



# Know your opponent: Which countries might fight the European carbon border adjustment mechanism?

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## ABSTRACT

The European Union (EU) plans to activate a carbon border adjustment mechanism (CBAM) in January 2023. This is meant to secure fair competition for European energy-intensive industries, incentivize countries both inside and outside the EU to cut emissions, and hinder carbon leakage from the EU. Early reactions from some large economies suggest that CBAM will encounter significant international opposition, especially from countries whose industry is dependent on fossil fuels. The purpose of this paper is to identify which countries are likely to resist CBAM most fiercely. This is done by creating a multidimensional CBAM Opposition Index based on the following indicators: trade with the EU, carbon intensity, litigiousness in the World Trade Organization (WTO), domestic public opinion on climate change, and capacity for innovation. The analysis indicates that the following countries are most likely to mount opposition to CBAM: Iran, Ukraine, the USA, the United Arab Emirates, Egypt, China, India, Kazakhstan, Russia, and Belarus. How the EU handles opposition from these countries will be decisive for the fate of CBAM. The index can serve as a tool for policymakers inside and outside the EU who need to negotiate over CBAM and want to anticipate the stances of other countries and understand their drivers.

## 1. Introduction

The EU Emissions Trading System (ETS) is the world's largest platform for trading greenhouse gas (GHG) emission allowances (Bayer and Aklın, 2020). In order to fulfill the Paris Agreement and reach the EU's emissions reduction target for 2030, the sectors covered by the ETS must reduce their emissions by 43% compared to 2005 levels (European Commission, 2018). To achieve this, the EU needs to further raise the price of ETS allowances (Joltreau and Sommerfeld, 2019). For many years, the price of emissions was allowed to remain low and some high-emitting sectors were granted free allowances (Clò et al., 2013; Hu et al., 2015). The number of available emissions allowances will be reduced and sectors previously exempted will have to start paying for their allowances (Hájek et al., 2019).

However, it is feared that the tightening of the ETS will render European energy-intensive industry uncompetitive (Joltreau and Sommerfeld, 2019; Kuik and Hofkes, 2010). The viability of tightening the ETS therefore hinges on the introduction of a mechanism to ensure that external producers selling energy-intensive goods to the EU do not pay a much lower price for their emissions than their European competitors.

The purposes of the EU's CBAM are: to ensure a level playing field for

companies selling energy-intensive goods in the EU; to limit carbon leakage, that is to say, to prevent energy-intensive industries from moving elsewhere when the cost of emissions goes up in the EU (Kuik and Hofkes, 2010; Schinko et al., 2014); and to encourage other countries and economic blocs to introduce or tighten their carbon pricing (Eyland and Zaccour, 2014; Jakob, 2021; Li et al., 2013; Tavoni et al., 2011).

A detailed plan for the EU's CBAM was leaked in June 2021 and officially presented as a part of European Green Deal in July 2021 (European Commission, 2021a). The plan has "produced howls of protest from EU trade partners" (Fleming and Giles, 2021). This includes public criticism from major economies such as China, India, Japan, and the United States (BASIC, 2021; Hook, 2021). Some authors argue that the imposition of CBAM-like measures will be particularly challenging for developing countries (Zhang, 2010), above all for China due to the high share of energy-intensive industries in its exports (Li and Zhang, 2012).

Should the resistance mount, CBAM might be torpedoed. Opposition might come in the form of WTO litigation and retaliatory trade measures. While the EU and many researchers argue that CBAM is compatible with international trade law, the issue remains complex and

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it is likely CBAM will be challenged under international trade legislation (Black, 2017; Mehling et al., 2019; Porterfield, 2019).

CBAM will cover five sectors: aluminum, cement, electricity, fertilizers, and iron and steel. However, retaliatory trade measures will not necessarily be limited to these five sectors. They could instead target European interest groups that European policymakers are thought to be dependent upon. When the Trump administration imposed tariffs on Chinese exports to the US, the Chinese retaliation targeted American agricultural exports in the hope of undermining support from farmers who had voted for Donald Trump (Bown, 2021; Tankersley and Bradsher, 2018). CBAM could trigger a similar pattern of interaction.

CBAM could promote the decarbonization of energy supplies for industry both within the EU and among its trade partners. The five sectors covered by CBAM are all energy- and carbon-intensive. For example, global steel production relies heavily on the use of coal and coke (Zhang et al., 2021). Energy-efficient technologies and low-carbon energy sources for such industries have been discussed extensively in the literature (Song and Oh, 2015; Zhou et al., 2010). CBAM may accelerate the uptake of such solutions.

The EU's CBAM will have the greatest consequences for the countries that export most to the EU and whose goods have the highest carbon content due to relying on carbon-intensive energy sources (Chen and Zeckhauser, 2018). Those countries could mount fierce resistance. A first step towards handling such resistance is to identify which countries it is likely to come from. That is the purpose of this article. Once identified, European policymakers can try to analyze the interests of these counterparts, work out counterstrategies, adapt the design of CBAM, and/or engage them in dialogue.

There is a growing body of research on CBAM. It addresses a variety of aspects, such as carbon leakage (Böhringer et al., 2017; Mehling et al., 2019; Naegele and Zaklan, 2019), WTO rules (Balistreri et al., 2019; Kaufmann and Weber, 2011; Porterfield, 2019; Trachtman, 2017), the ability to induce global climate cooperation (Al Khourdajie and Finus, 2020; Farrahi Moghaddam et al., 2013; Hecht and Peters, 2019; Sanctuary, 2018), impacts on the domestic economy (Fouré et al., 2016; McKibbin et al., 2018), design issues (Cosbey et al., 2019; Kortum and Weisbach, 2017), and possible impacts on non-EU countries (Tagliapietra and Wolff, 2021; Tang et al., 2015; Zhong and Pei, 2021). However, we found no existing study which has sought to identify potential antagonists to the EU CBAM related sectors using multidimensional criteria.

## 2. Methods

### 2.1. Selection of countries

We carried out an initial delimitation of potential CBAM opponent countries using two criteria. First, we identified countries which export products to the EU in any of the five sectors covered by the current iteration of CBAM: aluminum, cement, electricity, fertilizers, and iron and steel. The export data were extracted from the UN Comtrade Database using Combined Nomenclature codes from the leaked CBAM document (European Commission, 2021b). A detailed data source description is provided in Section 2.3.

As a second criterion, among these countries we chose the top 50 destinations for exports from the EU (not limited to the five CBAM sectors). The rationale behind this was that, should the launch of CBAM trigger a trade war, the EU will be most sensitive to actions by the countries to which the EU exports its own goods. Accordingly, these are potential opponents of importance. Two of the 50 countries—Iraq and Panama—were later omitted from our analysis due to lack of data.

### 2.2. Index construction steps

For the purpose of identifying which countries are likely to be most antagonistic towards CBAM, we constructed a composite index

following the state-of-the-art approach to index construction (Becker et al., 2017; Freudenberg, 2003). The index was constructed in four steps: selection of index subdimensions; data normalization; weighting and aggregation; and robustness check and sensitivity analysis (Nardo and Saisana, 2008; Saltelli, 2007). The obtained index was rescaled from 1 to 100, where 100 signifies the highest potential opposition to CBAM and 1 the lowest. The data were collected and analyzed using Stata 16.1. The complete dataset is available in the open access repository Mendeley Data (Sabyrbekov and Overland, 2021).

#### 2.2.1. Choosing index subdimensions

The selection of subdimensions for the index was based on a review of the academic literature on CBAM. In addition, we sought to ensure that each subdimension represented a distinct aspect of the likelihood of opposing CBAM and that they did not overlap. To check this, we ran a correlation analysis of the selected subdimensions.

The overall selection of subdimensions was guided by considerations about exposure and adaptability. Exposure consists of CBAM-applicable exports to the EU and the carbon intensity of the economy of the exporting country. Adaptability consists of the technological capacity measured in terms of patent applications; track-record of WTO litigiousness measured in terms of the number of initiated WTO disputes; and domestic public opinion on climate change. In the next paragraphs, we describe the five subdimensions and their relationship to CBAM.

