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Climate clubs and carbon border adjustments: a review

To cite this article: Indra Overland and Mirza Sadaqat Huda 2022 *Environ. Res. Lett.* **17** 093005

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TOPICAL REVIEW

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OPEN ACCESS

RECEIVED
11 February 2022REVISED
7 August 2022ACCEPTED FOR PUBLICATION
30 August 2022PUBLISHED
9 September 2022

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E-mail: indra.overland@nupi.no**Keywords:** climate club, carbon border adjustment mechanism (CBAM), climate multilateralism, European Union (EU)Supplementary material for this article is available [online](#)**Abstract**

Nobel Memorial Prize winner William Nordhaus and others have proposed a climate club as the ultimate climate-mitigation measure. Meanwhile, the European Union (EU) is pressing on with the creation of a carbon border adjustment mechanism (CBAM) that would put pressure on the rest of the world to introduce the same level of carbon pricing as the EU. There are strong linkages between the concepts of a climate club and CBAM. However, the EU long studiously avoided referring to a climate club in its official communication, and the relationship between the two concepts remains unclear. This study seeks to clarify the relationship through a systematic review of the climate club and carbon border adjustment literatures to highlight synergies and contradictions, reduce fragmentation, and increase actionability. A tailored Boolean search string is used to extract relevant literature, which is then categorised along eight parameters. The VOSviewer network analysis and visualisation software is used to examine cross-citations and bibliographic coupling. The review finds that there are connections between the objectives, methods and concerns of the two branches of literature but that there are divergences in terms of conceptual roots, disciplinary frames and the views that authors take of CBAM/a climate club. Only 7% of the studies relate to international relations theory. Several large emitters, geopolitically important states and developing countries are ignored by the literature. Although the cooperation/resistance of Asian countries will be decisive for the fate of any climate club initiative, only 15% of authors are based in Asia and Western scholars dominate the field. A five-pronged research agenda is proposed to address the identified gaps: enhanced interaction between the fields of research, coverage of a broader range of countries, additional analysis by Asia-based researchers, more contributions from political science and international relations scholars and further work on how to calculate tariffs.

1. Introduction

A significant body of literature argues that a suitable framework for global climate governance can only be created if the countries that are most concerned about climate change form a climate club (Nordhaus 2015b, Sabel and Victor 2017, Leal-Arcas 2021). Proponents of such a club argue that a stable coalition of countries committed to reducing emissions will have a greater chance of success than a globally negotiated environmental agreement, as the climate club will not be hobbled by the need for consensus or the deadlocks and spoilers that have held back global climate negotiations under the

United Nations Framework Convention on Climate Change (UNFCCC) (Rennkamp and Marquard 2017, Paroussos *et al* 2019, Tagliapietra and Wolff 2021a).

The climate club concept set forth by Nordhaus, involving trade tariffs against non-members, remains a theoretical construct and has numerous critics who see it as unrealistic or too aggressive (Chen and Zeckhauser 2018, Zefferman 2018). By contrast, the European Union (EU) concretised the outline of its carbon border adjustment mechanism (CBAM) on 14 July 2021 and announced that it will be implemented in a transitional form as soon as 1 January 2023 and tariffs should become operational in 2026. CBAM is yet to be adopted but negotiations within

the EU continue. As we discuss below, the EU's CBAM is in practice similar to a climate club (Bierbrauer *et al* 2021).

The EU needs to introduce CBAM to address some of the shortcomings of the Emissions Trading System (ETS) (EC 2021). The ETS has been utilizing free allowances as a stop-gap measure to address leakage, which weakens the incentives for European businesses to increase energy efficiency and reduce emissions, while revenue from the sale of permits is foregone (Lecuyer and Quirion 2013, Tagliapietra 2015, Kortum and Weisbach 2017, Tagliapietra and Zachmann 2018). The Paris Agreement allows countries to decide whether to put a price on greenhouse gas (GHG) emissions and what the price should be (Leal-Arcas 2016, 2019). This results in discrepancies between the cost of emissions in different countries, which in turn can cause 'carbon leakage'—the relocation of production of carbon-intensive goods to countries with lower emission costs (Monjon and Quirion 2010, 2011, Böhringer 2014, Branger *et al* 2016). The EU's CBAM will address carbon leakage by imposing a fee on imports from areas with lower emissions pricing. The size of the fee will be based on the emissions from the production of the goods in question. If the emission content of traded products is low, the CBAM charge will be correspondingly low (Böhringer *et al* 2022; see also, Böhringer *et al* 2012b for a discussing of this preceding the EU's initiative).

In a full-fledged Nordhaus-type climate club, a trade tariff to incentivise membership is decisive for the development of the club. Thus, an effective climate club would depend on something like the EU's CBAM. By contrast, a CBAM can, in principle, be launched simply as a measure against carbon leakage, without reference to a climate club. This is what the EU is currently trying to do. (German Chancellor Olaf Scholz and some EU representatives have recently started discussing a climate club but they do so without reference to CBAM.) However, the EU's CBAM is still likely to trigger the same international dynamic as a climate club initiative. This is because a CBAM creates a situation in which outsider countries can choose between paying the adjustment fee when they export goods to the EU or collecting the revenue themselves by putting a price on carbon at home (Meunier *et al* 2014, Tagliapietra and Veugelers 2021). If they choose the latter—which is the less conflictual and possibly most financially attractive option—they de facto become part of the EU CBAM area. The EU's CBAM is therefore likely to function as a self-expanding climate club. Some EU trade partners may fall in line quickly, and this would ratchet up the pressure on others to follow suit, which would generate more pressure on yet other countries to also fall in line. This domino effect is also how a climate club is expected to play out. Thus, these two concepts seem to be concomitant. However, the EU long studiously avoided any reference to the term 'climate club' in

its official communication about CBAM. The resulting discursive disconnect between the EU's CBAM policy initiative and the concept of a climate club is the puzzle that drives this study. We attempt to answer two questions related to this puzzle:

- (a) Do the two branches of academic literature talk past each other?
- (b) How can their research findings be brought together and made actionable for policymakers?

To answer these questions and reduce the fragmentation in this field, we survey the climate club and carbon border adjustment literatures and assess the similarities, differences and linkages between them at the levels of definitions, rationales, perceptions, geography of authorship, country coverage, disciplines, policy implications and cross-citations.

By covering all these aspects in a systematic and often quantitative manner, we hope to increase the accessibility and usefulness of these studies. The only existing review of the climate club literature, Hovi *et al* (2016), limits itself to an excellent but brief and largely qualitative examination of the rationale, conceptual roots and variety of climate club models on offer. There are four reviews of carbon border adjustments, only two of which are peer-reviewed academic articles. Branger and Quirion (2014) provide a quantitative overview of carbon leakage ratios, while Böhringer *et al* (2022), review research findings on carbon leakage, competitiveness, cost-effectiveness, equity and cooperation. The other two reviews belong to the grey literature (Zhou *et al* 2010, Condon and Ignaciuk 2013). While these existing CBAM reviews are important, they do not engage with the concept of a climate club and are several years old, predating numerous publications driven by the Paris Agreement and the EU's launch of its CBAM initiative. Our review is the first to synthesise the climate club and carbon border adjustment literatures and is thus different from a review of only the climate club or carbon border adjustment literature.

