2017

The Opportunities and Limitations of Neutral Carbon Tariffs

Juscelino F. Colares
Case Western Reserve University School of Law, juscelino.colares@case.edu

Ashwin Rode

The Opportunities and Limitations of Neutral Carbon Tariffs

Juscelino F. Colares, *Case Western Reserve University*, *School of Law and Department of Political Science*, and Ashwin Rode, *University of Chicago*, *Department of Economics and Energy Policy Institute at Chicago*[*]

Send correspondence to: Juscelino F. Colares, Case Western Reserve University; Email: colares@case.edu

[The final, official version of this article appeared in print in October/November 2017, as indicated below:

> **Juscelino F. Colares and Ashwin Rode, *The Opportunities and Limitations of Neutral Carbon Tariffs*, 19.2 AMERICAN LAW AND ECONOMICS REVIEW 423 (2017), available at https://academic.oup.com/aler/article/19/2/423/3868721/The-Opportunities-and-Limitations-of-Neutral?guestAccessKey=3c4accf2-53af-4807-8364-e89647ebadd5.**

The final, official abstract is available at:

> **https://academic.oup.com/aler/articleabstract/19/2/423/3868721/The-Opportunities-and-Limitations-of-Neutral**

This is an academic, courtesy copy.]

[*] We are most thankful to the editor, Abraham Wickelgren, and three referees for their comments and suggestions. For helpful comments, we are grateful to Jonathan Adler; Kevin Clermont; Peter Gerhart; Jeff Rachlinski; Cassandra Robertson; and seminar participants at the University of Minnesota Law School and Energy Policy Institute at Chicago. We are also thankful to Robert Deacon and Don Clark for the early introduction and encouragement. A version with traditional "law review" references will be available following publication at the corresponding author's institutional website.

Because carbon taxes can lead to loss of competitiveness, applying tariffs on imports from non-carbon-restricting countries helps address the cost disadvantage faced by producers in carbon-restricting countries. Such tariffs, known as border carbon adjustments ("BCAs"), can also help reduce possible carbon "leakage," or the growth in foreign emissions due to increased production of carbon-intensive goods in non-carbon-restricting countries. We demonstrate that BCAs that do not exceed the burdens imposed by carbon taxation on domestic like products could be consistent with World Trade Organization ("WTO") rules. However, "neutral" (i.e., nondiscriminatory) BCAs might still be inefficiently high from a global welfare perspective. This stems from the misaligned focus of BCAs on imports rather than production—the real cause of emissions. The discrepancy between neutrality and efficiency enables carbon-restricted industries to seek inefficiently high BCAs. Recognition of this discrepancy strengthens the case for multilateral alternatives that curb global carbon emissions. (*JEL*: F13, F18, H23)

Introduction

When nations cannot agree on binding emission cuts, unilateral attempts to internalize the social cost of carbon raise costs to carbon-restricting first movers, while allowing other nations to enjoy the benefit of a shared public good (i.e., mitigated climate change) without contributing to its cost (Stavins, 2014). Invariably, first movers are called to address the cost disadvantage that their carbon-intensive sectors face in international competition with counterparts in non-carbon-restricting nations. A border carbon adjustment ("BCA") constitutes a potential policy option in addressing this cost disadvantage.

BCAs are border measures whose purpose is to offset the cost disadvantage producers of goods and services operating in emission-restricting countries face when in competition with more carbon-intensive imports from non- or more lax emission-restricting countries (Veel, 2009). Besides putting industries on both sides of the border on a level playing field, such offsetting reduces potential leakage of carbon emissions.[1] For this reason, BCAs increase the effectiveness of unilateral climate action, though they are a second-best alternative when compared to globally coordinated internalization measures, such as country-by-country, carbon taxation set at the rate of marginal damage. As far as implementation is concerned, BCAs can be enforced either by requiring importers to purchase emission allowances from an existing

[1] The term carbon leakage illustrates two adverse economic effects that may result from a country's effort to reduce emissions: (i) higher emission costs may shift production of GHG-intensive goods and services to non-carbon-restricting nations, where such costs are not imposed, resulting in the growing emissions there; and (ii) the reduction in fossil fuel use in carbon-restricting nations may lower global energy prices, thereby inducing more energy consumption in non-carbon-restricting nations (Winchester et al., 2011; Her Majesty's Treasury, 2006).

emission-trading scheme and to relinquish such allowances when they clear imports from customs, or by subjecting imports to tariffs that adjust for their domestic carbon charges.

