Southeast Asian Journal of Economics Vol.13(2), August 2025: 99-135
Received: January 24, 2024
Revision: Aprill 1, 2024
Accepted: August 4, 2024

Impact of Trade in Environmental Goods on Environmental Quality: A Case of Asian Countries

Thi Khanh Linh Nguyen
Faculty of International Economics, Foreign Trade University, Hanoi, Vietnam
Corresponding author: nguyenkhanhlinh2002bn@gmail.com
Thi My Hanh Nguyen
Faculty of International Economics, Foreign Trade University, Hanoi, Vietnam.
Xuan Truong Pham
Faculty of International Economics, Foreign Trade University, Hanoi, Vietnam.

Abstract

This study aims to examine the impact of trade in environmental goods on environmental quality in 30 Asian countries from 2000 to 2020. Our analysis revealed the different impacts of trade in overall and specific environmental goods on environmental quality in each Asian region. Specifically, our results suggest a positive relationship between trade in overall and particular environmental goods and environmental quality in East Asia and South Asia, a negative relationship between trade in overall environmental goods and specific environmental goods (environmental goods on the OA list), and environmental quality in West Asia. However, in Southeast Asia, we found only a negative association between trade in Environmentally Preferable Products (EPPs) and environmental quality. The findings from this study shed light on the vital importance of trading environmental goods in affecting environmental quality in Asian regions. Empirical evidence suggests that Asian nations in each region need to have particular policies appropriate to economic conditions to improve environmental quality through the exchange of environmental goods in the future.

Keywords: trade, environmental goods, environmental quality, CO2 emissions.

1. Introduction

In the 21st century, unprecedented economic growth has been witnessed worldwide. However, this growth also entails many consequences, one of which is a serious deterioration in environmental quality. Climate change is the most obvious consequence of the degradation in environmental quality that humans are facing today, and the main factor contributing to increased global warming and deterioration of environmental quality must include carbon dioxide (CO_2) emissions. According to the Intergovernmental Panel on Climate Change Report 2022 (Pörtner et al., 2022), global CO_2 emissions have increased from 23 billion tons in the 1990s to 37 billion tons in 2021, and Asia leads in CO_2 emissions in the world during this period. If increasing greenhouse gases (like CO_2) and global warming are not addressed, they can pose serious threats to human health and the natural environment (United Nations, 2017).

The problem of deterioration of environmental quality is alarming globally. Countries and regions have been setting goals to improve the environment, such as carbon neutrality by 2050. However, environmental goals can only be achieved when we are aware of human activities that can cause environmental degradation, thereby providing feasible solutions to limit their negative impacts. Undeniably, human activities are the main factor of environmental degradation that cause climate change (Ahmed & Le, 2021). International trade, an important economic activity, is one of the crucial aspects affecting environmental quality (Hatfield-Dodds et al., 2015). According to the World Trade Organization (2021), international trade has recently accounted for more than 20–30% of global greenhouse gas emissions. It affects carbon emissions in both positive and negative directions (Gao et al., 2021). While trade expansion significantly increases the use of energy and other resources, leading to increased CO_2 emissions (Mrabet et al., 2021), trade has the potential to diffuse green technologies and thus improve the carbon efficiency of countries (Gaigné & Tamini, 2021).

Therefore, trade can be said to have the ability to reduce environmental degradation through the spread of environmental goods, especially green technology. Environmental goods include many different types of goods used to protect the environment (prevent, reduce, and eliminate pollution as well as any other environmental degradation), resource management (conserving and maintaining natural resources), as well as environmental monitoring (Liu et al., 2022). Global trade in these goods has grown since the early 2000s, with the value of global environmental goods trade tripling from 748 billion USD in 2000 to 2,790 billion USD in 2020. Asia is the region with the most positive contribution to the development of trade in environmental goods in the period 2000–2020, with the import value leading the world at 40–45% of the world's total import value, while export value is only behind Europe. Some countries with significant growth rates in environmental goods trading in Asia include China, Japan, and South Korea, followed by India, Thailand, Malaysia, Indonesia, and Vietnam (UN Environment, 2018).

Asian countries have been aware of serious environmental quality deterioration in the region and have taken active steps to promote trade in environmental goods to improve environmental quality. The latest Asian Integration Economic Report (Asian Development Bank, 2023) also highlighted the issue of climate change and environmental degradation and emphasized the importance of trade in environmental goods in reducing CO_2 emissions and improving environmental quality. However, previous studies have presented inconsistent results about the effect of trade on environmental goods and environmental quality. A large majority of scholars pointed out the positive impact of environmental goods trading on environmental quality by using different methods and diverse regions. Regarding developed countries, most of the studies found a positive impact of trading environmental goods on environmental quality (Cane et al., 2021; Gönel et al., 2017; Lee et al., 2023). For developing countries, researchers almost included that increasing trade in environmental goods will enhance environmental quality (Ahmad et al., 2022; Ali et al., 2024). Unlike prior authors focusing on a group of countries, Li et al. (2022), Liu et al. (2022), Mao et al. (2023), and Ramos (2014) have found a positive relationship between trade in environmental goods and pollution levels in one nation, such as China and Argentina. As for different groups of countries (low-, middle-, and high-income), both Alvi et al. (2023) and Ha (2022) came to the same conclusion that increasing trade in environmental goods will improve the environment. However, some studies found negative effects of environmental goods trading on the environment in slowly developing regions in Europe (Central and Eastern Europe) and newly industrialized countries (Argentina) (Ramos, 2014; Zugravu-Soilita, 2018; Hu et al. 2020; Bai et al., 2023). Considering the above research, we also find that few studies focus on assessing the impact of trade in environmental goods on environmental quality in Asia, and most studies clarify the effect of trading environmental goods in OECD and APEC lists trading on the environment.

If environmental goods were to be limited to the OECD and APEC's narrow lists, only a few advanced developing countries would benefit from trade in environmental goods. Most developing countries do not yet have well-developed markets for such products. Other criteria could also be applied to identify environmentally preferable products (EPPs), for example. Lists of EPPs (in the UNCTAD10 list, Appendix II) include products that cause less damage to the environment during one of their life-cycle stages because of how they are manufactured, collected, used, destroyed, or recovered. In particular, developing countries have suggested that negotiations should not be limited to industrial products (which are of interest to developed countries) but should also include agricultural goods (which are of particular interest to developing countries) because developing countries generally have negative trade balances in traditional environmental goods but considerable export opportunities in EPPs, which often include natural resource-based, raw, and processed commodities (United Nations Economic and Social Commission for Western Asia, 2007).

Therefore, in this study, we choose to evaluate the contribution of environmental goods trading to environmental quality in Asian countries. More specifically, given that a large majority of Asian countries examined in our study are developing ones, we consider explicit types of environmental goods derived from the extremely comprehensible categorization of environmental goods proposed by UNCTAD to obtain a proper interpretation of empirical results without restricting the analysis to the shortest list of environmental goods. In addition, this study will also seek to analyze other determinants affecting environmental quality, such as economic growth, FDI, renewable energy, and urbanization in Asian countries. The remainder of this paper is organized as follows. Section 2 presents the literature review, Section 3 discusses the methodology employed in this study, Section 4 provides empirical findings and discussion, and Section 5 offers important policy implications and concludes this research.

2. Literature Review: Trade in Environmental Goods and Environmental Quality

Environmental goods play an important role in creating sustainable development. Increasing access to and use of environmental goods not only reduces water and air pollution but also improves energy efficiency and creates favorable conditions for waste treatment (Uddin & Khan, 2013). The use of environmental goods can spread around the world through international trade because this is a channel that promotes the popularity and uptake of goods.

