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Impacts and Implications of Asymmetric Climate Policies on Trade and Environment: Evidence From EU

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Abstract

This paper critically addresses the need for a unified global climate policy, as opposed to region-specific emission trading systems, with a primary aim to contribute valuable insights to the ongoing discourse. Focused on the aluminum, cement, and iron and steel industries outlined in the EU's Carbon Border Adjustment Mechanism (CBAM) proposal, our comprehensive analysis using gravity model for trade, centers on testing the validity of the Pollution Haven Hypothesis and Porter Hypothesis. Drawing on data from 10 major EU economies and 19 OECD partners across continents, our study demonstrates that carbon leakage predominantly occurs through trade channels, wherein countries import carbon-intensive products from less regulated nations. Our findings substantiate the Pollution Haven Hypothesis, revealing unintended pollution havens resulting from stringent environmental regulations, leading to carbon leakage through trade or production relocation. In contrast, supporting the Porter Hypothesis, our research underscores how stringent environmental policies can drive innovation within polluting countries, obviating the need for relocation or product imports. By substantiating both hypotheses, our paper advocates for a globally uniform climate policy and emphasizes the potential drawbacks of asymmetrical approaches. The central aim is to contribute to the understanding of how such policies may inadvertently contribute to trade-induced leakage, undermining the positive impact of local systems on a global scale. In light of ambitious climate targets, our study underscores the urgency for synchronized global efforts, reinforcing the call for consistent policies to effectively address the challenges of climate change.

Keywords: Global climate policy; Carbon leakage; Pollution Haven Hypothesis; Porter Hypothesis; Emission trading systems, Gravity Model

JEL Code: Q54, Q56, F18, Q58, O44

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1. Introduction

The importance of greenhouse gas emissions and their negative externalities on global warming, human health, the environment, water, and air quality has been marked over the last three decades (Sohag et al., 2019). Industrial revolution and globalization created welfare for most nations, but left question marks regarding the social and environmental impacts for many countries (Christmann & Taylor, 2001). Among the many types of emissions that are hazardous for the environment, carbon dioxide emissions (CO_2) stand as the highest contributing factor to the climate change (Cai et al., 2018). Given the negative outcomes of the increased carbon emissions, worldwide steps are taken through various initiatives to mitigate carbon dioxide emissions and shift to greener and clean economies (Suárez-Varela & Rodríguez-Crespo, 2022). Conference of the Parties (COP), an initiative of the United Nations (UN), gathered the world leaders to take actions to solve the environmental problems and provide support for the most vulnerable countries that witness the negative consequences of climate change. Following these assemblies, participating countries mostly agreed upon various actions, such as urging nations keep the emissions under control and to keep the global warming well below 2°C degrees with the Kyoto Protocol (1997) and Paris Agreement (2015) (Taşkın et al., 2021). Recently, Glasgow Meeting (2021) further stress to reach to “net zero” carbon emissions as of 2030, which stays as a far-fetched objective. Despite the enormous efforts to minimize carbon emissions, 2022 witnessed a new high of 321 Mt of global energy-related CO_2 emissions (IEA, 2023)

The inevitable necessity to cut down emissions created various mechanisms in Europe that are also shaped by the European Union (EU) Green Deal, 2030 Agenda and provided instruments like Emission Trading System (ETS) and carbon tax. The ETS mechanism in EU has gone through 4 phases. Phase 1 (2005-2007) involves the free allocation of all allowances and fee for non-compliance was €40 per ton of carbon dioxide. The allowance system went through a change that considers market auctions and a higher penalty of €100 per ton in Phase 2 (2008-2013). About 40 percent of the all-greenhouse gas emissions in EU were captured by the system as of the end of Phase 3 (2014-2020) and 57 percent of the allowances were auctioned primarily. The last phase of the ETS, Phase 4 (2021-2030) calls for reductions of emissions by 43 percent in industry, power, and intra-Europe aviation sectors. The price surge during these phases, made the non-compliance very costly for the firms, gave rise to shifts in the investment behavior of firms (Verde, 2020) Overall, ETS mechanism in EU has strict implications for the companies that are not compliant to the system, thus many polluting industries in major European countries faded their productions in EU, shifting their attention to lest stringent countries. Given the imposed sanctions in the EU ETS system and the price put on pollution in the EU give rise to limited amount of tradable carbon allowances and crafts, one of the most developed regulatory systems (De Beule et al., 2022).

It's widely believed that industries releasing a lot of pollution within a country that has tougher environmental regulations than its trading partners often face significant increases in production costs (Naegele & Zaklan, 2019). As a result, these industries tend to become less competitive internationally, which could lead to a loss in their share of the market. To prevent this loss, these industries might decide to move to countries with less strict environmental standards. In either case, the export of goods that cause a lot of pollution from a country with strict environmental rules usually goes down, while the import of these goods is expected to go up. Carbon leakage is especially discussed for considering the offshore investments of developed countries to developing or underdeveloped countries to shift their carbon dioxide emissions from the high-regulation areas to unregulated areas (Ellerman et al., 2016). Changes in trading patterns due to the strictness of environmental regulations might result in the emergence of pollution havens (Copeland & Taylor, 1994). Besides, stringent environmental regulations prompt the exploration and adoption of cleaner technologies and environmental enhancements (Porter & Linde, 1995). Yet, the creation of pollution havens or generation of carbon leakage is not only limited to non-EU countries, but also to EU or EU candidates with less stringent environmental policies.

Carbon leakage may lead the businesses to relocate their production facilities to countries with less stringent environmental regulations and create pollution havens in them or lose market share to competitors in those regions. The relocation of business production facilities to less stringent environmental regulations to preclude the costs related to emissions in countries with stricter regulations might lead to higher carbon dioxide emissions in the countries where the production is relocated. Moreover, it is also possible that businesses in a country where there are tighter environmental regulations like ETS' may lose their market share to other competitors operating in less strict markets, since those competitors are capable of producing their goods less costly (Naegele & Zaklan, 2019). It is obvious that relocation is not a trouble-free action for firms as firms relocating from stricter environmental regulations witness relocation costs and opportunity costs that include upfront expenses, increased reliance on foreign suppliers, weakened national competitiveness and may be loss of market share (Calel & Dechezleprêtre, 2016). During the first two phases of the EU ETS, some countries overallocated carbon allowances to their industries, which created room for multinational companies (MNEs) to take advantage of the lower environmental standards. This conduct witnesses in industries that do not get compensation for environmental costs, pointing to the possibility that EU may have inadvertently promoted intra-regional pollution haven effect (De Beule et al., 2022). In cases where countries impose carbon taxes, succesfully reduce the externalities of firm activities within coutries' borders. However, these taxes do not decrease the carbon emissions where goods are consumed. Moreover, it is evident that, increase in imports in countries with carbon taxes indicating that firms may be outsourcing production to countries with less stringent regulations Schroeder & Stracca, 2023). Carbon leakage due to the increasing stringency from regulated areas to non regulated areas also documented. The lekage appers to be happening from EU to Africa via relocation of production especially with multinational firms' subsidiaries (Kanzig et al., 2023).

