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Titolo

The effects of the Carbon Border Adjustment Mechanism on the economies of the East Asia and Pacific region

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Abstract

The European Commission has introduced a new tool to address the climate emergency and reduce greenhouse gas emissions through the ‘Fit for 55’ package. This instrument is the "Carbon Border Adjustment Mechanism" (CBAM) and allows for addressing the problem of carbon leakage.

The CBAM requires European importers to buy greenhouse gas emission allowances equal to the amount of CO2 emitted in the product's production process, at a Price equal to that set by the European Emission Trading System. By its nature, the CBAM protects the competitiveness of European companies in the steel and iron, aluminum, fertilizer, cement, electricity, and hydrogen sectors.

The objective of this thesis is to analyze the risks in terms of exposure and vulnerability of countries in the East Asia and Pacific region, which include two of the ten largest economies in the world and some of the countries most harmed by climate change. Through the creation of a risk index based on six sub-dimensions of exposure and vulnerability, this study allows for the calculation of the risk associated with each of the countries in the East Asia and Pacific region following the introduction of CBAM and provides guidance to policymakers in these countries as to which economic, administrative, and environmental sectors urgently need to be acted upon in time.

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1. Introduction

Climate change represents an "existential threat" to humanity, said United Nation’s Secretary Antonio Guterres (United Nations, 2018). The European Union’s (EU) strategy for addressing this challenge and complying with the Paris Agreement was set out in 2019 through the European Green Deal, a set of initiatives aimed at making Europe the world's first net-zero-emissions continent. Within the framework of the Green Deal, the EU has decided to implement the **Carbon Border Adjustment Mechanism** (CBAM) as a pivotal instrument to reduce global emissions and establish equitable conditions among nations with different climate regulations (European Union, 2023).

The CBAM is a new economic and environmental policy that aims to tackle the issue of "**carbon leakage**". This phenomenon arises when corporations transfer their industrial activities to countries with less rigorous climate legislation to evade increased expenses associated with carbon emissions.

The mechanism, which is a key component of the "Fit For 55" package, seeks to address the disparity in competitiveness between European enterprises that are bound by rigorous climate rules and their global counterparts. The transitional phase started on 1 October 2023, whereas the final phase will commence on 1 January 2026. The current version of the CBAM encompasses imports of products related to six industries, namely steel and iron, cement, aluminum, fertilizer, energy, and hydrogen, into the EU (European Union, 2023).

The goal of this mechanism is to mitigate the phenomenon of 'carbon leakage' and safeguard the competitive position of European enterprises in comparison to their counterparts located outside of Europe. Currently, the competitiveness of European companies is ensured by the distribution of permits ("allowances") under the European Emission Trading System (EU ETS), which are allocated free of charge to enterprises classified as EITE (Emission Intensive Trade Exposed). These companies operate in sectors and subsectors that exhibit a notable risk of carbon leakage.

The primary objective of this analysis is to determine the countries in the **East Asia and Pacific region** that are most vulnerable to the CBAM. This will be achieved by creating a **comprehensive risk index** that incorporates six subdimensions: the proportion of a country's exposure to CBAM relative to its GDP, the level of export diversification, the carbon intensity of the electricity mix, the statistical capacity, the innovation capacity, and the trade elasticity. These subdimensions offer valuable insights into the potential variations in the extent of negative repercussions that the new mechanism may impose on the eleven countries being analyzed, hence indicating their respective levels of vulnerability.

International organizations and institutions like the Intergovernmental Panel on Climate Change (IPCC) underscore the pressing need to confront global concerns pertaining to the rapid acceleration of climate change. Additionally, there is a demand for new policies that may effectively balance environmental objectives with economic competitiveness. The implementation of the CBAM poses significant inquiries on climate justice, since it has the potential to disproportionately impact economies characterized by varying levels of development and adaptive capacity.

This thesis aims to offer a comprehensive and unbiased examination of the risk levels of countries in the East Asia-Pacific region following the implementation of CBAM. It also aims to contribute to the discussion on the CBAM by analyzing the literature on carbon border adjustments and the equity and climate justice implications of this mechanism.

2. Literature Review

The literature on CBAM is extensive, and the earliest studies on the concept of border adjustments or carbon tariffs date back to the second half of the last century. Therefore, the chapter is organized as follows: section 2.1 provides the context and definition of the concept of Border Carbon Adjustments. Section 2.2 focuses on the origins of this concept in both the economic-fiscal and economic-environmental literature. Section 2.3 addresses one of the most debated issues regarding CBAM, namely the ability to counter carbon leakage. Section 2.4 shows the limitations of this mechanism in avoiding resource shuffling, providing some indications of how this problem could be remedied. Finally, Section 2.5 compares the effectiveness of CBAM with that of free allowances in the ETS in terms of protecting business competitiveness.

2.1 Definition of Border Carbon Adjustments

The terms border carbon adjustments (BCAs), border tax adjustments (BTAs), and carbon border adjustment mechanisms (CBAMs) are used to describe the concept of applying a financial cost equivalent to the domestic price of emissions on imported goods that would otherwise not be subject to regulation.

The definition of the CBAM proposed by the European Commission as a "**border adjustment**" mechanism instead of a "carbon tariff" is still under debate (Bray, 2023). The reason this mechanism has been labeled a 'border adjustment' - and not a tariff - is that it aims to level the playing field between EU and non-EU companies.

The competitive advantage currently enjoyed by non-European companies can be attributed to the regulatory framework imposed on European companies. Specifically, European companies are obligated to participate in the EU ETS which necessitates the purchase of emission permits for each metric ton of carbon dioxide emitted (Bayer and Aklin, 2020). Thus, the CBAM mechanism would not be a tariff because it does not penalize non-EU producers compared to EU producers: it simply aims to ensure equal treatment.

However, border adjustment mechanisms traditionally encompass not only the imposition of a tax on imports, but also the provision of a **rebate** for exports. Nevertheless, the broader concerns of the World Trade Organization over export subsidies, along with the potential negative impact on promoting emission reductions within the EU, have caused many experts and advocates to ignore the incorporation of export rebates in the CBAM (Mehling et al., 2019).

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2.2 Origin of the concept

The origin of the concept of carbon border adjustments can be traced back to the scholarly work of Alan J. Auerbach, an esteemed economist affiliated with the University of California Berkeley. He initially introduced the notion in a seminal essay published in the American Economic Review in 1997 (Auerbach, 1997). Auerbach collaborated with economist M. Devereux, who, alongside colleague Stephen R. Bond, originally introduced the notion of destination-based corporate tax (Devereux and Bond, 2002).

According to the author's perspective, as further elaborated in a subsequent essay published in 2016, border adjustments differ from import tariffs or export subsidies since “they are **paired and equal adjustments** that create a level tax playing field for domestic and overseas competition” (Auerbach and Holtz-Eakin, 2016). Auerbach’s work, however, focused on the examination of border adjustment in international taxation, outside the realm of environmental economics.

The initial conjectures on a CBAM at the European level were posited in 2007 by the European Commission (Assous et al., 2021). In 2009, a more structured proposition was put forth by the French government, but within the context of a tariff-based import regime. The French President, Nicolas Sarkozy, made a formal appeal to the Commission for the implementation of a tax on imports that would be contingent upon the level of CO2 emissions (Assous et al., 2021). However, this proposition, commonly referred to as the **'Carbon Inclusion Mechanism**,' faced significant opposition from many member countries. Only Italy and its president, Silvio Berlusconi, expressed their support. The notion was subsequently revived by French minister Montebourg in the year 2012 (Assous et al., 2021).

In July 2021, the European Commission unveiled a more articulate proposal based on the concept of carbon border adjustments, which had been absent from public discourse for over ten years. This proposal was subsequently incorporated into the "**Fit for 55**" package. The CBAM has emerged as a vital component of the European Green Deal in response to the issue of 'carbon leakage'. The European Parliament granted approval for its implementation in the summer of 2022, and it subsequently became effective on 1 October 2023, albeit in a transitional state where monetary contributions were not required (European Union, 2023).

2.3 CBAM and carbon leakage

The primary aim of the CBAM is to tackle the issue of carbon leakage, which refers to the occurrence of increased emissions in a nation with less stringent laws due to emission reductions in a country with more rigorous mitigation policies.

The shift in emissions is ascribed to the decline in competitiveness of enterprises operating within the regulated region, leading them to prioritize expanded production in areas where such rules are not in place, thereby gaining a competitive edge. This version of carbon leakage, commonly known as the **competition channel** in academic literature, is widely recognized (Cameron and Baudry, 2023).

However, it is important to note that this is not the sole condition via which carbon leakage occurs. Indeed, it is possible to identify at least two additional mechanisms via which carbon leakage can happen. The identification of these channels is crucial in order to comprehend if the implementation of CBAM also impacts them or if its objective is solely to mitigate the consequences on the competition channel.

The second channel is identified as the **energy channel**. Leakage through the energy channels is an indirect form of leakage channel that has implications on global energy markets. The prices of fossil fuels are expected to decrease in global markets because of a reduction in demand for fossil fuels in regulated regions, like the EU. The decrease in price could potentially incentivize enterprises operating within the unregulated sector to increase their use of fossil fuels, thereby leading to a corresponding rise in their greenhouse gas emissions (Arroyo-Currás et al. 2015).

The third and final channel is the **innovation channel**, which operates in the opposite direction compared to the previous two channels. Firms operating inside the regulated area are incentivized to allocate resources towards research and development activities, as well as the creation and adoption of technology and processes aimed at mitigating carbon emissions. This process stems from the imposition of stringent environmental restrictions (Di Maria and Van Der Werf, 2008).

The potential for these improvements to diffuse into other areas, particularly those lacking environmental regulations, is noteworthy. Despite the possibility for negative carbon leakage, which refers to the reduction of carbon emissions in both regulated and unregulated regions, this mechanism is not commonly taken into account in policy discussions.

The phenomenon of carbon leakage via the innovation channel can be interpreted as a three-step progression. In the beginning, climate policies incentivize the adoption of pre-existing low-carbon processes and technologies by making them more economically viable for enterprises. Furthermore, these rules incentivize investment in research and innovation focused on low-carbon technologies, therefore leading to enhanced environmental performance.

As a result, there is a drop in emissions within the controlled territory. The second phase is the dissemination of low-carbon technologies to countries that do not have climate policies in place. This process can be facilitated by means of international innovation funding and efforts focused on technology transfer. During the final phase, corporations operating in unregulated areas incorporate these advancements, thereby diminishing the carbon intensity of their manufacturing processes and consequently resulting in a decline in emissions. It is worth noting that the innovation channel stands out as the sole channel exhibiting a negative carbon leakage effect, which has the potential to reduce emissions in both regulated and unregulated regions .

