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Research papers

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Impacts of CBAM on EU trade partners: consequences for developing countries

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Résumé

Cet article analyse l'impact de l'introduction du mécanisme d'ajustement aux frontières du carbone (CBAM) sur les partenaires commerciaux de l'Union européenne (UE), en se concentrant particulièrement sur ses conséquences socio-économiques et externes potentielles pour les économies en développement et émergentes. Il utilise des données commerciales et des matrices MRIO (Multi-regional Input-Output) pour étudier la distribution géographiquement et sectoriellement inégale des impacts du CBAM. L'introduction du CBAM par l'UE fait actuellement l'objet de négociations, et la plupart des analyses sur le sujet ont porté sur les conséquences pour les économies de l'UE. Cependant, ce mécanisme d'ajustement carbone, qui vise à réduire les incitations pour les entreprises européennes à externaliser leurs émissions de carbone et à promouvoir une transition à faible émission de carbone plus généralisée, pourrait avoir un impact disproportionné sur certaines économies non européennes. Bien que la plupart des revenus du carbone soient générés par la Russie, la Chine et l'Ukraine, le degré d'exposition des économies qui exportent des produits du CBAM vers l'Europe varie considérablement, de nombreuses économies en développement voyant plus de 2% de leurs exportations et 1%de leur production affectées par cette mesure. Les économies d'Europe de l'Est, principalement dans les Balkans, ainsi que le Mozambique, le Zimbabwe et le Cameroun, en Afrique, sont celles dont les exportations sont les plus exposées.

En termes socio-économiques, nous pouvons également inclure le Maroc et le Tadjikistan dans le groupe des économies les plus exposées. Le CBAM est certainement une étape importante vers une dynamique européenne de tarification du carbone. Ses conditions de mise en œuvre peuvent également favoriser une transition mondiale (plutôt que locale) à faible émission de carbone si les revenus du carbone générés par ce mécanisme sont utilisés pour soutenir les pays en développement les plus touchés en dehors de l'UE.

Mots-clés

Transition bas carbone, Vulnérabilités macro-économiques, Risque pays, Tableau d'entrées-sorties, Mécanisme d'ajustement carbone aux frontières.

Abstract

This article analyses the impact of the introduction of the Carbon Border Adjustment Mechanism (CBAM) on the European Union (EU) trade partners, focusing especially on its potential socio-economic and external consequences for developing and emerging economies. It uses trade data and Multi-regional Input-Output (MRIO) matrices to investigate the geographically and sectorally uneven distribution of CBAM's impacts. The introduction of CBAM by the EU is under discussion, and most of the literature on the topic has analysed the consequences for the EU economies. However, this carbon adjustment mechanism, which seeks to reduce the incentives for firms to outsource their carbon emissions and promote a more generalized low-carbon transi-tion, might disproportionally impact some non EU economies. Despite most carbon revenues would be generated by Russia, China and Ukraine, the degree of exposure of economies that export the CBAM products to Europe varies substantially, with many developing economies having more than 2% of their exports, and 1% of their production impacted by this measure. East European economies, mainly in the Balkans, as well as Mozambique, Zimbabwe and Cameroon, in Africa, are those where exports are the most exposed. In socio-economic terms, we can also include Morocco and Tajikistan in the group of most exposed economies. CBAM is certainly an important step towards a European pricing carbon dynamics. Its implementation conditions may also promote a global (rather than local) low-carbon transition if the carbon revenues generated by this mechanism are used to support the most impacted developing countries outside the EU.

Acknowledgements

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Keywords

Low-carbon transition, Macroeconomic vulnerabilities, Country risk, Input-output, Carbon border adjustment mechanism

JEL Classification

F18, Q58, C67

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1. Introduction

Until now, European industrial sectors exposed to competition from outside Europe were protected through the granting of free GHG emission allowances. However, the Commission is considering abolishing these allowances, becuse they are considered to be suboptimal for achieving the decarbonisation of the European economy. As a result, the competitiveness of exposed sectors vis-à-vis their foreign counterparts which are not subject to similar restrictions could be threatened. This is the main justification for the Carbon Border Adjustment Mechanism (CBAM), which was analyzed and confirmed empirically long ago (Monjon and Quirion, 2011)[1]. The vast majority of the literature on the impacts of CBAM, see (EUCommission, 2021; Kuusi et al., 2020) for example, focuses on the consequences for EU countries, with special attention to the impacts on EU firms competitiveness and the effectiveness of the measure in reducing emissions.

More recently, however, a literature on the impacts of the low-carbon transition has been discussing the effectiveness of this type of measures on developing countries. The introduction of these type of measures might generate external and socio-economic constraints on these countries because they have low capacity to adapt their productive structure. Indeed shifting from carbon-intensive industries to green industries (Mealy and Teytelboym, 2020) and technological changes within industries needs large investments which are costly in these economies (Ameli et al., 2021). In this vain, this paper addresses the potential impacts of the introduction of CBAM on developing and emerging economies.

We also discuss alternative institutional designs with the aim of increasing the capacity of CBAM to promote an effective low-carbon transition in developing countries. Besides analysing the directly impacted economies and industries using trade data, this analysis follows (Espagne et al., 2021) and evaluates the indirect impacts on employment and wages using Multi-regional Input-Output (MRIO) matrices. The advantage of these matrices is that they allow for identifying the indirect impacts within countries and across trade partners because imported inputs used in the production of the directly impacted sectors are included.

The paper is divided in four sections besides this introduction. The next section presents a literature review on the estimated impacts of CBAM. Even though it is a recent discussion, many studies addressed the consequences and the effectiveness of this measure. The third section describes the methods applied to analyse these impacts and the data sources. The fourth section applies the method and presents the results of the analysis. The last section discusses possible institutional designs to increase the effectiveness of CBAM given the findings of the paper.

[1]These authors found that the most efficient way to tackle leakage is auctioning combined with border adjustment, which generally induces a negative leakage (a spillover). This holds even if the border adjustment does not include indirect emissions, if it is based on EU (rather than foreign) average emissions, or (for some values of the parameters) if it only covers imports. These restrictions are all included in the current CBAM proposal.

2. Literature review

The reaffirmation of the EU's climate ambitions under the "Fit for 55" plan involves a more rapid reduction in emission quotas. This reduction sends a signal to European producers that they should start making more carbon-efficient technology choices. The European Commission published in July 2021 a detailed proposal for a regulation establishing a CBAM, supported by an impact assessment which compares different possible scenarios (EUCommission, 2021). Under the chosen impact assessment scenario, companies importing non-EU goods must surrender carbon allowances equal to the carbon footprint of the imported products. The value of the allowances to be surrendered depends in practice on three parameters: the price of carbon in the EU-ETS, the GHG emission control policies in the countries of origin of the goods, and the carbon content of the imported products.

Due to the lack of detailed and reliable data for non-EU countries, default carbon content of imported goods is computed on the basis of sectoral benchmarks of the 10% least efficient European producers of equivalent goods. Importers have however the opportunity to prove that their products have a better carbon footprint than this average. This choice, while facilitating the concrete implementation of the mechanism, may threaten its capacity to effectively tax imports in line with their carbon footprint, as the most inefficient producers (at least those which are less efficient than the 10% lowest Europeans) may have no incentive to invest in more carbon efficient technologies.