Many scholars have pointed out the positive impact of environmental goods trading on environmental quality by using different methods and diverse regions. Regarding developed countries, most of the studies found a positive impact of trading environmental goods on environmental quality (Can et al., 2021; Gönel et al., 2017; Lee et al., 2023). Can et al. (2021) used the Environmental Kuznets Curve–EKC hypothesis and assessed the impact of the green openness index based on the OECD's environmental goods list of 255 products on the environment in OECD countries and pointed out that traditional environment-friendly goods, as well as environmentally preferable goods, stimulate environmental sustainability. Lee et al. (2023) proved that the diffusion of green products through economic complexity and international trade was a viable means to create sustainable development in the European Union from 2000 to 2018 using Quantile regression and Driscoll-Kraay-OLS fixed effects regression.

In respect of developing countries, researchers almost included that increasing trade in environmental goods will enhance environmental quality (Ahmad et al., 2022; Ali et al., 2024). Ahmad et al. (2022) utilize the Continuously Updated and Fully Modified model to evaluate the impact of green trade on CO_2 emissions in BRICS countries from 2001 to 2018. The authors pointed out that green trade has the potential to reduce CO_2 emissions and contribute to improved environmental quality. Ali et al. (2024) assessed the role of trade in environmental goods and low-carbon technology in improving environmental quality in G20 countries from 1994 to 2018. By using quantile regression (MMQR) and Ridge regression, they found that green goods improve environmental quality, while low carbon technology reduces environmental quality.

Unlike prior authors using samples of developing countries, Li et al. (2022), Liu et al. (2022), Mao et al. (2023), and Ramos (2014) focus on environmental consequences through the relationship between trade in environmental goods and pollution levels in one nation. Ramos (2014) evaluated the impact of the elimination of multilateral tariffs on environmental goods on the environment in Argentina and found out that the UNCTAD environmental goods list was the only list that led to a three-win situation (trade–development–environment) for Argentina. Li et al. (2022), H. Liu et al. (2022), and Mao et al. (2023) concluded that green trade can reduce pollution levels, although overall trade openness is not environmentally beneficial in China. Green imports and green exports are both beneficial to China's environment. However, the impact of green trade is limited by the purchasing power and absorptive capacity as well as the classification of environmental goods. Furthermore, green trade mainly improves local green technology innovation to benefit the environment.

As for different groups of countries (low-, middle-, and high-income), both Alvi et al. (2023) and Ha (2022) came to the same conclusions. Environmental goods trade has a positive effect on environmental quality using different econometric methods and different measures of the environmental goods value chain. Specifically, each link between trade and environmental quality exists in the long run or in high-income countries, and this effect is stronger in countries with advanced institutional structures. Moreover, they also determined that importing environmental goods reduces emissions, while non-environmental goods imports have increased emissions in high-income countries for a long time. Environmental goods imported to middle-income countries reduce emissions in both the short and long term. However, in the short term, imports of non-environmental goods in middle-income countries have an insignificant impact on emissions.

Most previous studies have shown that trade in environmental goods improves environmental quality, though some studies found negative effects of environmental goods on the environment. The groups with negative impact are mainly countries in Central and Eastern Europe (the slowest developing region in Europe due to lack of raw materials and investment capital in economic development and infrastructure construction) (Ramos, 2014; Zugravu-Soilita, 2018) and newly industrialized countries (Argentina). In addition, in groups of developed countries such as the G7, Bai et al. (2023) also found a negative impact of green trade on environmental quality, as increasing the proportion of environmental goods in total goods in trade is ineffective and harms the environment because it increases carbon emissions from the consumption process. Hu et al. (2020) also noted that the liberalization of environmental goods trade is not beneficial to the environment in the absence of other policies because the impact of green goods on many end uses of conventional energy can lead to deterioration of environmental quality.

Previous studies have examined the impact of environmental goods trading on environmental quality. However, we find that (1) research results on the effect of trade in environmental goods on the environment are still inconsistent, (2) few studies focus on assessing the impact of trade in environmental goods on environmental quality in Asian countries as well as different geographical regions of Asia, and (3) most previous authors collected data of trade in overall environmental goods without classifying specific groups of environmental goods to evaluate the impact. For those reasons, we evaluate the influence of overall and some specific environmental goods on environmental quality in different geographical regions of Asia to fill the literature gap.

3. Methodology

This paper will focus on examining the influence of trade in environmental goods on environmental quality in 30 Asia countries in four regions (Southeast Asia, East Asia, West Asia, and South Asia) from 2000 to 2020 within a newly adjusted model based on a model proposed by previous studies.

3.1Model Settings and Data

Previous studies (Gönel et al., 2017; Lin, 2017; Liu et al., 2022) have proposed a research model on the impact of trade in environmental goods on environmental quality as follows:

$$y_{it} = \beta_0 + \beta_1 * X_{it} + \beta_2 * Z_{it} + \epsilon_i + \tau_t + \varepsilon_{it} \quad (1)$$

where y_{it} presents the explained variable, X_{it} denotes the explanatory variables, and Z_{it} signifies the control variables. Parameter τ_t is the year-fixed effect, parameter ϵ_i is the city-fixed effect, parameter ε_{it} denotes the stochastic error term.

In this study, the authors chose the total import and export value of environmental goods representing environmental goods trade as the main explanatory variable in the model based on previous research (Zugravu-Soilita, 2018, 2019). According to Zugravu-Soilita (2019), the total import and export value of environmental goods is used to evaluate the impact of environmental goods trade on environmental quality instead of considering the export and import value separately because many countries only record the export value of environmental goods without recording the import value, or vice versa. In Asia, this matter happened in some countries, e.g., Laos, Mongolia, Vietnam, Kuwait, and Yemen, in some years of our period examined. Furthermore, the tariff reductions on environmental goods agreed upon in the negotiations create changes in both exports and imports, so it is necessary to look at overall trade to estimate the full impact of them on environmental quality. In addition, the authors chose to include dummy variables representing regions in Asia to examine the impact of environmental goods trade on environmental quality in each region (Southeast Asia, West Asia, South Asia, and East Asia). Therefore, the import-export value of environmental goods and the interaction variable between the import-export value of environmental goods and dummy variables representing regions in Asia are included as independent variables in the model.

In addition, the authors included control variables in the model to explain environmental quality. Cole (2004) and Grossman and Krueger (1995) have shown that economic growth and environmental quality have an inverted U-shaped nonlinear relationship (Environmental Kuznets Curve–EKC), so we included the variable GDP per capita (gdppc) and squared GDP per capita (gdppc2) in the model to evaluate the impact of economic growth on environmental quality. In addition, based on Liu et al. (2022), Liu et al. (2021), and Twum et al. (2021), foreign direct investment, renewable energy, urbanization, and human capital are variables correlated with environmental quality, so researchers added them as control variables of the model.

For the dependent variable, the authors chose CO_2 emissions per capita (co2pc) to represent environmental quality based on previous studies (Gönel et al., 2017; Zugravu-Soilita, 2018, 2019).

Then, based on model (1), the authors proposed a research model as follows:

$$co2pc_{it} = \beta_0 + \beta_1 * eg_{it} + \beta_2 * (eg_{it} * D_i) + \beta_3 * gdppc_{it} + \beta_4 * gdppc2_{it} + \beta_5 * fdi_{it} + \beta_6 * urban_{it} + \beta_7 * rene_{it} + \beta_8 * hc_{it} + \epsilon_i + \tau_t + \varepsilon_{it} \quad (2)$$

where *co2pc*, *eg*, D_i, *gdppc*, *gdppc2*, *fdi*, *urban*, *rene*, and *hc* stand for CO_2 emissions per capita, trade in environmental goods, dummy variable presenting regions in Asia, GDP per capita, squared GDP per capita, foreign direct investment, urbanization, renewable energy, and human capital, respectively.