Although BCAs have not yet been adopted by any country, their adoption is likely to be seriously considered by the European Union ("EU"), particularly as the EU-wide carbon Emissions Trading System ("ETS") moves towards auctioned allowances.[2] During his term in office, France's President Sarkozy publicly voiced support for BCAs (Winchester et al., 2011). In the U.S., the Waxman-Markey Climate Change Bill of 2009, which passed the House of Representatives but died in the Senate, included a provision for BCAs.[3]

BCAs have also received favorable endorsements from trade law experts. Many scholars have written persuasive articles about the legality of BCAs,[4] and the World Trade Organization ("WTO") Secretariat and the United Nations Environment Program ("UNEP") have jointly issued a white paper discussing the WTO-compatibility of different types of carbon-restricting border measures with WTO rules (WTO-UNEP, 2009). Yet, nearly all legal analyses resort to the General Agreement on Tariffs and Trade' ("GATT") environmental conservation and public health exceptions. When applicable, these generous regulatory exceptions allow WTO Members

[2] In 2009, the EU Parliament and the EU Council granted the EU Commission the power to alleviate the cost burden of ETS and put EU-based energy-intensive industries "on a comparable footing" by either increasing free emission allocations, or by introducing "an effective carbon equalisation system," which would be implemented through BCAs (Council Directive 2009/29, 2009).

[3] Also known as "Climate Bill" or "Waxman-Markey," the American Clean Energy and Security Act, H.R. 2454, 111th Cong. (2009), called for the inclusion of "provisions that recognize and address the competitive imbalances" and potential for "carbon leakage" that might result from an international carbon-restricting agreement if some countries are allowed free ride without the possibility of remedies. Notably, in attempt to mitigate Sections 766-67's costly implicit endorsement of BCAs (and secure votes), Section 782(e)(1) would authorize granting free allowances to energy-intensive, "Trade-Vulnerable Industries" (American Clean Energy and Security Act, H.R. 2454, 111th Cong., 2009).

[4] Among such scholars are: Colares, 2013; Tran, 2010; Veel, 2009; Howse and Eliason, 2008; Sindico, 2008; Zhang & Assunção, 2004. A few trade law experts have expressed skepticism in regard to the WTO-legality of BCAs. Joost Pauwelyn, for instance, states that "it remains unclear whether" BCA-imposing Members would be able to overcome GATT art. II:2(a)'s restriction on "maximum tariff ceilings," because BCAs "target not the physical features of the imported product itself, but rather [its] process or production method" (Pauwelyn, 2007). Although not discussing BCAs specifically, Roessler (2003) has argued that "the only place to take into account regulatory objectives that require the products distinctions not made by the market is Article XX of the GATT," ruling out, presumably, the legality of regulatory measures without resort to one of the exceptions under GATT, art. XX. GATT stands for General Agreement on Tariffs and Trade (see GATT (1947) in References).

to deviate from the trade system's preference for tariff-based measures, even permitting Members to impose bans—the most trade-restrictive measure—and non-neutral BCAs.

Due to the legal permissiveness of GATT regulatory exceptions, protectionism could find an easier entry into the border adjustment process under the cloak of exempted environmentalism. While a legal argument premised solely on the neutrality of border adjustments (i.e., not relying on GATT exceptions) would seem more compelling as a matter of policy, it would be fairly controversial as a matter of law because such measures rely on the elimination of environmental tax differentials based on *unincorporated* Process and Production Methods ("*u*-PPMs"). To date, no WTO (or pre-WTO) report has approved "tax" equalizations based on production process characteristics that target unincorporated inputs (e.g., emissions). To be clear, even if an importing country demonstrates that it adjusts only for the burden that product taxes or charges impose on domestic like products—such burden being at most equivalent to the carbon tax or charge imposed on the domestically produced good—it would be hard to demonstrate GATT-consistency where the adjustment in question was not based on a physically incorporated feature of the final product.