This article provides an update at a point in time when the field has been transformed by the EU's push to establish its CBAM. Few climate-club proponents would have expected the first serious attempt to establish a climate club to be launched without reference to their research or at least to the climate club terminology. Therefore, it is a good time to adapt the map to the altered terrain and to consider the looming global clash over the EU's CBAM. A CBAM or climate club is contentious because it represents an unprecedented shift away from consensus-based international regime formation to unilateral standard-setting by a coalition of the willing in an attempt to finally break the deadlock that has held back climate policy since the early 1990s (Raiser *et al* 2020, Schreyer *et al* 2020, Carattini and Löschel 2021). The EU's CBAM has already drawn criticism from several governments around

the world and is poised to become the most contested international climate policy issue in the 2020s (Ghanekar 2021, GT 2021). According to the *Financial Times*, CBAM ‘has produced howls of protest from EU trade partners’ (Fleming and Giles 2021). The Chinese authorities perceive CBAM as a unilateral measure that violates World Trade Organization (WTO) rules and can undermine the country’s cement and steel industries (Reuters 2021). CBAM may thus become a wildcard in the complex tripartite relationship between China, the EU and the United States.

This study is divided into five main sections. In section 2, we describe our methodology. In section 3, we describe the results of the systematic review, including definitions, publication outlets, geographic representation of authors, coverage of countries and academic disciplines represented in the literature. In the same section, we provide an overview of the genealogical roots of extant studies, the rationales for climate club/carbon border adjustments and the opportunities and challenges they entail. Furthermore, we summarise the authors’ perceptions of the effectiveness of a climate club/carbon border adjustment and analyse cross-citations between the two groups of literature. In section 4, we discuss the implications of our findings for the relationship between the climate club and carbon border adjustment literatures and attempt a synthesis between them. We also relate this to the EU’s CBAM initiative and explain why it is presented and promoted without reference to a climate club. Section 5 concludes the article and culminates in a proposal for a forward-looking research agenda.

2. Methods

The stages of research for this review are outlined in figure 1. The flowchart adheres to the preferred reporting items for systematic reviews and meta-analyses standard for visual representation of systematic literature reviews (Moher *et al* 2009).

We took the same methodological approach to gathering literature as Szulecki and Overland (2020). In the first step, we harvested literature from the Web of Science and Scopus databases. This means that the searches were limited to the peer-reviewed academic literature, as these databases mostly do not cover the grey literature. Test runs were carried out to identify the optimal search terms and arrive at a complex Boolean search string which was used to conduct searches in the databases (see the first box in figure 1). The searches were delimited to the titles and abstracts of papers. We conducted database searches in December 2021, resulting in an initial list of 556 publications. Next, all titles and abstracts were checked and the most relevant publications selected, resulting in a list of 114 publications to which 8 more were added as recommended by peer reviewers to arrive at a total of

122 publications covered by this review. Although our focus is on the climate club and carbon border adjustment literatures, we also included ‘climate unilateralism’ in the search string, as it has some similarities to the concept of a climate club.

In the next analytical step, we categorised the publications along eight parameters: publishing outlet, year of publication, number of citations, geographic location of authors, countries covered, definition of climate club/carbon border adjustment, disciplinary identity of the studies and positive or negative perceptions of climate clubs/carbon border adjustments.

In the final empirical-analytical step, we used the VOSviewer network analysis application to visualise and compare the interlinkages between and intralinkages within the two branches of literature. We looked both at citations and at overlaps between the cited sources (bibliographical coupling).

3. Results

3.1. Definitions

The relationship between the concept of a climate club and that of carbon border adjustments depends on how each of them is defined and understood. There are many different conceptualisations of climate clubs and carbon border adjustments, but only a handful of studies provide explicit definitions. We collected 16 definitions, which are included in the supplementary material that accompanies this article.

The understanding of what a ‘climate club’ is varies. Some studies take a broad view of the concept to include any international constellation that focuses on climate change and has a membership smaller than the UNFCCC (Zefferman 2018, Hagen and Eisenack 2019, Unger *et al* 2020). Other scholars have a narrower understanding of the climate-club concept and link it to excludable club goods which are understood as benefits that can accrue only to club members and cannot be accessed by non-members (Nordhaus 2015b, Sprinz *et al* 2018, Paroussos *et al* 2019, Mandel *et al* 2020). Usually these are in the form of exemption for trade tariffs that apply to those countries that choose to remain outside the club. This narrower understanding of the concept predominates, is also clearer and more specific. It is also the one we focus on in this article.

Most studies of carbon border adjustments do not define the concept itself, but many provide definitions of relevant economic terms, such as ‘indirect taxes’ (Tamiotti 2011), ‘carbon leakage’ (Droege 2011, Ladly 2012) and ‘welfare changes’ (Böhringer *et al* 2012a, Li *et al* 2013). These terms are then used to outline the economic implications of carbon border adjustments (Wang *et al* 2012, Zhang *et al* 2017). Publications on climate unilateralism tend to define terms such as ‘legitimacy’ (Karlsson-Vinkhuyzen and McGee 2013), ‘polycentricity’ (Dorsch and Flachsland 2017)

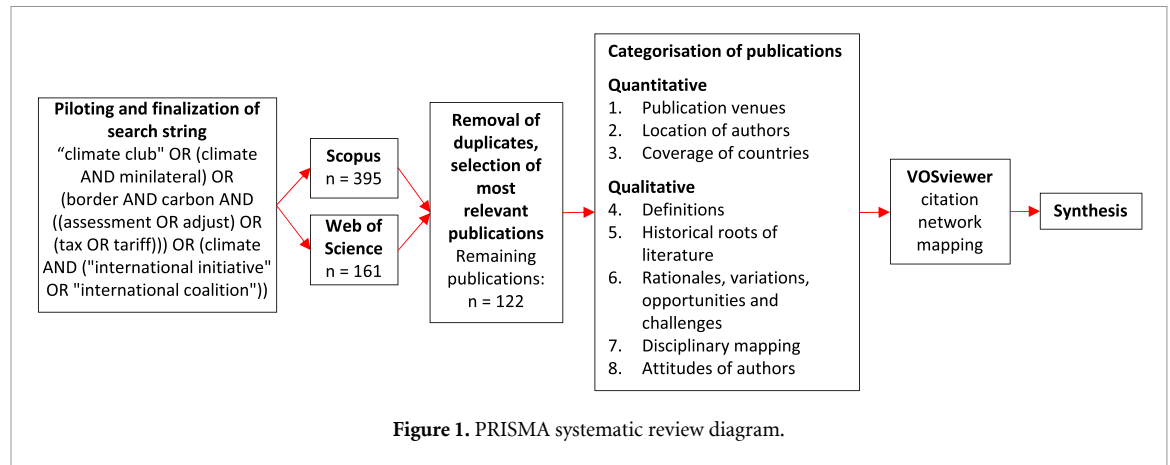


Figure 1. PRISMA systematic review diagram.

Table 1. Selected definitions from the literature.

Climate club	Carbon border adjustment	Climate minilateralism
‘...an agreement by participating countries to undertake harmonized emissions reductions. The agreement envisioned here centers on an international target carbon price that is the focal provision of an international agreement’ (Nordhaus 2015b: 1341).	‘...defined here as a specific duty on imports that is a function of climate policy. This is distinct from a border measure that is not explicitly tied to the levels of domestic emission taxes’ (Sanctuary 2018: 829).	‘Based on economic theories of cooperation, the minilateral forum would be structured to create specific benefits that can be limited to those countries that are willing to join the institution and abide by its rules’ (Falkner 2016: 89).

and the concept of ‘minilateralism’ itself (Gampfer 2016).

