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The Impact of International Textile Trade CO2 Emissions on the European Green Economy: An ARDL Model With Stationary Variables

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International trade in textiles has a negative impact on climate change. Negative impacts on climate change can occur through production, exports, and imports by rail, maritime, road, air transport, and postal services. The research aims to create an ARDL model with stationary variables and find out how can be minimised the amount of carbon dioxide (CO2) released into the environment during the production, import, and export of textile products.

Keywords: carbon dioxide, textile, international trade, export, import

Introduction

The main contributor to climate change is carbon dioxide (CO2) (Shen, Liu, & Tian, 2022; Umar & Safi, 2023). A lot of it is released into the environment because of international trade. Insufficient participation, carbon leakage, and unambitious targets are undermining existing climate change agreements, which are being influenced by international trade. The need to mitigate the effects of climate change is less important than the need to adapt to climate change (Bayramoglu, Jacques, Nedoncelle, & Neumann-Noel, 2023). A major role is given to adapting to climate change, as the changes associated with it are inevitable. The ability to adapt to changing climatic conditions, stabilise the world's economic and social systems, mitigate potential losses, and adapt to, cope with, or take advantage of the opportunities offered by climate change. The desired goal around the world is to achieve sustainable development through a production process that is based on low carbon emissions (Khan et al., 2022).

The quality of the environment is greatly influenced by the emission of carbon dioxide (Goudarzi et al., 2023; Latif et al., 2023). The concentration of carbon dioxide in the atmosphere is increasing due to human activities. The main global cause of climate change is economic growth (Zhou, Li, Ozturk, & Ullah, 2022). The textile industry is an important contributor to carbon dioxide emissions (Li, Zhang, Qian, & He, 2023). Industrial countries emit the most carbon dioxide (Nitescu & Murgu, 2022). Technological development helps ensure sustainable development and economic growth (Costantini, Laio, Ridolfi, & Sciarra, 2023). The textile manufacturing industry faces the challenge of reducing its ecological impact (Broadbent, 2023). Carbon

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dioxide emissions contribute the most to global warming. The concentration of carbon dioxide in 2020 was 48% higher than in the pre-industrial period (up to the year 1750). Carbon dioxide is generated by the combustion of fossil fuels. High textile production and transport costs have a negative impact on international trade. Textile products are imported and exported by rail, road, maritime, air transport, and postal services. Textile products sent by post can be transported by rail, maritime, road, and air transport. Most carbon dioxide is released into the environment during the export and import of textile products by road and air transport. The most environmentally friendly and least carbon-emitting ways of transporting products are sea, rail, and post. Every tonne of carbon dioxide emitted into the atmosphere contributes to global warming. The reduction of carbon dioxide emissions into the atmosphere slows the warming of the climate. Emissions of carbon dioxide have to reach net zero for global warming to stop completely[1]. Climate change affects many areas of our lives and has a major impact on international trade. Adaptation to and the fight against climate change is one of the main priorities of the European Union and the whole world. In order to find out which way of transporting the textile products emits the least CO2 and to confirm the claim that the least carbon dioxide is emitted when textiles are exported by post using rail transport, we will develop an ARDL model with stationary variables.

Methods and Data

The European Union emits CO2 into the environment during export and import of textile products by maritime, road, rail, air transport, and post. CO2 emitted into the environment because of international trade in textiles affects the European green economy. To find out whether CO2 emissions are affected by textile exports and imports, we will look for stationary processes among statistical data, establish causality, and create an ARDL model; thus the following indicators will be needed:

- how many millions of tonnes of textiles are exported by road in the European Union;
- how many millions of tonnes of textiles are exported by rail in the European Union;
- how many millions of tonnes of textiles are exported by maritime in the European Union;
- how many millions of tonnes of textiles are exported by air in the European Union;
- how many millions of tonnes of textiles are exported by post in the European Union;
- how many millions of tonnes of textiles are imported by road in the European Union;
- how many millions of tonnes of textiles are imported by rail in the European Union;
- how many millions of tonnes of textiles are imported by maritime in the European Union;
- how many millions of tonnes of textiles are imported by air in the European Union;
- how many millions of tonnes of textiles are imported by post in the European Union;
- the amount of CO2 in millions of tonnes released when transporting textiles by rail in the European Union;
- the amount of CO2 in millions of tonnes released when transporting textiles by road in the European Union;
- the amount of CO2 in millions of tonnes released when transporting textiles by air in the European Union.

