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A PRACTICAL RESEARCH TO EXPLAIN THE IMPORTANCE OF WASTE RECYCLING AND RENEWABLE ENERGY GENERATION FOR INDUSTRIAL PRODUCTION AND SUSTAINABILITY

Abstract

Purpose: As an indicator of economic growth, industrial production's energy and raw material needs are subject to environmental studies. The link between the ecological harm caused by plastic waste and the concept of sustainable economic growth through renewable energy is a topic of current debate in the literature. This research aims to discover whether there is a connection between plastic waste and production.

Methodology: This paper investigates the links between plastic import, renewable energy generation, export, and exchange rates on industrial output in Türkiye by using the ARDL Bounds Test and causality analysis for 2008:Q1-2023:Q3.

Results: Research findings reveal that plastic waste import and export positively affect industrial output in the long run. While renewable energy generation decreases industrial production in the short run, it positively affects industrial production in the long run.

Conclusion: The study emphasizes the evaluation of renewable energy and circular economy opportunities to ensure sustainable economic growth, while underlining the transformation of threats into opportunities.

Keywords: ARDL, causality, industrial production, international trade, renewable energy, waste import

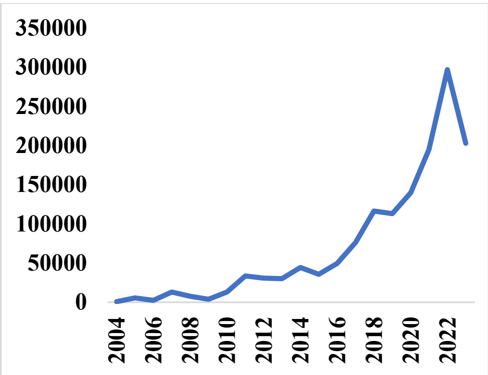
1. *Introduction*

The issues of global warming and environmental degradation threaten human health, nature, economy, and production (Wade & Jennings, 2016). Conversely, the increasing world population also requires additional consumption, negatively affecting the environment through waste. The steps taken to protect the environment become complex at this point. This is because the goal of providing clean air, organic food, healthy soil, and a peaceful and sustainable living environment for all living beings, primarily pursued by developed economies for their own countries, ignores developing or underdeveloped countries.

The complex agenda has paved the way for the emergence of the circular economy concept. The concept of the circular economy represents a shift away from the traditional linear model of production and consumption, aiming to minimize waste and maximize resource efficiency (Corvellec et al., 2022). In a circular economy, products are designed with durability, repairability, and recyclability, ensuring that materials can be reused or regenerated at the end of their life cycle (Suzanne et al., 2020). This approach reduces the strain on finite resources and minimizes environmental pollution and greenhouse gas emissions associated with extraction, production, and disposal (Honic et al., 2019). The circular economy fosters a more sustainable and resilient economic system that benefits businesses and the environment by promoting reuse, remanufacturing, and recycling. In this context, plastic waste and renewable energy are essential.

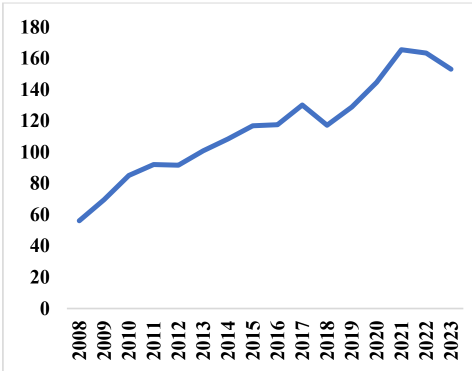
After China banned the import of plastic waste at the beginning of 2018 (Brooks et al., 2018), the risk of becoming a haven for waste for developing and underdeveloped countries increased further. Since economic activities are designed to meet the needs and desires of an increasing population, the increase in waste leads former waste-hosting regions to seek new disposal sites, as they no longer wish to accept more waste (Liu et al., 2018). As a developing economy, Türkiye increased its waste imports by over three times within a few years immediately after China's import ban. By opening its doors to these wastes, it has become a significant global waste center (ITC, 2024). This situation makes Türkiye an example that needs to be examined in many different contexts, especially regarding plastic waste imports.

Figure 1 Plastic waste import of Türkiye (in thousand USD, 2004-2023)



Source: trademap.org

Figure 2 Industry Production Index (%) of Türkiye in years



Source: tuik.gov.tr

Figure 1 illustrates the change in Türkiye's plastic waste import over the years. It can be said that China's ban on plastic waste imports in 2018 led to a significant surge in Türkiye's plastic waste imports in the following years. As a result of this surge, Türkiye has become the third-largest importer of waste in the world and now ranks first among developing countries (ITC, 2024). With this increase, environmental pollution in Türkiye has reportedly risen, adversely affecting many organisms, including marine life. Türkiye has become a dumping ground for European countries (Greenpeace, 2024). On the other hand, Türkiye's industrial production index, as seen in Figure 2, has increased from around 60 to 160 levels over approximately 15 years.

Mass production and unlimited consumption result in more waste in modern societies. Most of the global population uses electronic devices daily (Shinde et al., 2023). Moreover, factories producing goods and services other than electronic devices also require energy for production (Ahmed et al., 2022). Therefore, the energy issue in the global economic system also stands out as another important topic concerning the environment. The environmental impacts of various energy generation methods are not only the subject of scientific research but also of political agreements such as the Paris Agreement, the Kyoto Agreement, and the EU Green Deal. However, differing energy generation capabilities among countries often result in environmental concerns being overlooked.

Nevertheless, renewable energy sources, created to promote global sustainability, have become a trendy area of scientific research and a valuable opportunity for countries facing difficulties in energy supply. Indeed, the ability to transform the blessings offered by nature, especially solar and wind energy, into production opportunities can be expressed as an essential step. Thus, countries with suitable natural resources, whether underdeveloped or developing, will relax to meet their energy needs from abroad. Just as in the case of waste import, examining renewable energy sources is crucial for Türkiye's energy production. Türkiye, which lacks fossil fuel resources such as oil and natural gas, does not have an actively operating nuclear power plant either (Mukhtarov et al., 2022). Despite using alternatives with high environmental impacts, such as thermal power plants, hydroelectric power plants, and stations converting natural gas to energy, Türkiye has a high potential for renewable energy sources, such as wind, solar, and geothermal power, owing to its geographical advantages (Bilgili et al., 2022). Especially in recent decades, the Turkish government has invested in incentives towards these renewable energy production opportunities, indicating a valuable area where the effects of energy obtained from these sources on the economy need to be examined (Bölük & Kaplan, 2022; Kul et al., 2020).

In addition to environmental issues, as a developing economy, Türkiye must also have an exceptionally critical management model regarding its trade balance (Blavasciunaite et al., 2020). The long-standing trade deficit (Muratoğlu, 2020) has been seen as a significant obstacle to Türkiye's advancement from developing country status. The fact that imports exceed exports results in continuous currency depreciation in the country because of the need for exchange to sustain imports. Therefore, in addition to environmental issues, it is believed that exports and exchange rates are also concepts that must be considered in research on the economy of this country.

