



Effect of the WTO Trade Facilitation Agreement on Trade of Environmental Goods

Nori Ayufi¹

¹ Master of Applied Economics, School of Economics and Public Policy, University of Adelaide, Australia.

Email : noriayufibiz@gmail.com

Abstract: *The World Trade Organisation's Trade Facilitation Agreement (WTO TFA) is designed to streamline cross-border trade by reducing administrative delays and costs through improved border procedures. Despite this goal, TFA's specific influence on the trade of environmental goods has not yet been empirically investigated. Therefore, this study fills the gap by using panel data from 2017 to 2021 and applying random-effect estimation to investigate the relationship between TFA and trade of environmental goods in developing and least-developed countries. The outcome indicates that there is no evidence the TFA impacts the trade of environmental goods. The result is robust across alternative estimation methods, subsample analysis, and the use of different standard errors. One possible explanation is that TFA implementation may not be sufficiently targeted towards environmental goods, or the commitment under the TFA does not accurately capture actual implementation. In contrast, control variables such as GDP, population, and industrialisation level significantly impact the trade of environmental goods.*

Keywords: *Trade Facilitation Agreement; Trade in Environmental Goods; Developing Countries; Least Developed Countries; Nontariff Barriers*

Copyright © 2026 Author | This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 International License

Article History:

Received on 17 Mar 2025

Revised on 20 Oct 2025

Accepted on 29 Des 2025

Doi: 10.37479

Indexing:

Google Scholar; Portal Garuda; Crossref; SINTA 3 (Science And Technology Index)

The journal allows the authors to hold the copyright without restrictions and allow the authors to retain publishing rights without restrictions. international license.

INTRODUCTION

Improving the ease of trade procedures may considerably affect international trade and the global economy (Persson, 2013). Despite this, exporters and importers often experience barriers related to the inconvenient bureaucracy of shipping products from one country to another (Fliess & Kim, 2008). To address this issue, World Trade Organisation (WTO) members agreed to establish the Trade Facilitation Agreement (TFA), which attempts to streamline paperwork, modernise processes, and standardise customs procedures. This Agreement aims to decrease the time and cost of conducting international trade. The TFA, which entered into force on February 22, 2017, is anticipated to increase global exports by 2.7% and contribute more than 0.5% to GDP growth from 2015 to 2030. Specifically, for developing countries, this Agreement is projected to increase exports by 3.5% and economic development by 0.9% (World Trade Organization, 2017).

At the same time, the world is facing environmental problems, such as pollution and environmental degradation, which worsen every year (Stott, 2016). The rapid economic development fuelled by fossil fuels, including industry and transportation, is the main cause of this problem (Atkinson, 2014). One way to address this problem is by promoting environmentally responsible economic development, such as reorienting production away from pollution-intensive products and toward environmentally friendly products (Zugravu-Soilita, 2018). It also means utilising environmental goods, which industries produce or use to minimise environmental damage and efficiently

use available resources (Tran, 2022). However, there are several challenges in obtaining environmental goods, for instance, tariffs and nontariff barriers in the trade of environmental goods, which can make environmental goods more expensive and less competitive (de Melo & Solleder, 2020). Therefore, to ensure the ease with which countries can obtain environmental goods, there should be an effort to remove the trade barriers associated with environmental goods, such as trade liberalisation and trade facilitation.

Even though the main purpose of the TFA is to enhance trade performance by eliminating administrative nontariff barriers, there is no research on its specific impact on trade in environmental goods. This gap motivates a study investigating whether the TFA affects the increasing trade value of environmental goods. Therefore, this study examines the impact of the TFA on trade in environmental goods from 2017-2021 among 120 WTO developing and least-developed countries (LDC) members who signed the TFA. This research only focuses on developing countries and LDC members for two reasons. First, the TFA has the unique feature of incorporating the participation of developing countries and LDCs by allowing them to choose the timelines for their implementation (Almodarra, 2022; Czapnik, 2015; Finger, 2014; Finger & Wilson, 2007; Hillberry & Zurita, 2022; Irish, 2017). Second, knowing whether the TFA commitment rate can be an alternative way to measure the degree of barriers to trade in environmental goods because developing countries and LDCs are more likely to be absent from international negotiations about trade in environmental goods (Khatun, 2012; Matsumura, 2021; Scobie, 2020).

In this study, the estimation of the effect of the TFA on trade in environmental goods is conducted by random effect panel data analysis to show how countries' commitment rate may affect the trade value of environmental goods. The dependent variable here is the value of trade in environmental goods, and the variable of interest is the countries' TFA commitment rate. Control variables, such as gross domestic product (GDP), population, and level of industrialisation, are also included in the model. The panel data model is preferred because it can address unobserved heterogeneity, such as countries and time-specific effects (Wooldridge, 2010). Some country-specific characteristics might significantly influence the demand for trade in environmental goods, which is complicated to observe; for instance, the strictness of environmental regulation. To check the robustness of this study, I conducted four tests. First, instrumental variable two-stage least-squares (IV 2SLS) random effect panel data estimation is conducted because the TFA commitment rate may be endogenous since countries' commitment can be influenced by governance indicators (Hillberry & Zurita, 2022; Kumari & Bharti, 2021). Second, the bootstrap method estimates a parameter's sampling distribution by resampling the original data. Third, for the subsample analysis, the analysis of developing countries and LDCs is conducted separately. Finally, by using regression with different standard errors, the variance-covariance matrix estimator (VCE) standard error is calculated.

The results show no evidence that the TFA commitment rate may influence trade in environmental goods in developing countries and LDCs. This result is robust to the panel data analysis, IV 2SLS, subsample, bootstrap, and use of different standard errors. This insignificance may be due to the self-designated commitment of developing and least-developed countries not representing the quality of trade facilitation implementation. The flexibility of developing countries and LDCs in choosing their commitments under the TFA should be informative about their capacities concerning commitments (Hillberry & Zurita, 2022). Therefore, further gap analysis is needed in every country to determine whether this commitment is met through actual implementation. Evidence in Indonesia and Nigeria shows a gap between implementation and commitment (Isra et al., 2020; Odularu, 2019). The other reason is that implementing the TFA may facilitate only general goods but not specifically the trade of environmental goods (Beverelli et al., 2015; Fu et al., 2023).