In line with the goals of EU to mitigate carbon dioxide emissions a new tariff on energy-intensive industry imports which is called the Carbon Border Adjustment Mechanism (CBAM). CBAM is expected to tackle carbon leakage and will impose a tax on imports that pay less for carbon emissions than they would in the EU (Lin & Zhao, 2023). CBAM is effective as of 2023 and will be fully operational as of 2026, which applies to iron and steel, hydrogen, aluminium, electricity, fertilizer, and cement industries. Aluminum and steel production considering the trade and emission intensity, these industries stand as the riskiest sectors in the EU, which makes them worthy of investigation (European Commission, 2015). Aluminum production in Europe has declined by 40% since 2000, while demand has increased by 30%, which has led to an increasing reliance on imports to meet demand (Saevarsdottir et al., 2019). Cement industry is also very vital in terms of being a significant green house gas emitter, due to the accelerated consumption alongside with the intensive emissions per tone from the production process and fuel combustion (Demailly & Quirion, 2006). The European cement sector has made significant developments in upstream activities, focusing on innovations in plant operations, increased energy and material efficiency, higher utilization of alternative fuels with low carbon intensity, and greater substitution of clinker to minimize emissions (Supino et al., 2016). The projections of Szabó et al. (2006) signifies that the uninterrupted growing trend in cement industry will continue as of the last estimation date, 2030, and further highlight that developing regions will import an increased portion of their consumption. Thus, the cement sector will continue its significance in terms of trade and production in the EU.

In this paper, the objective is to explore whether the strictness of regulations in one of the world's robust emission trading systems, the European Union Emission Trading System, has an impact on the overall import of carbon-intensive goods from the European Union's major trading partners. By examining the relationship between the stringency of regulations within the EU Emission Trading System and the trade dynamics involving carbon-intensive products, the paper sheds light on how environmental policies and emission trading mechanisms interact with trade patterns.

This study distinguishes itself from existing literature for several reasons. Firstly, OECD Environmental Policy Stringency Index has been employed as a proxy for measuring the stringency of environmental regulation based on the environmental policy instruments, primarily related to climate and air pollution. Secondly, EU-ETS countries and their net imports were investigated separately, centering on the import of carbon-intensive products which are pointed by the CBAM proposal. This approach enabled a focus on the trade of carbon-intensive products between major trade partners of the EU. Thirdly, the study explores the period between 2005 and 2021, providing a wide spectrum of samples for analysis. This extensive timeframe allows for the gain of unique insights into the impacts of the ETS on trade patterns.

2. Literature Review

The issue of whether environmental regulations unintentionally lead to the emergence of pollution havens, particularly through the trade of carbon-intensive products from strictly regulated areas to more leniently regulated areas, is a key topic explored in financial literature. Researchers address this inquiry by examining trade data between trading nations or data related to foreign direct investment. Identifying the source of carbon leakage and classifying the channels through which it occurs is essential to investigate the pollution haven effect. Since the primary focus of this paper concerns the trade of carbon-intensive products between member countries of EU ETS and non-EU ETS countries, the paper aims to present a brief literature in terms of trade patterns and the relationship with trade agreements and ETS's.

Studies conducted before settlement of the ETS' mainly focus on the periods where trade agreements were in force. Grossman and Krueger (1991) conducted research on examining the influence of environmental regulations on the trade patterns between the United States and Mexico, within the context of the free trade agreement. Their research findings showed that the pollution abatement cost had a statistically insignificant effect on the volume of imports from Mexico to the USA. Tobey (1990) suggested that the cost of polluting constitutes a relatively small portion of the total cost. Producing the product instead of importing from environmentally less stringent countries would not be economically rational. Harris et al. (2002) presented that the relationship between bilateral trade and environmental regulations is statistically insignificant. Contrary to studies conducted before ETS' were in charge and providing no evidence to support Pollution Haven Effect, Van Beers and Van Bergh (1997) investigated the impact of countries' environmental policies' stringency on exports and imports. Their proxy for the stringency of environmental policies consisted of recycling rates, changes in energy intensity, the ratio of protected areas to national territory, and the level of energy sources, such as unleaded petrol. The results pointed out that strict regulations are directly related to a negative impact on trade between countries. Jug and Mirza (2005) investigated the pollution haven effect in the years between 1996-1999, within the continent of Europe. Authors found strong evidence to support the hypothesis of strict environmental regulations might create pollution havens. Moreover, their findings presented that the abatement cost has the same impact on whether trading dirty or clean industries. Levinson and Taylor (2008) conducted a comprehensive study covering the period between 1977 and 1986, showed that imports to the U.S from Canada and Mexico experienced a significant increase when abatement cost rose. Cole (2003) provided evidence on the significance of the relationship between Environmental Kuznets Curve and Pollution Haven Hypothesis (PHH). However, the effect of the PHH appeared to be relatively small when compared to other explanatory variables within the research. Kyoto agreement shares similar functioning principles with ETS', as the Kyoto Protocol itself enforces own binding commitments. Aichele and Felbermayr (2015) investigated whether the Kyoto Protocol creates pollution havens due to its binding regulatory power. The research demonstrated that Kyoto protocol has led to an increase in the import of carbon intensive products from non-committed countries.

Following the establishment and widespread implementation of ETS', concerns have increased on the emergence of pollution havens. In contemporary literature, significant attention is directed towards exploring the potential advantages and disadvantages of carbon pricing mechanisms. Due to having the world's largest ETS and the distinctive separation of geographical regions, China has attracted researchers' interests. Studies conducted within mainland China focus on the potential carbon and investment leakage from pilot ETS regions to non-ETS areas and whether if China became pollution haven for other countries. Caiv et al. (2018) provided evidence on China has become pollution haven for 22 developed countries. On the other hand, the study also revealed that 19 developing countries have become pollution haven for China. Gao et al. (2020) investigated carbon leakage in 28 industries, between 2005-2015 in among 30 regions of China. Authors employed difference-in-differences and difference-in-difference-in-difference methods. Their results supported the idea that ETS encourage outsourcing from less stringent areas. Besides, authors presented that ETS contributes to meeting climate targets and emission mitigation in pilot areas.

Studies conducted in the EU and covering early phases of the EU ETS tend to provide statistically insignificant results on the emergence of pollution havens. Rubashkina and Galeotti (2015) and Martinez-Zarzoso et al. (2016) presented empirical evidence in favor of the weak version of the Porter Hypothesis (Porter and Linde, 1995) which suggests that environmental policies triggers firms to engage in innovation and adopt sustainable practices in their production processes. Naegele and Zaklan (2019) found no evidence of carbon leakage resulting in emergence of pollution hens within the EU ETS, focusing on European manufacturing. Branger et al (2016) presented that carbon prices do not have a significant effect on the net imports of cement and steel for the first and second phases of EU ETS. Esmaeili et al. (2023) examined the impact of foreign direct investment (FDI), economic complexity and renewable energy usage on CO_2 emissions in N-11 countries. The results supported the pollution hypothesis by noting the detrimental effects of FDI on environmental quality. Aminu et al. (2023) investigated the link between sustainable financing in energy use and CO_2 emissions in Sub-Saharan African countries. The results support the validity of both Environmental Kuznets Curve (EKC) and Pollution-Haven Hypothesis in the region, where the increases in economic activity are associated with increase carbon emissions and financial development can mitigate this impact. Naqvi et al. (2023) focused on 87 middle-income countries for the 1990-2017 period and noted the existence of EKC and pollution hypothesis. The results indicated that FDI is the cause of the increased ecological footprint in these countries.

