are in a stronger position to compete in the global market. While traditional fossil fuels continue to be a driving force behind exports for countries such as Russia and Mexico, the literature suggests that long-term competitive advantage increasingly hinges on overcoming the technological challenges of the green transformation. Consequently, our findings corroborate the argument in recent literature that modernizing the energy sector through digitalization and renewable energy is critical to achieving macroeconomic resilience and export growth.

Overall, this study makes a valuable contribution to the existing literature by providing one of the first comprehensive, product-level analyzes of energy export competitiveness in the E-7 countries, employing a combination of descriptive indices and robust econometric techniques.

6.2. Conclusion

This study uses the Balassa Index and Net Export Index (NEI) methods to examine the export competitiveness of the energy sector and its sub-product groups in the E-7 countries (Brazil, Russia, India, China, Indonesia, Mexico and Türkiye) for the period 2005-2024. It also investigates the key determinants affecting energy sector export performance through panel data analysis.

The findings reveal significant polarization in energy exports within the E-7 group. Russia has a strong competitive advantage in crude oil (code 3330) and natural gas (code 3432), while Brazil, Mexico and Indonesia are also highly specialized in crude oil. Conversely, Türkiye, China and India are at a significant competitive disadvantage in crude oil and most traditional energy subgroups. Almost all E-7 countries are at a disadvantage in electricity (code 3510) exports; only Russia shows a weak advantage. Analysis of the Net Export Index, which measures a country's trade performance, reveals that Brazil, Russia and Mexico specialize in exporting products in the 3330 category, 'Petroleum oils and oils obtained from bituminous minerals (crude oil)'. Specifically, Russia and Mexico achieving a value of 1 in this product group indicates that both countries are absolute net exporters. Furthermore, it is understood that Russia (for 3432, during the 2005-2014 period) and Indonesia have specialized in the export of product groups coded 3432, "Other parts of oils obtained from petroleum coke-bitumen-oils" and 3354, "Natural gas - in gaseous form". India and China demonstrate export specialization in the category coded 3449, 'Other gaseous hydrocarbons'. Finally, Russia, China, Mexico and Türkiye exhibit export specialization in the category coded 3510, 'Electrical energy', while the remaining countries have not been found to specialize in this area.

The results of the panel data analysis show that the strongest positive determinants of energy sector exports are energy prices, per capita energy consumption and per capita GDP. Although renewable energy consumption has a positive and significant effect, real exchange rate appreciation was identified as the only factor with a negative effect on energy exports.

In light of these findings, countries need to develop long-term strategies to reduce dependence on imports of crude oil and natural gas. To this end, domestic production and exploration activities should be encouraged, as should the management of strategic reserves. A top priority should be diversifying E-7 countries energy export basket. It is extremely important to establish production and export capacity in promising areas such as renewable energy equipment, solar panels, wind turbine components, battery technologies and green hydrogen.

The increased efficiency of energy-intensive sectors should be supported and the positive impact of increased per capita energy consumption on exports should be evaluated while prioritizing the production of added value per unit of energy. Investments in renewable energy should be considered a strategic area in terms of environmental commitments and export potential, and the necessary infrastructure for research and development, production and certification should be developed rapidly. Energy diplomacy should be strengthened and long-term contracts that create mutual dependence should be concluded with

neighboring countries and those in the European Union, particularly with regard to the trade of natural gas and electricity.

Moreover, by implementing the right policies in renewable energy and energy technology, E-7 countries could become a major player in the export market in the medium to long term. This transformation appears to present E-7 countries with a strategic opportunity, both economically and geopolitically. Although the empirical analysis is based on panel data for the E-7 group as a whole, recommendations for individual countries should be interpreted with caution and with consideration of country-specific structural differences.

This study has several limitations. Firstly, the analysis only covers five energy sub-product groups at the SITC 4-digit level, with broader energy technology products excluded due to data availability issues. Secondly, while the model treats energy prices as exogenous, reverse causality may be present for major exporters.

