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Short and Long-Term Analysis of Relations between Transportation and Industrial Sectors Energy Consumption and Foreign Trade in New Industrialized Countries

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ABSTRACT

This study investigates the effects of transport sector energy consumption, industrial sector energy consumption and imports on exports in Newly Industrializing Countries (Mexico, Turkey, Brazil, China, India, Indonesia, South Africa and Thailand). In the study, using data for the period 1990-2022, tests that take into account horizontal cross-section dependence and heterogeneity and long and short-run analyses at panel and country level were applied. As a result of the study, it is found that transportation sector energy consumption has a negative effect on exports and imports have a positive effect on exports in both short and long run. Moreover, the negative effect of transportation energy consumption decreases from the short-run to the long-run, whereas the positive effect of imports increases from the short-run to the long-run. In addition, it is determined that the positive effect of imports on exports is higher than the negative effect of transportation energy consumption in both the short and long run.

Keywords: Transportation Energy Consumption, Export, Import, Short and Long Run Analysis
JEL Classifications: F10, F14, Q43, O18, C23

1. INTRODUCTION

With the industrial revolution, the economic structures of countries have undergone a major transformation. Rapid developments in the industrial sector enabled large-scale production to be realized in a short time. Other sectors were also positively affected by these developments in the industrial sector. Intensive transportation activities have emerged in order to provide inputs to the industrial sector and to deliver the goods produced in this sector to consumers. The developments in the industry and the increase in the transaction volume of the transportation sector have brought along high energy consumption.

Developments such as the ability to produce more in a shorter time and to deliver products to consumers in a shorter time with the development of transportation services lead to an increase in consumption. For countries that meet their domestic production and consumption needs under these developments, foreign trade has started to develop especially since the 1980s. In this period, exports of surplus products from domestic consumption and imports of products and inputs that cannot be produced domestically have gained importance. On the one hand, the free movement of goods and services between countries, the removal or reduction of barriers to international trade such as taxes and quotas, and on the other hand, the free movement of capital movements between countries have enabled an increase in international trade on a global scale.

The removal of barriers to international trade, the development of domestic industries in countries and the increase in transportation services support the economic growth and development of countries. In many countries, export-oriented industrialization and growth policies guide the economy. Especially in newly industrializing and developing countries, export-oriented growth policies both receive support from the industrial sector and contribute to the further development of the industrial sector. In a complementary policy, international trade activities, the industrial sector and the transportation sector support each other to ensure the growth of national economies. However, in general, there is a need for intensive energy consumption in order to realize these economic activities and sectoral productions.

Energy consumption has been used in almost all sectors as one of the main input sources of the economy throughout history (Abdulqadir, 2023). With the development of the industrial sector, energy demand has started to increase significantly. Transportation activities within production and distribution networks also rely heavily on energy resources. In addition, the transition of societies to modern lifestyles, urbanization and population growth also lead to increased energy consumption. As a result, the supply-production-distribution-consumption processes, which are the basis of economic growth, cannot function without energy consumption.

Considering international trade as one of the main dynamics of economic growth, countries adopt free foreign trade policies in order to integrate with the global economy, especially to increase their export potential. With the removal of barriers to free trade, transportation costs become one of the biggest constraints to foreign trade (Micco and Perez, 2001: 38). In addition to the development of transportation infrastructure and modes of transportation, the energy input used in the transportation sector constitutes the largest transportation costs. Moreover, in many countries, the share of the transportation sector in total energy consumption can be quite high. The transportation sector fulfills an important function by assuming an intermediary role for the overall economy (Neves et al., 2017). The transportation sector is a multidimensional sector that finds a place in the public and private sectors of the economy, in the agricultural and industrial sectors and in the social lives of people. It continues to exist in almost every field both in the national economy and in the lives of societies. Although transportation systems and means of transportation are diverse, transportation infrastructures are largely based on energy consumption (Achour and Belloumi, 2016). As such, the transportation sector is intertwined with energy consumption and commercial activities.

An analysis of the information in Graph 1 and Table 1 reveals that energy consumption in the industrial and transportation sectors has a significant share in total energy consumption. When analyzed by sectors, in all countries except Mexico, the share of industrial energy consumption in total energy consumption in the 1990-2022 period has been higher than that of the transportation sector. In Mexico, the share of transportation sector energy consumption is higher. On the other hand, it is understood that China has the highest average value of energy consumption in the industrial sector and Mexico has the highest average value of energy consumption in the transportation sector.