Several methodologies have been employed to empirically evaluate the carbon leakage resulting from the EU ETS via the competition mechanism. Microeconomic research endeavors to examine the competitiveness indicators at the business or sector level, encompassing factors such as value added, employment, and total factor productivity. The immediate effects of the EU ETS on these parameters are often found to be limited, inconclusive, or potentially beneficial (Verde, 2020).

Overall, the aggregate findings of these research indicate that the extent of carbon leakage resulting from the EU ETS seems to be negligible. Nevertheless, it is imperative to acknowledge that a significant portion of the existing literature mostly examines the initial phases of the EU ETS, during which the issuance of emission allowances was predominantly free and carbon prices were relatively low (Cameron and Baudry, 2023).

The potential for carbon leakage in the future may increase as the EU ETS becomes more rigorous and the allotment of free allowances decreases. Furthermore, it is worth noting that certain corporations subject to regulations may opt to relocate their manufacturing operations from regulated facilities to unregulated ones. This strategic move can result in a deceptive reduction of emissions inside the regulated areas, hence posing significant dangers associated with carbon leakage.

In summary, the literature shows that is possible to pursue the mitigation of the greenhouse gas emissions released by highly polluting industrial sectors (such as steel and iron, aluminum, cement, and fertilizers) through fostering cooperation with nations lacking regulatory frameworks, while also implementing international carbon pricing measures such as the EU ETS and CBAM. There are currently mixed results on the extent of carbon leakage caused by the EU ETS. Should allowance prices remain high, the introduction of CBAM can limit this phenomenon by acting on the competition and energy channels.

Furthermore, it is essential that efforts are made to enhance the effectiveness of the innovation channel by advocating for the widespread adoption of environmentally friendly technology in nations with lax. In addition, it is recommended that part of the proceeds generated from the sale of CBAM allowances be reinvested in a European fund to promote the deployment of green technologies with which to reduce emissions from industrial sectors, earmarked specifically at countries that are most exposed to CBAM and least able to adapt, such as the Least Developed Countries. The benefits of such an approach are described in Chapter 6.

2.4 CBAM and resource shuffling

The discourse surrounding the effectiveness of a CBAM frequently incorporates an examination of the viability of a climate club as a supplementary and more influential strategy, specifically in relation to mitigating the challenge of **resource shuffling** (or reshuffling). This phenomenon entails the export of goods with a reduced carbon footprint to the EU, while other, “dirtier” products are redirected to alternative markets (Perdana and Vielle, 2023).

This process should be kept in mind because it has already occurred in the only other case of CBAM-like policy implemented to date, namely the cap-and-trade system adopted in California, which applied a border adjustment on imported electricity. Some companies managed to avoid the new taxation without investing in low-carbon energy sources, but simply directing clean electricity to California and more polluting electricity to other states (Caron et al., 2015).

In order to counter the phenomenon of resource shuffling, some studies suggest the creation of a **climate alliance** that aligns with the CBAM, enabling participating nations to effectively coordinate import taxes as a means to address issues of leakage and resource shuffling (Jakob, 2023).

The legislative proposal put up by the EU presents the possibility of establishing coordination with regions that express interest in establishing a climate club. This may potentially involve entering into agreements with prominent nations such as China and the United States. Given the substantial contribution of these three nations to both global GDP and greenhouse gas emissions, the establishment of a climate club might potentially yield relevant economic and environmental benefits.

The literature shows that the creation of a coalition serves to decrease carbon leakage, raise productivity in energy-intensive sectors, and improve the overall welfare of the group in comparison to scenarios with non-CBAM or unilateral implementation (Bohringer et al., 2021).

Some signs show that the establishment of a climate club may not be far off. First of all, some countries, including the United States, the United Kingdom, Australia, and Canada have already announced that they will consider the possibility of introducing a carbon border adjustment in their legislation as well (Hibbard et al., 2018).

In addition, the G7 countries are in the process of launching a **Climate Club** during the COP28 in Dubai, which will aim precisely at reducing carbon leakage. According to the Terms of Reference for the Climate Club released in December 2022, the club will be built on three pillars: advancing ambitious and transparent climate change mitigation policies, transforming industries, and boosting international climate cooperation and partnerships (Reuters, 2022).

It is not necessary for the CBAM mechanism to be the same in all countries, but the literature suggests that coordination between the different schemes could make it possible to avoid procedures becoming too bureaucratic or protectionist (Perdana and Vielle, 2023).

2.5 CBAM versus free allowances

The EU ETS currently operates as a major instrument within European climate policy, covering around 40% of all emissions within the region. Currently, industries that are susceptible to global competition are granted **free allocation** of ETS allowances in order to mitigate the risk of carbon leakages. The implementation of differential pricing mechanisms for emissions, which provide preferential treatment to companies with high emission levels, can effectively safeguard their competitiveness and mitigate the risk of carbon leakage. Nevertheless, the provision of free allocation diminishes the motivation to mitigate emissions (Bellora and Fontagné, 2023).

The rationale behind the implementation of the CBAM by the European Commission is as follows. The proposed mechanism aims to replace the existing practice of freely allocating emission allowances to companies that are most susceptible to leakage. By doing so, it intends to offer stronger incentives for these industries to decrease their emissions, while still ensuring a certain level of protection against leakage.

There exists a dichotomy between two contrasting approaches in the development of the CBAM. One approach leans towards **conservatism**, prioritizing the mitigation of potential retaliatory actions from trading partners, albeit with a relatively smaller environmental impact. Indeed, to avoid legal challenges at the World Trade Organization (WTO) level, the EU decided to include only import taxation without also incorporating rebates for exporters.

In addition, the Commission ignored proposals put forward by the European Parliament that aimed to ease the burden of the CBAM on industries in Global South countries in order to respect the principle of ‘common but differentiated responsibilities. However, exempting or reducing tariffs for some countries could have caused complications with the WTO, so no exceptions were allowed.

The other approach entails a more elaborate design that significantly curbs carbon leakage, minimizes costs for European exporters of ETS products, but exhibits a higher degree of discrimination against trading partners. This approach also pairs the carbon border adjustment with corresponding **export rebates**, which in this way allows European companies to be more competitive in the foreign market. However, this approach, which would reduce carbon leakage more substantially than the current mechanism, has been shelved because it is too susceptible to legal challenge.

The ultimate agreement adopts a moderate approach, wherein the design omits the provision of rebates to exporters, but instead employs the exporter's emission intensity as a benchmark. This version of the CBAM has been found to be more efficient in mitigating carbon leakages compared to the allocation of free allowances (Bellora and Fontagné, 2023).

Nevertheless, there are certain drawbacks associated with this design, extending beyond the sectors directly affected by the ETS. Firstly, the cost of ETS allowances rises, resulting in increased expenses for industries utilizing ETS-like products as intermediate consumptions. Additionally, the absence of rebates means that energy-intensive, trade-exposed sectors no longer receive free allowances for their export markets, further impacting their competitiveness.

3. Methodology

The methodology used for this study draws from various work done in past years to create an index of risk with respect to CBAM and determine which countries or geographic areas are most likely to experience negative impacts as a result of the introduction of this measure. This approach was preferred over a **Computable General Equilibrium** (CGE) model, since the literature on quantifying CBAM impacts through CGE models is already extensive and would have been beyond the scope of this study.

The choice of countries analyzed (pertaining to the East Asia and Pacific geographic area) stems from **gap analysis** in the existing literature, as well as the need to deepen the understanding of risks for countries with which the EU has the most significant trade. In fact, China, South Korea, Japan, and the Association of South-East Asian Nations (ASEAN) are all among the EU's top 10 trading partners (Eurostat, 2023).

The choice to employ a risk index stems from the effectiveness and widespread use this methodology has had in the study of CBAM effects, as shown in sections 3.1 and 3.2. Although this approach does not allow to quantify impacts in monetary terms, it provides useful information on which geographic areas are most vulnerable and which countries may be most likely to oppose CBAM implementation.

3.1 CGE models

Numerous studies have been conducted with the objective of measuring the economic and environmental efficiency of a CBAM within the context of general equilibrium. In their study, Babiker and Rutherford (2005) conducted a quantitative analysis to assess the efficacy and implications of different border carbon adjustment mechanisms, namely voluntary export limitations, countervailing tariffs, free allowances, and export refunds. The focus of their investigation was on the implementation of these mechanisms within the framework of the Kyoto Protocol subsequent to the withdrawal of the United States.

In their study, Böhringer et al. (2015) examine the effects on EITE firms of introducing a carbon tariff, highlighting the cost disadvantage generated for these firms in foreign markets. The scholarly works conducted by Antimiani et al. (2013) investigate the implications of implementing a border carbon adjustment at the borders of a coalition comprising Europe, the United States, and other Annex I nations.

Fouré et al. (2016) examine the consequences of CBAM in the context of potential retaliatory actions that trade partners may undertake if they perceive the mechanism to be inconsistent with World Trade Organization regulations.

Through a CGE model, Chen and Guo (2017) analyze the economic impact of the introduction of a carbon tariff by three countries (the EU, the United States and Japan) on China's trade in industrial products. The value of the carbon tariff in the study is quite low, amounting to $20 per ton of CO2 emissions.

In their study, Böhringer et al. (2018) undertake a quantitative analysis to assess the implications of carbon offsetting at the borders of the Organization for Economic Co-operation and Development. Specifically, they examine the scenario where the OECD imposes taxes on its own emissions and potentially provides lump-sum transfers as compensation to non-OECD nations.

Bao et al. (2013) focus once more on the effects of a carbon border adjustment on the Chinese economy, implemented in this case only by the EU and the United States. The three scenarios analyzed assume a carbon tariff value of $20, $50 and $80 on exports from seven energy sectors and 30 non energy sectors. With regards to the Chinese economy, Lin and Zhao (2023) analyze the magnitude of the green paradox related to the introduction of CBAM based on Chinese steel and aluminum future markets through the event study method.

In Mörsdorf's (2022) study, a comparison is made between three different designs of the European Commission's proposed CBAM. The focus of the comparison revolves around the distinction between scope 1 and scope 2 emissions, as well as the reimbursement provided to exporters. The analysis is conducted within the context of an exogenous carbon price of US$50 in the EU.