Exporting countries can furthermore claim that their already implemented climate policies leading to an equivalent carbon price and hence reduce accordingly the adjustment cost for the importer. If the originating countries also have a carbon price on the same sectors, then the calculation of the exact adjustment is trivial. It is, however, difficult to assess how this correspondence will be calculated when the country of origin has no carbon price but still claims to have climate policies. Finally, importers are not directly integrated into the intra-European ETS and the carbon price of the EU-ETS exogenously imposed to them.

The list of sectors covered by the CBAM is for now a shortlist of high emitting sectors exposed to carbon leakage. The impact assessment focuses on four industrial sectors (cement, aluminium, iron/steel and fertilisers), as well as the electricity sector. Restricting the CBAM to certain sectors and excluding all manufactured or semi-manufactured products considerably simplifies the implementation of the mechanism, as the value chains to be considered within the CBAM's scope are relatively simple. Finally, the CBAM only takes into account direct emissions, even if, for many industrial goods, indirect emissions, linked to earlier stages in the value chain, account for a significant proportion of the total volume of emissions linked to the product.[2]

[2]The goods currently selected for CBAM are fairly basic and hence do not have much embodied emissions but this might change as the CBAM is extended to more complex goods. AG: SHOULD WE ADD A GRAPH TO SHOW THIS?

2.1. Impact assessment of CBAM within the EU

The original impact assessment of the European Commission (EUCommission, 2021) quantifies the effects of each scenario on a number of economic and environmental variables, mainly using a general equilibrium model called JRC-GEME3. The authors of the Commission's impact assessment were limited by the low granularity of the input-output table used by the JRC-GEM-E3 model (from the GTAP project). Indeed, the nomenclature of the latter does not allow the distinction between the four industrial sectors covered by the study. The GTAP data was therefore supplemented by data from another input-output table (Exiobase) for the concerned sectors.

The variables analysed in the impact assessment are mainly trade flows between the EU and the rest of the world, production, GDP, unemployment, and GHG emissions. According to the study, the impact of the mechanism on European GDP remains minimal (around 0.2% decrease by 2030). The effect on production by sector is more marked, as the CBAM has a double impact on production. On the one hand, by increasing the price of imports, it improves the competitiveness of European companies competing with non-European firms not subject to the EU-ETS. On the other hand, European products lose competitiveness in non-European markets, due to the increase in the price of non-European inputs (impacted by the CBAM) embodied in these exports. The CBAM, therefore, might increase or decrease EU competitiveness, impacting positively or negatively output, depending on the elasticity of substitution and the structure of each product value chain.

The strongest impact of the CBAM is on trade flows, with a significant drop in both imports and exports. The drop in imports and exports is on average 10% in the sectors covered. The analysis conducted by (Kuusi et al., 2020) obtains similar results, in a scenario where the price of a tonne of carbon reaches 25 euros. The scenario studied in (Kuusi et al., 2020) introduces a CBAM on some fifteen industrial sectors. They show that the sectors for which the relative decrease in imports are the most significant are precisely those that were retained for the impact study. This suggests that the Commission has focused on sectors likely to be strongly impacted by the mechanism.

Aggregate impacts on employment are again very low (+0.05% by 2030). It should be noted that this impact varies according to the sector, ranging from -0.48% to +2.59%. Although these figures remain low, they remind us that the implementation of such a mechanism can generate tensions on the labour market, with possible labour shortages in certain sectors, or the weakening of certain employment basins. This raises the question of the geographical distribution of the effects of the mechanism, which is not addressed in the impact study of the European Commission.

The environmental impact of CBAM results in a leakage ratio of -29%, which means that a one-tonne reduction in European emissions is accompanied by a 0.29-tonne reduction in non-European emissions. At the extreme opposite, an immediate abolition of free allowances without CBAM would result in a leakage rate of +42%. This confirms the previous meta-analysis results of (Branger and Quirion, 2014b), based on articles published between 2004 and 2012, who show that a CBAM could indeed reduce the rate of carbon leakage. However, they also find that Armington elasticities, which measure the degree of substitutability between

products from different countries, are a key parameter in explaining the differences obtained in the carbon leakage models.[3]

Surprisingly, the scenario of the EU commission impact study in which free allowances are phased out performs better than an identical scenario in which free allowances are eliminated immediately.[4] In a way, the impact assessment seeks to demonstrate that the extension of free allowances is based on scientific evidence rather than political maneuvering. It remains to be seen why this scenario outperforms both the scenario with immediate abolition of allowances and the baseline scenario (maintaining the current system). The Commission argues that the transitional phase will allow European companies to better prepare for the disappearance of free allowances, but it does not elaborate on the specificities of the model that could explain the superiority of this scenario.

The impact study uses a carbon price of 47 euros per tonne in 2030. It would be legitimate to question that level and its compatibility with meeting climate change objectives. The Carbon Pricing Leadership Corporation reminds us that a carbon price of at least 50 to 100 dollars per tonne is necessary at that point in time to meet the commitments of the Paris Agreement. The price per tonne of CO2 in the CBAM will be aligned with the price of a tonne of carbon in the ETS, which fluctuates with supply and demand, and the current price in the ETS system is close to 60 euros per tonne.

Finally, the risk of circumvention through resource shuffling could seriously undermine the effectiveness of the scheme. Resource shuffling consists of artificially reallocating emissions between different production factors, sectors or companies. By manipulating carbon accounting in this way, a state or a company could claim to have reduced the carbon content of goods exported to the EU without having made any real changes to the production process. These maneuvers are both difficult to anticipate *ex ante* and difficult to measure *ex post*. (Stede et al., 2021) estimate a risk of resource shuffling of between 50% and 80% for the aluminium sector. Acknowledging this risk and the difficulty of estimating it, the Commission explicitly states that it has ruled it out in its modelling. The annex to its study nevertheless compares the impacts of the mechanism according to whether the risk of resource shuffling materialises or not.

In the end, as (Böhringer et al., 2022) note, CBAM raises more concerns about legal feasibility and practical implementation than about fundamental theory. If it is perceived abroad as a form of protectionism, it could lead to trade conflicts. At the same time, it has also been proved that internationally traded goods are biased towards high carbon products because of differentiated import tariff or non-tariff barriers. In this regard, the CBAM proposal could mark a turning point not only for Europe, but also for the global trade system.

2.2. Impact of CBAM outside the EU

[3] See also (Böhringer et al., 2022; Cameron et al., 2022) for a meta-analysis of leakage rates in existing simulation studies.

[4] Some opponents of the plan blame the Commission for bowing to pressure from industry lobbies to extend free allowances until 2035.

The impacts of CBAM goes beyond the impact on the EU countries. One of the aim of CBAM is to foster global transition dynamics. It is thus crucial to analyze the potential effects on the rest of the world. CBAM will likely change the price dynamics of some countries and probably disproportionately impact some economies.