Studies covering the later phases of the EU ETS are more likely to provide evidence of the relationship between strict regulations and pollution havens. De Beule et al. (2022) provided evidence on existence of pollution has an effect specifically examining the channel of investment leakage resulting in carbon leakage in EU ETS. In their study, Beck et al. (2023) found significant amount of carbon leakage via carbon dioxide-related taxes in Denmark. Antoci et al. (2021) conducted their research to investigate the relocation decisions of firms facing abatement costs. Their simulations showed policies that lower the cost of green technologies are more effective in encouraging firms to reduce emissions. Bolat et al. (2023) investigated the EU frontrunner countries, by considering the coordination with the ETS and addressing risks regarding carbon leakage. The results reported macroeconomic carbon rebound effect for the EU ETS, which represents a more significant issue than leakage.

Increase in the carbon prices, the stricter the environmental standards have become, decrease in the amount of free allocated allowances strengthen the position of leakage impact from regulated areas to non-regulated areas. Recent study conducted by Wang and Kuusi (2024) investigated the leakage effect from EU ETS by employing gravity analysis particularly focusing on the trade channel instead of centering re-location of production. They revealed that the leakage occurred due to implementation of the EU ETS through the increase in import of carbon-content of 13%. However, their study also displayed a decrease in the export of carbon-content from EU ETS which aligns with the Porter Hypothesis. From an interior perspective from EU ETS, Kruse-Andersen and Sorensen (2022) suggested that countries imposing stricter environmental regulations in addition to the EU ETS regulations while aiming to reduce emissions more aggressively than the EU ETS, should design their climate policies aligning with the EU ETS standards. Otherwise, the asymmetrical climate policies among countries, no matter if they participate in the same ETS, led to carbon leakage. Authors proposed that the carbon price should be higher in sectors covered by the ETS compared to those that are not covered. The variations in pricing may help to achieve more aggressive domestic emission reduction targets while maintaining economic competitiveness and managing carbon leakage risks. Ambec et al. (2024) investigated policies that affecting carbon leakage primarily focusing on the CBAM and its functioning mechanism. They suggested that CBAM may limit leakage occurring due to imports, however it may increase leakage embodied in exports. It has been pointed out that regardless of the enforcement of mitigating regulations, leakage would happen due to the asymmetry in policies.

Prior to the introduction of the ETS, the focus of the literature was primarily on understanding the effects of environmental regulations on trade patterns, particularly in the context of free trade agreements. However, with the implementation of the ETS, studies shifted their attention to analyzing trade between countries that participate in the ETS and non-ETS countries. In addition to investigating carbon leakage and the emergence of pollution havens, the literature also explored the validation of the Porter Hypothesis, suggesting that strict regulations may trigger firms to adopt environmentally friendly practices and encourage their involvement in sustainable production and services which stands in contrast to the Pollution Haven Hypothesis.

3. Data and Methodology

3.1. Model and Data

The gravity model of trade or also known as "Trade-Flow Equation" is a model that frequently employed in the financial literature due to its high explanatory power with respect to bilateral trade and its ability in explain the factors influencing trade volume. The model is based on Newton's universal law of gravity, which assumes that the gravitational force between two objects is positively related to the mass of the objects and negatively related to the distance separating them.

The initial version of the gravity model of trade which was proposed by Isard (1954) developed with a lack of theoretical background , however, Tinbergen (1962) and Anderson (1979) contributed to the theoretical background of the gravity model of trade by suggesting that the model could be derived from the Heckscher-Ohlin-Samuelson (HOS) model, initially proposed by Heckscher et al. (1991) and further enriched with the Stolper and Samuelson (1941) (Capoani, 2023). HOS model derivation has four base theories. The initial theory which is known as Heckscher – Ohlin theory, assumes that the trade pattern and specializing in production of various products based on varying factor endowments. The second theory examines how the price of factors that are involved in the trade and price of traded goods equalize across countries. The Stolper and Sameulson theory, stands as the third proposition, characterizes the relationship between goods prices and factor prices while holding a constant level of factor endowments. The fourth core theory, the Rybczynski (1955) theory, centers on the intersection between goods outputs and factor endowments at constant goods prices. (Mikić, 1998). After the development of the gravity model of trade, it has been accepted and used widely in the studies (Bergstrand, 1990; Eaton & Kortum, 2002) To date, the gravity model, initially proposed by Tinbergen (1962) and subsequently formalized by Linnemann (1966), remains the most widely recognized and extensively applied model in scholarly literature (Capoani, 2023).

Kabir et al. (2017) suggested that the development and application of the gravity model of trade can be categorized into four distinct groups:

Generalized Gravity Model

Trade between countries is aimed at being explained by taking their economic magnitude (i.e., GDP) and the geographical distances between them into account. The generalized gravity model can be extended by incorporating variables such as whether countries share a border, have a common language, or use a common currency.

Intra-industry trade

Models examined in the context of intra-industry trade particularly concentrate on the bilateral trade flow among monopolistically competitive markets while suggesting specialization and intra-industry trade intensify, the ratio of bilateral trade to the product of trading partners' income tends to increase.

Product-based model

Gravity model of trade can also be applied to account for product differentiation resulting from variations in factor endowments, as well as the influence of preferences, distance, pricing, and tariffs.

Structural gravity model

Models based on the structural gravity model are specifically constructed around the concept of elasticity in consumer preference switching while analyzing shifts in the overall economic equilibrium.

The equation below represents a basic gravity model of trade for countries *i* and *j* by taking their GDP's and geographical distance between countries into account (Tinbergen, 1962):

$$T_{ij} = \alpha \frac{GDP_i GDP_j}{D_{ij}} \tag{1}$$

where T_{ij} stands for the interaction between country i and j; $GDP_i GDP_j$ stands for GDPs for countries respectively i and j and D_{ij} stands for representing the distance between countries i and j; α is the constant for the equation. However, commonly accepted principles underlying the gravity model are based on versions of the demand-driven model proposed by Anderson (1979) through the incorporation of a demand-driven model, which assumes that products can be easily replaced with one another and that there are differences in products based on where they come from.

This paper adopts Van Beers and Van Bergh (1997) gravity model of trade and aligns with the objectives of the study. The Van Beers and Van Bergh (1997) model can be formulated as follows:

$$\begin{aligned} lnIMP_{ijt} = {} & \beta_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnPOP_{it} + \beta_4 lnPOP_{jt} \\ & + \beta_5 lnDIST_{ij} + \beta_6 ADJ_{ij} + \beta_7 TRADE_{ij} + \beta_8 SC_{it} + \beta_9 SC_{ij} + e_{ij} \end{aligned} \tag{2}$$

where ln is the natural logarithm and β_0 is the constant of the equation. Rest can be defined as:

IMP_{ijt} = Net import from the country i to j at year t

GDP = Gross Domestic Product of country i and j at year t

POP = Population of countries i and j in millions

$DIST_{ij}$ = Distance between country i and j

ADJ_{ij} = Dummy variable, 1 if countries are adjacent, otherwise 0

$TRADE_{ij}$ = Dummy variable, 1 if countries have trade agreement, otherwise 0

SC = Stringency of environmental regulations of countries i and j

e_{ij} = Log-normally distributed disturbance term

Van Beers and Van Bergh (1997) version of the gravity model of trade can be augmented by shared language or a shared border. Considering the aim of the paper, which is to find the impact of the stringency of environmental regulations and policies on trade patterns, the paper employs OECD Stringency Index as a proxy for measuring the environmental stringency. The gravity model of trade proposed by Van Beers and Van Bergh (1997), as well as Jug and Mirza (2005) is extended by incorporating the OECD Stringency Index.

