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The economic impacts of the European Union's Carbon Border Adjustment Mechanism on developing countries: the case of Vietnam

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Abstract

Purpose – This paper aims to assess the economic impacts of the European Union's Carbon Border Adjustment Mechanism (CBAM) on Vietnam.

Design/methodology/approach – We constructed a general equilibrium model to assess the economic impacts of the CBAM on the macroeconomic indicators of Vietnam. We also constructed a generic partial equilibrium model to provide a zoomed-in view of the impact on each group of CBAM-targeted commodities, which is not possible in the general equilibrium model. Both the general equilibrium and the partial equilibrium models were calibrated with publicly available data and a high number of value sets of hyperparameters to estimate the variations of the estimated impacts.

Findings – The results suggest that the current form of the EU's CBAM is unlikely to produce substantial effects on the overall economy of Vietnam, mainly because the commodities affected by it represent a small portion of Vietnam's exports. However, at the sectoral level, the CBAM can reduce production outputs and export values of steel, aluminium, and cement.

Social implications – The CBAM by itself may not lead to significant decreases in greenhouse gas emissions, but it could provide a rationale for implementing carbon pricing strategies, which might result in more significant economic effects and help in reducing greenhouse gas emissions. This highlights the necessity of supplementary policies to tackle global climate change.

Originality/value – We constructed economic models to evaluate the impacts of the European Union's Carbon Border Adjustment Mechanism on Vietnam, both at the macroeconomic level and zooming in on directly impacted groups of commodities.

Keywords Climate change, Aluminium, Steel

Paper type Research paper

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1. Introduction

Carbon pricing is a critical policy tool to internalise carbon emissions' social cost, incentivising emission reductions and facilitating the transition to a low-carbon economy (UNFCCC, 2023). Within the realm of carbon pricing mechanisms, a Carbon Border Adjustment Mechanism (CBAM) has emerged as a new carbon-pricing approach to ensure a level playing field for industries exposed to international competition. CBAM operates by imposing a carbon price on imported goods based on their embedded carbon content, therefore, it discourages carbon-intensive production processes and encourages the adoption of cleaner technologies globally. Moreover, this mechanism mitigates the risk of carbon leakage, wherein production shifts to regions with laxer environmental regulations (Jakob, 2021; Grubb *et al.*, 2022).

The world's first CBAM was presented by the European Commission in 2021 (European Commission, 2021), and then approved by the European Parliament and the European Council in 2023 (European Parliament and the Council, 2023). This is part of the EU's target to accelerate the reduction of greenhouse gas (GHG) emissions and achieve carbon neutrality by 2050 (Council of the European Union, 2021). The CBAM proposal aims to address the risk of carbon leakage caused by non-European Union countries whose policies to mitigate climate change are less ambitious (European Parliament, 2022b). CBAM will complement the EU's Emission Trading Scheme (EU ETS) and requires importers to buy certificates based on the GHG emission intensity of products they import into the EU at a price equal to that of EU ETS emission allowances (European Court of Auditors, 2020). Mandatory carbon prices in exporting countries will be credited under the CBAM, so only the differential to the EU ETS price remains to be paid. The CBAM payment will apply from 2026 to six imported commodity groups, namely iron and steel, cement, aluminium, fertilisers, electricity, and hydrogen (European Parliament and the Council, 2023).

Vietnam and the EU are important trading partners with strong economic ties. The two parties entered a Free Trade Agreement in 2019. In 2022, Vietnam was the EU's 16th trade-in goods partner and the EU's largest trading partner in ASEAN (European Commission, 2024). Data from the General Statistics Office of Vietnam showed that the EU was Vietnam's third largest export market in 2022, after the US and China, with an export value of more than 50 billion USD, accounting for about 15% of the total. From an international trade perspective, CBAM is an additional tax that reduces the competitiveness of goods imported to the EU from countries with zero or low costs of GHG. Due to the strong trade ties, Vietnam may be among the countries most economically affected by CBAM.

In addition to economic impacts, CBAM may influence Vietnam's climate policy. In particular, while being a low-middle-income country, Vietnam recognises the importance of mitigating climate change and has set an ambitious target to achieve net-zero emissions by 2050 (Prime Minister of Vietnam, 2022), similar to many developed countries. Vietnam also plans to set up its own carbon market by 2028 (Government of Vietnam, 2022b), and the introduction of CBAM may prompt Vietnam to accelerate carbon pricing. This is because the CBAM tax rate is the differential between the EU ETS price and domestic carbon price; as a result, carbon pricing can retain part of the revenue that would be paid to the EU in Vietnam rather than to the EU.

In this paper, we attempt to assess the economic impacts of the EU's CBAM on Vietnam, both with and without Vietnam's carbon pricing. We constructed a general equilibrium model to estimate the impacts of the CBAM on macroeconomic indicators such as Gross Domestic Product (GDP), fossil fuel prices, and employment. As the CBAM-targeted commodities are only part of Vietnam's exports, and at this stage, the CBAM only impacts the commodities exported to the EU, the expected economic impacts of the CBAM on the entire economy of Vietnam may not be large if it is not accompanied by carbon pricing. As a result, we constructed a generic partial equilibrium framework to offer a more detailed insight into the

impacts on each targeted group of commodities. To ensure the applicability of this framework to all targeted commodities, the model is specified to be generic with one supply of each targeted group of commodities, rather than decomposing the supply into different partitions that data may not support.