Furthermore, countries should diversify their energy export portfolio towards renewable energy equipment, including solar panels, wind turbine components, battery technologies and green hydrogen. These areas offer environmental compliance and high export potential within the European Union market. Future research could extend the analysis by incorporating post-2024 data, examining renewable energy sub-products separately, or applying dynamic panel models to address endogeneity more effectively.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Author contributions

CRediT: **Mahsun Yalcin:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing; **Levent Gokdemir:** Conceptualization, Project administration, Resources, Supervision, Validation, Writing – review & editing.

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Data availability statement

The data that support the findings of this study are openly available in the public domain. Trade data were obtained from the World Integrated Trade Solution (WITS) database. Macroeconomic and energy-related data were obtained from the Bank for International Settlements (BIS) Data Portal and the World Bank open databases.

References

Ahmed, M., and M. Azam. 2016. "Causal Nexus between Energy Consumption and Economic Growth for High-, Middle- and Low-İncome Countries Using Frequency Domain Analysis." *Renewable and Sustainable Energy Reviews* 60: 653–678. https://doi.org/10.1016/j.rser.2015.12.174.

Aktas Cimen, Z. 2024. "Sınırda Karbon Düzenlemesi Ve Seçilmiş Sektörlerde Türkiye'nin Küresel Rekabet GÜCÜ." *Politik Ekonomik Kuram* 8 (1): 1–17. https://doi.org/10.30586/pek.1378742.

Akyuz, C. K. 2019. "Açıklanmış Karşılaştırmalı Üstünlükler İndeksi Kullanılarak Kağıt Ve Kağıt Ürünleri Sanayi Sektörünün Rekabet Gücünün Belirlenmesi." *Bartın Orman Fakültesi Dergisi* 21 (1): 164–171. https://doi.org/10.24011/barofd.525879.

Amighini, A. 2004. China in the International Fragmentation of Production: Evidence from the ICT Industry In *United Nations Conference on Trade and Development (UNCTAD).* Università Commerciale Luigi Bocconi.

