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Carbon Border Adjustment Mechanism (CBAM) and Its Implications for Developing Economies: A Systematic Literature Review

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Abstract

Despite growing interest in the European Union's Carbon Border Adjustment Mechanism (CBAM), there remains a significant research gap in reviewing its nuanced impacts on the least developed economies—particularly in terms of sectoral vulnerabilities, institutional constraints, and the absence of empirical evidence from real-world implementation. Thus, we systematically investigate the CBAM implications for developing countries through a structured literature review. We offer a novel contribution by examining CBAM's overlooked impacts on the smallest and least developed economies, highlighting distributional effects on labor-intensive sectors and small exporters. Starting with an initial pool of 1,197 articles sourced via Publish or Perish, we apply the PRISMA and PICO frameworks to screen and refine the selection, ultimately analyzing 37 peer-reviewed articles published between 2015 and 2024 in Q1–Q3 Scopus-indexed journals. Our review identifies five major thematic concerns: trade competitiveness, industrial vulnerability, green technology access, climate justice, and policy responses. It finds that CBAM poses significant economic risks for carbon-intensive exports from the Global South, particularly in sectors such as iron, fertilizer, cement, and aluminum. Countries like Indonesia, India, China, and Vietnam face varying degrees of exposure depending on emission intensity and trade composition. We highlight the absence of embedded climate justice mechanisms and structural barriers to green technology access, which may hinder just net-zero transitions. In response, scholars recommend policy mechanisms such as revenue redistribution, differentiated carbon accounting, and international capacity-building. We conclude by contrasting CBAM with protectionist measures such as those enacted during the Trump administration, emphasizing CBAM's environmental rationale while calling for adaptive, equitable strategies that align global climate goals with sustainable development in vulnerable economies. Our study advances academic discourse by elucidating the varied ways in which CBAM is conceptualized and debated across different scholarly perspectives. It also offers practical recommendations for policymakers—including financial assistance, technology transfer, and institutional capacity building—to better align climate ambition with the principles of development equity.

Keywords:
Carbon Border Adjustment Mechanism, carbon leakage, climate policy, developing economies, trade equity

1. Introduction

Amid accelerating global climate change, the trajectory of carbon dioxide (CO_2) emissions continues to pose a critical threat to climate stability, as shown in Figure 1. In 2024, global energy-related CO_2 emissions rose by 0.8%, reaching a historic peak of 37.8 gigatons (Gt). This increase contributed to record atmospheric CO_2 concentrations of 422.5 parts per million (ppm), approximately 3 ppm higher than in 2023 and 50% above pre-industrial levels. While CO_2 emissions from fuel combustion grew by about 1% (357 Mt), emissions from industrial processes declined by 2.3% (62 Mt). Notably, the growth in CO_2 emissions was lower than the global gross domestic product (GDP) growth rate of 3.2%, suggesting a return to the long-term trend of decoupling emissions from economic output, a trend that had been disrupted in 2021 (IEA, 2025).

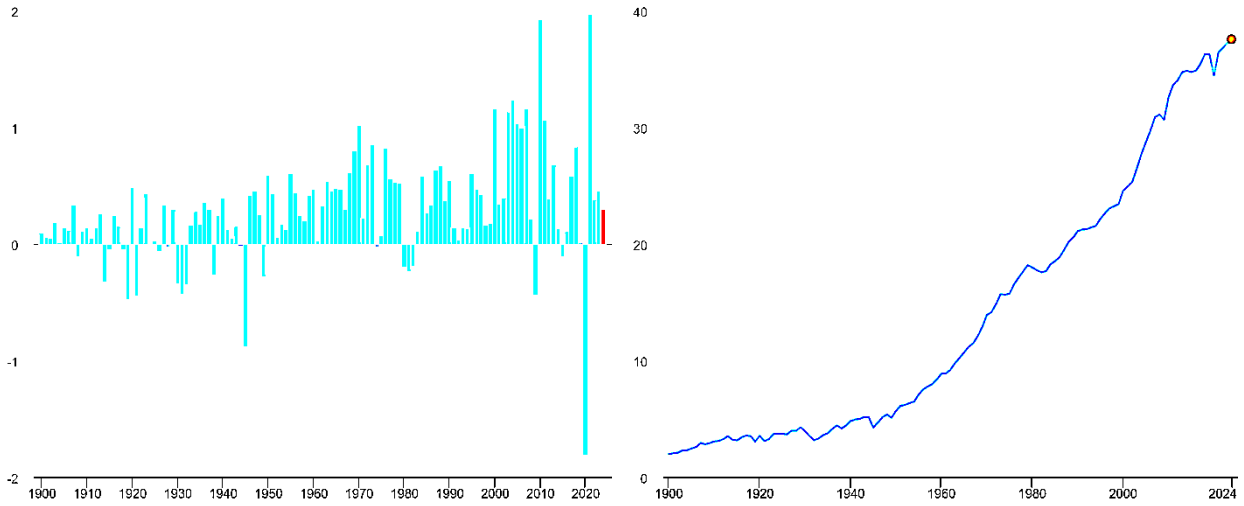

Figure 1. Annual change in CO_2 emissions & energy-related CO_2 emissions, 1900–2024 (IEA, 2025).