- (1) *Trade*: This subdimension consists of two parts: (a) the exports of countries to the EU in the five sectors covered by CBAM and (b) the size of EU exports to these countries. The former is measured in terms of the share of the CBAM-applicable sectors in total exports to the EU. Clearly, the implementation of CBAM will have a higher impact on countries that export more of the CBAM-applicable products to the EU market. The second is EU exports to a given country as a share of total EU exports. The higher the share of EU exports to a country, the more vulnerable is the EU to trade retaliation from that country. Since retaliation against CBAM may be asymmetric, we take into consideration all EU exports and do not limit this indicator to the five CBAM-applicable sectors.
- (2) *Carbon intensity*: CBAM-related fees will be highest for the goods with the highest carbon content. Thus, we included the carbon intensity of the economy of the trade partners exporting to the EU. Ideally, this would be based upon the specific carbon intensity of each CBAM-applicable sector or good exported to EU, but such data are unavailable for many countries. However, the carbon intensity of a country's whole economy represents a reasonable approximation of sectoral carbon intensity since the sector is embedded in the national economy and its environmental regulations.
- (3) *Track record of confrontation in WTO/quarrelsomeness*: There is an ongoing discussion in the literature as to whether or not CBAM is in conformation with WTO rules (Cottier et al., 2014; Kaufmann and Weber, 2011; Ladly, 2012; Trachtman, 2017). As an indicator of the risk that countries will challenge CBAM in the WTO, we used the number of past WTO disputes they initiated between 1995 and 2018.
- (4) *Climate change opinion*: This subdimension represents public concern about climate change. In countries where the population is climate sceptic or at least not worried about climate change, the government may be more inclined to challenge the EU over CBAM. In countries with a high level of public concern about climate change, governments may be less inclined to fight against CBAM, as they might lack domestic support.
- (5) *Innovation capacity*: The development and implementation of new technologies is key to the decarbonization. A strong capacity for innovation can therefore make it easier for a country to adapt its economy to international decarbonization trends. This

subdimension is measured in terms of the total number of patent applications per 100,000 inhabitants from 1995 to 2019.

To ensure the robustness of the analysis and maximize the policy angles, we developed five different versions of the index (Table 1). The multiple the versions are also useful for identifying the specific reasons why a specific country might oppose to the CBAM.

2.2.2. Normalization

For each subdimension we normalized the data using maximum and minimum values, in accordance with Formula 1:

$$I_c = \frac{x_c - \min(x)}{\max(x) - \min(x)} \tag{1}$$

where  $I_c$  is the subdimension for country  $c$ ,  $x_c$  is the value of the variable  $x$ , and  $\max(x)$  and  $\min(x)$  are the maximum and minimum values. The resulting normalized values are between 0 and 1.

2.2.3. Weighting and aggregation

Since no evidence in the literature suggests a hierarchical relationship, we used equal weighting for all subdimensions. Before aggregation, we made sure that for all subdimensions, a higher score indicates greater opposition to CBAM. To achieve this, we subtracted 1 from the normalized values of patent applications and climate concern because these two subdimensions in their raw data format are negatively associated with the likelihood of opposition to CBAM.

2.2.4. Robustness check and sensitivity analysis

To check the robustness of the obtained index, we used a different normalization technique drawing on Cherchye et al. (2008) and Saisana et al. (2005). While the minimum-maximum technique may be sensitive to outliers, a z-score based normalization approach solves this issue by using standard deviation (Formula 2).

$$ZI_c = \frac{x - \mu_x}{\sigma} \tag{2}$$

where  $ZI_c$  is a z-score normalized subdimension,  $\mu_x$  is the mean value of the subdimension, and  $\sigma$  is the standard deviation.

The resulting z-score based index was compared with the min-max based index to see if there were any changes in country rankings. As a secondary check, we also ran a correlation assessment between the two versions of the index.

Finally, we performed a sensitivity analysis by dropping one variable at a time in the final aggregated index while making sure that all remaining subdimensions had equal weight in the overall index. This also allowed us to construct five different versions of the index (see Section 3.2). We used visualization at every step to spot irregularities.

2.3. Data description

All data are from 2019, except the data on WTO disputes and innovation capacity. The WTO disputes indicator includes the total number of disputes initiated by the countries between 1995 and 2018. Innovation capacity is a long-term process, so we used the total number of patent applications from 1995 to 2019. Detailed descriptions of the data

Table 1  
Five versions of the CBAM Opposition Index.

| Index version | Trade                       |                               | Carbon intensity | WTO appeals | Climate change awareness | Innovation capacity |
|---------------|-----------------------------|-------------------------------|------------------|-------------|--------------------------|---------------------|
|               | EU exports to trade partner | Exports to EU in five sectors |                  |             |                          |                     |
| I             | X                           | X                             | X                | X           | X                        | X                   |
| II            | X                           | X                             | X                | X           | X                        |                     |
| III           | X                           | X                             | X                | X           |                          |                     |
| IV            | X                           | X                             | X                |             |                          |                     |
| V             | X                           | X                             |                  | X           |                          |                     |

and sources are provided in Table 2.

3. Results

3.1. Descriptive data

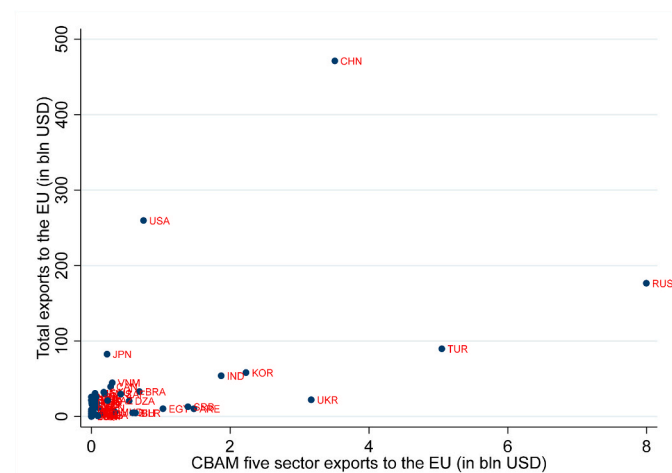
Table 3 provides summary statistics for each subdimension. The countries varied significantly in terms of the share of CBAM-applicable goods in their total exports to the EU, with the five largest being the

Table 2  
Selected subdimensions and data sources.

| Indicator   | Measurement unit   | Data source and availability   | Rationale   |
|---|--|--|---|
| (1a) Share of the five CBAM-applicable sectors in total exports to the EU | Share  | United Nations Comtrade Database   | High exports of CBAM-applicable products to the EU imply high costs generated by CBAM, and a correspondingly higher level of opposition from EU trade partners. |
| (1b) Share of EU exports to the country in total EU exports               | Share  | United Nations Comtrade Database   | If a country retaliates, the greater the EU exports to this country, the more damage to the EU.   |
| (2) Carbon intensity of the economy                                       | Greenhouse gas emissions (metric tons) per USD of GDP                                    | Calculated using CO2 emissions data from the Global Carbon Budget (Friedlingstein et al., 2020) and GDP (2010 constant USD) from the World Development Indicators of the World Bank. | Higher carbon intensity means higher emissions cost. Thus, opposition is likely to be stiffer.  |
| (3) Track record of WTO litigiousness                                     | Number of initiated appeals between 1995 and 2018  | WTO Dispute Settlement (WTO, 2021).  | The more WTO disputes a country has been involved in, the more likely it is to oppose CBAM in the WTO.  |
| (4) Climate change opinion  | Share of respondents who see climate change as a very serious or somewhat serious threat | The Lloyd's Register Foundation (Gallup, 2019). All samples are probability-based and nationally representative of the resident adult population.                                    | Higher domestic public concern about climate change may make it more difficult for governments to engage in protracted conflict over CBAM.                      |
| (5) Innovation capacity   | Total number of patent applications by residents from 1995 to 2019 per 100,000 people    | World Intellectual Property Organization Data (WIPO, 2021) and population size from the World Development Indicators of the World Bank.  | Countries with higher levels of innovation may be better positioned to adjust their industry and exports to CBAM.   |