The data for environmental goods trade values come from the UN COMTRADE's world-trade database reporting flows at a high level of product disaggregation. We combined this database with the environmental goods' (EGs) classification lists (Hamwey, 2005) in Appendix II, specified at the HS 6-digit level, and Appendix III and obtained a new dataset for trade in environmental goods. Thus, we obtained several environmental goods trade variables: *eg* (trade in overall environmental goods), *aoa* (trade in Class A EGs, OECD + APEC (OA) list), *aeop* (trade in end-of-pipe products from the OA list), *actp* (trade in cleaner technologies and products from the OA list), *aoe* (trade in other types in Class A not included in the OA list), *bct* (trade in Clean Technologies, Class B EGs), and *bepp* (trade in Environmentally Preferable Products, Class B EGs). There are other Class B EGs that are very particular classifications reported in Appendix II that are not considered in this study.

Here, we focus on the most discussed categories of environmental goods. In addition, there are three dummy variables: SEA (presents Southeast Asia if SEA =1, denotes other regions in Asia if SEA =0), WA (presents West Asia if WA =1, denotes other regions in Asia if WA =0), and SA (presents South Asia if SA =1, denotes other regions in Asia if SA =0), which are presented in multiplicative forms namely: *eg * SEA, eg * WA, eg * SA* enables us to differentiate between slope coefficients of the two regions' trade value in environmental goods (Gujarati, 2004, p. 307; Wooldridge, 2016, p. 242). The base category is East Asia, particularly where SEA = WA = SA = 0, the coefficient of eg_{it} (β_1) implies when environmental goods trade in East Asia increase by 1 billion, the mean CO_2 emissions in East Asia increase by β_1 unit.

The data for CO_2 per capita (*co2pc*) comes from Our World in Data; GDP per capita (*gdppc*), foreign direct investment (*fdi*), urbanization (*urban*), and renewable energy (*rene*) are obtained from the World Development Indicators released by the World Bank; and human capital (*hc*) is sourced from the Penn World Table released by the University of Groningen in The Netherlands.

We have chosen a sample from 30 Asian countries of four regions in 21 years. However, our sample actually includes over 525 observations; fewer than 20% have missing values, which comes from the absence of import and export data of some countries, such as Yemen, Lao, Vietnam, Mongolia, and Pakistan, and FDI data in Indonesia in some early years of our period examined. Little and Rubin (2002) suggested that 20% or less of missing data is acceptable, as it does not have a significant effect on the results of the analysis.

We expect $\beta_1, \beta_2 < 0$, since expanding environmental goods trading may lead to less CO_2 emissions because trading of environmental products may increase energy efficiency and decrease environmental degradation (UNCTAD Secretaria, 1995). Based on the EKC hypothesis, we expect $\beta_3 > 0,\ \beta_4 < 0$.

This is because, in the first step of development, nations take into consideration economic concerns only, such as expanding employment opportunities or increasing income levels. To put it simply, ecological issues have low importance to the public and governments at a low level of development. Nevertheless, the ecological sensitivity of a society rises with more development (Ahmed & Wang, 2019). Hence, GDP per capita (*gdppc*) is expected to decrease environmental quality. However, the quadratic form of GDP (*gdppc2*) that denotes a high-income level is expected to improve environmental quality because environmental degradation decreases with more development (Hu et al., 2020). We expect $\beta_7 < 0$ because renewable energy is both cost-effective and environmentally friendly and reduces CO_2 emissions (Gielen et al., 2019). We also expect $\beta_8 < 0$, as human quality reflects the educational level a person has, and countries with higher human quality have a better understanding of the cause-and-effect relationships involving environmental issues through their learning at school, thus creating changes in their actions encountering environmental problems like decreasing CO_2 emissions (Mahmood et al., 2019). Lastly, we still consider whether β_5 and β_6 are greater or less than 0 since FDI and urbanization can either boost CO_2 emissions or reduce them. All symbols, variables' names, and data sources are displayed in Table 1. Before running the empirical analysis, *co2pc*, *gdppc*, and *gdppc2* are transformed into logarithmic form to reduce errors in the estimation process.

Table 1. Data and variables

Symbol	Variable	Source	Measurement of variable	Expected signs	Base
Explained variable					
lnco2pc	Logarithm of CO_2 emissions per capita	Our World in Data	Ton per capita		Zugravu-Soilita (2018); Anwar et al. (2022)
Explanatory variables					
eg	Trade in overall environmental goods	UN Comtrade	Billion USD	-	Zugravu-Soilita (2018, 2019)
aoa	Trade in Class A environmental goods – OA list	UN Comtrade	Billion USD	-	
aeop	Trade in end-of-pipe products in the OA list	UN Comtrade	Billion USD	-	
actp	Trade in cleaner products and technologies in the OA list	UN Comtrade	Billion USD	-	
aoe	Trade in other type Class A environmental goods not included in the OA list	UN Comtrade	Billion USD	-	
bct	Trade in Class B environmental goods - Clean Technologies	UN Comtrade	Billion USD	-	
bepp	Trade in Class B environmental goods – Environmentally Preferable Products	UN Comtrade	Billion USD	-	
*eg*SEA*	Interactive effects between trade in environmental goods and Southeast Asia		Billion USD	-	
*eg*WA*	Interactive effects between trade in environmental goods and West Asia		Billion USD	-	
*eg*SA*	Interactive effects between trade in environmental goods and South Asia		Billion USD	-	
Control variables					
lngdppc	Logarithm of GDP per capita	WDI	USD (2015)	+	Grossman & Krueger (1995); Talukdar & Meisner (2001); Cline (2021)
lngdppc2	Squared logarithm of GDP per capita	WDI		-	
fdi	FDI net inflow (% of GDP)	WDI	%	+/-	Atici (2012); Liu et al. (2022)

urban	Urban population (% of total population)	WDI	%	+/-	Liu et al. (2021); Anwar et al. (2022)
rene	Renewable energy consumption (% of total final energy consumption)	WDI	%	-	Anwar et al. (2022); Gielen et al. (2019)
hc	Human capital index, based on years of schooling and returns to education	Penn World Table 10.0		-	Liu et al. (2022); Twum et al. (2021)

Source: Compilation by the authors.

3.2 Empirical Methodology

The authors consider estimating the research model based on panel data analysis models: Pooled OLS, Fixed effects model (FEM), and Random effects model (REM). To select the most suitable model for the data sample among the three estimation models, POLS, FEM, and REM, the authors rely on the process proposed by Park (2011). The process of selecting the most suitable model for the sample is carried out through the following three steps: 1) regress POLS and REM model; 2) perform the Breusch-Pagan Lagrange multiplier (LM) test to choose between the POLS and REM models; if the null hypothesis is rejected, REM is better than the POLS model; and 3) regress the REM and FEM and save the results, then conduct the Hausman test to choose REM or FEM; if the null hypothesis is rejected, choose the FEM model; otherwise, choose the REM model. After choosing the appropriate regression model, the authors checked the model for errors and corrected errors (if any) to ensure the reliability of the research model and to use the best model for analysis and discussion.

4. Results and Discussions

The authors proceeded to select a regression model with the basic model with the independent variable, the overall environmental goods trade value (*eg*), and then regress the models with the independent variable, the value trade of Class A environmental goods on the OA list (*aoa*), end-of-pipe products in OA list (*aeop*), cleaner products and technologies in OA list (*actp*), other Class A goods (*aoe*), Class B clean technologies (*bct*), and Class B environmentally preferable products (*bepp*).

For a data sample of 30 Asian countries from 2000 to 2020, when choosing between the POLS and REM using the Breusch-Pagan LM test, the authors obtained a P-value = 0.000, so REM is more suitable than POLS. Next, the authors performed the Hausman test and obtained P-value = 0.8556 > 0.05, so REM is more proper than FEM. Therefore, among the three methods, POLS, REM, and FEM, REM is the most relevant for our sample.

