# Carbon Border Tax Adjustment:
# An Economic Review for Policy Makers

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I certify that all material in this dissertation which is not my own work has been identified and that no material is included for which a degree has previously been conferred upon me.

Signed: Daniel Boucher

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## Abstract

Throughout this paper, An economic survey is conducted of the literature surrounding carbon Border Tax Adjustments taking on a systematic literature review approach. An analysis of the literature on the effectiveness of BTAs in resolving the issue of carbon leakage and its use as a tool to address competitiveness concerns is undertaken. An overall consolidation of research articles is made to determine the overall viewpoint on BTAs as a policy tool. We see that overall BTA policies are seen in research to reduce carbon leakage with a majority of articles showing a significant level with minor disputes with different studies finding leakage rates of varying magnitudes. On the competitiveness front, we find that overall the literature on BTAs agrees that it is a beneficial tool to promote fair domestic and foreign competitiveness. This paper also outlines policy-specific recommendations for implementing a BTA based on the articles reviewed.

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# 1 Abbreviations

BAT: Best Available Technology
BTA: Border Tax Adjustment
CBAM: Carbon Border Adjustment Mechanism
CGE: Computable General Equilibrium
ETS: Emissions Trading System
EU: European Union
GHG: Greenhouse Gas Emissions
PSALSAR: Protocol, Search, Appraisal, Synthesis, Analysis, Report
UK: United Kingdom
USA: United States of America

# 2 Tables, FLowcharts and Figures

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# 3 Introduction

With carbon emissions being one of the main contributors to climate change, on varying occasions, it has been seen that governments have implemented policies that aim to slow and compress the negative effects of climate change (Köppl & Schratzenstaller, 2023). The most opted-for policies to reduce carbon emissions are seen to be either the carbon tax, which we see in the UK, Singapore, and South Africa, or the emissions trading system(ETS), which we see in the European Union (EU), Tokyo, New Zealand, South Korea, and nine states in the USA, in the Regional Greenhouse Gas Initiative (Huang, et al, 2021). However, even with these policies being effective in reducing emissions, we see that both of these policies unintentionally give rise to the issue of industries that produce large amounts of emissions causing firm relocation to countries with less strict environmental regulations, thereby avoiding or paying less in carbon taxes on goods they have produced. Hence a decrease in the emissions of the initial country will result in an increase in emissions in the country of relocation, this issue is known as Carbon Leakage.

We see that with ambitious climate targets, such as those set in the Kyoto Protocol, it is expected that more developed countries will lead in taking action to reduce emissions, with developing countries not being expected to meet the same targets (Protocol, K, 1997). Furthermore, an example of such disparity in emission reduction is seen during the Kyoto Protocol, when Eastern European countries negotiated low emission reduction objectives to allow them to catch up to a level of development, similar to that of other Annex B countries (Protocol, K, 1997). It can be expected that firms will move production to these countries with the hope of cost reduction via having to pay less carbon taxes, contributing to the issue of leakage.

With different unilateral and domestic policies being implemented and this increase in demand for policies to address the carbon leakage concern, one solution to address this increase in emissions in the relocated region is for countries with more ambitious climate policies to require that when importing from countries with less stringent climate policies an adjustment is made to make up for the difference between the two countries' carbon pricing. A mechanism to address such a market failure is a carbon border tax adjustment (BTA), which has emerged as a promising policy with one intended function being to reduce carbon leakage (Böhringer et al., 2012). A BTA is a levy applied at the border on imports and can potentially provide rebates for exports that is based on the emissions used in the production of a good in order to countervail any negativity produced from the disparity in carbon pricing (Majocchi & Missaglia, 2002). As a BTA policy is there to address the issues that arise from the difference in two countries' climate policy it is hence complementary and is implemented in conjunction with another carbon policy like that of a carbon tax or an emissions trading system (ETS).

In terms of efficiency-based rationale, a country can implement a BTA regardless of what other countries do. From an environmental rationale, BTAs will only seriously affect, and are aimed at, countries that do not take similar climate action on emission reduction (Mattoo, A., et al, 2013). The CEPS Special Report No. 79 publication, accurately foresaw a substantial escalation in the attention devoted to the issue of carbon leakage spanning the period from 2013 to 2020 and extending into subsequent years (Marcu, A., et al, 2013). Now in these subsequent years, we can see that carbon leakage is atop of the UK and EU agendas with the UK government having launched a consultation into addressing carbon leakage risk to support decarbonisation as of the 30th of March 2023, expressing that a potential policy measure could be that of a BTA (GOV UK Carbon Leakage, 2023). We see that a Carbon Border Adjustment Mechanism (CBAM) policy within the European Union, which is, in essence, a BTA, is due to be brought into its transitional period on the 1st of October 2023.

The intended purpose of a BTA is mainly twofold, as stated to address leakage concerns but also to address issues of competitiveness. It can be seen that in countries with lower or no carbon pricing the benefit of lower production costs will be seen due to tax savings which the same good produced domestically would not receive. Therefore by applying a BTA on goods based on their emissions that are due to be imported, the good will no longer benefit from savings made at the expense of environmental damage and hence the playing field will be levelled. With BTAs being able to address carbon leakage, and competitiveness and promote climate policy cooperation, a review of the economic literature should be undertaken (McCorriston & Sheldon, 2005). .

This economic survey will go into the dynamics surrounding the carbon border tax adjustment adjustment, exploring its potential effects on the environment, industry, global trade, and the consumer, and looking at the specific modeling techniques used to analyse each of the above variables. Throughout this review, we will delve into the underlying economic substance that is involved in a carbon BTA and its potential to address environmental and economic issues making a comparative analysis of studies on their results in order to consolidate how beneficial BTAs could be. Also within this investigation, we will analyse different articles to synthesise the best policy design for a BTA. The overall aim of this paper is to provide an analysis of the consensus of the literature on the limitations and drawbacks of a carbon BTA policy as well as the collective benefits. Another avenue that will be reviewed is BTA's effects on international trade, competitiveness, and welfare.

## 3.1 Purpose and Objectives of this Review

This paper aims to assess the existing knowledge and identify any gaps in the literature. Furthermore, the purpose of this review is to investigate a BTA's ability to achieve its intended purpose and also review the economic impacts of BTA implementation. With the overall aim of consolidating the literature on areas of agreement and disagreement to eventually make recommendations to be used by policymakers when designing and implementing a BTA.

### 3.1.1 Objectives

The objectives of this review are to:

- Assess the existing knowledge of BTAs.
- Determine the overall consensus on a BTA's ability to address the main reasons for implementation.
- Identify other aspects in BTA literature of article agreement and disputes.
- Identify aspects for optimal policy implementation under differing circumstances.

## 3.2 Scope and Structure of this Review

The scope of this review is designed to be comprehensive, such that it focuses on BTAs, but also incorporates analysis of the EU CBAM where relevant. The inclusion of CBAM content aims to provide a holistic understanding of border adjustments in both environmental and economic contexts, given that the EU CBAM is in due course to be implemented.

The paper is structured as such: The Introduction starts by overviewing the issue of carbon leakage and competitiveness establishing the potential for BTA's to mitigate both. This is followed by a section that discusses the methodology used to systematically review the articles. Then the overall review of the content is presented covering competitiveness and carbon leakage. Following on a chapter on BTA policy design is pertained, where competitiveness and leakage are further explored in the context of policy design. Then an overview of the EU CBAM policy is conducted. Then we proceed with a discussion of the content of the articles reviewed and policy suggestions are made based on the findings. We finally comment on future research avenues of BTAs and the main conclusions reached from this survey.

# 4 Methodology, Data, and Synthesis

## 4.1 Methodology

Throughout this paper a comparative analysis approach is used, conducting a systematic literature review. A criteria checklist will be used throughout, which a paper must meet in order to be an addition to this review. For the analysis, I will be using a Protocol, Search, Appraisal, Synthesis, Analysis, Report (PSALSAR) framework as outlined by Wondimagegn Mengist, et al. (2020). Breaking down the steps of our methodology, the Protocol step is to define the scope of the review, which we have already done. The Search stage involves defining search strings that are going to be used and then searching databases for studies. The Appraisal step is defining the inclusion requirements for studies and then conducting a quality check on the articles identified in the search stage. The Synthesis step involves the extraction of data and then categorising the data for further analysis. The Analysis step involves analysing the synthesised data, identifying trends, gaps, and any results in the data. The Analysis steps involves aspects of the PRISMA methodology. The analysis also involves determining conclusions and creating recommendations. The Report step involves the writing of the report (Wondimagegn Mengist, et al. 2020).

The criteria checklist for article inclusion is shown in Table 1.

| Requirement | Description |
|---|---|
| Relevance to Research | In order to be included the article must contribute to this articles objectives. |
| Publication Date | There is no limitation for inclusion with regards to publication date. |
| Peer-Reviewed | For an article to be included it must have undergone a peer-review process. |
| Publication Type | The article must be of an appropriate academic type (e.g., journal article, conference paper). |
| Methodology and Study Design | The article uses suitable research methods and study design for the review's objectives. |
| Geographic Scope | There is no limitation for inclusion with regards to geographic scope. |
| Language | The language requirements are such that the article is published in English. |
| Availability of Full Text | In order to be included the full text of the article must be accessible for review. |
| Exclusion Criteria | If an article is not peer reviewed it will not be included, similarly if an article fails to meet other inclusion requirements it will be excluded. If an articles main focus is not on BTAs it will be excluded (e.g., An article focuses on another climate policy and briefly comments on BTAs). |

Table 1: Journals most present

The criteria for document inclusion did include the type, being of a research/academic, and the category being in the field of economics. There were no limitations on the publication dates or location of publication searched. All papers included had to have a main focus on BTAs.

## 4.2 Data

### 4.2.1 Appraisal: Article Selection Process

The Articles for this analysis have been taken from a variety of sources including the Wiley Online Library and Google Scholar search engine. The papers were selected from searching for a keyword and abbreviation strings: ”Border Adjustment Tax”, ”Border Tax Adjustment”, ”Border Carbon Adjustment”, ”BAT”, ”BTA”, and ”BCA” with search terms also being followed or preceded by ”Carbon” in order to specify the area of interest that this paper is reviewing. Such strings were chosen based when defining the scope of the review.