This result differs from those of previous empirical studies on the factors that can impact trade of environmental goods. While this study finds no evidence that the TFA affects trade in environmental goods, other factors, such as tariff reduction, removing nontariff barriers, environmental regulation, and digitisation, significantly affect trade in environmental goods (Costantini & Crespi, 2008; de Melo & Solleder, 2020; Ha & Thanh, 2022; He et al., 2015; Helble & Majoe, 2020; Matsumura, 2021; Tamini & Sorgho, 2018). Additionally, these results also differ from those of previous studies on the impact of the TFA on trade performance, such as on trade efficiency and export diversification, which have significant effects (Beverelli et al., 2015; Fu et al., 2023).

This study makes three contributions to the literature. First, this is the first study that investigates the impact of the TFA on the trade in environmental goods. Second, to the best of our knowledge, this study may be among the first studies to utilise the TFA commitment rate as the variable of interest. Because the TFA has been implemented for a short period since 2017, several previous studies that incorporate the TFA utilised the number of commitments A in cross-sectional analysis, the ratification status dummy variable, and the projection of the TFA to conduct the simulation before implementation (Beverelli et al., 2015; Fu et al., 2023; Hillberry & Zurita, 2022). Third, the finding that no evidence shows the effect of the TFA on trade in environmental goods can be an input for evaluating the actual implementation of the TFA and trade in environmental goods in the future.

This research is organised as follows. The introduction is in Section 1. Methodology is in Section 2 which contains information about the data and empirical analysis. The results are shown in Section 3. Discussion are shown in Section 4. Finally, the study's conclusions are presented in Section 5.

METHODOLOGY

Data

This study analyses the impact of the Trade Facilitation Agreement (TFA) on trade of environmental goods using yearly panel data of 120 countries for five years spanning from 2017 to 2021. There are 121 developing and Least-Developed Countries (LDC) that signed the TFA. However, since the control variables are mostly taken from the World Development Indicators (WDI), the data for Chinese Taipei is merged with China. Therefore, in this study, we also consider Chinese Taipei and China as one country, leaving 120 countries to analyse. Some countries' trade value data were also not available in specific years. It may be because there was no trade in environmental goods

in those years. Therefore, the total number of observations in the samples is 558. [Table A](#) in the appendix provides detailed information on these countries.

Table 1. Description of variables

Variable	Description	Measure	Source	Obs	Mean	Min	Max
TEG	Environmental goods trade value	The value of trade (export and import) of environmental goods (US Dollar thousand)	Trade map	600	15,070,133.7	0	871,110,628
logteg	The logarithm of Environmental goods trade value	The logarithm of the trade value (export and import) of environmental goods (US Dollar thousand)	Trade map	595	12.27	6.86	20.50
TFA	TFA commitment rate	The annual average percentage of implementation commitment of the Trade Facilitation Agreement	WTO TFA Database	600	53.56	0	100
logtfa	The logarithm of the TFA commitment rate	The logarithm of the annual average percentage of implementation commitment of the Trade Facilitation Agreement	WTO TFA Database	569	3.75	-0.40	4.60
INCOME	Real output growth	Real GDP per capita (constant 2015 US Dollar)	World Development Indicators	600	8200.32	263.36	80477.68
logincome	The logarithm of real output growth	The logarithm of real GDP per capita (constant 2015 US Dollar)	World Development Indicators	600	8.27	5.57	11.29
POPU	Population	Total population	World Development Indicators	600	48,981,634.84	47606	1,417,173,173

Variable	Description	Measure	Source	Obs	Mean	Min	Max
logpopu	The logarithm of the population	The logarithm of the total population	World Development Indicators	600	15.82	10.77071	21.06853
INDUS	Industrialisation level	Value added of the industrial sector to GDP	World Development Indicators	593	26.26	4.08	63.24
logindus	The logarithm of the Industrialisation level	The logarithm of value added of the industrial sector to GDP	World Development Indicators	593	3.18	1.41	4.15

Source: Author's calculation (2023)

For the baseline analysis, the dependent variable is trade in environmental goods. The goods classified as environmental goods are based on the APEC environmental goods list (Asia-Pacific Economic Cooperation, 2012). [Table B](#) in the appendix provides detailed information on these goods. Originally, the Harmonised System (HS) code for these products is only available in 2002, 2007 and 2012. Therefore, the product's HS code was converted to HS 2022. Then, the trade value data is obtained from the Trade Map provided by the International Trade Center (ITC), with values expressed in thousands of US dollars.

The variable of interest, the yearly average commitment rate to the TFA, is obtained from the WTO TFA Database (World Trade Organization, 2023). WTO TFA Database (TFAD) shows the member countries' commitment since the entry into force. The control variable comprises the per-capita income, population, and industrialisation level taken from the WDI. [Table 1](#) presents the description of the variables used in the study, including their definitions, measures, data sources, and descriptive statistics. In addition, the instrumental variable two-stage least-squares is also conducted to test the robustness of this study. The instrument used for TFA is World Governance Indicators (WGI), as described in [Table 2](#).

Table 2. Worldwide Governance Indicators

Variable	Description	Obs	Mean	Standard deviation	Min	Max
WGI1	Control of Corruption	600	-0.28	0.72	-1.60	2.14
WGI2	Government Effectiveness	600	-0.24	0.73	-1.79	2.28
WGI3	Political Stability and Absence of Violence/Terrorism	600	-0.22	0.84	-2.79	1.60
WGI4	Regulatory Quality	600	-0.20	0.70	-1.58	2.23
WGI5	Rule of Law	600	-0.27	0.69	-1.87	1.84
WGI6	Voice and Accountability	600	-0.24	0.76	-1.81	1.30

Source: Author's calculation (2023)

Empirical Analysis

To examine the impact of the Trade Facilitation Agreement (TFA) on the trade of environmental goods, this study utilises the environmental and trade literature to create an empirical model. According to the literature, the trade performance of environmental goods can be influenced by the country's nontariff barrier (Almodarra, 2022; Banga, 2014; Beverelli et al., 2015; Flentø & Ponte, 2017; Fliess & Kim, 2008; Frey, 2015; J. Fu et al., 2023). Here, the countries' TFA commitment rate could be used to determine how well the countries' efforts to reduce nontariff barriers, especially in streamlining custom procedures.