Our findings indicate that CBAM would have some impacts on the production outputs and export values of steel, aluminium, and cement. However, the direct effects on Vietnam's macroeconomic indicators would be modest, because of the small share of directly affected commodities in Vietnam's export portfolio. CBAM alone is insufficient for achieving notable reductions in greenhouse gas (GHG) emissions. However, CBAM can serve as a rationale for implementing carbon pricing, which is crucial for Vietnam to achieve its climate targets.

The remainder of the paper is organised as follows. In section 2, we summarise background information on the EU's CBAM. In section 3, we provide an overview of relevant information on Vietnam in relation to the CBAM-targeted commodities. Section 4 briefly describes the materials and methods, with detailed model specifications supplied in the Appendix. Section 5 presents the estimated macroeconomic impacts of the CBAM. Section 6 presents the estimated impacts on each of the individual targeted groups of commodities. Section 7 discusses the policy implications of the results, and section 8 concludes.

2. Background information on carbon pricing and the EU's CBAM

2.1 Carbon pricing as an economic approach to climate change

Climate change economic instruments aim to provide a clear carbon price signal to support lower carbon activities. Carbon pricing increases the prices of goods across the economy in proportion to their emission content (Stiglitz *et al.*, 2017), and by raising the relative price of carbon-intensive goods, carbon pricing encourages individuals and businesses to purchase less carbon-intensive alternatives (Kennedy, Kaufman, & Obeiter, 2015). Two main types of carbon pricing instruments are carbon taxes and emission trading systems or ETS (World Bank, 2022). Carbon tax is a policy tool that the government uses to impose a fee on GHG emissions, hence, it provides a financial motivation to reduce emissions. In a carbon tax scheme, the government sets the carbon price, and the market decides the amount of emissions reductions encouraged by the price (Royal Society, 2002). An ETS sets a cap on the quantity of GHG emissions in specific sectors of an economy. The government allocates or sells tradable emission allowances to entities covered under the cap, with each allowance representing permission to emit a specific volume of emissions. These entities must submit allowances for their emissions during the compliance period, and they can buy extra allowances if necessary or sell any surplus allowances. This system is commonly referred to as a "cap-and-trade" system. On the other hand, ETS can also use a "baseline-and-credit" approach, where there is no fixed limit on total emissions per sector, but covered entities can "earn" emission credits if they emit less than the baseline. These credits can be traded with entities that require additional credits to cover their surplus emissions compared to the baseline. In ETS, the emission price is not fixed by the government unless the government chooses to do so by imposing a price on the allocation of allowances (World Bank, 2022).

2.2 The overall context of CBAM in relation to the EU ETS

The EU has pledged to become the world's first carbon-neutral continent by 2050 (European Commission, 2019). Toward this objective, the European Commission introduced the European Green Deal in 2019, which includes an updated target for 2030 to reduce GHG emissions by at least 55% compared to 1990 levels (European Commission, 2019). In 2021, the European Commission proposed a set of legislative measures known as the "Fit for 55" package to align the EU's sectoral legislation, including climate, energy, transport, and

taxation, with its 2030 GHG emission reduction targets (Council of the European Union, 2021). The "Fit for 55" package includes a reform of the EU ETS, with changes to expand covered sectors, reduce annual allowances, and phase out free emission allowances. The tightening of the EU ETS is expected to support the EU's decarbonisation effort; however, it may also increase the carbon prices of the covered sectors, which could result in the risk of carbon leakage (KPMG, 2022b). Carbon leakage occurs when GHG emissions-intensive production moves to non-EU countries with less stringent climate policies, leading to an increase in global GHG emissions (European Commission, 2021). Therefore, the European Commission proposed CBAM as an essential toolbox to address the risk of carbon leakage and prevent increases in global emissions (European Commission, 2021).

The ideology in the CBAM proposal was approved by the Council of Europe and the European Parliament in 2022 (Council of the European Union, 2022b; European Parliament, 2022a). The European Commission, the Council of Europe, and the European Parliament started their negotiations on the final text of CBAM, and they reached a provisional agreement (European Parliament, 2022b). In February 2023, the European Parliament's Committee on the Environment, Public Health and Food Safety released a provisional agreement resulting from interinstitutional negotiations on CBAM regulation (European Parliament, 2023), and the CBAM regulation was formally approved by the Council of Europe and the European Parliament in May 2023 (European Parliament and the Council, 2023).

2.3 Objectives and scopes

The main objective of CBAM is to mitigate the risk of carbon leakage, ensure fair competition for the EU industry, and foster global environmental responsibility (Council of the European Union, 2022a). CBAM will be implemented at borders by imposing an additional charge on imports of specific emission-intensive goods, mirroring the carbon pricing applied to domestic products under the ETS. This charge is determined by the carbon footprint of the goods, i.e. emissions produced during their manufacturing processes, and any compulsory carbon pricing in exporting nations. By applying equivalent carbon pricing to imported goods, CBAM is also viewed as an effective means to equalise opportunities for EU producers and importers and mitigate the competitive pressures the EU industry faces in the international market (European Parliament and the Council, 2023).

CBAM also aims to reduce GHG emissions by encouraging the adoption of more efficient emission-reducing technologies in manufacturing industries of third countries (European Parliament and the Council, 2023). The EU plans to collaborate with low and middle-income countries to facilitate the reduction of carbon emissions in their manufacturing sectors. Furthermore, the EU plans to provide technical assistance and funding generated from the sale of CBAM certificates to the least developed countries, assisting them in meeting the new obligations set by this regulation. The European Commission suggested that imports from certain countries and territories with climate policies equivalent to or aligned with the EU ETS may be exempt from CBAM (European Parliament and the Council, 2023). This initiative aims to encourage third countries with less ambitious existing climate policies to increase their climate efforts and join the global fight against climate change.