**Table 3**  
Summary statistics of the subdimensions.

| Variable  | Mean | Std. dev. | Min    | Max   |
|---|------|-----------|--------|-------|
| Exports to the EU in the five CBAM-applicable sectors as a share of total exports to the EU | 2.91 | 4.34      | 0.0004 | 14.37 |
| Share of EU exports to the country in total EU exports                                      | 1.58 | 3.41      | 0.14   | 21.71 |
| CO2 emissions in kg per USD of GDP  | 0.65 | 0.38      | 0.11   | 1.65  |
| Total number of initiated WTO disputes 1995–2018  | 9    | 19        | 0      | 124   |
| Share of respondents who see climate change as a threat                                     | 0.74 | 0.13      | 0.49   | 0.95  |
| Number of patent applications per 100,000 inhabitants                                       | 376  | 1200      | 0      | 6296  |



**Fig. 1.** Exports to the EU in the five CBAM-applicable sectors plotted against total exports to the EU.

United Arab Emirates (14%), Ukraine (14%), Belarus (13%), Bosnia and Herzegovina (12%), and Iran (12%). The five smallest exporters of CBAM relevant goods to the EU were Kuwait, Nigeria, Bangladesh, Peru, and Senegal.

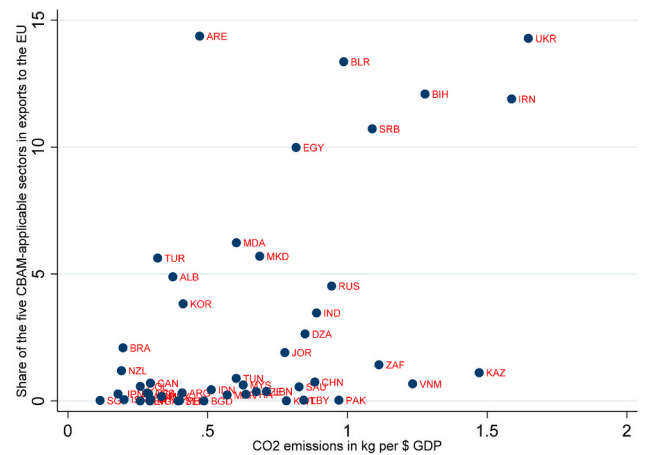
The top five export destinations for EU goods were the USA (21%), China (11%), Russia (4%), Turkey (4%), and Japan (3%). At the bottom of the list of the EU's 50 main trade partners, with less than 1% of EU exports combined, were Senegal, Jordan, Bangladesh, Albania, and Moldova.

EU trade partners vary in terms of the volumes of their total exports to the EU in the five CBAM sectors. China and the USA are the largest overall exporters to the EU, while Russia and Turkey have the largest exports to the EU in the five sectors. Fig. 1 plots the exports of countries to the EU in the five CBAM sectors against their total exports to the EU.

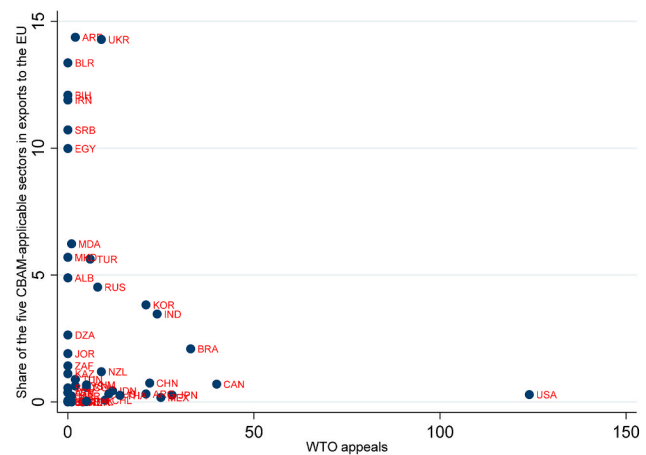
The carbon intensity indicator ranged from 0.11 to 1.65 kg per USD of GDP. The most carbon intensive economies among the EU's 50 main trade partners in 2019 were Ukraine (1.65), Iran (1.60), Kazakhstan (1.47), Bosnia and Herzegovina (1.28), and Vietnam (1.23). The least carbon intensive were Israel (0.21), Brazil (0.20), New Zealand (0.19), Japan (0.18), and Singapore (0.11). Fig. 2 plots the exports of countries to the EU in the five CBAM sectors against their carbon intensities.

Countries with a high share of CBAM-applicable exports to the EU and with high carbon intensity of GDP include Ukraine, Iran, Bahrain, Belarus, and Serbia (see Fig. 2). Countries such as Kazakhstan, Pakistan, South Africa, and Vietnam have a low share of exports to the EU but high carbon intensity.

The United States initiated the largest number of WTO appeals between 1995 and 2018 (see Fig. 3). Most other countries had much



**Fig. 2.** Exports to the EU in the five CBAM-applicable sectors as a share of total exports to the EU plotted against carbon intensity of GDP at country level.



**Fig. 3.** Exports to the EU in the five CBAM-applicable sectors as a share of total exports to the EU plotted against the number of WTO appeals 1995–2018.

smaller numbers, but Brazil and Canada also initiated numerous appeals.

The level of public concern about climate change was highest in Chile (95%), followed by Korea (94%), Japan (94%), Singapore (91%) and Peru (90%). The lowest levels of climate change concern were registered in the United Arab Emirates (49%), Libya (50%), Saudi Arabia (52%), Indonesia (54%), and Bangladesh (55%) (see Fig. 4 for details).

### 3.2. CBAM Opposition Index

#### 3.2.1. Main index

The main version of the composite index ranges from 100 for Iran to 1 for Japan. The top ten potential opponents of the EU's CBAM are thus Iran, Ukraine, USA, United Arab Emirates, Egypt, China, India, Kazakhstan, Russia, and Belarus. Some other major economies, such as, Saudi Arabia, Indonesia, and South Africa are among the top 16. The full index ranking table can be found in Table A.1 in the appendix and is presented visually in Figs. 5 and 6. The full rankings for all countries and all index versions are presented in Tables A.1–A.5 in the appendices.

#### 3.2.2. Index without innovation capacity

We see that technological capacity also plays an important role in the



Fig. 4. Share of exports to the EU in the five CBAM-applicable sectors plotted against the share of the population who see climate change as a serious threat.

index, mediating the impacts of the other components. If we exclude the innovative capacity subdimension, the United States moves up to first place. Japan and Korea move up as well but remain at the lower end of the scale (see Fig. 7). This means that any attempt to anticipate the reaction of these countries to CBAM will depend on whether or not one thinks the countries will see that their capacity for innovation will

enable them to handle the higher cost of GHG emissions well and benefit from the markets for green technologies that CBAM will help expand.

3.2.3. Index with trade, carbon intensity and WTO disputes

In the version of the index with three dimensions—trade, carbon intensity, and WTO disputes—the USA, Ukraine, Iran, Bosnia and Herzegovina, and Belarus are at the top (see Fig. 8). The top ten also include China and India (eighth and tenth place, respectively). Singapore, Israel, Peru, Nigeria, and Colombia have the lowest scores.

3.2.4. Index with trade and carbon intensity

This version of the index has only two subdimensions: trade with the EU and carbon intensity (see Fig. 9). The top three countries are Ukraine, Iran, and Bosnia and Herzegovina.

3.2.5. Index with trade and WTO disputes

In an even simpler index version with the trade and WTO disputes dimensions only, the top CBAM opponents are Bosnia and Herzegovina, Iran, Belarus, the UAE and the USA (see Fig. 10).

The different versions of the index show similar patterns with some exceptions (see Fig. 11). The main index includes WTO appeals and thus considers the likelihood that opposition to CBAM will manifest itself in the use of international trade agreements. Iran, Ukraine, the USA and the United Arab Emirates are important opponents in all versions.