There is a close relationship between international trade and energy consumption (Narayan and Smyth, 2009). Export and import activities involve processes such as procurement, production, storage and distribution. All processes rely heavily on transportation services and energy consumption. The fact that production takes place with energy consumption and the high energy consumption of vehicles engaged in national and international transportation makes the issues of export, import, transportation and energy consumption related.

Industrialization and liberal policies expand markets by increasing production through energy consumption (Foster et al., 2010). Recently, especially in developing countries, there has been an increase in international trade volume and energy consumption in order to achieve economic growth and increase welfare (Raza et al., 2015). International trade enables intersectoral interaction within the economy (Yoshino and Nakahigashi, 2000), increased exports lead to an expansion in export-related sectors, and increased sectoral production increases sectoral energy consumption. As a result of all these economic activities, there is an increase in energy consumption (Sadorsky, 2012). In addition, the energy consumption of the industry and transportation sectors, which are the main production areas in the economy, has a direct impact on the economy (Costantini and Martini, 2010).

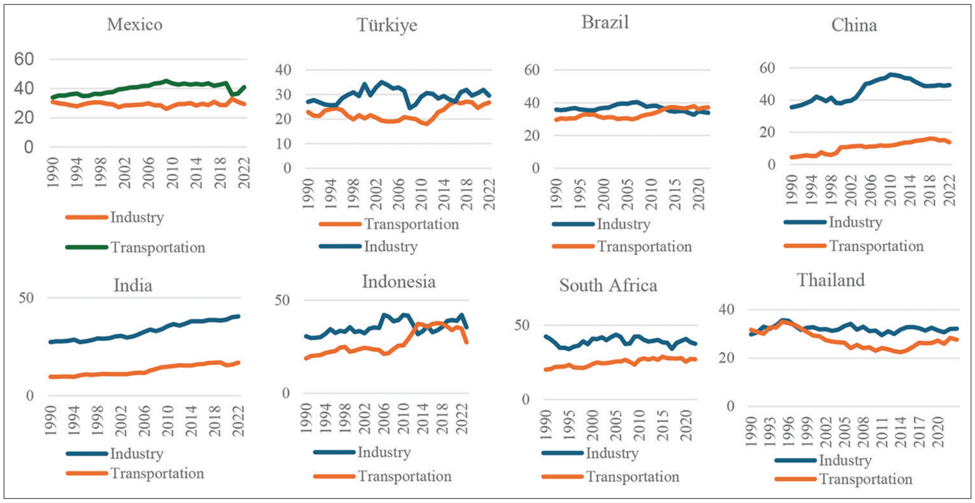
Graph 2 presents information on energy consumption in the industrial and transportation sectors in the NIC countries analyzed in this study. The information in the graph shows that China has the highest energy consumption in both industry and transportation sectors. China is followed by India and Brazil, while energy consumption in all sectors has been on an upward trend in the relevant period in all countries.

As a result of the removal of barriers to international trade by many countries, transportation costs have become one of the most important determinants of trade between countries. Energy consumption has an important place in transportation costs. Because the vehicles used during transportation operate with a large amount of energy consumption. On the other hand, in international trade, it is very important to produce products, improve product quality and increase product diversity in order to gain competitive advantage especially in exports. For this reason, the industrial sector should have an advanced structure and have high technology tools and equipment. These factors consist of systems that operate with direct energy consumption. Moreover, imports are one of the most important factors for exports in developing and newly industrialized countries. This is because

Table 1: Average shares of energy consumption of ındustry and transportation sectors in total energy consumption in NIC countries (Average for 1990-2022)