Indeed, import adjustments could have a strong burden-shifting effect, as suggested by (Böhringer et al., 2022). Import adjustments on embodied carbon applied by industrialized countries such as the EU countries are likely to shift some of the burden of emissions pricing to developing or emerging countries. Exporting countries subject to CBAM could suffer a loss in export revenues, in employment and wage share, or in fiscal revenues, as we confirm in this paper. As explained by (Böhringer et al., 2022), this outcome may be at odds with the principle of common but differentiated responsibilities articulated in the United Nations Framework Convention on Climate Change and reaffirmed in Article 4(3) of the Paris Agreement. Counter to that argument, CBAM would also contribute to reallocating the responsibility of emissions to consumer countries (in this case the EU) and restrict the "ecologically unequal exchange" of globalization.

(Eicke et al., 2021) propose a first analysis of the CBAM impact on countries from the "Global South", considering two different scenarios, mainly CBAM addressing only emission-intensive sectors and CBAM targeting the whole economy. Completing an important literature of country case-studies' impacts of CBAM, especially on China (Voituriez and Wang, 2011; Bao et al., 2013; Chen and Guo, 2017), the authors develop a broad socio-economic and institutional framework to assess CBAM's impacts. The variables of interest are the export structure of countries, their emissions intensity, emissions reduction targets, and institutional capacities to monitor and report product-based emissions. Additionally, the paper assesses different drivers of exposure and of the ability to adapt to a CBAM for Mozambique, Bosnia and Herzegovina, and Morocco, identified as relatively high-risk. It highlights the importance of the capacity to monitor, report and verify the carbon content of exporting countries, beyond the mere trade effect.

Complementary to (Eicke et al., 2021), (Lim et al., 2021) brings new empirical evidence to the potential retaliation effects from other economies, developing a large set of scenarios generally leading to outcomes detrimental to CBAM. (Lim et al., 2021) however miss some strong political economy arguments that could also question the international implications of a European CBAM. From a legal perspective, even if import charges of CBAM may be WTO-compatible, they may not be sufficient to bring many pollution-intensive countries into a carbon-pricing coalition (Böhringer et al., 2022). China, and other large non-OECD countries, such as India, Indonesia and Thailand, currently share the view that CBAM is a protectionist and discriminatory policy measure.

In the end, the potentially regressive nature of CBAM necessitates careful attention to institutional design, especially if the goal is to enhance global climate ambitions together with the EU's own decarbnization strategy. (Brandi, 2021) argues that least developed countries (LDCs) should be exempted from the CBAM, instead receiving targeted support from the EU. In other words, building a development-friendly CBAM, as suggested by (UNCTAD, 2021), is key to the success of this emblematic part of the Fit for 55 package. It should come with a

broader set of development policies to accompany the most exposed countries towards their own carbon neutrality strategy.

This paper contributes to this literature on the impacts of CBAM for developing and emerging economies as well as the potential institutional design to make CBAM foster an equitable and effective low carbon transition. Its novelty lies in the use of an MRIO table bringing both detailed sectoral and geographical data, and hence allowing us to systematically assess multidimensional exposure, both direct and indirect, of countries to CBAM. We consider the potential impact on the external position, measured by the capacity of impacted industries to raise foreign currency, and on socio-economic indicators, such as employment and wages.

3. Method and data

With the aim of analysing the potential impacts of CBAM on EU partners, we first calculate the share of these countries' exports of the products involved to the EU. Secondly, based on sectorial carbon-intensity, we estimate the carbon revenue that could be generated by the taxation.[5] Finally, based on (Espagne et al., 2021), we estimate the direct and indirect output, wages and employment related to the production of the goods exported to the EU.

3.1. Exports by EU partners

The UN COMTRADE database (UN, 2003) provides data on countries' exports and imports by product and partner. One could calculate countries' exports of the products involved in CBAM either based on their exports to the EU countries or based on the EU countries' imports by partner. Because the EU data is more complete, we decided to use the EU imports. The total exports of a country to the EU is, therefore, given by the total imports of the 27 EU countries.

There are five products impacted by the CBAM: Aluminium, Cement, Electricity, Fertilizers and Iron and Steel. Based on the Harmonized System Classification, we identify the following products as those impacted by the CBAM:

- Cement: Portland cement, aluminous cement, slag cement, supersulphate cement and similar hydraulic cements, whether or not coloured or in the form of clinkers (2523)
- Electricity: Electrical energy (2716)
- Fertilizers: Fertilizers, mineral or chemical, nitrogenous (3102)
- Iron and steel: Iron and steel (72)
- Aluminium: Aluminium and articles thereof (76)

[5] Note that these two approaches are mutually exclusive and should hence not be added.

3.2. Emission-intensity by product

Once the value of exports of these products to the EU (EX^{EU}) is calculated, we can estimate the carbon revenue that would be obtained from CBAM by country and product based on their carbon content. Data on carbon-intensity by country and product is obtained from (Cabernard and Pfister, 2021), who merged the EORA-26 and the EXIO MRIO tables into a Regionalized MRIO (RMRIO) table. The advantage of this dataset is that it provides emission-intensity (CO2eq per USD) data for 189 countries and 163 sectors, giving us enough granularity at the sectoral and geographical level combined.

The emission-intensity by product and country is calculated as the summation of the emissions of the sectors related to the product under consideration divided by the summation of total output, as follow:

$$e_{i,k} = \frac{\sum_{j}^{j \in i} emissions_{j,k}}{\sum_{j}^{j \in i} output_{j,k}} \tag{1}$$

where e is the carbon-intensity, i is each one of the five products in CBAM, k is the country under consideration and j is the sector in the RMRIO (which is in the CBAM products, as presented in Table 1).

Table 1: Correspondence CBAM Products and RMRIO Sectors

CBAM	RMRIO Sectors
Cement	Manufacture of cement, lime and plaster
Electricity	Production of electricity by coal
	Production of electricity by gas
	Production of electricity by nuclear
	Production of electricity by hydro
	Production of electricity by wind
	Production of electricity by petroleum and other oil derivatives
	Production of electricity by biomass and waste
	Production of electricity by solar photovoltaic
	Production of electricity by solar thermal
	Production of electricity by tide, wave, ocean
	Production of electricity by Geothermal
	Production of electricity nec
Fertilizers	N-fertiliser
Iron and Steel	Manufacture of basic iron and steel and of ferro-alloys and first products thereof
	Re-processing of secondary steel into new steel
Aluminium	Aluminium production

3.3. Impacts on revenue and output

Rather than using the carbon-intensity for each country individually to estimate the carbon revenue, we consider that the carbon-intensity that will be used in the computations of the

CBAM ($\hat{e}$) is the lowest value between the actual carbon-intensity of the country and the worst 10% carbon-intensity among the EU countries ($e_{j,EU-}$), as follow:

$$\hat{e}_{j,k} = \min[e_{j,k}, e_{j,EU-}] \tag{2}$$

The underlying assumption is that industries with low carbon-intensity will prove that they will not need to pay the default amount, whilst those with high carbon-intensity will pay the default amount defined by the EU.