When the relevant literature is evaluated in general, it is worth noting that the number of studies directly examining the impact of waste imports and renewable energy on industrial production is quite limited. To resolve this gap in the literature, this study investigates the effects of the amount of imported plastic waste and renewable energy production on the Turkish economy with data for the period 2008Q1-2023Q3, using the Autoregressive Distributed Lag (ARDL) Bounds Test and causality methods. The study aims to contribute significantly to the existing literature. In the remaining parts of the paper, the theoretical framework will be drawn, and a summary of the literature on the subject will be presented. The following section introduces the data and method used in the study. Following the section presenting the empirical findings of the research, the final part of the paper will provide the conclusion, discuss policy implications, and offer recommendations for future research.

2. *Theoretical framework and literature review*

The Environmental Kuznets Curve (EKC) stands out as an important approach used to explain the model of the study. Initially proposed by Kuznets (1955) in his study examining the relationship between income inequality and economic development, the concept suggests a reversed U-shaped curve later associated with the ecological footprint by Grossman and Krueger (1991). It is believed that a rise in income leads to a reduction in environmental degradation. There are numerous studies in the literature aimed at testing the validity of this belief (Zhang et al., 2019; Destek & Sinha, 2020; Dogan & Inglesi-Lotz, 2020; Pontarollo & Muñoz, 2020; Ahmad et al., 2021). An increase in income is related to becoming a developed country, and the process of development is the process that shapes the curve. Considering that there are more developing and underdeveloped countries in the world (UN, 2024), the analyses to be conducted for the EKC will provide great opportunities to test the theory in the future. These significant opportunities to be obtained within the research context also draw attention to the variables, another vital aspect of scientific research.

Data representing environmental degradation or regulation can potentially be a variable for environmental and economic studies, particularly in EKC research. Similarly, when looking at the data used to contemplate the state of the environment in the literature, it is observed that carbon dioxide (CO_2) emissions (Akadiri & Adebayo, 2022; Kirikkaleli et al., 2022; Raihan et al., 2022a; Zahoor et al., 2022) are predominantly used as an environmental variable. However, the concept of the environment is not limited to air alone. Just as air is not the only element in nature affected by pollution, soil and water also suffer from contamination. Therefore, various methods to measure environmental pollution should be considered in scientific research. While waste is frequently highlighted in the literature as a noteworthy topic, it often needs to be addressed.

Walter and Ugelow's (1979) Pollution Haven Hypothesis (PHH), which builds on Pethig's (1976) study from a few years earlier, represents another theoretical approach examining the relationship between environmental pollution and the economy. According to this theory advocated by Antweiler et al. (2001), waste tends to flow towards low-income countries. Bashir (2022) attributed this flow to multinational corporations (MNCs) preferring less developed or developing countries with lower environmental standards. Baek (2016) and Ma et al. (2022) also reported that businesses generating poor environmental conditions tend to migrate to countries with weaker regulations. As can be seen, the PHH primarily associates investments with the environment. This typical association draws attention to the fundamental problem of insufficient capital, which is one of the main issues for less developed and developing countries. Securing capital, regarded as one of the biggest challenges for economic development in these countries (Bashir et al., 2020), is crucial for increasing production and ensuring economic development (Ma et al., 2022).

As seen from the theoretical background, the EKC and the PHH offer a wide range of environmental and international economic research opportunities regarding their testing. Studies confirming or refuting these theories will be discussed below, but several essential points specific to this study need to be addressed. Firstly, Türkiye is classified as a developing country (UN, 2024). Additionally, Türkiye has experienced rapidly increasing plastic waste imports (ITC, 2024). Considering these two facts, it is believed that Türkiye's economy and environmental issues need to be examined from different perspectives and through various methods. Therefore, in this study, the industrial production index (IPI) has been taken as the dependent variable to indicate economic development, and the country's plastic waste imports (PIM) have been considered an explanatory variable from an environmental perspective. In this context, it is beneficial to also refer to the literature.

According to Brooks et al. (2018), finding an alternative country to accept plastic waste banned for import by China until 2030 does not appear feasible. This situation highlights global plastic waste recycling as a significant issue. Yu (2010) describes this problem as extremely dangerous in terms of pollution in economic and environmental systems. When examining scientific research on this issue, studies focusing on the flow of plastic waste (Ma et al., 2020; Xu et al., 2020; Olatayo et al., 2021; Siddique et al., 2022), plastic waste trade networks (Shi et al., 2021; Wang et al., 2020; Zhao et al., 2021), and research analyzing their environmental impacts (Huang et al., 2020; Wen et al., 2021) are noteworthy. Wang et al. (2021) examined the effect of waste recycling processes on economic growth from a unique perspective. They found that the rise in plastic consumption influences economic growth in certain countries. However, these countries also exhibit high rates of plastic waste separation. Indeed, Bishop et al. (2020) emphasized the importance of monitoring plastic waste, particularly in European countries, within the circular economy framework. Although these studies are crucial for monitoring waste management and trade, they also provide valuable guidance for research conducted on countries. In a survey of waste importation in Türkiye, Gündoğdu and Walker (2021) found that waste importation has the largest share in polluting Türkiye's seas. A study investigating the environmental impact of waste importation in Japan and China (Sun & Tabata, 2021) revealed that reducing waste importation in China resulted in increased CO_2 emissions. This increase was linked to implementing new production methods rather than waste recycling.

Additionally, the same study found that Japan's reduced waste exports decreased carbon emissions because of the utilization of recycled waste. Kuan et al. (2022) suggested in their research on waste importation in Japan and Malaysia that Malaysia emerged as the primary destination for waste following China's import bans. This study compared the laws related to environmentally friendly recycling of imported waste and concluded with recommendations. Similarly, Chen et al. (2021) highlighted waste management issues in Malaysia by studying the excessive importation of waste from Malaysia's perspective. In another study similar to the one conducted in Malaysia, Thapa et al. (2024)

emphasized the importance of considering socio-ecological factors when recycling the waste that Vietnam would import from the EU. In a study measuring the dynamics of plastic waste import and export in the Asian region after China's ban (Nakayama & Osako, 2024), it was reported that the increase in plastic waste imports led to water pollution and significant adverse environmental effects. At first glance, while studies examining the environmental impacts of waste trade, its relationship with the environment, trade flows, and networks can be more readily observed, it is more challenging to find studies examining the place of imported waste within the economy.