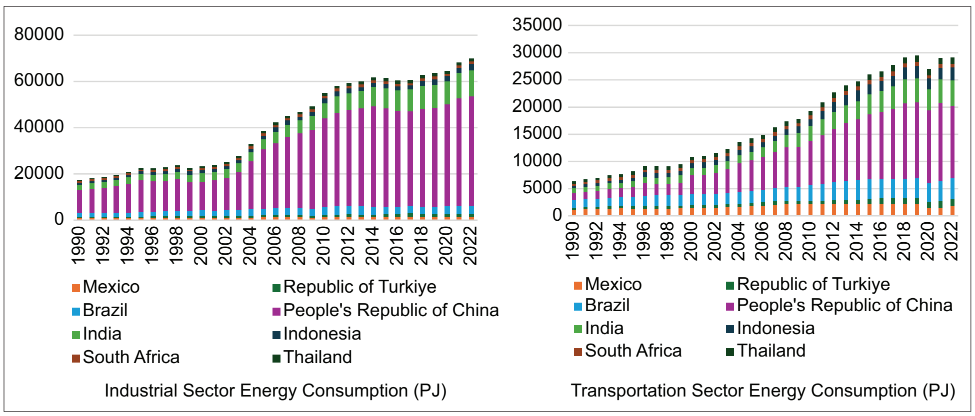
Sectors	Mexico	Turkiye	Brazil	China	India	Indonesia	South Africa	Thailand
Industry (PJ)	29.30	29.62	36.50	46.05	33.05	35.448	39.12	32.13
Transportation (PJ)	39.84	22.38	33.16	10.77	13.01	27.36	24.97	27.61

Graph 1: Shares of energy consumption of ındustry and transportation sectors in total energy consumption in NIC countries



Source: IEA, 2024

Graph 2: Shares of energy consumption of ındustry and transportation sectors in total energy consumption in NIC countries (1990-2022, PJ)



Source: IEA, 2024

countries obtain the input resources they need to realize export-oriented production through imports. Therefore, imports become a necessity for exports, especially in countries with insufficient resources. In the light of this information, this study examines the relationship between imports and energy consumption in the industrial and transport sectors of exports, which is an important source of economic growth and development and a fundamental component of international trade in 8 newly industrializing countries.

2. LITERATURE REVIEW

Most of the empirical studies on exports and energy consumption are prepared within the scope of economic growth (Fatima et al., 2021; Gozgör and Can, 2017). On the other hand, the effects of energy consumption on the economy are mostly analyzed in terms of renewable and non-renewable energy resources (Halilbegović et al., 2023). In this study, energy consumption is analyzed on a sectoral basis and its relationship with international trade is investigated. Although the empirical analysis in this study consists of panel cointegration and short and long-run analyses within the scope of NIC countries, it is seen that different methods are used for different countries when other studies in the literature are examined. One of the studies examining the relationship between energy consumption and exports was conducted by Sadorsky (2011). In this study, the effects of energy consumption on international trade were investigated with annual data for the 1980-2007 period for 8 Middle Eastern countries. Panel causality and cointegration tests are applied and different results were obtained from short-run and long-run analyses. In the short run, a bidirectional causality between energy consumption and imports and a unidirectional causality from exports to energy consumption were found. As a result of the FMOLS estimator applied for the long-run analysis, it is determined that exports and imports increase energy consumption. According to these results, a 1% increase in exports increases energy consumption by 0.11% and a 1% increase in imports increases energy consumption by 0.04%. These results show that the energy consumption of these Middle Eastern countries, which consume fossil resources to a large extent, increases with the increase in their exports and imports. A similar study was conducted by Katircioğlu et al. (2014) on the Canadian economy. In the study, the relationship between energy consumption and international trade is investigated using the ARDL estimator with annual data for the period 1960-2010. The long-run estimations revealed that energy consumption has a positive effect on exports. The authors argue that the effect of energy consumption on exports is through the income channel and that exports will be negatively affected if energy-saving policies are implemented.

Suleman et al. (2025) investigated the effects of international trade on renewable energy consumption in MINT (Mexico, Indonesia, Nigeria and Turkey) countries. Analyses were carried out with the GMM estimator within the scope of annual data for the period 1995-2022. As a result of the study, it is determined that trade balance and trade volume positively affect renewable energy consumption. On the other hand, exchange rate increases in foreign trade have a negative effect.

Rather et al. (2024) investigated the effects of energy consumption on export volume in 18 developing countries for the period 2000-2024. In the study, energy consumption is analyzed separately as energy consumption from renewable and non-renewable sources. Panel cointegration and GMM estimator methods reveal that non-renewable energy consumption has a positive effect on exports, while renewable energy consumption has a negative effect.

Asghar et al. (2024) analyzed the relationship between energy consumption and exports in 116 developed and developing countries. For this purpose, estimations were made using the Fixed Effects Model with data for the period 2010-2019. As a result of the study, it was found that energy consumption has a positive effect on exports and this effect is higher in developed countries than in developing countries.