Based on the carbon-intensity and countries exports, we can then calculate the carbon revenue (CR) by country and product as follows:

$$CR_{j,k} = \hat{e}_{j,k} EX^{EU}_{j,k} CP \tag{3}$$

where exports EX^{EU} of product j by country k to the EU, and CP is the price of carbon, which we consider here as USD 60.00 per tonne, approximately the current price in the ETS.

The underlying assumption of the carbon revenue presented in the last equation is that exports do not drop due to the introduction of CBAM. There are two possible reasons for this to happen: either these products have a price elasticity of substitution equal to zero (they are price-inelastic) or final prices do not change. If the price increase for almost all suppliers, and there are no possibilities of replacing the impacted products by alternative inputs, one could expect a very low price elasticity of substitution. On the other hand, if the suppliers of these products are price-takers, all the carbon revenue will be embodied in the selling price, and final price will not change. In this case, the impact is a drop in the export revenues of the country under consideration.

The other extreme case would be a 100% drop in exports from the partner country to EU. In this case the assumption is that demand is perfectly elastic in relation to prices. Even though one could expect that this extreme case might not happen, if there are other suppliers (within EU or in countries that have a similar carbon price) that can produce these goods, they can absorb these exports, and hence the effects will be very significant for the impacted country. The consequences of this would be probably more important for the trade partners than an increase in carbon revenue, because it will reduce production in the industry itself and on its supply chain due to direct and indirect impacts, with impacts on wages and employment.

We use the EORA-26 MRIO database (Lenzen et al., 2012; Lenzen et al., 2013) when estimating these direct and indirect impacts on production, wages and employment. The advantage of using MRIO is that the indirect impact is not only due to the supply of inputs for domestic producers, but also internationally. If, for example, Country A produces inputs used by another country B to produce of aluminium, and this aluminium is exported to an EU country, then Country A will be impacted indirectly, and it is accounted in the MRIO framework.

The total output (direct and indirect) potentially impacted by the introduction of CBAM is, therefore, given by:

$$\Delta \mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1} \Delta \mathbf{Y} \tag{4}$$

where $\Delta\mathbf{X}$ is a column-vector of the total change in output (for all sectors and countries), **I** is an identity matrix, **A** is the MRIO technical coefficient matrix, and $\Delta\mathbf{Y}$ is the direct impact, which is given by the exports to EU by country and sector.

Once the total output by sector is estimated, we can compute the total (direct and indirect) potential impact on wages and employment to analyse the socio-economic exposure generated by the introduction of CBAM. To do this, we need to multiply element-by-element the change in total output by the column-vector of wages per output (**w**) and employment by output (**n**):

$$\Delta\mathbf{W} = \mathbf{w} \odot \Delta\mathbf{X} \tag{5}$$

and

$$\Delta\mathbf{N} = \mathbf{n} \odot \Delta\mathbf{X} \tag{6}$$

where $\odot$ denotes the element-wise multiplication, and $\Delta\mathbf{W}$ and $\Delta\mathbf{N}$ are the column-vectors of the total potential impact on wages and employment, respectively.

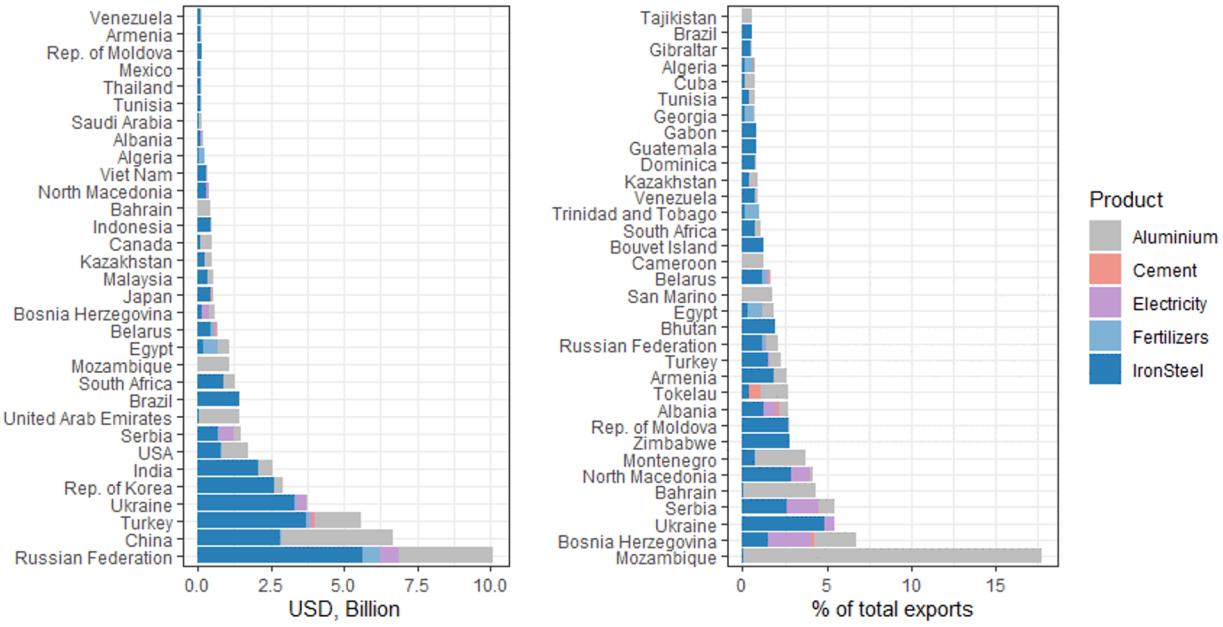
4. Potential impacts of CBAM

The introduction of the CBAM will impact countries proportionately to their exports to the EU. In terms of volume, the most impacted economies are Turkey, Ukraine, China and Russia, as presented in Figure 1, left panel. Russia exports about 10 billion dollars (USD) of the CBAM products, relatively evenly distributed across Iron and Steel, Aluminium, Fertilizers and Electricity. China, Ukraine and Turkey each export more than USD 2.5 billion of CBAM products to Europe concentrated in the same two products. In particular, Iron and Steel is the most impacted product in Turkey, as well as in the USA, in other BRICS countries (Brazil, India and South Africa), in South Korea and in Ukraine.

Even though the total impact is relevant, from the point of view of the partner, the impact of CBAM in the economy will depend on its relative relevance (for example, as a share of total exports). As we can see from the same figure, right panel, except for Ukraine and Russia, the most impacted countries in terms of volume are not the same in terms of the share of exports. Mozambique is the most impacted economy as almost 20% of its exports are Aluminium to EU countries. Serbia, Bosnia-Herzegovina, Montenegro, North Macedonia and Bahrain are also very impacted countries (more than 5% of Serbian and Bosnian exports are CBAM products to the EU, and more than 3% in Montenegro, North Macedonia and Bahrain), but differently from Mozambique, in some of these countries, the impact is not due to a specific product export. In the case of the first two, it is due to the export of Iron and Steel, Electricity and Aluminium, and, in the case of North Macedonia, it is due to the exports of Iron and Steel and Electricity.

Other countries that are very impacted relatively to total exports are Armenia, Tokelau, Albania, Moldova and Zimbabwe. In all these economies, CBAM products' exports to EU represent more than 2.5%, and the product mix varies significantly from one country to another. In the case of Zimbabwe and Moldova, it is due mainly to exports of Iron and Steel, while in the case of Armenia and Albania, the product mix is more heterogeneous.