3.2 Relative Risk Index

The study conducted by Eicke et al. (2021) focuses on the development of a relative risk index to evaluate the consequences of implementing the CBAM of the EU. The research examines the impact on major global economies, while also providing a detailed examination of nations in the Global South. The approach outlined in this study encompasses two separate scenarios. The first scenario focuses on the implementation of a CBAM exclusively for certain industrial sectors, namely aluminum, cement, fertilizer, electricity, and iron and steel. In contrast, the second scenario explores the potential of applying CBAM to all imports over an extended period.

The sub-dimensions used in the construction of the relative risk index are divided into two categories. The first sub-dimension measures **exposure**, while the other three measure **vulnerability**.

Exposure refers to the importance of trade with the EU to the country's economy. In the first scenario, the proxy measuring exposure is the ratio of the economic value of CBAM-covered exports to GDP. In the second scenario, the total value of exports of EITE companies is used instead of CBAM-exports.

Regarding vulnerability, there are three sub-dimensions considered by the study. The first sub-dimension measures the **diversification** of each country's exports by calculating the percentage of exports in CBAM-covered sectors in relation to total exports, as far as the first scenario is concerned. In the second scenario, on the other hand, diversification is calculated as the ratio of exports to the EU to total exports.

The second subdimension provides information on the country's greenhouse gas **emissions**. This subdimension is the same in both scenarios. The proxy for emissions corresponds to the carbon intensity of final energy consumption, supplemented by a binary variable indicating the presence or absence of emission reduction targets for the country.

Finally, the third subdimension of vulnerability is the country's **statistical capacity**. This variable is crucial because CBAM implementation will require exporting companies to report in detail the CO2 emissions associated with the production of goods destined for the EU market.

Certain major countries, like Australia, Canada, and Japan, were not included in the analysis due to insufficient data regarding their statistical capabilities. This decision was made to concentrate on economies that are in the process of development.

In conclusion, this study provides an analysis of case studies conducted in three countries, namely Morocco, Bosnia, and Mozambique. The first case study focuses on Morocco, examining its high emissions and the challenges it faces in adhering to carbon limitations. The second case study examines Bosnia, which is characterized by high emissions and a limited level of trade diversification. Lastly, the third case study explores Mozambique, a country with low emissions and little statistical capacity.

3.3 Opposition Index

The study by Overland and Sabyrbekov's (2022) is important because it focuses on creating an **opposition index** to understand which countries are most likely to oppose CBAM implementation.

The authors employed a multi-step procedure to develop the opposition index for the implementation of the CBAM in this scenario. The initial selection process was identifying the nations that engage in the exportation of commodities within the sectors that fall under the scope of the CBAM to the EU.

The development of the index involved four primary stages: the identification of index sub-dimensions, the normalization of data, the assignment of weights, and the aggregation of results. The process concluded with a thorough examination of the index's robustness and a sensitivity analysis. The resulting index was adjusted to a numerical scale ranging from 1 to 100, with 100 indicating the greatest possible resistance to CBAM and 1 representing the least.

Several sub-dimensions have been incorporated in the opposition index. The first subdimension is the **trade exposure** between countries and the EU in sectors covered by the CBAM, focusing both on the exports of countries to the EU and the EU's exports to these countries.

Carbon intensity is assessed at the macroeconomic level of a nation's economy. The proxy for assessing the climate gas emissions of the industrial sectors covered by CBAM is the carbon intensity of the economy, measured in tons of CO2e per dollar of GDP.

The third subdimension analyzes the number of **WTO appeals** by each country. It is assumed that if a country has several precedents of legal disputes before the WTO, it is likely to be intent on using this instrument as well. The number of legal disputes is calculated over the period 1995 - 2019.

In addition, another variable included in the index is **public perception of climate change**. The greater the concern about global warming, the more likely the CBAM is to be accepted. The measurement of the perception of climate emergency is obtained by stratified polling.

Finally, the last subdimension is **innovation capacity**. As highlighted in section 2.3, CBAM provides competitive advantages to those companies and countries most able to exploit technological innovation in the sectors covered by the mechanism. For this reason, the index includes a variable that measures the number of patent applications per 100,000 individuals.

3.4 Selection of countries

Most studies on the effects of CBAM focus on a subset of countries, mainly major exporters to Europe or major emitters of greenhouse gases (Eicke et al., 2021). In this study, the aim is to further investigate the effects of CBAM by analyzing its effects on the **East Asia and Pacific** (EAP) **region**. Many countries pertaining to this region have been neglected in the analysis of CBAM impacts, even though they include four of the ten largest trading partners of the EU, namely China, South Korea, Japan, and ASEAN (Eurostat, 2023).

Moreover, combating climate change is a priority in this area, since - according to World Bank estimates - this region includes 13 of the 30 most climate-vulnerable countries in the world. The EAP region also bears 70% of the world's natural disasters, which have affected more than 1.6 billion people in the region since 2000 (World Bank, 2022).

Finally, this region will play a leading role in GHG mitigation efforts since it accounts for one-third of global GHG emissions and 60 percent of global coal consumption (World Bank, 2022).

For these reasons, the study focused on the following eleven countries pertaining to the East Asia and Pacific geographical area: **Australia, China, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore, South Korea, Thailand,** and **Vietnam**.

3.5 Index construction steps

The findings of this research are derived from an index of risk, which encompasses two distinct dimensions: **exposure** and **vulnerability**. The first dimension is determined by a single variable, while the second is composed of five different features.

A country's trade exposure to the EU corresponds to the ratio of the economic value of exports in the six sectors covered by the CBAM to the value of the country's GDP.

This work analyses vulnerability through five different indicators, such as export diversification (the proportion of CBAM-covered exports compared to the total value of a country's exports), carbon intensity of the electricity mix, statistical capacity (measured by the SPI score, an index that evaluates a country's statistical performance), innovation capacity (the number of registered patents per 100,000 population) and trade elasticity. The statistics presented in this study have been sourced from various reputable sources, such as UN Comtrade, the World Bank, and the World Intellectual Property Organization (WIPO).

3.5.1 Description of the subdimensions

In order to evaluate a nation's **exposure** to the CBAM, the metric employed involves calculating the proportion of the total value of exports directed towards the EU among sectors subject to the CBAM (namely, iron and steel, cement, aluminum, fertilizer, electricity, and hydrogen) relative to the country's Gross Domestic Product.

The rationale for selecting this variable is based on the premise that countries with more exposure in these six industries relative to their GDP are more likely to face increased risk. The data pertaining to the exposure of various countries was acquired from the United Nations Comtrade Database.

The **vulnerability** of various nations was then delineated based on five sub-dimensions. The assessment often evaluates a nation's capacity or incapacity to effectively adjust to the newly introduced CBAM mechanism. The four sub-dimensions can be delineated as follows:

Export diversification refers to the strategic process of expanding the range of products or services that a country export. The concept of export diversification pertains to the capacity of a nation to redirect its production, originally intended for foreign markets, towards sectors that are not subject to the coverage of CBAM. In certain nations, particularly those facing initial challenges in emissions reduction within their industrial sectors, a strategic approach to export diversification could prove advantageous. This would enable them to absorb any potential decline more effectively in exports within sectors subject to CBAM. On the contrary, a nation characterized by limited export diversification may experience heightened adverse repercussions because of the implementation of this policy.

In this study, export diversification is quantified as the proportion of the value of exports covered by the CBAM relative to the entire value of a country's exports. The data has been sourced from the United Nations Comtrade Database.

The inclusion of a variable that measures the **carbon intensity of the electricity mix** is crucial in the analysis due to the requirement imposed by the CBAM for importers to purchase allowances equivalent to the carbon dioxide content of imported products. Ideally, it would be advantageous to consider the carbon intensity of the energy utilized solely by the industries responsible for manufacturing the products that fall under the purview of the CBAM. Nevertheless, due to the unavailability of precise data pertaining to individual industries, a substitute variable was employed to assess the carbon intensity of the energy composition on a nationwide scale.

The variable employed in this study quantifies the carbon intensity of the electricity mix, which measures the amount of carbon dioxide emitted per kilowatt hour. The data was sourced from the Ember Climate data catalogue.

Statistical capacity refers to the ability of a system or organization to collect, analyze, and interpret data in a rigorous and reliable manner.

Statistical capacity plays a crucial role in assessing the risk associated with each country, as it pertains to the ability of their statistics and data collection systems to meet the requirements of the CBAM in relation to greenhouse gas emissions during production. Due to the unavailability of data pertaining to the statistical capacity of individual enterprises, a surrogate indicator was employed to gauge the statistical capacity of specific countries at the national level. This approach was based on the notion that the statistical capacity of firms is inherently linked to that of the respective countries. This assumption arises from the observation that a significant portion of the data required by exporting companies is not internally owned by the company, but rather needs to be acquired from the energy distributor or other middlemen.

The variable employed in this study is the Statistical Performance Indicator (SPI) Score, which has been created by the World Bank. The SPI Score evaluates the development of national statistics systems, with its comprehensive score being determined by five fundamental aspects of statistical performance: utilization of data, quality of services, breadth of subject coverage, availability of information sources, and adequacy of infrastructure and resources.

The CBAM also seeks to increase the **innovation capacity** within industries that have a significant environmental impact, with the goal of advancing the creation and implementation of solutions capable of mitigating emissions. Companies are motivated to adopt this approach to minimize or eliminate the need to purchase allowances when exporting goods to Europe. Assessing a country's innovation capacity is a complex task, and various indicators can be employed as proxies to estimate it. The proxy for the innovation capacity is the number of patents registered in each country per 100,000 individuals. The data employed to assess the level of innovation capacity relies on the World Intellectual Property Organization (WIPO) database.

The last subdimension included in the risk index is the **trade elasticity**. The concept of trade elasticity measures “the response of quantities traded to changes in the prices of tradable goods” (Devarajan et al., 2023).

The inclusion of this subdimension was motivated by the plausibility that countries with higher elasticity may have a more pronounced negative response to an increase in export prices. Countries with lower elasticity should not experience a substantial decrease in their exports even when faced with a price hike, such as the one expected with the implementation of the CBAM. The trade elasticity variable was derived from a study conducted by the World Bank (Devarajan et al., 2023).

The summary scheme listing the two categories and five sub-dimensions that make up the comprehensive index is shown in Figure 1.