Ilechukwu and Lahiri (2022) investigated the effects of energy consumption on international trade for the period 1990-2014 with a data set covering a total of 152 OECD and non-OECD countries. Aiming to examine the impact of energy consumption on bilateral trade between countries, the authors constructed a Gravity Model with renewable energy consumption, export and import variables. As a result of the study, it is determined that increases in renewable energy consumption have a negative effect on exports and a positive effect on imports for the entire panel. It is also found that the negative effect on exports is higher than the positive effect on imports, suggesting that the decrease in exports as a result of renewable energy consumption is greater than the increase in imports. However, these results are the opposite in OECD member countries. In OECD member countries, renewable energy consumption has a positive effect on exports.

Koengkan (2018) investigated the effects of trade openness on energy consumption for Andean countries consisting of Bolivia, Ecuador, Peru and Colombia. Arellano-Bond dynamic GMM estimator method was applied with annual data for the period 1971-2014. The results of the study show that trade openness has a positive effect on energy consumption. A similar study for the economies of China, Japan and South Korea was conducted by Dou et al. (2021). In this study, it was concluded that trade openness increased energy consumption in the period 1970-2019. Alam et al. (2024) examined the impact of trade openness on energy consumption through renewable and non-renewable energy sources. In the study on the Indian economy, long-run forecasts were made with the AARDL (Augmented Autoregressive Distributed Lag) method with annual data for 1980-2023. The results show that trade openness has a positive effect on both renewable and non-renewable energy consumption.

Örgün and Pala (2017) examined the relationship between trade openness, energy consumption and GDP in 28 EU member countries. In the study, panel VECM and causality tests were used with annual data for the period 1996-2013. As a result of the analysis, it is determined that there is bidirectional causality between trade openness and both energy consumption and GDP. Adewuyi and Adeniyi (2015) examined the relationship between total energy consumption, electric energy consumption and transportation sector energy consumption with exports and imports in 6 West African countries. As a result of the study using the VECM estimation method with data for the period 1971-2010, it was found that there was a positive link from total energy consumption to transportation sector energy consumption for Côte d'Ivoire, a positive link from transportation sector energy consumption to exports for Ghana, a positive link from both total energy consumption and transportation sector energy consumption to exports and imports for Nigeria, and a positive link from energy consumption to imports for Benin.

Shahbaz et al. (2014) applied panel cointegration and MG estimators with annual data for the period 1980-2010 in 91 economies belonging to low, middle and high income groups in order to test the export-oriented energy consumption hypothesis. The results show that there is a long-run relationship between trade openness and energy consumption. While this relationship is in the form of inverted U in high-income countries, it is determined that this relationship is U-shaped in middle and low-income countries.

Sadorsky (2012) analyzed the relationship between energy consumption and international trade in 7 South American countries for the period 1980-2007 using VECM-based causality and FMOLS estimator. Short and long run relationships were analyzed separately. As a result of the analyses, it was found that there is bidirectional causality between energy consumption and exports in the short run, as well as between exports and DGP. In the long run, it is observed that there are causality relations between exports and imports and energy consumption.

Costantini and Martini (2010), who analyzed energy consumption on a sectoral basis, conducted their study on 26 OECD member countries and 45 non-OECD countries. In the study, panel cointegration and causality tests were applied with annual data for the period 1960-2005. In the study, energy consumption is analyzed as industrial, transportation, commercial and residential sectors. The findings of the analyses differed for OECD and non-OECD countries. In the panel of OECD member countries, bidirectional causality between total energy consumption and GDP, bidirectional causality between industrial sector energy consumption and industrial sector energy prices and industrial sector value added, and bidirectional causality between transportation sector energy consumption and GDP were found. In non-OECD countries, a bidirectional relationship was found between transportation sector energy consumption and GDP, while unidirectional causality was found from total energy consumption to GDP.

The literature review reveals that studies have been conducted with various types of energy consumption and international trade indicators. Energy consumption is frequently considered as total energy consumption, renewable and non-renewable energy consumption. As international trade indicators, exports, imports, trade volume and trade openness variables are used. In addition, most of the studies have found positive effects between energy consumption and exports. On the other hand, as the level of development of countries increases, the relationship between energy consumption and trade is found to differ. In this study, energy consumption is analyzed at the sectoral level and the impact of energy consumption on exports is investigated in the industrial and transportation sectors where the highest energy consumption takes place. In this respect, this study is expected to contribute to the literature.

3. METHODS

This study investigates the effects of industrial sector energy consumption, transportation sector energy consumption and import volume on export volume in NIC countries. For this purpose, panel data analysis is performed.