However, even assuming neutral BCAs were adjudged GATT-consistent without the use of a regulatory exception—a result we do not intend to prove in this article—no GATT provision requires that externality-internalizing measures optimally offset the environmental harm they are meant to address. Trade rules proscribe treatment that affords *protection*, not the imposition of measures that come short of maximizing *welfare*. Thus, the possibility that neutral BCAs—the most benign BCAs and the benchmark for our analysis—might be GATT-exempted should invite serious scrutiny if BCAs prove to be significantly inefficient from domestic and global welfare perspectives. Yet, only one trade law article has even mentioned the possibility of an "optimality gap" between a WTO-consistent measure and global (or even domestic) welfare (Horn and Mavroidis, 2011; Horn, 2006 (economics article)). As of this writing, no legal or economic research has sought to explain, much less formalize, how that gap emerges.

As Grossman and Helpman (1994) and others have illustrated, trade policy is not determined in a vacuum but is the outcome of a political process that can include rent-seeking activity by industries.[5] Producers in carbon-restricting countries would naturally favor the imposition of BCAs as they serve to "level the playing field" vis-à-vis competitors in non-carbon-restricting countries. While BCAs that equalize the level of exaction on imports to the level of exaction imposed on domestic like products seem intuitively fair and legally tenable (at least under one GATT exception), they may not be defensible on the grounds of economic efficiency.

This article provides the first exploration of how neutral BCAs relate to economic efficiency. To do so, we translate neutrality into an analytical construct that enables comparisons with efficiency, which, commonly, is expressed in analytical terms. Through a general equilibrium model that takes our neutral BCA benchmark as the starting point, we characterize economically efficient BCAs and show how they relate to the domestic carbon tax (or equivalent measure). We find that when the carbon-restricting country taxes carbon at the efficient rate, the BCA levels that maximize global welfare are lower than those permitted under the neutrality ceiling. The intuition for this finding is that BCAs, while combating the source of the negative externality (i.e., production resulting in emissions in non-carbon-restricting countries), simultaneously encourage consumption of carbon-intensive goods in non-carbon-restricting countries. We go on to show that for goods whose supply in the carbon-restricted country is highly price-elastic and whose production in the non-carbon-restricting country is highly carbon-intensive, the welfare-maximizing BCA levels are likely to be below those permitted under the neutrality ceiling, regardless of the domestic carbon tax rate imposed in the restricting country.

This discrepancy between neutrality and efficiency opens the door for industries to lobby for and secure inefficiently high BCAs that are WTO-compliant. Our analysis reveals that the trade law literature focus on GATT-compliant BCAs, although important, misses a fundamental point: GATT legality, however achieved, must be contextualized and enriched by the concept of economic efficiency. Otherwise, the world risks disregarding lower-cost, neutral alternatives (e.g., country-by-country taxation that prices in the environmental cost of emissions

[5] Briefly stated, rent-seeking refers to economic actors' pursuit of narrow, concentrated, unearned benefits or collective goods (i.e., rents), provided by governments through legislation or other public means, that imposes socially spread distributed costs. Tollison originally defined rent-seeking as the "activity of wasting resources in competing for artificially contrived transfers." (Tollison, 1982).

arising from production activities). Only such alternatives can provide a sufficiently robust argument for global coordination on carbon emissions.