Most studies of climate clubs, carbon border adjustments and minilateralism treat the state as the primary actor (Das 2015, Reingewertz 2017, Schwerhoff 2017, Martin and van den Bergh 2019). Only a few see a role for cities (Steffen *et al* 2019) or non-state actors (van Asselt 2014, Green 2017). In table 1, we provide a typical definition from each subfield of literature. The definition by Nordhaus (2015b) is particularly influential and has been cited in numerous other studies (Carlson 2016, La Rovere, 2016, van den Bergh 2017, Chen and Zeckhauser 2018, Barrage 2019).

The definitions in table 1 highlight the linkages between the three concepts. Nordhaus’ (2015b) definition of a ‘climate club’ rests on two elements: (a) an agreement among a group of countries to undertake emissions reductions through a harmonised carbon price, and (b) a penalty jointly levied upon non-participating countries in the form of a small and uniform tariff on imports from those countries (Nordhaus 2015a, 2015b, Barrage 2019). Part (i) of Nordhaus’s definition focuses on the norms of cooperation in a club arrangement and resonates with Falkner’s (2016, p 89) understanding of minilateralism, which he describes as a forum ‘to create specific benefits that can be limited to those countries that are willing to join the institution and abide by its rules’. Part (ii) of Nordhaus’s definition of penalties on non-members overlaps with Sanctuary’s

(2018, p 829) definition of carbon border adjustment as a ‘specific duty on imports that is a function of climate policy’.

Falkner’s (2016, p 89) definition of climate minilateralism shows that it is essentially the same as a climate club. This could explain why ‘minilateralism’ has fallen out of favour in the climate literature as the debate has gravitated towards climate club terminology.

3.2. Main journals

We identified the ten main journals where the debate on climate clubs, carbon border adjustments and climate minilateralism is unfolding (see table 2).

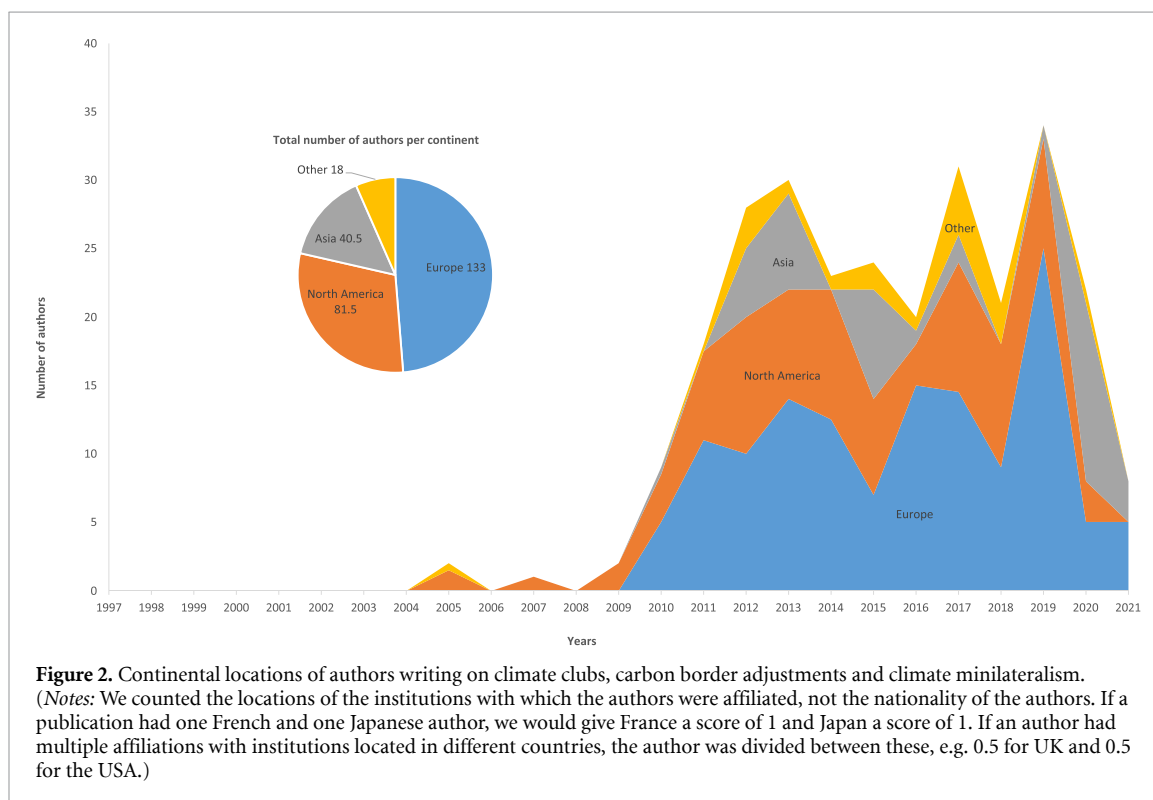
Table 2 shows that the literature is scattered among a large number of journals, most of which have only published studies in one of the subgroups of the reviewed literature. This indicates that despite the logical interconnections, they are also disconnected in some ways. Beyond the top ten journals represented in table 2, most journals have only published on one of the three topics, and only once. This dispersion indicates that climate clubs and carbon border adjustments are topics which many publishing outlets and authors have covered once, but that few have pursued over time. This may have contributed to the lack of interaction between the branches of literature.

3.3. Locations of authors

Figure 2 shows that there is a paucity of research by academics based in non-Western countries. Almost

Table 2. Number of articles in the ten main publishing outlets.

Journal	Articles on climate clubs	Articles on carbon border adjustments	Articles on unilateralism	Total
Climate Policy	6	8		14
Energy Policy		10		10
Energy Economics		9		9
Climatic Change	5			5
Global Environmental Politics			4	4
Climate Change Economics	1	3		4
Environmental and Resource Economics		3		3
Energy Journal		2		2
Ecological Economics		3		3
Journal of Env. Economics and Managem.		2		2
Total	12	40	4	56