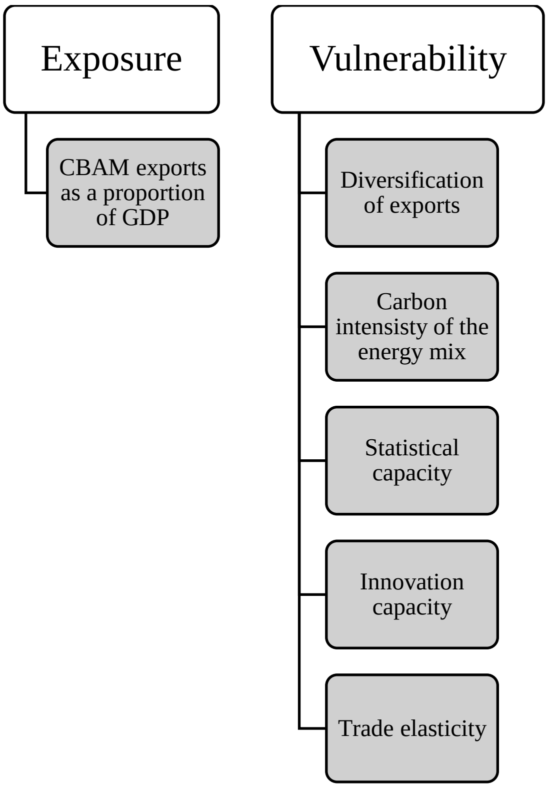

Figure 1. Structure of the comprehensive risk index.
The index is composed of two subdimensions – exposure and vulnerability – and six subdimensions

3.5.2 Normalization

The normalization of values was performed according to the **MinMax method**: the min-max normalizer linearly scales each feature to the interval [0,1]. This is done by scaling the values of each feature so that the minimum value is 0 and dividing by the new maximum value, which is the difference between the original maximum and minimum values. The formula is $z = \frac{x - min(x)}{[\max(x) - \min(x)]}$.

3.5.3 Weighting and aggregation

Since there is no evidence of a hierarchical relationship in previous studies on the subject, it was not possible to use specific weight values provided in the literature (Overland and Sabyrbekov, 2022). Therefore, it was decided to assign a **greater weight** to the variable measuring trade exposure, since it is intuitively the feature most involved in identifying a country's level of risk in terms of economic impact following the introduction of CBAM.

Specifically, the variable measuring exposure was assigned a weight of 0.3 while the other variables were assigned an equal weight of 0.14.

3.5.4 Sensitivity analysis

Ultimately, a sensitivity analysis was conducted wherein different variables were systematically removed from the final aggregate index. This enabled the construction of four distinct iterations of the index. Visualization techniques were employed at every stage of the process in order to detect anomalies.

The results of the four iterations of the index are presented in the Appendix (Table A.1 to A.4).

4. Results

The analysis of the results provides insight into how the different variables affect the comprehensive risk index value for each country, to highlight country-specific characteristics that can increase or decrease the level of risk following the introduction of CBAM.

The section is organized as follows: section 4.1 presents the results on trade exposure to the EU, both in absolute terms and in relation to each country's GDP. Section 4.2 provides information on countries' export diversification by analyzing the percentage of CBAM-covered exports in the total and graphically showing the interaction between the trade exposure and export diversification variables. Section 4.3 focuses on describing the carbon intensity of the electricity mix and, similarly to section 4.2, compares this variable with the one on trade exposure. Section 4.4 analyzes the results related to statistical capacity and shows a first version of the risk index, calculated on the basis of only four variables. Section 4.5 focuses on the analysis of innovation capacity and presents a second version of the index, again calculated on four sub-dimensions. Section 4.6 introduces the variable measuring the trade elasticity of each country and shows the results of the fourth version of the index, calculated on five variables. Finally, section 4.7 shows the results provided by processing the latest version of the risk index, which combines all six sub-dimensions of exposure and vulnerability.

In the final version of the index, the 11 countries under analysis are sorted in descending order according to the value of the **comprehensive risk index**. The value of the index, because of the way it is constructed, ranges from 0 to 1. The countries with the most exposure and vulnerability have an index with higher values while the least endangered countries have the lowest values.

4.1 Trade exposure

The calculation of the **trade exposure** of the 11 countries under consideration starts by examining export data in absolute terms in the six sectors covered by the CBAM. Figure 2 shows that, in absolute value, the largest exporters to the EU in the six sectors are China and South Korea.

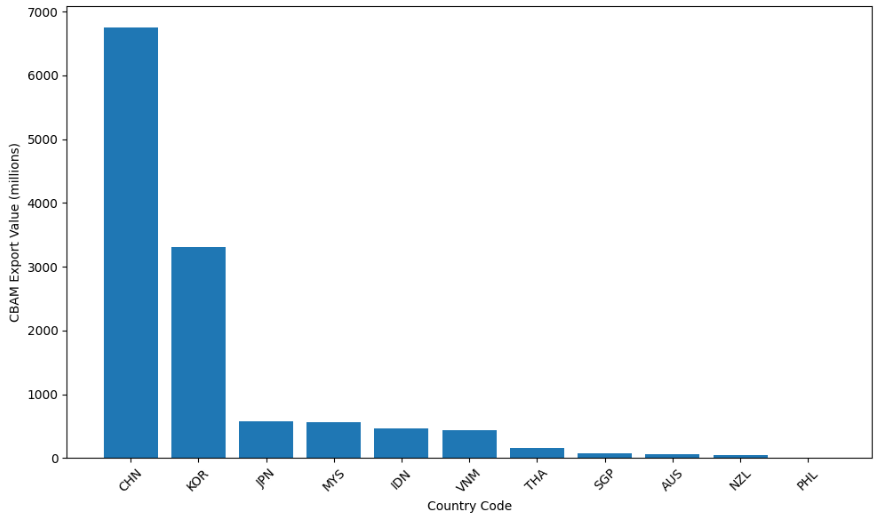

***Figure 2**. Trade exposure, measured as the value of CBAM exports to the EU*

Figure 3 shows the value of **CBAM-covered exports in relation to each country's GDP** value. The countries for which CBAM exports contribute the most to GDP are South Korea, Malaysia, and Vietnam. They weigh little for Hong Kong, Australia, and the Philippines.

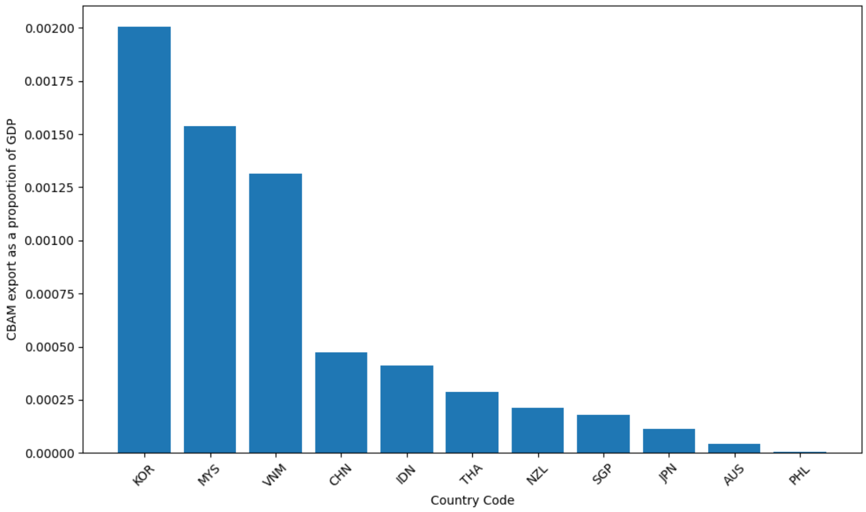

***Figure 3**. Value of CBAM-covered exports as a proportion of each country's GDP*

4.2 Export diversification

The variable regarding **export diversification** is calculated as the value of **CBAM-covered exports as a proportion of the country's total export**. Figure 4 displays that South Korea is the most vulnerable country from this point of view. In contrast, for countries such as Singapore and the Philippines, CBAM-covered exports account for less than 1‰ of total exports.

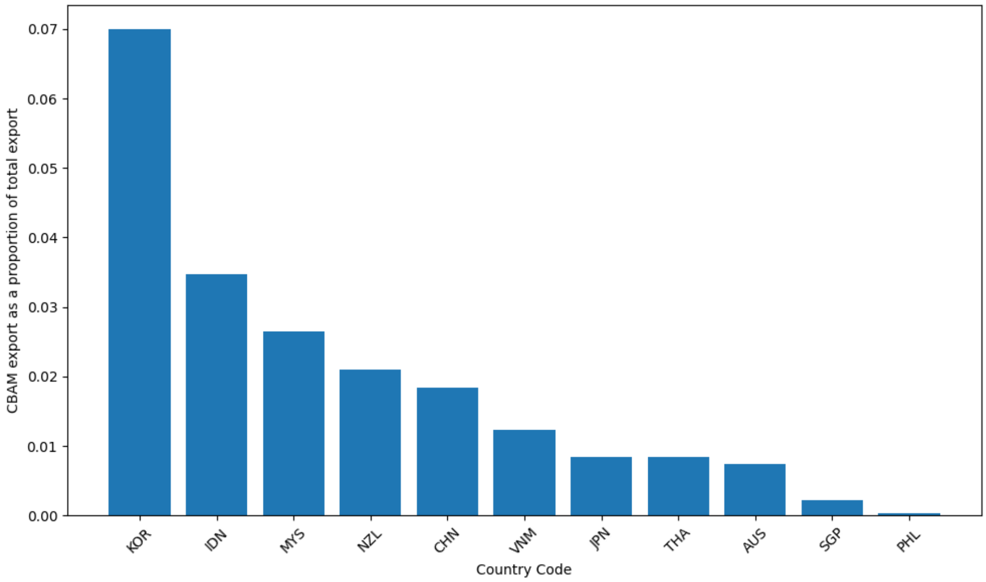

Figure 4. *CBAM exports as a proportion of total exports*

Figure 5 shows how the variables on **trade exposure** and **export diversification** interact. South Korea is characterized by a heightened level of risk, mostly stemming from its limited trade diversification. Indonesia and Malaysia exhibit a moderate level of risk, which is mitigated to some extent by a moderate level of trade diversification. Both Singapore and the Philippines exhibit a low level of risk, mostly attributed to their significant trade diversification and minimal exposure to export risks associated with the CBAM.