The rest of this article is organized as follows: Section I translates neutrality into analytical terms by formalizing the WTO non-discrimination principles. Being non-discriminatory, such benign BCAs still seek to equalize carbon taxes on the basis of unincorporated inputs to production processes, which, under the prevailing view, require resort to the environmental exception under GATT art. XX.[6] Section II describes the economic environment and the equilibrium of the model; Section III characterizes the optimal BCAs and compares these to neutral BCAs; Section IV considers extensions to the model, particularly two possible responses by the unregulated country: the subsequent imposition of an emissions tax and the adoption of cleaner production technologies in response to BCAs. Section IV also considers the case where the carbon-regulating country sets its BCAs with an objective other than global welfare. Because we demonstrate that neutral BCAs can be exposed to industry rent-seeking and, thus, further deviate from optimality, we conclude by recommending resort to multilaterally negotiated emission reductions as the preferred solution to this coordination problem.

I. Domestic Climate Policy, Neutrality and GATT Article XX

In WTO parlance, neutrality means not discriminating between foreign and domestic products or among foreign products. Non-discrimination between foreign and domestic products or the National Treatment ("NT") Principle is a requirement of GATT art. III,[7] while non-discrimination among foreign products or the Most Favored Nation ("MFN") Principle is a requirement of GATT art. I.[8] Note that many commentators have argued for the GATT-legality

[6] Specifically, GATT art. XX(g)'s exception, commonly known as "GATT's environmental" exception, allowing derogation from free trade to domestic measures "relat[ed] to the conservation of exhaustible natural resources."

[7] Henceforth, unless otherwise indicated, we use the terms NT-neutrality and neutrality interchangeably.

[8] While we formalize MFN-neutrality in this Section, we discuss it separately, in more detail, in Appendix A.2.

of BCAs by resorting to the GATT Article XX(g) exception,[9] which we discuss in Section I.B. To these scholars, the problem with BCAs that requires resort to the exception stems not from deviations from neutrality, but from their targeting emissions as an unincorporated production input (i.e., the *u*-PPM issue). While we understand the literature's focus on the *u*-PPM controversy, we begin by first defining neutral BCAs as a benchmark. We hope that WTO jurisprudence evolves beyond the *u*-PPM question, eventually making BCAs less controversial. Our use of neutral BCAs reflects our support for adopting the more efficient policy option among BCAs, in case optimal domestic emission-pricing measures are not universally adopted. If deemed WTO-consistent, neutral BCAs should help the trade system avoid opening the door to worse options.

A. Formalizing Neutral BCAs

Suppose a good i is produced in two countries: *Home* (H) and *Foreign* (F). Carbon emissions are proportional to the production of good i, but the emissions intensity of production may differ across jurisdictions. Each unit of output produced in *Home* results in α_{Hi} tons of carbon emissions, while each unit produced in Foreign results in α_{Fi} tons. Producers in *Home* face a tax on carbon emissions, which we represent as an output tax, denoted t_{Hi}.[10] In contrast, *Foreign* is a non-carbon-restricting jurisdiction where producers pollute at no cost. However, *Home* can impose a BCA in the form of a tariff, τ_i, on imports from *Foreign*.[11]

The NT-principle describes a relationship of non-discrimination between *Home*'s carbon measure on the domestically produced good and its BCA on the imported good. Under a NT-

[9] Note 4 provides a list of these commentators. Despite some BCA-skepticism, Pauwelyn (2007) argues that "[a] U.S. carbon tax or emission credit requirement or other regulation on imports can still be justified under GATT Article XX."

[10] Because emissions are proportional to output, a tax on emissions can be represented as a (good-specific) tax on output. This representation also applies if, instead of a tax, the emissions regulation takes the form of a cap-and-trade program where permits for emissions must be bought at a market price. (We assume each producer is a price-taker in the emission-permit market).