Earlier, in 2022, global CO_2 emissions had already increased by 1.5%, consuming an estimated 13% to 36% of the remaining carbon budget required to limit warming to 1.5 °C (Liu et al., 2023). These successive increases underscore the growing urgency for deeper decarbonization and stronger international climate cooperation. As more countries adopt net-zero targets, it becomes essential not only to monitor their emissions trajectories but also to evaluate the effectiveness of their pledges in limiting global temperature rise. Achieving net-zero by 2050 will require substantial investments in carbon capture and storage infrastructure. For example, Europe alone is projected to require 0.2 Gt of CO_2 storage by 2030 and 1.3 Gt by 2050 (van de Ven et al., 2023). This reinforces the need for immediate, coordinated, and enforceable global climate policy interventions, particularly those that manage cross-border carbon flows and ensure accountability for long-term mitigation commitments.

In 2022, the European Union (EU) introduced the Carbon Border Adjustment Mechanism (CBAM) as part of its strategy to achieve climate neutrality by 2050, aiming for a 55% reduction in greenhouse gas (GHG) emissions by 2030 compared to 1990 levels (Grácová, 2024). CBAM targets imports from carbon-intensive industries to prevent carbon leakage, in which production shifts to countries with less stringent climate policies. Functioning alongside the EU Emissions Trading System (EU ETS), CBAM will gradually replace the free allocation of emissions allowances with a more equitable system for imported goods (European Council, 2022). As the tightening of the EU ETS is expected to accelerate decarbonization, it also raises carbon prices in covered sectors. This, in turn, heightens the risk of carbon leakage, which undermines global GHG mitigation efforts by incentivizing the relocation of emission-intensive industries to jurisdictions with more lenient climate regulations (KPMG, 2022). CBAM thus serves as a critical policy instrument to counter this risk and safeguard the EU's environmental objectives against being compromised by international trade dynamics (Chu et al., 2024).

Table 1 presents carbon tariffs on iron, fertilizer, cement, and aluminum for ten developing Asian countries. India faces the highest tariff on iron at 55.38%, while Indonesia sees the highest on fertilizer at 138.72% and aluminum at 12.14%. China's tariffs are consistently high, with 17.25% on iron, 61.60% on fertilizer, 68.40% on cement, and 4.29% on aluminum. Malaysia and Thailand are the most affected in the cement sectors, at 84.75% and 88.74%, respectively. Vietnam and Pakistan also show high fertilizer tariffs, at 87.66% and 86.87%. Iran faces 69.24% on fertilizer and 63.13% on cement. Bangladesh has the lowest iron tariff at 0.68%, but higher rates in fertilizer (55.78%) and cement (56.28%). The Philippines records the lowest aluminum tariff at 0.14% and fertilizer at 21.51%. These variations reflect differing carbon intensities and sectoral vulnerabilities to CBAM across countries.

Table 1. CBAM exposure in 10 countries.

Country Name	Carbon Tariff (%)			
	Iron	Fertilizer	Cement	Aluminum
Bangladesh	0.677	55.783	56.283	2.285
China	17.246	61.602	68.401	4.289
Indonesia	12.652	138.718	66.113	12.135
India	55.375	58.168	64.728	3.509
Iran	5.763	69.238	63.126	4.076
Malaysia	3.970	48.843	84.748	1.403
Pakistan	3.621	86.867	55.474	2.863
Philippines	4.994	21.514	54.645	0.138
Thailand	3.166	46.211	88.735	0.578
Vietnam	3.247	87.664	69.933	0.464

However, the effectiveness of these commitments is often challenged by persistent structural issues such as carbon leakage, which arises when industries relocate to countries with lower or no carbon pricing, thereby undermining global emission reduction efforts and creating uneven competitive landscapes. For instance, while the EU initially assumed a carbon price of € 30 per ton, actual market prices dropped to around € 4 per ton, intensifying market distortions (Prentice, 2013). In the United States, a carbon price of USD 10 per metric ton under the RGGI framework led to a 2.1% decline in employment within participating states, while neighboring non-participating states experienced a 0.8% increase, reflecting both leakage and regional competitiveness effects (Casey et al., 2020).

Carbon leakage is most pronounced in petroleum products, where demand remains relatively inelastic in Annex I countries. This contributed to GDP declines of 0.12% in the United States and 0.16% in Mexico, largely due to weakened trade and falling petroleum prices (Adkins et al., 2011). Moreover, studies in China, where the carbon price is set at RMB 86.70 per ton, found leakage in all cases examined, although 18 out of 44 scenarios still resulted in net GHG reductions (Kondo et al., 2019). These patterns illustrate the complex and often contradictory effects of uneven carbon pricing in a globally interconnected economy.

Developing countries face significant challenges under CBAM due to limited capacity to meet strict standards and the use of generalized emission data that may unfairly raise costs. Carbon leakage remains a risk, and climate efforts such as reforestation or renewable energy investments are often unrecognized. Countries with high exposure, such as Cameroon (93%), Mozambique (74%), Albania (57%), Venezuela (44%), and Turkey (43%), are especially vulnerable without financial support from CBAM revenues (Do, 2025).