The control variables for this study consist of income, population, and industrialisation levels. Per capita income, measured by GDP per capita, can explain wage gaps, missing trade, and home bias in consumption (Markusen, 2013). A higher GDP per capita increases trade openness and imports, resulting in greater output and economic

growth (Kohli, 2004). Countries with higher GDP per capita exhibit higher income elasticities of demand, indicating that their demand for goods is more responsive to income changes. As GDP per capita increases, there is greater demand for imported goods, leading to increased trade (Slaughter, 2001). In addition, many studies also consider GDP per capita a significant factor affecting environmental performance (Q. Fu et al., 2020). The income level indicates a country's economic status, which is the foundation for environmental improvement and stimulates increased trade in environmental goods. Previous studies have also used population and industrialisation levels as control variables to measure environmental efficiency. These factors significantly enhance trade in environmental goods and the environmental performance index (Q. Fu et al., 2020; Ha & Thanh, 2022). Therefore, this study also employs the yearly total population and percentage of industrial value added to GDP in the model.

This study uses panel data to consider the existence of unobserved heterogeneity or country-specific effects. The country-specific characteristic that might significantly influence trade in environmental commodities is the level of interest in environmental concerns, as shown by the adoption of environmental regulations. However, this variable is difficult to observe since interest in environmental issues may also not be affected by regulation, for example, by conducting a social licence. Because panel data account for unobserved heterogeneity between countries, they perform better than ordinary least squares (OLS) in assessing the relationship between the TFA and the environmental goods trade. This is because OLS regression ignores potential heterogeneity across countries, which may bias coefficient estimates and standard errors.

The following panel model was developed based on the environmental and trade literature above with the primary goal of investigating the effect of the TFA and trade in environmental goods:

$$\log TEG_{it} = \alpha_i + \beta_1 \log TFA_{it} + \beta_2 \log INCOME_{it} + \beta_3 \log POPU_{it} + \beta_4 \log INDUS_{it} + \varepsilon_{it} \quad (1)$$

The dependent variable is the total value of trade in environmental goods for country i and year t , denoted as TEG_{it} . The variable of interest TFA_{it} measures the average commitment rates of countries towards the TFA in country i and year t . The parameter of interest β_1 captures the marginal effect of an increase in the commitment rate of the TFA on trade in environmental goods. The term α_i denotes country-specific effects that affect the trade in environmental goods. The control variables include $INCOME_{it}$, $POPU_{it}$, and $INDUS_{it}$. The variable $INCOME_{it}$ represents the real GDP per capita (in constant 2015 US dollars). The variable $POPU_{it}$ denotes the total population, whereas the variable $INDUS_{it}$ denotes the level of industrialisation, which refers to the value added to the GDP. Finally, ε_{it} is the error term. Due to the large magnitudes of some variables, the economic data between countries vary and fluctuate dramatically. Therefore, this study uses the logarithms of TFA, income, population, and industry to obtain easier-to-observe results, thereby avoiding the calculation difficulties induced by the large absolute values and enormous variances of certain variables.

However, based on the literature, there is a probability that the variable of interest, TFA, is endogenous. The country's decision on the number of commitments A may also be influenced by the quality of governance (Hillberry & Zurita, 2022; Kumari & Bharti, 2021). Therefore, the OLS estimation result may be unbiased and consistent because the variable of interest may be correlated with the error term (Wooldridge, 2010). To address endogeneity, instrumental variable two-stage least-squares (IV 2SLS) is also incorporated to check the robustness of this study by considering the quality of governance indicators as instruments. The quality of governance indicators consists of control of corruption, government effectiveness, political stability and absence of violence, regulatory quality, rule of law, and voice and accountability (Kaufmann & Kraay, 2023). The model for IV 2SLS is the following:

First stage Model:

$$\log TFA_{it} = \delta_0 + \delta_1 WGI1_{it} + \delta_2 WGI2_{it} + \delta_3 WGI3_{it} + \delta_4 WGI4_{it} + \delta_5 WGI5_{it} + \delta_6 \log WGI6_{it} + \delta_7 \log INCOME_{it} + \delta_8 \log POPU_{it} + \delta_9 \log INDUS_{it} + \vartheta_{it} \quad (2)$$

Second stage Model:

$$\log TEG_{it} = \alpha_i + \beta_1 \log \widehat{TFA}_{it} + \beta_2 \log INCOME_{it} + \beta_3 \log POPU_{it} + \beta_4 \log INDUS_{it} + \varepsilon_{it} \quad (3)$$

$\log \widehat{TFA}_{it}$ represents the regression result of the endogenous variable $\log TFA_{it}$ on the instruments, which are the governance indicators. Then, $WGI1_{it}$, $WGI2_{it}$, $WGI3_{it}$, $WGI4_{it}$, $WGI5_{it}$, and $WGI6_{it}$ represent each of the worldwide governance indicators.

RESULTS

Baseline results

Table 3 shows the regression results on the impact of the Trade Facilitation Agreement (TFA) on trade in environmental goods. In all models, the coefficient on the variable of interest, $\log TFA$, is insignificant in influencing environmental goods trade, indicating that higher country commitment to TFA does not substantially contribute to increased environmental goods trade. The regression results of the control variable and trade in environmental goods demonstrate that the $\log income$, $\log popu$, and $\log indus$ coefficients in the random effect model are positive and statistically significant at 1%. First, the $\log income$ random effect model result demonstrates that a 1% rise in per capita income corresponds to a 1.118% increase in trade in environmental goods. This is due to the promotion of upgrading industry equipment and increased trade in environmental goods. This aligns with Fu et al. (2020),

which suggests that GDP per capita increases the environmental performance index. Second, the regression result of logpopu also shows that the population increase of 1% will increase the trade in environmental goods by 0.8%. This finding also aligns with Fu et al. (2020) and Ha & Thanh(2022), which show that improving living standards for the bigger population positively affects the environment because of the pressure of the increasing population density. Lastly, the regression analysis of logindus indicates that an increase of 1% in industrialisation leads to an increase of 0.6% in the trade of environmental goods. This result is consistent with prior studies conducted by Fu et al. (2020) and Ha & Thanh (2022), indicating the importance of industrialisation in facilitating the trade of environmental goods.