The list of the articles used in this review was created on the 1st of August 2023. The database search of the article selection process is presented in the following flow diagram in Table 2. When a paper met the inclusion requirements they were exported to an Excel document for further analysis, where they were split into a table of the Authors, Year, Title, Keywords, and Journal. A total of 98 articles were initially identified for review. These identified papers were then filtered by reading the abstract and 34 articles were excluded due to having a non-economics focus, such as focusing on the World Trade Organisation(WTO) and the Global Agreement on Tariffs and Trade(GATT) or access to the article was restricted or articles were identified as duplicates. Then a skim read of the whole paper and a full read of the conclusions led to 17 papers being excluded because the main focus was not on BTAs. A total of 47 articles were found to be pertinent to this review and hence analysed.

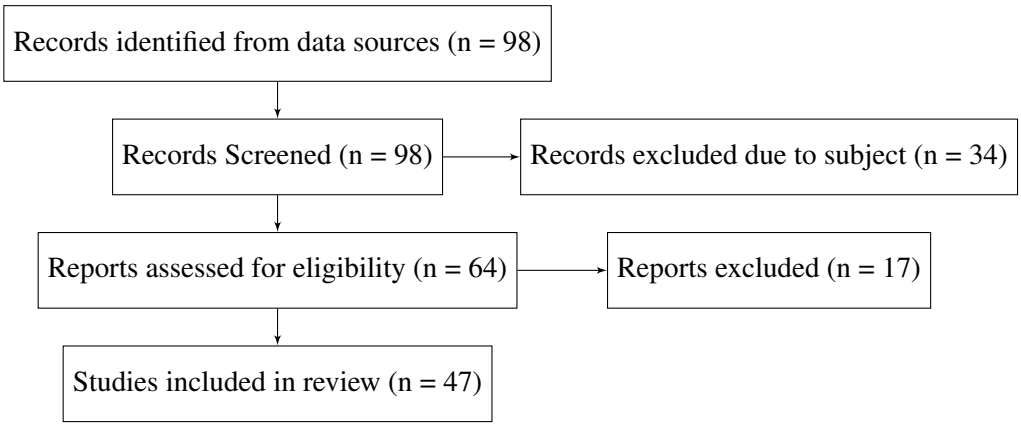


Table 2: A flowchart of the paper selection process.

### 4.2.2 Descriptive Statistics: Publication Journals

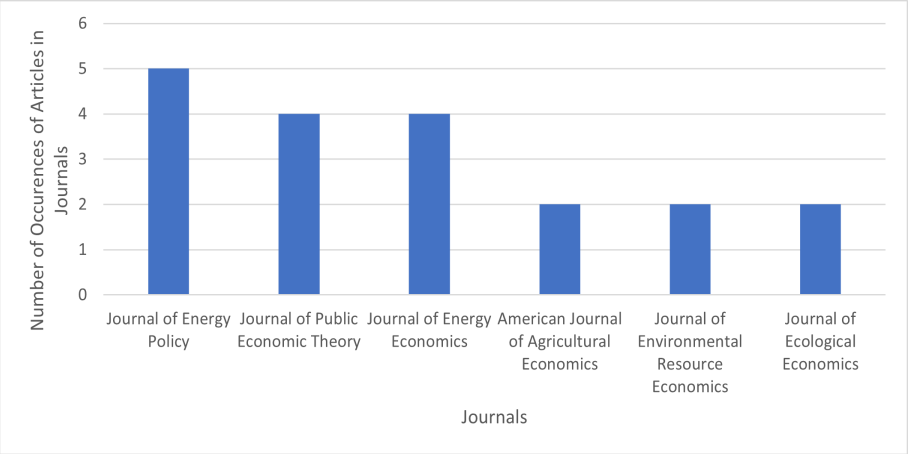


Figure 1: Journals most present

In Figure 1 we can see a breakdown of the Journals which are providing the most articles for this review. These are the Journal of Energy Policy, the Journal of Public Economic Theory, and the Journal of Energy Economics, providing 5, 4, and 4 papers respectively from each Journal. With the exception of the other 3 journals in Figure 1, we see that all other papers are published in separate journals or reviews.

#### 4.2.3 Descriptive Statistics: Publication Year Distribution

We can see in Figure 2 that the papers in this review spanned from 2002 through to 2023. We see in our set of articles that no publications were made in 2003, 2004, 2006, 2007, and 2009. With a high number of publications in 2010, 2013, 2021, and 2023, the latter is most probably due to the increase in CBAM literature. It is worth noting that there is literature much older, on BTAs but it does not focus on the environmental and emissions aspects but still provides valuable insight into BTA design.

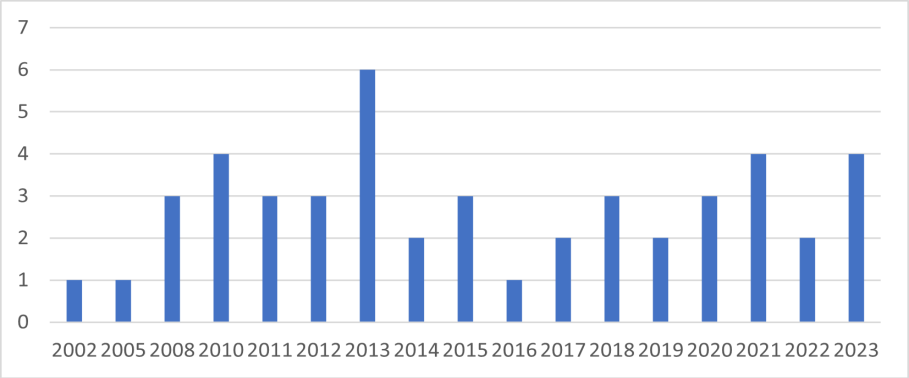


Figure 2: Paper Frequency by Year

#### 4.2.4 Descriptive Statistics: Citations

In terms of citations of papers, we see that 16 papers were cited more than 50 times. The top 10 articles with the most citations were as such:

1. Böhringer et al (2012) with 433
2. Kuik and Hofkes (2010) with 334
3. Branger and Quirion (2014) with 248
4. McKibbin et al (2008) with 177
5. Böhringer et al (2017b) with 166
6. Keen and Kotsogiannis (2014) with 102
7. Dissou and Eyland (2011) with 100
8. Sakai and Barrett (2016) with 91
9. Demailly and Quirion (2008) with 79
10. Burnaiaux et al (2013) with 62

It is expected that older articles will have higher citations and hence oppositely some of the lowest cited papers are those that have been published most recently such as:

1. Bellora and Fontagné (2023) with 3
2. Korpar et al. (2023) with 2
3. Clausing and Wolfram (2023) with 1

Although these articles lack a high amount of citations they are highly valuable due to them being more currently relevant due to them containing more recent information on the subject matter.

### 4.2.5 Descriptive Statistics: Models

Depending on what the article is aiming to achieve, different modeling approaches are used. We can see from Figure 3, that the most common method for analysis is the use of a CGE model and the second most used is a game theoretic approach. When investigating environmental effectiveness it is common for the use of CGE modeling techniques as illustrated by Conrad (2001). Which involves a system of equations that replicate market equilibrium, which is then calibrated using real-world data. Upon introducing a policy change, such as a BTA, the model is then re-solved and the results are analysed to assess the policy's impact. Articles such as Böhringer, et al.(2012), Kuik and Hofkes (2010), Burniaux, et al (2013), Alexeeva-Talebi, et al (2008), and Winchester (2012) all make use of such modeling. In total out of the articles reviewed we see a total of 23 using a CGE modeling approach. 8 articles make use of a game theoretic approach, the most recent being Elboghdadly and Finus (2022), we also see this approach being used by McCorriston and Sheldon (2005) and Anouliès (2015) to name a few. The methodology for the game theoretic approach involves defining the environment and each aspect of the research you are looking at conducting and then maximising a variable, in the BTAs case that will usually be a country's welfare. Depending on the study either a Cournot or a Stackelberg game is played, and the number of stages within the studies varies, often a 2-stage or 3-stage game is played. We also see within the articles the use of Input-Ouput models, a Geographic model, Numerical Simulations, Qualitative Analysis, and General/Partial Equilibrium models.

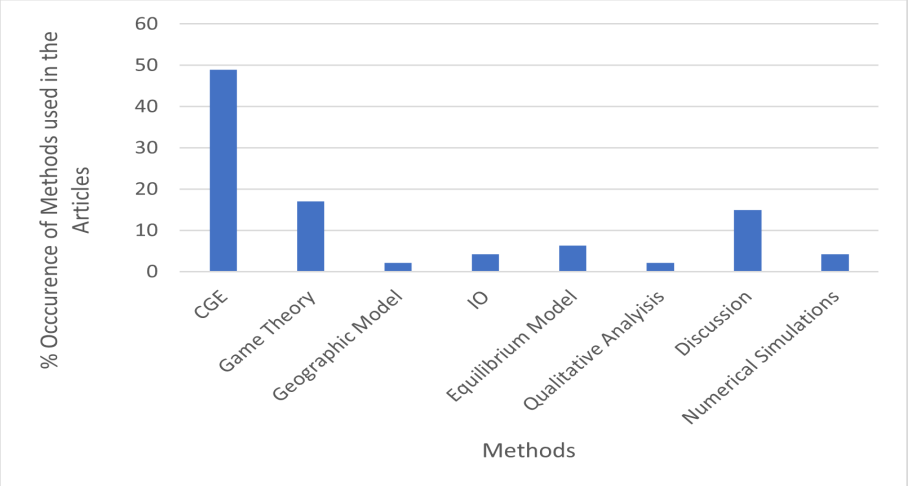


Figure 3: Models used within Articles

### 4.3 Synthesis

Our synthesis involved identifying all the articles that conclude similar results on different aspects of a BTA. Out of the 47 articles reviewed, we saw that 8 of the articles are qualitative such that they are discussion papers and provide valuable insight into BTAs. We see that the other 39 papers are of a quantitative nature. We uniquely identify Branger and Quirion (2014) as this is the only paper in our articles that uses a meta-analysis approach to quantify leakage reduction and competitiveness. References are used throughout to identify areas where there is overlap in the literature. Throughout the articles we see that a BTA is also referred to as a Border Carbon Adjustment, Carbon Border Tax Adjustment, Carbon Border Adjustment Mechanism, and in some papers just as a Tariff. Throughout this review, we will refer to such a mechanism as a BTA, with the exception of when referring to EU CBAM-specific articles or the EU CBAM as a case study due to its pertinence as it nears implementation.