This situation has reignited debates around fairness in global climate governance and the role of trade mechanisms in enforcing climate policy. CBAM is framed as a tool to address carbon leakage and level the playing field by taxing carbon-intensive imports, based on the logic of Pigouvian taxation and the polluter pays principle (Mehling et al., 2022). At its core, CBAM reflects a broader shift toward integrating environmental costs into international trade, challenging long-standing principles of free

trade and non-discrimination under World Trade Organization (WTO) law (Schippers & De Wit, 2022; Selicato, 2022). These tensions are particularly stark for low- and middle-income countries that lack the technical infrastructure for carbon accounting or the fiscal space for domestic carbon pricing.

Recent efforts to systematically review the CBAM literature include Zhong (2024), who employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method to focus on CBAM's effectiveness in protecting competition, reducing carbon leakage, and limiting global welfare loss. The academic literature has responded by examining CBAM from legal, economic, and political perspectives. Legal analyses focus on compatibility with WTO rules, emphasizing the need for non-discriminatory implementation and exemptions for vulnerable countries (Mehling et al., 2022; Selicato, 2022). Economically, general equilibrium and input-output models have been used to estimate emission reductions, welfare effects, and trade shifts resulting from CBAM (Ernst et al., 2022; Korpar et al., 2023; Perdana & Vielle, 2022). Other studies adopt country case analyses—such as Turkey (Acar et al., 2022a), China (Chen, 2024; Song, 2024), and Russia (Ulanov & Skorobogatko, 2022) to explore sectoral exposure and policy readiness. A few contributions also examine global political dynamics, suggesting that CBAM may either fragment or consolidate climate cooperation depending on how it is implemented.

Despite this growing body of work, key gaps remain. Most notably, there is limited research on how CBAM affects the smallest and least developed economies, whose export portfolios are often more vulnerable and whose emissions profiles are poorly captured by EU data. Much of the modeling remains macro-level, overlooking social and distributional consequences within developing countries, such as the impact on labor-intensive sectors or small exporters (Beaufils et al., 2023a). Moreover, while some studies acknowledge the institutional challenges these countries face, few offer grounded policy recommendations or adaptive strategies tailored to their contexts (Acar et al., 2022a; Ulanov & Skorobogatko, 2022). The potential for CBAM to catalyze more inclusive carbon pricing or facilitate technology transfers remains underexplored, particularly in regions that currently lack formal climate instruments. Lastly, empirical studies are still scarce. Most findings to date rely on projections rather than real-world outcomes, leaving open questions about the mechanism's effectiveness and unintended consequences as implementation proceeds.

Our study addresses critical gaps in the existing CBAM literature by focusing on its overlooked impacts on the smallest and least developed economies, particularly those with vulnerable export portfolios and limited representation in EU emissions data. Unlike prior macro-level analyses, it emphasizes the social and distributional consequences within developing countries, including effects on labor-intensive sectors and small exporters. By integrating context-specific policy insights and exploring underexamined pathways such as inclusive carbon pricing and technology transfer, this research offers a more grounded and empirically informed perspective on CBAM's implementation and its implications for equitable climate governance. It further provides actionable policy recommendations—such as targeted financial support, facilitated technology transfer, and strengthened institutional capacity—to promote a more equitable alignment between climate objectives and development needs.

2. Methods and Materials

This research adopts the Systematic Literature Review (SLR) method to provide a structured, transparent, and replicable synthesis of existing knowledge on CBAM. Systematically reviewing prior studies is essential for identifying research gaps, highlighting underexplored issues, and evaluating methodological trends (Rahmah & Maulayati, 2023). To strengthen the rigor of the review process, this study integrates the PRISMA protocol and the Population, Intervention, Comparison, Outcome (PICO) framework. Although originally developed for health sciences, these tools are increasingly applied in interdisciplinary policy research due to their ability to reduce bias and clarify analytical dimensions (Nowell et al., 2022). PRISMA supports transparent literature identification and screening, while PICO enables clear categorization of target populations (e.g., developing countries), types of policy interventions (CBAM designs), and outcome measures (e.g., emissions, competitiveness, well-being) (Gunnell et al., 2022). Few CBAM-related reviews—such as Zhong (2024)—have applied these

frameworks explicitly, making this study a novel methodological contribution to the climate–trade policy literature.

2.1. Research Questions

To guide this study systematically, the PICO framework is employed to structure the research questions. Originally developed for evidence-based reviews, PICO clarifies four key elements: Population, Intervention, Comparison, and Outcome (see Table 2). We adopt the framework to examine how CBAM affects developing countries, forming the basis for the research questions. After establishing the PICO framework to define the study's core components, a set of research questions in Table 3 was developed to provide clear direction for the SLR. These questions aim to investigate the specific impacts of CBAM on developing countries, particularly in terms of trade dynamics, equity considerations, and access to green technologies. These research questions serve as the foundation for the review by delineating its scope and analytical focus. With this framework in place, the next step involves identifying, selecting, and analyzing relevant literature to gather evidence that addresses the key themes and issues outlined.

Table 2. PICO summary.

PICO	Description
Population (P)	Developing countries affected by the EU's CBAM
Intervention (I)	Implementation of CBAM policies
Comparison (C)	Countries or sectors without CBAM exposure or with alternative climate mechanisms
Outcome (O)	Impacts on trade competitiveness, carbon emissions, access to green technology, and equity

Table 3. Research questions.