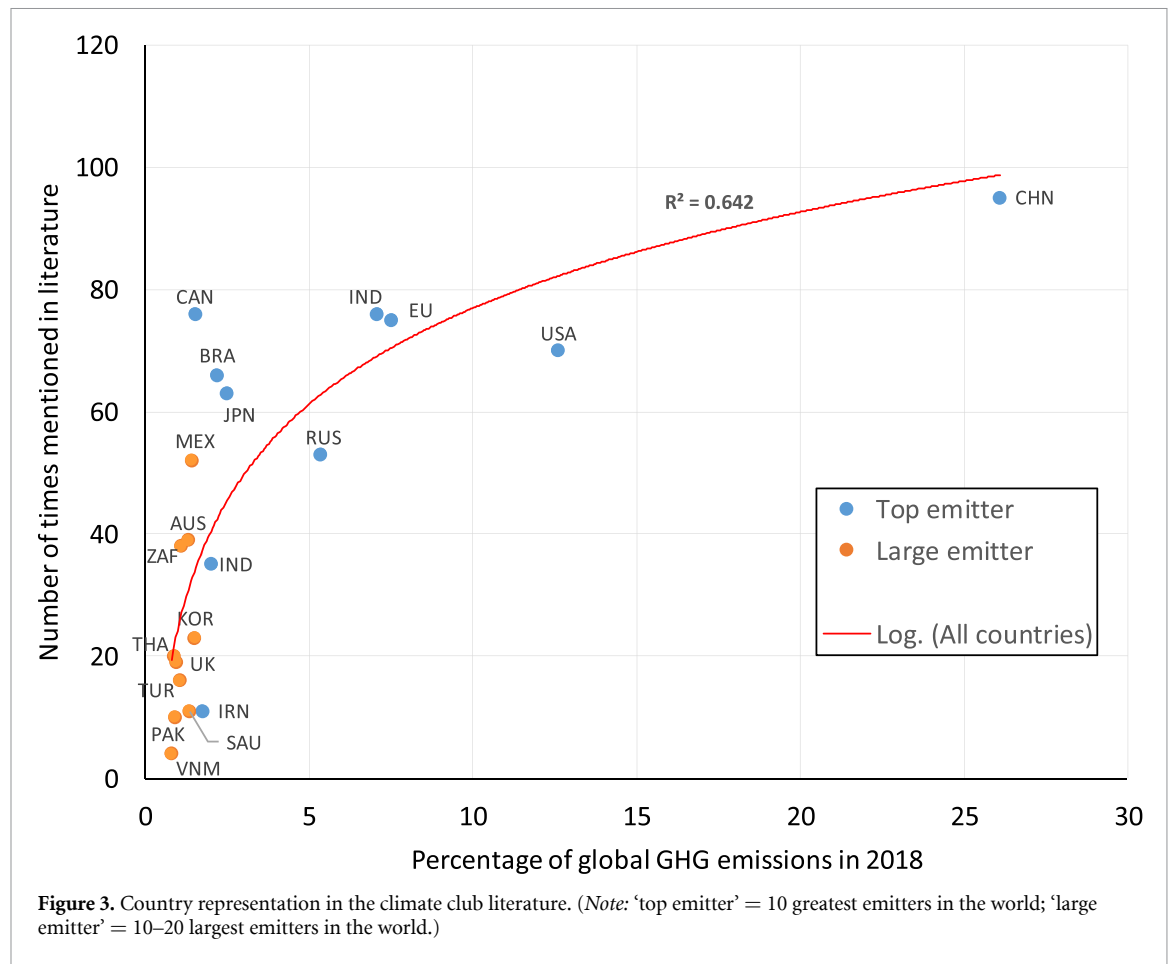
50% of the literature was penned by academics based in Europe and 30% in North America. Only 15% of the studies were authored by academics based in Asia, and 7% in other parts of the world. It is also notable that the share of contributors from other parts of the world has declined over time, approaching zero in 2019–2021. The lack of Asia-based research is particularly problematic, considering that much of the tension over the EU's CBAM or a climate club would be expected to arise between Asian and Western countries.

Several Asian states are among the world's ten largest emitters of GHGs, continue investing heavily in coal, and are export-dependent economies

dependent on international trade (Overland *et al* 2021). If such countries do not start taking an interest in this topic, they may be ill prepared when the EU's CBAM is launched.

3.4. Coverage of countries

There is some diversity in the geographic representation of countries in the literature. Most studies have retained a global focus while referring to individual countries to exemplify certain aspects of a climate club or CBAM (Lininger 2015a, 2015b, Hermwille *et al* 2017, Bjarne *et al* 2019, Mandel *et al* 2020). In-depth studies of single countries have also been conducted, including studies of Brazil (La Rovere 2016),



South Africa (Rennkamp and Marquard 2017), the United States (Metcalf and Weisbach 2009, Weber and Peter 2009) and China (Voituriez and Wang 2011, Li *et al* 2012).

We review the literature’s representation of the countries that make the largest contributions to global GHG emissions. We used data from the Climate Data Explorer of the World Resources Institute (WRI 2021) to identify the 20 largest emitters in the most recent year available (2018). As shown in figure 3, we differentiate between *top emitters* (the countries ranked 1–10 and jointly responsible for almost 70% of GHG emissions) and *large emitters* (the countries ranked 11–20 and jointly responsible for more than 11% of GHG emissions).

Our results show that while there is a correlation between the number of studies that mention a particular country and its emissions, there are important exceptions. The four largest contributors of GHGs—China, the USA, the EU and India—have received similar numbers of mentions in existing studies. However, in some cases, countries with low emission levels have received more academic attention than those with high emission levels. For example, although Russia contributes a larger proportion of global GHG emissions than Brazil, it is mentioned less frequently. Despite being among the world’s top emitters, Indonesia has been mentioned only 35 times

in existing research; indeed, Canada, which produces lower levels of emissions, has been mentioned more than twice as often as Indonesia, while Iran, which is the world’s 9th largest GHG contributor, seems to be off the academic radar. One possible explanation for the small number of studies that mention Indonesia and Iran is that their emissions are mainly generated by sectors other than industry. However, these countries are economically and geopolitically influential and their role in global climate governance may become greater if the scope of climate clubs and CBAMs is expanded to include emissions from agriculture and land use change.

Within the *large emitter* category, Mexico received the highest number of mentions, followed by Australia and South Africa. One possible explanation for the greater academic attention to South Africa and Brazil than to countries with higher levels of emissions is their membership in BASIC, a climate alliance of the major newly industrialised countries—Brazil, South Africa, India and China. Some scholars argue that BASIC can influence the formation of a climate club (Hovi *et al* 2017, Rennkamp and Marquard 2017, Sprinz *et al* 2018).

Another gap lies in the lack of analysis of emerging economies, such as Pakistan and Vietnam. While the large GHG emissions of such countries are mostly not from industries relevant to the EU’s CBAM,

their economies tend to be unstable and sensitive to changes in international trade practices.

Ecologically vulnerable developing states have important stakes in global climate change mitigation efforts (Sultan *et al* 2013, Huda 2017, Leal-Arcas 2017, Venugopal *et al* 2021). If the low representation of some geopolitically important countries and major developing countries within the literature is carried over into practical policy, this can heighten the risk of retaliation against a climate club or CBAM (Fouré *et al* 2016).

3.5. Historical roots of the literature

The relationship between the concept of a climate club and that of carbon border adjustments is affected by the genealogy of the two concepts. The concept of a climate club grew out of a pre-existing broader literature theorising about all kinds of clubs and processes of inclusion and exclusion related to club membership. Hovi *et al* (2016) trace the origins of club theory to studies from the early 20th century on the use of tolls on congested roads (Pigou 1920, Knight 1924). Also, Potoski (2015) and Sprinz *et al* (2018) engage with the literature on club theory, particularly that of Buchanan (1965). A study by Keohane and Nye (2002) was one of the earliest attempts to conceptualise the role of clubs in international affairs, which in a subsequent publication they developed further into the concept of a climate club (Keohane and Victor 2011).

The literature on border taxes refers to earlier studies by James Markusen and Allan Williams on the international externalities of domestic and foreign production processes (Williams 1966, Markusen 1975). Scholarship on carbon border adjustments has been shaped by the work of academics such as James Hansen (Hansen *et al* 1981), although the concept of carbon taxes was first proposed by David Wilson in the 1970s (cited in Sutherland 2020). Scholars of carbon border adjustments refer to several historical documents. For example, De Schutter (2014) and Holzer (2014) refer to the 1970 report of the General Agreement on Tariffs and Trade Working Party on Border Tax Adjustments, while Pirlot (2017) engages with the 1968 report of the Organisation for Economic Co-operation and Development (OECD) on tax adjustments applied to exports and imports in OECD member countries. These policy documents are not concerned with climate change and GHG emissions but with other issues in international trade.