In the initial proposal, the CBAM would apply to five categories of commodities with specific custom commodity codes, namely aluminium, cement, electricity, fertilisers, iron and steel (European Commission, 2021). In 2022, the EU Parliament proposed the inclusion of two additional sectors: chemicals and polymers (European Parliament, 2022a). Following negotiations, an agreement has been reached that CBAM would cover the five initial sectors proposed by the Commission, plus hydrogen (Council of the European Union, 2022b; European Parliament, 2022b). Consequently, the CBAM will include six categories of commodities. The custom commodity codes for these groups are shown in Appendix 1.

The CBAM is estimated to cover more than 50% of the total emissions from sectors under the EU ETS when it is fully phased in (Taxation and Customs Union, 2022). The greenhouse gases subject to the CBAM include carbon dioxide (CO_2), nitrous oxide (N_2O), and perfluorocarbons (PFCs). Additionally, the CBAM applies to indirect emissions, defined as GHG emissions from electricity production processes consumed during the production of goods.

The CBAM exemptions may apply to imports from specific countries or territories (European Parliament and the Council, 2023). A general exemption will be granted to countries implementing the EU ETS or having a domestic ETS fully linked with the EU ETS. In such cases, the carbon price paid in the originating country must be charged without any additional rebate beyond those applied in the EU ETS. If the exporting country has an integrated electricity market with the EU internal market and it is infeasible to apply CBAM, the importation of electricity will be exempt under different conditions. These conditions include the obligations of the exporters to adhere to the EU law regarding electricity, implement the principal provisions of the EU electricity market legislation, commit to achieving climate neutrality by 2050, demonstrate progress in aligning domestic legislation with the EU law concerning climate action, and institute effective measures to prevent indirect imports from non-compliant third countries.

2.4 Plans for implementation

The CBAM will commence with a three-year transitional phase, starting from October 2023 (European Parliament and the Council, 2023). During this transition period, importers only have reporting obligations without any financial adjustments required. Every quarter of a calendar year, importers need to submit a report containing information about the total quantity of each type of goods (in MWh for electricity and tonnes for other goods), total embedded (direct and indirect) emissions in the imported goods (in tonnes of CO_2e per MWh for electricity or tonnes of CO_2e per tonne of each type of goods other than electricity), and the carbon prices paid in the country of origin. The calculations of embedded emissions must follow the methods in the implementing regulation based on actual emissions or default values provided by the Commission.

Starting from 2025, importers of CBAM goods are required to register as authorised CBAM declarants before importing CBAM goods. Once the definitive system takes effect in 2026, declarants will need to submit an annual CBAM declaration for the preceding year. The declaration should include information on the quantity of the imported goods, the total embedded emissions, and the corresponding number of CBAM certificates to be surrendered after adjusting for the reduction due to the carbon price paid in the country of origin.

From 2026, authorised declarants will be required to purchase CBAM certificates from the competent authority of each Member State. The price of these certificates will be determined based on the average price of the closing prices of EU ETS allowances on the common auction platform in the week prior to import. The number of certificates purchased must correspond to the declared and verified embedded emissions. Although CBAM certificates cannot be traded, declarants will have the ability to resell a limited number of excess certificates (up to one-third of the total purchased certificates) to the competent authority at the purchased price after the required certificates have been surrendered (European Parliament and the Council, 2023).

3. CBAM-targeted commodities in Vietnam

There are six broad groups of commodities targeted by CBAM: (1) iron and steel, (2) aluminium, (3) cement, (4) fertilisers, (5) electricity, and (6) hydrogen. Among these groups,

electricity and hydrogen are not directly impacted because Vietnam does not export electricity and hydrogen to the EU. As a result, our CBAM-targeted groups of commodities include iron and steel (hereafter referred to as steel), aluminium, fertilisers, and cement.

Table 1 provides an overview of key data for the four targeted groups of commodities in Vietnam. Over the 5-year period from 2017 to 2021, Vietnam exported 7.3 billion USD worth of steel products annually to 123 trade partners, of which nearly 1 billion USD was exported to the EU market, accounting for 13% of the total export value. Meanwhile, Vietnam exported 696 million USD worth of aluminium to 88 trade partners, of which the export to the EU market amounted to 48 million USD, representing 7% of the total aluminium export value. The EU markets accounted for less than 1% of Vietnam's fertilisers and cement export markets.

Vietnam imported CBAM-impacted commodities from numerous trading partners, including the EU, and in many cases, there was two-way trade, i.e. the export and import of the same group of commodities occurred concurrently. In particular, Vietnam imported iron and steel from 84 trade partners with a total annual value of 11 billion USD, of which 211 million USD originated from the EU. Similarly, Vietnam imported 2.8 billion USD worth of aluminium from 69 exporters, with only 27 million USD coming from the EU. Fertilisers and cement were also imported from 59 and 39 trading partners, respectively, with the EU accounting for only small shares in both cases.