The gravity equation utilized in this paper has undergone several modifications. Firstly, the dependent variable, denoted as $NETIMP_{ijt}$ which represents the net import of carbon-intensive products from non-EU-ETS countries to EU-ETS countries in year t, has been modified to measure the net tonnage rather than its value in US Dollars. Secondly, the independent variables employed in the gravity model of trade, such as geographical distance, remain time-invariant. Variables that repeat due to the panel data structure GDP, GDP per capita, and the OECD stringency variable for partner countries, may potentially lead to estimation issues. Consequently, in line with existing literature (Wei, 1996; Baxter & Kouparitsas, 2005; Trotignon, 2010) independent variables are modified.

Equation (3) is formulated as follows, where β_0 is the constant of the equation and e_{ij} is the log normally distributed disturbance term:

$$NETIMP_{it} = \beta_0 + \beta_1 REMOTE + \beta_2 POPGROWTH + \beta_3 GDPDISTANCE + \beta_4 STRINGENCy + e_{ij} \quad (3)$$

$NETIMP$ = Net import (amount in tons) of country i at year t
$REMOTE$ = (GDP of country i at year t) / (GDP world at year t) * Distance between country i and j
$POPGROWTH$ = Population growth rate ratio of countries i and j at year t
$GDPDISTANCE$ = (Maximum values – Minimum values) of countries of GDP per capita i and j at year t
$STRINGENCY$ = OECD Stringency Index of country j at year t

The independent variable that differentiates the paper, referred to as *STRINGENCY* is obtained from the OECD Environmental Policy Stringency Index. The OECD Environmental Policy Stringency Index (EPSI) serves as a measure that is both specific to individual countries and capable of international comparison, evaluating the rigor of environmental policies. This index assesses the level of strictness across 13 environmental policy tools, with a primary focus on matters such as climate change and air pollution. The index has superiority in the sense that it combines three main causes, which are market based, non-market based and technology support related policies, that can affect the households and organizations related to environment. Market-based policies focus on taxation of detrimental behaviors, non-market-based policies consider standards regarding green applications and technology support aims to trigger innovation and technological progress regarding green technologies (Mihai et al., 2023; Hassan et al., 2024). The variable *REMOTE* has been computed for each partner country (non-EU-ETS) by multiplying the geographical distance between the partner country and the home country (EU-ETS) by the ratio of the partner country's GDP to the world GDP. *POPGROWTH* has been calculated by taking the ratio of the population growth rate for home and partner countries. By calculating the difference between the maximum and minimum values of GDP per capita for both partner and home countries (i and j) at year t results in the variable of *GDPDISTANCE*. By calculating this difference, the deviation of GDP per capita for two countries from each other at year t can be captured. This provides insights into the disparity between the two countries in terms of income per capita. In the context of selecting the net import-dependent variable, the focus is towards carbon-intensive products. Specifically, products that are at risk of leakage according to the European Union Carbon Border Adjustment Mechanism (European Comission, 2021) are prioritized. Distinctly, the focus is on three primary carbon-intensive products: iron and steel, aluminum, and cement[3]. We have included SITC codes that are specifically addressed in the CBAM proposal. **Table 1** provides definitions, calculation methods, and sources for both dependent and independent variables.

We have included ten major EU economies as part of the EU-ETS, along with nine major trade partners of the EU. EU-ETS countries are Austria, Belgium, Denmark, France, Germany, Netherlands, Italy, Sweden, Spain, and Poland. Non-EU-ETS countries are: China, India, Indonesia, Japan, Korea Republic, Russia, Turkiye, United Kingdom and United States. The study's data comprises annual measurements spanning seventeen years (2005–2021) which encompasses the first phase of the EU-ETS (2005-2007), the second phase of the EU-ETS (2008-2012), and the third phase of the EU-ETS (2013-2020). We have incorporated data from 2021, which marks the beginning of the anticipated fourth phase, set to conclude in 2030.

Table 1: Summary of Variables

Variable Name	Variable Type	Calculation Method[4]	Data Source
NETIMP	Dependent Variable	Subtracting the export tonnage from the import tonnage of the sum of the tonnage of all sub-articles related to the product.	WITS Database
REMOTE	Independent Variable	Geographical Distance between the home and partner countries multiplied by the product of GDP partner and GDP World.	CEPII Database IMF Database
POPGROWTH	Independent Variable	Dividing the population growth rate of the home and partner countries.	World Bank
GDPDISTANCE	Independent Variable	Difference between the maximum and minimum values of GDPs of countries.	IMF database
STRINGENCY	Independent Variable	Obtained the stringency coefficient for each country.	OECD Database

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[3] The sub-articles related to iron and steel (72,73), aluminum (76), and cement (25) based on their SITC codes are not displayed in this paper. However, they can be provided upon request.

[4] For each variable, we take the natural logarithm (ln) of the result, except for the Stringency and Population Growth variables, as these are single-digit and easy to interpret.

3.2. Methodology

Balanced panel data for each country participating in the EU-ETS was utilized in the study, focusing on the import of carbon-intensive products (sum of all relevant articles) from both non-EU-ETS and EU-ETS countries between 2005 and 2021. Individual regressions were conducted for each of the 10 EU countries, examining their net imports from both EU and non-EU countries. These regressions were performed separately for three carbon-intensive products: Aluminum, Cement, and Iron and Steel.

$$NETIMP_{it} = \beta_0 + \beta_1 REMOTE + \beta_2 POPGROWTH + \beta_3 GDPDISTANCE + \beta_4 STRINGENCY + \mathrm{Dummy}_{\mathrm{EU}} + e_{ij} \quad (4)$$

The validity of the Pollution Haven Hypothesis will be verified under a significant inverse relationship between the sign of β_4 and *NETIMP,* suggesting that an increase in trading partners environmental stringency is expected to have a negative impact on net imports. A statistically significant negative sign associated with STRINGENCY indicates that the home country imports carbon-intensive products instead of producing them domestically, regardless of whether the country belongs to the EU-ETS or not. A positive sign of the coefficient for *STRINGENCY* serves as an indicator supporting the validation of the Porter Hypothesis which implies that an increase in *STRINGENCY* leads to an increase in net imports for the related carbon-intensive product. Distinguishing between EU and non-EU countries could hold significance, especially within the context of uniform carbon trading in the EU-ETS. However, each country is accountable for its own carbon limits, which implies that each country, particularly companies, operating in the related country must bear the cost of buying carbon credits. Nevertheless, a dummy variable (1 if the country is part of EU-ETS, 0 otherwise) is included in the analysis to contribute to differentiating the impacts for EU-ETS and non-EU-ETS countries.

REMOTE encompasses two components in its calculation: 1) the relative size of the economy of the trading country compared to the world and 2) the geographical distance between countries, indicating spatial separation. The coefficient of the *REMOTE* variable, denoted as β_1, is notably influenced by the GDP of the partner countries. The population growth rate, denoted as *POPGROWTH*, is defined as the ratio of the population growth rate of the home country to that of the trading partner. The variable *GDPDISTANCE*, calculated as the difference between the maximum and minimum values of GDP per capita among trading countries, is utilized to capture the influence of the disparity in GDP per capita between countries on the net import of carbon-intensive products.