We will evaluate the stationarity of the time series using the unit root test. Stationarity evaluation will tell us which statistical indicators are stationary and which are non-stationary (see Table 1).

[1] Klimato kaitos padariniai—Europos Komisija (europa.eu).

Table 1

Unit Root Test Values (Integration and Probabilities)

Time series values	Model without shift and trend	Model with shift	Model with shift and trend	Time series integration
Textile exports by road (millions of tonnes)			I (1)	
Undifferentiated	0.7968	0.2787	0.2153	
Differentiated 1 time	0.000			
Textile exports by sea (millions of tonnes)				I (1)
Undifferentiated	0.9555	0.7014	0.7788	
Differentiated 1 time	0.000			
Textile exports by air (millions of tonnes)				I (1)
Undifferentiated	0.7893	0.5176	0.4638	
Differentiated 1 time	0.000			
Textile exports by post (millions of tonnes)				I (0)
Undifferentiated	0.0407	-	-	
Textile exports by rail (millions of tonnes)				I (1)
Undifferentiated	0.3701	0.0617	0.1838	
Differentiated 1 time	0.000			
Textile imports by road (millions of tonnes)				I (1)
Undifferentiated	0.7422	0.6681	0.8337	
Differentiated 1 time	0.000			
Textile imports by sea (millions of tonnes)				I (1)
Undifferentiated	0.7712	0.0546	0.1410	
Differentiated 1 time	0.000			
Textile imports by air (millions of tonnes)				I (1)
Undifferentiated	0.5749	0.0615	0.0634	
Differentiated 1 time	0.000			
Textile imports by post (millions of tonnes)				I (0)
Undifferentiated	0.0002	-	-	
Textile imports by rail (millions of tonnes)				I (1)
Undifferentiated	0.6052	0.0806	0.2810	
Differentiated 1 time	0.000			
GDP per capita (millions of euros)				I (1)
Undifferentiated	1.000	0.9913	0.8107	
Differentiated 1 time	0.000			
Total CO2 amount (millions of tonnes)				I (1)
Undifferentiated	0.1383	0.9182	0.1856	
Differentiated 1 time	0.000			
CO2 amount released by road transport (millions of tonnes)				I (1)
Undifferentiated	0.5798	0.1893	0.1559	
Differentiated 1 time	0.000			
CO2 amount released by rail transport (millions of tonnes)				I (0)
Undifferentiated	0.0005	-	-	
CO2 amount released by air transport (millions of tonnes)				I (1)
Undifferentiated	0.1953	0.7973	0.2564	
Differentiated 1 time	0.000			

After evaluating the stationarity of the series using the unit root test, we found that textile exports by post (millions of tonnes), textile imports by post (millions of tonnes), and the amount of CO2 released into the environment by rail transport (millions of tonnes) are stationary processes without a shift or trend. All other remaining indicators are integrated first-order processes.

In the European Union, the least amount of textiles is exported and imported by post. According to statistical data, rail and maritime transport emit the least CO2. In order to determine whether there is a relationship between textile exports by post and the amount of CO2 released into the environment by rail transport (millions of tonnes), textile exports by post, and textile imports by post, because these processes are stationary (see Table 2), we will perform a Granger causality test.

Table 2

Granger Causality Test Results

*H:	I = 1	I = 2	I = 3	I = 4	I = 5	I = 6
TEP→TIP	0.9839	0.7708	0.0018	0.0010	0.0143	0.0350
TIP→TEP	0.2211	0.2380	0.1253	0.1669	0.0498	0.0016
COG→TIP	0.1563	0.1258	0.7831	0.9285	0.8819	0.8115
TIP →COG	0.2993	0.0799	0.1933	0.2634	0.0038	0.0647
COG→TEP	0.5491	0.8055	0.0628	0.8361	0.8441	0.5617
TEP→COG	0.0455	0.0093	0.0161	0.1317	0.2380	0.5386

Notes. *Abbreviations: Textile exports by post (millions of tonnes)—TEP; Textile imports by post (millions of tonnes)—TIP; Amount of CO2 released into the environment by rail transport (millions of tonnes)—COG.