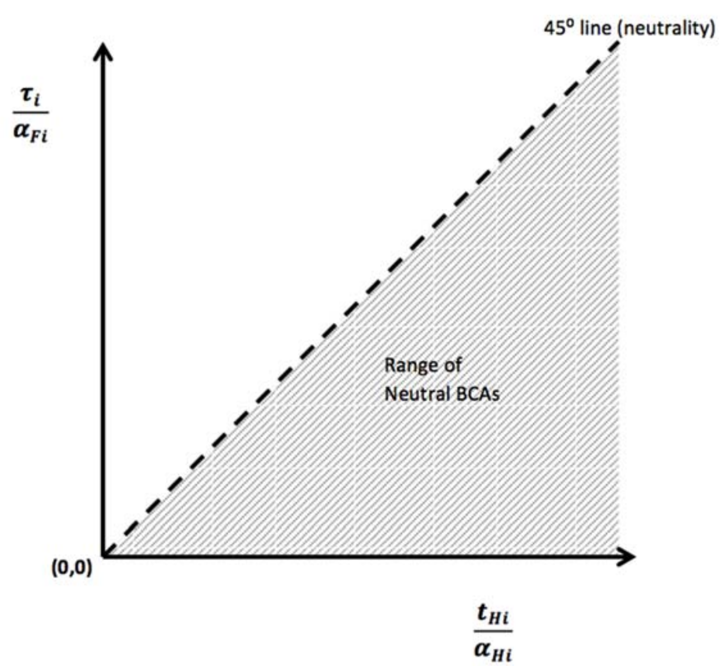
[11] An import tariff would apply if *Home* is a net importer of the good. If *Home* is a net exporter, the corresponding BCA measure would be an export rebate. The analytical representation is the same as the tariffs interpreted as a subsidy when net imports are negative. As we are primarily interested in the case where *Home* imports the polluting good, the ensuing discussion is framed in terms of tariffs. However, we do address the legal basis for export rebates in Appendix A.1.

neutral BCA, the carbon content of imported goods (α_{Fi}) cannot be taxed at a higher rate than that of domestically produced goods (α_{Hi}). Thus, a tariff, τ_i, qualifies as neutral if:

$$\frac{\tau_i}{\alpha_{Fi}} \leq \frac{t_{Hi}}{\alpha_{Hi}} \qquad (1)$$

Figure 1 (see below) graphically illustrates the relationship between Home's carbon measure and a NT-neutral BCA. Instead of output, we have used carbon emissions as the measuring unit; hence the horizontal and vertical axes are $\frac{t_{Hi}}{\alpha_{Hi}}$ and $\frac{\tau_i}{\alpha_{Fi}}$ respectively. The 45-degree line demarcates the highest possible import tariff that satisfies NT-neutrality for any given carbon tax at *Home*.[12] Formalizing neutrality thusly allows for intuitive comparisons with the efficiency-based concepts we introduce later in Sections II-IV.

Figure 1: Neutral Tariff as Function of *Home* Emissions Tax



GATT's other neutrality requirement, the MFN-principle, can also be expressed analytically. Assume a second foreign country, denoted $\tilde{F}$ that does not mitigate emissions

[12] As Poterba and Rotemberg (1995) explain, "when it is possible to measure the amount of the taxed intermediate good that is used to produce an imported final good, an import tax equal to the tax on the intermediate good times the amount of the intermediate good used in domestic production of the final good will raise the marginal cost of domestic and foreign producers by the same amount."

either. A unit of good i produced in $\tilde{F}$ results in $\alpha_{\tilde{F}i}$ tons of carbon emissions. Let $\tilde{\tau}_i$ denote the tariff on *Home*'s imports from $\tilde{F}$. The tariffs τ_i and $\tilde{\tau}_i$ are consistent with the MFN-principle if:

$$\frac{\tau_i}{\alpha_{Fi}} = \frac{\tilde{\tau}_i}{\alpha_{\tilde{F}i}} \quad (2)$$

This analytical structure, relating domestic carbon measures, tariffs and carbon intensities forms the basis of our legal and economic analysis. Section I.B discusses briefly the legal basis for implementing neutral BCAs in light of pre- and post-WTO, GATT jurisprudence.[13] While Section I.B addresses the core legal issues pertaining to product BCAs, non-lawyers, willing to bypass this important discussion, may skip to Section II where we provide a formal analysis of the efficiency of NT-neutral BCAs.