Figure 1: Exports of CBAM products to EU countries, by country (2019)



Source: authors' elaboration based on COMTRADE data

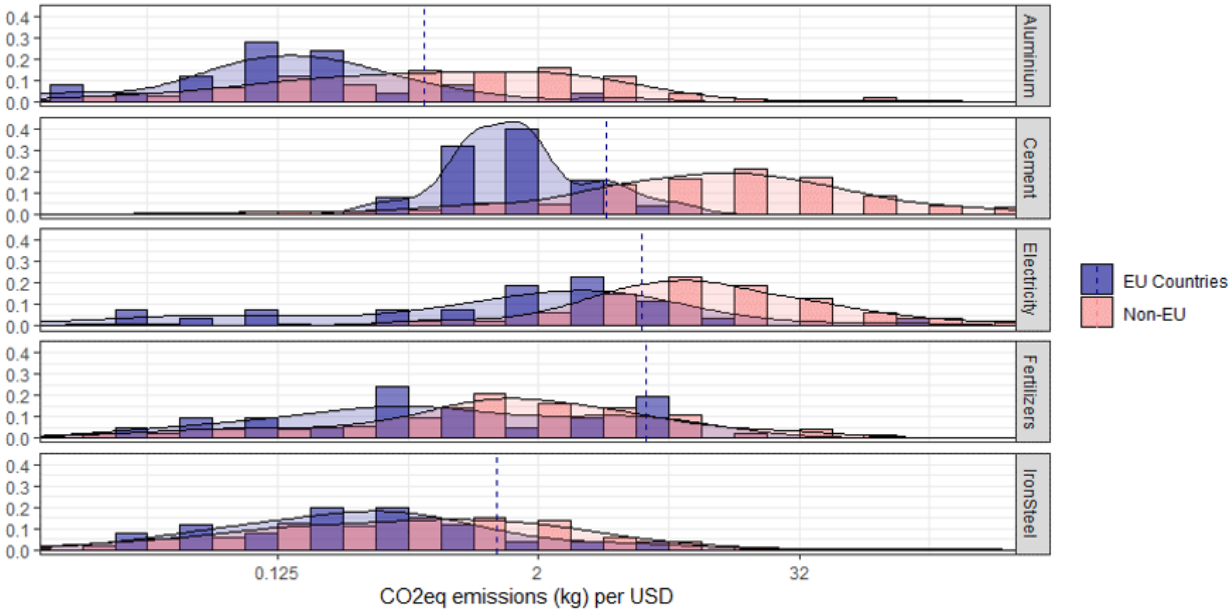
The analysis of the impact of the CBAM, however, needs to account for the emission-intensity, as the carbon revenue contribution by country will depend on the CO2 emissions by product and the country-specific CO2 intensity. Figure 2 presents the CO2eq intensity distribution, in logarithmic scale, across EU countries and non-EU countries, and the dashed line is the limit of the first decile (10% worst) of the EU countries.

For all products but Fertilizers, the carbon-intensity tends to be higher in non-EU countries than in EU countries. In the case of Iron and Steel, the carbon-intensity of the EU and non-EU countries are very similar, with both curves almost coinciding. In this case, the carbon-intensity is relatively low, and most countries are below the EU 10% worst emission-intensity, which is 1.21 kg per USD.

In the case of Aluminium, the carbon-intensity is much lower for the EU countries. The worst 10% limit is 0.59 kg per USD, but most of the other countries present an emission intensity much higher than this. The majority of non-EU countries presents an emission-intensity higher than 1 kg per USD.

Cement and Electricity are the most carbon-intensive among the CBAM products. Moreover, the difference between the EU and non-EU countries is very high. In most of EU countries, Cement's carbon-intensity ranges from 0.5 to 2.0 kg per USD, Electricity's carbon-emission ranges from 1.0 to 4.0 kg per USD. The EU worst 10% limit is 4.14 for Cement and 6.00 kg per USD for Electricity.

Figure 2: Distribution of emission-intensity, by product (2015)



Source: authors' elaboration based on COMTRADE and RMRIO data
Scales are in logarithm

4.1. Potential carbon revenue

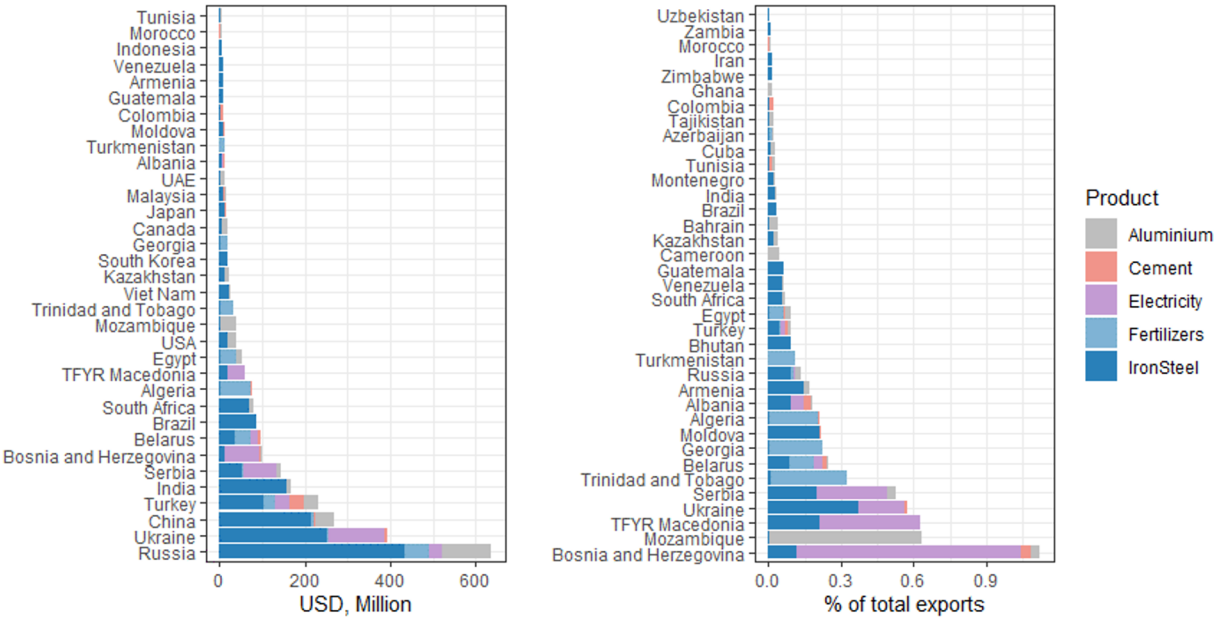
Considering a carbon price of USD 60.00 per tonnes in Europe (and 0 outside Europe), the total carbon revenue from the introduction of CBAM by product and country is presented in Figure 3.