On the other hand, renewable energy has gained prominence in recent years in studies exploring the connection between the economy and the environment. While economic growth is found to increase pollution (Raihan et al., 2022a; Raihan & Tuspekova, 2022; Zahoor et al., 2022), it is noted that economic growth in developed countries reduces air pollution (Ahmad et al., 2021). In developing countries, the initial stages of economic growth are associated with a rise in air pollution (Khan et al., 2020; Fan & Hao, 2020; Ahmad et al., 2021; Kirikkaleli et al., 2021; Akadiri & Adebayo, 2022; Aslan et al., 2022; Raihan et al., 2022b; Raihan et al., 2022c;). Furthermore, the utilization of renewable energy is found to abate environmental pollution (Saidi & Omri, 2020; Anser et al., 2021; Kirikkaleli et al., 2022; Raihan & Tuspekova, 2022; Xue et al., 2022) and promote economic growth (Saidi & Omri, 2020; Shahbaz et al., 2020; Wang & Wang, 2020; Wang et al., 2022). Additionally, several studies indicate that both renewable and non-renewable energy consumption contribute to economic growth (Rahman & Velayutham, 2020), while others suggest that non-renewable energy consumption drives economic growth, with insignificant effects from renewable energy consumption (Ivanovski et al., 2021). These studies utilize various econometric models, time series, or panel data analysis methods. In some of these studies, despite including different variables such as technology and environmental policy in the models, it is noteworthy that CO_2 emissions are the sole variable considered in assessing the environment. As mentioned, this is a significant environmental and economic research limitation.

In addition to all these studies, it is known that some other factors besides the environment also impact economic growth and development. Among these issues, exports are particularly well-known, especially for developing countries. Studies directly examining the influence of exports on growth, conducted decades ago, are often cited (Emery, 1967; Marin, 1992; Al-Yousif, 1997). However, it cannot be said that there are no recent studies on the relationship between exports and economic growth. Mensah and Okyere (2020) determined a mutual relationship between exports and economic growth.

Similarly, Orhan et al. (2022) reached a comparable conclusion in their study. In some studies, exports are not considered in isolation; trade openness influences economic growth (Bahramian & Saliminezhad, 2020; Chen et al., 2022). Studies on the correlation between trade balance and economic development are also evident (Blavasciunaite et al., 2020). It is worth noting that relatively few recent studies directly examine the relationship between exports and economic growth, as this topic has naturally become a focal point in the historical development of economics. Nevertheless, examining individual studies conducted in various countries with different levels of economic growth, such as China (Kong et al., 2021), Nigeria (Omoke & Charles, 2021), Madagascar (Rasoanomenjanahary, 2022), Türkiye and South Korea (Demirel & İşcan, 2021), where the relationship between exports and economic growth has been empirically tested and observed, would facilitate progress in research.

Taking into account all the studies discussed in the theoretical framework in the literature, the analysis of the impact of variables such as plastic waste imports and renewable energy combined with waste energy, which are included in the model established for this research, on industrial production, and consequently on the economy, in conjunction with exports, presents an exceptionally unique research opportunity. Thus, the relationship between the environment, the economy, and foreign trade can be thoroughly understood, especially in developing countries like Türkiye.

3. Data and methodology

3.1 Data

In this study, the Autoregressive Distributed Lag (ARDL) Bounds Test and causality analysis will be performed to reveal the effects of explanatory variables on the dependent variable in the long and short term. The study dataset consists of up-to-date data on the Turkish economy from 2008:Q1-

2023:Q3. Explanations regarding the data used in this study are given in Table 1. The industrial production index has been evaluated as a proxy for production level and economic growth. This paper aims to empirically test the impact of plastic waste imports and renewable and waste energy generation on production levels and growth. In addition, the model also included exports of goods and services and the exchange rate as additional explanatory variables.

Table 1 Definition of the variables

Variable	Variable description	Unit	Data source
IPI	Industry production index	Index	tuik.gov.tr Turkish Statistical Institute
PIM	Plastic imports	Thousand USD	ITC, trademap.org
EXP	Exports of goods and services	Billion USD	tuik.gov.tr Turkish Statistical Institute
RWEP	Renewable + waste energy production	GWh	teias.gov.tr Türkiye Electricity Transmission Inc.
EXC	Exchange rate	TRY/USD	evds.tcmb.gov.tr Electronic Data Delivery System / Central Bank of the Republic of Türkiye

Source: Authors

3.2 Methodology

This study employs ARDL methodology to examine the interaction between variables in the research model. The most significant benefit of the ARDL method is that it allows the investigation of the cointegration relationship between stationary variables at different levels. For this reason, this research used the ARDL method because it is novel and shows the long- and short-term interactions of variables at various levels of stationarity.

$$(IPI)_t=\beta_0+\beta_1 PIM_t+\beta_2 EXP_t+\beta_3 RWEP_t +\beta_4 EXCt+_{\varepsilon t} \quad (1)$$

The long-run form of the model is given in Eq. 1. represents the slope, and to indicate the coefficients of independent variables in Model 1. ε_t stands for the residuals.

$$\Delta IPI_t = \theta_0 + \rho_0 IPI_{t-1} + \beta_1 \Delta PIM_t + \rho_1 PIM_{t-1} + \beta_2 \Delta EXP_t + \rho_2 EXP_{t-1} + \beta_3 \Delta RWEP_t + \rho_3 RWEP_{t-1} + \beta_4 \Delta EXC_t + \rho_4 EXC_{t-1} ECT_{t-1} + \varepsilon_t \quad (2)$$

$$\Delta \ln(IPI)_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta \ln(PIM)_{t-i} + + \sum_{i=0}^{p} \theta_i \Delta \ln(EXP)_{t-i} + \sum_{i=0}^{p} \lambda_i \Delta \ln(RWEP)_{t-i} + \sum_{i=0}^{p} \varphi_i \Delta \ln(EXC)_{t-i} + ECT_{t-i} + e_t \quad (3)$$

Eq. 1 shows the effect of the change in explanatory variables on the dependent variable in level form. The lagged value of the dependent variable and the impact of changes in the explanatory variables on the dependent variable are shown in Eq. 2., while the effect of changes in the logarithmic values of the explanatory variables on the dependent variable is explained in Eq. 3. *ln* shows the natural logarithm of the variables, Δ represents the first difference operator, and *p* indicates the optimal lag length in Eq. 3. Additionally, the error correction term (ECT) representing the conditional error correction (EC) component of the ARDL model is predicted as part of the ARDL Bounds Test (Pesaran et al., 2001). The F-test is employed to determine the long-term effect of the independent variables on the dependent variable.

If there is no cointegration between the variables in the equations above, the null hypothesis is $H_0:\delta_1=\delta_2=\delta_3=\delta_4...=0$, and the alternative hypothesis is $H_1:\delta_1\neq\delta_2\neq\delta_3\neq\delta_4...\neq 0$.

Considering the theoretical and technical connections, plastic imports have a positive impact on industrial production, exports of goods and services have a positive impact on the industrial production index because they increase the demand for industrial production, renewable energy production has a positive effect on the industrial production index by providing cheaper energy to the industrial sector, and the exchange rate has a positive impact on the demand side. It is expected to affect the industrial production index positively and negatively because the industrial sector increases its costs due to input imports.

4. Empirical outcomes

4.1 Preliminary statistics

Table 2 presents the basic descriptive statistics for all variables, including measures of central tendency, variability, and the results of normality tests for each country.