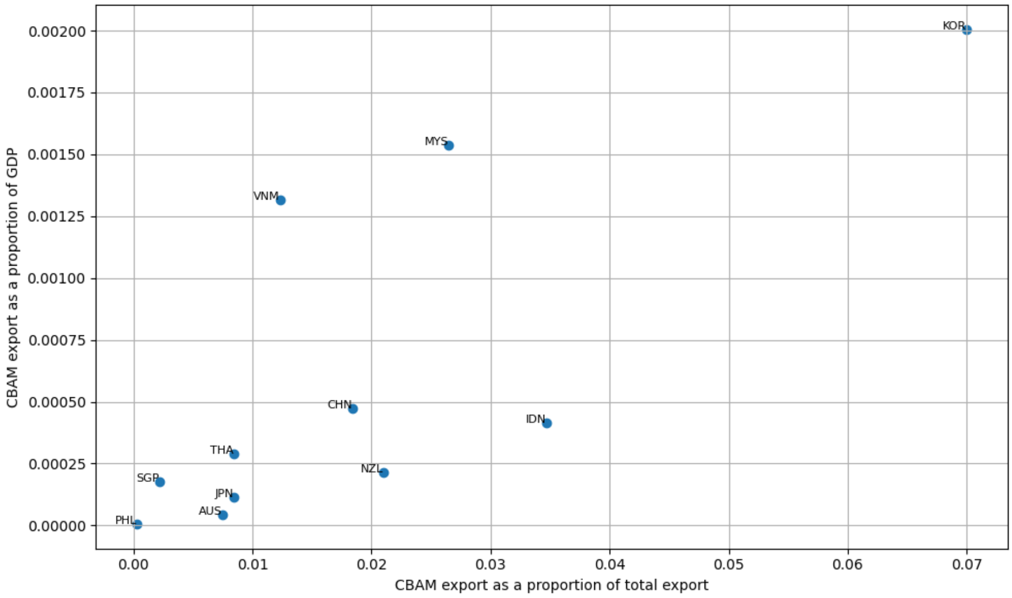

Figure 5. *Trade exposure plotted against export diversification*

4.3 Carbon intensity of the electricity mix

The variable chosen to analyze the carbon intensity of the energy mix of the countries under consideration is the **amount of CO2 equivalent** (CO2e) **released to produce one kilowatt-hour of electricity,** measured in tons of CO2e. The countries with the cleanest electricity mix, displayed in Figure 6, are New Zealand, with significantly lower values than any other country, and Vietnam. In contrast, the countries with the highest values of carbon intensity are Indonesia and the Philippines.

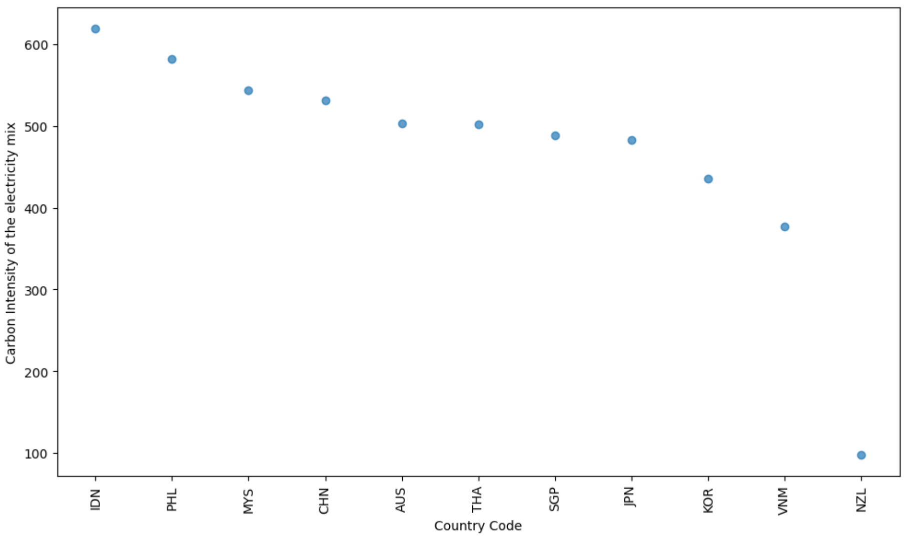

Figure 6. *Carbon intensity of the electricity mix*

These findings are consistent with the literature on renewable energy generation in the East Asia Pacific area. **Indonesia** has been the subject of several studies examining its potential for expanding clean energy sources. However, at present, it remains one of the world's 10 largest emitters of CO2 due to an energy mix dominated by coal. Even today, Indonesia has coal-fired power plants with a total installed capacity of 40 GW, and another 10 GW are under construction (Resosudarmo et al., 2023). The reasons behind the country's dependence on fossil fuels are diverse: in particular, the lobby of mining industries active in fossil fuel extraction is very strong.

As for **New Zealand**, the country's energy mix is by far the least polluting of those analyzed. The carbon intensity is about a quarter that of the country with the second cleanest mix, Vietnam. New Zealand is also a positive exception worldwide: after Iceland and Norway, it is the country with the highest proportion of total primary energy supply from renewable sources. Currently, more than 80 percent of electricity is derived from renewable sources thanks to the abundance of **geothermal energy** and hydropower (Verma et al., 2018).

Figure 7 exhibits the analysis of the interaction between the **carbon intensity** and **trade exposure**. Korea and Malaysia are the countries in the most dangerous position, due to relatively high carbon intensity and high exposure to the EU market. New Zealand exhibits low risk, due to low carbon intensity and low CBAM export exposure.

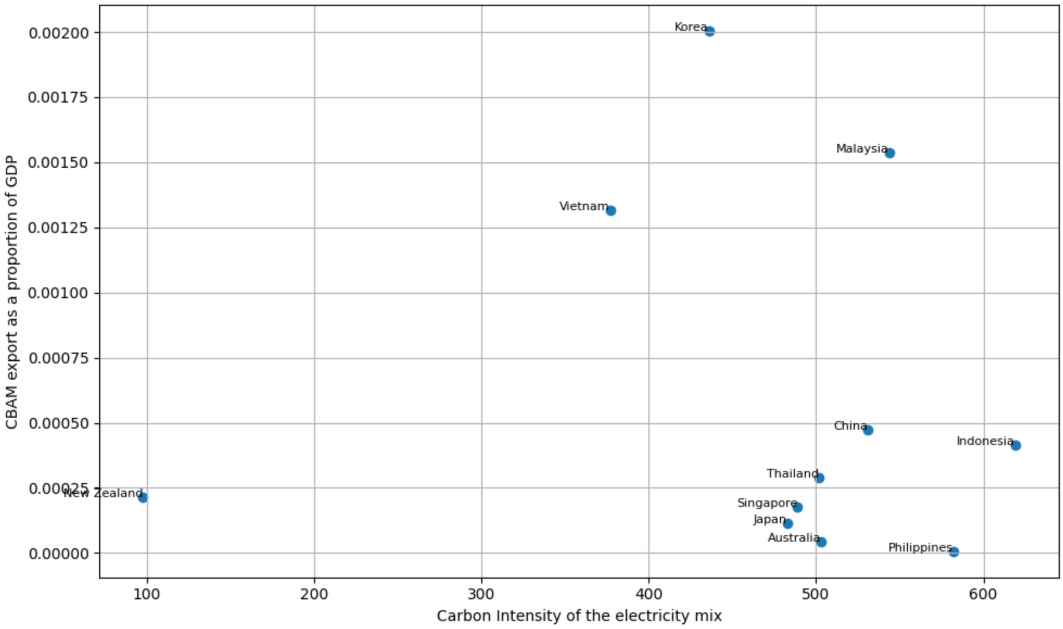

Figure 7. *Carbon intensity of the electricity mix plotted against trade exposure*

4.4 Statistical capacity

The variable under analysis is the "Statistical Performance Indicator" score, which is a statistical performance index focusing on five dimensions: data use, data services, data products, data sources, and data infrastructure calculated each year by the World Bank. South Korea and Australia have the highest statistical capacity: the SPI Overall Score is above 80. In contrast, China and Vietnam have the lowest values: they are the only two countries with an SPI Overall Score below 70.

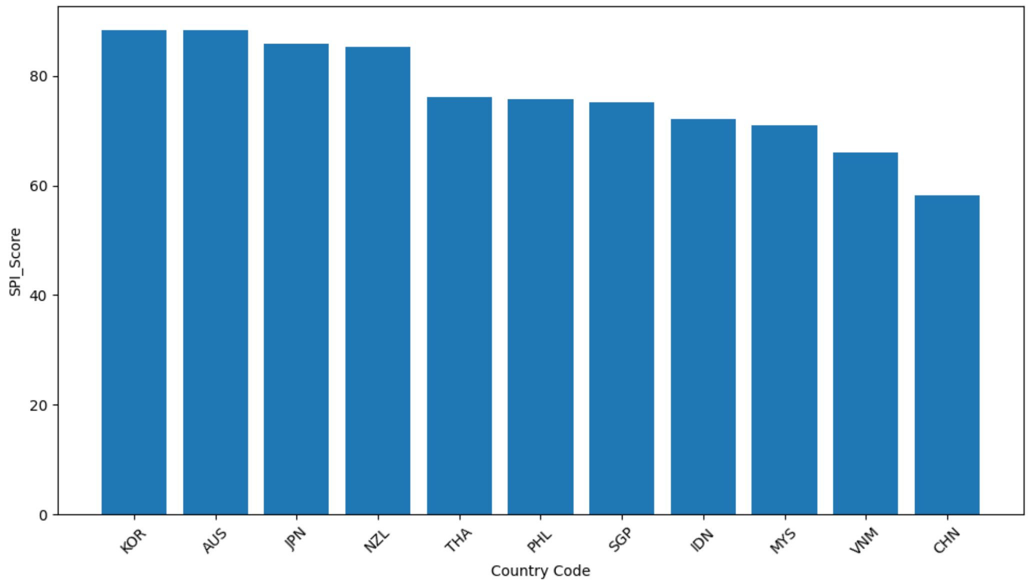

Figure 8. *Statistical Performance Indicator - Overall Score*

The position of **China**, which ranks last with an Overall Score of 58.6, is worthy of further analysis. The Statistical Performance Indicator value is considerably lower than other advanced economies in the region. Globally, China ranks in the third quintile, while almost all other countries in the East Asia and Pacific region fall between the top 20 percent and the second quintile. The most important gaps in China's statistical system occur in two areas: **Data Services** (indicator pillar 2) and **Data Sources** (indicator pillar 4).

Data services refer to those services that connect organizations, enterprises and individuals using statistical data with data providers. Data sources, on the other hand, include all sources of statistical data, which can be either public or private entities. China's Statistical System performs worse in these two areas than its neighboring countries, and this could be a disadvantage for Chinese companies following the introduction of CBAM.