The most impacted countries in absolute terms are the same as before, but with some changes in the product composition. Iron and Steel becomes even more relevant than before, representing the most important contributor for South Africa, Brazil, India, China, Ukraine and Russia. In the case of Turkey and Belarus, the product mix is heterogeneous, comprehending Iron and Steel, Fertilizers, Cement and Aluminium. Ukraine and the Balkan countries (Macedonia, Bosnia-Herzegovina and Serbia) are important exporters of electricity, which has a high carbon-intensity. Consequently, they are the most impacted economies.

These results become even clearer when we analyse the carbon revenue as a share of exports. In the case of Mozambique, despite the EU market being very important as a share of exports, because aluminium is the main product (and it has relatively low carbon-intensity), the carbon revenue is relatively lower than it is for Bosnia-Herzegovina. For this country, as well as for Serbia and Macedonia, Electricity will be the product that will contribute the most due to the CBAM implementation.

The other most potentially impacted economies in relative terms are Armenia, Albania, Algeria, Moldova, Georgia, Belarus and Trinidad and Tobago. In the case of Algeria, Georgia and Trinidad and Tobago, it is mainly due to Fertilizers exports, whilst in the case of Armenia and Moldavia, this is mainly due to Iron and Steel exports.

Figure 3: Potential carbon revenue, by country (2019)



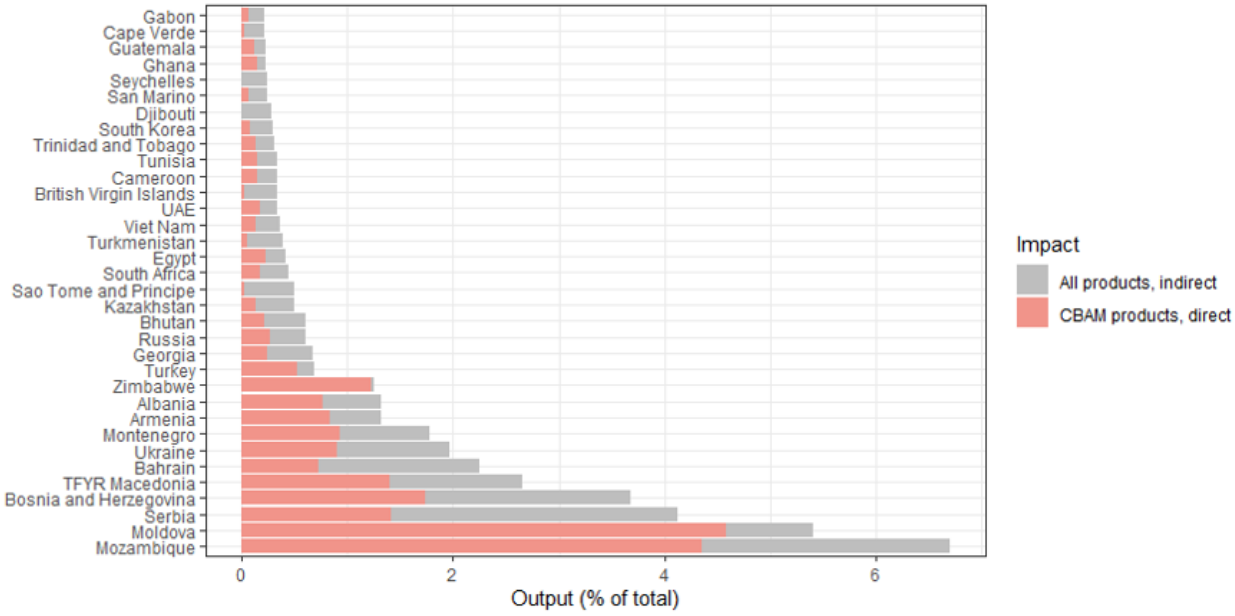
Source: authors' elaboration based on COMTRADE and RMRIO data

4.2. Countries' exposure

The estimation of the potential carbon revenue is based on the hypothesis that demand is not impacted by the implementation of CBAM. As discussed before, however, this might happen either if the exporter countries absorb all the carbon revenue in their price (and we have no price changes) or if the demand is inelastic in relation to prices (and hence demand is not impacted by price changes). Nevertheless, if prices change and demand evolves accordingly, the impact of CBAM will not only affect the sector directly involved, but also all the related sectors. The drop in demand will impact the sectors that produce these goods and the sectors that supply inputs for the production of these goods. Employers from these industries and from all industries in the supply chain will be affected.

Figure 4 presents the direct and indirect potentially impacted industries by country. The most impacted countries tend to be the same as before: Zimbabwe, Albania, Armenia, Montenegro, Ukraine, Bahrain, Macedonia, Bosnia-Herzegovina, Serbia, Moldova and Mozambique. Nevertheless, one can see that some countries, such as Bosnia-Herzegovina and Serbia, are relatively more impacted due to the indirect impacts. These impacts account not only for the direct suppliers of inputs for the production of the CBAM products, but for all indirect suppliers within the country. Therefore, those countries that depend more on productive linkages with the impacted industries tend to be the most impacted. Some countries that were not in the list of potentially most impacted economies appear now because they provide inputs for other countries to export to Europe. This is, for example, the case of Kazakhstan, in which the direct impact is low, but the indirect one is very high.

Figure 4: Potential impact on output, by country (2019)



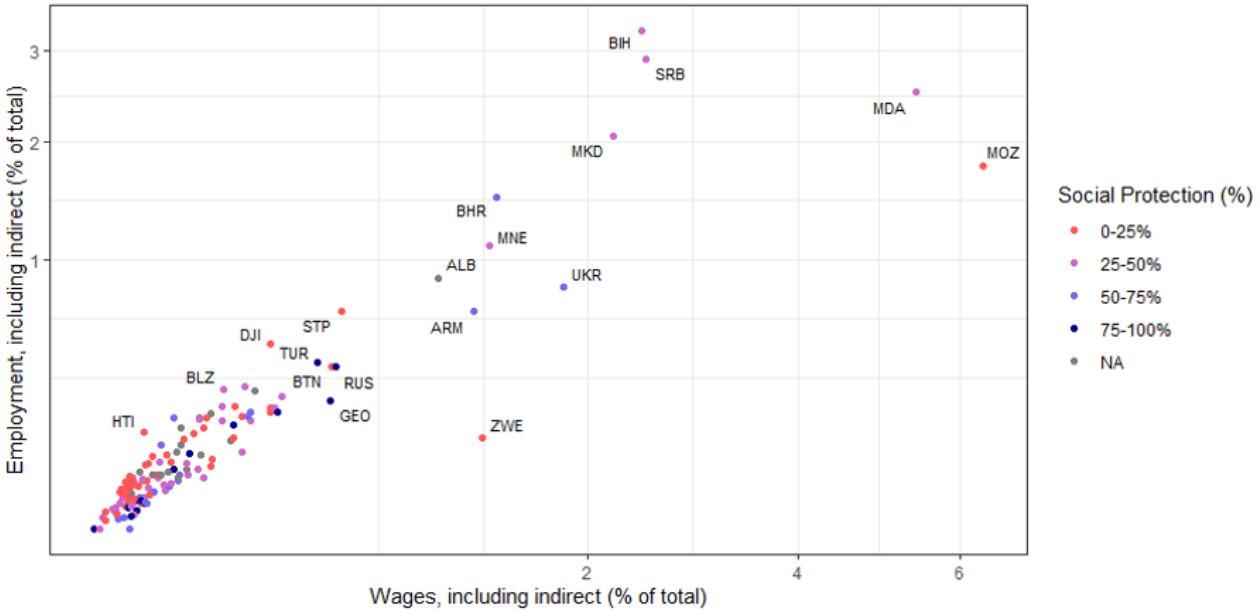
Source: authors' elaboration based on COMTRADE and EORA data

Besides the potential impact on output, one can also analyse the potential socio-economic impacts of the implementation of the CBAM based on the direct and indirect importance of these industries to generate well-payed jobs. Following (Espagne et al., 2021), we estimate the share of employment and wage bill that might be impacted by the CBAM in the EU trade partners with the aim of identifying those countries that are most exposed to this policy. Figure 5 presents, in the vertical axis, the share of wages and in the horizontal axis the share of employment. The colour of the point is the level of Social Protection Coverage, based on the International Labor Organization (ILO) data.