In summary, the two branches of literature grew out of separate academic lineages unrelated to climate change. This results in different intellectual baggage and terminological and analytical frameworks.

3.6. Climate club variations

The literature discusses two types of climate club. First, 'transformational' or 'Buchanan' clubs are those

in which the production and allocation of club goods are the primary goals. These clubs address the free-rider issue by facilitating benefits for members and penalties for non-members (Weischer *et al* 2012, Nordhaus 2015a, Hovi *et al* 2017).

The second type is what we would call a 'voluntary' or 'pseudo-climate club'. The goal of such a club is to bring together a group of like-minded countries concerned about climate change or focused on a specific aspect of climate change mitigation. In such a club, membership is not clearly demarcated and the excludable benefits are small, leaving the door open to free-riding (Green 2017; Sabel and Victor 2017, Stua 2017a). Table S3 in the supplementary material describes the membership and objectives of 29 such voluntary climate clubs that are currently in operation.

Climate club scholars emphasise the advantages of the Buchanan model in addressing climate change. Stua (2017a) argues that a climate club could contribute greatly to climate governance by rewarding effective climate action with private goods for participating club members, while safeguarding the public good of climate change mitigation. A number of scholars have argued that a climate club can address the critical problem of freeriding on the climate action of others through a combination of club goods for members and tariffs for non-members (Hovi *et al* 2017, Rennkamp and Marquard 2017, Nordhaus 2020). Hovi *et al* (2017) suggest that even a club with only a handful of major actors as initial members can grow and eventually reduce global emissions as long as the club pursues an open membership policy and if certain conditions are met.

Nordhaus (2015b) presents an economic model in which a group of countries agrees on a target carbon price. The countries are then to meet this price requirement through a carbon tax, cap and trade, or hybrid regime. Non-member countries, that is, those that do not comply with the carbon price, are penalised with tariffs on exports to the countries that are part of the club. His analysis indicates that a relatively low tariff rate will induce high club participation if the international target carbon price is approximately USD 50 per ton. Hovi *et al* (2016) classify the Nordhaus proposal as a 'top-down model' for a climate club, where the regime is cemented before countries decide whether to participate. By contrast, other scholars conceive of a climate club as a bottom-up initiative by a small group of states (Sabel and Victor 2017, Sprinz *et al* 2018, Zefferman 2018). In such a scenario, the club is initiated by a coalition of countries which then implements multiple strategies to increase membership. This can include club goods, such as preferential market access and 'conditional commitments' which require members to deepen their mitigation efforts if new members join the club (Hovi *et al* 2017, p 1078). In a bottom-up climate club, the mitigation requirements for members

are more flexible and dynamic than in the Nordhaus model.

There is also some diversity in the conceptualisation of tariffs, penalties and club goods within the literature. Nordhaus (2015a, p 9) recommends 'uniform penalty tariffs' across all imports from non-members into a club region. Sælen (2016) shows that the use of side payments can be more effective as incentives than club goods or conditional commitments. He argues that side-payments in the form of technology transfers or emissions trading could encourage reluctant countries to join climate clubs. Hovi *et al* (2017) conception of a climate club requires each member to spend 1% of its GDP on mitigation in exchange for favourable trade agreements. These approaches differ from studies that recommend tariffs on the carbon content of imports from non-members (Weischer *et al* 2012, van den Bergh 2017, Stua 2017b).

3.7. Carbon border adjustment variations

Studies of carbon border adjustments are marked by divergent views on their effectiveness. Proponents of carbon border adjustments argue that they can enhance the global mitigation effort by generating revenues for sustainable development, incentivising efficiency, and encouraging recalcitrant parties to increase the domestic cost of emissions (Anouliès 2015, Balistreri *et al* 2018, Bullock 2018, Antón 2020). By contrast, other scholars take a more critical view and argue that carbon border adjustments will be abused for protectionist purposes, resulting in trade wars, generating little welfare and disrupting international cooperation on climate policy (Kuik and Hofkes 2010, Moore 2011, Antimiani *et al* 2013, 2016, Black 2017). Researchers have compared the effectiveness of carbon border adjustments with rebates for exporters (Fischer 2012, Jakob *et al* 2013, Böhringer *et al* 2017a), an international cap and trade system (Hecht and Peters 2019), shared responsibility (Chang 2013) and punitive tariffs (Irfanoglu *et al* 2015).

A defining feature of this literature is the large number of studies that undertake complex economic modelling of carbon border adjustments, particularly in the context of energy-intensive industries (Fouré *et al* 2016, Trachtman 2016, Böhringer *et al* 2017b, McKibbin *et al* 2018). Although several studies mention the risk of carbon border adjustments triggering trade wars (Condon and Ignaciuk 2013, Mason *et al* 2015, Zhang 2016), scholars have not explicitly examined the implications of these mitigation mechanisms for domestic or international politics. This is an important gap in the literature.

3.8. Opportunities and challenges

While more than half of the reviewed studies hold favourable perceptions of climate clubs/carbon border adjustments, there is some variation in the

opportunities and challenges they are thought to bring. Nordhaus (2015b) argues that in addition to addressing the free-rider problem, a climate club can overcome the 'small coalition paradox', which arises when coalitions are either small or shallow. His study indicates that even small trade penalties imposed on non-members of a climate club can induce a large, stable coalition with a large reduction in greenhouse emissions. Some scholars have argued that a climate club can facilitate technology diffusion, low-cost climate finance, improved reporting and transparency, and catalyse the adoption of new technologies (Springmann 2013, Paroussos *et al* 2019, Leal-Arcas 2020, Mandel *et al* 2020). The benefits provided by carbon border adjustments include the prevention of carbon leakage (Babiker and Rutherford 2005, Winchester 2012, Böhringer *et al* 2016, Cosbey *et al* 2019, Yu *et al* 2021), welfare creation (Eyland and Zaccour 2014, Schinko *et al* 2014) and increases in energy efficiency (Dorsey-Palmateer and Niu 2020). The main advantages expected from climate unilateralism are rapid progress in negotiations among a small group of important countries (Eckersley 2012), increased proliferation of environmental norms (Karlsson-Vinkhuyzen and McGee 2013) and greater levels of problem-solving effectiveness (Gampfer 2016).

There are significant overlaps in the challenges that a climate club and a CBAM are likely to encounter. A climate club or CBAM may end up privileging the voices of a small number of countries, thereby reproducing existing international hierarchies. Some authors argue that if poor and ecologically vulnerable countries do not have a voice in the decision-making process, these initiatives may not achieve global legitimacy (Eckersley 2012, Weischer *et al* 2012, Mattoo *et al* 2013). Other challenges include potential retaliation by non-members of a climate club, those at the receiving end of carbon border adjustments, or those who are excluded from a unilateral forum (Ghosh *et al* 2015, Carlson 2016, Andersen 2018, Rocchi *et al* 2018).

3.9. Disciplinary mapping of the literature

We classify the 122 publications covered in this review into three major disciplinary groups: economics, international relations (IR) and political science. This classification is based on the methodology/conceptual framework of each publication, the journal's disciplinary profile and the academic background of the authors. According to our classification, 70% of the studies belong to economics. These studies use technical modelling and economic theories to analyse the prospects for a climate club, CBAM, or climate unilateralism (Babiker and Rutherford 2005, Burniaux *et al* 2013, Moghaddam *et al* 2013, 2014, Liang *et al* 2016, Zhang *et al* 2020). We classify 23% of the reviewed studies as political science. This category includes studies that examine climate clubs

and carbon border adjustments through interdisciplinary lenses combining public policy, law and economic perspectives, and may thus err on the high side. (Ghosh *et al* 2015, Mehling *et al* 2019, Charlotte *et al* 2020). Finally, we found that only 7% of the studies belong to the IR category.