The first version of the **index** – displayed in Figure 9 – combines the variables on **exposure**, **diversification**, **carbon intensity**, and **statistical capacity**. In this simplified version, South Korea and Malaysia exhibit very high risk. The risk index value is above 0.6 for both countries. On the other hand, Australia and New Zealand are at the bottom of the ranking, and their risk index value is equal to or below 0.2.

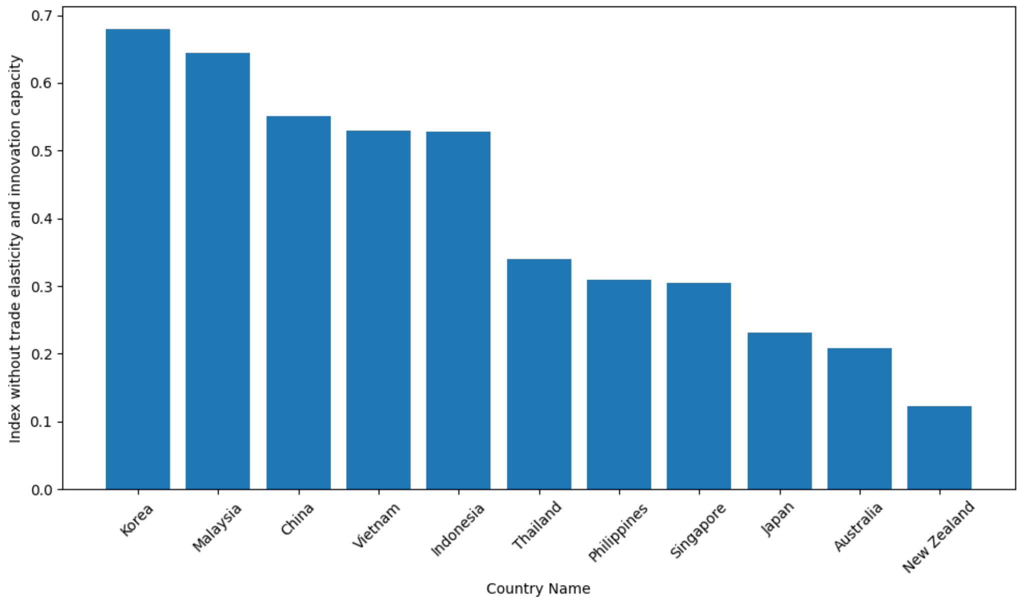

Figure 9. *CBAM Comprehensive risk Index with trade elasticity and innovation capacity dimensions omitted.*

4.5 Innovation capacity

The variable considered here is the **number of patent applications** registered in each country, **per 100,000 people**. South Korea and Japan are by far the countries with the highest number of patents in relation to population, exceeding 7,000 patents filed per 100,000 population. In contrast, Vietnam, the Philippines, and Indonesia are the countries where this ratio is lower.

These data can be interpreted in more detail to make some points. First, the numerator of the ratio is the number of patents registered in the country between 1995 and 2019. The choice of this time window is consistent with studies by other authors and allows reducing the influence of marked fluctuations in a specific year. The denominator of the ratio is the population of the country.

In absolute numbers, the country with the largest number of patent applications is China, while if we calculate the ratio based on inhabitants it ranks sixth.

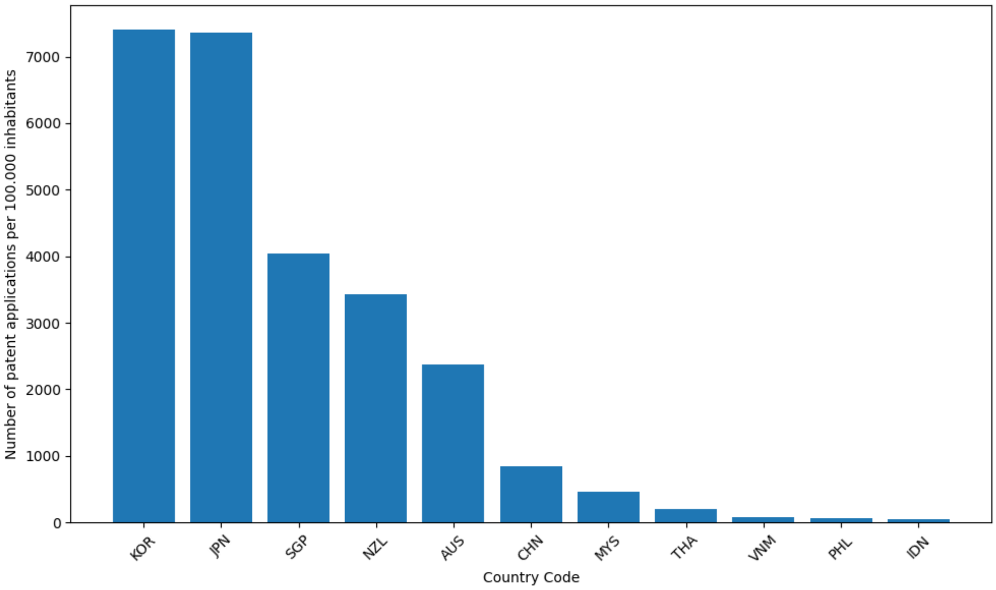

Figure 10. *Innovation capacity, measured as patent applications per 100.000 inhabitants*

The second version of the index in Figure 11 includes only variables on **trade exposure, export diversification, carbon intensity and innovative capacity**. Despite the introduction of innovative capacity, Malaysia and South Korea maintain a very high risk, while the index drops dramatically for Japan, which in fact can rely on considerable innovative capacity.

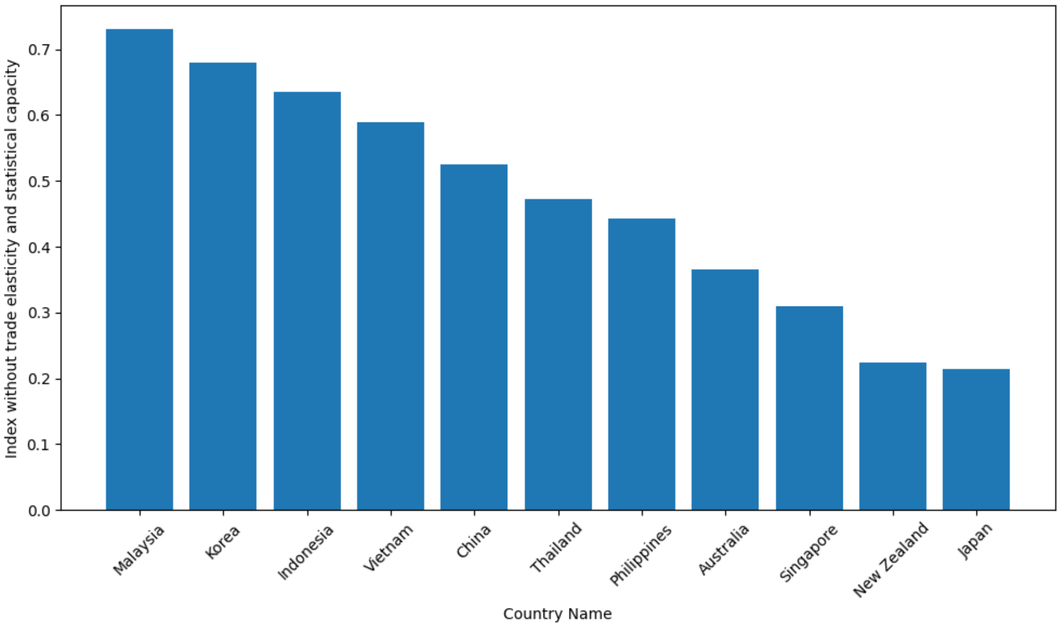

Figure 11. *CBAM Comprehensive risk Index with trade elasticity and statistical capacity dimensions omitted*

4.6 Trade elasticity

This variable measures the **response of quantities traded to changes in the prices of tradable goods**. New Zealand is the country where trade elasticity is highest, followed by Japan. At the other end of the spectrum, we find China and Thailand, with trade elasticity values below 0.5. These findings are presented in Figure 12.

In fact, the literature shows that for developed countries the elasticity of trade tends to be greater than 1 (for both exports and imports), while for the least developed countries it tends to be between 0.6 and 0.7 (Devarajan et al., 2023). Data on export elasticity for the geographical area of interest, namely the East Asia and Pacific region, show that the average export elasticity is 0.82, that for the high - income countries in the region is 1,35 while that for the developing countries in the region is 0.52.

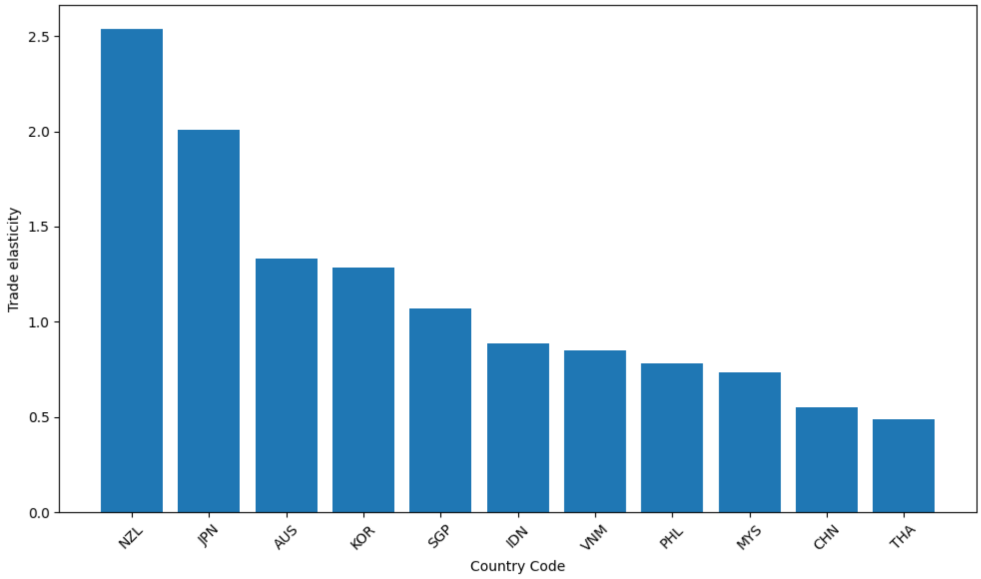

Figure 12. Trade elasticity for export

The third version of the index includes variables on **exposure, diversification, carbon intensity, statistical capacity,** and introduces **trade elasticity**. The first two positions remain unchanged, while the index drops drastically for Thailand, whose trade elasticity is minimal. In the new index, the position of New Zealand is worse, because the country exhibits the highest value of trade elasticity.