In terms of the synthesis that is conducted throughout, we aim to integrate the perspectives from the different articles in order to build conclusions and critical arguments. In the context of this paper, are synthesis involves screening articles and identifying areas of overlap, identifying key themes and disputes throughout. An iterative approach was undertaken in which a document would be broken down into the different components which were identified, the next article would be analysed and we would identify overlap, and then redo this for all the articles. As stated in the introduction, carbon leakage and competitiveness have been identified as key reasons for BTA implementation. On further thematic synthesis, we also identify welfare effects as a theme throughout the literature. Similarly, we identify Policy Design as a key theme throughout the literature with articles often researching variations in BTA design such as Import vs. Import-Export BTAs and variations in emissions content determination. With regard to policy implementation, we identify in the literature the influence on foreign climate policy as another area covered in the literature and furthermore thematic synthesis further identified the legal aspect of BTA implementation. The CBAM is also found in a variety of papers as either motivation for research or the centre of articles due to its near implementation.

# 5 The Literature Content

Throughout this section, we will highlight the synthesis of all the articles and outline where there is overlap in the research. A breakdown of the complete content of the articles is conducted, where firstly a dive into the environmental content is reviewed, followed by the economic impacts and competitiveness content, then a breakdown of different specific aspects of policy design, and finally a section on the CBAM.

”Domestic” or ”Abating” is used throughout this paper to refer to the country that is implementing the BTA, and likewise, when using ”Foreign” or ”Non-Abating”, this refers to the country with the less stringent climate policy that will have the BTA made on the goods they are exporting.

## 5.1 BTAs and the Environment

One of the intentions of BTAs shown in the literature is to address the issue of carbon leakage. More often than not when investigating carbon leakage, CGE modeling is used as opposed to game theoretic methods. This is due to the functionality of CGE models where you can impose a policy and see the outcome on other variables, such as leakage rate. Whereas in game theoretic models the indirect effects are modeled, and they are hence used more for competitiveness modeling, to identify for example firm placement.

It is important to highlight what the literature is actually referring to when it uses the phrase carbon leakage, the European Commission specifies: ”Carbon Leakage is the official term for when a reduction of emissions in one country results in an increase in emissions in another, usually where there is less stringent or no climate policy.”(European Commission Carbon Leakage, N/A). With leakage being one of the main purposes of BTA implementation it is important to review whether a BTA effectively addresses such an issue. With this, the literature usually measures the success of a BTA in, terms of environmental effectiveness, as well as its ability to reduce and alleviate carbon leakage.

### 5.1.1 Leakage and the Environmental Conversation

The intention of a policy to reduce leakage and its actual ability to do so are not the same and it is seen throughout the literature that there is a disparity in a BTA's effectiveness in addressing carbon leakage. Often such disputes are not over a policy's ability to reduce leakage, but more so to if the extent that leakage is reduced warrants implementation. We find that papers such as Sakai and Barrett (2016) are skeptical of such a policy. Their main argument in this regard is that the amount such a policy would reduce carbon leakage would not be sufficient to warrant implementation when there could be potential negative welfare effects. Similar conclusions are made by McKibbin et al. (2008) where leakage reduction is shown,

but due to the administrative complexity of a BTA it is difficult to justify. Similarly agreeing, Kuik and Hofkes (2010) whilst investigating carbon leakage within the iron and steel industry found that a BTA would not be that effective due to a modest reduction in the macro rate of leakage. In terms of global emissions, it is shown that there is potential for a BTA to not actually result in a reduction in global emissions and potentially cause the opposite in certain market dynamics (Fang, et al., 2020). Lockwood and Whalley (2010) also identify inefficiencies with a BTA policy and saw that when reviewing older arguments if there is a differential between carbon taxes between countries that affects the prices that producers charge a BTA is valid, however, if this is not the case any intended impacts are absorbed into the exchange rate. Hence they wouldn't protect local producers or effectively tackle the leakage issues they are intended to address.

In contrast, we see several studies that show differing results in which they found a BTA policy valid in reducing carbon leakage [(Banerjee, 2021), (Bellora & Fontagné, 2023),(Böhringer et al., 2012),(Branger & Quirion, 2014),(Burniaux et al., 2013),(Demailly & Quirion, 2008),(Ismer et al., 2020),(Ramadhani & Koo, 2022),(Balistreri et al., 2019)]. Similarly, Tsakiris, et al. (2019) found that when looking at a modeled small open economy where pollution per unit of consumption differs between domestically produced and imported quantities of the same good the first best policy is consumption taxes on all polluting goods in conjunction with a BTA. Likewise, Yomogida and Tarui (2013) noted that when setting an emissions tax without a BTA there is potential for a negative externality, which means that a positive emissions tax isn't necessarily justified. However, when researching the emissions tax with a BTA it found there was a positive externality, so has a beneficial effect on the global environment.

### 5.1.2 Leakage Reduction Estimates

In terms of modeling, results vary in terms of estimates for the amount that leakage is reduced by, but a majority of papers do show reductions. In one example, with the use of 12 CGE models, it is seen that in the reference case where there is no BTA implemented, carbon leakage was found to have a mean of 12% and once a BTA was implemented the mean value was found to drop to around 8% (Böhringer, et al. 2012). A majority of simulation literature will show a reduction in the leakage rates, but in many cases, it is shown not to have a grand reduction, like that in Balistreri et al. (2019) where without a BTA a leakage rate of 18.3% is present, but, with a BTA this is reduced to 16%. Branger and Quirion (2014) found that using a meta-analysis approach to compare 25 different carbon leakage studies, without a BTA the carbon leakage would range from 5% to 25% and from -5% to 15% with a BTA policy, with the results having statistical significance. An important point raised is that the two most efficient features of a BTA to reduce carbon leakage are the inclusion of all sectors and the inclusion of export rebates in the policy. Burniaux, et al (2013) look at welfare analysis investigating the structure of BTAs

with models that take a unilateral approach looking at how a BTA policy would affect the USA and Japan. It looks at a BTA applying to the embodied carbon content on imported goods, but also a policy based on domestic carbon contents as this would be more feasible. Similar to Branger and Quirion (2014), the paper sees that in the basic unilateral case, the carbon leakage rate decreases by 3.2% points for the US case and 8% points for Japan. Overall the paper concludes that BTAs have only small welfare effects and BTAs are most effective at reducing carbon leakage.

With leakage being targeted, it is seen that leakage is reduced but there is an opportunity for firms in non-abating countries to take advantage of different production lines for different markets. If the BTA was viewed as an emissions tax by the non-implementing country that had separate production lines for different markets, then carbon leakage would be reduced by about 33%. Whereas when firms operated a single production line for all markets carbon leakage fell by 80% (Winchester, 2012). This intuitively makes sense as firms will create a low emissions variety of the product for the markets where BTAs are applied so that when trading with these countries the adjustment will be less for the low emissions variety of the products. Hence a lower reduction in leakage occurs due to high emissions still being produced in other production lines, where products that will be used for trading with countries with a lack of a BTA are made.

### 5.1.3 Overall Consensus of the Effectiveness in the Literature

In terms of the overall literature, there is positivity for BTAs to be used to alleviate carbon leakage, with a majority of articles showing favour for implementation in this aspect. Almost all modeling articles show that estimates for carbon leakage would be decreased in varying degrees under a BTA. The articles with reductions on the lower end usually would result in that implementation was not recommended due to welfare costs[(Kuik & Hofkes, 2010), (Sakai & Barrett, 2016)]. With a majority of papers showing leakage reduction amounts that address the issue at hand, it can be expected that implementing a BTA is a valid tool for addressing carbon leakage.

## 5.2 Economic Impacts of BTAs

This chapter explores the impacts of BTAs on international trade, their implications for competitiveness, and their influence on firm relocation. In the context of the literature, competitiveness concerns in the articles are often measured by output change and changes in global market share (Zhou et al., 2013). It is important to determine what effects a BTA would have on the economy, and often variables such as import level, export level, GDP, goods pricing, and production level are investigated. This section aims to outline what the literature finds in terms of a BTA to address competitiveness and also its impact on the economy.

### 5.2.1 Competitiveness

Another suggestion for BTA implementation is due to its ability to level the playing field with regard to competitiveness. With firms moving to non-abating countries and benefiting from a lack of carbon pricing resulting in production in these countries being lower in cost. This then results in a competitive advantage in both the domestic and foreign markets in terms of pricing. Such an advantage could be dissolved by getting foreign countries that are exporting goods to incur the same climate policy-associated costs as if production were domestic, therefore making domestically-produced goods just as attractive as foreign-produced goods. This good be achieved through a BTA. Economic theory shows that there is little case for a BTA when all instruments can be freely deployed, meaning a country is able to implement any policy instrument without facing limitations or constraints. However, in order to obtain Pareto-efficiency in terms of competitiveness there is a requirement that a BTA is imposed when there are constrained carbon taxes in some countries. Therefore a BTA would be in place to counter the effect of additional emissions from inappropriate carbon pricing and or to resolve any trade distortions that the pricing creates (Keen and Kotsogiannis,2014).

