MAPPING THE INTERDEPENDENCE OF CARBON-ENERGY-INDUSTRY THROUGH THE CARBON BORDER ADJUSTMENT MECHANISM WITH SUSTAINABLE DEVELOPMENT GOALS

[Drielli Peyerl, University of Amsterdam, +31685533297, d.peyerl@uva.nl]
[Bob van der Zwaan, University of Amsterdam, TNO,
Johns Hopkins University, +31650009613, bob.vanderzwaan@tno.nl]

Overview

In December 2019, the European Commission announced a policy package focused on achieving the ambitious target of reducing emissions by 55% by 2030 and reaching climate neutrality by 2050 - the European Green Deal. As part of this initiative, the Carbon Border Adjustment Mechanism (CBAM) is introduced as an environmental policy instrument. It aims to assign a fair cost to the carbon emissions generated during the production of carbon-intensive goods imported into the European Union (EU) and to promote cleaner industrial production practices in non-EU countries (European Commission, 2024). CBAM will initially target sectors with high carbon intensity and susceptibility to carbon leakage, such as cement, iron and steel, and aluminium. Currently in a transitional phase from 2023 to 2025, its implementation and evaluation of its impacts remain complex. Although part of a European policy based on the Paris Agreement, CBAM can directly impact not only EU countries but also non-EU countries that export goods to Europe. In addition to being part of the EU's broader climate action strategy and aligning with trade policy, CBAM is a self-assessment tool for EU importers, requiring them to report the greenhouse gas emissions embedded in their imports. However, the implications of CBAM could reshape global carbon and energy markets while also driving geopolitical shifts—either fostering international cooperation on climate goals or intensifying tensions over economic competitiveness. This work aims to map the carbon-energy-industry interdependence through CBAM, exploring synergies and trade-offs with Sustainable Development Goals (SDGs). The 2030 Agenda establishes 17 SDGs and 169 more specific targets to be met by 2030. These goals and targets can aid in mitigating and balancing the positive and negative impacts of CBAM across different countries. Developing methodologies and tools across different policies, international agreements and global action plans can enhance interdependencies and move beyond the competition narrative between them, boosting synergies and reducing potential trade-offs.

Methods

The methodological assessment adopts an approach focused on examining the possible interactions, mutual benefits, and challenges between CBAM and the SDGs. The first step is a qualitative data analysis, using *Atlas.ti* to identify the key dimensions outlined in the CBAM regulation. A total of 495 codes are identified and classified into categories based on similarity and frequency of occurrence, enabling the identification of three major dimensions within the dataset: carbon, energy, and industry. The second step maps the carbon-energy-industry interdependence to the 169 SDG targets and the 17 SDGs, identifying synergies and trade-offs. The scoring ranges from -3 (makes it impossible to achieve the SDG target) to +3 (inextricably linked to the achievement of the SDG target), with 0 indicating no direct influence or a neutral interaction (Gjorgievski et al., 2022; Nilsson et al., 2016). These interactions are used to measure the impact of a mitigation action on the achievement of an SDG target. A systematic literature review is conducted to collect evidence of potential interactions. The third step is guided by the question: How does CBAM implementation create synergies and trade-offs with the SDGs? This methodological step is entirely based on Equation 1 for quantifying the synergies and trade-offs between CBAM and SDGs:

$$P_{\mathrm{SDG}} = \frac{1}{3G} \sum_{i=1}^{G} \sum_{\mathrm{Interdependence}} \left[S(\mathrm{Interdependence}, i) - T(\mathrm{Interdependence}, i) \right] \tag{1}$$

where P_{SDG} represents the overall result for a specific SDG, G is the number of targets per goal under consideration, S indicates the synergies grade, and T indicates the trade-offs grade - as previously described, and the term Interdependence refers to the relationship between carbon-energy, carbon-industry, and energy-industry. In the fourth step, the gross domestic product, the carbon emission intensity of exports (kg/USD), and the percentage of

exports to Europe by industrial sector are also used to assess the impact on different countries and geopolitical relations related to CBAM and the SDGs.

Results

The interdependence between carbon-energy-industry is a critical factor in achieving both the aims of CBAM and the SDGs. The relationship between carbon-energy closely aligns with several SDGs, particularly SDGs 7 (affordable and clean energy), 8 (decent work and economic growth), and 13 (climate action), while the link between carbon-industry is entirely dependent on the interaction between energy-industry, and carbon-energy. A key example is the role of a carbon price in advancing SDG 7 with a highlight on targets 7.2 (increase the share of renewable energy) and 7.3 (improvement of energy efficiency). Countries with limited technological innovation and high carbon intensity may strongly oppose CBAM, potentially creating trade-offs with target 7.3. The implementation of CBAM may lead to geopolitical tensions, particularly concerning local energy access - when industries may compete with the use of renewable sources. In addition, it is crucial for the EU to support the process of technology transfer and innovation, particularly when the exporting country relies on the technology. The interdependence between energy and industry is also decisive for the progress of SDG 9 (industry, innovation, and infrastructure). This relationship is primarily influenced by geographic factors, such as the cost of electricity and the best sites with high renewable energy potential in each country. To effectively address these interconnections, strategies and mitigation actions must be implemented to foster synergies between CBAM and SDGs. The analysis of carbon-energy-industry interdependence should be integrated into strategic planning to ensure that each dimension is optimized for sustainability. Table 1 summarizes the mitigation actions that influence each of these dimensions and provides potential pathways for implementing the CBAM in a way that aligns with the SDGs.

	DIMENSIONS	MITIGATION ACTION
INTERDEPENDENCE	Carbon	⇑ Decrease emission footprint Foster sustainable international trade Implement carbon pricing
	Energy	⇑ Decrease energy production and consume Increase the use of clean energy Increase energy efficiency Reduce the electricity price
	Industry	⇑ Employ the precise data collected Optimize industrial processes to reduce greenhouse gas emissions Promote the development of technology and innovation

Table 1 – The interdependence of CBAM and SDGs in mitigation actions.

Conclusions

In conclusion, CBAM has the potential to reshape both domestic and global markets while contributing to the progress of the SDGs. By targeting carbon-intensive sectors and promoting cleaner industrial practices, CBAM creates both opportunities and challenges, especially in terms of its impact on non-EU countries. The interdependence between carbon, energy, and industry is key to understanding the synergies and trade-offs with SDGs. Strategic planning and targeted mitigation actions will be essential to ensure that CBAM supports sustainability and fosters international cooperation while minimizing any potential negative impacts on geopolitical relations. The framework developed in this work provides a comprehensive approach to aligning CBAM with the SDGs, supporting more effective and integrated policies.

References

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