B. BCAs and the Process and Production Method ("PPM") Controversy

Because BCAs would effectively extend domestic *u*-PPM regulations to imports, reliance on GATT art. XX's environmental exception might be necessary if BCAs are to be deployed in a GATT-consistent manner.[14] While, to date, WTO Members have not implemented BCAs, GATT has allowed the imposition of border tax adjustments ("BTAs") on inputs *incorporated* into the final imported product. All GATT has required is for Members imposing BTAs not to tax imports in excess of domestic like products.[15] Indeed, trade adjudicators have both approved and struck down BTAs depending on whether they satisfy or violate this equivalence condition.[16]

[13] By the express language of Article 1(a) of the General Agreement on Tariffs and Trade 1994, the provisions of GATT remain effective "as rectified, amended or modified by the terms of the" more recent WTO agreements (see GATT (1994) in References). Since 1995, WTO panels and the Appellate Body have deliberated and made rulings on disputes submitted by aggrieved Members under the supervision of the Dispute Settlement Body ("DSB"), established pursuant to Article 2(1) of the Understanding on Rules and Procedures Governing the Settlement of Disputes.

[14] In another paper, Colares (2017) makes a more parsimonious argument that reliance on GATT art. XX is not necessary to secure WTO approval of neutral BCAs.

[15] Textually, GATT art. II:2(a) refers to "a charge equivalent to an internal tax" that is consistent with art. III:2. Article III:2 requires, in turn, parity of border measures with "internal taxes or other internal charges of any kind" (GATT, 1947). Thus, by referring to taxes or charges interchangeably, both provisions do not refer to "taxes" in a strict sense.

[16] For instance, compare *US–Petroleum and Imported Substances Taxes* or *Superfund* (1987), ¶¶ 2.3-2.4 & 3.1.1, a GATT Panel Report upholding a U.S. BTA on certain chemicals and on certain substances

1. Bans, BTAs and PPMs

Both GATT drafting history and jurisprudence look favorably on adjustments for indirect taxes on inputs *embodied* in final products.[17] In particular, at least one prior decision upheld a BTA corresponding to an environmental internal tax. The GATT panel in *United States–Taxes on Petroleum and Certain Imported Substances* heard a challenge under GATT art. III:2 (and implicitly under GATT art. II:2(a)) to U.S. legislation that imposed a BTA on certain chemicals and on certain substances made from such chemicals, all of which had been subject to a domestic tax (the so-called "Superfund" tax) (*US–Petroleum and Imported Substances Taxes* or *Superfund*, 1987). The GATT panel, following the Legal Drafting Committee's views on BTAs, held that so long as (i) the environmental BTA is an adjustment for a domestic tax imposed on products, the only remaining issue is (ii) whether the BTA is nondiscriminatory. After making affirmative determinations on both questions, the panel approved the U.S. BTA.

Because carbon emissions are not physically embodied in final products (i.e., emissions are "unincorporated," in WTO parlance), one cannot rely solely on the *Superfund* decision to make the case for the WTO-compatibility of emissions-based tariffs (Pauwelyn, 2007).[18] Indeed, before creation of the WTO, two unadopted GATT Panel Reports struck down U.S. bans on imported tuna not harvested under conditions that minimized incidental dolphin deaths, an *unincorporated* PPM ("u-PPM") requirement imposed on domestic shrimpers (Report of the

made from petroleum that had been subject to an *equivalent* domestic tax, with *India–Additional Duties* (2008), ¶¶ 214, 221, a WTO Panel Report striking down India's BTAs "insofar as [they] result[ed] in the imposition of charges on imports . . . *in excess of* excise duties . . . sales taxes, value-added taxes and other local taxes and charges" applied on domestic like products (emphases added). The secondary literature has made tentative arguments for the compatibility of BCAs with GATT arts. II:2(a) and III:2 (see sources in note 4 and WTO-UNEP (2009). We shall not repeat those arguments here.

[17] For instance, in the early decades of GATT, the Legal Drafting Committee, commenting on GATT art. II:2(a), observed that a charge "equivalent" to an internal tax could be "imposed on perfume because it contains alcohol," explaining that such a charge "must take into consideration the value of the content and not the value of the whole" (GATT Analytical Index, 2017).