Table 2 Descriptive statistics

Variable	N	Mean	Median	SD	Min	Max	Skewness	Kurtosis
IPI	63	4.580	4.583	5.032	0.263	3.975	-0.230	2.223
PIM	63	8.287	8.254	10.375	1.22	5.160	-0.520	2.760
EXP	63	5.012	5.017	5.460	0.268	4.553	-0.121	1.927
RWEP	63	5.001	5.053	6.731	1.197	2.768	-0.201	1.824
EXC	63	1.242	1.064	3.289	0.184	0.830	0.788	2.595

Note: N and SD stand for the number of observations and the standard deviation, respectively.

Source: Authors' own calculations

Table 3 represents the correlation matrix. This table indicates a positive and robust correlation between IPI, PIM, EXP, EXC, and RWEP.

Table 3 Correlation matrix

Variables	IPI	PIM	EXP	EXC	RWEP
IPI	1.00000				

PIM	0.93365	1.00000			
	0.00000	----			
EXP	0.95744	0.90868	1.00000		
	0.00000	0.00000	----		
EXC	0.88832	0.85720	0.89462	1.00000	
	0.00000	0.00000	0.00000	----	
RWEP	0.94829	0.92202	0.94648	0.92816	1.00000
	0.00000	0.00000	0.00000	0.00000	----

Source: Authors' own calculations

The unit root tests give information about the stationarity structures of the variables. Table 4 gives unit root test results for all variables at both levels and first differences. The results indicate that most variables are stationary after differencing, supporting the use of the first-differenced data in the analysis.

Table 4 Stationarity test results

Level								
Variable	ADF				PP			
	Intercept		Trend and intercept		Intercept		Trend and intercept	
	t-Statistics	Prob.	t-Statistics	Prob.	T-Statistics	Prob.	T-Statistics	Prob.
lnIPI	-0.3198	0.916	-2.7831	0.2093	0.8423	0.799	-5.8878	0.0000***
lnPIM	-1.2969	0.625	-3.3453	0.0686*	-1.0679	0.723	-3.4060	0.0598*
lnEXP	-0.9291	0.772	-4.5845	0.0025***	-0.5236	0.878	-4.6261	0.0022***
lnRWEP	-1.4259	0.563	-0.1436	0.9928	-1.4559	0.549	-2.3789	0.3866
lnEXC	2.9701	1.000	0.4157	0.9988	5.3136	1.000	1.4950	1.0000
1st differences								
lnIPI	-9.7289	0.000***	-9.6346	0.0000***	-27.9338	0.000***	-25.9640	0.0001***
lnPIM	-8.5204	0.000***	-8.4546	0.0000***	-9.5642	0.000***	-9.5622	0.0000***
lnEXP	-9.8189	0.000***	-9.7364	0.0000***	-11.7442	0.000***	-11.5943	0.0000***
lnRWEP	-4.7795	0.000***	-5.0357	0.0007***	-8.5959	0.000***	-8.7483	0.0000***
lnEXC	-6.0035	0.000***	-6.8486	0.0000***	-6.0035	0.000***	-6.7986	0.0000***

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Source: Authors' own calculations

Table 5 Lag selection for the ARDL model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1200.602	NA	1.29e+13	41.53802	41.68012	41.59337
1	-1028.533	314.4714	5.93e+10	36.15632	36.86682	36.43307
2	-1009.403	32.32289	5.37e+10	36.04839	37.32729	36.54655
3	-985.4595	37.15429	4.17e+10	35.77446	37.62176	36.49402
4	-929.0058	79.81378	1.08e+10	34.37951	36.79520	35.32047
5	-895.1625	**43.17944***	**6.22e+09***	33.76422*	36.74831*	34.92659*

Note: * indicates lag selection.

Source: Authors' own calculations

The F-bounds test reveals the long-run relationship between the variables. If the F value is more significant than the critical values, these results gauge a long-run cointegration between the variables. Table 6 shows the F-statistic and essential limits for the model. This table verifies the long-run cointegration. Consequently, the long-run ARDL model can be estimated.

Table 6 ARDL Bounds Test results

k	F-stat.	Critical values		
		Sig.	Lower limit	Upper limit
4	8.1559	1%	4.412	5.545
		5%	4.323	4.333
		10%	3.31	3.668

Source: Authors' own calculations

Table 7 presents the ARDL long-run results, verifying that plastic import, renewable and waste energy, and exports of goods and services positively affect the industrial production import for Türkiye at a 1% significance level.

Table 7 Long-run ARDL model results (dependent variable: lnIPI)

Variables	Coefficient	T- Stat.	prob.
C	2.203552	4.567189	0
LNIPI(-1)	-0.344757	-1.933263	0.0595**
LNPIM	0.053946	3.094866	0.0034*
LNEXP(-1)	-0.302409	-1.879623	0.0666**
LNEXC	-0.009426	-0.459403	0.6482
LNRWEP(-1)	0.094988	3.231759	0.0023*
D(LNIPI(-1))	-0.481232	-3.425203	0.0013*
D(LNIPI(-2))	-0.516758	-3.721686	0.0005*
D(LNIPI(-3))	-0.709538	-6.708069	0*
D(LNEXP)	0.351886	3.789391	0.0004*
D(LNEXP(-1))	0.321234	2.569807	0.0136*
D(LNEXP(-2))	0.37092	3.119127	0.0032*
D(LNEXP(-3))	0.376466	4.014426	0.0002*
D(LNRWEP)	-0.12048	-1.51112	0.13770

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Source: Authors' own calculations

Table 8 presents the short-run results for the ARDL model. The UECM model was estimated to have a maximum lag of 4, and a model with lag components (4.0.4.0.1) was selected based on the Schwarz Information Criterion. Critical values represent the essential values derived from Pesaran et al. (2001). According to the short-run ARDL model findings, exports of goods and services increase the industrial production index by 1%, and renewable and waste energy generation raises the industrial production index by 5%. Moreover, the error correction term (ECT) is negative and statistically significant at 1%.

Table 8 Error correction coefficient model results (dependent variable: lnIPI)

Predicted			
Variables	**Coefficient**	**T-stat.**	**prob.**
D(LNIPI(-1))	-0.481232	-6.124642	0.00*
D(LNIPI(-2))	-0.516758	-5.443115	0.00*
D(LNIPI(-3))	-0.709538	-8.940275	0.00*
D(LNEXP)	0.351886	4.593693	0.00*
D(LNEXP(-1))	0.321234	3.590105	0.00*
D(LNEXP(-2))	0.37092	4.008069	0.00*
D(LNEXP(-3))	0.376466	4.924277	0.00*
D(LNRWEP)	-0.120481	-2.276526	0.027*
ECT(-1)*	-0.344757	-7.3738	0.00
R-square	0.844767		
Adj. R-square	0.819929		
N	59		
Simulations	2500		
Prob.	0.000		
F-statistics	8,155939		
RMSE	0.9818		

Note: * and ** denote significance at the 1% and 5% levels, respectively.