In order to determine which one of a fixed effect or random effect model is appropriate for this study, I performed a weight calculation (theta) and the Hausman test. The theta calculation result is 0.9004, which is close to one. Therefore, the random effect model is preferred. In addition, the Hausman test is used to assess the consistency and efficiency of fixed and random effect models. If the P-value exceeds 0.05, it is not statistically significant to reject the null hypothesis and choose the random effect model over the fixed effect model (Wooldridge, 2010). Results suggest that using the random effect model is more appropriate for this research, as its P-value exceeds 0.05. This implies that the null hypothesis cannot be rejected. Therefore, the result of the random effect model is preferable to estimate the result.

Table 3. Regression result of the impact of TFA on trade in environmental goods

Variables	OLS	FE	AREG	RE
logtfa	0.0860 (1.00)	-0.0535 (-0.71)	-0.0535 (-0.71)	-0.00777 (-0.12)
logincome	1.174*** (17.46)	0.709*** (3.02)	0.709*** (3.02)	1.118*** (10.39)
logpopu	0.862*** (24.48)	1.370* (1.90)	1.370* (1.90)	0.873*** (12.34)
logindus	0.986*** (6.34)	0.479** (2.41)	0.479** (2.41)	0.637*** (3.74)
N	558	558	558	558

Notes: The table shows the regression result of the Trade Facilitation Agreement (TFA) effect on Trade in Environmental Goods (TEG). The dependent variable is the logarithm of the total trade value of the goods on the APEC environmental goods list in developing and least developed countries (LDC) WTO members. The t statistics are represented by the numbers in parenthesis, while the symbols *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Author's calculation (2023)

Robustness check

Table 4 displays the results of the robustness test. In general, the result confirms that there is no evidence that the Trade Facilitation Agreement (TFA) affect trade in environmental goods. Multiple robustness checks were conducted. First, using instrumental variable two-stage least squares (IV 2SLS) random effect panel data estimation to address any potential endogeneity in the variable of interest. Second, the bootstrap technique is used by resampling from the original dataset. Third, a sub-sample regression analysis is conducted separately on developing and least developed countries (LDCs). Last, by conducting regression using different standard errors, which is variance-covariance matrix estimation (VCE) robust standard error.

Instrumental variable two-stage least squares

The endogeneity issue arises when there is a correlation between the independent variable and the error term. One solution for endogeneity is by using the instruments for the endogenous variable. The variable of interest, TFA, may be endogenous because it can be related to the quality of governance (Hillberry & Zurita, 2022; Kumari & Bharti, 2021). According to the results presented in Table 4, there is insufficient evidence to indicate that the commitment rate of the TFA has any impact on the trade of environmental goods. Therefore, the same outcome with the previous random effect regression indicates that the model is robust. The first stage estimation in the 2SLS also reveals that some indicators of governance quality, which are political stability (WGI3), regulatory quality (WGI4), and rule of law (WGI5), have an influence on the TFA.

The estimation results obtained by the IV 2SLS method indicate a statistically significant and positive impact of the control variable, which aligns with the results of the random effects regression. The regression result shows that the impact of the coefficient of income per capita (logINCOME) and population (logPOPU) is less than the result obtained from the random effect regression model. A 1% rise in GDP per capita and population resulted in an increase of 0.926% and 0.8% in the trade value of environmental goods, respectively, with a statistically significant level of 1%. The coefficient of industrialisation (logINDUS) level shows a lower effect and is less significant after correcting for endogeneity. One per cent increase in industrialisation may increase the level of trade in environmental goods by 0.46%, with a 5% significance level.

Bootstrap technique

To assess the robustness of the result, a bootstrap technique is also used. This method involves resampling the data with replacement and estimating the parameters for each resampled dataset. The technique was repeated 1000 times, and the estimated coefficients and their standard errors were obtained. The result is shown in Table 4 (column 5). After that, I compared the bootstrap and original results and found that the results were very similar, which shows no evidence that TFA affects trade in environmental goods. This finding suggests the model is robust when confronted with different data sets.

Sub-sample regression

The result of the robustness check using sub-sample analysis is presented in Table 4 (columns 6 and 7). The sample is divided into developing and least developed countries (LDCs). The estimation is then carried out using the same model used in the previous section. This test aims to assess potential differences in the relationship between TFA and trade in environmental goods across different categories of countries. The result shows almost the same result for both samples, that there is no evidence that TFA affects trade in environmental goods. The regression results for the control variable in both sub-samples indicate a statistically significant and positive impact, with a consistent significance level with the regression results presented in the previous section. The finding implies that the model has robustness when the sample is divided into sub-samples.

Table 4. Robustness check of the impact of TFA on trade in environmental goods

VARIABLE	Baseline		Robustness Check					
	(1) OLS	(2) RE	(3) IV 2SLS 1 st stage	(4) IV 2SLS 2 nd stage	(5) RE Bootstrap	(6) RE Developing	(7) RE LDC	(8) RE VCE Robust SE
<i>S</i>	<i>logTEG_{it}</i>	<i>logTEG_{it}</i>	<i>logTFA_{it}</i>	<i>logTEG_{it}</i>	<i>logTEG_{it}</i>	<i>logTEG_{it}</i>	<i>logTEG_{it}</i>	<i>logTEG_{it}</i>
<i>logTFA_{it}</i>	0.0860 (1.00)	- 0.00777 (-0.12)		0.589 (1.27)	-0.00777 (-0.12)	-0.0425 (-0.59)	-0.0972 (-0.87)	- 0.00777 (-0.12)
<i>WGI1_{it}</i>			0.077 (0.77)					
<i>WGI2_{it}</i>			0.006 (0.06)					
<i>WGI3_{it}</i>			0.139 *					
<i>WGI4_{it}</i>			(1.91) - 0.198 *					
<i>WGI5_{it}</i>			(- 1.75) 0.296 **					
<i>WGI6_{it}</i>			(2.02) - 0.032 (- 0.32)					
<i>logINCOME_{it}</i>	1.174** * (17.46)	1.118** * (10.39)	0.184 ** 2.08	0.926* ** (5.31)	1.118*** (12.36)	1.086*** (7.36)	1.022** * (3.70)	1.118** * (-0.12)
<i>logPOP_{it}</i>	0.862** * (24.48)	0.873** * (12.34)	0.170 *** 2.82	0.800* ** (7.47)	0.873*** (40.06)	0.911*** (11.01)	0.558** * (5.02)	0.873** * (11.23)
<i>logINDUS_{it}</i>	0.986** * (6.34)	0.637** * (3.74)	0.222 * 1.93	0.463* * (2.19)	0.637*** (2.86)	0.642*** (3.72)	0.995** * (2.87)	0.637** (2.16)
N	558	558	558	558	558	432	126	558