Before performing long-run and short-run forecasts with panel data analysis, some pre-tests should be performed and the appropriate econometric methods should be decided. For this purpose, firstly, Pesaran (2004) investigates cross-section dependence with the CDLM test. This test, which is used when T is greater than N (T>N), is an improved version of the LM test. The hypotheses of this test are as follows;

- H_0: There is no cross-sectional dependence between units.
- H_1: There is cross-section dependence between units.

The equation for the CDLM test is expressed as in Equation 1.

$$CDLM = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\hat{\rho}_{ij}^{2}-1) \quad (1)$$

Following the examination of horizontal cross-section dependence, homogeneity tests are applied secondly. In this study, homogeneity is investigated using the Delta (Δ) test developed by Pesaran and Yamagata (2008). The hypotheses of this test are as follows;

- H_0: Slope coefficients are homogeneous
- H_1: Slope coefficients are heterogeneous.

Delta test statistic is given in Equation 2.

$$\Delta = \sqrt{N}\,\frac{N^{-1}S-K}{\sqrt{2K}} \quad (2)$$

The corrected Delta Test statistic is given in Equation 3.

$$\Delta_{adj} = \sqrt{N}\,\frac{N^{-1}S-E(Z_{it})}{\sqrt{Var(Z_{it})}} \quad (3)$$

The information obtained as a result of CSD and homogeneity examinations determines which of the first-generation or second-generation tests should be applied in the rest of the study. If horizontal cross-section dependence and heterogeneity are determined, the analysis continues with the second generation tests. After the tests for CSD and homogeneity, the third step is to investigate stationarity with unit root tests. In line with the findings of the stationarity analysis, one of the methods such as VAR analysis, ARDL method or cointegration method can be preferred. In order to choose the appropriate method, the stationarity levels of the variables are important. Cointegration method is preferred when all variables are stationary at the same level and at least difference. In this way, long-term relationships can be analyzed.

In this study, the LM Peseran and Shin (CIPS) panel unit root test is applied. For this panel unit root test developed by Pesaran (2007), the CADF regression based on lagged cross-section means is as shown in equation 4.

$$\Delta Y_{it} = a_i + p_{it-1}^{*} + d_0\,\bar{Y}_{t-1} + d_1\,\Delta\bar{Y}_t + \varepsilon_{it} \quad (4)$$

After estimating the CADF regression in Equation 4, the mean t statistics of the lagged variables in the equation are calculated as in Equation 5 and the CIPS statistic is obtained.

$$CIPS = \frac{1}{N}\sum_{i=1}^{N}CADF_i \quad (5)$$

Since horizontal cross-section dependence and heterogeneity are determined, second-generation cointegration tests that take these situations into account are used (Yerdelen Tatoğlu, 2017:195). Pedroni (1999; 2004) panel cointegration test is one of the second generation tests. In the Pedroni panel cointegration test, there are 7 test statistics that test the cointegration relationship. 4 of these test statistics are panel statistics (Panel v, Panel Philips-Perron type rho, Panel Philips-Perron type t and Panel ADF type t statistics) and 3 of them are group statistics (Group Philips-Perron type rho, Group Philips Perron type t and Group ADF type t statistics) (Pedroni, 1999; Pedroni, 2004). The hypotheses tested with these 7 test statistics are as follows;

- H_0: There is no cointegration relationship
- H_1: There is cointegration relationship.

In panel data analyses, when cross-sectional dependence, heterogeneity and unit root are detected, second-generation tests constitute the best methods for estimating long-run relationships (Le et al., 2020: 31). One of the second generation tests is the Dynamic Common Correlated Effects (DCCE) estimator developed by Chudik and Pesaran (2015), which takes into account cross-sectional dependence and can also be applied to heterogeneous series. The DCCE estimator is an improved version of the CCE estimator. The CCE estimator is not a sensitive test in the presence of lagged values of the dependent variable and weak exogenous variables in the panel. The DCCE estimator is preferred because it overcomes these shortcomings of the CCE estimator (Chudik and Pesaran, 2015; Pesaran, 2006). Another advantage of this test is that it can obtain regression with Jackknife