Source: Authors' own calculations

Table 9 gives the stability diagnostic test results for the ARDL model. The model stability conditions confirm a higher explanatory power and normality, and the model has no autocorrelation, heteroscedasticity, or omitted variable bias problem.

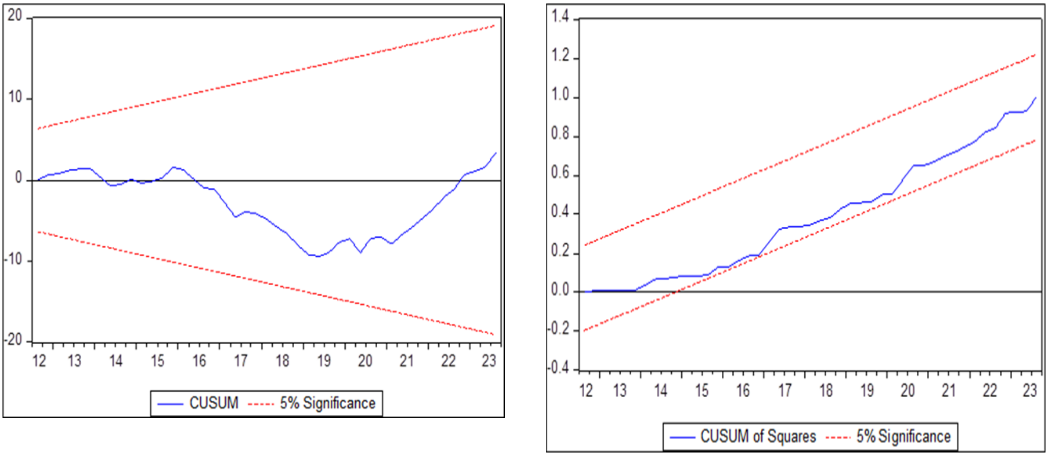
Table 9 Diagnostic tests

Tests	Coeff/prob.
R^2	0.844767
Durbin–Watson test	1.596204
Jarque–Bera normality test	0.4490 (0.7989)
Heteroskedasticity test: ARCH	0.989 (0.4761)
Breusch–Godfrey LM test	1.509 (0.2324)
Ramsey Reset Test (F-statistic)	0.0005 (0.9818)

Source: Authors' own calculations

Figure 3 represents the CUSUM and CUSUMQ graphs. The graphs show that the estimated parameters remained stable throughout the sample period, with no evidence of structural changes.

Figure 3 CUSUM and CUSUMQ diagrams



Source: Authors' own calculations

Table 10 gives the results of causality analysis between the variables used in the model. The Toda-Yamamoto causality test provides significant convenience, allowing causality analysis even if the variables are not stationary. In addition, it offers a crucial advantage as it will enable causality analysis even if there is no cointegration relationship between the variables. When the causality relationship between the variables in the model is examined, it confirms that there is a one-way causality relationship from plastic waste imports to the industry index, one-way causality from the industry index to exports, and one-way causality from the industry index to renewable energy production. It also shows a one-way relationship from the exchange rate to the industrial index and from plastic imports to the industrial index. Again, plastic imports, exports, and renewable energy production have a one-way causality relationship. In addition, while there is a bidirectional causality relationship between exports and renewable energy production, there is no causality relationship between renewable energy and the exchange rate. These findings prove that plastic imports and exchange rates are essential indicators for industrial production.

Table 10 Toda-Yamamoto causality test results

Variables	Lag	Chi-square	Prob.	Results
PIM → IPI	5	22.14524	**0.0004**	***There is causality***
EXP → IPI	5	55.53975	1.0107	There is no causality
RWEP→ IPI	5	34.34522	2.0323	There is no causality
EXC→ IPI	5	13.69841	**0.0176**	***There is causality***
PIM→EXP		23.40516	**0.0002**	***There is causality***
PIM→RWEP		14.38812	**0.0133**	***There is causality***
PIM→EXC		9.851841	0.0795	There is no causality
EXP→IPI		55.53975	1.0107	There is no causality
EXP→PIM		44.14490	2.1645	There is no causality
EXP→RWEP		14.82574	**0.0111**	***There is causality***
EXP→EXC		30.42721	1.2150	There is no causality
RWEP→IPI		34.34522	2.0323	There is no causality
RWEP→PIM		30.27557	1.3016	There is no causality
RWEP→EXP		18.87559	**0.0020**	***There is causality***
RWEP→EXC		10.44204	0.0636	There is no causality
EXC→IPI		13.69841	**0.0176**	***There is causality***
EXC→PIM		12.81401	**0.0251**	***There is causality***
EXC→EXP		14.56130	**0.0124**	***There is causality***
EXC→RWEP		6.954116	0.2240	There is no causality
IPI→EXC		7.058540	0.2163	There is no causality
IPI→EXP		18.94047	**0.0019**	***There is causality***
IPI→PIM		41.36816	7.9056	There is no causality
IPI→RWEP		16.00339	**0.0068**	***There is causality***

Source: Authors' own calculations

5. Discussion & conclusion

The findings of this study, when viewed in the context of the EKC and the PHH, have different implications regarding the relationship between Türkiye's economic development, represented by increased production and the environment. It has been found that as production increases, indicating economic growth, renewable energy production also increases in Türkiye. As a developing country, Türkiye may be seen as deviating from the EKC approach. Furthermore, from the perspective of the PHH, it is observed that as production increases, waste imports do not increase; conversely, an increase in waste imports is associated with a decline in production. This situation suggests that the PHH may not be applicable to Türkiye. Therefore, as a developing country, Türkiye aims to mitigate the environmental degradation implications suggested by the EKC and PHH approaches and transform these challenges into opportunities.

The findings obtained from the ARDL test results show that plastic imports and exports of goods positively affect the industrial production index in Türkiye in the long term. While renewable and waste energy production have a negative impact on industrial production in the short term, this effect becomes strongly positive in the long term. The findings from the ARDL analysis prove that plastic waste imports significantly contribute to the increase in industrial production. While renewable energy production has a negative effect in the short term, it strongly supports increased industrial output in the long term. These findings provide vital information for policymakers.

The study proves that the circular economy offers essential opportunities, especially with the use of plastic waste in the industry, to solve the production problems of developing countries and reduce the damage caused by industrial production to the environment. Similarly, to prevent the damage caused by fossil fuels to the environment, renewable and waste energy is an excellent alternative to meet the energy needs of industrial production. To increase industrial production and promote growth in developing countries like Türkiye, policymakers should create strategies regarding the circular economy, waste management, and waste recycling in their countries. They should also provide funds, training, and regulations to support the development of technologies that will facilitate the use of waste as raw materials and inputs in industry. In addition, developing countries should develop long-term programs and policies to expand renewable and waste energy use to achieve sustainable development goals in industrial production. For this purpose, plans and investment programs should be developed to build infrastructure for renewable energy production and to promote the development of national technologies.

As the empirical findings of this study indicate, developing countries locally and the whole world globally will be able to act in line with common interests for a sustainable and livable world with strategies such as circular economy management, waste recycling, and the expansion of renewable energy production.