Effectively by imposing such a policy, you're addressing the potential competitive disadvantage that domestic suppliers would experience from having to pay their domestic carbon tax, which non-domestic suppliers do not have to adhere to. Therefore BTAs would address this issue by shifting the competitive landscape such that countries have equal advantages from a competitive standpoint in each market. Quite a few papers see BTAs effective in addressing competitiveness concerns [(Alexeeva-Talebi et al., 2008), (Anouliès, 2015),(Böhringer et al., 2012),(Dissou & Eyland, 2011),(Zhou et al., 2013)]. Anouliès (2015) finds that the competitive disadvantage in the domestic market is fully eliminated from BTA implementation. The purpose should be highlighted that a BTA is there to correct the competitiveness shift that is created when carbon pricing is introduced and not to create a competitive advantage for the abating country. Essentially bringing back the so-called neutrality that was present before any climate policy was introduced (Dissou & Eyland, 2011). Kuiks and Hofkes (2010), even with some level of hostility towards BTAs from a macro leakage perspective, identify that a BTA would

be justified in terms of sectoral competitiveness when looking into the iron and steel industry.

Zhou, et al (2013) found that introducing a BTA policy in Japan prevented competitiveness loss in the energy-intensive trade-exposed sectors, but due to the competitiveness effects of the carbon policy being small, the effects of the BTA to protect industrial competitiveness are also small. Dissou and Eyland (2011) found that the rising suggestion of BTAs, to be used to address the loss of competitiveness induced by stringent domestic policies, imposed on non-fossil and energy-intensive products reduces the negative competitiveness impacts on domestic industries. On further investigation, the simulation suggests that a BTA policy can actually improve competitiveness and domestic firms are able to increase market share. This however cannot be fully attributed to the BTA as the recycling method of the BTA revenues matters, whether proceeds go to gross output or proceeds go to exports on domestic goods. However, the benefits produced by an increase in global market share for domestic energy-intensive industries will typically be offset by a rise in production and hence a rise in domestic emissions (Burniaux, et al., 2013).

It is seen that often there is potential for BTAs to administer a positive effect to domestic countries whilst causing negative effects in foreign countries. Niu et al (2013) generalise their findings on China, that any export-driven country will experience a negative impact on their economy as the product of BTAs being applied. In like manner BTAs risk harming less developed countries, this would be due to a reduction in economic growth led by exports and hence less gain from international trade (Clausing & Wolfram, 2023). With the use of modeling the ability of a BTA to shift the economic burden of emissions from developed to developing countries in the period of 2000 to 2007 would have increased rapidly, but would have declined after the 2008 financial crash (Böhringer, et al.,2021). Similarly, regressive effects are seen in other papers where a shift from richer to poorer countries occurs in terms of emissions burden [(Balistreri et al., 2019),(Böhringer et al., 2012)]. Uniformly, Dissou and Eyland (2011) have suggested that a BTA may have negative distributional impacts.

McCorriston and Sheldon (2005), the most cited paper using a game theoretic approach, state that the intended purpose of a BTA is in order to prevent domestic goods from being disadvantaged in comparison to foreign goods and identify that in theory a neutral outcome should be expected from BTAs as there should not be any significant affect on import volume or the market share of imports. However, there is the caveat, that if markets are not perfectly competitive BTAs can be discriminatory giving domestic advantage, hence it is pertinent to consider the market structure when determining the level and design of a BTA. A BTA should be used for a neutral competitiveness outcome and not implemented with the intention of gaining a competitive advantage.

### 5.2.2 Impacts on Exports and Imports

It is important to identify how a BTA will impact export and import levels, as this can indicate how a BTA will affect global trade. Shen and Li (2010) make use of a 41-sector CGE model to identify estimates for the impacts on China's exports. It is estimated that imposing a BTA of 30 and 60 dollars per ton of carbon on China's exports will lead to a decline in gross industrial output of 0.62% and 1.22%. A decline of 3.53% and 6.95% in export volume and 1.22% and 2.39% in industrial employment. Li (2013) suggests that to avoid such negative effects on output, a reduction in capital tax could be implemented, which could reduce distorting effects. Shen and Li (2010) found in the foreign country, there is an increase in unemployment and Majocchi and Missaglia (2002) found that in the domestic country, a reduction in unemployment would occur. Amalgamating both findings results in the emergence that there is to some extent a regressive unemployment effect, effectively in turn that the foreign country is worse off and the implementing country benefits. With regards to exports, Ramadhani and Koo (2022) take the outlook from the exporting country that will have the BTA applied to their goods, a similar approach to Shen and Li (2010), which is an uncommon approach seen in the literature. They find a similar result in terms of exports that a BTA applied to these goods would adversely impact the export level of Indonesia, there is however a small decrease in global emissions which supports the results of McKibbin et al. (2018). This impact on exports is expected due to the goods now being perceived to be at a similar or higher cost to that of the equivalent domestic good of the country that has applied the BTA, hence an increase in domestic purchases of the good can be expected.

From the perspective of the implementing country, McKibbin, et al. (2018) find, in terms of a BTA policy in the USA, that BTAs will usually create lower net exports than a standalone carbon tax stating that a BTA will raise the value of the dollar relative to other currencies, hence lowering exports more than imports. The level of imports does still decrease due to imports becoming more expensive. Kuiks and Hofkes (2010) also see that there will be an increase in the costs of imports as a product of a BTA. Bellora and Fontagné (2023) find similar results in terms of an EU BTA in which both a reduction in imports and exports would occur. Exports are seen to be reduced more than imports, which is in line with McKibbin, et al. (2018). Anouliès (2015) found a similar effect on the export market. Additionally, Demailly and Quirion (2008) find a slight increase in consumer prices for the implementing country. They also find that there would be a small decrease in price competitiveness and production in the non-implementing countries.

### 5.2.3 Impact on GDP

In terms of GDP estimates, Bellora and Fontagné (2023) found that when modeling different BTA scenarios the effect on the GDP was that all scenarios were found to decrease EU GDP by around 1.2% to 1.3%. Likewise, Böhringer et al (2012)

found similar estimates of GDP losses in the range of 0.13% and 0.63%. Although with GDP reductions expected it is still seen in Korpar et al. (2023) that they argue that with minute economic costs with regard to GDP and welfare losses, it still appears a valuable tool to introduce a BTA. Such a result of GDP reduction can be expected due to a reduction in international trade (McKibbin and Wilcoxen, 2008). This international trade reduction can be expected due to the goods under a BTA being equally competitive in both the domestic and foreign markets which would result in a shift from the case under no BTA where an increase in domestic purchasing is realised as there is no longer a benefit of importing the equivalent foreign goods.

### 5.2.4 Effects on Production and Relocation

The introduction of a BTA in the context of large emerging countries would see a shift from energy-intensive to energy-extensive sectors, this is expected due to the latter sector being less exposed to BTAs (Li, et al, 2013). Whilst the implementing country will see a shift to energy-intensive industries (Korpar, et al.,2023). In terms of the effects on production at a sector-specific level, a study by Demailly and Quirion (2008) on the cement industry estimated that when Annex B countries (except the USA and Australia) import from the rest of the world a BTA policy created a loss in production of 2%, instead of the 7.5% that occurs without any BTA policy. This also would create a spillover effect as emissions in the rest of the world would also decrease. In terms of domestic welfare and production, raising the BTA rate increases domestic profits and increases revenue produced, reinforcing domestic market production. Moreover, it enhances environmental conditions by cutting down overall production, leading to fewer emissions. Even more so, when considering welfare it is seen that the effect of a BTA on welfare is tied to the size of the implementing country, the bigger the country, the broader the market affected by the adjustment. Hence, this leads to a reduction in imports and agrees with the previous literature that a BTA would strengthen domestic production (Anouliès, 2015).

In terms of production location, it is expected that in the absence of a BTA, a firm will choose to locate in a country or region with a less stringent climate policy resulting in a competitive advantage and an increase in leakage. Hence the converse is to be expected that once a BTA has been implemented, firms will choose to not relocate as the benefits to be taken advantage of in terms of cost savings from a lower carbon price or tax will have been reduced to a point where there is little gain. Such a result is shown by Elboghdadly and Finus (2022). Employing a game theoretic approach they found that without a BTA the country with the lower carbon tax is where firms will be located and that the country employing the BTA will have the same effective carbon tax rate as the exporting foreign country with the BTA applied. The BTA equilibrium results show that under a BTA only a partial relocation of production to a country with less austere environmental policies

will occur, which will cause an increase in welfare for the country that imposed the BTA. Similarly, Li, et al. (2013) state that a BTA would result in the relocation of output from foreign countries to countries with BTAs, and hence a welfare transfer. So essentially a BTA has the ability to dissuade relocation to countries with lower carbon pricing. Furthermore with regards to welfare, with environmental impact not taken into account, it is seen that a BTA will improve welfare. The meta-analysis shown in Branger and Quirion (2014) shows that without a BTA the welfare variation of 13 studies for the implementing country is between -1.58% to 0.02% and with BTA implementation ranges from - 0.9% to 0.40%. Therefore we can see a welfare shift but the variation is still seen to be negative even when a BTA has been implemented due to consumers having to pay more for goods, due to price rises in the implementing country.

### 5.2.5 Influence on Foreign Climate Policy

In terms of international policy, even though a BTA is an unilaterally implemented policy, it has the additional benefit that it promotes uniformity in carbon pricing by encouraging a foreign country to raise its carbon price to a closer level to that of the domestic carbon price. This is due to the fact that the disparity between carbon pricing would be less meaning that a smaller BTA will be made. So in essence a BTA can act as an incentive to exporting countries with weaker climate policies to improve and implement more stringent climate measures with the overall goal of eventually reducing global emissions.

When a BTA is announced for implementation, a foreign country can react by changing/implementing a climate policy. Eyland and Zaccour (2012) observe that a BTA has the added benefit of addressing the issue of free-riding, where an entity benefits from a resource without contributing to the maintenance of such resource. In our context that would be countries benefiting from global climate efforts without having to implement stringent climate policy. The actual influence on foreign policy is that a BTA in the above context initially alleviates the issue of free-riding by encouraging foreign countries to increase their tax level. Similarly, an article by Mason, et al (2015) researched using a dynamic approach such a situation where the developed domestic country cares about climate-related damage, whereas the foreign exporting country cares less. The article agrees with other literature that a BTA will induce the foreign country to alter its behaviour with the optimistic outcome being an adoption of climate policy, such as a carbon tax.