Table 2: Explanations and summary statistics of variables

Variable names	Description	Mean	Standard deviation	Min	Max	Data sources
EX	Exports (Exports of goods and services (% of GDP))	26.71	14.70	6.73	71.41	WB (WDI)
INEN	Industrial sector energy consumption (PJ)*	5182.77	9886.69	363.32	47260.87	IEA
TREN	transportation sector energy consumption (PJ)*	2104.03	2586.30	368.65	14448.8	IEA
IM	Imports (Imports of goods and services [% of GDP])	26.18	13.35	6.95	69.45	WB (WDI)

*(1 GWh=0.0036 PJ)

Table 3: Slope homogeneity and cross-sectional dependence tests results

Slope homogeneity		
Tests	Δ t-ist	P-value
Δ	4.641*	0.000
Δadj	5.038*	0.000

*Indicates significance at 1% level. The null hypothesis is slope homogeneity (no heterogeneity)

Cross-sectional dependence		
Variable	CD_{LM}-test	P-value
LnEX	12.88	0.000
LnINEN	26.45	0.000
LnTREN	27.40	0.000
LnIM	13.34	0.000

*Indicates significance at 1% level. The null hypothesis is no crosssectional dependence

correction under small sample data. In this way, it can obtain robust regression results in the case of missing data and unbalanced panel data (Ditzen, 2018).

With globalization, trade and economic relations between countries are increasing. In addition, there may be unobservable economic factors and shocks in each country. Considering these factors, this study uses the DCCE estimator to take into account country-specific effects due to the presence of horizontal cross-sectional dependence and heterogeneity of slope coefficients. Moreover, this estimator separates long-run and short-run effects. Regression equation 6 shows the DCCE estimator when the variables are difference stationary;

$$\Delta Y_{it} = a_i (Y_{it-1} - \theta_i^{'} X_{it-k}) + \sum_{k=1}^{p} \tau_k \Delta Y_{it-k} + \sum_{k=1}^{p} \delta_k \Delta X_{it-k} + \sum_{k=1}^{p} \beta_k \Delta \bar{Y}_{t-k} + + \sum_{k=1}^{p} \gamma_k \Delta \bar{X}_{t-k} + e_{it} \quad (6)$$

In the DCCE estimation model in Equation 6, it is seen that the cross-section averages of the variables with the first difference are included in the regression equation in order to express unobservable factors.

4. MODEL AND DATA SET

The sample of the study consists of annual data for 8 NIC countries (Mexico, Turkey, Brazil, China, India, Indonesia, South Africa and Thailand) for the period 1990-2022. The econometric model created for the purpose of the study is expressed in 9.

$$LnEX_{it} = \beta_0 + \beta_1 LnTREN_{it} + \beta_2 LnINEN_{it} + \beta_3 LnIM_{it} + u_{it} \quad (7)$$

In Equation 1, "i" represents cross-section units, "t" represents the time dimension, and "u_{it}" refers to the error term.

When the summary statistics are analyzed in Table 2, it is seen that the share of exports in GDP is 26.71% on average and the share of imports in GDP is 26.18% on average in the panel of NIC countries. Total energy consumption in the industrial sector was 5182 PJ on average and total energy consumption in the transportation sector was 2104PJ on average.

5. RESULTS

Table 3 presents the results of horizontal cross-section dependence and homogeneity tests.

When the results in Table 3 are analyzed, firstly, there are results regarding homogeneity. It is seen that the probability values of Δ and Δadj test statistics are <0.05. In this case, the null hypothesis is rejected and it is determined that there is no homogeneity and the variables show heterogeneous characteristics. Secondly, Table 3 presents the results for cross-section dependence. It is seen that the probability values of the CDLM test statistic are <0.05. Therefore, the null hypothesis is rejected for all variables and it is determined that there is cross-section dependence.

According to the unit root test results in Table 4, LnEX, LnTREN and LnEM variables are found to contain unit root at their level values. On the other hand, LnINEN variable does not contain a unit root at 10% significance level in the model with constant. Therefore, it is decided that all variables are non-stationary at their level values. Therefore, the difference stationarity of the variables is analyzed. The information obtained reveals that all variables are difference stationary in both the model with constant and the model with constant and trend. The fact that all variables are stationary in their first differences enables the cointegration method to be applied.