Research Questions	Descriptions
RQ_1	What are the economic and trade impacts of CBAM on developing countries compared to regions not subject to CBAM?
RQ_2	How does CBAM affect the competitiveness of carbon-intensive industries in developing nations?
RQ_3	What challenges do developing countries face in accessing green technology under CBAM implementation?
RQ_4	To what extent does CBAM align with principles of climate justice and equitable responsibility between developed and developing countries?
RQ_5	What policy mechanisms are proposed to mitigate the negative impacts of CBAM on low- and middle-income countries?

2.2. Literature Search Protocol and Data Collection

We adopt a systematic and transparent search strategy to identify relevant literature addressing the implications of the CBAM for developing countries. Guided by the PRISMA framework, the search focuses on capturing peer-reviewed journal articles, policy papers, and institutional reports published between 2015 - 2024, reflecting the period during which CBAM gained global policy attention. Three major academic databases—Scopus, Google Scholar, and PubMed—are used to conduct the search due to their extensive interdisciplinary coverage. The keyword strategy combines terms such as "carbon border adjustment," "CBAM," and "carbon tariff" with contextual terms like "developing countries," "low-income countries," and "climate justice." Boolean operators (AND, OR) are applied to structure the search effectively. Only English-language documents are considered, and all search results are managed and deduplicated using reference management software such as Mendeley.

The inclusion and exclusion criteria in Table 4 are used to select relevant studies for this research on the CBAM, focusing on its economic, environmental, and policy implications, particularly in developing countries. These criteria are designed to ensure the inclusion of high-quality, credible, and relevant literature that directly contributes to the understanding of CBAM and its broader economic, environmental, and policy impacts, with particular emphasis on its effects on developing countries and the Global South.

Table 4. Inclusion and exclusion criteria.

No.	Inclusion Criteria	Exclusion Criteria
1	Publications written in English and published between 2015 and 2024.	Publications written in languages other than English or published before 2015.
2	Peer-reviewed journal articles, institutional reports, and policy papers from credible sources.	Non-academic or non-peer-reviewed materials such as news articles, blogs, opinion pieces, or social media content.
3	Journal articles published in Scopus-indexed journals ranked in Q1, Q2, or Q3 according to the Scimago Journal Rank (SJR), or with an Impact Factor listed in Journal Citation Reports (JCR).	Journals not indexed in Scopus.
4	Articles that directly or indirectly analyze CBAM and its economic, environmental, trade, legal, or policy-related implications.	Articles that do not focus on CBAM or fail to address its impact on economic, environmental, trade, or governance dimensions.
5	Studies that assess the impacts of CBAM on developing countries, low-income regions, or the Global South, either as a primary or comparative focus.	Studies focusing exclusively on the EU or developed countries without addressing implications for developing economies.

Each article selected for full-text review is assessed using the six criteria outlined in Table 5. These questions are arranged from general publication quality to specific relevance for the study. The responses to these questions determine each paper's score: a "Yes" is assigned to papers that meet the quality evaluation standards, while a "No" is assigned to those that do not. This systematic evaluation ensures that only pertinent, reliable, and high-quality literature is included in the review.

Table 5. Quality assessment.

No.	Quality Assessment Question
1	Is the publication written in English, published between 2015–2024, and available in full text?
2	Is the article published in a peer-reviewed journal and indexed in Scopus?
3	Is the article published in a journal ranked Q1 to Q3 in Scopus SJR, or listed in JCR with an official impact factor?
4	Does the article directly or indirectly analyze CBAM and its economic, environmental, trade, legal, or policy implications?
5	Does the article assess or discuss the impacts of CBAM on developing countries, low-income regions, or the Global South?

Our analysis aims to provide comprehensive insights and address all the research questions defined earlier in the study. The findings will form the basis for drawing conclusions and enhancing the overall understanding of the research topic. During the documentation phase, the entire process leading to these findings will be recorded in a paper using the standard SLR format. This structured approach ensures a clear, methodical presentation that adheres to established academic standards.

3. Results and Discussions

3.1. Results

As shown in Figure 2, an initial total of 1,197 records were identified through Scopus and Google Scholar using Publish or Perish software and keyword combinations related to CBAM, carbon pricing, trade policy, and developing countries. After removing 45 duplicate entries, 1,155 records remained for initial screening. Titles and abstracts were reviewed to exclude 328 publications that were not relevant to CBAM, leaving 827 records for full-text evaluation. At this stage, 476 articles were excluded due to insufficient discussion of economic, environmental, legal, or policy implications, while 189 others were excluded for not addressing issues related to developing countries, low-income regions, or the Global South. A total of 162 full-text articles proceeded to the final quality assessment phase.