In the REM, the error variance is proven to be constant; however, the phenomenon of autocorrelation of noise exists. With the short panel data sample (N = 30 countries > T = 21 years), REM with robust standard errors is estimated to control this autocorrelation phenomenon (Fávero, 2013). The robust REM model is the authors' final choice of model. The POLS, FEM, REM, and robust REM estimation results for the model with the core independent variable, the overall environmental goods trade value (*eg*), are presented in Table 2.

Table 2. Impact of trade in overall environmental goods (*eg*) on CO_2 emissions

Model	**(1)**	**(2)**	**(3)**	**(4)**
Explained: lnco2pc	**OLS**	**FE**	**RE**	**RE robust**
eg	0.000610*	-0.00132***	-0.00108***	-0.00108***
eg_SA	0.0147***	-0.00726***	-0.00706***	-0.00706***
eg_SEA	-0.00309*	-0.00306*	-0.00249	-0.00249
eg_WA	0.0105	0.00866**	0.00911**	0.00911*
lngdppc	3.443***	2.731***	2.915***	2.915***
lngdppc2	-0.151***	-0.118***	-0.130***	-0.130***
fdi	-0.00283***	-0.0002	-0.000242	-0.000242**
urban	0.000721	0.0135***	0.0109***	0.0109*
rene	-0.0157***	-0.0145***	-0.0139***	-0.0139***

hc	-0.275***	-0.191***	-0.177***	-0.177
Constant	-16.10***	-13.37***	-13.97***	-13.97***
No. of obs.	525	525	525	525
R^2	0.878	0.73	0.8461	0.8474
Breusch – Pagan test	[2485.91]***			
Hausman test	[5.50]			
Autocorrelation	[4.973]**			

Note: *** , * *, and * indicate significant levels at 1%, 5%, and 10%, respectively. Chi-square is presented in brackets [ ].

Source: Data processing result in Stata by authors.

The equation to estimate the impact of overall environmental goods trade on CO_2 emissions based on the RE robust model is as follows:

$$\widehat{lnco2pc} = -13.97 - 0.00108 * eg - 0.00706 * eg_{SA} - 0.00249 * eg_{SEA} + 0.00911 * eg_{WA} + 2.915 * lngdppc - 0.130 * lngdppc2 - 0.000242 * fdi + 0.0109 * urban - 0.0139 * rene - 0.177 * hc \quad (3)$$

Besides the model with the main independent variable (*eg*), REM robust models of the core independent (*aoa*, *aeop*, *actp*, *aoe*, *bct*, and *bepp*) are estimated to further access the influence of trade in environmental goods to CO_2 emissions. Results are presented in Table 3.

Table 3. Impact on CO_2 emissions of trade in specific environmental goods (*aoa*, *aeop*, *actp*, *aoe*, *bct*, *bepp*)

Explained variable: lnco2pc	(1) AOA	(2) AEOP	(3) ACTP	(4) AOE	(5) BCT	(6) BEPP
aoa	-0.00204**					
aoa_SA	-0.0117***					
aoa_SEA	-0.00548					
aoa_WA	0.0173*					
aeop		-0.00289***				
aeop_SA		-0.0159***				
aeop_SEA		-0.00877				
aeop_WA		0.0151				

actp			-0.00573**			
actp_SA			-0.0424***			
actp_SEA			-0.00352			
actp_WA			0.130***			
aoe				-0.0172***		
aoe_SA				-0.160***		
aoe_SEA				0.0143		
aoe_WA				0.235		
bct					-0.00278***	
bct_SA					-0.0218***	
bct_SEA					-0.00935	
bct_WA					0.0181	
bepp						-0.0111**
bepp_SA						-0.128***
bepp_SEA						0.0323*
bepp_WA						0.8
lngdppc	2.847***	2.816***	2.878***	3.027***	2.921***	3.008***
lngdppc2	-0.126***	-0.124***	-0.129***	-0.137***	-0.131***	-0.139***
fdi	-0.000249**	-0.000243**	-0.000242**	-0.000209*	-0.000239**	-0.000205*
urban	0.0109*	0.0116**	0.00836	0.0105*	0.0109*	0.00678
rene	-0.0139***	-0.0145***	-0.0146***	-0.0144***	-0.0149***	-0.0162***
hc	-0.164	-0.144	-0.198*	-0.232**	-0.156	-0.208**
Constant	-13.72***	-13.66***	-13.54***	-14.27***	-14.00***	-13.71***
No. of obs.	525	529	525	529	529	529
R^2	0.8474	0.8475	0.8549	0.8478	0.8491	0.8425
Autocorrelation	[4.951]**	[5.098]**	[4.674]**	[4.651]**	[5.127]**	[4.635]**

Note: *** , * *, and * indicate significant levels at 1%, 5%, and 10%, respectively. Chi-square is presented in brackets [ ].

Source: Data processing result in Stata by authors.

The estimation results in Table 2 (Model 4) and Table 3 (Models 1 – 6) indicate that increasing environmental goods trade will help reduce CO_2 emissions in East Asia and South Asia; in West Asia, boosting trade in some types of environmental goods will raise CO_2 emissions, and in Southeast Asia, spreading trade in only one type (*bepp*) will gain CO_2 emissions. Specifically, for East Asia, the regression coefficients of the variables *eg*, *aoa*, *aeop*, *actp*, *aoe*, *bct*, and *bepp* in each model (these variables represent the trade of the East Asia region when the dummy variables SA=SEA=WA=0) are both statistically significant at the 1% and 5% levels and negative, indicating that increased green goods trade in East Asia will reduce CO_2 emissions and improve environmental quality. If the trade value in overall environmental goods expands by 1 billion USD, CO_2 emissions will be reduced by approximately 0.108%. For trade in different environmental goods, the impact of trade in other Class A environmental goods not included in OA list (*aoe*) on decreasing CO_2 emissions is largest among specific environmental goods with a coefficient of -0.0172, and the smallest impact on CO_2 emissions is trade in Class A environmental goods – the OA list with a coefficient of -0.00204.

For South Asia, the coefficients of the variables *eg_SA*, *aoa_SA*, *aeop_SA*, *actp_SA*, *aoe_SA*, *bct_SA*, and *bepp_SA* are all negative and significant at a 1% level, showing the impact of environmental goods trade on reducing emissions in South Asia is larger than East Asia. The coefficient of *eg_SA* is – 0.00706, reflecting if the overall environmental goods trade in South Asia increases by 1 billion USD, South Asia's CO_2 emissions decrease more than East Asia's by 0.706% and the total CO_2 emissions reduction is 0.814%. Regarding specific types of environmental goods, the impact of trade in Class A environmental goods not included in the OA list on environmental quality in South Asia is the largest, with the slope coefficient of *aoe_SA* being -0.160, showing if upsurging this trade by 1 billion USD, the CO_2 emissions abatement is greater in East Asia by 16% and the total reduction is 17.72%. Other types of environmental goods: Class B - environmentally preferable products, end-of-pipe products in the OA list, cleaner products and technologies in the OA list, and Class B – clean technologies all contribute to reducing emissions in South Asia with smaller impact levels, respectively.

Findings show a negative relationship between environmental goods trade in East Asia and South Asia and CO_2 emissions are in line with previous authors (Alvi et al., 2023; Can et al., 2021; Gönel et al., 2017; Uddin & Khan, 2013). East Asia includes developed countries such as Japan and Korea and developing countries with high-middle income levels like China. These advanced countries have a large demand for environmental goods and have many favorable conditions for investing in green innovation to increase environmental goods export value, which increases the opportunity to cut down on environmental pollution in this region (Liu et al., 2022). South Asia is an area with large CO_2 emissions and serious pollution but can minimize environmental degradation thanks to the development of the environmental goods trade. Dahal and Pandey (2018) found that by reducing environmental pollution, improving energy efficiency, increasing the use of renewable energy, promoting environmental industries, and creating green jobs, environmental goods trade can reverse environmental degradation and stimulate growth in South Asia.