The index versions can serve a variety of purposes, depending on the focus of the analysis. The simplest version, with trade and carbon intensity only, shows which countries are most exposed, while the version which includes innovative capacity attests to adaptivity.

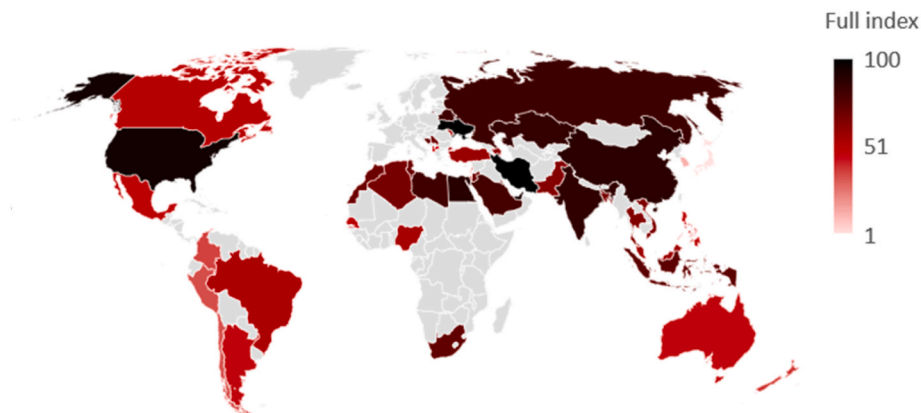


Fig. 5. CBAM Opposition Index plotted on the world map.

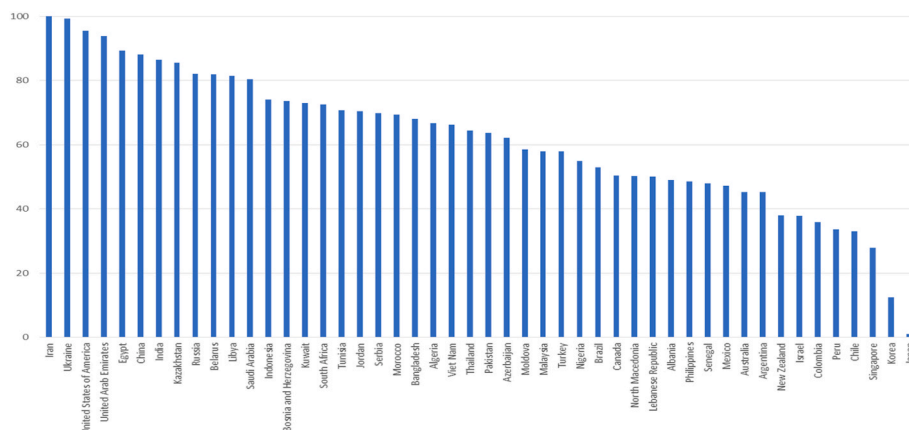


Fig. 6. CBAM Opposition Index, main version with all dimensions.

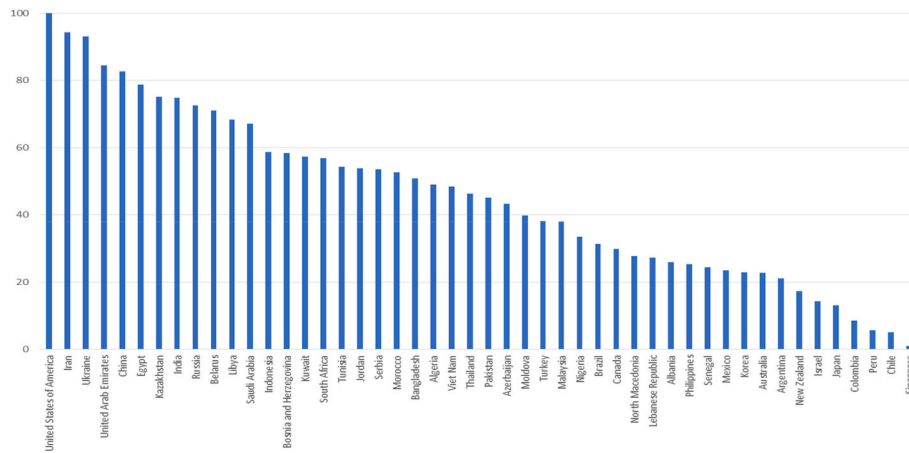


Fig. 7. CBAM Opposition Index with innovation capacity/patent applications dimension omitted.

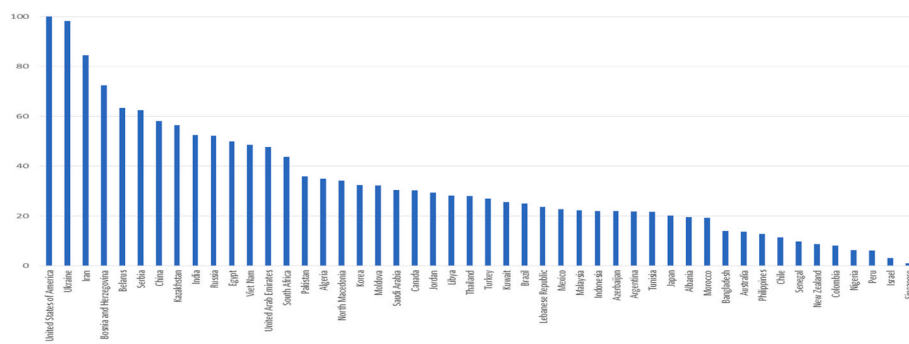


Fig. 8. CBAM Opposition Index based on trade, carbon intensity and WTO appeals dimensions only.

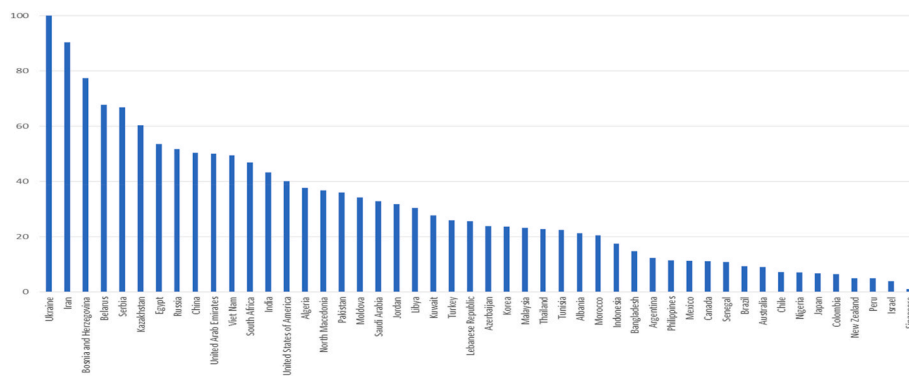


Fig. 9. Index based on the trade and carbon intensity dimensions only.

#### 4. Conclusion and policy implications

The early reactions of other countries indicate that the EU’s CBAM will encounter some resistance. This study has used a multidimensional index to assess which countries are most likely to become the greatest opponents of CBAM. The index can serve as a useful tool for policymakers inside and outside the EU who need to negotiate over CBAM and want to anticipate the stances of other countries and understand their drivers.

The CBAM Opposition Index shows that the greatest opponents are likely to be Iran, Ukraine, the USA, the United Arab Emirates, Egypt, China, India, Kazakhstan, Russia, and Belarus. A high share of CBAM-exposed exports to the EU along with high carbon intensity and low levels of technological innovation entail that CBAM will be a major issue

for these countries. Our findings also suggest that large economies such as the USA, Russia, China, and India are likely to use the WTO platform to oppose CBAM based upon their prior history of dispute initiation. In finalizing the design of CBAM, the EU may need to take into account the interests of these countries, or prepare to face off with them in the WTO.