It is seen through non-cooperative game theory in which there are two countries and two firms, that a BTA encourages country participation in cooperative international climate agreements (Anouliès, 2015). As stated, policies built out of domestic self-interest could result in unsavoury trade relations. Similarly, it is seen that BTAs could lead to large stable climate agreements resulting in large global welfare gains, this is with the assumption that there is no restriction on membership to the treaty (Al Khourdajie & Finus, 2020). If there is a restriction on membership, this

may identify the motives of the implementing countries, that they probably serve domestic and not global interests. Correspondingly, Ramadhani, et al. (2022) in the context of Indonesia show that the introduction of a carbon tax on domestic production will cause the negative impact of a BTA to be alleviated, which therefore promotes the adoption of said carbon tax. Collectively the literature agrees that BTAs can be used to encourage policy implementation, however, this is subject to an appropriate level of BTA being set. Through a Nash game, it is shown that in terms of global welfare, the preferred Nash equilibrium is one where a BTA increases the tax level of the foreign country. However, an alternative Nash equilibrium, which is less preferred, is one where a BTA decreases the foreign countries' tax level (Eyland & Zaccour, 2012). With the two Nash equilibrium essentially being polar opposites it is important to consider the design of a policy to avoid the latter outcome, where a BTA causes a decrease in the foreign countries' tax level.

Alternatively, instead of influencing a country to adopt a more stringent climate policy, it can be seen that there is potential for BTAs to promote an increase in more efficient production techniques that produce lower emissions. Niu et al (2013) outline that China should promote low-carbon development whilst taking countermeasures to deal with the threat of carbon BTAs. Similarly, both Shen and Li (2010) and Shen (2011) agree that China needs to take countermeasures in order to counter the potential negative results of a BTA to their economy. A potential countermeasure could be to adopt the best available technology (BAT) with the aim of reducing emissions in production. Sakai and Barrett (2016) show that countries like China and India could find decreases in their BTA rates of up to 85% due to the adoption of BAT. Such an adoption would only occur if a policy were based on embodied emissions and not avoided. It is shown that a BTA has the potential to encourage non-abating countries not in climate coalitions to adopt low-cost mitigation options, essentially making use of more efficient production practices (Winchester, 2012).

It has been shown by Rocchi, et al (2015) that China will be most subjected to an EU BTA policy due to its polluting production system and the high amount of trade volume to the EU. When a BTA is imposed on China it has been shown by Niu et al (2013) that there will be a negative effect on the macro-economy, in which these negative effects would scale with an increase in the BTA rates applied on the border. Therefore in a more extreme case, instead of a country improving in terms of environmental development to counter a BTA, there is the issue of countries implementing retaliatory tariffs to counter the effects of BTAs. Lim, et al. (2021) identify that it is highly likely that major exporters of energy-intensive products may respond to being subjected to BTAs by implementing a retaliatory tariff, which will offset most of the BTA's intended benefits and will reinforce the advantageous price competitiveness of their energy products. The issue with such tariffs is they would be put in place, not with environmental concerns in mind, but to maintain a competitive advantage for their goods. Additionally, such tariffs

would further shake the international trade dynamic, which would be most likely be negative for future aspirations of cooperative policy.

### 5.2.6 Overall Consensus of Impacts in the Literature

In terms of competitiveness, many articles state that a BTA could be used to address such concerns [(Al Khourdajie & Finus,2020), (Anouliés,2015), (Eyland & Zaccour,2012), (Mason et al.,2015), (Sanctuary,2018), (Winchester,2012)]. Several studies have displayed that effectiveness can also be very limited and that introducing a BTA is not an appropriate tool, given the considerable costs and potential to distort markets[(Kuik & Hofkes,2010),(Sakai & Barrett, 2016)]. Although with concerns about market distortion, the overall consensus of the articles is that in theory a BTA can be used to address competitiveness concerns and cause domestic goods to have an equal advantage in both domestic and foreign markets. Additionally, through the research and estimates in the articles, it is seen that the implementation of a BTA will result in reductions in GDP and a loss in production levels, a loss in export levels, and reductions in industrial employment in the non-abating country. Whilst in the abating country there is a reduction in export and import level, with the addition that a welfare increase will be realised. This highlights that when considering implementing a policy the ability to address leakage and competitiveness should not obscure a policymaker's vision resulting in neglection of these impacts on the economy and said factors should be priced into the pros and cons list of the policy design. It is also seen that the literature agrees that a BTA will promote international adoption or improvement of climate policy in foreign countries where the BTA applies to their exported goods. It is also expected that under a BTA firms will either choose not to or only partially relocate to the non-abating country.

## 5.3 BTA Policy Design

It is seen that difficulty can arise when choosing the trade-off between leakage and competitiveness concerns (Winchester, 2012), and additionally a significant source of negativity towards BTAs is based on policy implementation complexity. It could be argued that the justification for a BTA is difficult due to the administrative complexity and potential negative effects on international trade when the benefits produced by a BTA for traded goods and services are small (McKibbin, et al, 2008). Additionally, with regard to policy design, it is seen that the efficiency of a BTA is heavily dependent on the climate policy that it will be used in conjunction with, whether this is a carbon tax or a cap and trade system (Keen and Kotsogiannis,2014).

One issue identified with unilateral policy implementation is the difficulty of identifying policy motivation, and with the potential of BTAs being pursued for protectionist benefits, it can be very difficult to disentangle from the climate motivations (Sanctuary, 2018). This motivates the idea that BTAs are only valid in the context of cooperative policy making and there is a lack of a case for them when they are implemented for domestic self-interest (Keen and Kotsogiannis, 2014). Mattoo, et al. (2013) stress that an international concurrence on trade measures within a global climate change accord is heavily sought after and should be pursued. In like manner, Clausing and Wolfram (2023) state that countries should coordinate border adjustments in such a way that motivates optimistic policy, rather than conflict. Coordination and cooperation are desired when it is seen that a BTA's success is dependent importantly on the size of the abatement coalition and the coalition's emission reduction targets (Böhringer et al, 2012).

The need for an appropriate design of a BTA is pertinent for its effectiveness and depending on the implementing countries' goals and climate policies the design should vary. This chapter aims to explore the complex interplay between trade policy design and climate action. When designing a BTA it is important to consider the configuration that such a policy should take, the pricing level, the coverage, the metric for determining emissions content, and also consider how revenues produced should be used.

### 5.3.1 BTA Coverage

When designing a BTA it is important to consider which goods a BTA should apply to. With goods varying in terms of embodied emissions, it does not seem practical to apply a BTA to all goods when the ability to address competitiveness and reduce leakage would be minimal in certain goods, especially with the additional administration required. Therefore a BTA could be considered for goods being produced in energy-intensive industries. Such importance of having a targeted BTA which only applies to a few products is seen in which a policy could be designed such that it only applies to the products that are most at risk of carbon leakage (Monjon

& Quirion, 2010). Identifying the products most exposed gives an opportunity for administrative burden easing and hence a more implementable policy and there is always the option to later alter the policy and increase the coverage. In terms of the products most exposed to a BTA, in an EU context, it is seen that products such as coke, refined petroleum products, chemical products, other non-metallic mineral products, basic metals, and fabricated metal products would be most affected by a BTA, but furthermore, electronic products would also be heavily exposed due to the high amount of exports of these goods being traded to the EU (Rocchi, et al,2015).

### 5.3.2 BTA Configuration: Import-Only versus Import-Export

The configuration of a BTA can take multiple forms, it is seen that a policy could take the form where it only applies to imports however, BTAs focused solely on imports only partly deal with competitiveness challenges in domestic countries, as they don't offset the competitive disadvantages that domestic exports face in foreign markets. Similarly, Evans, et al. (2021) in terms of the EU ETS showed that an import-only BTA policy can level the playing field in EU markets but cannot address competitiveness in non-EU markets. Ideally, a balanced approach where a BTA is applied to imports and rebates on exports could resolve this. Such a case is identified to be optimal for policy discussion by Keen and Kotsogiannis (2014). The reason for making rebates is to maintain competitiveness not only in the domestic market but also in foreign markets (Mattoo et al., 2013). When referring to Import-Only, this is a situation where a BTA only applies to imports, whereas Import-Export refers to a BTA on imports and the addition of rebates made on Exports.

In terms of leakage reduction estimates with regard to differing policy designs, a more recent article by Bellora and Fontagné (2023) makes use of a CGE model to research the potential designs for a BTA policy in conjunction with an ETS in terms of an EU setting. The article presented three different model scenarios for review. The first scenario takes the form that uses emissions directly induced by the production process of sectors covered by the ETS. The second scenario differs where the reference emissions considered are emissions by sector in the exporter country. The final scenario adds a rebate technology to scenario 2 that introduces a refund to European exporters. The papers found that scenario one is the most compatible with WTO standards but reduces carbon leakage the least, with a carbon leakage rate baseline of 76.1%, the rate is reduced to 35.6%, compared to, the more difficult-to-implement, scenarios 2 and 3 which both reduce carbon leakage more, with a reduction of leakage rate to 31.5% and 31% respectively. These are similar findings to a high proportion of articles reviewed within this paper. A key point to outline from this is that by implementing rebate technology to exports carbon leakage is reduced further than import only, but only by a small amount. Such a result is also identified by Monjon and Quirion (2010).

Ismer, et al. (2020) similarly researched different policy designs, using three different models, the first being an import-only BTA, the second being the same as the first with the addition of export rebate technology, and finally, a model that takes into account dynamic free allowance allocation, the latter model does not need to be considered for this review. They identify that the second model with the rebate technology effectively addresses carbon leakage more so than without the technology. This produces similar results in terms of leakage as Bellora and Fontagné (2023), that the addition of rebates on exports will make the policy environmentally more valid. Similar conclusions are drawn with regard to the addition of rebates on exports in terms of leakage [(Balistreri et al.,2019),(Branger & Quirion., 2014),(Dissou & Eyland., 2011),(Mattoo, et al., 2013),(Böhringer et al., 2012)].