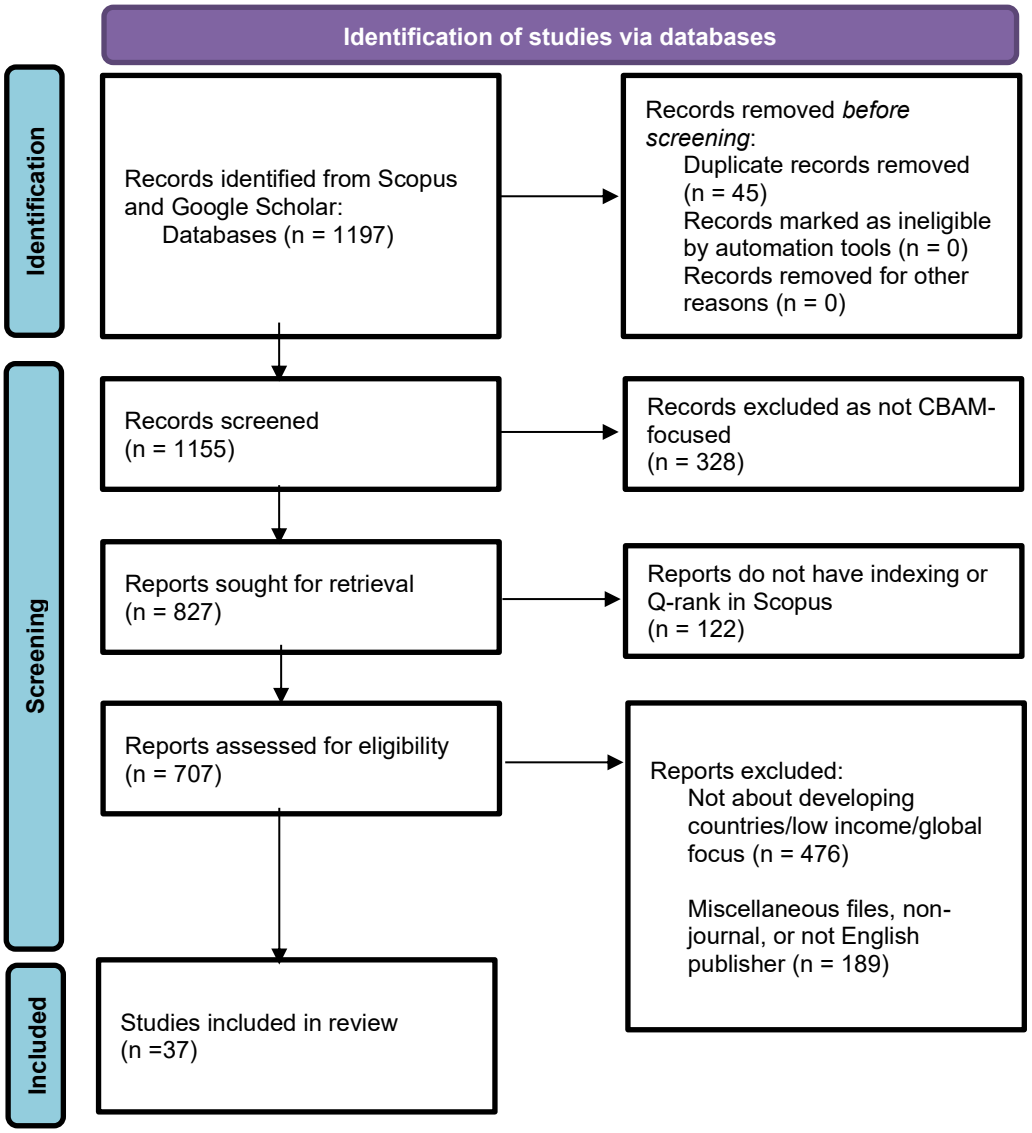

Figure 2. Research protocol - PRISMA flow diagram.

The final selection applied quality criteria based on peer-review status, journal indexing (Scopus), and Scimago Journal Rank (Q1–Q3). A total of 122 records were excluded at this stage for being non-peer-reviewed, published in unindexed journals, or lacking sufficient academic credibility. As a result, 37 high-quality articles were included in the final synthesis, as shown in Table 6. This multi-stage filtering process ensured that only the most relevant and credible sources were retained, aligning with the study's

aim to provide a rigorous and policy-relevant analysis of CBAM and its implications for developing economies.

Table 6. Result of search criteria (SC) final phase.

Journal	Publication Year	Publisher	Quantity	Q-Rank	SJR
International Economics and Economic Policy	2023	Springer	1	Q2	0.510
Discover Sustainability	2024	Springer	1	Q1	0.724
Environmental and Resource Economics	2022	Springer	1	Q1	1.381
Global Journal of Flexible Systems Management	2021	Springer	1	Q1	1.148
Environmental Science and Pollution Research	2023	Springer	1	Q1	1.004
International Environmental Agreements	2022	Springer	1	Q1	0.906
Climate Policy	2024	Taylor and Francis Ltd.	2	Q1	2.275
Energies	2021	MDPI	2	Q1	0.713
Environment Development and Sustainability	2022	Springer	1	Q1	0.958
Communications Earth and Environment	2023	Springer	1	Q1	2.953
Fundamental Research	2024	KeAi Communications Co.	1	Q1	1.182
Journal of Environmental Law	2022	Oxford University Press	1	Q1	1.008
British Accounting Review	2023	Academic Press	1	Q1	1.544
Sustainability Switzerland	2022	MDPI	1	Q1	0.688
Energy Research Letters	2021	Asia-Pacific Applied Economic Association	1	Q2	0.536
International Organisations Research Journal	2021	National Research University Higher School of Economics	1	Q2	0.273
International and Comparative Law Quarterly	2023	Cambridge University Press	1	Q1	0.748
Journal of Economic Perspectives	2023	American Economic Association	1	Q1	8.262
Journal of Common Market Studies	2024	Wiley-Blackwell Publishing Ltd.	1	Q1	1.635
Oxford Review of Economic Policy	2023	Oxford University Press	1	Q1	1.706
Georesursy	2021	Georesursy LLC	1	Q3	0.309
Energies	2022	MDPI	1	Q1	0.713
Energies	2024	MDPI	1	Q1	0.713
Environmental Economics and Policy Studies	2023	Springer	1	Q2	0.592
Climatic Change	2022	Springer	1	Q1	1.570
World Trade Review	2022	Cambridge University Press	1	Q1	0.554
Voprosy Ekonomiki	2022	Voprosy Ekonomiki	1	Q1	0.326
International Journal of Production Research	2024	Taylor and Francis Ltd.	1	Q1	2.242
Environmental Research Letters	2022	Institute of Physics	1	Q1	2.144
Sustainability Switzerland	2023	MDPI	2	Q1	0.688
Legal Studies	2022	Willey-Blackwell	1	Q2	0.378
Oxford Review of Economic Policy	2023	Oxford University Press	1	Q1	1.706
Advances in Climate Change Research	2023	KeAi Communications Co.	1	Q1	1.500
Total			**37**		