For West Asia, a coefficient is significant in the model whose main independent variables are *eg*, *aoa*, and *actp*, and the coefficients of *eg_WA*, *aoa_WA*, and *actp_WA* are positive, and absolute values are larger than coefficients of *eg*, *aoa*, *and actp*, indicating that environmental goods trade in the West Asian increases CO_2 emissions and declines environmental quality.

The coefficient of *eg_WA* is 0.00911 and significant at 10%, and the coefficient of *eg* is -0.00108, implying that increasing overall environmental goods trade by 1 billion USD will increase CO_2 emissions by (0.00911-0.00108) *100= 0.803%. For trade in Class A environmental goods – the OA list, the impact of this trade on CO_2 emissions is greater; specifically, when increasing trade value by 1 billion USD, average emissions increase (0.0173- 0.00204) *100=1.526%. Trade in cleaner technologies and products in the OA list has the greatest impact with a coefficient of *actp_WA*= -0.130 and significant at a 1% level, showing that trade in these products increased by 1 billion USD, emissions upsurge by (0.130-0.00573) *100 = 12.427%.

Last, for Southeast Asia, the only coefficient of *bepp_SEA* in the model with the main explanatory variable – *bepp* is 0.0323 and significant at a 1% level, and the absolute value is greater than the coefficient of *bepp* (-0.0111), revealing that environmental goods trade value has a positive impact on CO_2 emissions. Specifically, if the trade value of Class B environmentally preferable goods in Southeast Asia increases by 1 billion USD, the CO_2 emissions per capita boost (0.0323-0.0111) *100 = 2.12%.

The results point out a positive relationship between environmental goods trade in West Asia and Southeast Asia, confirming the findings of Bai et al. (2023), Dijkstra and Mathew (2016), Hu et al. (2020), Ramos (2014), and Zugravu-Soilita, 2018. Increasing the proportion of environmental goods in total goods in trade is ineffective and has a negative impact on the environment because it increases carbon emissions from the consumption process (Bai et al., 2023). Kuriyama (2021) argues that although developing countries (such as those in Asia) lack a comparative advantage in knowledge-intensive products, they are still interested in export earnings through integration with the global supply chain. Such environmental goods' export revenues are associated with higher CO_2 emissions (Schaffartzik et al., 2019). In addition, Hu et al. (2020) stated that environmental goods trade is not beneficial to the environment without other policies when the diversity of usages of environmental goods can cause damage to the environment. Countries in West Asia and Southeast Asia may lack environmental policies (such as carbon taxes) in promoting the production of environmental goods, which may use fossil energy and increase CO_2 emissions, so promoting trade and use of environmental goods reduces CO_2 emissions cannot compensate for the total CO_2 releasing into the environment.

Table 4. Summary of the impact of trade in specific environmental goods on CO_2 emissions

Region	**East Asia**	**South Asia**	**West Asia**	**South East Asia**
1 billion USD increase in *eg*	Decrease 0.108% CO_2 emissions	Decrease 0.814% CO_2 emissions	Increase 0.803% CO_2 emissions	Inconclusive
1 billion USD increase in *aoa*	Decrease 0.204% CO_2 emissions	Decrease 1.374% CO_2 emissions	Increase 1.526% CO_2 emissions	Inconclusive
1 billion USD increase in *aeop*	Decrease 0.289% CO_2 emissions	Decrease 1.879% CO_2 emissions	Cannot conclude	Inconclusive
1 billion USD increase in *actp*	Decrease 0.573% CO_2 emissions	Decrease 4.813% CO_2 emissions	Increase 12.427% CO_2 emissions	Inconclusive
1 billion USD increase in *aoe*	Decrease 1.72% CO_2 emissions	Decrease 17.72% CO_2 emissions	Inconclusive	Inconclusive
1 billion USD increase in *bct*	Decrease 0.278% CO_2 emissions	Decrease 2.458% CO_2 emissions	Inconclusive	Inconclusive
1 billion USD increase in *bepp*	Decrease 1.11% CO_2 emissions	Decrease 13.91% CO_2 emissions	Inconclusive	Increase 2.12 % CO_2 emissions

Source: Compilation by the authors.

Besides the influence of our core variable above, the impact of our control variables on CO_2 emissions is also remarkable. First, the coefficients of *lngdppc* are positive and those of *lngdppc2* are negative, and both coefficients are statistically significant at a 1% level in all models; therefore, we validate the EKC hypothesis in our sample. Our findings align with the conclusions of Hanif et al. (2019) and Sephton and Mann (2016). This result shows that when the income level of countries starts to increase, environmental parameters remain secondary. However, after a certain level of income, the environmental attitude of the public is expected to change. In other words, they become more inclined toward environmental sustainability.

Second, the coefficients of FDI are all negative and significant at the 5% and 10% levels. The coefficient of FDI in the model, where the core independent variable is the overall environmental goods trade value at -0.000242, points out that if increasing the ratio of FDI inflows to GDP by 1%, CO_2 emissions decrease by 0.0242%. This result supports the findings of Atici (2012) and Zhu et al. (2016). FDI inflows into developing countries help develop specialized technological and management skills as well as innovative production techniques; such technologies can also be transferred indirectly to domestic enterprises through backward or forward links. Therefore, in developing countries such as those in Asia with high emissions, increasing FDI will improve the environmental quality of the region.

Third, the consumption of renewable energy in Asian countries contributes to improving environmental quality by reducing CO_2 emissions. The coefficient of *rene* is negative (-0.0139) and statistically significant at the 1% level in all models, indicating that if increasing the ratio of renewable energy consumption to total energy by 1%, emissions decrease by 1.39%. These findings support the views of Dogan and Seker (2016) and Liu et al. (2017). The consumption of renewable energy contributes to improving environmental quality because its consumption produces very few by-products that emit carbon. Therefore, the consumption of renewable energy will reduce emissions and stimulate environmental efficiency in Asia countries.

Fourth, urbanization has a positive relationship with CO_2 emissions because the coefficients of urban are positive and statistically significant in five of the seven models. This result is in accordance with the outcomes of Clancy et al. (2008), Madlener and Sunak (2011), Cabañero (2023), and Liu et al. (2021). Strong urbanization, when large numbers of people migrate from rural areas to cities, leads to a focus on production activities and industrial development. Technologies serving industrial activities consume large amounts of fossil fuels such as coal and petroleum and produce large amounts of CO_2 into the environment. Families in urban areas rely more on commercial products and services (Clancy et al., 2008). The continuous growth of energy consumption, such as the use of heating systems and electrical appliances, produces more greenhouse gases. In addition, the construction of public infrastructure for urbanization, such as highways, bridges, and wastewater systems, requires high energy inputs and produces higher carbon emissions (Madlener & Sunak, 2011).

Lastly, human capital has the weakest influence on environmental quality among the factors affecting environmental quality in this study. The regression coefficient of human capital (*hc*) is negative and statistically significant at the 5% and 10% levels in the three models with the main independent variables: *actp*, *aoe*, and *bepp*. This result is similar to the research of Mahmood et al. (2019) and Ouyang et al. (2020). Human capital plays an important role in improving environmental quality because well-educated people tend to respond more quickly to environmental regulations. Ouyang et al. (2020) argue that advanced human capital has a positive impact on environmental regulations, which will ultimately improve environmental performance in countries, confirming the positive interaction between human capital and environmental quality.