In terms of competitiveness, the addition of rebate technology is shown to address competitiveness concerns more so than a policy without rebates [(Korpar et al., 2023),(Mattoo et al., 2013),(Ramadhani & Koo, 2022),(Sanctuary, 2018),(Balistreri et al., 2019),(Böhringer et al., 2012)]. This is due to the addition of rebates addressing the issue of competitiveness in foreign markets, meaning that a BTA would result in domestic goods being just as attractive as foreign goods in both the abating country's and non-abating country's markets. With the potential for rebates to be funded using revenues produced from the BTA, which is a suggestion seen in the articles, this adds to the attractiveness of the policy, as subsidies would not have to be provided by the implementing government.

The addition of rebates sounds like it solves a majority of issues in terms of addressing leakage and competitiveness in foreign markets. Therefore, it is important to highlight the issues that come as well. In terms of the negatives of the addition of rebate technology, Ismer et al. (2020) identify inefficiencies from a domestic country's perspective that rebates could lead to fraud where manufacturers claim cleaner production of domestic goods than what is actually the case. Additionally, many articles identify that with the addition of rebate technology the ability for a BTA to conform to WTO regulations is less feasible[(Al Khourdajie & Finus, 2020),(Bellora & Fontagné, 2023),(Evans et al., 2021),(Korpar et al., 2023)]. It can hence be considered that if a BTA policy can overcome the legal issues associated then from a leakage and competitiveness point of view an Import-Export rebate will provide the best results.

### 5.3.3 Embodied vs. Avoided Emissions

Calculating carbon taxes is relatively straightforward, however, when calculating BTAs this can be significantly more difficult and complex and would require data on the foreign countries' embodied carbon content on their exports. This data could be very difficult to obtain whilst also verifying its authenticity and even more complexities arise when a produced good contains resources that have been produced in a range of differing countries (McKibbin, et al, 2008). Therefore it is seen in the literature two different methods for calculating the emissions content of goods to be used in the BTA. The first is using the embodied carbon content of foreign imports as already stated, known as embodied emissions. The BTA would be based on the emissions used in the manufacturing process of the foreign goods to be imported. Alternatively, the second is using the carbon content of the equivalent domestic good, known as avoided emissions. The content amount used for adjustments could be made on either a domestic average or alternatively the use of Best Available Technology (BAT) carbon content. The argument for using avoided emissions is that the data is much more readily available and a more attainable policy from an administrative side. However, the issue then arises that production most probably will not be as efficient in less developed countries, and hence the production will involve higher emissions than that of the domestic counterpart used for adjustment, therefore carbon leakage would still be occurring, just on a smaller scale. With the use of BAT it is seen that a policy would further contribute less to emissions reductions than that of a policy based on embodied emissions (Kuik & Hofkes, 2010). The suggestion of basing a BTA on the avoided carbon content of domestic goods, instead of the embodied carbon content of foreign goods, has been a policy design in multiple papers [(Burniaux, et al., 2013),(Bellora and Fontagné, 2023)].

From a welfare perspective, and in order to be less regressive it is shown that basing a BTA on the emissions content from domestic production would still partially address competitiveness concerns in developed countries, whilst being less malicious to developing countries' trade, additionally reducing global welfare cost (Mattoo, et al, 2013). In a similar light, such results are shown by Demailly and Quirion (2008), who additionally see that a policy based on embodied emissions is only slightly more efficient than one based on avoided emissions in terms of leakage. Although a policy based on avoided emissions may be less regressive, basing a policy on the domestic emissions content of goods would no longer incentivise non-abating countries to improve production efficiency in terms of emissions, as essentially the price level they will have to pay is predetermined. Such incentivisation is seen in the context of embodied emissions looking at regional average vs firm-specific targeting. BTAs targeted at a firm level are incentivised to adopt cleaner production when a policy is designed to target the specific emission intensities of foreign producers rather than a foreign regional average (Böhringer et al., 2017a). However, a lack of motivation to adopt cleaner production would be even

more present with a policy based on avoided emissions due to a firm's lack of contribution to the adjustment amount, which their emissions would contribute to if an embodied emission foreign regional average was used.

Further looking into embodied emissions specifics, Böhringer et al. (2017a), investigated the design of a policy based on embodied emissions and whether an embodied content BTA should be targeted at a regional average of the content or firm-specific content. They find that the difference in leakage rates to be similar, with the benchmark without a BTA being 20.2% which is reduced to 18.5% for the regional average content used and 16.8% for the firm-specific embodied carbon content. When the addition of the firm's electricity usage is taken into account in the firm-specific case, this is further reduced to 11.4%. It is seen that the firm-specific version results in lower welfare costs than that of a regional version.

The synthesis identified that if the policy is to be designed with only competitiveness in mind, it is seen that the use of embodied emissions is preferred to avoided emissions [(Mattoo et al., 2013),(Rocchi et al., 2015),(Rocchi et al., 2018),(Sakai & Barrett, 2016),(Kuik & Hofkes, 2010)]. If carbon leakage reduction is the main goal then embodied emissions are also preferred over avoided emissions [(Branger & Quirion, 2014),(Rocchi et al., 2015),(Kuik & Hofkes, 2010)]. However, a need to weigh up the positive effects produced by choosing embodied over avoided against the negative administrative and welfare effects on non-abating countries should be considered.

In terms of determining emissions content, it can be seen that certain countries are more exposed than others when BTAs are implemented using embodied emissions. This can be seen through the difference in rates between avoided and embodied emissions would be similar for countries like Australia, Indonesia, Japan, and the USA, whereas the difference would be much higher for countries like China, India, or Russia (Rocchi, et al, 2015). This will be down to certain countries having more emission-efficient production that is closer to that of the country implementing the BTA. However, in the aspect of effectiveness to address leakage, it highlights how a policy based on avoided emissions will likely result in a BTA only applying to a small proportion of the actual amount embodied in goods, due to the large differences between avoided and embodied emissions for certain countries.

To further show the purview of the potential difficulties in terms of administration we outline an example to calculate the emissions on a good which is shown by McKibbin et al (2008). To calculate the emissions we need to find the directly and indirectly produced emissions for the good. The direct emissions are relatively straightforward to find, but it becomes more difficult to attain the indirectly produced emissions. When looking at an aircraft, there is a direct use of energy when it is assembled, but, energy is used in the production of all parts and materials, so the indirect emissions would require the energy consumption of the production chain going back through all the intermediate products at each stage. Energy is used to produce sheet metal from aluminum and producing aluminium from bauxite and

mining bauxite itself. In reality, this is a tiny proportion of the overall production steps and this is not taking into account all the emissions in the production of the aeroplane, we can already see that this is already becoming quite cumbersome and this is only one small stage of the production. Essentially the ability to account for each stage could become very strenuous to keep track of and hence the cost of accounting for all of these stages could accrue a large amount of costs associated with the administration. Regardless of the costs, if the accounting is not done reliably it essentially renders the BTA unreliable and prone to being taken advantage of.

### 5.3.4 Pricing Level

With BTAs being sought after it is important to identify at what pricing level the adjustment should be made up to. When considering the adjustment level it initially seems reasonable to make the adjustment to the same level as that of the domestic level, as intuitively this seems the optimal policy to reduce leakage and correct any competitive disadvantage that may have realised. However, it is identified in the literature that there is concern over the implementing country exploiting a BTA by benefiting from unregulated regions and practically charging a ”rent” due to the price level of the BTA being too high (Balistreri, et al.,2019). From a welfare perspective, to avoid this issue the BTA pricing level should be set below that of the domestic pricing to avoid encouraging the consumption of high-emission goods in regions with little regulation. This is similarly shown by McCorriston and Sheldon (2005) where it is shown that setting a BTA equal to the level of the domestic carbon tax/pricing is likely to be discriminatory.

Eyland and Zaccour (2012) investigate such matters in which they model different policy options where the BTA is modeled by choosing various percentages of the differential in taxation that will be used as a BTA on imports. They find that the implementation of a partial BTA is Pareto improving for both countries. It is seen that the level of BTA to be set for Pareto improvement for both countries in terms of welfare is at 50% of the differential in taxation when there is no GHG-intensive industry subsidisation involved. Additionally, at the 25% level of the differential, the foreign country is incentivised to increase its tax level and the 72% level of the differential would cause both the domestic and foreign country to set the same tax level, which identifies the benefits of a partial BTA. Therefore from a welfare perspective setting the BTA level to that below the domestic level is preferred. It is seen that by setting the BTA level to the domestic level a BTA in this model causes foreign taxation to rise to a very high level, bringing up the issue of market distortion. As a by-product of this result, it further highlights the need for a well-designed policy that takes into account not just the domestic benefits but the global market. Sanctuary (2018) saw that a BTA and the exporter's emission tax can complement each other and by tying the BTA level to both the importer and exporter taxes there is potential to induce both countries to set higher emissions taxes and

hence reduce global emissions. It is also seen that setting a higher BTA level closer to that of the domestic level is more efficient at addressing leakage (Balistreri, et al.,2019).

It is therefore important to make a tradeoff between welfare and leakage and identify a compromise level to which the adjustment should be made to address leakage, whilst also not negatively affecting welfare too significantly. This is an area that could be researched further, such that the adjustment level can be modeled taking into account both leakage and welfare in the same model.

### 5.3.5 Revenue Usage

If such a BTA were implemented a new revenue source would be produced for the implementing government. With this new revenue, consideration should be given to the appropriate usage, in order to obtain the most efficient policy. Potential options for such implementation could be retaining the revenues, which could be used to further support the policy or alternatively, the revenues could be recycled to the foreign country. McKibbin, et al. (2018) found that depending on how the revenues produced from BTAs are used will have different outcomes. Under a lump sum rebate, where households receive a yearly lump sum payment, BTAs have a negative impact by lowering domestic output further than it would fall under a standalone carbon tax. Whereas with a capital tax swap, where the revenues are used to reduce the marginal tax rate, BTAs can mitigate the negative effects of the carbon tax on most industries. Revenues produced could be given back to the taxed country so they could pursue climate efforts, however, this has been shown that there is potential for a reduction in BTA policy effectiveness in terms of competitiveness of domestic country (Böhringer, et al,2012). However if revenues were given back to foreign countries the policy could be interpreted as less protectionist (Monjon & Quirion, 2010).