Our analysis also indicates that CBAM opposition in Ukraine, Bosnia and Herzegovina, Serbia, and Vietnam may be largely driven by the carbon intensity of their energy supply. To soften the impact of CBAM in such countries, the EU and other interested actors could offer support for their decarbonization, for example through technology transfers.

In smaller developing economies such as Algeria, Bangladesh, and Morocco, lower innovation capacity plays a bigger role as a potential driver of CBAM opposition. To soften the impact of CBAM in such countries, the EU and other interested actors could offer to support the

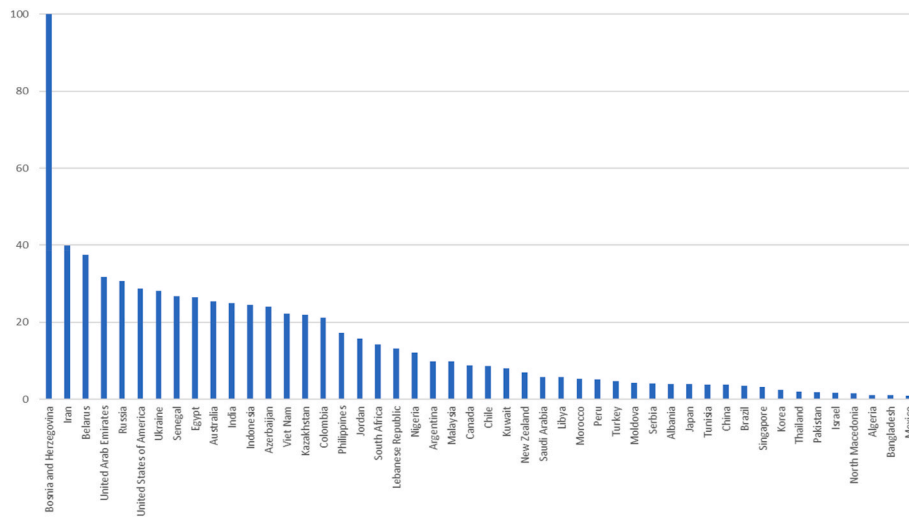


Fig. 10. Index with trade and WTO disputes dimensions only.

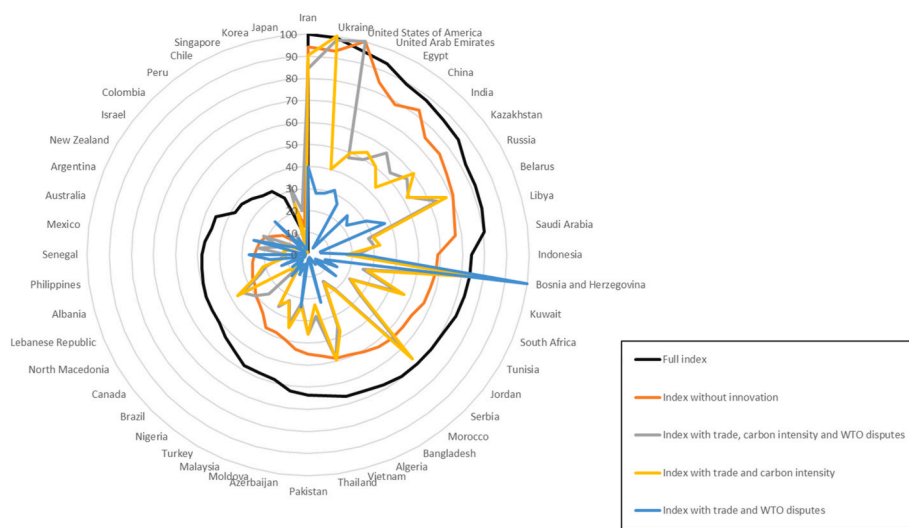


Fig. 11. Different versions of the index, sorted by the full index.

development of greater capacity for innovation.

On the one hand, the index can be useful for the EU in understanding how CBAM will be opposed and how to approach opponents. On the other hand, it can also be useful for countries that oppose CBAM and wish to identify potential allies.

Japan is one of the most interesting countries in the context of the CBAM Opposition Index. In the main version of the index, it is the country ranked as least likely to oppose the CBAM. One of the reasons for this is that Japan is the top-ranked country on the innovation/patents indicator. But when we omitted this indicator in the sensitivity analysis, Japan moved up only four places from the bottom and it is placed low in all five versions of the index. This indicates that Japan does not have much to lose from CBAM, and little to gain from opposing it. However, in the real world, Japan is one of the countries that has spoken out most loudly against CBAM. This fits with the trend in Japanese policy in which it moved away from the pro-climate position it held in the 1990s, but our index indicates that there could be scope for Japan to change its position again. As the EU’s fifth largest trade partner, the world’s third largest economy and a highly export-dependent country, Japan will be an important interlocutor for the EU as it tries to implement CBAM.

Another implication of our findings is that coordination with the China and/or USA will be very important for the viability of the EU’s

CBAM. China and the USA are the largest economies and most powerful countries among the potential opponents. If one or both of them can be won over, it will be more difficult for other countries to resist.

**CRedit authorship contribution statement**

**Indra Overland:** Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Rahat Sabyrbekov:** Methodology, Data curation, Formal analysis, Calculations, Investigation, Methodology, Visualization, Writing – original draft.

**Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Data availability**

The data are publicly available and the sources are listed in the article.

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## 6. Appendices

**Table A.1**  
Full index version with list of all countries

| Ranking | Country                | Full index |
|---------|------------------------|------------|
| 1.      | Iran                   | 100        |
| 2.      | Ukraine                | 99         |
| 3.      | USA                    | 96         |
| 4.      | United Arab Emirates   | 94         |
| 5.      | Egypt                  | 89         |
| 6.      | China                  | 88         |
| 7.      | India                  | 86         |
| 8.      | Kazakhstan             | 86         |
| 9.      | Russia                 | 82         |
| 10.     | Belarus                | 82         |
| 11.     | Libya                  | 81         |
| 12.     | Saudi Arabia           | 80         |
| 13.     | Indonesia              | 74         |
| 14.     | Bosnia and Herzegovina | 74         |
| 15.     | Kuwait                 | 73         |
| 16.     | South Africa           | 73         |
| 17.     | Tunisia                | 71         |
| 18.     | Jordan                 | 70         |
| 19.     | Serbia                 | 70         |
| 20.     | Morocco                | 69         |
| 21.     | Bangladesh             | 68         |
| 22.     | Algeria                | 67         |
| 23.     | Vietnam                | 66         |
| 24.     | Thailand               | 64         |
| 25.     | Pakistan               | 64         |
| 26.     | Azerbaijan             | 62         |
| 27.     | Moldova                | 59         |
| 28.     | Malaysia               | 58         |
| 29.     | Turkey                 | 58         |
| 30.     | Nigeria                | 55         |
| 31.     | Brazil                 | 53         |
| 32.     | Canada                 | 50         |
| 33.     | North Macedonia        | 50         |
| 34.     | Lebanon                | 50         |
| 35.     | Albania                | 49         |
| 36.     | Philippines            | 49         |
| 37.     | Senegal                | 48         |
| 38.     | Mexico                 | 47         |
| 39.     | Australia              | 45         |
| 40.     | Argentina              | 45         |
| 41.     | New Zealand            | 38         |
| 42.     | Israel                 | 38         |
| 43.     | Colombia               | 36         |
| 44.     | Peru                   | 34         |
| 45.     | Chile                  | 33         |
| 46.     | Singapore              | 28         |
| 47.     | Korea                  | 12         |
| 48.     | Japan                  | 1          |

**Table A.2**  
Index version without innovation capacity

| Ranking | Country              | Index without innovation |
|---------|----------------------|--------------------------|
| 1.      | USA                  | 100                      |
| 2.      | Iran                 | 94                       |
| 3.      | Ukraine              | 93                       |
| 4.      | United Arab Emirates | 85                       |
| 5.      | China                | 83                       |
| 6.      | Egypt                | 79                       |
| 7.      | Kazakhstan           | 75                       |
| 8.      | India                | 75                       |
| 9.      | Russia               | 73                       |
| 10.     | Belarus              | 71                       |