Before modeling the data, panel cross-sectional dependence tests for each country are conducted. The cross-sectional dependence tests were investigated via Breusch and

Pagan (1980), Pesaran (2004) scaled Lagrange Multiplier (LM) and Pesaran (2006) Cross Dependence (CD) tests. Based on cross-sectional dependence the appropriate unit root test determines the integration order between variables. For those countries with no cross-sectional dependence, first-generation unit root tests including Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979), Levin-Lin-Chu (LLC) test (Levin et al., 2002) and Fischer-Phillips-Perron (PP) test (Phillips & Perron, 1988) are used. Conversely, second generation unit root tests for countries showing cross-sectional dependence are conducted. Panel version of the unit root tests is formulated as follows:

$$\Delta y_{i,t} = \rho y_{i,t-1} + \alpha_{mi} d_{m,t} + \varepsilon_{i,t} \tag{5}$$

where Δ stands for the first difference operator, individuals $i = 1, \ldots, N$ and contains $t = 1, \ldots, T$ time series observations, d_m stands for the deterministic variables, α_{mi} stands for the coefficient vectors. ρ is the distinctive operator for the LLC test, including the homogeneity restriction. Null hypothesis assuming that $\rho = 0$ where the alternative is $\rho < 0$, increasing the possibility of rejecting the unit root rather than other tests (Fidrmuc, 2009). Null hypothesis for the unit root tests implies that there is no unit root in the series, where alternative hypothesis implies the existence of unit root while suggesting series are stationary.

For countries that show cross sectional dependence, the second-generation unit root test introduced by Pesaran (2007) are carried out, which is an extension of the ADF regressions while including the average values the lagged and first differences of cross-section for each panel series (Taşkın et al., 2020). The formulated version of the corss-sectional ADF (CADF) presented as follows:

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \beta_i \bar{y}_{i,t-1} + \gamma_i \Delta \bar{y}_{i,t} + \varepsilon_{i,t} \tag{6}$$

Variables $\bar{y}_{i,t-1}$ and $\Delta \bar{y}_{i,t}$ are proxies for the common factors between the cross-sectional units.

If series are integrated at the same order, the estimates proceed by employing OLS, FM-OLS and DOLS. OLS estimators may exhibit biased and inconsistent results when used in panel data analysis (Abidin et al., 2016). Hu et al. (2018) suggested that the employment of the FMOLS estimator has the capability to eliminate the issue of endogeneity and effectively address concerns related to serial correlation and cross-sectional heterogeneity in panel regression analysis. Additionally, employing the DOLS estimator is expected to mitigate the endogeneity bias, a common concern within Gravity models (Stack & Pentecost, 2011). Moreover, Kao and Chiang (2000), presented evidence on the panel DOLS estimator exhibits superior sample properties compared to both panel OLS and FMOLS estimators. Even when the size of the sample is limited, FM-OLS and DOLS methods offer more accurate estimations by effectively addressing endogeneity, serial correlation and omitted variable issues. For the cases when the series are not integrated at the same order even after taking the first and second differences, we employed ARDL estimator. ARDL (p, q) where p and q specify the lag lengths (Insel & Tekce, 2009). Including lagged values let us estimate the dynamic relationship. The selection process of whether applying fixed effects model or random effects model is based on the results of the Hausman test. Hausman (1978) developed a group of statistical tests to specify the model selection. Tests are used for the choice of models in panel data when comparing the estimates of the fixed or random effects model (Sheytanova, 2014)

4. Empirical Results

The results of the cross-sectional dependence tests indicate the existence of the dependence among the series for all countries. Consequently, second-generation unit root tests are conducted to determine whether series are stationary or not, in addition to specifying the order of integration. Series were found to be stationary at 1% and variables are found to be integrated at level I(0) for Austria, Belgium, Denmark, Italy, Germany, and France. For these countries we employed OLS, FM-OLS, and DOLS. For Poland, Netherlands, Spain, and Sweden, the variables were integrated at different orders, therefore ARDL is applied. Additionally, the results of the Haussmann tests indicate that the random effects model is preferable for all variables concerning countries Austria, cement, and aluminum for Belgium, Denmark, France, Germany. Moreover, it suggests the random effects model for iron and steel and aluminum in Italy. However, the Haussmann test indicates that the fixed effects model is suitable for iron and steel in Belgium and for cement in Italy.

The estimation results validate the existence of both the PHH and Porter Hypothesis for various countries and carbon intensive products. The variable *STRINGENCY* exhibits statistical significance across EU-ETS countries in the analysis, as presented in empirical results for each country in Table 2-11. Trade patterns, especially for carbon-intensive products, seem to be influenced either positively or negatively by the environmental stringency within those countries. In each product category, we presented strong evidence on the inverse relationship between the coefficients of *GDPDIST* and *STRINGENCY* across a majority of countries. In the case of aluminum, Austria, Belgium, France, Germany, and Italy display a statistical significance of the variable *STRINGENCY* with a negative coefficient. For cement, Belgium, Denmark, Germany, Spain, and Sweden display positive coefficient for *STRINGENCY* while Italy, France, and Poland display negative coefficient for *STRINGENCY*. For cement, Belgium, Denmark, Germany, Spain, and Sweden display positive coefficient for *STRINGENCY* while Italy, France, and Poland display negative coefficient for *STRINGENCY*. In the case of iron and steel, Austria, Denmark, Poland (in the short run), and Italy exhibit negative sign of the *STRINGENCY*. Belgium, France, Germany Netherlands, Poland (in the long run) Spain, and Sweden exhibit positive and statistically significant coefficient for *STRINGENCY*. These results suggest that for the cases with a negative sign of the *STRINGENCY*, when trading countries implement less stringent environmental policies, the net import of carbon intensive products tend to increase which provides evidence for the existence of the PHH. On the other hand, cases with positive signs of *STRINGENCY* validate the existence of the Porter Hypothesis. Our findings are in line with the conclusions presented by Martinez et al. (2017), providing support for both the Porter Hypothesis and the Pollution Haven Hypothesis, particularly in relation to carbon-intensive products. Our research aligns with the results presented by Jug and Mirza (2005) and, demonstrating that stringent environmental regulations within countries exert a negative impact on the trade dynamics of industries known for their high levels of pollution. In addition to the perspectives outlined by Tobey (1990) and Van Beers, and Van Bergh (1997), our research goes deeper, showing a more detailed connection. We discovered that imports categorized as 'dirty' referred to as carbon-intensive products— are notably influenced not only by the environmental stringency of the importing country but also by that of the exporting nation. These environmental policies from different countries affecting each other highlight how trade and environmental policies together affect the movement of carbon-heavy products.

Table 2: Results of Austria[5]

	OLS			**FM-OLS**			**Dynamic OLS**		
	Aluminum	**Cement**	**Iron & Steel[6]**	**Aluminum**	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**
GDPDIST	-2.0851	2.8380	1.3061	4.1002*	-73.2885*	-4.4272**	5.7103*	-88.3979*	-6.0519*
	(-0.9352)	(0.2109)	(0.3901)	(3.2233)	(-5.0825)	(-2.350)	(3.9743)	(-6.2427)	(-3.1039)
POPGROWTH		0.0016	0.0010	0.0071	-0.0811	-0.0054	0.0109	-0.0750	-0.0069
	(0.0113)	(0.0434)	(0.1132)	(0.434)	(-0.4326)	(-0.2243)	(0.4872)	(-0.3401)	(0.2289)
REMOTE	-9.3969**	-70.3118**	-53.0088*	-1.1894	0.8739	3.2706	-2.5539	0.3065	2.2723
	(-2.2809)	(-2.2014)	(-5.5402)	(-0.6474)	(0.0419)	(1.2021)	(-1.154)	(0.014)	(0.7566)
STRINGENCY	3.3494	-5.7930	-14.6793*	**-9.4462***	**213.2270***	**11.1993***	**-12.1334***	**260.4904***	**17.3126***
	(1.3122)	(-0.3777)	(-3.8335)	**(-3.2468)**	**(6.4653)**	**(2.5992)**	**(-3.5494)**	**(7.7322)**	**(3.732)**
EU-Dummy	-33.2573**	46.9533	12.0383						
	(-2.1659)	(0.4302)	(0.392)						
C	67.6952**	146.6276	216.4978						
	(2.113)	(0.6649)	(4.2779)						
Number of Obs	306	306	306	288	288	288	288	288	288
R-Square	0.025	0.019	0.720	0.072	0.271	0.050	0.342	0.570	0.421

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[5] For Austria, cross-sectional dependence was detected for each carbon-intensive product at a significance level of 1%. The results of the second-generation unit root test indicated that all variables are integrated at the zero order, I(0). Since they are integrated at the same order, we proceeded with the OLS, FM-OLS and DOLS. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively. Haussmann results indicates that the random effects model should be preferred for all variables.