Notes: The table presents the results of a robustness check of the random effect estimate model, which examines the impact of the Trade Facilitation Agreement (TFA) on trade in environmental goods (TEG) among developing and least-developed countries (LDCs) that are members of the World Trade Organisation (WTO). The methods to ensure the analysis's robustness include utilising instrumental variable two-stage least squares (IV 2SLS) (3 & 4). This analysis employs governance indicators as instruments, such as control of corruption, government effectiveness, political stability, regulatory quality, rule of law, and voice and accountability are denoted by WGI1-WGI6, respectively; bootstrap technique, by resampling from the original dataset in 1000 repetition (5); sub-sample regression, examine the results separately for developing countries (6) and LDCs (7); and using VCE robust standard errors (8). The numbers in parentheses correspond to the t statistics, whereas the symbols *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Author's calculation (2023)

Variance-covariance matrix (VCE) robust standard error

The VCE robust standard error is a method to correct for heteroskedasticity and autocorrelation in the error terms of a regression model. The result of the robustness check using VCE robust standard error is presented in [Table 4 \(columns 8\)](#). The result indicates that the main results of this research remain valid when subjected to the robust standard error of VCE. The magnitudes of the coefficients for the variable of interest remain unchanged from the initial model and continue to be statistically insignificant. The results for the control variable are also the same as the regression result in the previous section. Therefore, the result of the robustness check using VCE robust standard error confirms the robustness of the result of this study.

DISCUSSION

The result shows that the countries' commitment to TFA does not substantially contribute to increased environmental goods trade. This might be because developing and least-developed countries (LDCs') self-designated commitment does not reflect the actual quality of trade facilitation implementation. Developing countries and LDCs' flexibility in choosing their commitments under the TFA is supposed to be informative to portray their quality of commitments implementation (Hillberry & Zurita, 2022). Evidence in Indonesia and Nigeria shows a gap between implementation and commitment (Isra et al., 2020; Odularu, 2019). It does not rule out the possibility that this gap also occurs in other countries. Therefore, this implementation needs further gap analysis to see whether the commitment meets the actual implementation. The other reason the results show no evidence that TFA may affect trade of environmental goods may be that the implementation of TFA may only facilitate general goods but not specifically in the trade of environmental goods (Beverelli et al., 2015; Fu et al., 2023).

The result of this study is different from previous empirical studies on the determinants that might impact the trade of environmental goods. In contrast to the findings of the present study, other factors such as the reduction of tariffs, the elimination of non-tariff barriers, the implementation of environmental regulations, and the process of digitisation, significantly influence the trade of environmental goods (Costantini & Crespi, 2008; de Melo & Solleder, 2020; Ha & Thanh, 2022; He et al., 2015; Helble & Majoe, 2020; Matsumura, 2021; Tamini & Sorgho, 2018). The observed outcome diverges due to differences in the variables of interest and the utilisation of different datasets. Furthermore, examining the effect of TFA on the trade of environmental goods is a novelty to the existing literature in this field.

The findings of this study differ from other research examining the effects of TFA on trade performance, specifically about trade efficiency and export diversification (Beverelli et al., 2015; Fu et al., 2023). In their study, Beverelli et al. (2015) conducted a simulation to examine the impact of the TFA on export diversification. To mirror the effects of the TFA, the authors used the OECD trade facilitation indicator (TFI) as a proxy since the actual implementation of the TFA had not yet taken place at the time of the study. This study suggests using the actual implementation of TFA for future research. The result may differ from this study because it uses TFI instead of the countries' commitment rate and studies general goods rather than environmental goods. In their study, Fu et al. (2023) use the time-varying stochastic frontier gravity model and trade inefficiency model to evaluate the effects of trade facilitation between China and the countries included in the Belt and Road Initiative. The study specifically concentrates on the trade of fresh agricultural goods from 2011 to 2020. The results may differ due to different settings on the country and product.

CONCLUSION

This research investigates the effect of the World Trade Organisation (WTO) Trade Facilitation Agreement (TFA) on the trade of environmental goods within developing and least-developed countries (LDCs). The analysis uses a random effect panel data model for five years between 2017 and 2021 and includes 120 countries. The results show that countries' commitment to the TFA does not significantly affect trade of environmental goods, although other control variables, such as GDP, population, and industrialisation, are significantly positive. This finding is supported by various robustness tests, including instrumental variable two-stage least squares (IV 2SLS), the bootstrap technique, subsample regression, and different standard errors.

This nonsignificant difference may be because of several reasons. First, there may be a gap between the commitment rate and countries' actual implementation of TFA due to self-designated commitment. Second, implementing the TFA does not facilitate the trade of the goods contained in APEC Environmental Goods. Third, there is a limitation in this analysis because of the short observation period. Using the TFA commitment rate to study its impact on trade of environmental goods may be too early due to its limited implementation duration, which spans just five years as of 2021. Hence, it is essential for future research on the impact of the TFA on trade of environmental goods to account for the gap in the country's commitment rates to the TFA and to conduct the study at a later stage after its implementation.

The insignificance of the impact of the TFA on the trade of environmental goods has two policy implications. First, every WTO member country should evaluate the implementation of the TFA by conducting a gap analysis. If there is a gap between commitment and implementation, they should exert some effort to reduce or eliminate the gap, such as by learning from other countries or strengthening the regulation. Second, evaluate the environmental

good list endorsed by APEC to include the more relevant products that are needed or abundant in developing countries and LDCs.