3.2. Discussions

3.2.1. Economic and Trade Impacts of CBAM on Developing Countries

The CBAM introduced by the European Union has generated substantial concern regarding its potential economic implications for developing nations. Quantitative studies have shown that developing countries heavily reliant on carbon-intensive exports to the EU are likely to experience reduced trade flows, GDP contraction, and welfare losses. For instance, Magacho et al. (2024) used MRIO matrices and trade data to reveal that countries such as Mozambique, Cameroon, Morocco, and Tajikistan may face a decline in export volumes exceeding 2%, along with significant losses in tax revenue and jobs. Similar findings were confirmed by Chepeliev (2021), who observed that Ukraine's iron and steel industry may shrink by 3.9% under CBAM. Sofuoğlu & Kirikkaleli (2023) note that developing nations tend to have higher material footprints, which correlate positively with CO_2 emissions, further increasing their vulnerability under CBAM.

Multiple simulation models and computable general equilibrium (CGE)-based assessments also support these conclusions. Sun et al. (2024) and Acar et al. (2022) use general equilibrium models to demonstrate that developing countries, including Turkey and China, are disproportionately affected by carbon tariffs. The impact on Turkey's GDP is projected to range from 2.7% to 3.6% by 2030. Zhu et al. (2024) confirm similar negative export and terms-of-trade effects for China. Moreover, the effectiveness of CBAM in reducing global emissions is disputed. While Korpar et al. (2023) report a negligible global emissions reduction of 0.08%, the sectoral shifts induced by CBAM may actually move production toward more emission-intensive sectors. This underscores the mechanism's inadequacy as a standalone climate mitigation tool for global decarbonization.

In the context of Asia, and ASEAN in particular, the impacts of CBAM are becoming increasingly relevant. Many Southeast Asian economies (such as Vietnam, Thailand, and Malaysia) rely on exports of manufactured goods, including steel, aluminum, and cement, that fall within the scope of CBAM-regulated sectors. Studies such as those by Acar et al. (2022) and Zhu et al. (2024) on Turkey and China suggest similar vulnerabilities may arise in ASEAN economies due to comparable industrial structures and emission intensities. Moreover, Faichuk et al. (2022) and Shen et al. (2023) highlight how agri-food and industrial goods exports from emerging Asia could face value erosion under CBAM, particularly when exporters lack adequate carbon tracking systems. Given ASEAN's limited institutional capacity to adopt regionally harmonized carbon pricing or emissions reporting frameworks, the bloc remains highly susceptible to unilateral climate trade policies such as CBAM.

In Indonesia’s case, exposure to CBAM could be particularly disruptive due to its dual dependence on fossil-fuel-intensive exports and limited readiness for carbon regulation. Sectors like palm oil, nickel, aluminum, and steel—major foreign exchange earners—are likely to fall under CBAM scrutiny in the near future. As shown by Magacho et al. (2024), economies with low carbon efficiency and heavy reliance on commodities are the most at risk. Furthermore, studies such as Lin & Zhao (2023) and Zhao et al. (2024) show that countries without transparent carbon accounting and border adjustment protocols are likely to face trade penalties. Indonesia, despite its nationally determined contribution (NDC) commitments, still lacks an integrated carbon pricing framework or emissions registry robust enough to ensure CBAM compliance. Without targeted policy interventions, Indonesia risks losing competitiveness in EU markets and missing its broader climate targets.

3.2.2. CBAM and Competitiveness of Carbon-Intensive Industries in Developing Nations

CBAM’s direct economic repercussions are closely intertwined with its effects on industrial competitiveness in the Global South. Studies such as Shen et al. (2023) and Zhu et al. (2024) highlight how stock markets and trade volumes of firms in countries like China respond negatively to CBAM policy announcements. Companies with high carbon intensity experience pronounced declines in market value. The steel, fertilizer, and aluminum sectors are identified as especially vulnerable due to their significant exposure to EU markets (Lin & Zhao, 2023). Demirdelen et al. (2023) provide life

cycle assessments of synthetic yarn production, showing high carbon footprints for polypropylene and polyester exports, with implications for textile producers in countries such as Turkey.