[6] Hausmann test results indicate that Iron and Steel requires Fixed Effects model in cross-sectional estimation for OLS.

	OLS			**FM-OLS**			**Dynamic OLS**		
	Aluminum	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**
GDPDIST	0.4713	2.2341	4.6872***	2.5731**	-2.9678	4.3809**	3.0279*	-1.6464	3.7345***
	(0.2769)	(0.5965)	(1.7841)	(2.4495)	(-0.764)	(2.2914)	(2.8432)	(-0.553)	(1.9483)
POPGROWTH	-0.0002	0.0014	0.0052	-0.0008	0.0096	0.0163	-0.0007	0.0125	0.0028
	(-0.0529)	(0.1524)	(0.7718)	(-0.0529)	(0.1677)	(0.5774)	(-0.0389)	(0.2276)	(0.0808)
REMOTE	3.7983	-10.8806	0.4635	1.4132	3.4673	-11.3218*	1.6246	0.7871	-10.9037*
	(1.1133)	(-1.3148)	(0.0886)	(0.8846)	(0.5869)	(-3.8938)	(0.9622)	(0.1667)	(-3.5881)
STRINGENCY	**-4.5220***	3.8674	3.5439	**-9.8533***	14.6320	**-9.1712****	**-11.4906***	11.4006	**-8.4160****
	(-2.7646)	(1.0795)	(1.4029)	**(-4.0139)**	(1.612)	**(-2.0527)**	**(-4.3371)**	(1.5394)	**(-1.7649)**
EU-Dummy	-0.4334	15.2399	-4.6465						
	(-0.0248)	(0.2514)	(-0.1765)						
C	-4.9727	25.3193	-82.8740***						
	(-0.1795)	(0.3544)	(-1.9517)						
Number of Obs	306	306	306	288	288	288	288	288	288
R-Square	0.031	0.01	0.022	0.141	0.007	0.094	0.428	0.583	0.449

Table 3: Results of Belgium[7]

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[7] For Belgium, cross-sectional dependence was detected for aluminum at a significance level of 1%, Pesaran CD results for both cement and iron and steel are insignificant, however Pesaran LM and Breush Pagan LM is statistically significant at 1%. Nevertheless, we employed both first- and second-generation unit root tests for each variable. The results indicated that all variables are integrated at the level, I(0). Since they are integrated at the same order, we proceeded with the OLS, FM-OLS and DOLS. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively.

	OLS			**FM-OLS**			**Dynamic OLS**		
	Aluminum	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**
GDPDIST	0.9296	1.3061	-1.2761	1.5892	-13.6427*	-2.9877	1.4056	-9.5731**	-2.6515
	(1.4308)	(0.1734)	(-0.4801)	(1.3417)	(-2.8326)	(-0.8175)	(1.0314)	(-2.0862)	(-0.6364)
POPGROWTH	0.0005	0.0013	-0.0010	0.0004	-0.0252	-0.0012	0.0011	-0.0216	-0.0017
	(0.2993)	(0.079)	(-0.1579)	(0.1813)	(-0.337)	(-0.1479)	(0.2862)	(-0.2346)	(-0.139)
REMOTE	-1.0493	-9.0769	4.2815	-3.6158	10.7451	4.0209	-3.7776	8.8214	-6.8841
	(-1.5887)	(-0.656)	(1.0786)	(-1.3397)	(1.4501)	(0.4828)	(-1.1308)	(1.2013)	(-0.6742)
STRINGENCY	**1.8551***	**22.6099***	**-4.7311****	**2.7638***	**35.0990***	**-5.4128*****	**2.6999****	17.2197	**-11.2282***
	(3.208)	**(3.6454)**	**(-2.1216)**	**(2.6001)**	**(2.8811)**	**(-1.6505)**	**(2.0167)**	(1.403)	**(-2.7438)**
EU-Dummy	-3.3863	19.8160	30.2462**						
	(-1.2945)	(0.2564)	(1.7609)						
C	-6.5471	-56.9225	2.8538						
	(-0.8183)	(-0.4661)	(0.0763)						
Number of Obs	306	306	306	288	288	288	288	288	288
R-Square	0.043	0.045	0.022	0.341	0.048	0.739	0.486	0.424	0.814

Table 4: Results of Denmark[8]

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[8] For Denmark, cross-sectional dependence was detected for cement and iron and steel at a significance level of 1%. Pesaran CD exhibits significance at 5% level for aluminum. The results of the second-generation unit root test indicated that all variables are integrated at the zero order, I(0). Since they are integrated at the same order, we proceeded with the OLS, FM-OLS and DOLS. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively. Haussmann results indicates that the random effects model should be preferred for all variables.

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Table 5: Results of France[9]

	OLS			**FM-OLS**			**Dynamic OLS**		
	Aluminum	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**
GDPDIST	-1.0199	-32.7083	-0.3637	0.9835	59.7172**	1.2156	1.2603	34.3205**	-1.0703
	(-0.6397)	(-1.363)	(-0.1227)	(0.7559)	(2.3167)	(0.2579)	(0.9941)	(2.5492)	(-0.2)
POPGROWTH	0.0022	-0.0029	0.0003	0.0033	0.2880	0.0906	0.0028	0.013	0.0841
	(0.3287)	(-0.0291)	(0.2881)	(0.1367)	(0.6022)	(1.0364)	(0.1001)	(0.0437)	(0.7079)
REMOTE	2.2313	168.4571**	1.8382	4.9243**	-70.1573***	2.3656	6.3566*	24.9473	11.1316
	0.4929	2.3129	0.1898	(2.5011)	(-1.7986)	(0.3317)	(2.8717)	(1.0612)	(1.1917)
STRINGENCY	-0.5747	**-56.7994*** **	**25.6480***	**-7.1762****	-57.8616	**26.0743****	**-9.6601***	**-128.1857***	23.0228
	(-0.2513)	**(-1.6508)**	**(6.0367)**	**(-2.0642)**	(-0.8401)	**(2.0705)**	**(-2.72)**	**(-3.3988)**	(1.5362)
EU-Dummy	-17.2353	521.3429	-57.049						
	(-0.7228)	(1.2116)	(-0.7789)						
C	17.3716	-211.0425	28.2517						
	(0.5558)	(-0.411)	(6.0367)						
Number of Obs	306	306	306	288	288	288	288	288	288
R-Square	0.007	0.032	0.113	0.101	0.024	0.024	0.479	0.766	0.325

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[9] For France, cross-sectional dependence was detected for each carbon-intensive product at a significance level of 1%. The results of the second-generation unit root test indicated that all variables are integrated at the zero order, I(0). Since they are integrated at the same order, we proceeded with the OLS, FM-OLS and DOLS. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively. Haussmann results indicates that the random effects model should be preferred for all variables.