Table 1 also provides a summary of the production of the commodity affected by the CBAM in Vietnam. Vietnam's average annual production of iron and steel products from the 5-year period from 2017 to 2021 was 18 million tonnes, with an average emission intensity of 2.17 tCO_2e per tonne of steel. Meanwhile, Vietnam produced 1.2 million tonnes of aluminium products annually. While there is no precise estimate for the emission intensity of aluminium in Vietnam, the global average estimate stands at 16.6 tCO_2e per tonne of aluminium (International Aluminium Institute, 2022). The annual production of fertilisers in Vietnam was 7 million tonnes, with an emission intensity of 2.22 tCO_2e per tonne of fertilisers. Lastly, Vietnam's cement production exceeded 100 million tonnes annually, with an emission intensity of nearly 0.9 tCO_2e per tonne of cement.

4. Materials and methods

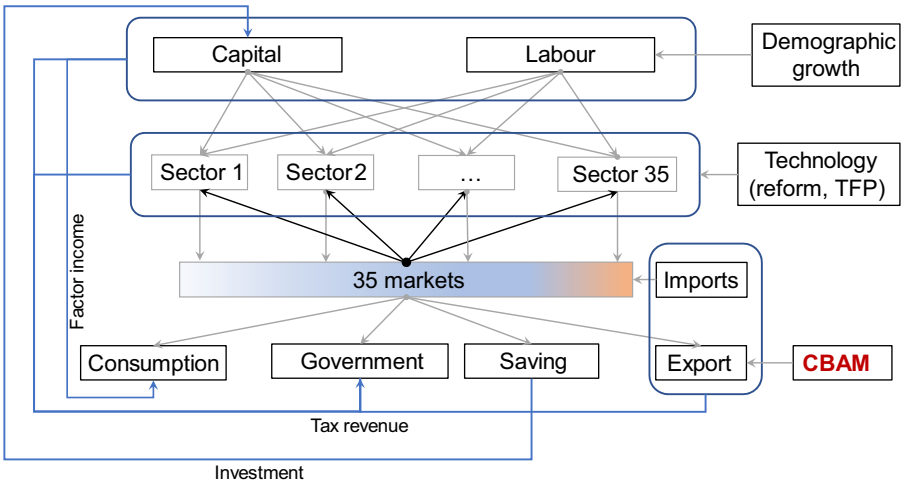
4.1 A summary of modelling frameworks

Figure 1 depicts the computable general equilibrium model (CGE) used to assess the impacts of the CBAM on macroeconomic indicators. Our CGE modelling begins with the IO table for

	Steel	Aluminium	Fertilisers	Cement
Annual export value (million USD)	7,277	696	294	1,233
Number of export trade partners	123	88	57	60
Annual export value to EU (million USD)	969	48	1	11
Annual import value (million USD)	11,053	2,762	867	26
Number of import trade partners	84	69	59	39
Annual import value from EU (million USD)	211	27	40	<1
Annual domestic production (million tonnes)	18	1.2	7	101
Average emission intensity (tCO_2e)	2.17	16.6	2.22	0.86
Average annual growth rate of production	10%	10%	4.5%	3%

Table 1. CBAM-targeted groups of commodities in Vietnam from 2017 to 2021 inclusive

Source(s): UN COMTRADE database, Vietnam's Ministry of Industry and Trade published data, previous studies (ADB, 2017; Springer, 2018; ERCST/WB, 2021), internal surveys, and communications with representatives for professional associations in Vietnam. There is no reliable estimate for the emission intensity of aluminium in Vietnam, and the corresponding number is taken from the global average estimate (International Aluminium Institute, 2022); Table by author



Source(s): Figure by authors

Figure 1. Schematic diagram of data-driven general equilibrium modelling

Vietnam published by the Asian Development Bank (ADB, 2023), then we construct a one-country CGE model as outlined by Rutherford and Paltsev (1999). The model includes 35 production sectors, a consumption sector, a government sector, investment and saving as well as import and export.

Each sector produces output using capital, labour, and outputs from other sectors as inputs. The output of each sector can be utilised for consumption, as inputs for other sectors (i.e. intermediate inputs), government consumption, investments, and exports. The general equilibrium model requires a clearing condition for each of the 35 sectors, where the sum of domestic production output and imports equals the sum of demands for use in the economy. Appendix 2 provides a detailed mathematical specification of the general equilibrium model and describes its calibration process.

CGE model is a common research tool for analysing a wide range of public policies and underpins many structural adjustment programs (Devarajan & Robinson, 2013). The domain of application falls under socio-economic categories, including international trade, fiscal reforms, poverty, agriculture, human development, labour markets, and recently extends to encompass environmental categories such as climate change and low-carbon policies (Cantele, Bal, Kompas, Hadjikakou, & Wintle, 2021; An, Zhang, Zhou, & Wang, 2023). They are commonly developed at the country level and have recently grown in popularity at subnational disaggregation to examine impacts on a specific region (Ghaith, Kulshreshtha, Natcher, & Cameron, 2021). The wide interest in using the CGE modelling approach is attributed to its advantages, including the ability to capture the economy-wide impacts of a change in only a corner of an economy. However, data shortage and pre-model aggregation bias pose significant challenges to modelling, and the results depend on the quality of available data, particularly in relation to the input and output of each economic sector in an economy.

Figure 2 graphically summarises the generic partial equilibrium framework used to assess the impacts on each sector targeted by the CBAM. Commodities affected by the CBAM, produced domestically, can be consumed within domestic markets or exported to various international markets, some of which are subject to the CBAM. These commodities can also be imported from international producers. This partial equilibrium modelling does allow two-way trade — that is, the simultaneous export and import of a group of commodities.