REFERENCES

- Almodarra, B. B. M. (2022). The Special and Differential Treatment Provision in the Trade Facilitation Agreement: New Teeth for an Old Gum? *African Journal of International and Comparative Law*, 30(2). <https://doi.org/10.3366/ajicl.2022.0401>
- Asia-Pacific Economic Cooperation. (2012). *ANNEX C - APEC List of Environmental Goods*. https://www.Apec.Org/Meeting-Papers/Leaders-Declarations/2012/2012_aelm/2012_aelm_annexc.
- Atkinson, C. L. (2014). Deforestation and Transboundary Haze in Indonesia: Path Dependence and Elite Influences. *Environment and Urbanization ASIA*, 5(2), 253–267. <https://doi.org/10.1177/0975425315577905>
- Banga, R. (2014). Trade facilitation and “hollowing-out” of Indian manufacturing. *Economic and Political Weekly*, 49(40).
- Beverelli, C., Neumueller, S., & Teh, R. (2015). Export Diversification Effects of the WTO Trade Facilitation Agreement. *World Development*, 76. <https://doi.org/10.1016/j.worlddev.2015.07.009>
- Costantini, V., & Crespi, F. (2008). Environmental regulation and the export dynamics of energy technologies. *Ecological Economics*, 66(2–3). <https://doi.org/10.1016/j.ecolecon.2007.10.008>
- Czapnik, B. (2015). The Unique Features of the Trade Facilitation Agreement: A Revolutionary New Approach to Multilateral Negotiations or the Exception Which Proves the Rule? *Journal of International Economic Law*, 18(4). <https://doi.org/10.1093/jiel/jgv041>
- de Melo, J., & Solleder, J. M. (2020). Barriers to trade in environmental goods: How important they are and what should developing countries expect from their removal. *World Development*, 130. <https://doi.org/10.1016/j.worlddev.2020.104910>
- Finger, J. M. (2014). The WTO trade facilitation agreement: Form without substance again? *Journal of World Trade*, 48(6). <https://doi.org/10.54648/trad2014045>
- Finger, J. M., & Wilson, J. S. (2007). Implementing a trade facilitation agreement in the WTO: What makes sense? *Pacific Economic Review*, 12(3). <https://doi.org/10.1111/j.1468-0106.2007.00356.x>
- Flentø, D., & Ponte, S. (2017). Least-Developed Countries in a World of Global Value Chains: Are WTO Trade Negotiations Helping? *World Development*, 94. <https://doi.org/10.1016/j.worlddev.2017.01.020>
- Fliess, B., & Kim, J. A. (2008). Nontariff Barriers Facing Trade in Selected Environmental Goods and Associated Services. *Journal of World Trade*, 535–562. <http://www.kluwerlawonline.com/api/Product/CitationPDFURL?file=Journals\TRAD\TRAD2008023.pdf>
- Frey, C. (2015). Tackling climate change through the elimination of trade barriers for low-carbon goods: Multilateral, plurilateral and regional approaches. In *Legal Aspects of Sustainable Development: Horizontal and Sectorial Policy Issues*. https://doi.org/10.1007/978-3-319-26021-1_22
- Fu, J., Chen, L., & Xue, H. (2023). The Impacts of Trade Facilitation Provisions on Fresh Agricultural Products Trade between China and the BRI Countries. *Agriculture (Switzerland)*, 13(2). <https://doi.org/10.3390/agriculture13020272>
- Fu, Q., Chen, Y. E., Jang, C. L., & Chang, C. P. (2020). The impact of international sanctions on environmental performance. *Science of the Total Environment*, 745. <https://doi.org/10.1016/j.scitotenv.2020.141007>
- Ha, L. T., & Thanh, T. T. (2022). Effects of digital public services on trades in green goods: Does institutional quality matter? *Journal of Innovation and Knowledge*, 7(1). <https://doi.org/10.1016/j.jik.2022.100168>
- He, Q., Fang, H., Wang, M., & Peng, B. (2015). Trade liberalization and trade performance of environmental goods: evidence from Asia-Pacific economic cooperation members. *Applied Economics*, 47(29). <https://doi.org/10.1080/00036846.2015.1011319>
- Helble, M., & Majoe, A. (2020). Can environmental regulations drive international trade? Lessons for Asia from the European Union’s performance of buildings directive. *Journal of Economic Integration*, 35(1). <https://doi.org/10.11130/jei.2020.35.1.69>
- Hillberry, R., & Zurita, C. (2022). Commitment behaviour in the World Trade Organization’s Trade Facilitation Agreement. *World Economy*, 45(1). <https://doi.org/10.1111/twec.13165>
- Irish, M. (2017). Development, reciprocity and the WTO Trade Facilitation Agreement. *Manchester Journal of International Economic Law*, 14(1).
- Isra, A., Prof, A., Huala, A., & Prita, A. (2020). Trade Facilitation Agreement WTO: In Indonesia Perspective. *South East Asia Journal of Contemporary Business, Economics and Law*, 23.
- Kaufmann, D., & Kraay, A. (2023). *Worldwide Governance Indicators 2023 update*. <https://Databank.Worldbank.Org/Source/Worldwide-Governance-Indicators>.
- Khatun, F. (2012). Trade in Environmental Goods by Least Developed Countries: Issues for Negotiations. *South Asia*