Both a climate club and a CBAM would have important implications for IR because of their potential to exacerbate pre-existing tensions between developed and newly industrialised countries, as well as to cause political discord within countries. Several studies have examined possible consequences, such as retaliation by non-member countries of a climate club, trade wars, counter-coalitions and interactions between domestic and international political processes (Victor *et al* 2007, Aijun *et al* 2013, Böhringer *et al* 2016, Hovi *et al* 2016, van den Bergh 2017, Chen and Zeckhauser 2018). However, the majority of these studies examine the conflict potential of a climate club or CBAM in silos that are removed from broader academic IR debates.

The carbon border adjustment literature is heavily dominated by economists, and not a single study specifically on this topic was categorised as IR. This is particularly paradoxical, considering that the main or only real-world route to a possible climate club is the EU's CBAM. While a few studies of climate clubs examine IR issues, all studies of climate unilateralism make some connection to IR frameworks. Thus, it appears that the linkage between this broader field of research and IR was lost when unilateralism fell out of favour.

The disconnect between the climate club, carbon border adjustment and broader IR literatures is indicative of a larger climate gap in the extant IR literature. A meta-analysis by Sending *et al* (2019) finds that between 2015 and 2019, only 0.77% of the articles in five top IR journals were about climate change or a related topic. Sending *et al* (2019, p 184) argue that while there is a long tradition of specialised research on specific aspects of climate change which could be loosely classified as IR, there is a conspicuous absence of studies of how climate change may affect 'systemic shifts in the international system, the status of sovereignty, the drivers of foreign policy, or the endurance of alliances and functioning of international institutions'. This gap is surprising, given the likely substantial impact of environmental policy and decarbonisation on future geopolitical trends (O'Sullivan 2017, Huda 2020, 2021, Vakulchuk *et al* 2020, Overland 2021). The lack of climate club and carbon adjustment studies within the IR literature is concerning, considering that such a club/mechanism would be fundamentally political, inter-state and diplomatic by nature, and likely to trigger retaliation from non-member countries, trade wars, counter-coalitions and interactions between domestic and international political processes. The paucity of IR

work on these topics may undermine the political feasibility of such initiatives by leaving them unprepared to tackle the political and diplomatic conflicts that they might trigger. In other words, the extant literature fails to inform policymakers about 'the international political conditions under which a climate club may or may not be formed, and what the consequences might be' (Sending *et al* 2019, p 188). In an era of continuing failure to mitigate climate change and growing anti-globalization and hostility between China and the United States, this research gap could have consequences for climate change mitigation, as well as global peace and stability.

3.10. Attitudes towards climate clubs, carbon border adjustments and climate unilateralism

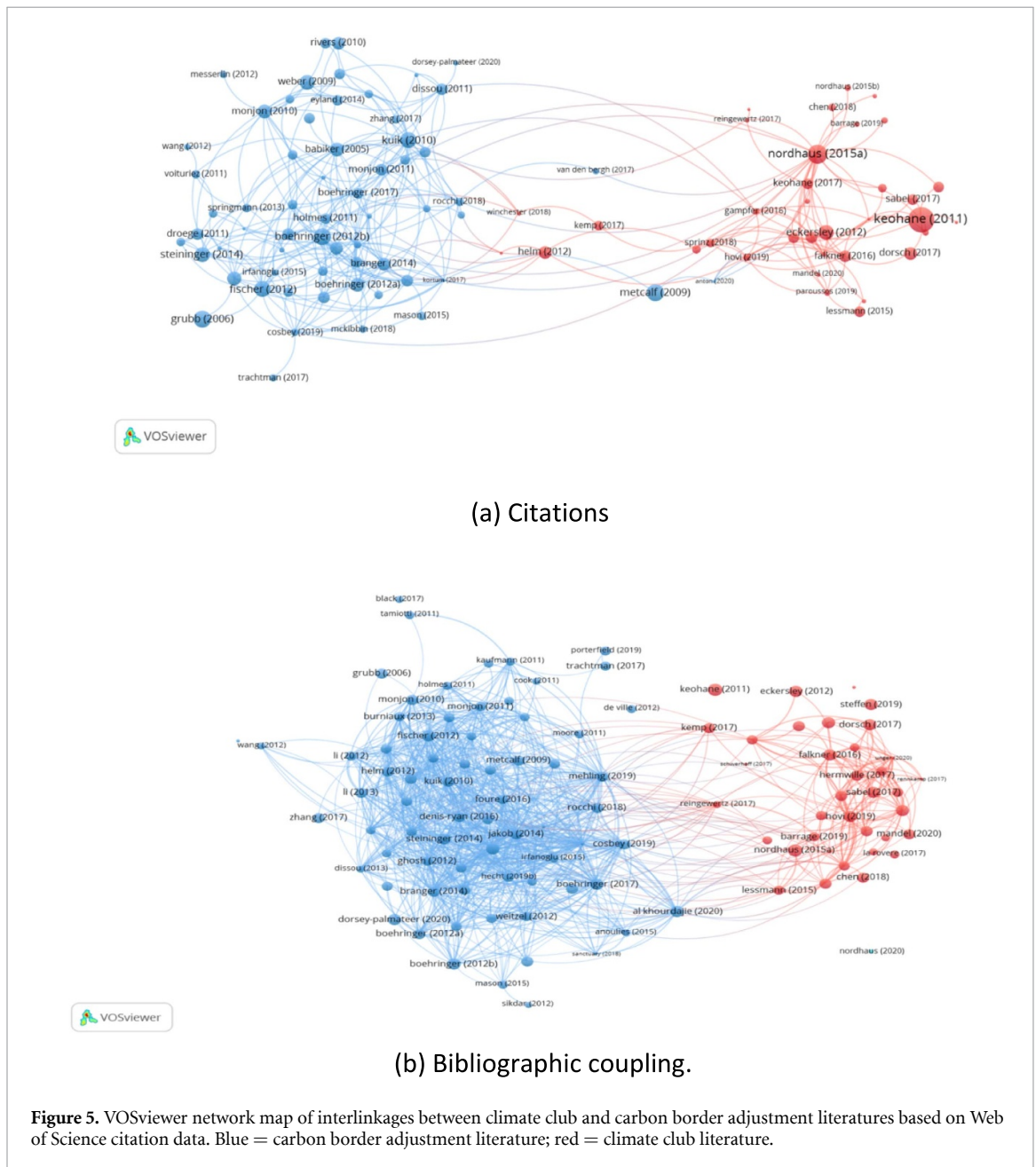
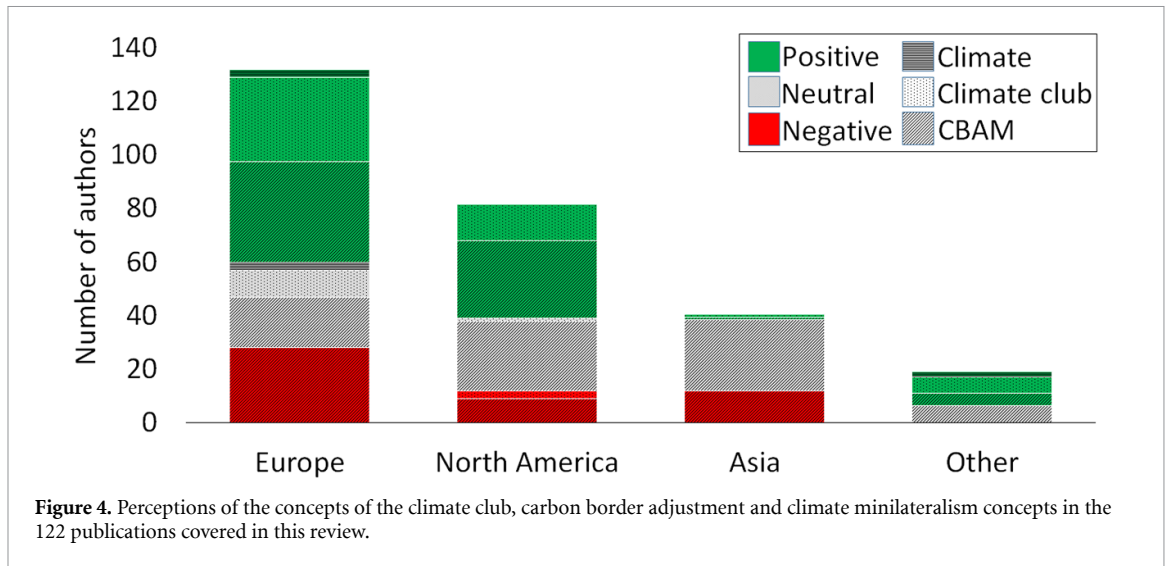
We sought a broad overview of whether authors take a positive or negative view of the concepts of a climate club, carbon border adjustments and climate unilateralism. We divided the perceptions in the 122 publications into three categories: positive, neutral and negative. A detailed table showing our classification of the perceptions in each publication is included in the supplementary material.