Arellano, M. 1987. "Computing Robust Standard Errors for Within-Groups Estimators." *Oxford Bulletin of Economics and Statistics* 49 (4): 431–434. https://doi.org/10.1111/j.1468-0084.1987.mp49004006.x.
Aynagoz Cakmak, Ö. 2005. "Açıklanmış Karşılaştırmalı Üstünlükler Ve Rekabet Gücü: Türkiye Tekstil Ve Hazır Giyim Endüstrisi Üzerine Bir Uygulama." *Ege Academic Review* 5 (1): 65–76.
Azam, M. 2020. "Energy and Economic Growth in Developing Asian Economies." *Journal of the Asia Pacific Economy Taylor & Francis Journals* 25 (3): 447–471. https://doi.org/10.1080/13547860.2019.1665328.
Azam, M., and M. Haseeb. 2021. "Determinants of Foreign Direct Investment in BRICS- Does Renewable and Non-Renewable Energy Matter?" *Energy Strategy Reviews* 35: 100638. https://doi.org/10.1016/j.esr.2021.100638.
Balassa, B. 1965. "Trade Liberalization and Revealed Comparative Advantage." *Manchester School of Economic and Social Studies* 33: 99–123 https://doi.org/10.1111/j.1467-9957.1965.tb00050.x.
Balassa, B., and M. Noland. 1989. "Revealed Comparative Advantage in Japan and the United States." *Journal of International Economic Integration* 4 (2): 8–22. https://doi.org/10.11130/jei.1989.4.2.8.
Binboga, G., and N. Demirbas. 2025. "Türkiye'nin Badem Ticaretinde Küresel Rekabet Gücünün Analizi." *Anadolu Tarım Bilimleri Dergisi* 40 (1): 15–37. https://doi.org/10.7161/omuanajas.1511384.
BIS Data Portal. 2025. Effective exchange rates. https://data.bis.org/topics/EER/data?data_view=table&filter=FREQ%3DM%255EEER_BASKET%3DB%255EEER_TYPE%3DR%255EYEAR%3D2005%257C2006%257C2007%257C2008%257C2009%257C2010%257C2011%257C2012%257C2013%257C2014&rows=REF_AREA&cols=TIME_PERIOD.
Borowski, P. F. 2021. "Digitization, Digital Twins, Blockchain, and Industry 4.0 as Elements of Management Process in Enterprises in the Energy Sector." *Energies* 14 (7): 1885. https://doi.org/10.3390/en14071885.
Borowski, P. F. 2025. "Economic and Technological Challenges in Zero-Emission Strategies for Energy Companies." *Energies* 18 (4): 898. https://doi.org/10.3390/en18040898.
Breusch, T. S. 1978. "Testing for Autocorrelation in Dynamic Linear Models." *Australian Economic Papers* 17 (31): 334–355. https://doi.org/10.1111/j.1467-8454.1978.tb00635.x.
Breusch, T. S., and A. R. Pagan. 1979. "A Simple Test for Heteroscedasticity and Random Coefficient Variation." *Econometrica : Journal of the Econometric Society* 47 (5): 1287–1294. https://doi.org/10.2307/1911963.
Chaturvedi, P., A. Rajput, A. Verma, and A. Singh. 2024. "Competitiveness of Indian Rice in the Global Market: A Comprehensive Revealed Comparative Advantage (RCA) and Nominal Protection Coefficient (NPC) Evaluation." *Journal of Experimental Agriculture International* 46 (10): 66–72. https://doi.org/10.9734/jeai/2024/v46i102925.
Cizmeci, H. 2010. Türkiye Seramik Kaplama Malzemeleri Sektörünün Rekabet Gücü. Uşak Üniversitesi Sosyal Bilimler Enstitüsü, Yüksek Lisans Tezi.