The competitiveness risk is further aggravated by structural rigidities. As Magacho et al. (2024) note, most macroeconomic models overestimate developing countries' ability to shift between sectors. In practice, rigid labor markets and high dependence on a few carbon-intensive sectors make transitions extremely costly. Faichuk et al. (2022) highlight this issue within agri-food exports, where high fertilizer use in developing countries leads to significant emission footprints, threatening market access under CBAM. The burden on firms in these regions is amplified by insufficient domestic carbon accounting mechanisms (Huang et al., 2022; Zhao et al., 2024). Consequently, the policy, in its current form, may induce industrial devaluation and hinder long-term economic development in countries that lack decarbonization infrastructure.

Across the ASEAN region, similar structural and technological challenges emerge. Many Southeast Asian economies possess carbon-intensive industrial clusters—particularly in textiles, petrochemicals, and cement—that mirror the vulnerabilities seen in studies on Turkey and China. ASEAN firms often operate with outdated machinery, poor access to renewable energy inputs, and limited ability to monitor emissions effectively. Studies by Sun et al. (2024) and Korpar et al. (2023) indicate that without integrated carbon governance frameworks, these firms face higher carbon-adjusted export prices, diminishing their global competitiveness. The lack of mutual recognition agreements (MRAs) on carbon accounting between ASEAN and the EU further increases the uncertainty and compliance burden faced by local exporters.

For Indonesia specifically, the challenge is especially pronounced in sectors like steel, aluminum, and fertilizers—core industries for both domestic infrastructure and export markets. Demirdelen et al. (2023) and Faichuk et al. (2022) provide insight into the high emission intensities of these sectors in developing contexts. In Indonesia, where industrial energy supply still relies heavily on coal, firms face higher embedded carbon costs. Lin & Zhao (2023) and Zhao et al. (2024) suggest that without standardized monitoring, reporting, and verification (MRV) systems, Indonesian industries may not be able to credibly demonstrate lower carbon footprints. These risks create a competitiveness gap that pushes EU-bound orders to countries with verified lower emissions, further marginalizing Indonesian exporters unless decisive technological and regulatory reforms are enacted.

3.2.3. Challenges in Accessing Green Technology Under CBAM

One of the recurring concerns in CBAM literature is the limited ability of developing countries to access and deploy green technologies essential for compliance. According to Magacho et al. (2024), CBAM can deepen existing technological disparities by penalizing high-emission production without offering adequate support for transitioning. Hancock & Wollersheim (2021) and Durán (2023) emphasize that green hydrogen and renewable energy technologies remain largely concentrated in developed regions due to cost and infrastructure gaps. This results in an uneven playing field where EU industries can decarbonize faster, leaving developing economies technologically and economically stranded.

Furthermore, the political and legal design of CBAM does not inherently facilitate technology transfer. Mehling & Ritz (2023) and Pirlot (2022) argue that CBAM lacks mechanisms to redistribute carbon tariff revenues to support clean transitions in low-income countries. While Jakob (2023) and Smith et al. (2024) stress the importance of engaging vulnerable partners in diplomatic efforts, there remains no binding commitment for doing so. Even international cooperation schemes like "carbon clubs" are structured around mutual enforcement rather than support, making participation challenging for countries without green infrastructure (Clausing & Wolfram, 2023; Perdana & Vielle, 2023). This technological exclusion contradicts global climate justice goals and hampers inclusive climate transitions.

In the broader ASEAN context, this lack of access to green technology has significant implications. Countries such as Vietnam, the Philippines, and Laos continue to face challenges in financing renewable

energy transitions, retrofitting industrial production, and upgrading transportation systems. Drawing from the structural vulnerabilities identified in China and Turkey (Acar et al., 2022; Sun et al., 2024), one can infer that ASEAN countries, characterized by similar industrial emissions profiles, will face major hurdles in complying with CBAM without external support. Moreover, the concentration of clean technology patents and supply chains in OECD countries (Durán, 2023; Hancock & Wollersheim, 2021) makes technology transfer expensive and politically sensitive, especially in the absence of structured agreements between ASEAN and the EU.

In Indonesia, these challenges are particularly acute. Despite policy commitments toward renewable energy in national planning documents, implementation remains slow due to budget constraints, fossil fuel dependence, and a lack of research and development capacity. Studies by Lin & Zhao (2023) and Zhao et al. (2024) have shown that technological readiness plays a crucial role in shaping CBAM vulnerability. Indonesia's export-oriented sectors—such as mining, agriculture, and heavy industry—lack access to emission-reducing technologies, while state support mechanisms remain limited. Without clear pathways for public-private collaboration or international financial partnerships, the country risks falling further behind in green industrial competitiveness, increasing its exposure to carbon-adjusted trade measures like CBAM.

3.2.4. CBAM and Climate Justice

The implementation of CBAM raises critical concerns about climate justice, particularly in relation to the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC). Scholars argue that CBAM overlooks historical emissions disparities by applying uniform carbon pricing across countries, regardless of their developmental status (Bashmakov, 2022; Durán, 2023). It has also been emphasized that countries in the Global South lack both the institutional capacity and technological infrastructure to comply with CBAM in a manner equitable to that of their developed counterparts (Zhong, 2024). This raises ethical and legal questions about fairness, especially for countries with negligible historical responsibility for global emissions.

Beyond these structural inequities, empirical studies have shown that CBAM could reinforce economic dependencies and undermine development trajectories in the Global South. Countries in Africa and Asia with significant trade exposure to the EU are disproportionately affected, potentially reversing gains made through trade liberalization (Beaufils et al., 2023). CBAM also risks entrenching climate discourse in authoritarian contexts such as Russia, where carbon compliance may be used to justify political centralization rather than genuine environmental reform (Korppoo, 2022; Stranadko, 2022). These concerns highlight the broader tension between trade-based environmental measures and inclusive global climate governance.