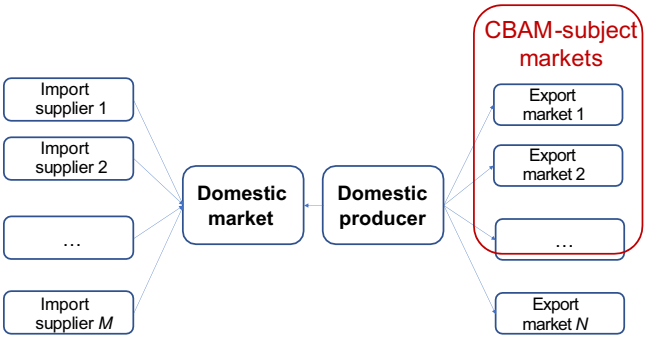


Figure 2.
Schematic diagram of data-driven partial equilibrium modelling

Source(s): Figure by authors

The advantage of using a partial equilibrium framework is that it can provide a zoomed-in view of each individual group of commodities, which is not possible in the general equilibrium framework. The partial equilibrium framework also explicitly allows the number of import trading partners to be different from the number of export trading partners – which is the case in all four impacted sectors (see Table 1). The disadvantage of the partial equilibrium framework is that it can only provide an impact assessment for individual sectors rather than the entire economy. Appendix 3 provides a detailed mathematical specification of the partial equilibrium model and describes its calibration process.

We combined various data sources to calibrate the general and partial equilibrium models. We obtained import and export trade data of the CBAM-targeted commodities from national statistics agencies, such as the General Statistics Office (GSO) and the Ministry of Industry and Trade (MoIT). We were assisted by data experts from the Central Institute for Economic Management and GSO. Additionally, we used trade data from the UNCOMTRADE database, GHG emissions data from the International Energy Association, and the macroeconomic indicators from the World Development Indicators database of the World Bank for our analysis.

4.2 Scenarios for impact assessment

CBAM impacts were assessed by comparing projected outcomes in a Business-As-Usual (BAU) scenario with scenarios involving CBAM and carbon pricing. We drew from Vietnam's government documents and existing literature to parameterise and calibrate key assumptions in these scenarios. For example, our BAU scenario in the general equilibrium analysis was parameterised using the assumption that increases in labour, capital, and total factor productivity would generate an annual GDP growth rate of 6.5%, a conservative target set by Vietnam's master plan for 2021–2030 with a vision to 2050 (National Assembly of Vietnam, 2021, p. 4). Our BAU scenario in the partial equilibrium analysis was parameterised using the assumption that each sector would grow at an annual rate comparable to the 5-year historical rate indicated in Table 1.

The models developed for this research can be used to assess the impacts of different levels of the CBAM tax rate and carbon price in Vietnam. While uncertainties surround these two key parameters, and there is no reliable data to predict their numerical values, they are indispensable for producing concrete numerical simulations. Therefore, we must use our best available knowledge to specify these parameter values.

Some previous studies suggested that a high carbon price is not favoured in Vietnam, at least in the beginning stage, and that carbon pricing in Vietnam should start at only a low level, ranging from 2 to 5 USD per ton of CO_2e (e.g. Do & Burke, 2021, 2023). We do not object to their arguments, but to the best of our knowledge, there is no information from the Vietnamese government about possible carbon price levels. As a result, we use the average cost to reduce emissions in Vietnam's National Determined Contribution (NDC) (Government of Vietnam, 2022a: Table 2), which is 11 USD per ton of CO_2e as the planned carbon price should carbon pricing take effect in Vietnam from 2028. This carbon price is in addition to any existing environmental non-carbon-index tax on goods harmful to the natural environment, as specified in Vietnam's Law on Environmental Protection (Article 2).

In relation to the price of CBAM certificates linked to the EU ETS price, we convert the latest carbon price in the EU ETS (approximately 80 EUR per ton of CO_2 in 2022) to around 65 USD per ton of CO_2 (2019 USD value). We assume that this price would increase in real terms during the 2026–2030 period. The incremental rate of ETS for simulation over the 2026–2030 period is specified at 30%, corresponding to the updated phase-out plan for free emission allowances in the EU's industrial sectors from 30% in 2026 (European Court of Auditors, 2020) to 0%, i.e. completely removed in 2034 (KPMG, 2022a, p. 3). This incremental rate in the EU ETS reflects the price response to the reduction in allowable emissions (see, e.g. Engström *et al.*, 2020; D'Arcangelo, Pisu, Raj, & Dender, 2022: Tables 1 and 3) and the overall declining trend in emissions among EU countries with ETS in place (see, e.g. European Commission, 2022).

	Steel		Aluminium		Fertilisers		Cement	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Indicators	CBAM only	CBAM and carbon pricing	CBAM only	CBAM and carbon pricing	CBAM only	CBAM and carbon pricing	CBAM only	CBAM and carbon pricing
Production output (%)	−0.9 [−1.8, −0.0]	−4.9 [−9.0, −0.5]	−0.5 [−0.9, −0.0]	−7.8 [−14.6, −0.7]	−0.0 [−0.0, −0.0]	−6.1 [−11.2, −0.8]	−0.1 [−0.2, −0.0]	−17.5 [−28.7, −3.3]
Export value (%)	−3.8 [−5.5, −0.7]	−7.2 [−13.9, +0.2]	−4.5 [−5.6, −2.3]	−14.3 [−29.0, −2.6]	−0.0 [−0.0, −0.0]	−12.0 [−29.0, −0.4]	−0.6 [−0.7, −0.3]	−36.0 [−69.1, −3.0]
Import value (%)	−0.3 [−1.4, +0.6]	+0.5 [−1.4, +3.2]	−0.4 [−0.9, +0.0]	+4.5 [−0.7, +11.7]	−0.0 [−0.0, +0.0]	+9.0 [−0.4, +22.7]	−0.3 [−1.0, +0.0]	+79.9 [−4.8, +276.7]
Revenue of carbon pricing (mil 2019 USD)		+1.2 [+1.1, +1.3]		+0.6 [+0.5, +0.6]		+0.2 [+0.2, +0.2]		+1.9 [+1.6, +2.2]
Emission (mil tCO_2e)	−1.0 [−2.0, −0.0]	−5.6 [−10.3, −0.6]	−0.3 [−0.5, −0.0]	−4.3 [−8.0, −0.4]	−0.0 [−0.0, −0.0]	−1.3 [−2.4, −0.2]	−0.3 [−0.4, −0.0]	−36.3 [−59.7, −6.8]