Demir, İ. 2001. Türkiye Beyaz Eşya Sanayinin Rekabet Gücü ve Geleceği. İktisadi Sektörler ve Koordinasyon Genel Müdürlüğü Sanayi Dairesi Başkanlığı, Uzmanlık Tezi, Yayın No DPT. 2571.
Demir, M. A. 2022. "Türkiye'de Fındığın 2016-2021 Dönemi İçin Rekabet Durumu: Normalleştirilmiş Açıklanmış Karşılaştırmalı Üstünlük Endeksinin Üç Varyasyonu Ile Analiz." *Finans Ekonomi ve Sosyal Araştırmalar Dergisi* 7 (4): 907–914. https://doi.org/10.29106/fesa.1178221.
Donges, J. B., and Riedel, J. 1976. The Expansion of Manufactured Exports in Developing Countries: An Empirical Assessment of Supply and Demand İssues. Kieler Arbeitspapiere, Kiel Working Papers No: 49, June 1976.
Driscoll, J. C., and A. C. Kraay. 1998. "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data." *Review of Economics and Statistics* 80 (4): 549–560. https://doi.org/10.1162/003465398557825.
Erkan, B. 2009. *Ülkelerin İhracat Performanslarının Belirlenmesinde Açıklanmış Karşılaştırmalı Üstünlüklerinin Kullanılması: Yükselen Ekonomiler Örneği*. Manisa: Celal Bayar Üniversitesi Sosyal Bilimler Enstitüsü, Doktora Tezi.
Erkan, B. 2012. "Ülkelerin Karşılaştırmalı İhracat Performanslarının Açıklanmış Karşılaştırmalı Üstünlük Katsayılarıyla Belirlenmesi: TÜRkiye-Suriye ÖRneği." *ZKÜ Sosyal Bilimler Dergisi* 8 (15): 195–218.
Erkan, B. 2016. "Türkiye'nin Canlı Hayvan, Et Ve Deniz Ürünleri İhracatındaki Rekabet Gücünün Analizi." *İnsan ve Toplum Bilimleri Araştırmaları Dergisi* 5 (7): 1843–1864. https://doi.org/10.15869/itobiad.259288.
Froot, K. A. 1989. "Consistent Covariance Matrix Estimation with Cross-Sectional Dependence and Heteroskedasticity in Financial Data." *Journal of Financial and Quantitative Analysis* 24 (3): 333–355. https://doi.org/10.2307/2330815.
Godfrey, L. G. 1978. "Testing for Higher Order Serial Correlation in Regression Equations When the Regressors Include Lagged Dependent Variables." *Econometrica : Journal of the Econometric Society* 46 (6): 1303–1310. https://doi.org/10.2307/1913830.
Gujarati, D. N., and D. C. Porter. 2014. *Temel Ekonometri, (2. Baskı)*. İstanbul: Literatür Yayıncılık.
Gul, S., X. Zou, C. H. Hassan, M. Azam, and K. Zaman. 2015. "Causal Nexus between Energy Consumption and Carbon Dioxide Emission for Malaysia Using Maximum Entropy Bootstrap Approach." *Environmental Science and Pollution Research International* 22 (24): 19773–19785. https://doi.org/10.1007/s11356-015-5185-0.
Gurpınar, K., and M. Barca. 2007. "Türk Mobilya Sektörünün Uluslararası Rekabet Gücü Düzeyi Ve Nedenleri." *Eskişehir Osmangazi Üniversitesi İİBF Dergisi* 2 (2): 41–61.
Hausman, J. A. 1978. "Specification Tests in Econometrics." *Econometrica : Journal of the Econometric Society* 46 (6): 1251–1271. https://doi.org/10.2307/1913827.
Hinloopen, J., and C. V. Marrewijk. 2001. "On the Empirical Distribution of the Balassa Index." *Review of World Economics/Weltwirtschaftliches Archiv* 137 (35): 1-35.