The obtained results show that textile exports by post do not affect the textile imports by post and vice versa in the first year. In the second year, textile exports by post also do not affect the textile imports by post and vice versa. In the third year, textile exports by post affect textile imports by post, but textile imports by post do not affect textile exports by post. In years four, five, and six, textile exports by post affect textile imports by post and vice versa. The amount of CO2 (millions of tonnes) released into the environment by rail transport does not affect the textile imports by post. Textile imports by post affect the amount of CO2 (millions of tonnes) released into the environment by rail transport in the fifth year. The amount of CO2 (millions of tonnes) released into the environment by rail transport does not affect the textile exports by post. Textile exports by post in the first, second, and third years affect the amount of CO2 (millions of tonnes) released into the environment by rail transport.

We found that there is a relationship between the amount of CO2 (millions of tonnes) emitted by rail transport and textile exports by post. Next, we will calculate the SC values (see Table 3).

Table 3

SC Values

COG lags	TEP values of lags			
	0	1	2	3
0	1.849543	1.830712	1.393423	1.105059
1	-0.068970	0.108005	-0.301207	-0.157359
2	0.097364	0.245076	-0.162771	-0.078032
3	-0.068168	-0.059570	-0.047032	-0.059691
4	-0.507398*	-0.342930*	-0.268048	-0.109319
5	-0.374239	-0.220120	-0.148074	-0.004811
6	-0.496304	-0.315770	-0.349138*	-0.223158
7	-0.321710	-0.142238	-0.316765	-0.294075
8	-0.183070	-0.003621	-0.145829	-2.141548*

According to the SC values, we obtained the following models:

- SV = -0.507 ARDL (4.0);
- SV = -0.343 ARDL (4.1);
- SV = -0.349 ARDL (6.2);
- SV = -2.142 ARDL (8.3).

The most suitable model is ARDL (4.1) (see Table 4).

Table 4

ARDL Model Results

Independent variables	ARDL (4.1)
c	0.196068
COG (-1)	0.175525***
COG (-2)	-0.102968
COG (-3)	0.132561
COG (-4)	0.628560
TEP	7.850342**
TEP (-1)	-1.1487548***
Corrected R2	0.986547
Mean of errors	1.24e-15
Normality of errors: J-B probability	0.728186
Breusch-Pagan-Godfrey test probability	0.3008
LM test probability when 1 = 8	0.1118
Sum(Yt -i), I = 1…4	0.196068

Notes. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Results and Discussion

If the textile exports by post decrease by one percentage point, then in the following years CO_2 emissions (millions of tonnes) into the environment by rail transport decrease by 1.14875 percentage points.

Textile exports by post can be forecasted using the Holt-Winters additive method (see Table 5).

Table 5

Exponential Smoothing Methods

Indicator/model	Single	Double	Holt-Winters non-seasonal	Holt-Winters additive	Holt-Winters multiplicative
Textile exports by post (millions of tonnes)	0.0090	0.0085	0.0091	0.0082	0.0083

After extending the sample by four years, we forecast the values of the indicators based on the model with the smallest error (see Table 6).

Table 6

Forecast of Indicators

Indicator	Model	2023	2024	2025	2026
Textile exports by post (millions of tonnes)	$y_t = 0.0103 + (-0.0013) \cdot \tau + c_t$	0.011812	0.011811	0.011810	0.011810

In summary, we can say that the obtained ARDL (4.1) model is very accurate and stable. It meets the requirements of residual errors. A decrease in the textile exports by post reduces the amount of CO2 emitted when exporting textiles by rail transport. The least amount of textiles is exported by post, and the least amount of CO2 is released into the environment when transporting textiles by rail. The export of products by rail transport emits the least amount of CO2 into the environment. Rail is the most environmentally friendly mode of transport.

Conclusion

The negative impact on climate change occurs through product export and import by rail, maritime, road, air transport, and post. The developed ARDL model with stationary variables confirms that the least amount of carbon dioxide is released into the environment when exporting textile products by rail transport. Rail is the most environmentally friendly way of exporting.

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