5. Conclusions

In the context of countries and regions making efforts to set goals to improve environmental quality, typically carbon neutrality by 2050, our research has identified the relationship between environmental goods trade and some other factors on environmental quality in Asian countries. With a data set of 30 Asian countries over 21 years (2000 to 2020), the authors have estimated a number of models and found that trade in overall and some specific environmental goods have impacts on environmental quality; however, the direction of influence varies between regions in Asia. A positive effect between environmental goods trade and environmental quality is found in East Asia and South Asia. In contrast, a negative effect between green goods trade and environmental quality is found in Southeast Asia and West Asia. Other factors found to have a relationship with environmental quality include (1) Economic growth, (2) Foreign direct investment, (3) Urbanization, (4) Renewable energy, and (5) Human capital.

Based on these outcomes, Southeast Asian and West Asian countries cannot but increase trade in environmental goods to improve the environmental quality. Those nations need to have specific policies for both exporters (proposed solutions for businesses) and importers of environmental goods (proposed solutions for consumers) so that trade in environmental goods has a more positive impact on environmental quality. Some methods for the exporters should include effectively controlling pollution emissions during production and packaging processes, improving the green competitiveness of products, encouraging the use of renewable energy, and promoting businesses using green technology. Moreover, for the importers, some measures raising awareness of the meaning and importance of consuming environmental goods are reducing taxes on green goods and promulgating green labels.

Regarding East Asian and South Asian countries, these nations should take some measures to promote trade in environmental goods to enhance environmental quality. Governments should pay attention to the role of environmental regulations in optimizing trade structures to promote the development of green trade. Furthermore, accompanying measures would be necessary to ensure the possibility of reducing emissions provided by green trade, including financial and technical support that can enhance a region's capacity to position itself positively in global green chains and absorb environmental technologies. For example, governments can actively promote the development of green finance by helping private market participants identify and invest in eco-industries and eco-firms. Moreover, nurturing a desirable environment for green innovation can improve the international competitiveness of environmental products.

Although this research has achieved certain results, it still cannot avoid some limitations, such as the lack of data for countries in Central Asia. The authors recently considered the trade of the most popular environmental goods, which are Class A environmental goods, Class B – clean technology, and Class B – EPP. Therefore, in further studies, the authors will collect data on other Class B environmental goods trade and trade in environmental goods in Central Asia to further assess the impact of trading environmental goods on environmental quality in Asian countries.

Acknowledgments

We thank the editor, Vasileios Zikos, and two anonymous referees for comments that substantially improved this paper.

References

Ahmad, M., Ahmed, Z., Bai, Y., Qiao, G., Popp, J., & Oláh, J. (2022). Financial inclusion, technological innovations, and environmental quality: Analyzing the role of green openness. *Frontiers in Environmental Science*, *10*. https://www.frontiersin.org/articles/10.3389/fenvs.2022.851263

Ahmed, Z., & Le, H. P. (2021). Linking information communication technology, trade globalization index, and CO2 emissions: Evidence from advanced panel techniques. *Environmental Science and Pollution Research International*, *28*(7), 8770–8781. https://doi.org/10.1007/s11356-020-11205-0

Ahmed, Z., & Wang, Z. (2019). Investigating the impact of human capital on the ecological footprint in India: An empirical analysis. *Environmental Science and Pollution Research International*, *26*(26), 26782–26796. https://doi.org/10.1007/s11356-019-05911-7

Ali, E. B., Shayanmehr, S., Radmehr, R., Bayitse, R., & Agbozo, E. (2024). Investigating environmental quality among G20 nations: The impacts of environmental goods and low-carbon technologies in mitigating environmental degradation. *Geoscience Frontiers*, *15*(1), 101695. https://doi.org/ 10.1016/j.gsf.2023.101695

Alvi, S., Ahmad, I., & Rehman, A. (2023). Trade of environmental versus non-environmental goods and carbon emissions in high and middle-income countries. *Environmental Science and Pollution Research*, *30*(24), 65283–65295. https://doi.org/10.1007/s11356-023-26972-9

Anwar, A., Sinha, A., Sharif, A., Siddique, M., Irshad, S., Anwar, W., & Malik, S. (2022). The nexus between urbanization, renewable energy consumption, financial development, and CO2 emissions: Evidence from selected Asian countries. *Environment, Development and Sustainability*, *24*(5), 6556–6576. https://doi.org/10.1007/s10668-021-01716-2

Asian Development Bank. (2023). *Asian economic integration report 2023: Advancing digital services trade in Asia and the Pacific* (0 ed.). Asian Development Bank. https://doi.org/10.22617/TCS230031-2

Atici, C. (2012). Carbon emissions, trade liberalization, and the Japan–ASEAN interaction: A group-wise examination. *Journal of the Japanese and International Economies*, *26*(1), 167–178.

Bai, J., Han, Z., Rizvi, S. K. A., & Naqvi, B. (2023). Green trade or green technology? The way forward for G-7 economies to achieve COP 26 targets while making competing policy choices. *Technological Forecasting and Social Change*, *191*, 122477. https://doi.org/10.1016/j.techfore.2023.122477

Cabañero, J. G. (2023). Do financing sources affect CO2 emissions? The case of growing ASEAN. *Southeast Asian Journal Of Economics*, *11*(1), Article 1.

Can, M., Ahmed, Z., Mercan, M., & Kalugina, O. A. (2021). The role of trading environment-friendly goods in environmental sustainability: Does green openness matter for OECD countries? *Journal of Environmental Management*, *295*, 113038. https://doi.org/10.1016/j.jenvman.2021.113038

Clancy, J., Maduka, O., & Lumampao, F. (2008). Sustainable energy systems and the urban poor: Nigeria, Brazil, and the Philippines. In P. Droege (ed.) *Urban energy transition: From fossil fuels to renewable power* (pp. 533–562). Elsevier. https://doi.org/10.1016/B978-0-08-045341-5.00024-4

Cline, W. R. (2021). The economics of global warming (1992). In J. W. Dash (Ed.) *World scientific encyclopedia of climate change*, (pp. 3–10). World Scientific Publishing. https://doi.org/10.1142/9789811213953_0001

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: Examining the linkages. *Ecological Economics*, *48*(1), 71–81. https://doi.org/10.1016/j.ecolecon.2003.09.007

Dahal, K., & Pandey, P. R. (2018). Green growth and trade in environmental goods and services: A South Asian perspective. *Working Papers*, Article wp/18/01. South Asia Watch on Trade, Economics and Environment. https://ideas.repec.org//p/saw/wpaper/wp-18-01.html

Dijkstra, B. R., & Mathew, A. J. (2016). Liberalizing trade in environmental goods and services. *Environmental Economics and Policy Studies*, *18*(4), 499–526. https://doi.org/10.1007/s10018-015-0121-6

Dogan, E., & Seker, F. (2016). Determinants of CO2 emissions in the European Union: The role of renewable and non-renewable energy. *Renewable Energy*, *94*, 429–439. https://doi.org/10.1016/j.renene.2016.03.078

Fávero, L. P. L. (2013). Panel data in accounting and finance: Theory and application. *Brazilian Business Review*, *10*(1), 127–149. https://doi.org/10.15728/bbr.2013.10.1.6

Gaigné, C., & Tamini, L. D. (2021). Environmental taxation and import demand for environmental goods: Theory and evidence from the European Union. *Environmental and Resource Economics*, *78*(2), 307–352. https://doi.org/10.1007/s10640-020-00534-w

Gao, J., Gao, F., Yin, B., & Zhang, M. (2021). International trade as a double-edged sword: The perspective of carbon emissions. *Frontiers in Energy Research*, *9*, 764914. https://doi.org/10.3389/fenrg.2021.764914

Gielen, D., Boshell, F., Saygin, D., Bazilian, M. D., Wagner, N., & Gorini, R. (2019). The role of renewable energy in the global energy transformation. *Energy Strategy Reviews*, *24*, 38–50. https://doi.org/10.1016/j.esr.2019.01.006

Gönel, F. D., Terregrossa, N. T., & Akgün, O. (2017). *Air pollution and imports of environmental goods in OECD countries*. https://www.etsg.org/ETSG2012/Programme/Papers/437.pdf

Grossman, G. M., & Krueger, A. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, *110*(2), 353–377.