Ilgun, F. M. 2016. "Mali Sürdürülebilirlik: OECD Ülkelerine Yönelik Panel Veri Analizi." *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi* 30 (1): 69–90.
Karacor, Z., and B. Guvenek. 2010. "Enerji Piyasası Reformlarının Elektrik Enerjisi Piyasasına Etkisi: EÜAŞ Ve Ayrıcalıklı Şirketler Üzerine Bir Analizi." *Yönetim ve Ekonomi Dergisi* 17 (1): 147–166.
Kusat, N. 2018. "Açıklanmış Karşılaştırmalı Üstünlükler İndeksi Çerçevesinde AB Aday Ülkeleri Enerji Sektörü Rekabet Gücü Analizi (2006-2016)." *Uluslararası Bilimsel Araştırmalar Dergisi* 3 (1): 362–376. https://doi.org/10.21733/ibad.415206.
Laursen, K. 2015. "Revealed Comparative Advantage and the Alternatives as Measures of International Specialization." *Eurasian Business Review* 5 (1): 99–115.
Liesner, H.H. 1958. "The European Common Market and British Industry." The Economic Journal 68 (270): 302–316. https://doi.org/10.2307/2227597.
Ozdamar, G., and M. Albeni. 2011. "Türkiye Otomotiv Sanayisi Dış Ticaret Rekabet Gücü Üzerine Bir İnceleme." *Süleyman Demirel Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 1 (13): 193-216.
Pesaran, M. H. 2004. "General Diagnostic Tests for Cross Section Dependence in Panels." *CESifo Working Paper* 2004 (1229).
Prasad, R. N. 2004. "Fiji'S Export Competitiveness: A Comparison with Selected Small Island Developing States." *Economic Department Reserve Bank of Fiji, Working Paper 2004/06*, 1–40.
Raza, A., M. K. Azam, and B. Bakhtyar. 2025. "Exploring the Linkage between Energy Consumption and Economic Growth in BRICS Countries through Disaggregated Analysis." *Journal of the Knowledge Economy* 16 (1): 3869–3891. https://doi.org/10.1007/s13132-024-02045-1.
Rogers, W. 1993. "Regression Standard Errors in Clustered Samples." *Stata Technical Bulletin* 13: 19–23.
Saricoban, K. 2022. "RCEP Ülkelerinin Dış Ticareti Ve Standart Ürün Grupları Bazında İhracattaki Karşılaştırmalı ÜStÜNlÜKleri." *Elektronik Sosyal Bilimler Dergisi* 21 (84): 1991–2012. https://doi.org/10.17755/esosder.1140018.
Saricoban, K., and E. Kaya. 2017. "Determination of the Seafood Export Competitiveness: The Comparative Analysis of Top Ten Countries Having Lion Share from Seafood Export." *Journal of Business, Economics and Finance (JBEF* 6 (2): 112–124. http://doi.org/10.17261/Pressacademia.2017.500.
Saricoban, K., and E. Kaya. 2021. "An Analysis on the Competitiveness and Specialization Levels of the Countries in the Export of Wood and Articles of Wood." *Forestist* XX (X): 1–16. https://doi.org/10.5152/Forestist.2021.21021.
Saricoban, K., L. Kösekahyaoğlu, and B. Erkan. 2017. "Türkiye'nin İmalat Sanayi Ürün Gruplarındaki İhracat Rekabet Gücünün Belirlenmesi: 1996-2015 Dönemi Analizi." *Journal of Life Economics* 4 (3): 49–72.
Türkiye Cumhuriyet Merkez Bankası (TCMB). 2025. Piyasa katılımcıları anketi. (25.12.2025). https://TCMB.gov.tr/wps/wcm/connect/f7471426-8864-4850-809f-426de2266e03/PKA Metaveri.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-f7471426-8864-4850-809f426de2266e03nIqgLKA#:~:text=Uygun%20Ortalama%3A%20Veri%20analizi%20sonucunda,en%20uygun%20%C5%9Fekilde%20%C3%B6zetleyen%20istatistiktir.
Utkulu, U. 2005. "Türkiye'nin Dış Ticareti Ve Değişen Mukayeseli ÜStÜNlÜKler." T.C. Dokuz Eylül Üniversitesi Yayınları.
Utkulu, U., and D. Seymen. 2004. "Revealed Comparative Advantage and Competitiveness: Evidence for Turkey Vis-À-Vis the Eu/15." *European Trade Study Group 6th Annual Conference, ETSG* September: 1–26.
Veeramani, C. 2006. *India and China: Changing Patterns of Comparative Advantage?* 1–20. Mumbai: Indira Gandhi Institute of Development Research.
Vollrath, T. L. 1991. "A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage." *Weltwirtschaftliches Archiv. Bd. 127* H. 2 (1991): 265–280. https://doi.org/10.1007/BF02707986.
Wang, K.-H., S.-M. Li, O.-R. Lobonţ, and N.-C. Moldovan. 2025. "Is Green Innovation the "Golden Ticket" in Achieving Energy Security and Sustainable Development?" *Economic Analysis and Policy* 87: 297–314. https://doi.org/10.1016/j.eap.2025.06.016.
WITS2025) World Integrated Trade Solution. Trade Data. https://WITS.worldbank.org/.
Wooldridge, J. M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.
World Bank Commodity Price2025) World Bank Commodity Price Data. https://www.worldbank.org/en/research/commodity-markets.
World Bank2025a) GDP per capita (current US $). https://data.worldbank.org/indicator/NY.GDP.PCAP.CD.
World Bank2025b) Energy use (kg of oil equivalent per capita). https://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE.
World Bank. 2025c. Renewable energy consumption (% of total final energy consumption). https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS.
Yalcin, M. 2020. BRICS Ülkelerinin İhracat Rekabet Güçlerinin Belirlenmesi ve Türkiye ile Bir Karşılaştırma, Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü, Yüksek Lisans Tezi, Burdur.
Yalcin, M. 2023. "Türkiye'nin Ve Sebze Sektöründe Söz Sahibi Ülkelerin İhracat Rekabet Güçlerinin Karşılaştırmalı Analizi." *Dicle Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 34: 443–466. https://doi.org/10.15182/diclesosbed.1310554.
Yalcin, M. 2024a. "Comparative Analysis of Export Competitiveness Specialization Levels of Türkiye and Leading Countries in the Cereal Sector." *Anadolu Üniversitesi Sosyal Bilimler Dergisi* 24 (4): 1751–1766. https://doi.org/10.18037/ausbd.1350075.

Yalcin, M. 2024b. "MIST Ülkelerinin İhracat Rekabet Güçlerinin Karşılaştırmalı Analizi." *İzmir İktisat Dergisi* 39 (2): 488–506. https://doi.org/10.24988/ije.1309730.

Yildiz, B. 2021. Sağlık Sektöründe Ekonomik Ve Finansal Rantabilitenin Ekonometrik Modellemesi: İlaç Şirketleri Üzerine Bir Uygulama In *Finansal Ekonometri Uygulamaları*M. Ural and Ü. ve Aydın, eds. Ankara: Seçkin Yayıncılık.

Zheng, M., and X. Zhang. 2025. "Digitalization and Renewable Energy Development: Analysis Based on Cross-Country Panel Data." *Energy* 319: 135077. https://doi.org/10.1016/j.energy.2025.135077.