Similarly, Banerjee (2021) specifies that depending on the revenue recycling schemes there are different impacts on macroeconomic variables. If revenues are collected from the production sectors and recycled back to firms, it will help the production sector to restore any production that may have been diminished by the implementation of a BTA, In the model used here there was the implementation of a domestic tax adjustment in conjunction with the BTA. Furthermore, the usage of revenues produced from BTAs could be used in order to fund rebates or alternatively could be appropriately used such that further mitigation efforts are pursued e.g. To further restore competitiveness, reduce GHG emissions, for research and development for a low-carbon economy, more green infrastructure, or be used for other civil uses such as reducing government debt. The articles in this review did not have vast amounts of content on revenue usage and hence we identify this as an area that could be pursued further within the research to identify the optimal recycling mechanism for revenues.

### 5.3.6 Legal Considerations

As stated earlier in the context of rebates, there is a discussion around the legal aspects of BTA implementation. It is expected that any new policy for implementation is to conform to WTO/GATT regulations. This is in order to avoid new trade barriers and avoid new policies being considered protectionist. Many of the articles state and highlight the importance of legal considerations and often will comment on which of their models is most abiding by WTO regulations [(Alexeeva-Talebi et al., 2008), (Ismer et al., 2020), (Majocchi and Missaglia, 2002), (McCorriston & Sheldon, 2005), (Sakai & Barrett, 2016)]. In the articles, one of the most prominent arguments against BTAs is in terms of them not abiding by these trade regulations. This highlights the need for design to be heavily evaluated before implementation.

With the argument of them not abiding by said regulations, this outlines the need for clarification in terms of a BTA's ability to conform. GATT Article:III:2 (2012) states the following: "The products of the territory of any contracting party imported into the territory of any other contracting party shall not be subject, directly or indirectly, to internal taxes or other internal charges of any kind in excess of those applied, directly or indirectly, to like domestic products. Moreover, no contracting party shall otherwise apply internal taxes or other internal charges to imported or domestic products in a manner contrary to the principles set forth in paragraph 1." GATT, being a foundational treaty of the WTO, contains Article:III:2 which aims to ensure imported goods are not treated less favourably than domestic goods. As BTAs may differentiate based on production and processing methods, in order for BTAs to not violate GATT, these differentiations must be recognised under the equality of the national treatment principle (McCorriston & Sheldon, 2005).

## 5.4 The EU Carbon Border Adjustment Mechanism

Any case studies of real-world implementation would be highly valuable for analysis, however, there is a lack of any implemented cases of a BTA policy. What we do see is that a policy is due to be implemented in due course. Over the last couple of years within the European Union, there has been debate and demand over whether a BTA is a viable policy to be implemented in conjunction with their current ETS. We see such demand in the earliest study in our article set which states that the EU could achieve targets set by the Kyoto Protocol, however, it would necessitate the implementation of a compensatory BTA that is in line with WTO regulations (Majocchi and Missaglia, 2002). As of the 1st of October 2023, such a policy is going to be in its first stages of implementation (PWC, 2023).

Through the CBAMs transitional period, an import adjustment will be applied to cement, iron, steel, aluminium, fertilisers, electricity, and hydrogen based on carbon emissions content. The choice of goods is due to them being the most prone to being subject to carbon leakage. The roll-out of the CBAM policy is that between 1st of October 2023 to 31st of December 2025 quarterly greenhouse gas emissions of the goods subjected to the policy will be reported. Then as of 2026, there will be a requirement for importers to purchase CBAM certificates to cover the emissions in production stages, which will be linked to the carbon pricing within the EU ETS (PWC, 2023). The requirement to purchase CBAM certificates is effectively the same as importers having to pay an additional fee at the border in terms of a BTA.

As a by-product of its due implementation and discussion throughout the previous years, it is seen in the literature that the focus of many articles is that of an EU BTA, and in more recent years the phrase CBAM has been coined. Such articles where the CBAM is discussed and or researched are Bellora and Fontagne (2023), Ismer, et al. (2020), Korpar, et al. (2023), Lim, et al. (2021), Rocchi, et al. (2015), and Evans, et al (2021).

The motivation for a CBAM are outlined by the European Commission:

> ”This Regulation establishes a carbon border adjustment mechanism (the ‘CBAM’) for addressing greenhouse gas emissions embedded in the goods referred to in Annex I, upon their importation into the customs territory of the Union, in order to prevent the risk of carbon leakage.”

From Article 1, as shown above, of the proposal for the CBAM within the EU, we can see that the European Commission’s main aim of the CBAM is to address carbon leakage and not necessarily address competitiveness concerns, additionally stating that the CBAM is there to complement the current EU ETS (European Commission, 2021). There is critique in the literature for the CBAM, stating that it will drive up trade costs and cause more trade distortion, claiming that the CBAM will

be too costly for the world economy. It has also been said that the CBAM poses the risk of deteriorating the international trade environment (Lim, et al.,2021). At the 27th United Nations Climate Change Conference in 2022, the CBAM was discussed by the members, it was seen that India, China, Brazil, and South Africa all had negative opinions on the proposal and all opposed the plan. The reason for such opposition is that they claimed that there would be market distortion. But in contrast, due to the near negligible costs in terms of reduction in GDP and welfare to foreign countries with whom goods are being traded seen in the modeling in the literature, these concerns about such a policy restricting international trade for domestic gain are misplaced in terms of an EU CBAM and that there is no reason that such a policy will cause turbulence in international markets (Korpar et al., 2023).

The CBAM has not been the only proposed BTA policy, we see that other BTA-style policies discussed are The Clean Competition Act in 2021 and the FAIR Transition and Competition Act in 2022, within the United States of America, both policies were put forward to Congress (US Congress, CCA, 2021),(US Congress, FAIR, 2022). With the CBAM being the first example of BTA policy implementation it will be a pertinent case study for the future implementation of similar BTA policies in other countries. As the leading carbon BTA policy, data on the effectiveness of addressing competitiveness concerns and reducing leakage will be invaluable for future research and potential suggestions for changes in BTA policy design for the future.

# 6 Discussion, and Key Policy Recommendations

## 6.1 Discussion

Unilateral policy implementation may cause unnecessary and unwarranted tension between trading countries and as stated with the potential for retaliatory tariffs to offset any benefit produced from a BTA (Lim, et al., 2021), this once again highlights the need for cooperative policy-making. In general with cohesive climate action being the overall goal there is always the avenue of exploring alternative policy tools to BTAs. Such alternatives could take the form of international carbon pricing agreements and would further harmonise climate policies. However, in reality, an international carbon pricing agreement on a large scale is not viable due to disagreement between governments and would potentially produce a vast amount of bureaucracy. A more realistic suggestion could be that of sectoral agreements, where countries can negotiate sector-specific agreements to establish common carbon pricing within certain industries, but one could imagine how this could similarly be difficult to implement.

As shown through the literature, a BTA policy implemented by a country or collective of countries would create a new trade dynamic, causing only partial relocation, hence, promotion of domestic firm placement (Elboghdadly and Finus, 2022), whilst also promoting non-abating countries exporting to increase their climate policies so that they are less or unaffected by the imposed BTA (Ramadhani, et al., 2022). In some cases, countries still have negative opinions on the CBAM policy, which brings to light the issue of regressive policies in the scope of BTAs and how this could disproportionately affect certain economies (Balistreri et al., 2019). In order to be less regressive consideration could be given to whether and how to provide differential treatment for developing countries, which may face unique challenges in terms of having different capacities for addressing carbon emissions in their economies. The issue with this suggestion is essentially a BTA would not actually achieve its intended goal, additionally what metric could be used to distinguish between who the policy does and does not apply to? There is potential that when a country is considered to be at a certain level of development the BTA could be applied, using GDP, the Human Development Index, the level of industrialisation, and other variables as metrics for development. However, this could be discriminatory and unfair.

Highlighted in the literature is the challenging issue of BTA implementation with regard to the ability to determine embodied carbon content due to the administrative burden that accompanies it (McKibbin, et al, 2008). The alternative of avoided emissions shows inefficiencies such that basing a BTA on avoided emissions could potentially neglect the aspect of a BTA policy to promote the pursuit of lower carbon production methods in non-abating countries, as the BTA price for each good is essentially predetermined. An area identified for research within the field is the collaboration between eco-labeling and BTAs and how the former could be used

to track and account for the embodied carbon content through production stages. As explored in an article by Pan, et al. (2019) they make the suggestion of using blockchain for carbon trading, even with the potential difficulties that arise with such implementation. This article identifies the potential to extend such technology and makes the suggestion that there is the opportunity for this to be extended to track the embodied carbon content of goods for efficiency purposes through the production stages of a good. Therefore, this article makes the suggestion that there is potential for research on the use of blockchain in conjunction with BTAs for a similar carbon accounting purpose to that of carbon trading.

From a legal perspective, the importance of policies conforming to WTO and GATT regulations is pertinent and there is often dispute and disagreement over whether such policies do due to room for interpretation (McCorriston & Sheldon, 2005). Therefore, with the vast amount of discussion on which configuration of BTA is most likely to abide by such regulations, often identifying that an import with export rebates BTA could potentially be in breach of WTO regulations it hence seems reasonable to expect the WTO to undertake a trade policy review in order to outline their regulations on BTAs specifically. Such a need for an outline is needed as such policy tools become more prominent and are beginning to be implemented globally such as that of the EU CBAM.