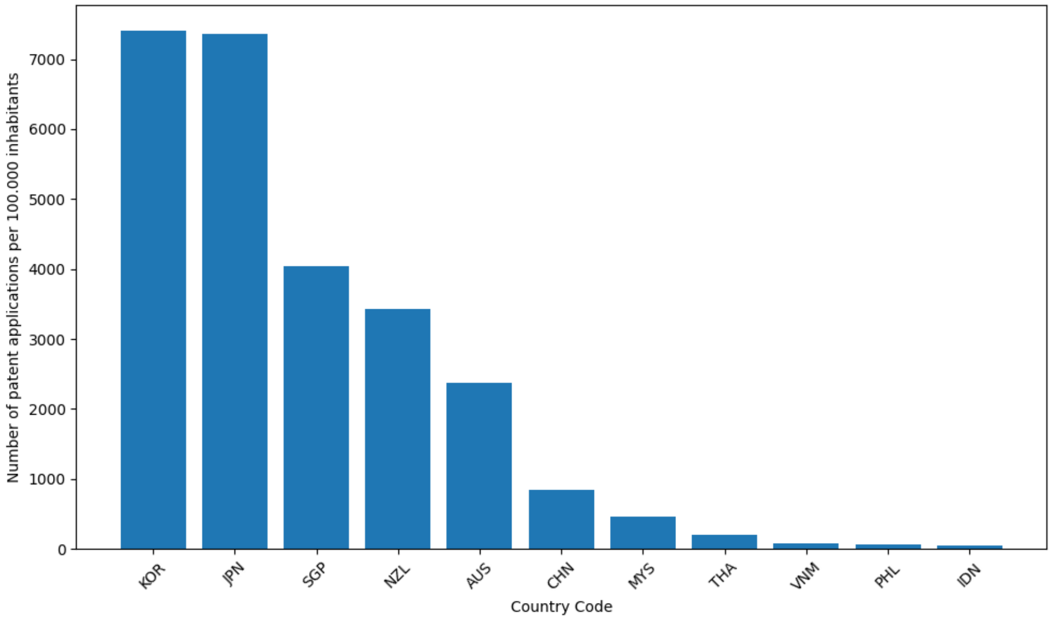

Figure 13. CBAM Comprehensive risk Index with innovation capacity dimension omitted

4.7 Comprehensive risk index

This comprehensive index integrates the **six sub-dimensions** to determine the risk levels of different countries. The index calculation formula and summary statistics are provided in Table 1.

Table 1. *Formula of the CBAM comprehensive risk index and summary statistics*

Formula	**N**	**Mean**	**Standard deviation**	**Values range**
$\mathbf{0.3 \times \mathit{ExpCBAMperGDP} + 0.14 \times (\mathit{PctExpCBAM} + \mathit{Carbon\_Intensity} + \mathit{SPI\_Score\_Compl} + \mathit{PatPerCap\_Compl} + \mathit{Trade\_Elast})}$	11	0.421	0.138	0.252 0.632

As anticipated in section 3.5, the variable that has the greatest weight is **trade exposure**. The weight assigned to this feature is 0.3, which is slightly more than twice the weight assigned to the other five variables. There are no studies in the literature that provide clear guidance on what weights should be assigned to each variable. Often each variable is associated with the same weight.

However, the choice to assign a greater weight to trade exposure stems from the idea that it is the characteristic that should be given the greatest consideration in understanding the country's level of risk, not least because the impact on GDP in terms of growth or contraction is decisive both in the public discussion and in the possibility of financing public investment on the green and digital transition.

Based on the risk index associated with the CBAM, shown in Figure 14, **Malaysia, South Korea,** and **Vietnam** emerge as the country with the highest level of vulnerability. Malaysia is the sole one exhibiting levels over 0.6. However, Malaysia has often been overlooked by previous studies, despite significant CBAM commodity exports (especially iron, steel, and aluminum).

Most countries falling within the medium range, specifically Indonesia, China, Thailand, and the Philippines, exhibit risk index values ranging from 0.3 to 0.5.

In contrast, New Zealand, Singapore, Australia, and Japan are the countries least impacted by the CBAM, each exhibiting value equal to or below 0.3. The main reason for the low level of risk is the low trade exposure in CBAM sectors to the EU, the widespread use of low - carbon energy in the electricity mix, and the high statistical and innovative capacity. These factors counterbalance possible negative effects of features such as trade elasticity. In fact, although New Zealand and Japan are the countries where this value is highest, they are still in the lower part of the ranking relative to the CBAM comprehensive risk index.

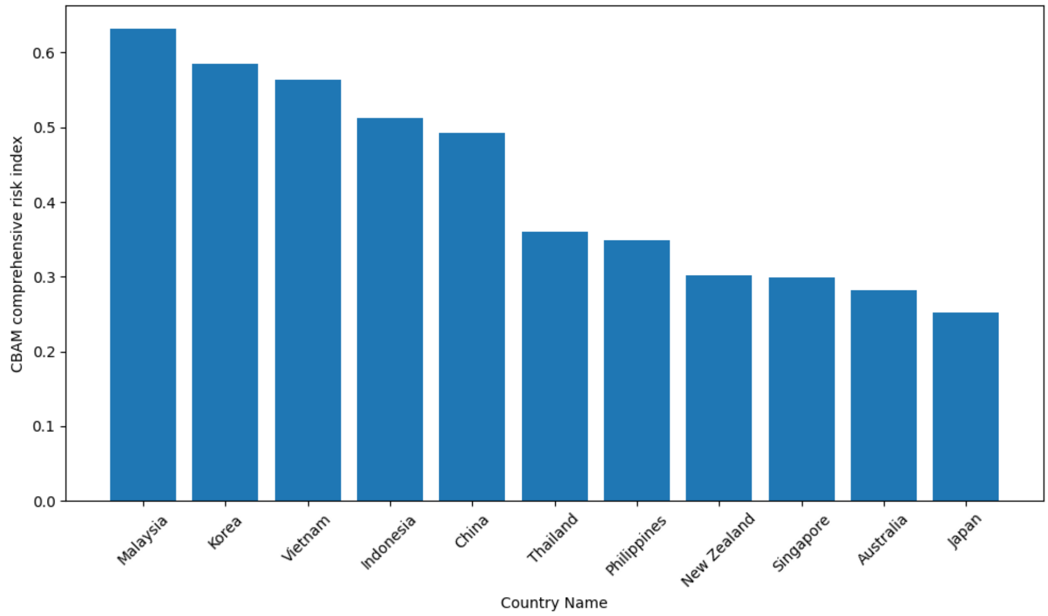

Figure 14. *CBAM comprehensive risk index*

5. Discussion

This analysis does not consider the economic of the CBAM impact – in terms of reduced exports or GDP – on countries in the East Asia and Pacific region, as has been done in several other studies. The objective is to analyze countries' **exposure** and **vulnerability** conditions through the construction of a risk index that examines export value, trade diversification, carbon intensity of the energy mix, statistical capacity, innovative capacity, and trade elasticity. In this way, using a different approach from that taken in CGE-based studies, it is possible to highlight which countries need to prepare in advance for the introduction of CBAM.

The CBAM comprehensive index, depicted in Figure 14, shows that Malaysia is the country with the highest risk value, followed by South Korea and Vietnam.

The characteristics that most affected the value of the overall index for **Malaysia** were the relatively high exposure value, second only to that of Korea, and the very low penetration of renewable energy in the energy mix.

In terms of exposure, Malaysia has the EU as its third largest trading partner, to which it exports mainly cement and steel. In addition, Malaysia also exports a significant amount of secondary goods that include raw materials covered by the CBAM, such as steel and aluminum (Martinus and Laopirun, 2023). On the energy side, moreover, Malaysia is a country where renewable energy penetration in the energy mix is lowest. In 2019, the share of energy produced from renewable sources was only 2 percent (Abdullah et al., 2019).

South Korea exhibits the second highest value of the comprehensive risk index associated with CBAM. The country has the highest values in the sample in terms of trade exposure, and at the same time has the lowest values in terms of export diversification.

These values are partly balanced by high statistical and innovative capacity, but this does not fully counterbalance the negative aspects listed above.

In terms of exposure, the EU is the third largest trading partner for South Korea and is the destination for more than 13 percent of its exports. In addition, South Korea is among the three largest steel exporters to the EU, so it is plausible that Korean steelmakers should take the introduction of the CBAM into great consideration and take advantage of the transitional phase to best adapt to the new rules (Schott and Hogan, 2022).

A more detailed analysis of the country's energy mix data shows that the low penetration of renewable energy sources has been going on for quite some time. In 2018, Korea had the lowest share of renewable energy in energy supply among all countries surveyed by the IEA. In 2022, only 5 percent of electricity generation was covered by renewable sources such as wind and solar, which is far below the global average of 12 percent. When compared with other countries with comparable economies in the region, Korea lags far behind in this respect: in Japan and China, for instance, the share of electricity produced from renewable sources is 12 percent and 14 percent, respectively (Kim et al., 2022).

On the other hand, it should be kept in mind that the share of energy produced from low-carbon sources in the total – which also includes nuclear power generation – is higher than that produced from renewable sources alone. In this case the percentage rises considerably reaching about 17 percent of primary energy production, being higher than that of Japan. In fact, South Korea produces about 12 percent of its primary energy through its nuclear power plants. As a result, the carbon intensity of the energy mix is relatively low (Kim et al., 2022).

In contrast, the countries with the lowest values of the risk index related to the introduction of CBAM include New Zealand, Singapore, Australia, and Japan.

New Zealand has by far the lowest values from the perspective of the carbon intensity of the electricity mix. It is the only country with a value below 100 gCO2e per kilowatt-hour. By 2021, the country had already achieved 80 percent electricity generation from renewable sources, through the marked development of geothermal and hydropower sources (Verma et al., 2018). At the same time, it has low exposure to the EU and is also one of the countries with the highest statistical capacity.

The main risk factor for New Zealand is trade elasticity, which has the highest value among those analyzed.

Singapore ranks at the bottom of the risk index due to its low trade exposure to the EU and the low weight of CBAM exports in total exports. In fact, among the country's top 5 trading partners, the EU does not appear (Martinus and Laopirun, 2023).