In ASEAN, climate justice concerns are particularly pronounced. Many Southeast Asian economies continue to grapple with poverty alleviation, energy access, and industrial development, yet face punitive carbon pricing mechanisms through CBAM. This creates a paradox in which developing countries are expected to bear the costs of decarbonization without having reaped the historical benefits of industrial growth. CBAM should therefore be complemented by financial and technological support instruments that promote fairness across jurisdictions (Jakob, 2023; Pirlot, 2022). Without such measures, ASEAN nations may increasingly view CBAM not as a climate tool, but as an economic barrier.

Indonesia, with its high carbon intensity and pressing development priorities, exemplifies this justice dilemma. Although the country has made progress in climate policy through its Nationally Determined Contributions (NDCs), it remains heavily reliant on coal and extractive industries for economic growth. CBAM could unintentionally penalize Indonesia’s growth model, particularly in sectors that are employment-intensive and vital to rural livelihoods (Huang et al., 2022; Lin & Zhao, 2023). Unless CBAM revenues are partially redirected to support affected developing countries or the mechanism is adjusted to reflect differentiated capabilities, it risks deepening North–South divides in climate responsibility and undermining international cooperation.

3.2.5. Policy Mechanisms to Mitigate CBAM's Impact and Its Comparison with Trump-Era Tariffs

To address the multifaceted challenges posed by CBAM, scholars have proposed a range of policy mechanisms designed to support developing countries in their transition toward low-carbon economies. One key recommendation is the adoption of flexible carbon intensity accounting that considers national circumstances and sectoral differences (Mehling & Ritz, 2023; Zhong, 2024). Such flexibility would enable countries with limited monitoring capacity to pursue gradual compliance pathways. Enhancing domestic GHG control and improving emissions data accuracy can also strengthen readiness and reduce income losses associated with CBAM (Bashmakov, 2022).

Fiscal redistribution is another central theme. A portion of CBAM revenues could be earmarked for capacity building and green infrastructure development in the Global South (Kuehner, 2022). Emerging policy trends increasingly align climate action with broader Sustainable Development Goals (SDGs), which can be leveraged to build public support for CBAM-linked reforms (Hsieh & Yeh, 2024). Innovations such as blockchain-based emissions tracking and differentiated treatment for least developed countries may help reduce administrative burdens and enhance fairness (Durán, 2023; Gerbeti, 2021).

It is also instructive to compare CBAM with other recent trade-related policy tools, particularly the tariff-based protectionist measures introduced under former U.S. President Donald Trump and reportedly reconsidered in 2025. While both CBAM and Trump-era tariffs function as border measures affecting trade flows, their underlying rationales and global implications differ significantly. Trump's reciprocal tariffs primarily targeted specific countries (e.g., China) and sectors (e.g., steel and aluminum) to protect domestic industries, citing trade deficits and unfair competition as justification. These actions were widely criticized for fueling trade wars and undermining multilateralism (Alfvegren, 2025; Welfens, 2020).

In contrast, CBAM is framed within a climate policy agenda aimed at preventing carbon leakage and promoting global decarbonization. Although both policies can disrupt international trade, CBAM claims legitimacy under environmental objectives aligned with the Paris Agreement. Nevertheless, CBAM may unintentionally replicate protectionist logic if not implemented equitably (Mehling & Ritz, 2023; Pirlot, 2022). Unlike Trump's tariffs, which overtly pursued national economic gains, CBAM aspires to serve a global environmental good—though its legitimacy depends heavily on whether revenues are redistributed and fairness principles are upheld.

4. Conclusions

This study set out to systematically examine the implications of the European Union's CBAM for developing economies. Employing the systematic literature review (SLR) method, we identified, selected, and analyzed 37 high-quality academic sources published between 2015 and 2024 to assess CBAM's impact on trade competitiveness, emission control, access to green technologies, and climate justice in low- and middle-income countries.

The findings reveal that while CBAM aims to prevent carbon leakage and establish a level playing field for industries subject to asymmetric climate regulations, it risks functioning as a disguised form of green protectionism if not designed and implemented equitably. This concern aligns with classical and modern trade theories—particularly the theory of comparative advantage and the Stolper-Samuelson theorem—which suggest that external interventions such as border tariffs can distort optimal trade flows and disproportionately affect less developed economies reliant on emission-intensive exports. Moreover, when viewed through the lens of strategic trade theory, which supports selective protectionism for infant industries under national development goals, CBAM appears problematic: it imposes protection externally, justified by environmental objectives, but without reciprocal developmental support for affected countries.

We also highlight a notable gap in empirical validation from developing regions, underscoring the need for more inclusive and context-sensitive analysis. This paper contributes to the academic discourse by clarifying how CBAM is conceptualized and contested across diverse strands of scholarship, and by offering actionable insights for policymakers—such as financial assistance, technology transfer, and institutional capacity building—to help align climate ambition with development equity. Future research should deepen empirical engagement with CBAM-affected countries, integrate sector-specific modeling approaches, and explore cooperative alternatives that uphold both climate imperatives and economic sovereignty.

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