Overall, 53% of the studies were found to be positive towards the concept of a climate club/carbon border adjustments/unilateralism, 29% were neutral and 18% clearly opposed them. These sceptical studies argued about the economic, technical and/or political disadvantages of these approaches to climate change mitigation. While climate club and unilateralism perceptions are overwhelmingly positive, a large portion of studies on carbon border adjustments take a neutral stance.

As shown in figure 4, the largest proportion of authors who are positive towards a climate club, carbon border adjustments or climate unilateralism was found in Europe. By contrast, the smallest share of positive views was found among Asian authors, where neutral views predominate. It is also noteworthy that the vast majority of negative views are directed at carbon border adjustments rather than a climate club or unilateralism and that this is valid regardless of which world region authors are based in. Only among authors based in North America is there a noticeable minority who take a negative view of a climate club.

3.11. Network mapping of cross-citations

In this section, we undertake a systematic examination of the interconnections between the climate club and carbon border adjustment literatures. We used the VOSviewer network analysis application to visualise the (dis)connectedness between the branches of literature (see figure 5). VOSviewer is a computer application for tracing and visualizing bibliometric networks. The software facilitates the graphical representation of networks based on



citations, bibliographic coupling, co-citation, or co-authorship relations. The number of publications included in the VOSviewer analysis is slightly different from that in the rest of this article because VOSviewer only processes citation data from Web of Science and some of the publications we cover in this review are not included in Web of Science. In an attempt to cover more publications, we experimented with processing combined data from the Dimensions and Scopus databases in Geography Markup Language and using the CitNetExplorer application for visualisation. However, this did not work well due to incompatibilities with the CitNetExplorer application.

To enhance the robustness of our analysis, we performed two types of visualisation using VOSviewer: citation analysis (panel a) and bibliographic coupling (panel b). Citation analysis counts the instances of publications citing each other. In bibliographic coupling, if two publications have some of the same sources in their bibliographies, they are counted as 'coupled'.

The citation and bibliographic coupling network maps provide similar impressions. First, they show that the climate club and carbon border adjustment literatures are indeed distinct and link more to works that are part of the same branch of literature than to those that are part of the other branch of literature. However, the visualisations also show that the two literatures are not entirely separate, as there are also some linkages between them.

4. Discussion and synthesis

This section first follows up the analysis of cross-citations undertaken in the preceding sections with a discussion of thematic overlaps and divergences between the climate club and carbon border adjustment literatures. Next, it tries to explain why the EU for a long time did not say anything about a climate club in its official communication on CBAM.

4.1. Commonalities between the branches of literature

4.1.1. Free-rider challenge

There is consensus in both groups of studies on the critical challenge posed by free riding. Studies of carbon border adjustments focusing on free riding include Al Khourdajie and Finus (2020), Dissou and Eyland (2011) and Droege (2011). Most such studies undertake analyses of particular mechanisms to address carbon leakage or focus on particular cases of interest (Hufbauer and Fickling 2011, Ghosh *et al* 2012). The climate club literature provides a more comprehensive explanation of the concept of public goods (Nordhaus 2015b, Rennkamp and Marquard 2017, Leal-Arcas 2018) and lays out measures to counteract free-riding in global climate policy (Keohane and Victor 2010, Weischer *et al* 2012).

4.1.2. Role of sanctions

A recurring theme in the two branches of literature is the use of sticks and carrots to encourage participation in global mitigation. Most of the literature on carbon border adjustments, climate clubs and climate unilateralism suggests that penalties for countries that do not undertake mitigation should be calculated as a tax on the embodied carbon of imports from those countries (Gampfer 2016, van den Bergh 2017, Böhringer *et al* 2018, Winchester 2018, Cosbey *et al* 2019). Irfanoglu *et al* (2015) study on carbon border adjustments and Nordhaus's (2015b) article on climate clubs suggest uniform adjustments on imports from countries that do not have effective climate mitigation policies. Despite divergent technical configurations of penalties, there is broad consensus across the two branches of literature regarding the necessity of such measures.

4.1.3. Compatibility with international law

An important debate in the literature concerns the compatibility of a climate club or carbon border adjustments with international trade law. Some studies on climate clubs (Keohane *et al* 2017) and carbon border adjustments (Helm *et al* 2012, Porterfield 2019) argue that such initiatives are consistent with WTO rules. Others have expressed concerns regarding the legality of such measures (Holmes *et al* 2011, Balistreri *et al* 2019). Particular concerns raised by scholars relate to the potential legal challenges arising from the violation of the WTO's most favoured nation clause (Falkner 2016, Stua 2017b) and the national treatment principle (Kaufmann and Weber 2011).

4.1.4. Justice and equity issues

Another red thread that binds the two branches of literature together is the impact on developing countries (Ghosh *et al* 2015, Guesnerie 2015, Tang *et al* 2015). Ladly (2012) and Gros and Egenhofer (2011) consider the tension between efficiency and equity, emphasising the impact of carbon border adjustments on developing countries. Some scholars argue that least-developed countries should be exempted from carbon border adjustments (Zhang 2016, Baatz 2018). Others have proposed that a climate club can benefit countries such as China and India by providing access to low-carbon technology and a stronger position in climate negotiations (Weischer *et al* 2012, Weitzel *et al* 2012, Paroussos *et al* 2019).

These findings indicate a strong correlation between the objectives, methods and concerns of climate clubs and carbon border adjustments. There is a need to recognise that these groups of literature belong together and should be read jointly.