Note(s): Positive numbers represent increases if CBAM is added from 2026 or carbon pricing is added from 2028 (other conditions remain), and negative numbers represent decreases
Numbers are rounded to the nearest 1-digit; −0.0 and + 0.0 (if any) refer to negative and positive numbers, respectively, with absolute values less than 0.05
Outside brackets are the estimated means, and inside brackets are the 95% confidence intervals
Source(s): Table by author

Table 2. Estimated impacts on individual commodity groups in 2030 with partial equilibrium analysis

	EU's CBAM only	Carbon pricing
GDP ($ bil)	−0.1	−6.4
	[−0.2, −0.0]	[−9.3, −3.6]
Domestic fossil fuel price (%)	−0.0	5.2
	[−0.0, −0.0]	[+4.8, +5.6]
Employment (%)	−0.0	−0.5
	[−0.0, −0.0]	[−1.0, −0.0]
Share of net export in GDP (%)	−0.0	−0.0
	[−0.0, +0.0]	[−0.0, +0.0]
Carbon pricing revenue ($ bil)	NA	4.4
		[+3.9, +4.9]
Fossil emissions (mil tCO_2e)	−1.1	−142.5
	[−2.1, −0.6]	[−176.1, −128.2]

Note(s): Positive numbers represent increases if CBAM is added from 2026 or carbon pricing is added from 2028 (other conditions remain), and negative numbers represent decreases
Numbers are rounded to the nearest 1-digit; −0.0 and + 0.0 (if any) refer to negative and positive numbers, respectively, with absolute values less than 0.05
Outside brackets are the estimated means, and inside brackets are the 95% confidence intervals
Source(s): Table by author

Table 3.
Estimated impacts on macroeconomic indicators in 2030

5. Macroeconomic impacts

Table 2 summarises the estimated impacts of the CBAM on key macroeconomic indicators in 2030. The CBAM alone would reduce Vietnam's GDP by approximately 0.1 billion 2019-value USD in 2030. This estimate has a 95% confidence interval from approximately 0 to 0.2 billion (CI = [0, 0.2]). The negative impact arises from CBAM affecting Vietnam's exports to the EU, which in turn, reduces GDP. However, this negative impact is insignificant compared to the size of Vietnam's economy due to the small share of CBAM-targeted commodities in the economy. For example, in 2019, the contribution of all four CBAM targeted groups of commodities to Vietnam's GDP was only 3.2%; only around 12.6% of the total output of these sectors was exported, and the EU also accounted for a small share of Vietnam's total export of the targeted commodities - 13% for steel, 7% for aluminium, and less than 1% for fertilisers and cement.

The CBAM would also have insignificant impacts on fossil fuel prices due to lower demand for Vietnam's high-emission products by the EU. The reported range of [−0.0, −0.0] indicates that at least 95% of the 10,000 estimated impacts are negative, but the numerical values are small (near zero with rounding). The impacts on employment and the share of net exports in GDP would be insignificant.

CBAM could reduce fossil fuel emissions from Vietnam's economy by affecting high-emission sectors, but its direct impact on fossil fuel emissions would also be negligible. The CBAM would reduce the fossil emissions from the economy by only 1 million tCO_2e in 2030 (CI = [0.6, 2.1] million). This impact is small compared to an estimated 297 million tCO_2e from Vietnam as estimated by the International Energy Agency. In summary, the direct impact of the CBAM would be small and insufficient to support Vietnam's implementation of its NDC.

If carbon pricing is implemented, the estimated reduction in GDP would be 6.4 billion USD in 2030 (CI = [3.6, 9.3]), around 1% of GDP in percentage terms. This negative impact arises because carbon pricing would make Vietnam's products, especially high-emission commodities, more expensive and less competitive. The fossil fuel price index would increase by 5.2% in 2030 (CI = [4.8%, 5.6%]) because carbon pricing would be included in the fuel price. Employment would decline by 0.5% in 2030 (CI = [0, 1%]). Net exports would worsen, but as GDP would also decline, the ratio of net exports to GDP would remain stable. The estimated revenue from carbon pricing would be 4.4 billion USD in 2030 (CI = [3.9, 4.9]).

The estimated reduction in fossil fuel emissions with carbon pricing is 143 million tCO_2e (CI = [128,176] million). This estimate does not include the GHG emissions generated by the technological changes within each sector to reduce the emission intensity. This impact is much more significant than the impact of CBAM without carbon pricing. In other words, while the CBAM alone is insufficient to have significant impacts on GHG emissions, if it can promote carbon pricing and technological progress inside individual sectors, the impact would be much more significant.