	OLS			**FM-OLS**			**Dynamic OLS**		
	Aluminum	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**
GDPDIST	14.4103*	-65.9004	0.0038	16.4329*	-332.4551*	-0.0129***	18.8862**	-419.1974*	-0.0148***
	(2.9134)	(-1.5119)	(0.6522)	(3.711)	(-5.4619)	(-1.9111)	(-2.5553)	(-5.9811)	(-1.7780)
POPGROWTH	-0.0046	0.0206		0.1405	-1.7605	-0.0000	0.0997	-1.4197	
	(-0.1346)	(0.069)	(0.0041)	(1.153)	(-1.0507)	(-0.012)	(0.5885)	(-0.5825)	(0.0939)
REMOTE	-4.5665	-32.4115	-0.0342***	-11.9344***	199.0314**	0.0047	-9.6169	191.4059***	0.0077
	(-0.316)	(-0.2357)	(-1.8311)	(-1.836)	(2.2282)	(0.4735)	(-1.3171)	(1.8226)	(0.6172)
STRINGENCY	-5.3752	**191.1652***	**0.0328***	**-21.3976****	**605.3782***	**0.0427***	**-30.5989****	**842.8532***	**0.0480****
	(-0.7716)	**(3.1194)**	**(3.9226)**	**(-2.0697)**	**(4.2599)**	**(2.6975)**	**(-2.5553)**	**(4.8937)**	**(2.331)**
EU-Dummy	-10.4981	-43.0070	-0.0881						
	(-0.1376)	(-0.0506)	(-0.7666)						
C	-53.5415	466.8362	0.0373						
	(-0.5276)	(-0.4667)	(0.2755)						
Number of Obs	306	306	303	288	288	285	288	288	285
R-Square	0.029	0.033	0.065	0.067	0.132	0.047	0.340	0.352	

Table 6: Results of Germany[10]

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[10] For Germany, cross-sectional dependence was detected for aluminum and cement at a significance level of 1%. Iron and steel exhibits cross-sectional dependence at 1%, except Pesaran CD. The results of the second-generation unit root test indicated that all variables are integrated at the zero order, I(0). Since they are integrated at the same order, we proceeded with the OLS, FM-OLS and DOLS. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively. Haussmann results indicates that the random effects model should be preferred for all variables.

Table 7: Results of Italy[11]

	OLS			**FM-OLS**			**Dynamic OLS**		
	Aluminum	**Cement[12]**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**	**Aluminum**	**Cement**	**Iron & Steel**
GDPDIST	1.2427	33.7769***	1.6738	1.3990	-2.2570	-6.1014**	-2.3395	33.2502	-6.5656**
	(0.4198)	(1.6826)	(0.2813)	(0.3503)	(-0.081)	(-2.3271)	(-0.3834)	(0.9359)	(-2.4623)
POPGROWTH	0.0016	0.0347	0.0163	0.0025	0.0611	0.0027	0.0098	0.0551	-0.1158
	(0.0887)	(0.2776)	(0.4374)	(0.1069)	(0.3718)	(0.0144)	(0.2507)	(0.2402)	(-0.4742)
REMOTE	3.2462	-182.0262*	13.9716	4.1972	-254.5836*	12.2882	-0.5161	-97.6608	9.6233
	(0.4881)	(-2.974)	(0.8434)	(0.3258)	(-2.8335)	(1.2275)	(-0.0268)	(-0.8711)	(0.7984)
STRINGENCY	**-7.8339****	**-152.5242***	**-34.1856***	-7.2630	**-172.3373***	4.0716	**-13.5548*****	**-93.4757****	11.3611
	(-2.1834)	**(-6.2825)**	**(-4.7493)**	(-1.4375)	**(-4.8897)**	(0.2229)	**(-1.9321)**	**(-2.2885)**	(0.6147)
EU-Dummy	2.3163		45.1792						
	(0.082)		(0.4482)						
C	-20.2784	225.099	-137.2265						
	(-0.2334)	(0.3802)	(-0.7169)						
Number of Obs	306	306	306	288	288	288	288	288	288
R-Square	0.017	0.558	0.071	0.692	0.555	0.009	0.776	0.764	0.384

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[11] For Italy, cross-sectional dependence was detected for iron and steel at a significance level of 1%. Cement and aluminum exhibits cross-sectional dependence at 1% for each test, except Pesaran CD. The results of the second-generation unit root test indicated that all variables are integrated at the zero order, I(0). Since they are integrated at the same order, we proceeded with the OLS, FM-OLS and DOLS. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively.

[12] Hausmann test results indicate that Cement requires Fixed Effects model in cross-sectional estimation for OLS.

Table 8: Results of Poland[13]

ARDL LONG RUN EQUATION

	Aluminum	**Cement**	**Iron & Steel**
GDPDIST	1.5922*	-2.4595**	-12.8907*
	(5.8873)	(-2.2327)	(-8.4276)
POPGROWTH	0.5125	-0.9277	-0.3779
	(0.3588)	(-0.5248)	(-0.0985)
REMOTE	-3.183	4.2251	11.556
	(-6.9774)	(2.2643)	(4.8566)
STRINGENCY	2.158*	**5.434****	**26.0173***
	(3.5781)	**(2.1935)**	**(7.9615)**

ARDL SHORT RUN EQUATION

	Aluminum	**Cement**	**Iron & Steel**
D(GDPDIST)	-17.9051	120.3343	12.6262
	-1.0362	-2.5514	0.9993
D(POPGROWTH)	6.8442	0.1465	2.5576
	1.4024	0.0318	0.3567
D(REMOTE)	27.3440	-24.75	-7.3489
	1.1926	-0.2281	-0.2377
D(STRINGENCY)	3.2676	**-28.433*****	**-11.4880****
	(1.0203)	**(-1.8448)**	**(-2.0382)**
COINTEQ	-0.2213**	-0.1987**	-0.1159**
	(-2.0614)	(-2.5514)	(-2.1468)
NUMBER OF OBS	288	288	288

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[13] For Poland, cross-sectional dependence is identified for aluminum at a significance level of 5%. Pesaran CD results for cement and iron and steel are statistically insignificant, but Pesaran LM and Breusch Pegan LM are significant at the 1% level. The results of the second-generation unit root test indicate the integration order as follows: Aluminum I(1), Cement I(0), Iron and Steel I(0), GDPDIST I(1), POPGROWTH I(1), REMOTE I(0), and STRINGENCY I(0). Since variables integrate at different orders, we employed the ARDL estimation technique. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively.