This study draws attention to the importance of plastic waste and renewable and waste energies for industrial production. This study was specifically designed for Türkiye, one of the largest importers of waste. When evaluating the relevant literature, it is noteworthy that the number of similar studies is relatively limited. Future research should be planned using different data sets, analysis methods, and comparable studies across various countries or country groups. By comparing the findings from studies conducted for other countries and country groups, valuable insights can be provided to policymakers to create various development and economic growth strategies.

References

1. Ahmad, M., Muslija, A. & Satrovic, E. (2021). Does economic prosperity lead to environmental sustainability in developing economies? Environmental Kuznets curve theory. *Environmental Science and Pollution Research*, *28*(18), 22588-22601. https://doi.org/10.1007/s11356-020-12276-9
2. Ahmed, N., Sheikh, A. A., Mahboob, F., Ali, M. S. E., Jasińska, E., Jasiński, M., Leonowicz, Z. & Burgio, A. (2022). Energy diversification: a friend or foe to economic growth in Nordic countries? A novel energy diversification approach. *Energies*, *15*(15), 5422. https://doi.org/10.3390/en15155422
3. Akadiri, S. S. & Adebayo, T. S. (2022). Asymmetric nexus among financial globalization, non-renewable energy, renewable energy use, economic growth, and carbon emissions: impact on environmental sustainability targets in India. *Environmental Science and Pollution Research*, *29*(11), 16311-16323. https://doi.org/10.1007/s11356-021-16849-0
4. Al-Yousif, Y. K. (1997). Exports and economic growth: Some empirical evidence from the Arab Gulf countries. *Applied Economics*, *29*(6), 693-697. https://doi.org/10.1080/000368497326624
5. Anser, M. K., Khan, M. A., Nassani, A. A., Aldakhil, A. M., Hinh Voo, X. & Zaman, K. (2021). Relationship of environment with technological innovation, carbon pricing, renewable energy, and global food production. *Economics of Innovation and New Technology*, *30(*8), 807-842. https://doi.org/10.1080/10438599.2020.1787000
6. Antweiler, W., Copeland, B. R. & Taylor, M. S. (2001). Is free trade good for the environment?. *American Economic Review*, *91*(4), 877-908. https://doi.org/10.1257/aer.91.4.877

7. Aslan, A., Ocal, O., Ozsolak, B. & Ozturk, I. (2022). Renewable energy and economic growth relationship under the oil reserve ownership: Evidence from panel VAR approach. *Renewable Energy*, *188,* 402-410. https://doi.org/10.1016/j.renene.2022.02.039
8. Baek, J. (2016). A new look at the FDI–income–energy–environment nexus: dynamic panel data analysis of ASEAN. *Energy Policy*, *91*, 22-27. https://doi.org/10.1016/j.enpol.2015.12.045
9. Bahramian, P. & Saliminezhad, A. (2020). On the relationship between export and economic growth: A nonparametric causality-in-quantiles approach for Turkey. The *Journal of International Trade & Economic Development*, *29*(1), 131-145. https://doi.org/10.1080/09638199.2019.1648537
10. Bashir, M. F. (2022). Discovering the evolution of Pollution Haven Hypothesis: A literature review and future research agenda. *Environmental Science and Pollution Research*, *29*(32), 48210-48232. https://doi.org/10.1007/s11356-022-20782-1
11. Bashir, M. F., Ma, B., Shahbaz, M. & Jiao, Z. (2020). The nexus between environmental tax and carbon emissions with the roles of environmental technology and financial development. *Plos One*, *15*(11). https://doi.org/10.1371/journal.pone.0242412
12. Bilgili, F., Zarali, F., Ilgün, M. F., Dumrul, C. & Dumrul, Y. (2022). The evaluation of renewable energy alternatives for sustainable development in Turkey using intuitionistic fuzzy-TOPSIS method. *Renewable Energy*, *189*, 1443-1458. https://doi.org/10.1016/j.renene.2022.03.058
13. Bishop, G., Styles, D. & Lens, P. N. (2020). Recycling of European plastic is a pathway for plastic debris in the ocean. *Environment International*, *142*, 105893. https://doi.org/10.1016/j.envint.2020.105893
14. Blavasciunaite, D., Garsviene, L. & Matuzeviciute, K. (2020). Trade Balance Effects on Economic Growth: Evidence from European Union Countries. *Economies*, *8*(3), 54. https://doi.org/10.3390/economies8030054
15. Bölük, G. & Kaplan, R. (2022). Effectiveness of renewable energy incentives on sustainability: evidence from dynamic panel data analysis for the EU countries and Turkey. *Environmental Science and Pollution Research*, *29*, 26613-26630. https://doi.org/10.1007/s11356-021-17801-y
16. Brooks, A. L., Wang, S. & Jambeck, J. R. (2018). The Chinese import ban and its impact on global plastic waste trade. *Science Advances*, *4*(6), eaat0131. https://doi.org/10.1126/sciadv.aat0131
17. Chen, H. L., Nath, T. K., Chong, S., Foo, V., Gibbins, C. & Lechner, A. M. (2021). The plastic waste problem in Malaysia: management, recycling and disposal of local and global plastic waste. *SN Applied Sciences*, *3*, 1-15. https://doi.org/10.1007/s42452-021-04234-y
18. Chen, S., Zhang, H. & Wang, S. (2022). Trade openness, economic growth, and energy intensity in China. *Technological Forecasting and Social Change*, *179*, 121608. https://doi.org/10.1016/j.techfore.2022.121608
19. Corvellec, H., Stowell, A. F. & Johansson, N. (2022). Critiques of the circular economy. *Journal of Industrial Ecology*, *26*(2), 421-432. https://doi.org/10.1111/jiec.13187
20. Demirel, T. & İşcan, İ. H. (2021). The effect of foreign trade on economics growth: the cointegration analysis in the case of South Korea and Turkey. *International Journal of Management Economics and Business*, *17*(1), 1-27. https://doi.org/10.17130/ijmeb.794267
21. Destek, M. A. & Sinha, A. (2020). Renewable, non-renewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organisation for economic Co-operation and development countries. *Journal of Cleaner Production*, *242*, 118537. https://doi.org/10.1016/j.jclepro.2019.118537
22. Dogan, E. & Inglesi-Lotz, R. (2020). The impact of economic structure to the environmental Kuznets curve (EKC) hypothesis: evidence from European countries. *Environmental Science and Pollution Research*, *27*, 12717-12724. https://doi.org/10.1007/s11356-020-07878-2
23. Emery, R. F. (1967). The relation of exports and economic growth. *Kyklos*, *20(*4), 470-486. https://doi.org/10.1111/j.1467-6435.1967.tb00859.x