- Economic Journal*, 13(2). <https://doi.org/10.1177/1391561412457232>
- Kohli, U. (2004). Real GDP, real domestic income, and terms-of-trade changes. *Journal of International Economics*, 62(1). <https://doi.org/10.1016/j.jinteco.2003.07.002>
- Kumari, M., & Bharti, N. (2021). Linkages Between Trade Facilitation and Governance: Relevance for Post-COVID-19 Trade Strategy. *Millennial Asia*, 12(2). <https://doi.org/10.1177/0976399620972346>
- Markusen, J. R. (2013). Putting per-capita income back into trade theory. *Journal of International Economics*, 90(2). <https://doi.org/10.1016/j.jinteco.2013.04.003>
- Matsumura, A. (2021). Gravity analysis of trade for environmental goods focusing on bilateral tariff rates and regional integration. *Asia-Pacific Journal of Regional Science*, 5(2). <https://doi.org/10.1007/s41685-020-00189-x>
- Odularu, A. (2019). Addressing trade facilitation commitments and implementation capacity gaps: Issues and evidence from Nigeria. In *Trade Facilitation Capacity Needs: Policy Directions for National and Regional Development in West Africa*. https://doi.org/10.1007/978-3-030-05946-0_2
- Persson, M. (2013). Trade facilitation and the extensive margin. *The Journal of International Trade & Economic Development*, 22(5), 658–693. <https://doi.org/10.1080/09638199.2011.587019>
- Scobie, M. (2020). International aid, trade and investment and access and allocation. *International Environmental Agreements: Politics, Law and Economics*, 20(2). <https://doi.org/10.1007/s10784-020-09480-w>
- Slaughter, M. J. (2001). Trade liberalization and per capita income convergence: A difference-in-differences analysis. *Journal of International Economics*, 55(1). [https://doi.org/10.1016/S0022-1996\(00\)00087-8](https://doi.org/10.1016/S0022-1996(00)00087-8)
- Stott, P. (2016). How climate change affects extreme weather events. *Science*, 352(6293), 1517–1518. <https://doi.org/10.1126/science.aaf7271>
- Tamini, L. D., & Sorgho, Z. (2018). Trade in Environmental Goods: Evidences from an Analysis Using Elasticities of Trade Costs. *Environmental and Resource Economics*, 70(1). <https://doi.org/10.1007/s10640-017-0110-2>
- Tran, T. M. (2022). International Environmental Agreement and Trade in Environmental Goods: The Case of Kyoto Protocol. *Environmental and Resource Economics*, 83(2), 341–379. <https://doi.org/10.1007/s10640-021-00625-2>
- Wooldridge, M. J. (2010). Econometric Analysis of Cross Section and Panel Data, Second Edition. In *Advanced Studies in Theoretical and Applied Econometrics* (Vol. 50).
- World Trade Organization. (2017). *Trade facilitation – Background*. https://www.wto.org/english/Tratop_e/Tradfa_e/Tradfa_introduction_e.htm
- World Trade Organization. (2023). *Trade Facilitation Agreement Database*. <https://tfadatabase.org/en/notifications>
- 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>

APPENDIX

Table A. Countries in the sample

Afghanistan	Central Republic	African	Georgia	Liberia	Nigeria	Solomon Islands
Albania	Chad		Ghana	Macao, China	North Macedonia	South Africa
Angola	Chile		Grenada	Madagascar	Oman	Sri Lanka
Antigua and Barbuda	China		Guatemala	Malawi	Pakistan	Suriname
Argentina	Colombia		Guinea	Malaysia	Panama	Tajikistan
Armenia	Congo		Guyana	Maldives	Papua New Guinea	Tanzania
Bahrain	Costa Rica		Honduras	Mali	Paraguay	Thailand
Bangladesh	Cote d'Ivoire		Hong Kong, China	Mauritania	Peru	Togo
Barbados	Cuba		India	Mauritius	Philippines	Tonga
Belize	Democratic Republic of the Congo		Indonesia	Mexico	Qatar	Trinidad and Tobago
Benin	Djibouti		Israel	Moldova, Republic of	Rwanda	Tunisia
Bolivia	Dominica		Jamaica	Mongolia	Saint Kitts and Nevis	Türkiye
Botswana	Dominican Republic		Jordan	Montenegro	Saint Lucia	Uganda
Brazil	Ecuador		Kazakhstan	Morocco	Saint Vincent and the Grenadines	Ukraine
Brunei Darussalam	Egypt		Kenya	Mozambique	Samoa	United Arab Emirates
Burkina Faso	El Salvador		Korea, Republic of	Myanmar	Saudi Arabia, Kingdom of	Uruguay
Burundi	Eswatini, Kingdom of		Kuwait, State of	Namibia	Senegal	Vanuatu
Cabo Verde	Fiji		Kyrgyz Republic	Nepal	Seychelles	Viet Nam
Cambodia	Gabon		Lao People's Democratic Republic	Nicaragua	Sierra Leone	Zambia
Cameroon	Gambia, The		Lesotho	Niger	Singapore	Zimbabwe

Table B. APEC Environmental Goods in HS 2022

HS 2022	Description
441873	"Flooring panels, assembled, of bamboo or with at least the top wear layer of bamboo"
441875	"Flooring panels, multilayer, assembled, of wood other than bamboo (excl. for mosaic floors)"
840290	"Parts of vapour generating boilers and superheated water boilers, n.e.s."
840410	"Auxiliary plant for use with boilers of heading 8402 or 8403, e.g. economisers, superheaters, ..."
840420	"Condensers for steam or other vapour power units"
840490	"Parts of auxiliary plant of heading 8402 or 8403 and condensers for steam or other vapour power ..."
840690	"Parts of steam and other vapour turbines, n.e.s."
841182	"Gas turbines of a power > 5.000 kW (excl. turbojets and turbopropellers)"
841199	"Parts of gas turbines, n.e.s."
841290	"Parts of nonelectrical engines and motors, n.e.s."
841470	"Gas-tight biological safety cabinets"
841490	"Parts of: air or vacuum pumps, air or other gas compressors, fans and ventilating or recycling ..."
841780	"Industrial or laboratory furnaces and ovens, nonelectric, incl. incinerators (excl. those ..."
841790	"Parts of industrial or laboratory furnaces, nonelectric, incl. incinerators, n.e.s."
841912	"Solar water heaters"