6. Sectoral analysis on individual commodity groups

Table 3 summarises the estimated impacts of the CBAM on the four targeted groups of commodities in Vietnam. The estimated impacts on each sector include the impacts of CBAM alone and the impacts of the CBAM and carbon pricing. When carbon pricing is in place, Table 3 also reports the estimated revenue from carbon pricing.

The estimated impacts on the steel group are in columns (1) and (2) of Table 3. Given that the EU accounts for 13% of Vietnam's steel export markets (see Table 1), the application of the EU's CBAM would have some negative impacts on key economic performance indicators of the steel sector. For example, production output would decline by approximately 0.9% with CBAM only (CI = [0%, 1.8%]). The estimated reduction in export value is approximately 3.8% in 2030 (CI = [0.7%, 5.5%]). The estimated impact on import values is modest, with the CI ranging from a reduction of 1.4% to an increase of 0.6% in 2030. As a result of the reduction in production output, the emission quantity would decline by about 1 million tCO_2e in 2030 (CI = [0, 2]).

Carbon pricing has both negative and positive impacts. Carbon pricing would increase the cost of production and reduce the competitiveness of products. As a result, production output and exports would decline with carbon pricing. However, carbon pricing - if implemented - would generate tax revenue from the steel sector of about 1.2 billion 2019-value USD (CI = [1.1, 1.3] billion) in 2030. In addition, with carbon pricing, emission quantity would decline by about 5.6 million tCO_2e in 2030 (CI = [0.6, 10.3] million), a much higher emission reduction than when there was no carbon pricing.

The estimated impacts on the aluminium group are presented in columns (3) and (4) of Table 3. Given that the EU accounts for 7% of Vietnam's aluminium export markets (see Table 1), production output would decline by approximately 0.5% (CI = [0%, 0.9%]) with CBAM only. The estimated mean of reductions in export value is approximately 4.5% in 2030 (CI = [2.3%, 5.6%]). The estimated impact on import values is small, with the CI ranging from a reduction of around 1% to a slight increase. As a result of the reduction in production output, the emission quantity would decline by about 0.3 million tCO_2e in 2030 (CI = [0, 0.5] million).

Carbon pricing would generate significant pricing revenue while reducing the cost-competitiveness of products. With carbon pricing, the production output and exports would reduce by around 7.8% (CI = [0.7%, 14.6%]). However, if implemented as a carbon tax, carbon pricing would generate tax revenue from the aluminium sector of about 0.6 billion 2019-value USD (CI = [0.5, 0.6]) in 2030. In addition, with carbon pricing, the emission quantity would decline by about 4.3 million tCO_2e in 2023 (CI = [0.4, 8.0]), a much higher emission reduction than when there was no carbon pricing.

The estimated impacts on the fertiliser group are presented in columns (5) and (6) of Table 3. The quantity of fertilisers exported from Vietnam to the EU is minimal (see Table 1), and CBAM alone would have little impact on key economic performance indicators of the fertiliser group. However, the estimated impact of carbon pricing is more significant. In particular, the estimated reduction in production output is expected to be around 6.6% (CI = [0.8%, 12.6%]), and the estimated reduction in exports is around 14.6% (CI = [0.4%,

40.8%]). Carbon pricing would generate revenue from the fertiliser sector, estimated at about 0.2 billion 2019-value USD in 2030. In addition, with carbon pricing revenue, the emission quantity would decline by about 1.3 million tCO_2e in 2023 (CI = [0.2, 2.4] million).

The last two columns, (7) and (8) of Table 3 present the estimated impacts of the CBAM on cement commodities. Given that the EU accounts for less than 1% of Vietnam's cement export markets, the application of CBAM in the EU would have only slightly negative impacts on key economic performance indicators of this group. The estimated reductions in production output are around 0.1% (CI = [0, 0.2%]), and the estimated reductions in export are around 0.6% (CI = [0.3%, 0.7%]). The estimated reductions in emission quantity are 0.3 million tCO_2e in 2030 (CI = [0, 0.4] million).

The economic impact of carbon pricing is substantial. With carbon pricing, the estimated output reduction is 22% (CI = [3.4%, 40.3%]), and the estimated reduction in exports is 36% (CI = [3.1%, 69.1%]). The estimated increase in imports is 79.9%, but there is significant uncertainty in this estimate, with CI ranging from a reduction of 4.8% to an increase of 276.7%. However, carbon pricing would generate a revenue of 1.9 billion 2019-value USD in 2030 (CI = [1.6, 2.2] billion). Furthermore, with carbon pricing, the estimated reduction in emission quantity is 36.3 million tCO_2e by 2030 (CI = [6.8, 59.7] million).

7. Policy implications

Our study estimates the impacts of the EU's CBAM and carbon pricing on macroeconomic indicators in Vietnam, as well as their effects on commodity groups targeted by CBAM. It is noted that the estimated impacts depend on various assumptions, parameters, and the realisation of numerous future uncertainties. While specific numerical results may vary across scenarios, they offer several direct policy implications for decision-makers to consider.

First, our analysis suggests that the CBAM alone would have a minimal direct impact on Vietnam's economy and its climate policies. The primary reason is that the CBAM only affects a limited number of commodities in Vietnam's export markets. However, should the CBAM extend beyond the current targeted sectors (Perdana & Vielle, 2023), potentially affecting a larger proportion of Vietnam's export value, or if other trade partners implement CBAM (see, e.g. Leal-Arcas *et al.*, 2022; Szulecki, Overland, & Smith, 2022), the impact on the macro economy would be more significant. It is crucial for Vietnam to engage in negotiations with its key trading partners to minimise any negative impacts that the introduction of a CBAM might have.