(continued on next page)



**Table A.2** (continued)

| Ranking | Country                | Index without innovation |
|---------|------------------------|--------------------------|
| 11.     | Libya                  | 68                       |
| 12.     | Saudi Arabia           | 67                       |
| 13.     | Indonesia              | 59                       |
| 14.     | Bosnia and Herzegovina | 58                       |
| 15.     | Kuwait                 | 57                       |
| 16.     | South Africa           | 57                       |
| 17.     | Tunisia                | 54                       |
| 18.     | Jordan                 | 54                       |
| 19.     | Serbia                 | 54                       |
| 20.     | Morocco                | 53                       |
| 21.     | Bangladesh             | 51                       |
| 22.     | Algeria                | 49                       |
| 23.     | Vietnam                | 48                       |
| 24.     | Thailand               | 46                       |
| 25.     | Pakistan               | 45                       |
| 26.     | Azerbaijan             | 43                       |
| 27.     | Moldova                | 40                       |
| 28.     | Turkey                 | 38                       |
| 29.     | Malaysia               | 38                       |
| 30.     | Nigeria                | 34                       |
| 31.     | Brazil                 | 31                       |
| 32.     | Canada                 | 30                       |
| 33.     | North Macedonia        | 28                       |
| 34.     | Lebanon                | 27                       |
| 35.     | Albania                | 26                       |
| 36.     | Philippines            | 25                       |
| 37.     | Senegal                | 24                       |
| 38.     | Mexico                 | 24                       |
| 39.     | Korea                  | 23                       |
| 40.     | Australia              | 23                       |
| 41.     | Argentina              | 21                       |
| 42.     | New Zealand            | 17                       |
| 43.     | Israel                 | 14                       |
| 44.     | Japan                  | 13                       |
| 45.     | Colombia               | 9                        |
| 46.     | Peru                   | 6                        |
| 47.     | Chile                  | 5                        |
| 48.     | Singapore              | 1                        |

**Table A.3**

Index with trade, carbon intensity and WTO disputes

| Ranking | Country                | Index with trade, carbon intensity and WTO disputes |
|---------|------------------------|---|
| 1.      | USA                    | 100   |
| 2.      | Ukraine                | 98  |
| 3.      | Iran                   | 85  |
| 4.      | Bosnia and Herzegovina | 72  |
| 5.      | Belarus                | 63  |
| 6.      | Serbia                 | 62  |
| 7.      | China                  | 58  |
| 8.      | Kazakhstan             | 56  |
| 9.      | India                  | 52  |
| 10.     | Russia                 | 52  |
| 11.     | Egypt                  | 50  |
| 12.     | Vietnam                | 49  |
| 13.     | United Arab Emirates   | 48  |
| 14.     | South Africa           | 44  |
| 15.     | Pakistan               | 36  |
| 16.     | Algeria                | 35  |
| 17.     | North Macedonia        | 34  |
| 18.     | Korea                  | 32  |
| 19.     | Moldova                | 32  |
| 20.     | Saudi Arabia           | 30  |
| 21.     | Canada                 | 30  |
| 22.     | Jordan                 | 29  |
| 23.     | Libya                  | 28  |
| 24.     | Thailand               | 28  |
| 25.     | Turkey                 | 27  |
| 26.     | Kuwait                 | 26  |
| 27.     | Brazil                 | 25  |
| 28.     | Lebanon                | 24  |
| 29.     | Mexico                 | 23  |

(continued on next page)

**Table A.3** (continued)

| Ranking | Country     | Index with trade, carbon intensity and WTO disputes |
|---------|-------------|---|
| 30.     | Malaysia    | 22  |
| 31.     | Indonesia   | 22  |
| 32.     | Azerbaijan  | 22  |
| 33.     | Argentina   | 22  |
| 34.     | Tunisia     | 22  |
| 35.     | Japan       | 20  |
| 36.     | Albania     | 20  |
| 37.     | Morocco     | 19  |
| 38.     | Bangladesh  | 14  |
| 39.     | Australia   | 14  |
| 40.     | Philippines | 13  |
| 41.     | Chile       | 11  |
| 42.     | Senegal     | 10  |
| 43.     | New Zealand | 9   |
| 44.     | Colombia    | 8   |
| 45.     | Nigeria     | 6   |
| 46.     | Peru        | 6   |
| 47.     | Israel      | 3   |
| 48.     | Singapore   | 1   |

**Table A.4**

Index with trade and carbon intensity

| Ranking | Country                | Index with trade and carbon intensity |
|---------|------------------------|---------------------------------------|
| 1.      | Ukraine                | 100                                   |
| 2.      | Iran                   | 90                                    |
| 3.      | Bosnia and Herzegovina | 77                                    |
| 4.      | Belarus                | 68                                    |
| 5.      | Serbia                 | 67                                    |
| 6.      | Kazakhstan             | 60                                    |
| 7.      | Egypt                  | 53                                    |
| 8.      | Russia                 | 52                                    |
| 9.      | China                  | 50                                    |
| 10.     | United Arab Emirates   | 50                                    |
| 11.     | Vietnam                | 49                                    |
| 12.     | South Africa           | 47                                    |
| 13.     | India                  | 43                                    |
| 14.     | USA                    | 40                                    |
| 15.     | Algeria                | 38                                    |
| 16.     | North Macedonia        | 37                                    |
| 17.     | Pakistan               | 36                                    |
| 18.     | Moldova                | 34                                    |
| 19.     | Saudi Arabia           | 33                                    |
| 20.     | Jordan                 | 32                                    |
| 21.     | Libya                  | 30                                    |
| 22.     | Kuwait                 | 28                                    |
| 23.     | Turkey                 | 26                                    |
| 24.     | Lebanon                | 26                                    |
| 25.     | Azerbaijan             | 24                                    |
| 26.     | Korea                  | 24                                    |
| 27.     | Malaysia               | 23                                    |
| 28.     | Thailand               | 23                                    |
| 29.     | Tunisia                | 22                                    |
| 30.     | Albania                | 21                                    |
| 31.     | Morocco                | 20                                    |
| 32.     | Indonesia              | 17                                    |
| 33.     | Bangladesh             | 15                                    |
| 34.     | Argentina              | 12                                    |
| 35.     | Philippines            | 11                                    |
| 36.     | Mexico                 | 11                                    |
| 37.     | Canada                 | 11                                    |
| 38.     | Senegal                | 11                                    |
| 39.     | Brazil                 | 9                                     |
| 40.     | Australia              | 9                                     |
| 41.     | Chile                  | 7                                     |
| 42.     | Nigeria                | 7                                     |
| 43.     | Japan                  | 7                                     |
| 44.     | Colombia               | 6                                     |
| 45.     | New Zealand            | 5                                     |
| 46.     | Peru                   | 5                                     |
| 47.     | Israel                 | 4                                     |
| 48.     | Singapore              | 1                                     |