According to the information obtained from Table 5, according to the Pedroni panel cointegration test, it is seen that the t statistic values for the group statistics are greater than the t table value of 1.96 at the 0.05 significance level. Therefore, the null hypothesis stating that there is no cointegration relationship is rejected and it is understood that there is a cointegration relationship. The existence of a cointegration relationship

Table 4: Panel unit root test results

CIPS Statistics	LnEX	LnINEN	LnTREN	LnIM
Level				
Constant	−1.795	−2.271***	−1.785	−1.944
Trend+Constant	−2.548	−2.563	−1.820	−2.722
First difference				
Constant	−4.910*	−5.140*	−4.609*	−4.843*
Trend+Constant	−5.009*	−5.235*	−4.520*	−4.889*
Critical value		%10	%5	%1
Constant		−2.21	−2.33	−2.55
Trend+Constant		−2.73	−2.84	−3.06

*, ** and ***Indicates significance at 1%, 5% and 10% level. The null hypothesis is non-stationarity. N, T=(8,33)

Table 5: Cointegration test results

Pedroni panel cointegration test			
Statistics	T Statistic	Statistics	T Statistic
Panel v	1.193	Grup rho	−0.081
Panel rho	−0.722	Grup PP	−2.097**
Panel PP	−2.041	GrupADF	−2.35**
Panel ADF	−2.506		

T table values are 1.960 for 5% significance level. ** indicates 5% significance level

Table 6: Estimation results of long and short run cointegration coefficients

Dynamic common correlated effects (DCCE) estimator	Coefficients	Z Stat.	P-value
Long Run			
LnTREN	**−0.502****	−2.22	0.027
LnINEN	−0.024	−0.10	0.921
LnIM	**1.67***	5.28	0.000
Constant	1.563	1.05	0.292
Short Run			
ECT-1	−0.793	−6.67	0.000
ΔLnTREN	**−0.801***	6.69	0.000
ΔLnINEN	0.147	0.64	0.520
ΔLnIM	**0.934***	7.78	0.000
Root MSE		0.05	
CD Statistic		2.07	
P-value		0.038	
R-squared (MG)		0.77	

*,** denote significance levels of 1%, 5% and 10%, respectively

implies that there is a long-run relationship between variables. However, the panel error correction model provides information on whether there are short-run relationships in addition to long-run relationships and the direction and magnitude of short and long-run relationships. In this study, the Dynamic Common Correlated Effects (DCCE) estimator is used to estimate the short and long run coefficients and to determine whether the error correction mechanism works.

The first part of Table 6 presents the long-run coefficients obtained from the DCCE estimator for the entire panel. The findings show that in the long run, transportation sector energy consumption has a negative effect on exports while imports have a positive effect. In the next part of the analysis, an error correction model was constructed to estimate the short-run coefficients. The results indicate that the error correction coefficient (Ect-1) is negative and statistically significant. This implies that the short-run deviations between the long-run correlated series are eliminated and these deviations will come to equilibrium after 1.26 periods. Finally, when the results of the short-run coefficients are analyzed, it is seen that they are similar to the long-run results. In the short run, transportation sector energy consumption has a negative effect on exports, while imports have a positive effect.

Table 7 presents the long-run and short-run estimation results for each country. The first part of Table 7 presents country-specific long-run coefficients. When the long-run estimates are analyzed by country, it is found that transportation sector energy consumption has negative and significant effects on exports in Mexico, Turkey, Brazil, India and Indonesia. Imports have a positive effect on exports in Mexico, Turkey, Brazil, China, India and Indonesia. In addition, only in Brazil, industrial energy consumption has a significant and positive effect on exports. The second part of Table 7 shows that transportation sector energy consumption has a negative effect on exports in Turkey and India, industrial sector energy consumption has a significant and positive effect only in India, and imports have a positive effect in Mexico, Brazil, India and South Africa.

Table 7: Country specific estimation results (DCCE model)