Second, the CBAM can incentivise producers to reduce emission intensity. Producers in CBAM-targeted sectors would benefit by reducing their emission intensity because that would reduce their tax bill. If this impact could spread out to other sectors, the emission intensity of the entire economy would be lowered. The government and international partners should provide support for studies that can provide further insights into the potential of energy transition to reduce the emission intensity of high-emission sectors, including those that do not export.

Third, it is technically possible to reduce emission intensity in the CBAM-targeted sectors because the emission intensity in the impacted sector of Vietnam remains higher than the global average. For example, the average emission intensity of Vietnam's steel sector is 2.17 tCO_2e per tonne of steel, while the global average is only 1.8 tCO_2e per tonne of steel (Liao, Wang, Xia, & Tang, 2022). The average emission intensity in Vietnam's fertiliser sector is 2.22 tCO_2e per tonne of fertilisers, while the global average ranges from 1.7 to 2.3 (Hoxha & Christensen, 2018). This result indicates room for improvement in emission intensity. It highlights the importance of research and development activities to promote technological progress for overall efficiency, i.e. more output produced with less input, and also emphasises the role of economic tools to further promote emission intensity reduction by substituting

fossil fuels with renewable inputs. Investing in research and development and implementing economic policies that encourage the adoption of cleaner technologies could lead to significant emission reductions and enhance the competitiveness of the CBAM-targeted sectors.

Fourth, the CBAM can also provide a justification for carbon pricing from a revenue-generation perspective. Vietnam's producers in CBAM-targeted sectors would pay a carbon price for their exports, and without carbon pricing, all pricing revenue is collected by the EU. With carbon pricing in Vietnam, part of that carbon pricing revenue on exports would be collected by Vietnam's government. In other words, if it were possible to impose carbon pricing on the export of CBAM commodities to the EU when CBAM is in place, carbon pricing would increase revenue while not further worsening producers' economic conditions. Therefore, the implementation of carbon pricing in Vietnam could reduce CBAM's effective tax rate, bringing more export value to Vietnam.

Fifth, carbon pricing is crucial for Vietnam to achieve its committed targets in reducing GHG emissions. By putting a price on carbon, the cost of emissions would increase, providing direct incentives for private economic agents to substitute high-emission inputs or consumption goods with alternatives (Chu, Do, Le, Ho, & Dang, 2023). In addition to this substitution effect, carbon pricing may generate considerable revenues, which can be used to support technological changes to further promote the energy transition process (Do & Burke, 2021). Therefore, if effectively implemented, carbon pricing would provide a framework for decision-makers in both the private and public sectors to reduce emissions.

Sixth, carbon pricing may have some negative impacts on the economy, especially in high-emission sectors. To mitigate these effects, Vietnam's government may consider reducing taxes such as corporate income tax, personal income tax, natural resources tax, and environmental tax to maintain the economy's competitive advantage. Carbon pricing can only be applied when information and data on GHG inventories are developed, updated, and widely published. Before implementing carbon pricing, it is necessary to prioritise the use of economic tools and market-based financial mechanisms, such as green credit and green bonds, to promote investment and facilitate the transition from brown to green technology.

Finally, accelerating Vietnam's clean energy transition is imperative. According to data from the IEA, emissions from fossil energy use (oil, coal, and gas) in Vietnam increased from 148 million tCO_2e in 2014 to 296 million tCO_2e in 2020, representing an annual growth rate of 12%, far exceeding economic and demographic growth rates. Consequently, fossil emissions per capita have risen, and Vietnam now requires more fossil emissions to produce one dollar of economic value-add. If this trend continues, it will become increasingly challenging for the country to achieve its emissions reduction targets. Therefore, reversing or slowing down this trend as soon as possible is crucial by ramping up solar and offshore wind power uptake (Do *et al.*, 2021, Do, Burke, Hughes, & Ta, 2022). Otherwise, Vietnam will have very limited time to achieve its committed emission targets, even with "hard braking" measures, which usually incur substantial costs in terms of economic and social conditions.

8. Conclusions

The concept of CBAM has emerged as a policy instrument in global climate agendas to address carbon leakages. By levying tariffs on imported goods based on their carbon footprint, CBAM aims to level the playing field for producers from different countries in relation to carbon pricing while incentivising global partners to adhere to similar environmental standards. This mechanism encourages a more sustainable approach to production and promotes cooperation in combating climate change on a global scale.

Here, we constructed a general equilibrium model to assess the impacts of the EU's CBAM and carbon pricing on Vietnam's macroeconomy. Additionally, we developed a generic

partial equilibrium model to assess the impacts of CBAM and carbon pricing on individual commodity groups that are directly targeted by the CBAM. The combination of general equilibrium modelling and partial equilibrium modelling allows us to investigate the impacts of CBAM on the macroeconomy and delve into more detailed analyses of specific commodity groups.

Our findings indicate that the current form of the EU's CBAM is unlikely to have significant impacts on the macroeconomy, primarily due to the small share of the affected commodities in Vietnam's exports. However, the CBAM can reduce production outputs and export values of steel, aluminium, and cement. The CBAM alone is insufficient to achieve significant reductions in GHG emissions. However, CBAM can justify and promote carbon pricing measures, which could yield more substantial economic impacts and contribute to GHG emission reductions. This suggests the importance of complementary policies in addressing global climate change.

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Appendix

The supplementary material for this article can be found online.

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