24. Fan, W. & Hao, Y. (2020). An empirical research on the relationship amongst renewable energy consumption, economic growth and foreign direct investment in China. *Renewable Energy*, *146*, 598-609. https://doi.org/10.1016/j.renene.2019.06.170
25. Greenpeace (2024). *Plastic*. https://www.greenpeace.org/turkey/tag/plastik
26. Grossman, G. M. & Krueger, A. B. (1991). *Environmental Impacts of a North American Free Trade Agreement* (NBER Working Paper No. 3914). Cambridge, MA: National Bureau of Economic Research. https://doi.org/10.3386/w3914
27. Gündoğdu, S. & Walker, T. R. (2021). Why Turkey should not import plastic waste pollution from developed countries?. *Marine Pollution Bulletin*, *171*. https://doi.org/10.1016/j.marpolbul.2021.112772
28. Honic, M., Kovacic, I. & Rechberger, H. (2019). Improving the recycling potential of buildings through Material Passports (MP): An Austrian case study. *Journal of Cleaner Production*, *217*, 787-797. https://doi.org/10.1016/j.jclepro.2019.01.212
29. Huang, Q., Chen, G., Wang, Y., Chen, S., Xu, L. & Wang, R. (2020). Modelling the global impact of China's ban on plastic waste imports. *Resources, Conservation and Recycling*, *154*. https://doi.org/10.1016/j.resconrec.2019.104607
30. Ivanovski, K., Hailemariam, A. & Smyth, R. (2021). The effect of renewable and non-renewable energy consumption on economic growth: Non-parametric evidence. *Journal of Cleaner Production*, *286*. https://doi.org/10.1016/j.jclepro.2020.124956
31. ITC (2024). *List of importers for selected products*. https://www.trademap.org/Country_SelProduct.aspx?nvpm=1%7c%7c%7c%7c%7c720449%7c%7c%7c6%7c1%7c1%7c1%7c1%7c%7c2%7c1%7c%7c1
32. Khan, M. K., Khan, M. I. & Rehan, M. (2020). The relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan. *Financial Innovation*, *6*(1), 1. https://doi.org/10.1186/s40854-019-0162-0
33. Kirikkaleli, D., Güngör, H. & Adebayo, T. S. (2022). Consumption–based carbon emissions, renewable energy consumption, financial development and economic growth in Chile. *Business Strategy and the Environment*, *31(*3), 1123-1137. https://doi.org/10.1002/bse.2945
34. Kong, Q., Peng, D., Ni, Y., Jiang, X. & Wang, Z. (2021). Trade openness and economic growth quality of China: Empirical analysis using ARDL model. *Finance Research Letters*, *38*. https://doi.org/10.1016/j.frl.2020.101488
35. Kuan, S. H., Low, F. S. & Chieng, S. (2022). Towards regional cooperation on sustainable plastic recycling: comparative analysis of plastic waste recycling policies and legislations in Japan and Malaysia. *Clean Technologies and Environmental Policy*, *24*(3), 761-777. https://doi.org/10.1007/s10098-021-02263-0
36. Kul, C., Zhang, L. & Solangi, Y. A. (2020). Assessing the renewable energy investment risk factors for sustainable development in Turkey. *Journal of Cleaner Production*, *276*. https://doi.org/10.1016/j.jclepro.2020.124164
37. Kuznets, S. (1955). International differences in capital formation and financing. In *Conference on Capital Formation and Economic Growth* (pp. 19-111). Princeton: Princeton University Press.
38. Liu, Z., Adams, M. & Walker, T. R. (2018). Are exports of recyclables from developed to developing countries waste pollution transfer or part of the global circular economy?. *Resources, Conservation and Recycling*, *136*, 22-23. https://doi.org/10.1016/j.resconrec.2018.04.005
39. Ma, B., Wang, Y., Zhou, Z., Lai, Y., Zhou, Z. & Bashir, M. F. (2022). Can controlling family involvement promote firms to fulfill environmental responsibilities? Evidence from China. *Managerial and Decision Economics*, *43*(2), 569-592. https://doi.org/10.1002/mde.3403
40. Ma, Z., Ryberg, M. W., Wang, P., Tang, L. & Chen, W. Q. (2020). China's import of waste PET bottles benefited global plastic circularity and environmental performance. *ACS Sustainable Chemistry & Engineering*, *8*(45), 16861-16868. https://doi.org/10.1021/acssuschemeng.0c05926
41. Marin, D. (1992). Is the export-led growth hypothesis valid for industrialized countries?. *The Review of Economics and Statistics*, *74*(4), 678-688. https://doi.org/10.2307/2109382

42. Mensah, A. C. & Okyere, E. (2020). Causality analysis on export and economic growth nexus in Ghana. *Open Journal of Statistics*, *10*(5), 872-888. https://doi.org/10.4236/ojs.2020.105051

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

44. Muratoğlu, G. D. (2020). Structural Shifts and Patterns in Turkey's Foreign Trade. In Akansel, I. (Ed.), *Comparative Approaches to Old and New Institutional Economics* (pp. 258-281). IGI Global. https://doi.org/10.4018/978-1-7998-0333-1.ch015

45. Nakayama, T. & Osako, M. (2024). Plastic trade-off: Impact of export and import of waste plastic on plastic dynamics in Asian region. *Ecological Modelling*, *489.* https://doi.org/10.1016/j.ecolmodel.2024.110624

46. Olatayo, K. I., Mativenga, P. T. & Marnewick, A. L. (2021). Comprehensive evaluation of plastic flows and stocks in South Africa. *Resources, Conservation and Recycling*, *170*. https://doi.org/10.1016/j.resconrec.2021.105567

47. Omoke, P. C. & Opuala–Charles, S. (2021). Trade openness and economic growth nexus: Exploring the role of institutional quality in Nigeria. *Cogent Economics & Finance*, *9(*1), https://doi.org/10.1080/23322039.2020.1868686

48. Orhan, A., Emikönel, M., Emikönel, M. & Castanho, R. A. (2022). Reflections of the "Export-Led Growth" or "Growth-Led Exports" Hypothesis on the Turkish Economy in the 1999–2021 Period. *Economies*, *10*(11), 269. https://doi.org/10.3390/economies10110269

49. Pethig, R. (1976). Pollution, welfare, and environmental policy in the theory of comparative advantage. *Journal of Environmental Economics and Management*, *2(*3), 160-169. https://doi.org/10.3390/economies10110269

50. Pontarollo, N. & Muñoz, R. M. (2020). Land consumption and income in Ecuador: A case of an inverted environmental Kuznets curve. *Ecological Indicators*, *108.* https://doi.org/10.1016/j.ecolind.2019.105699

51. Rahman, M. M. & Velayutham, E. (2020). Renewable and non-renewable energy consumption-economic growth nexus: new evidence from South Asia. *Renewable Energy*, *147,* 399-408. https://doi.org/10.1016/j.renene.2019.09.007

52. Raihan, A. & Tuspekova, A. (2022). Toward a sustainable environment: Nexus between economic growth, renewable energy use, forested area, and carbon emissions in Malaysia. *Resources, Conservation & Recycling Advances*, *15*, https://doi.org/10.1016/j.rcradv.2022.200096