Table 9: Results of Netherlands[14]

ARDL LONG RUN EQUATION

	Aluminum	**Cement**	**Iron & Steel**
GDPDIST	-7.2439*	-27.5986*	0.7881*
	(-7.0754)	(-4.0209)	(2.8171)
POPGROWTH	-0.0498	0.1032	0.0184
	(-0.6903)	(0.8626)	(0.1826)
REMOTE	8.2266*	-12.9535***	-4.9383*
	(6.7166)	(-1.7739)	(-7.1967)
STRINGENCY	**6.3382***	**92.5039***	**10.3828***
	(3.6692)	**(4.776)**	**(10.5635)**

ARDL SHORT RUN EQUATION

	Aluminum	**Cement**	**Iron & Steel**
D(GDPDIST)	-53.6298	522.0147	16.8106
	(-1.3625)	(0.5229)	(0.83)
D(POPGROWTH)	-24.3455	290.3930	4.8547
	(-1.0096)	(0.8374)	(0.9824)
D(REMOTE)	75.0402	703.0869	46.8859
	(1.4701)	(1.0823)	(1.3164)
D(STRINGENCY)	-3.9105	-142.4677	-5.5067
	(-0.4837)	(-0.8151)	(-0.5182)
COINTEQ	-0.3084*	-0.2304*	-0.3553*
	(-3.6604)	(-3.7418)	(-3.8039)
NUMBER OF OBS	288	288	288

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[14] For Netherlands, cross-sectional dependence is identified for cement and aluminum at a significance level of 1%. Pesaran CD results for iron and steel are statistically insignificant, but Pesaran LM and Breusch Pegan LM are significant at the 1% level. The results of the second-generation unit root test indicate the integration order as follows: Aluminum I(1), Cement I(0), Iron and Steel I(0), GDPDIST I(1), POPGROWTH I(1), REMOTE I(0), and STRINGENCY I(0). Since variables integrate at different orders, we employed the ARDL estimation technique. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively.

Table 10: Results of Spain[15]

ARDL LONG RUN EQUATION

	Aluminum	**Cement**	**Iron & Steel**
GDPDIST	-0.3306***	-6.7901*	-1.2684*
	(-1.7239)	(-4.6868)	(-4.817)
POPGROWTH	-0.0253	1.5833*	-0.2957
	(-0.4572)	(4.7063)	(-0.8267)
REMOTE	0.0232	13.2803*	1.4155*
	(0.0689)	(4.589)	(2.8859)
STRINGENCY	**1.2378***	**7.1341***	**0.9448****
	(3.3337)	**(4.3314)**	**(2.1275)**

ARDL SHORT RUN EQUATION

	Aluminum	**Cement**	**Iron & Steel**
D(GDPDIST)	4.6367	183.3747	1.6353
	(0.4241)	(0.7857)	(0.0873)
D(POPGROWTH)	2.0388	16.624	-4.5211
	(0.8189)	(0.4104)	(-0.9925)
D(REMOTE)	24.1627	119.3762	109.8826
	(0.7365)	(0.3893)	(1.3663)
D(STRINGENCY)	2.9395	-102.1159	-19.7534
	(0.7832)	(-1.1939)	(-1.5114)
D(CEMENT (-1))		-0.1817**	
		(-2.4211)	
COINTEQ	-0.4978*	-0.2856*	-0.5012*
	(-5.4227)	(-4.0466)	(-5.8937)
NUMBER OF OBS	288	270	288

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[15] For Spain, cross-sectional dependence is detected for each carbon-intensive product at a significance level of 1%, with the exception of Pesaran CD (insignificant for each product.) The results of the second-generation unit root test indicate the integration order as follows: Aluminum I(0), Cement I(0), Iron and Steel I(0), GDPDIST I(1), POPGROWTH I(0), REMOTE I(0), and STRINGENCY I(0). Since variables integrate at different orders, we employed the ARDL estimation technique. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively.

Table 11: Results of Sweden[16]

ARDL LONG RUN EQUATION

	Aluminum	**Cement**	**Iron & Steel**
GDPDIST	-7.2439*	-27.5986*	0.7881*
	(-7.0754)	(-4.0209)	(2.8171)
POPGROWTH	-0.0498	0.1032	0.0184
	(-0.6903)	(0.8626)	(0.1826)
REMOTE	8.2266*	-12.9535***	-4.9383*
	(6.7166)	(-1.7739)	(-7.1967)
STRINGENCY	**6.3382***	**92.5039***	**10.3828***
	(3.6692)	**(4.776)**	**(10.5635)**

ARDL SHORT RUN EQUATION

	Aluminum	**Cement**	**Iron & Steel**
D(GDPDIST)	-53.6298	522.0147	16.8106
	(-1.3625)	(0.5229)	(0.83)
D(POPGROWTH)	-24.3455	290.3930	4.8547
	(-1.0096)	(0.8374)	(0.9824)
D(REMOTE)	75.0402	703.0869	46.8859
	(1.4701)	(1.0823)	(1.3164)
D(STRINGENCY)	-3.9105	-142.4677	-5.5067
	(-0.4837)	(-0.8151)	(-0.5182)
COINTEQ	-0.3084*	-0.2304*	-0.3553*
	(-3.6604)	(-3.7418)	(-3.8039)
NUMBER OF OBS	288	288	288

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[16] For Sweden, cross-sectional dependence is detected for each carbon-intensive product at a significance level of 1%, with the exception of Pesaran CD (insignificant for each product.) The results of the second-generation unit root test indicate the integration order as follows: Aluminum I(0), Cement I(0), Iron and Steel I(0), GDPDIST I(0), POPGROWTH I(1), REMOTE I(0), and STRINGENCY I(0). Since variables integrate at different orders, we employed the ARDL estimation technique. t-statistics are presented in parentheses, where *, **, and *** denote significance levels of 1%, 5%, and 10%, respectively.

5. Conclusion

In this paper, the main objective is to show the importance of having a global uniform climate policy instead of separately functioning continent or union-based emission trading systems. To test this statement, we priorly tested the validity of the Pollution Haven Hypothesis and the Porter Hypothesis concerning various products and subcategories within the aluminum, cement, and iron and steel industries, as pointed in the EU's CBAM proposal. Utilizing a sample consist of 10 major EU economies and their 19 primary trading OECD partners from various continents, our analysis allows us to gain extensive insights. Our findings suggest that the leakage addressed in the CBAM proposal occurs through trade channels by importing carbon-intensive products from less regulated countries rather than being produced domestically. This outcome is aligned with the context of the Pollution Haven Hypothesis, which suggests that stringent environmental regulations may unintentionally create pollution haunts through carbon leakage via trade or relocation of production. Conversely, our evidence supports the validity of the Porter Hypothesis, which contrasts with the Pollution Haven Hypothesis by suggesting that stringent environmental policies could encourage polluting countries to innovate within their production processes, rather than seeking relocation opportunities or importing these products.

By presenting evidence validating both hypotheses, we strengthen our position on supporting the implementation of a uniform global climate policy rather than applying diverse climate policies with varying environmental regulations. Asymmetric climate policies among countries lead to leakage through trade where the ETS' might positively impact union-based systems and appear environmentally friendly, however, result in an overall increase in greenhouse gas emissions on a global scale. Understanding the importance of a global uniform climate policy highlights the need for international cooperation and coordination to address climate change. Therefore, it is of utmost importance for policymakers to prioritize the developments of mechanisms for designing common and unique standards and regulations to guarantee consistent applications across countries. Moreover, policymakers should also set consistent climate targets across countries to circumvent discrepancies that could challenge to meet global sustainable development goals. Also, climate policies should be harmonized with other policy objectives such as economic development and social equality plans to ensure holistic and effective outcomes. Climate related policies should be placed in broader policy frameworks and alignment with sustainable development goals should be ensured. The findings stressed the existence of carbon leakage through trade channels that emphasize the necessity to put measures to prevent relocation of carbon-intensive industries to less-regulated jurisdictions. This calls for effective implementation of mechanisms like carbon border adjustments or carbon pricing schemes, which will facilitate the risk of leakage.

In order to achieve the ambitious global climate targets, including limiting global warming to no more than 1.5 degrees Celsius, reducing emissions by 45% by 2030 and reaching net-zero emissions by 2050, the implementation of uniform climate policies becomes imperative. These goals demand a synchronized and focused effort on a global scale, emphasizing the necessity of consistent and uniform policies across nations to address the challenges of climate change effectively.

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