In all the articles found in the literature, the BTA research is based on economic theory and modeling due to a lack of implemented BTA policies. Therefore there is a lack of real-world empirical evidence of how a BTA would perform. With the introduction of the EU CBAM, a new opportunity presents itself for empirical analysis of BTA implementation in subsequent years. Meaning an assessment of the real-world effectiveness will be feasible. This will be invaluable to policymakers of countries and regions who have or are considering implementing similar policies to optimise such a tool.

## 6.2 Key Policy Recommendations

The ability to design a BTA that yields valuable results with regard to Leakage, Competitiveness, and Welfare, whilst also conforming to Legal standards is a difficult challenge to achieve. It still remains inconclusive as to what configuration the most appropriate design for implementation should take. From the literature and making use of the synthesis we do identify and note policy recommendations based on a welfare perspective and also based on an optimal leakage and competitiveness perspective. We also identify recommendations that would be most in line with WTO regulations. These recommendations are a precis of the literature to be used for policymakers when in the process of designing BTA policy. In practicality, a compromise between welfare, leakage, competitiveness, and legal recommendations would need to be made for a functioning policy. Here we outline recommendations for each case individually.

### 6.2.1 Leakage and Competitiveness Recommendations

For a country aiming to maximise leakage reductions and address competitiveness, the following policy recommendations are made:

1. A BTA policy should be applied to foreign goods being imported whilst also making rebates for domestic exports.
2. A BTA should base the carbon content of goods on the actual embodied content of the goods to be imported.
3. The pricing level of the BTA should be made to the level of the implementing countries' carbon pricing.
4. Revenues produced by a BTA should be retained by the country that set the policy.

Recommendation 1 is made on the basis of having a BTA that both makes a tariff on imported goods whilst also making a rebate on exported goods will maintain competitiveness most effectively whilst also reducing carbon leakage the most. This recommendation is only made if such a policy can abide by WTO/GATT regulations, alternatively, a BTA that applies only to foreign imported goods should be the next best policy. Recommendation 2 is suggested as an optimal policy in order to address competitiveness and reduce leakage the most. By basing the BTA on the embodied carbon content you will promote the adoption of cleaner production whilst also creating a neutral competitiveness outcome in both the domestic and foreign markets as desired. Recommendation 3 is made as it is shown that setting a BTA level closer to that of the domestic level results in greater leakage reductions. Recommendation 4 is due to the fact that giving BTA revenues to foreign countries that have had the BTA applied to their exports is shown to cause a reduction of competitiveness from the perspective of the implementing country (Bohringer, et al,2012). Additionally, by retaining such revenues, they can be used to fund the rebates, suggested in Policy Suggestion 1. Alternatively, rebates could also be used for further mitigation of environmental damage.

### 6.2.2 Welfare Recommendations

For a country trying to optimise welfare and aiming to be less regressive to developing countries the following recommendations:

1. A BTA policy should be applied to foreign goods being imported whilst also making rebates for domestic exports.
2. A BTA should base the carbon content of goods on the content of the equivalent domestic goods.
3. The pricing level of a BTA should be below that of the implementing countries' carbon pricing.

Recommendation 1 holds the same from a welfare perspective due to its ability to reduce global welfare costs. We make recommendation 2 due to the potentially negative effects of applying a BTA on developing countries' goods on their trade, to alleviate this a policy based on the carbon content of the equivalent domestic goods or using the best available technology could be pursued. This however is less efficient in addressing leakage but does have the additional benefit of being administratively easier to implement. Additionally, such a policy could result in producers being less incentivised to pursue cleaner production methods. Recommendation 3 is that a policy could be made by choosing an adjustment level that is made below that of the implementing country's carbon price. This recommendation is made due to it being less likely to result in market distortion. This recommendation also has the added benefit of being less likely to promote retaliatory tariffs and is made from a welfare perspective with the aim of reducing global welfare costs whilst also not being regressive to developing countries. The actual level of BTA to be set needs further investigation to consolidate an appropriate level that is most Pareto efficient for actual implementation.

### 6.2.3 Legal Recommendations

Although not the main field of focus for this paper, we do identify that the literature agrees, that the following recommendation is made for a BTA to be most likely to conform to WTO regulations:

1. A BTA policy should be applied to foreign imports only.
2. Revenues produced by a BTA should be not retained by the country that set the policy and given to the non-abating country.

Recommendation 1 is made from the literature identifying that the addition of rebates may not conform to WTO regulations. Recommendation 2 is made on the basis that a policy that gives revenues back could be considered less protectionist.

# 7 Conclusion

This paper presents a review of 47 articles relevant to the subject of BTAs. The overall literature varies on research specifics with papers ranging from policy design and implementation to effectiveness and limitations. Consolidating all the papers it is seen that a BTA is a tool to reduce carbon leakage and address competitiveness concerns. However, the actual extent is shown to vary in terms of its success and will be heavily dependent on the different design aspects that are utilised such as pricing level and how revenues produced from such a policy are used.

Out of the articles reviewed, a majority are supportive of a BTA policy in some capacity from an environmental perspective. There is still a dispute, in a small number of papers, over a BTA's effectiveness and to what extent they reduce carbon leakage. Even with a small amount of differing opinions present in the articles, which may be explained by the regions and designs of different models, when weighing up the literature we see that significantly more papers show that carbon leakage is effectively decreased when a BTA is implemented. With fewer coming to the conclusion that it is not a valuable policy worth implementing. With more papers coming to the conclusion that a BTA addresses the leakage issue to some extent, it can be found that such a policy is valid in an economy where there is a difference in carbon pricing from country to country. However actual implementation may yield different results as such conclusions are based on economic theory and modeling, which will be the case until there are case studies and data on implemented examples of such a policy.

This review would like to further highlight the benefits of a BTA in promoting the adoption of climate policies or alternatively the adoption of cleaner production methods, which are both beneficial for the global goal of emissions reduction and addressing the climate crisis. This therefore addresses the issue of free-riding as countries now want to implement climate policy and firms want to adopt as close to the best available technology as possible to decrease the effects of a BTA. However, there is the potential for firms to take it upon themselves to create separate production lines based on export location to avoid such a heavy BTA being made.

From a competitiveness perspective, the literature tends to agree that a BTA is beneficial in alleviating and addressing competitiveness concerns. We see that a majority of articles agree that BTAs are effective in addressing competitiveness to some capacity. Effectively leveling the playing field for domestic producers whilst also promoting domestic production. A dispute in terms of competitiveness that this paper identifies is to what extent a BTA should be implemented, and whether this should be made up to the domestic price level, such that the effective carbon tax rate for the foreign country is the same as that of the carbon tax of the domestic country. Alternatively, a partial BTA where the effective carbon pricing is lower than that of the domestic country, as the latter is more appropriate from a welfare

perspective, but the former addresses leakage more effectively. Furthermore, we identify that there is further need for research in terms of appropriate pricing levels of BTAs due to the potential for them to be priced such that they are discriminatory.

This article identifies policy implementation recommendations for policymakers for optimal results in terms of leakage reduction, competitiveness, and welfare as shown in the Policy Recommendations section. With the potential for a BTA to address competitiveness and leakage issues, it additionally has its configuration challenges. In reality, it can be expected that the design of a BTA may be difficult to create when there are many different components that need to be taken into account, such as the coverage, the addition of rebates, the basis of carbon content, the pricing level, revenue usage, and any legal considerations. Furthermore, the importance of appropriate policy design is emphasised and the pertinence of further research into designs of BTA policy is required. Such a requirement is needed as we not only want to find a policy that is designed to be optimal in addressing the independent cases of leakage, competitiveness, and welfare but also a case that is optimal for addressing them collectively.

The results of this review underscore the importance of policy design and in summary highlight that if the aim of reducing carbon leakage is at the top of the agenda, then an import and export BTA should be implemented to a price level made up to that of the domestic carbon tax policy. Similarly, the same strategy for competitiveness should be implemented. However if the main aim of a policy is for welfare maximisation, then an import-export should be implemented with a price level below that of the domestic level. It is seen the literature highlights that a BTA set at the domestic price level could cause market distortion so to avoid this the level of the BTA set should be heavily considered such that it is appropriate and does not negatively affect foreign nations, ideally setting a BTA below the domestic carbon price. Overall this paper consolidates the literature to highlight the need and importance of appropriate policy design.

# A The Articles

| No. | Citations | Author(s) | Year | Title |
|---|---|---|---|---|
| 1 | 53 | Al Khourdajie, A., & Finus, M. | 2020 | Measures to enhance the effectiveness of international climate agreements: The case of border carbon adjustments |
| 2 | 52 | Abrosova Tabeb, V., Ldichel, A., & Mennel, T. | 2008 | Climate policy and the problem of competitiveness: Border tax adjustments or integrated emission trading? |
| 3 | 19 | Anouliès, L. | 2015 | The strategic and effective dimensions of the border tax adjustment. |
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| 5 | 18 | Bandeiras, S | 2021 | Conjugation of border and domestic carbon adjustment and implications under production and consumption based accounting of India's National Emission Inventory: A recursive dynamic |
| 6 | 3 | Bellora, C., & Fontagné, L. | 2023 | EU in search of a Carbon Border Adjustment Mechanism |
| 7 | 433 | Böhringer, C., Balistreri, E. J., & Rutherford, T. F. | 2012 | The role of border carbon adjustment in unilateral climate policy: Overview of an Energy Modeling Forum study (EMF 29). |
| 8 | 335 | Böhringer, C., Bye, B., Fæhn, T., & Rosendahl, K. E. | 2017 | Targeted carbon tariffs: Export responses, leakage and welfare |
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| 11 | 248 | Branger, F., & Quirion, P. | 2014 | Would border carbon adjustments prevent carbon leakage and heavy industry competitiveness losses? Insights from a meta-analysis of recent economic studies. |
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| 17 | 31 | Evans, S., Mehling, M. A., Ritz, R. A., Sammon, P. | 2021 | Border carbon adjustments and industrial competitiveness in a European Green Deal |
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| 19 | 43 | Fang, Y., Yu, YG., Shi, Y., Liu, J. | 2020 | The effect of carbon tariffs on global emission control: A global supply chain model |
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Figure 4: Data

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