**Table A.5**  
Index with trade and WTO disputes

| Ranking | Country                | Index with trade and WTO disputes |
|---------|------------------------|-----------------------------------|
| 1.      | Bosnia and Herzegovina | 100                               |
| 2.      | Iran                   | 40                                |
| 3.      | Belarus                | 37                                |
| 4.      | United Arab Emirates   | 32                                |
| 5.      | Russia                 | 31                                |
| 6.      | USA                    | 29                                |
| 7.      | Ukraine                | 28                                |
| 8.      | Senegal                | 27                                |
| 9.      | Egypt                  | 26                                |
| 10.     | Australia              | 25                                |
| 11.     | India                  | 25                                |
| 12.     | Indonesia              | 24                                |
| 13.     | Azerbaijan             | 24                                |
| 14.     | Vietnam                | 22                                |
| 15.     | Kazakhstan             | 22                                |
| 16.     | Colombia               | 21                                |
| 17.     | Philippines            | 17                                |
| 18.     | Jordan                 | 16                                |
| 19.     | South Africa           | 14                                |
| 20.     | Lebanon                | 13                                |
| 21.     | Nigeria                | 12                                |
| 22.     | Argentina              | 10                                |
| 23.     | Malaysia               | 10                                |
| 24.     | Canada                 | 9                                 |
| 25.     | Chile                  | 9                                 |
| 26.     | Kuwait                 | 8                                 |
| 27.     | New Zealand            | 7                                 |
| 28.     | Saudi Arabia           | 6                                 |
| 29.     | Libya                  | 6                                 |
| 30.     | Morocco                | 5                                 |
| 31.     | Peru                   | 5                                 |
| 32.     | Turkey                 | 5                                 |
| 33.     | Moldova                | 4                                 |
| 34.     | Serbia                 | 4                                 |
| 35.     | Albania                | 4                                 |
| 36.     | Japan                  | 4                                 |
| 37.     | Tunisia                | 4                                 |
| 38.     | China                  | 4                                 |
| 39.     | Brazil                 | 4                                 |
| 40.     | Singapore              | 3                                 |
| 41.     | Korea                  | 2                                 |
| 42.     | Thailand               | 2                                 |
| 43.     | Pakistan               | 2                                 |
| 44.     | Israel                 | 2                                 |
| 45.     | North Macedonia        | 2                                 |
| 46.     | Algeria                | 1                                 |
| 47.     | Bangladesh             | 1                                 |
| 48.     | Mexico                 | 1                                 |

## References

- Al Khourdajie, A., Finus, M., 2020. Measures to enhance the effectiveness of international climate agreements: the case of border carbon adjustments. *Eur. Econ. Rev.* 124 <https://doi.org/10.1016/j.euroecorev.2020.103405>.
- Balistreri, E.J., Kaffine, D.T., Yonezawa, H., 2019. Optimal Environmental Border Adjustments under the General Agreement on Tariffs and Trade, Environmental and Resource Economics. Springer, Netherlands. <https://doi.org/10.1007/s10640-019-00359-2>.
- BASIC, 2021. Joint Statement Issued at the Conclusion of the 30th BASIC Ministerial Meeting on Climate Change Hosted by India on 8th April 2021.
- Bayer, P., Aklin, M., 2020. The European Union Emissions Trading System reduced CO 2 emissions despite low prices. *Proc. Natl. Acad. Sci. USA* 117, 8804–8812. <https://doi.org/10.1073/pnas.1918128117>.
- Becker, W., Saisana, M., Paruolo, P., Vandecasteele, I., 2017. Weights and importance in composite indicators: closing the gap. *Ecol. Indic.* 80, 12–22. <https://doi.org/10.1016/j.ecolind.2017.03.056>.
- Black, C.M., 2017. Taxation of cross-border transfers of carbon emission allowances under linked emissions trading schemes. *Transnat. Environ. Law* 6, 335–361. <https://doi.org/10.1017/S2047102516000352>.
- Böhringer, C., Rosendahl, K.E., Storrösten, H.B., 2017. Robust policies to mitigate carbon leakage. *J. Publ. Econ.* 149, 35–46. <https://doi.org/10.1016/j.jpubeco.2017.03.006>.
- Bown, C.P., 2021. The US–China trade war and Phase One agreement. *J. Pol. Model.* 43 (4). <https://doi.org/10.1016/j.jpolmod.2021.02.009>.
- Chen, C., Zeckhauser, R., 2018. Collective action in an asymmetric world. *J. Publ. Econ.* 158, 103–112. <https://doi.org/10.1016/j.jpubeco.2017.12.009>.
- Cherchye, L., Moesen, W., Rogge, N., Van Puyenbroeck, T., Saisana, M., Saltelli, A., Liska, R., Tarantola, S., 2008. Creating composite indicators with DEA and robustness analysis: the case of the Technology Achievement Index. *J. Oper. Res. Soc.* 59, 239–251. <https://doi.org/10.1057/palgrave.jors.2602445>.
- Clò, S., Battles, S., Zoppoli, P., 2013. Policy options to improve the effectiveness of the EU emissions trading system: a multi-criteria analysis. *Energy Pol.* 57, 477–490. <https://doi.org/10.1016/j.enpol.2013.02.015>.
- Cosbey, A., Droegge, S., Fischer, C., Munnings, C., 2019. Developing guidance for implementing border carbon adjustments: lessons, cautions, and research needs from the literature. *Rev. Environ. Econ. Pol.* 13, 3–22. <https://doi.org/10.1093/reep/rey020>.
- Cottier, T., Nartova, O., Shingal, A., 2014. The potential of tariff policy for climate change mitigation: legal and economic analysis. *J. World Trade* 48, 1007–1038.
- European Commission, 2021a. Regulation of the European Parliament and of the Council on the Establishment of a Carbon Border Adjustment Mechanism ('CBAM') LEAKED.
- European Commission, 2021b. Annexes to the Regulation of the European Parliament and of the Council on the Establishment of a Carbon Border Adjustment Mechanism ('CBAM').
- European Commission, 2018. Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 Amending Directive 2003/87/EC to Enhance Cost-