The most exposed countries in socio-economic terms are Moldova (MDA), Mozambique (MOZ), Bosnia-Herzegovina (BIH), Serbia (SRB), Macedonia (MKD), Ukraine (UKR), Montenegro (MNE), Bahrain (BHR), Albania (ALB). In these countries, the potential reduction in production puts at risk more than 0.5% of the wage bill and of the employment. In the case of Moldova and Mozambique, about 2% of employment is exposed. However, because the share of exposed wages is higher than 5%, it indicates that relatively well-payed jobs are the ones potentially impacted. The same problem at a lower scale is faced by Ukraine, where almost 1% of the employments are directly or indirectly related to the CBAM products exported to EU, and these jobs represent almost 2% of the wage bill.

Other countries, such as São Tome and Principe (STP), Armenia (ARM), Russia (RUQ), Georgia (GEO), Turkey (TUR) and Zimbabwe (ZWE), also present an important degree of socio-economic exposure since more than 0.5% of the wage bill will be impacted. However, in these economies (with special regards to Zimbabwe), the share of employment at risk is not as high as the share of wages, indicating that few but well-payed jobs are those that may be impacted by the introduction of CBAM in the European Union.

Figure 5: Potential impacts of CBAM on wages and employment, by country (2019)



Source: authors' elaboration based on COMTRADE and EORA data
Scales are in logarithm

High socioeconomic exposure does not necessarily imply high vulnerability. Countries like Ukraine, Bahrain and Armenia, despite having a relevant part of their well-paid jobs exposed to the adoption of CBAM, are less vulnerable than the other countries discussed above. Because they have a relatively better Social Protection Coverage (more than 50% of the labor force is covered), as indicated by the color of the points, the potential job losses in the impacted industries tend to imply relatively lower socioeconomic impacts. The case of Mozambique, on the other hand, is the most complicated, since about 2% of the jobs (more than 250 000 jobs) and 6% of the wage bill are exposed to the impact, and the country has a weak system of social protection (less than 25% of the work force is covered).

4.3. Expansion of CBAM

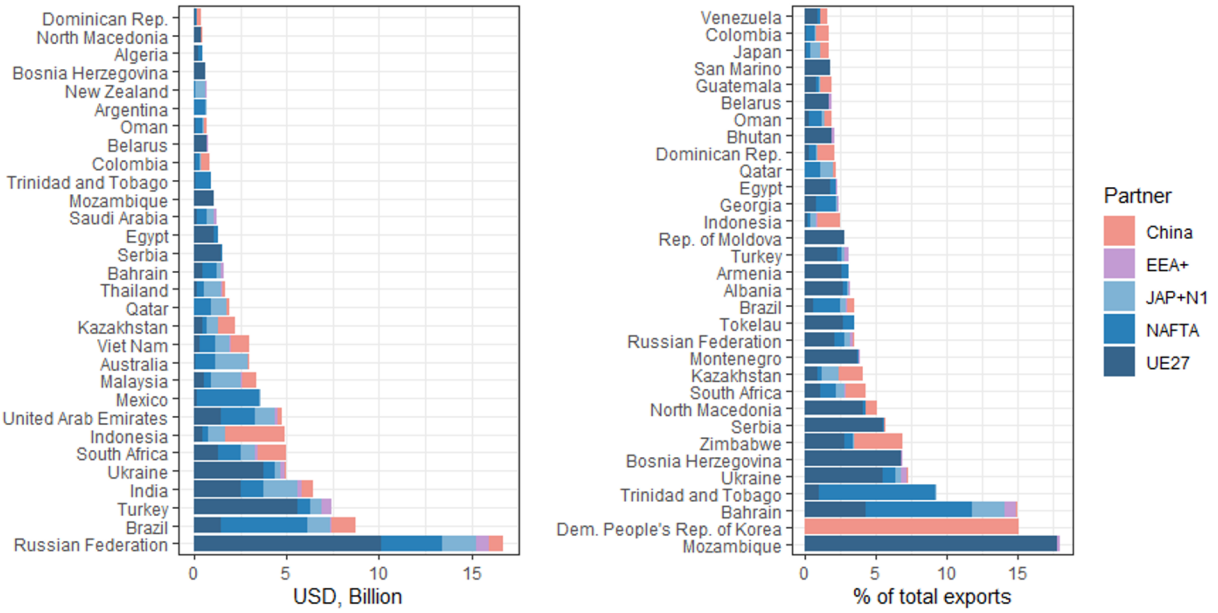
One of the main possible political impacts of CBAM is the stimulus it may generate for other countries do adopt similar measures. Because the value charged in CBAM discount the current carbon price applied in the country of origin, the introduction of the CBAM may lead to EU partners to adopt a carbon price mechanism. With the aim of understanding the impact of an expansion of CBAM to other developed countries, we calculate the share of exports that would be exposed in these partner countries. Essentially, we estimate the exports that would be impacted if the following countries adopt a CBAM-type measure:

- North American Free Trade Association (NAFTA), which includes USA, Canada and Mexico;
- Japan and the first group of "New Industrialized Economies (JAP+N1), which includes South Korea, Hong Kong and Singapore;

- United Kingdom, Switzerland, and other European Economic Area countries (EEA+), which includes Iceland, Liechtenstein and Norway;
- and China (despite not being a developed country)

In terms of total volume of exports, the other BRICS countries (Russia, Brazil, India and South Africa), as well as Indonesia, Malaysia, Mexico, Australia and Vietnam are the most impacted economies. For all these countries, exports of CBAM products to other developed countries and China represent more than 2.5 billion dollars per year. The inclusion of NAFTA is especially important for Brazil, which is expected since it is in the same continent. The inclusion of Japan and the N1 group is specially relevant for India, Australia and Malaysia. Finally, the inclusion of China has an amplified impact on Indonesia and Vietnam. In the case of South Africa, all groups of countries but EEA+ have relevant impacts.

Figure 6: Exports of CBAM products to selected countries, by country (2019)



Source: authors' elaboration based on COMTRADE data.