	Long run country coefficients							
	Mexico	Turkiye	Brazil	China	India	Indonesia	South Africa	Thailand
LnTREN	**−0.470* (0.004)**	**−1.066*** (0.082)**	**−1.318** (0.037)**	−0.447 (0.313)	**−0.914* (0.000)**	**−1.026*** (0.060)**	−0.770 (0.285)	−3.394 (0.740)
LnINEN	0.239 (0.580)	−0.142 (−0.75)	**1.612*** (0.083)**	−0.186 (0.735)	0.306 (0.193)	−0.308 (0.642)	0.117 (0.906)	−0.457 (0.523)
LnIM	**1.560* (0.001)**	**0.651* (0.000)**	**1.082* (0.003)**	**0.867* (0.004)**	**0.818* (0.000)**	**0.941* (0.000)**	1.128 (0.130)	0.426 (0.546)
	Short Run Country Coefficients							
	Mexico	Turkiye	Brazil	China	India	Indonesia	South Africa	Thailand
LnTREN	0.150 (0.438)	**−0.388** (0.038)**	−503 (0.871)	−0.941 (0.610)	**−1.121*** (0.058)**	−0.683 (0.388)	−1.105 (0.312)	0.660 (0.643)
LnINEN	−0.075 (0.803)	0.140 (0.826)	−0.197 (0.903)	−0.339 (0.687)	**1.486** (0.028)**	−0.405 (0.728)	0.069 (0.910)	−0.871 (0.299)
LnIM	**1.513** (0.017)**	0.814 (0.145)	**3.711** (0.014)**	1.897 (0.302)	**1.133* (0.005)**	1.644 (0.213)	**1.088*** (0.072)**	1.557 (0.227)

*, **, *** denote 1%, 5% and 10% significance, respectively

6. CONCLUSION AND RECOMMENDATIONS

This study examines the effects of transportation sector energy consumption, industrial sector energy consumption and imports on exports in the economies of 8 countries (Mexico, Turkey, Brazil, China, India, Indonesia, South Africa, Indonesia, South Africa and Thailand), which are considered as Newly Industrializing Countries, with data for the period 1990-2022. In this study, a panel data set was constructed and preliminary analyses were performed with cross-sectional dependence, homogeneity and unit root tests. In line with the information obtained from these sets, cointegration method and then tests for both panel and country-specific short and long-run forecasts were applied.

The detection of cointegration relationship between the horizontal cross-section dependent and heterogeneous series reveals that the variables of the countries in the panel move together in the long run. In addition, in order to determine whether there is a short-run relationship between these series that are related in the long run, estimations were made with the DCCE model based on the error correction model. The results obtained for the overall panel reveal that transportation sector energy consumption has a negative effect on exports in both the short run and the long run, while imports have a positive effect. Moreover, the negative effect of transportation energy consumption decreases from the short-run to the long-run, whereas the positive effect of imports increases from the short-run to the long-run. In addition, both in the short run and in the long run, the positive effect of imports on exports is higher than the negative effect of energy consumption in the transportation sector. The estimation results obtained for countries are consistent with the panel results. However, industrial sector energy consumption has a positive effect on exports in Brazil in the long run and in India in the short run. Another noteworthy point in the results of the analysis is that no significant effect of the variables on exports was found in Thailand.

The energy consumed in the transportation sector relies heavily on fossil fuels. The NIC countries analyzed in the study also obtain the energy resources they use through imports. This increases energy costs. In addition, vehicles transporting in the transportation sector can lead to excessive energy consumption. In the face of these situations, energy consumption in the transportation sector becomes inevitable and as energy consumption increases, costs increase and negatively affect exports. Especially in countries that do not have rich energy resources, increases in energy prices constitute an important cost factor and this situation makes production and commodity prices expensive and reduces competitiveness in foreign markets. In addition, serious environmental pollution occurs as a result of energy consumption of transportation systems. Measures to be taken to reduce this environmental pollution caused by energy consumption in the transportation sector also constitute a cost factor. On the other hand, newly industrialized countries can obtain the inputs they need for export-oriented production through imports. Intermediate goods and raw materials are imported and used as production inputs domestically. In this case, imports increase the volume of production and thus increase exports. In addition, importing high-tech production tools and equipment increases the variety and quality of products and provides a competitive advantage in exports. Importing high-priced domestic inputs from abroad at cheaper prices reduces production costs and has a positive impact on exports.

In this study, it is concluded that total energy consumption in the industrial sector has no significant effect on exports. Although energy consumption is an important factor in industry, there may be more important factors for export-oriented production. Factors such as access to raw materials, raw material prices, labor potential and prices, use of technology may be more determinant on exports. In this respect, other researchers can reach more meaningful results by investigating the effect of electricity consumption on industrial production. Because the tools and equipment used in the industrial sector are largely powered by electricity. They can also investigate the impact of factors such as labor costs, technology use, and access to raw materials on the industrial sector. Although energy consumption is an important factor, examining the effects of sectoral energy efficiency can provide more realistic results. In addition, other researchers can investigate the effects of green logistics practices in the transportation sector and the creation of digital systems in transportation systems on international trade. At the same time, studies can be directed by considering the environmental dimension of the transportation sector.

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