Australia shares some characteristics of **Singapore**. Exports to the EU in CBAM sectors do not particularly contribute to national GDP production (it is the second lowest value in the sample). The electricity mix is not among the country's strengths, as it is among the 5 countries with the highest carbon intensity. In fact, Australia still derives nearly half of its electricity generation from coal, however much its use is declining (De Rosa and Castro, 2020). However, good statistical capacity and significant export diversification allows it to offset this disadvantage.

Finally, **Japan** has by far the lowest risk value following the introduction of the CBAM. There are several reasons for this: first, Japan shares the highest value of innovative capacity with Korea, at nearly 7,400 patents per 100,000 population. Suffice it to say that the third country with the highest innovative capacity is Singapore, where, however, the number of patents per population is almost half that of Japan and Korea.

In addition, statistical capacity is significant and commercial exposure is relatively low. As in the case of New Zealand, the only problematic aspect is high trade elasticity.

6. Conclusions and policy implications

This section presents the conclusions drawn based on the results explained above and provides policy implications on possible future developments of the CBAM mechanism. The policy implications focus on three aspects: section 6.1 analyzes the possibility of CBAM extension to other industries; section 6.2 focuses on integration with other carbon border adjustment systems; and finally, section 6.3 presents measures to combine the new mechanism with compliance with climate justice principles.

The implementation process of CBAM is started. In fact, as of October 1, 2023, the transitional phase began, leading to full implementation by 2025. As a result, it is necessary for both the EU and trading partners to clearly define which countries are likely to be most adversely affected and what policies they should introduce to continue trading with the EU.

This study highlights which economies in the Southeast Asian region are the most at risk because of the introduction of CBAM. The reasons for this result are mainly related to the slow pace of energy transition, coupled with lower statistical and innovative capacity. The Southeast Asian countries are also joined by South Korea due to its high trade exposure to the EU.

It is therefore crucial that countries such as **Malaysia, Vietnam**, and **Indonesia** accelerate the decarbonization process of their energy sector and implement a statistical infrastructure in these two years that will allow exporters to easily access the data required by the new regulation.

On the other hand, the results also impose deep reflection on EU institutions. To prevent partner countries from opposing the new measure in the WTO, or simply deciding to reduce trade relations with the EU as described in section 2.3, the EU should increase economic support for **clean technology deployment** in Global South countries (especially those most impacted by the CBAM) and support the funding of the "Loss and Damage" fund under the United Nations Framework Convention on Climate Change (UNFCCC).

Otherwise, the EU risks being accused of trying to shift the burden of combating the climate crisis onto the shoulders of countries historically less responsible for greenhouse gas emissions.

6.1 Extension of CBAM

Although the mechanism is still in its transitional phase, the discussion in the European Parliament suggests that in the future the mechanism may be extended to the rest of the products covered by the ETS. Studies analyzing the impact in terms of emission reductions resulting from the extension of the CBAM show that its extension would more effectively reduce carbon leakage and foster the competitiveness of European companies.

However, even in the case of an extension of the mechanism to all ETS sectors, the impact on overall emissions would still be small (Böhringer et al., 2021, Zhong and Pei, 2022). This is why it is necessary for the EU to support the introduction of a similar and related mechanism in other major global economies, especially the United States and China. Moreover, the discussion of introducing a counterpart to the CBAM is already underway in these countries.

Should it be possible to create a **climate club** bringing together these three actors, described in detail in Section 2.3, the effect of such a mechanism could prove to be truly effective on the road to zero emissions. It would also shelter against potential phenomenon of resource shuffling.

These countries could also be joined by other states that are considering a similar policy, such as Australia. Australia has introduced from July 1, 2023, a major change to the Safeguarding Mechanism, which sets emission baselines to which the most polluting industrial sites must adhere. The Safeguard Mechanism is an output-based allocation system that addresses carbon leakage without resorting to free allocation of emission permits under the EU ETS (Meunier et al., 2014). Climate Change and Energy Minister Chris Bowen said the introduction of a CBAM-like measure is currently under consideration. By October 2024, the Australian government plans to finalize the policy proposals and analyze their feasibility (Ernst and Young, 2023).

6.2 Compatibility with the CBDR principle

Since its initial proposal in 2021, the CBAM has come under criticism from the perspective of equity and climate justice. Some of the most affected countries, such as Brazil, South Africa and India, have accused the EU of violating the principle of '**common but differentiated responsibilities**' (CBDR) that underlies international climate mitigation and adaptation policies (Dobson, 2022).

The CBAM respects the rule of "common responsibilities" since it is applied to all non-European countries and mirrors an equivalent measure (the EU ETS) that regulates companies in countries that are part of the union. However, according to some, the CBAM does not consider the need to differentiate responsibilities, especially with respect to Least Developed Countries.

The only **exemptions** established by the CBAM regulation are guaranteed for exporters trading goods below €150 in value, but these exemptions evidently apply only to companies with a very low volume of trade with the EU. No exemptions have been guaranteed for LDCs, because they would have increased the carbon leakage (Perdana and Vielle, 2022).

In addition, the cost of certificates imposed by the CBAM will not be the only cost that exporters in Global South countries will have to pay, because – as highlighted in Section 4.4 – the operational costs required to collect data on the emissions of the energy and materials used in the production process are added to it. These data will have to be validated by an independent source, since many developing countries do not have statistical infrastructure capable of providing them easily, it is likely that this operation will require a not inconsiderable cost.

To address these observations, the EU can commit to investing some of the revenues gained through the CBAM to encourage the green transition in trading partners as well, to generate positive spillovers not only on European soil (Banga, 2022).

The amendments proposed by the European Parliament go in this direction: they provide for a revenue share to be earmarked for the **financial support of LDCs**, equivalent to the revenues generated from the sale of certificates (Dobson, 2022). This decision can foster a CBAM implementation more attentive to the principles of equity and climate justice.

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8. Appendix

Table A.1. CBAM Comprehensive risk index

Country Name	Country Code	Carbon_Intensity	PctExpCBAM	ExpCBAMperGDP	Trade_Elast	SPI_Score_Compl	PatPerCap_Compl	Index_A1
Malaysia	MYS	0,856046	0,375534	0,766578	0,120235	0,573195	0,943975	0,631631
Korea	KOR	0,648752	1,000000	1,000000	0,388563	0,000000	0,000000	0,585224
Vietnam	VNM	0,535509	0,172111	0,655107	0,175464	0,742548	0,996384	0,563614
Indonesia	IDN	1,000000	0,494126	0,203308	0,195015	0,534875	1,000000	0,512355
China	CHN	0,831094	0,259560	0,233156	0,031281	1,000000	0,891640	0,491847
Thailand	THA	0,775432	0,116610	0,141137	0,000000	0,404881	0,978309	0,360874
Philippines	PHL	0,928983	0,000000	0,000000	0,143206	0,417770	0,997051	0,348181
New Zealand	NZL	0,000000	0,296710	0,103540	1,000000	0,100448	0,541312	0,302448
Singapore	SGP	0,750480	0,026838	0,085630	0,283480	0,438530	0,457142	0,299595
Australia	AUS	0,777351	0,102805	0,017466	0,411046	0,001400	0,684475	0,282030
Japan	JPN	0,738964	0,116878	0,053194	0,742913	0,082307	0,006678	0,252242

Table A.2. Index without innovation capacity

Country Name	Country Code	Carbon_Intensity	PctExpCBAM	ExpCBAMperGDP	Trade_Elast	SPI_Score_Compl	Index_A2
Malaysia	MYS	0,856046	0,375534	0,766578	0,120235	0,573195	0,656530
Korea	KOR	0,648752	1,000000	1,000000	0,388563	0,000000	0,656530
Vietnam	VNM	0,535509	0,172111	0,655107	0,175464	0,742548	0,481017
Indonesia	IDN	1,000000	0,494126	0,203308	0,195015	0,534875	0,450195
China	CHN	0,831094	0,259560	0,233156	0,031281	1,000000	0,441285
Japan	JPN	0,738964	0,116878	0,053194	0,742913	0,082307	0,310144
Singapore	SGP	0,750480	0,026838	0,085630	0,283480	0,438530	0,288071
New Zealand	NZL	0,000000	0,296710	0,103540	1,000000	0,100448	0,275565
Thailand	THA	0,775432	0,116610	0,141137	0,000000	0,404881	0,269303
Philippines	PHL	0,928983	0,000000	0,000000	0,143206	0,417770	0,260743
Australia	AUS	0,777351	0,102805	0,017466	0,411046	0,001400	0,231445

Table A.3. Index without trade elasticity and statistical capacity

Country Name	Country Code	Carbon_Intensity	PctExpCBAM	ExpCBAMperGDP	PatPerCap_Compl	Index_A3
Malaysia	MYS	0,856046	0,375534	0,766578	0,943975	0,730351
Korea	KOR	0,648752	1,000000	1,000000	0,000000	0,679213
Indonesia	IDN	1,000000	0,494126	0,203308	1,000000	0,634642
Vietnam	VNM	0,535509	0,172111	0,655107	0,996384	0,588453
China	CHN	0,831094	0,259560	0,233156	0,891640	0,525874
Thailand	THA	0,775432	0,116610	0,141137	0,978309	0,472522
Philippines	PHL	0,928983	0,000000	0,000000	0,997051	0,442988
Australia	AUS	0,777351	0,102805	0,017466	0,684475	0,365105
Singapore	SGP	0,750480	0,026838	0,085630	0,457142	0,309615
New Zealand	NZL	0,000000	0,296710	0,103540	0,541312	0,223807
Japan	JPN	0,738964	0,116878	0,053194	0,006678	0,214338

Table A.4. Index without trade elasticity and innovation

Country Name	Country Code	Carbon_Intensity	PctExpCBAM	ExpCBAMperGDP	SPI_Score_Compl	Index_A4
Korea	KOR	0,648752	1,000000	1,000000	0,000000	0,679213
Malaysia	MYS	0,856046	0,375534	0,766578	0,573195	0,645072
China	CHN	0,831094	0,259560	0,233156	1,000000	0,550797
Vietnam	VNM	0,535509	0,172111	0,655107	0,742548	0,530070
Indonesia	IDN	1,000000	0,494126	0,203308	0,534875	0,527663
Thailand	THA	0,775432	0,116610	0,141137	0,404881	0,340633
Philippines	PHL	0,928983	0,000000	0,000000	0,417770	0,309753
Singapore	SGP	0,750480	0,026838	0,085630	0,438530	0,305334
Japan	JPN	0,738964	0,116878	0,053194	0,082307	0,231732
Australia	AUS	0,777351	0,102805	0,017466	0,001400	0,207998
New Zealand	NZL	0,000000	0,296710	0,103540	0,100448	0,122408

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