4.2. Divergences between the branches of literature

Notwithstanding the interlinkages described above, the climate club and carbon border adjustment literatures are to some extent disconnected from each

other. Above, we described the divergences between the two branches of literature in terms of historical roots, disciplinary affinities and diffusion across publication outlets. Another disconnect is the lack of comparative analysis on the opportunities and challenges of a climate club and carbon border adjustments. Most studies engage with the other branch of literature only at a superficial level, if at all. Most cross-references are limited to brief, descriptive statements on corresponding concepts in the other branch of literature. For example, while some studies of carbon border adjustments refer to the Nordhaus concept of a climate club (2015b), they do not examine in detail the contradictions and complementarities between the two types of mechanism (Cosbey *et al* 2019, Al Khourdajie and Finus 2020). While some scholars of climate clubs do engage more deeply with studies on carbon border adjustments (e.g. Keohane and Victor 2010, van den Bergh 2017), many others do so only briefly (e.g. Weischer *et al* 2012, Potoski 2015). These weak linkages between the two branches of literature obscure the inherent overlaps between a climate club and carbon border adjustment. As a result, the extant literature does not explain the strategic considerations that lead policymakers to focus on one over the other, as in the case of the EU's prioritisation of CBAM discussed in the next section.

4.3. Why did not the EU openly state that CBAM is the foundation for a climate club?

As explained in the introduction, something like the EU's CBAM is the core mechanism required to enable a climate club to function. Conversely, the structural logic of CBAM should force the creation of a climate club as countries choose whether to implement carbon pricing similar to the EU or pay fees on their exports to the EU while avoiding carbon pricing at home (Tagliapietra *et al* 2019, Anderson *et al* 2020). Why, then, did the EU not simply state that its CBAM is the first step towards a climate club?

There are several possible reasons for this. First, the multiple disconnects between the climate club and carbon border adjustment literatures identified in this study may have influenced thinking and discourses in the EU. However, as we have seen, there are also some connections between the literatures; therefore, further explanation is needed. This is provided in the next paragraphs.

Second, the logic and argumentation that underpin CBAM are linked to domestic GHG emissions pricing and the risk of carbon leakage, and any consequences along the lines of a climate club are unintended side effects. This may render CBAM safer than an officially announced climate club in terms of avoiding trade conflicts. By contrast, a climate club involves a more explicit international agenda, where the stated aim is to force changes in the behaviour of other states. This increases the risk of trade and other international conflicts.

Third, as highlighted by Tagliapietra and Wolff (2021b), trade conflict is not only an external threat to a climate club or CBAM, but also to the internal cohesion among its participating states. Faced with a severe trade war, some states may opt out of the climate club, leaving it more vulnerable to further pressure. If launching it in the form of CBAM reduces this problem, this could be an important advantage.

Fourth, the concept of free riding used by Nordhaus (2015b) and other economists in their discussion of a climate club may be confusing for policymakers and others who are not familiar with economic theory and rational choice terminology. Free riding is an easy concept for a non-expert to understand if one is, for example, referring to someone riding a bus without a ticket or using a public hospital without paying taxes. However, the challenge of mitigating climate change is different because the good to be shared—avoidance of climate change—cannot even come into existence if not all actors are brought onboard from the start. It may, therefore, make more intuitive sense to think of climate mitigation as a mobilisation challenge rather than one of free riding or burden and benefit sharing.

Fifth, Nordhaus is by far the most famous proponent of a climate club. He is an American orthodox economist who has been criticised by environmentalists for his earlier work advocating a neoclassical growth model that discounts the long-term value of nature (Hickel 2018). He might not represent the type of intellectual tradition and source with which the European environmentalists, French politicians and other actors who actively promote CBAM are most likely to identify.

5. Conclusion

A climate club or CBAM might help overcome the debilitating deadlocks of global climate policy formation. The EU's plan for a CBAM is arguably one of the most important global climate policy developments since the signing of the Paris Agreement in 2015. The EU has been reluctant to discuss CBAM in terms of a climate club, and similarly, most European academics have refrained from linking the EU's CBAM to the concept of a climate club despite the evident linkages between them. This study has attempted to address the resulting research gap by bringing together the climate club and carbon border adjustment literatures.

In response to the first research question presented in the introductory section, it can be stated that the climate club and carbon border adjustment concepts face similar challenges, opportunities and legal and ethical ramifications. However, they are distinct in terms of their historical roots and affiliations with academic disciplines, and in how they are perceived by the authors writing about them. The presence of some cross-references highlights interactions between the two branches of literature, but does not

translate into an in-depth discussion of how climate club and carbon border adjustments relate to each other. Thus, to some extent, the two literatures talk past each other.

The gaps we have identified in the literature determine some priorities for a future research agenda, and also serve as answers to the second question presented in the introductory section. First, despite the many overlaps and connections between the climate club and carbon border adjustment literatures, there is a need for more direct interaction between them.

Second, the climate club concept as formulated by Nordhaus and used in this article is centred on benefits and penalties achieved through tariffs on imports. However, there is no consensus on how to determine the level and composition of tariffs. There is a divide between Nordhaus' suggestion of a uniform tariff across all imports and the more complex adjustments calibrated to carbon content suggested by the academics and policymakers involved in the EU's CBAM. There is an urgent need to address this issue.

Third, relatively few studies have been authored by Asian academics. The lack of research anchored in Asia, the region that makes the fastest growing contribution to global GHG emissions can undermine the political acceptance of the EU's CBAM or a future climate club initiative. Western climate-policy research is sometimes viewed with suspicion in Asian countries, and an initiative involving penalties for non-compliance with climate-club rules decided elsewhere may provoke a strong counter-reaction, threatening to undermine the initiative. Academics based in Asia should therefore actively engage in research on climate clubs and carbon border adjustments from the perspective of their countries and help inform their policymakers.

Fourth, the literature is dominated by the analysis of the top ten GHG emitters. This makes sense, as the success of a climate club or CBAM will depend on the behaviour of such countries. However, the long-term objective of such initiatives is to encourage mitigation among a larger number of countries, which means that the geographic scope of analysis also needs to be broadened. More research needs to be undertaken on how geopolitically important countries, such as Brazil, Iran, Saudi Arabia and Turkey, might react to such initiatives. In addition, the economic impact of a climate club on export-dependent countries such as Bangladesh, Mexico, and the Philippines needs to be examined. Researchers should also analyse the perceptions and potential roles of countries that are particularly vulnerable to climate change, such as island states and countries with low-lying territories. Considering the importance of patterns of cooperation, resistance and alliances in global climate governance, researchers should also study the responses from coalitions, such as BASIC.

Fifth, given that the impact of such initiatives on the international system could range from trade war to cold war, there is an urgent need for IR and political science scholars to engage more actively with this literature. There is a need to determine whether the existing IR literature can provide clues about how power, anarchy, and coalitions can determine the success or failure of CBAM or a climate club, or whether new IR tools need to be developed. An analysis could also be undertaken using the conceptual lens of peace and conflict, particularly to identify the impact of climate clubs on existing geopolitical tensions.

Data availability statement

This article is accompanied by a file containing supplementary materials. The data that support the findings of this study are available upon reasonable request from the authors.

Acknowledgments

This research was funded by the Swedish Energy Agency (Grant No. 48620-1) and The Swedish Research Council Formas (Grant No. 2019-01993). The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflict of interest

The authors have no competing interests.

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