53. Raihan, A., Muhtasim, D. A., Farhana, S., Pavel, M. I., Faruk, O., Rahman, M. & Mahmood, A. (2022a). Nexus between carbon emissions, economic growth, renewable energy use, urbanization, industrialization, technological innovation, and forest area towards achieving environmental sustainability in Bangladesh. *Energy and Climate Change*, *3.* https://doi.org/10.1016/j.egycc.2022.100080

54. Raihan, A., Muhtasim, D. A., Pavel, M. I., Faruk, O. & Rahman, M. (2022b). Dynamic impacts of economic growth, renewable energy use, urbanization, and tourism on carbon dioxide emissions in Argentina. *Environmental Processes*, *9*(2), 38. https://doi.org/10.1007/s40710-022-00590-y

55. Raihan, A., Begum, R. A., Said, M. N. M. & Pereira, J. J. (2022c). Relationship between economic growth, renewable energy use, technological innovation, and carbon emission toward achieving Malaysia's Paris agreement*. Environment Systems and Decisions*, *42*(4), 586-607. https://doi.org/10.1007/s10669-022-09848-0

56. Rasoanomenjanahary, M. A., Cao, L. & Xi, Y. (2022). The impact of trade openness on economic growth: empirical evidence from Madagascar. *Modern Economy*, *13*(5), 629-650. https://doi.org/10.4236/me.2022.135034

57. Saidi, K. & Omri, A. (2020). The impact of renewable energy on carbon emissions and economic growth in 15 major renewable energy-consuming countries. *Environmental Research*, *186.* https://doi.org/10.1016/j.envres.2020.109567

58. Shahbaz, M., Raghutla, C., Chittedi, K. R., Jiao, Z. & Vo, X. V. (2020). The effect of renewable energy consumption on economic growth: Evidence from the renewable energy country attractive index. *Energy*, *207.* https://doi.org/10.1016/j.energy.2020.118162
59. Shi, J., Zhang, C. & Chen, W. Q. (2021). The expansion and shrinkage of the international trade network of plastic wastes affected by China's waste management policies. *Sustainable Production and Consumption*, *25*, 187-197. https://doi.org/10.1016/j.spc.2020.08.005
60. Shinde, D. S., Deshmukh, P. D. & Patil, R. B. (2023). Analyzing side effects of increasing E-pollution on life and nature. *Materials Today: Proceedings*, *77,* 592-596. https://doi.org/10.1016/j.matpr.2022.10.079
61. Siddique, S., et al. (2022). Discerning the circularity of the plastic industry in Bangladesh through the lens of material flow analysis. *Sustainable Production and Consumption*, *33*, 700-715. https://doi.org/10.1016/j.spc.2022.08.001
62. Sun, N. & Tabata, T. (2021). Environmental impact assessment of China's waste import ban policies: An empirical analysis of waste plastics importation from Japan. *Journal of Cleaner Production*, *329.* https://doi.org/10.1016/j.jclepro.2021.129606
63. Suzanne, E., Absi, N. & Borodin, V. (2020). Towards circular economy in production planning: Challenges and opportunities. *European Journal of Operational Research*, *287*(1), 168-190. https://doi.org/10.1016/j.ejor.2020.04.043
64. Thapa, K., Vermeulen, W. J., De Waal, M. M., Deutz, P. & Nguyễn, H. Q. (2024). Towards a Just Circular Economy Transition: the Case of European Plastic Waste Trade to Vietnam for Recycling. *Circular Economy and Sustainability*, *4*, 851-876. https://doi.org/10.1007/s43615-023-00330-w
65. UN (2024). *Country Classifications*. https://unctadstat.unctad.org/EN/Classifications.html
66. Wade, K. & Jennings, M. (2016). *The impact of climate change on the global economy*. Schroders. https://mybrand.schroders.com/m/01053abe732aa4a1/original/The-impact-of-climate-change.pdf
67. Walter, I. & Ugelow, J. L. (1979). Environmental Policies in Developing Countries. *Ambio*, *8*(2/3), 102-109.
68. Wang, C., Zhao, L., Lim, M. K., Chen, W. Q. & Sutherland, J. W. (2020). Structure of the global plastic waste trade network and the impact of China's import Ban. *Resources, Conservation and Recycling*, *153.* https://doi.org/10.1016/j.resconrec.2019.104591
69. Wang, Q. & Wang, L. (2020). Renewable energy consumption and economic growth in OECD countries: A nonlinear panel data analysis. *Energy*, *207.* https://doi.org/10.1016/j.energy.2020.118200
70. Wang, Q., Dong, Z., Li, R. & Wang, L. (2022). Renewable energy and economic growth: New insight from country risks. *Energy*, *238.* https://doi.org/10.1016/j.energy.2021.122018
71. Wang, Y., Wei, W., Bi, Z., Cao, R., Li, J., Shu, D. & Lou, Z. (2021). Decomposing the decoupling of plastics consumption and economic growth in G7 and China: Evidence from 2001 to 2020 based on China's import ban. *Journal of Environmental Management*, *296.* https://doi.org/10.1016/j.jenvman.2021.113225
72. Wen, Z., Xie, Y., Chen, M. & Dinga, C. D. (2021). China's plastic import ban increases prospects of environmental impact mitigation of plastic waste trade flow worldwide. *Nature Communications*, *12*(1), 425. https://doi.org/10.1038/s41467-020-20741-9
73. Xu, W., Chen, W. Q., Jiang, D., Zhang, C., Ma, Z., Ren, Y. & Shi, L. (2020). Evolution of the global polyethylene waste trade system. *Ecosystem Health and Sustainability*, *6*(1), 1756925. https://doi.org/10.1080/20964129.2020.1756925
74. Xue, C., Shahbaz, M., Ahmed, Z., Ahmad, M. & Sinha, A. (2022). Clean energy consumption, economic growth, and environmental sustainability: What is the role of economic policy uncertainty?. *Renewable Energy*, *184*, 899-907. https://doi.org/10.1016/j.renene.2021.12.006
75. Yu, L. (2010). Polymorphism in molecular solids: an extraordinary system of red, orange, and yellow crystals. *Accounts of Chemical Research*, *43*(9), 1257-1266. https://doi.org/10.1021/ar100040r

76. Zahoor, Z., Khan, I. & Hou, F. (2022). Clean energy investment and financial development as determinants of environment and sustainable economic growth: evidence from China. *Environmental Science and Pollution Research*, *29,* 16006-16016. https://doi.org/10.1007/s11356-021-16832-9
77. Zhang, Y., Chen, X., Wu, Y., Shuai, C. & Shen, L. (2019). The environmental Kuznets curve of CO_2 emissions in the manufacturing and construction industries: a global empirical analysis. *Environmental Impact Assessment Review*, *79*. https://doi.org/10.1016/j.eiar.2019.106303
78. Zhao, C., Liu, M., Du, H. & Gong, Y. (2021). The evolutionary trend and impact of global plastic waste trade network. *Sustainability*, *13*(7). https://doi.org/10.3390/su13073662