Gujarati, D. N. (2004). *Basic econometrics* (4th ed.). McGraw-Hill Companies.

Ha, L. T. (2022). Trade values in environmental commodities and environment performance: Insights from global database. *Management of Environmental Quality: An International Journal*, *34*(3), 670–703. https://doi.org/10.1108/MEQ-05-2022-0143

Hamwey, R. (2005). *Environmental goods: Where do the dynamic trade opportunities for developing countries lie?* (EconWPA, International Trade). University Library of Munich, Germany.

Hanif, I., Faraz Raza, S. M., Gago-de-Santos, P., & Abbas, Q. (2019). Fossil fuels, foreign direct investment, and economic growth have triggered CO2 emissions in emerging Asian economies: Some empirical evidence. *Energy*, *171*, 493–501. https://doi.org/10.1016/j.energy.2019.01.011

Hatfield-Dodds, S., Schandl, H., Adams, P. D., Baynes, T. M., Brinsmead, T. S., Bryan, B. A., Chiew, F. H. S., Graham, P. W., Grundy, M., Harwood, T., McCallum, R., McCrea, R., McKellar, L. E., Newth, D., Nolan, M., Prosser, I., & Wonhas, A. (2015). Australia is “free to choose” economic growth and falling environmental pressures. *Nature*, *527*(7576), 49–53. https://doi.org/10.1038/nature16065

Hu, X., Pollitt, H., Pirie, J., Mercure, J.-F., Liu, J., Meng, J., & Tao, S. (2020). The impacts of the trade liberalization of environmental goods on power system and CO2 emissions. *Energy Policy*, *140*, 111173. https://doi.org/10.1016/j.enpol.2019.111173

Kuriyama, C. (2021). *A review of the APEC list of environmental goods*. (Policy Brief No. 41). Asia-Pacific Economic Cooperation.

Lee, C.-C., Olasehinde-Williams, G., & Gyamfi, B. A. (2023). The synergistic effect of green trade and economic complexity on sustainable environment: A new perspective on the economic and ecological components of sustainable development. *Sustainable Development*, *31*(2), 976–989. https://doi.org/10.1002/sd.2433

Li, J., Dong, K., Dong, X., & Shahbaz, M. (2022). How green trade influences pollution emissions in China: A provincial perspective. *Energy Economics*, *115*, 106330. https://doi.org/10.1016/j.eneco.2022.106330

Lin, F. (2017). Trade openness and air pollution: City-level empirical evidence from China. *China Economic Review*, *45*, 78–88. https://doi.org/10.1016/j.chieco.2017.07.001

Little, R. J. A., & Rubin, D. B. (2002). *Statistical analysis with missing data* (1st ed.). Wiley. https://doi.org/10.1002/9781119013563

Liu, H., Zhang, J., & Lei, H. (2022). Do imported environmental goods reduce pollution intensity? The end use matters. *Energy Economics*, *112*, 106130. https://doi.org/10.1016/j.eneco.2022.106130

Liu, X., Kong, H., & Zhang, S. (2021). Can urbanization, renewable energy, and economic growth make environment more eco-friendly in Northeast Asia? *Renewable Energy*, *169*, 23–33. https://doi.org/10.1016/j.renene.2021.01.024

Liu, X., Zhang, S., & Bae, J. (2017). The impact of renewable energy and agriculture on carbon dioxide emissions: Investigating the environmental Kuznets curve in four selected ASEAN countries. *Journal of Cleaner Production*, *164*. https://doi.org/10.1016/j.jclepro.2017.07.086

Madlener, R., & Sunak, Y. (2011). Impacts of urbanization on urban structures and energy demand: What can we learn for urban energy planning and urbanization management? *Sustainable Cities and Society*, *1*(1), 45–53. https://doi.org/10.1016/j.scs.2010.08.006

Mahmood, N., Wang, Z., & Hassan, S. T. (2019). Renewable energy, economic growth, human capital, and CO2 emission: An empirical analysis. *Environmental Science and Pollution Research International*, *26*(20), 20619–20630. https://doi.org/10.1007/s11356-019-05387-5

Mao, X., Liu, H., Gui, J., & Wang, P. (2023). Toward inclusive list-making for trade liberalization in environmental goods to reduce carbon emissions. *Geography and Sustainability*, *4*(3), 200–212. https://doi.org/10.1016/j.geosus.2023.04.002

Mrabet, Z., Alsamara, M., Mimouni, K., & Mnasri, A. (2021). Can human development and political stability improve environmental quality? New evidence from the MENA region. *Economic Modelling*, *94*, 28–44. https://doi.org/10.1016/j.econmod.2020.09.021

Ouyang, Y., Wang, K., Zhang, T., Peng, L., Song, G., & Luo, J. (2020). The influence of sports participation on body image, self-efficacy, and self-esteem in college students. *Frontiers in Psychology*, *10*, 3039. https://doi.org/10.3389/fpsyg.2019.03039

Park, H. M. (2011). *Practical guides to panel data modeling: A step by step analysis using Stata*. (International University of Japan Public Management & Policy Analysis Program). International University of Japan, Niigata, Japan.

Pörtner, H.-O., Roberts, D. C., Tignor, M. M. B., Poloczanska, E. S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A., & Rama, B. (Eds.). (2022). *Climate change 2022: Impacts, adaptation and vulnerability.* (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change). Cambridge University Press. https://www.cambridge.org/core/books/climate-change-2022-impacts-adaptation-and-vulnerability/161F238F406D530891AAAE1FC76651BD

Ramos, M. P. (2014). *The impact of trade liberalization of environmental products on welfare, trade, and the environment in Argentina*. UNCTAD Virtual Institute Project for Trade and Poverty, Tech. Rep. https://doi.org/10.13140/RG.2.1.2459.9206

Schaffartzik, A., Duro, J. A., & Krausmann, F. (2019). Global appropriation of resources causes high international material inequality – Growth is not the solution. *Ecological Economics*, *163*, 9–19. https://doi.org/10.1016/j.ecolecon.2019.05.008

Sephton, P., & Mann, J. (2016). Compelling evidence of an environmental Kuznets curve in the United Kingdom. *Environmental & Resource Economics*, *64*(2), 301–315.

Talukdar, D., & Meisner, C. M. (2001). Does the private sector help or hurt the environment? Evidence from carbon dioxide pollution in developing countries. *World Development*, *29*(5), 827–840. https://doi.org/10.1016/S0305-750X(01)00008-0

Twum, F. A., Long, X., Salman, M., Mensah, C. N., Kankam, W. A., & Tachie, A. K. (2021). The influence of technological innovation and human capital on environmental efficiency among different regions in Asia-Pacific. *Environmental Science and Pollution Research*, *28*(14), 17119–17131. https://doi.org/10.1007/s11356-020-12130-y

Uddin, S., & Khan, S. (2013). Air pollutions and environmental goods trade: Re-visiting the EKC hypothesis. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2828502

United Nations (2017). *UN climate change annual report 2017*. Retrieved from https://unfccc.int/resource/annualreport/

UNCTAD Secretaria. (1995). *Environmentally preferable products (EPPs) as a trade opportunity for developing countries*. United Nations Conference on Trade and Development. https://unctad.org/system/files/official-document/unctadcom70.pdf

UN Environment. (2018). *UN Environment Annual Report 2018*. Retrieved from https://www.unep.org/resources/annual-report-2018

Wooldridge, J. M. (2016). *Introductory econometrics: A modern approach.* South-Western Cengage Learning.