In terms of total exports, the most impacted economies are North Korea, Bahrain, Trinidad and Tobago, Zimbabwe, South Africa, Kazakhstan and Brazil. For all these countries, more than 2.5% of exports would be impacted by the adoption of CBAM-type measures. In the case of North Korea, Kazakhstan and Zimbabwe, the adoption of this type of measure by China is very relevant, whilst in the case of Bahrain and Trinidad and Tobago, it is the adoption by NAFTA that may lead to the highest exposure.

5. Conclusion

We have analyzed the impact of the introduction of the Carbon Border Adjustment Mechanism (CBAM) on the European Union (EU) trade partners, focusing especially on its potential socio-economic and external consequences for developing and emerging economies. Using trade

data and Multi-regional Input-Output (MRIO) matrices to investigate the uneven distribution of CBAM's impacts.

Differently from other studies that use general equilibrium models, and hence rely on strong assumptions about price-elasticities of substitution among countries and technological substitutions, we focus on two extreme scenarios. First, we identify the maximum carbon revenue generated for the EU by the introduction of CBAM if countries' exports' volumes to the EU are not impacted (which relies on the idea that these exports are inelastic in relation to price). Second, we assume on the contrary that all exports are impacted, as well as all suppliers of inputs for the industries that produce these export goods. Even though these extreme scenarios are fictitious, they illustrate the degree of exposure of each country, and the potential losses in terms of output, employment and wages, considering not only the direct impact, but also the impact on all productive chain (indirect impact). The use of MRIO tables allow us to verify that the indirect impact (either within or across countries) plays an important role on determining the degree of exposure of countries.

On the one hand, most carbon revenues would be generated by Russia, China and Ukraine. On the other hand, the degree of exposure of economies that export the CBAM products to Europe varies substantially, with many developing economies having more than 2% of their exports, and 1% of their production impacted by this measure. East European economies, mainly in the Balkans, as well as Mozambique, Zimbabwe and Cameroon, in Africa, are those where exports are the most exposed. In socio-economic terms, we can also include Morocco and Tajikistan in this group of most exposed economies.

The introduction of CBAM by the EU is currently under discussion, and most of the literature on the topic has analysed the consequences for the EU economies. However, this carbon adjustment mechanism, which seeks to reduce the incentives for firms to outsource their carbon emissions and promote a more generalized low-carbon transition, might disproportionally impact some non EU economies. The equity concerns could be addressed by returning the revenue from carbon import adjustments to paying countries or using it for technology transfer and international climate finance[6]. It is also argued that the principle of common but differentiated responsibility means that developed countries should invest in and take the main responsibility for the development and diffusion of the technologies needed to transform energy-intensive industries (Åhman et al., 2017).

[6] Addressing equity by exempting some or all developing regions is another possibility suggested by (Brandi, 2021). However, this latter solution could in specific circumstances undermine the legitimacy of CBAM by creating new forms of carbon havens (Branger and Quirion, 2014a).

References

Åhman, M., Nilsson, L. J., and Johansson, B. (**2017**). Global climate policy and deep decarbonization of energy-intensive industries. *Climate Policy*, 17(5):634–649.

Ameli, N., Dessens, O., Winning, M., Cronin, J., Chenet, H., Drummond, P., Calzadilla, A., Anandarajah, G., and Grubb, M. (**2021**). Higher cost of finance exacerbates a climate investment trap in developing economies. *Nature Communications*, 12(1):1–12.

Bao, Q., Tang, L., Zhang, Z., and Wang, S. (**2013**). Impacts of border carbon adjustments on china's sectoral emissions: Simulations with a dynamic computable general equilibrium model. *China Economic Review*, 24:77–94.

Böhringer, C., Fischer, C., Rosendahl, K. E., and Rutherford, T. F. (**2022**). Potential impacts and challenges of border carbon adjustments. *Nature Climate Change*, pages 1–8.

Brandi, C. (**2021**). Priorities for a development-friendly eu carbon border adjustment (cbam). Technical report, Briefing Paper.

Branger, F. and Quirion, P.a (**2014**a). Climate policy and the 'carbon haven'effect. *Wiley Interdisciplinary Reviews: Climate Change*, 5(1):53–71.

Branger, F. and Quirion, P.b (**2014**b). Would border carbon adjustments prevent carbon leakage and heavy industry competitiveness losses? insights from a meta-analysis of recent economic studies. *Ecological Economics*, 99:29–39.

Cabernard, L. and Pfister, S. (**2021**). A highly resolved mrio database for analyzing environmental footprints and green economy progress. *Science of The Total Environment*, 755 (1):142587.

Cameron, A., Baudry, M., et al. (**2022**). The case for a carbon border adjustment: Where do economists stand? Technical report, University of Paris Nanterre, EconomiX.

Chen, W. and Guo, Q. (**2017**). Assessing the effect of carbon tariffs on international trade and emission reduction of china's industrial products under the background of global climate governance. *Sustainability*, 9(6):1028.

Eicke, L., Weko, S., Apergi, M., and Marian, A. (**2021**). Pulling up the carbon ladder? decarbonization, dependence, and third-country risks from the european carbon border adjustment mechanism. *Energy Research & Social Science*, 80:102240.

Espagne, E., Godin, A., Magacho, G., Mantes, A., and Yilmaz, D. (**2021**). Developing countries' macroeconomic exposure to the low-carbon transition. *AFD Research Papers*, (220):1–42.

EUCommission (**2021**). Impact assessment report accompanying the document proposal for a regulation of the european parliament and of the council establishing a carbon border adjustment mechanism. Staff Document SWD/2021/643 final.

Kuusi, T., Björklund, M., Kaitila, V., Kokko, K., Lehmus, M., Mechling, M., Oikarinen, T., Pohjola, J., Soimakallio, S., and Wang, M. (**2020**). Carbon border adjustment mechanisms and their economic impact on finland and the eu.

Lenzen, M., Kanemoto, K., Moran, D., and Geschke, A. (**2012**). Mapping the structure of the world economy. *Environmental Science & Technology*, 46(15):8347–8381.

Lenzen, M., Moran, D., Kanemoto, K., and

Geschke, A. (**2013**). Building eora: A global multi-regional input-output database at high country and sector resolution. *Economic Systems Research*, 25(1):20–49.

Lim, B., Hong, K., Yoon, J., Chang, J.-I., and Cheong, I. (**2021**). Pitfalls of the eu's carbon border adjustment mechanism. *Energies*, 14(21):7303.

...

Mealy, P. and Teytelboym, A. (**2020**). Economic complexity and the green economy. *Research Policy*, page 103948.

Monjon, S. and Quirion, P. (**2011**). Addressing leakage in the eu ets: Border adjustment or output-based allocation? *Ecological Economics*, 70(11):1957–1971.

Stede, J., Pauliuk, S., Hardadi, G., and Neuhoff, K. (**2021**). Carbon pricing of basic materials: Incentives and risks for the value chain and consumers.

UN (**2003**). *UN comtrade*. Geneva: United Nations.

UNCTAD (**2021**). A european union carbon border adjustment mechanism: implications for developing countries.

Voituriez, T. and Wang, X. (**2011**). Getting the carbon price right through climate border measures: a chinese perspective. *Climate Policy*, 11(5):1257–1261.

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