841919	"Instantaneous or storage water heaters, nonelectric (excl. instantaneous gas water heaters, ..."
841933	"Lyophilisation apparatus, freeze drying units and spray dryers"
841939	"Dryers (excl. lyophilisation apparatus, freeze drying units, spray dryers, dryers for agricultural ..."
841960	"Machinery for liquefying air or other gases"
841989	"Machinery, plant or laboratory equipment, whether or not electrically heated, for the treatment ..."
841990	"Parts of machinery, plant and laboratory equipment, whether or not electrically heated, for ..."
842121	"Machinery and apparatus for filtering or purifying water"
842129	"Machinery and apparatus for filtering or purifying liquids (excl. such machinery and apparatus ..."
842132	"Catalytic converters or particulate filters, whether or not combined, for purifying or filtering ..."
842139	"Machinery and apparatus for filtering or purifying gases (excl. isotope separators and intake ..."
842199	"Parts of machinery and apparatus for filtering or purifying liquids or gases, n.e.s."
847420	"Crushing or grinding machines for solid mineral substances"
847982	"Mixing, kneading, crushing, grinding, screening, sifting, homogenising, emulsifying or stirring ..."
847983	"Cold isostatic presses"
847989	"Machines and mechanical appliances, n.e.s."
847990	"Parts of machines and mechanical appliances, n.e.s."
848530	"Machines for additive manufacturing by plaster, cement, ceramics or glass deposit"
848580	"Machines for additive manufacturing (excl. by metal, plastics, rubber, plaster, cement, ceramics ..."
848590	"Parts of machines for additive manufacturing"
850164	"AC generators "alternators", of an output > 750 kVA (excl. photovoltaic generators)"
850180	"Photovoltaic AC generators"
850231	"Generating sets, wind-powered"
850239	"Generating sets (excl. wind-powered and powered by spark-ignition internal combustion piston ..."
850300	"Parts suitable for use solely or principally with electric motors and generators, electric ..."
850490	"Parts of electrical transformers and inductors, n.e.s."
851411	"Hot isostatic presses"
851419	"Industrial and laboratory furnaces and ovens, resistance heated (excl. hot isostatic presses, ..."
851420	"Furnaces and ovens functioning by induction or dielectric loss"
851431	"Electron beam furnaces"
851432	"Plasma and vacuum arc furnaces"
851439	"Electric industrial or laboratory furnaces and ovens (excl. resistance heated, induction, dielectric, ..."
851490	"Parts of electric industrial or laboratory furnaces and ovens, incl. of those functioning by ..."
852411	"Flat panel display modules, whether or not incorporating touch-sensitive screens, without drivers ..."
852412	"Flat panel display modules, whether or not incorporating touch-sensitive screens, without drivers ..."
852419	"Flat panel display modules, whether or not incorporating touch-sensitive screens, without drivers ..."
852491	"Flat panel display modules, whether or not incorporating touch-sensitive screens, with drivers ..."
852492	"Flat panel display modules, whether or not incorporating touch-sensitive screens, with drivers ..."
852499	"Flat panel display modules, whether or not incorporating touch-sensitive screens, with drivers ..."
852990	"Parts suitable for use solely or principally with flat panel display modules, transmission ..."
853990	"Parts of electric filament or discharge lamps, sealed beam lamp units, ultraviolet or infrared ..."
854141	"Light emitting diodes "LED"
854142	"Photovoltaic cells not assembled in modules or made up into panels"
854143	"Photovoltaic cells assembled in modules or made up into panels"
854149	"Photosensitive semiconductor devices (excl. photovoltaic generators and cells)"

854151	"Semiconductor-based transducers (excl. photosensitive)"
854159	"Semiconductor devices, n.e.s."
854231	"Electronic integrated circuits as processors and controllers, whether or not combined with ..."
854232	"Electronic integrated circuits as memories"
854233	"Electronic integrated circuits as amplifiers"
854239	"Electronic integrated circuits (excl. such as processors, controllers, memories and amplifiers)"
854390	"Parts of electrical machines and apparatus, having individual functions, n.e.s. in chapter ..."
854921	"Electrical and electronic waste and scrap, of a kind used principally for the recovery of precious ..."
854929	"Electrical and electronic waste and scrap, of a kind used principally for the recovery of precious ..."
854931	"Waste and scrap of electrical and electronic assemblies and printed circuit boards, containing ..."
854939	"Waste and scrap of electrical and electronic assemblies and printed circuit boards (excl. for ..."
854991	"Electrical and electronic waste and scrap, containing primary cells, primary batteries or electric ..."
854999	"Electrical and electronic waste and scrap (excl. for the recovery of precious metal, electrical ..."
901380	"Optical appliances and instruments, n.e.s. in chapter 90"
901390	"Parts and accessories for lasers and other appliances and instruments, n.e.s. in chapter 90"
901580	"Instruments and appliances used in geodesy, topography, hydrography, oceanography, hydrology, ..."
902610	"Instruments and apparatus for measuring or checking the flow or level of liquids (excl. meters ..."
902620	"Instruments and apparatus for measuring or checking pressure of liquids or gases (excl. regulators)"
902680	"Instruments or apparatus for measuring or checking variables of liquids or gases, n.e.s."
902690	"Parts and accessories for instruments and apparatus for measuring or checking the flow, level, ..."
902710	"Gas or smoke analysis apparatus"
902720	"Chromatographs and electrophoresis instruments"
902730	"Spectrometers, spectrophotometers and spectrographs using optical radiations, such as UV, visible, ..."
902750	"Instruments and apparatus for physical or chemical analysis, using UV, visible or IR optical ..."
902781	"Mass spectrometers"
902789	"Instruments and apparatus for physical or chemical analysis, or for measuring or checking viscosity, ..."
902790	"Microtomes; parts and accessories of instruments and apparatus for physical or chemical analysis, ..."
903149	"Optical instruments, appliances and machines for measuring or checking, not elsewhere specified ..."
903180	"Instruments, appliances and machines for measuring or checking, not elsewhere specified in ..."
903190	"Parts and accessories for instruments, appliances and machines for measuring and checking, ..."
903289	"Regulating or controlling instruments and apparatus (excl. hydraulic or pneumatic, manostats, ..."
903290	"Parts and accessories for regulating or controlling instruments and apparatus, n.e.s."
903300	"Parts and accessories for machines, appliances, instruments or other apparatus in chapter 90, ..."
962000	"Monopods, bipods, tripods and similar articles"

Note: The APEC Environmental Goods list is available in HS 2002, 2007, and 2012. This list is converted to HS 2022 using a correspondence table provided by the United Nations Statistics Division (<https://unstats.un.org/unsd/classifications/Econ>)