World Trade Organization. (2021). *Trade and climate change information brief no. 4: The carbon content of international trade*. https://www.wto.org/english/news_e/news21_e/clim_03nov21-4_e.pdf

Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: Evidence from panel quantile regression. *Economic Modelling*, *58*, 237–248. https://doi.org/10.1016/j.econmod.2016.05.003

Zugravu-Soilita, N. (2018). The impact of trade in environmental goods on pollution: What are we learning from the transition economies' experience? *Environmental Economics and Policy Studies*, *20*(4), 785–827. https://doi.org/10.1007/s10018-018-0215-z

Zugravu-Soilita, N. (2019a). Trade in environmental goods and air pollution: A mediation analysis to estimate total, direct and indirect effects. *Environmental and Resource Economics*, *74*(3), 1125–1162. https://doi.org/10.1007/s10640-019-00363-6

Appendices

Appendix I: Asian Countries list in this paper

Armenia	Cyprus	Jordan	Lebanon	Philippines
Azerbaijan	Georgia	Kazakhstan	Sri Lanka	Saudi Arabia
Bangladesh	Indonesia	Korea	Mongolia	Singapore
Bahrain	India	Cambodia	Malaysia	Thailand
Brunei	Iran	Kuwait	Oman	Vietnam
China	Iraq	Laos	Pakistan	Yemen

Appendix II: Environmental goods classifications

UNCTAD has identified two types of environmental goods for analytical purposes:

1) Class A EGs, which include all chemicals and manufactured goods used directly in the provision of environmental services.

2) Class B EGs, which include all industrial and consumer goods not primarily used for environmental purposes but whose production, end-use, and/or disposal have positive environmental characteristics relative to similar substitute goods.

To analyze environmental good trade flows, these two broad sets of EGs have been further decomposed into 10 homogeneous groups of EGs.

Class A EGs have been subdivided into two groups:

1) OA list comprised of the group of all EGs included on the OECD and APEC lists while avoiding double-counting of goods appearing on both lists. OA list covers three groups: (A) pollution management, (B) cleaner technologies and products, and (C) resources management group. The first group includes mainly end-of-pipe products, while the other two generally cover clean technologies and products used to prevent environmental degradation.

2) Other – Class A – EGs list comprised of several goods used to provide environmental services that have not been captured by the OECD and APEC lists.

Class B EGs that have been subdivided into eight groups:

1) CT list comprised of clean technologies used for power generation.

2) EPP-core list comprised of consumer and industrial non-durable and semi-durable EPP goods. Goods on the EPP list have been selected based on environmentally superior end-use and disposal characteristics only (i.e., not based on PPMs).

3) CT-fuel list including fuels for CT and some conventional power generation technology applications.

4) EPP-RCY list comprised of recoverable materials that are reintegrated into the production cycle.

5) EPP-WOOD list comprised of wood and wood-based products including building supplies and furniture.

6) EPP-WSA list comprised of apparel manufactured from natural wool and silk fibers.

7) EPP-CM list comprised of raw cotton materials and cotton textiles.

8) EPP-CA list comprised of apparel manufactured from natural cotton fibers.

Source: (Hamwey, 2005)

Appendix III: Composition of EGs group lists examined in this paper

Class A environmental goods	
End-of-pipe products in the OA list (142 items)	230210, 252100, 252220, 281410, 281511, 281512, 281610, 281830, 282010, 282090, 282410, 283210, 283220, 283510, 283521, 283523, 283524, 283525, 283526, 283529, 283822, 380210, 392020, 392490, 392690, 560314, 580190, 591190, 681099, 690210, 690220, 690290, 690310, 690320, 690390, 690919, 701710, 701720, 701790, 730900, 731010, 731021, 731029, 732510, 780600, 840410, 840510, 840991, 841000, 841320, 841350, 841360, 841370, 841410, 841430, 841440, 841459, 841480, 841490, 841780, 841790, 841940, 841960, 841989, 842119, 842121, 842129, 842139, 842191, 842199, 842220, 842381, 842382, 842389, 842490, 842833, 846291, 847290, 847410, 847432, 847439, 847982, 847989, 847990, 848110, 848130, 848140, 848180, 850590, 851410,

	851420, 851430, 851490, 851629, 870892, 890710, 890790, 901320, 901540, 901580, 901590, 902229, 902290, 902511, 902519, 902580, 902590, 902610, 902620, 902680, 902690, 902710, 902720, 902730, 902740, 902750, 902780, 902790, 902830, 902890, 903010, 903020, 903031, 903039, 903083, 903089, 903090, 903110, 903120, 903130, 903149, 903180, 903190, 903220, 903281, 903289, 903290, 903300, 960310, 960350, 980390
Cleaner technologies and product in the OA list (32 items)	220100, 220710, 280110, 284700, 285100, 290511, 320910, 320990, 381500, 391400, 460120, 700800, 701990, 840420, 840999, 841011, 841012, 841013, 841090, 841381, 841911, 841919, 841950, 841990, 843680, 850231, 853931, 854140, 854389, 902810, 902820, 903210
Other Class A (46 items)	284700, 392321, 392329, 392620, 401519, 440130, 441700, 611610, 630533, 630611, 630612, 630619, 640110, 640191, 640192, 640199, 691010, 691090, 820110, 820120, 820130, 820140, 820150, 820160, 820190, 820210, 842820, 842832, 842833, 842839, 842890, 842959, 847490, 850530, 850590, 850810, 850820, 850880, 850890, 850910, 850930, 853949, 870490, 870892, 900490, 902000
Class B environmental goods	
Class B - Clean Technologies (86 items)	392510, 731010, 731100, 732211, 732219, 732290, 761100, 761300, 830249, 840211, 840212, 840219, 840220, 840290, 840310, 840390, 840410, 840420, 840490, 840681, 840682, 840690, 840890, 841011, 841012, 841013, 841090, 841181, 841182, 841199, 841350, 841360, 841370, 841381, 841391, 841620, 841630, 841869, 841911, 841919, 841950, 841990, 842129, 842139, 842199, 847960, 848110, 848130, 848140, 848180, 848190, 848310, 848360, 848410, 848490, 850131, 850132, 850133, 850134, 850161, 850162, 850163, 850164, 850211, 850212, 850213, 850220, 850231, 850239, 850240, 850300, 850421, 850422, 850423, 850431, 850432, 850433, 850434, 850440, 850490, 851150, 851610, 851621, 854140, 900190, 900290
Class B – EPP (106 items)	050900, 121110, 121120, 121190, 130110, 130120, 130190, 130219, 140190, 140310, 140390, 140410, 150510, 150590, 152110, 152190, 230690, 230890, 310100, 320190, 320300, 320910, 321000, 400110, 400121, 400122, 400129, 400280, 450110, 450200, 450310, 450390, 460120, 460191, 460210, 480610, 500200, 500400, 500600, 500710, 500720, 500790, 510111, 510119, 510121, 510129, 510130, 510310, 510320, 510400, 510510, 510521, 510529, 510610, 510710, 510910, 510910, 511111, 511119, 511190, 511211, 511219, 511290, 511290, 530110, 530121, 530129, 530210, 530290, 530310, 530410, 530521, 530591, 530710, 530720, 530810, 530890, 531010, 531090, 531100, 531100, 560710, 560721, 560729, 560750, 560890, 570110, 570220, 570231, 570241, 570251, 570291, 570310, 580110, 581099, 600129, 600199, 600241, 600291, 630120, 630510, 670100, 680800, 850680, 850780, 960310

Source: Organized by the authors.