- Effective Emission Reductions and Low-Carbon Investments, and Decision (EU) 2015/1814. *Official Journal of the European Union*.
- Eyland, T., Zaccour, G., 2014. Carbon tariffs and cooperative outcomes. *Energy Pol.* 65, 718–728. <https://doi.org/10.1016/j.enpol.2013.10.043>.
- Farrahi Moghaddam, R., Farrahi Moghaddam, F., Cheriet, M., 2013. A modified GHG intensity indicator: toward a sustainable global economy based on a carbon border tax and emissions trading. *Energy Pol.* 57, 363–380. <https://doi.org/10.1016/j.enpol.2013.02.012>.
- Fleming, S., Giles, C., 2021. OECD Seeks Global Plan for Carbon Prices to Avoid Trade Wars. *Financial Times*.
- Fouré, J., Guimbard, H., Monjon, S., 2016. Border carbon adjustment and trade retaliation: what would be the cost for the European Union? *Energy Econ.* 54, 349–362. <https://doi.org/10.1016/j.eneco.2015.11.021>.
- Freudenberg, M., 2003. Composite indicators of country performance: a critical assessment. *OECD Sci. Technol. Indus. Work. Pap.* 16, 35. <https://doi.org/10.1787/405566708255>.
- Friedlingstein, P., O'Sullivan, M., Jones, M.W., Andrew, R.M., Hauck, J., Olsen, A., Peters, G.P., Peters, W., Pongratz, J., Sitch, S., le Quééré, C., Canadell, J.G., Ciais, P., Jackson, R.B., Alin, S., Aragão, L.E.O.C., Arneth, A., Arora, V., Bates, N.R., Becker, M., Benoit-Cattin, A., Bittig, H.C., Bopp, L., Bultan, S., Chandra, N., Chevallier, F., Chini, L.P., Evans, W., Florentie, L., Forster, P.M., Gasser, T., Gehlen, M., Gilfillan, D., Gkritzalis, T., Gregor, L., Gruber, N., Harris, I., Hartung, K., Haverd, V., Houghton, R.A., Ilyina, T., Jain, A.K., Joetzjer, E., Kadono, K., Kato, E., Kitidis, V., Korsbakken, J.L., Landschützer, P., Lefèvre, N., Lenton, A., Lienert, S., Liu, Z., Lombardozi, D., Marland, G., Metzl, N., Munro, D.R., Nabel, J.E.M.S., Nakaoka, S.-I., Niwa, Y., O'Brien, K., Ono, T., Palmer, P.I., Pierrot, D., Poulter, B., Resplandy, L., Robertson, E., Rödenbeck, C., Schwinger, J., Séférian, R., Skjelvan, I., Smith, A.J.P., Sutton, A.J., Tanhua, T., Tans, P.P., Tian, H., Tilbrook, B., van der Werf, G., Vuichard, N., Walker, A.P., Wanninkhof, R., Watson, A.J., Willis, D., Wiltshire, A.J., Yuan, W., Yue, X., Zaehle, S., 2020. Global carbon budget 2020. *Earth Syst. Sci. Data* 12, 3269–3340. <https://doi.org/10.5194/essd-12-3269-2020>.
- Gallup, 2019. *The Lloyd's Register Foundation World Risk Poll Report*.
- Hájek, M., Zimmermannová, J., Helman, K., Rozenský, L., 2019. Analysis of carbon tax efficiency in energy industries of selected EU countries. *Energy Pol.* 134, 110955. <https://doi.org/10.1016/j.enpol.2019.110955>.
- Hecht, M., Peters, W., 2019. Border adjustments supplementing nationally determined carbon pricing. *Environ. Resour. Econ.* 73, 93–109. <https://doi.org/10.1007/s10640-018-0251-y>.
- Hook, L., 2021. John Kerry Warns EU against Carbon Border Tax. *Financial Times*.
- Hu, J., Crijns-Graus, W., Lam, L., Gilbert, A., 2015. Ex-ante evaluation of EU ETS during 2013–2030: EU-internal abatement. *Energy Pol.* 77, 152–163. <https://doi.org/10.1016/j.enpol.2014.11.023>.
- Jakob, M., 2021. Climate policy and international trade – a critical appraisal of the literature. *Energy Pol.* 156, 112399. <https://doi.org/10.1016/j.enpol.2021.112399>.
- Joltreau, E., Sommerfeld, K., 2019. Why does emissions trading under the EU Emissions Trading System (ETS) not affect firms' competitiveness? Empirical findings from the literature. *Clim. Pol.* 19, 453–471. <https://doi.org/10.1080/14693062.2018.1502145>.
- Kaufmann, C., Weber, R.H., 2011. Carbon-related border tax adjustment: mitigating climate change or restricting international trade? *World Trade Rev.* 10, 497–525. <https://doi.org/10.1017/S1474745611000292>.
- Kortum, S., Weisbach, D., 2017. The design of border adjustments for carbon prices. *Natl. Tax J.* 70, 421–446. <https://doi.org/10.17310/ntj.2017.2.07>.
- Kuik, O., Hofkes, M., 2010. Border adjustment for European emissions trading: competitiveness and carbon leakage. *Energy Pol.* 38, 1741–1748. <https://doi.org/10.1016/j.enpol.2009.11.048>.
- Ladly, S.D., 2012. Border carbon adjustments, WTO-law and the principle of common but differentiated responsibilities. *Int. Environ. Agreements Polit. Law Econ.* 12, 63–84. <https://doi.org/10.1007/s10784-011-9153-y>.
- Li, A., Zhang, A., 2012. Will carbon motivated border tax adjustments function as a threat? *Energy Pol.* 47, 81–90. <https://doi.org/10.1016/j.enpol.2012.04.023>.
- Li, A., Zhang, A., Cai, H., Li, X., Peng, S., 2013. How large are the impacts of carbon-motivated border tax adjustments on China and how to mitigate them? *Energy Pol.* 63, 927–934. <https://doi.org/10.1016/j.enpol.2013.08.020>.
- McKibbin, W.J., Morris, A.C., Wilcoxon, P.J., Liu, W., 2018. The role of border carbon adjustments in a U.S. carbon tax. *Clim. Change Econ.* 9, 1–41. <https://doi.org/10.1142/S2010007818400110>.
- Mehling, M.A., Van Asselt, H., Das, K., Droege, S., Verkuil, C., 2019. Designing border carbon adjustments for enhanced climate action. *Am. J. Int. Law* 113, 433–481. <https://doi.org/10.1017/ajil.2019.22>.
- Naegele, H., Zaklan, A., 2019. Does the EU ETS cause carbon leakage in European manufacturing? *J. Environ. Econ. Manag.* 93, 125–147. <https://doi.org/10.1016/j.jeem.2018.11.004>.
- Nardo, M., Saisana, M., 2008. OECD/JRC Handbook on constructing composite indicators. *Putting theor. pract.* 1–16.
- Porterfield, M.C., 2019. Border adjustments for carbon Taxes, PPMS, and the WTO. *Univ. Penn. J. Int. Econ. Law* 41, 1–41.
- Sabyrbekov, R., Overland, I., 2021. EU CBAM opposition dataset. <https://doi.org/10.17632/nw3cn6np2.1>.
- Saisana, M., Tarantola, S., Schulze, N., Cherchy, L., Moesen, W., Van Puyenbroeck, T., 2005. State-of-the-art report on composite indicators for the knowledge-based economy. *Knowl. Econ. Indic.: Dev. Innov. Reli- able Indic. Syst. - KEI 1–48*.
- Saltelli, A., 2007. Composite indicators between analysis and advocacy. *Soc. Indic. Res.* 81, 65–77. <https://doi.org/10.1007/s11205-006-0024-9>.
- Sanctuary, M., 2018. Border carbon adjustments and unilateral incentives to regulate the climate. *Rev. Int. Econ.* 26, 826–851. <https://doi.org/10.1111/roie.12344>.
- Schinko, T., Bednar-Friedl, B., Steininger, K.W., Grossmann, W.D., 2014. Switching to carbon-free production processes: implications for carbon leakage and border carbon adjustment. *Energy Pol.* 67, 818–831. <https://doi.org/10.1016/j.enpol.2013.11.077>.
- Song, C., Oh, W., 2015. Determinants of innovation in energy intensive industry and implications for energy policy. *Energy Pol.* 81, 122–130. <https://doi.org/10.1016/j.enpol.2015.02.022>.
- Tagliapietra, S., Wolff, G.B., 2021. Conditions are ideal for a new climate club. *Energy Pol.* 158, 112527. <https://doi.org/10.1016/j.enpol.2021.112527>.
- Tang, L., Bao, Q., Zhang, Z.X., Wang, S., 2015. Carbon-based border tax adjustments and China's international trade: analysis based on a dynamic computable general equilibrium model. *Environ. Econ. Pol. Stud.* 17, 329–360. <https://doi.org/10.1007/s10018-014-0100-3>.
- Tankersley, J., Bradsher, K., 2018. Trump Hits China with Tariffs on \$200 Billion in Goods, Escalating Trade War, vol. 17. *The New York Times*.
- Tavoni, A., Dannenberg, A., Kallis, G., Löschel, A., 2011. Inequality, communication, and the avoidance of disastrous climate change in a public goods game. *Proc. Natl. Acad. Sci. U. S. A.* 108, 11825–11829. <https://doi.org/10.1073/pnas.1102493108>.
- Trachtman, J.P., 2017. WTO law constraints on border tax adjustment and tax credit mechanisms to reduce the competitive effects of carbon taxes. *Natl. Tax J.* 70, 469–494. <https://doi.org/10.17310/ntj.2017.2.09>.
- WIPO, 2021. Total Patent Applications (Direct and PCT National Phase Entries). *WIPO Statistics Database*.
- WTO, 2021. WTO Dispute by member [WWW Document]. URL. [https://www.wto.org/english/tratop\\_e/dispu\\_e/dispu\\_by\\_country\\_e.htm](https://www.wto.org/english/tratop_e/dispu_e/dispu_by_country_e.htm), accessed 7.29.21).
- Zhang, X., Jiao, K., Zhang, J., Guo, Z., 2021. A review on low carbon emissions projects of steel industry in the World. *J. Clean. Prod.* 306, 127259. <https://doi.org/10.1016/j.jclepro.2021.127259>.
- Zhang, Z.X., 2010. The US proposed carbon tariffs and China's responses. *Energy Pol.* 38, 2168–2170. <https://doi.org/10.1016/j.enpol.2009.12.026>.
- Zhong, J., Pei, J., 2021. On the Competitiveness Impact of the EU CBAM: an Input-Output Approach. Available at: SSRN 3891356.
- Zhou, W., Zhu, B., Li, Q., Ma, T., Hu, S., Griffy-Brown, C., 2010. CO2 emissions and mitigation potential in China's ammonia industry. *Energy Pol.* 38, 3701–3709. <https://doi.org/10.1016/j.enpol.2010.02.048>.