[18] While noting that "the [*Superfund*] panel did not specify whether [the covered] chemicals still had to be physically present in the imported product" to be subject to a tariff, Pauwelyn (2007) indicates that "[n]o GATT or WTO decision was ever rendered on . . . a . . . [tax or tariff], not related to the physical characteristics of the final imported product." De Cendra (2006), referring approvingly to *Superfund*, also posits that "doubts over the capability of GATT . . . to tolerate BTAs coupled with emission trading schemes make an analysis . . . of Article XX of GATT necessary."

Panel, *US–Tuna/Dolphin II*, 1991; Report of the Panel, *US–Tuna/Dolphin I*, 1982). Resort to authority under the GATT art. XX environmental exception appears as the most likely route for BCA approval under the WTO system.

Among WTO cases invoking such exception, the 2001 Appellate Body Report in *United States–Import Prohibition of Certain Shrimp and Shrimp Products (Recourse to Article 21.5 by Malaysia)*, upholding a U.S. import ban based on a *u*-PPM requirement (Appellate Body Report, *US–Shrimp/Turtle Compliance*, 2001), holds most promise for BCAs.[19] The challenged U.S. measure—requiring the use of turtle excluder devices ("TEDs") on trawling nets to reduce the incidental bycatch of sea turtles, a protected species—was deemed justified under GATT art. XX(g)'s environmental exception, which gives Members discretion to adopt pro-environment border measures "made effective in conjunction with restrictions on domestic production or consumption."[20]

Specifically, Malaysia argued that "condition[ing] access to [a] market on compliance with policies and standards 'unilaterally' prescribed by the [importing Member] constituted . . . 'arbitrary or unjustifiable discrimination'" (Appellate Body Report, *US–Shrimp/Turtle Compliance*, 2001). In response, however, the Appellate Body ruled that imposing "regulatory programmes *comparable in effectiveness* to that of the importing Member gives sufficient latitude to the exporting Member" to implement measures that "achieve the level of effectiveness required" (*id.* at ¶ 144), thus allowing the latter to avoid the ban. In the Appellate Body's view, so long as border measures are flexible enough to accommodate varying but "comparably effective" methods of regulation prevailing abroad, Members are free to adopt environmentally motivated border measures (*id.* at ¶ 148).

2. A Cautious Legal Case for GATT-Consistent, Neutral BCAs

---

[19] This particular Report discussed two important, prior Reports that will also be mentioned in the following discussion, namely: Panel Report, *United States–Shrimp/Turtle* (1998); and Appellate Body Report, *US–Shrimp/Turtle* (1998). As before, full cites appear in References.

[20] Note that to qualify for a GATT art. XX(g) exception, a Responding Member must also comply with the strictures of the Article's chapeau, namely, the measure cannot be "applied in a manner [that] would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or [be] a disguised restriction on international trade . . ." (GATT, 1947).

While *US–Shrimp/Turtle Compliance* is most recognized for its reliance on a GATT regulatory exception to uphold a pro-environment ban, it is also noteworthy for marking the Appellate Body's first approval of a border measure that effectively implemented a *u*-PPM requirement (*id.* at ¶¶ 147-48). Surprisingly, nowhere in that ruling did the Appellate Body feel compelled to comment on the full implications of such a momentous decision. To the Appellate Body, the controlling question was, rather, whether the importing country's border measure accommodates "comparably effective" regulatory "programmes" in exporting countries. Although we recognize that the Appellate Body has yet to consider precisely whether tariffs implementing *u*-PPM requirements are GATT-compatible and note that this question remains controversial, *US–Shrimp/Turtle Compliance*'s endorsement of a *ban* enforcing a *u*-PPM is unequivocal.[21] Allowing importing Members to invoke GATT art. XX(g) to justify bans enforcing *u*-PPMs, yet not allowing Members to adopt trade-neutral *tariff* adjustments that do the same would not seem sensible. Bans are unquestionably the more trade-restrictive border measure.

Yet, BCA approval under Article XX(g) could be too permissive: carbon-intensive imports from non-carbon-restricting Members could be banned altogether for lack of a measure of "comparable effectiveness," regardless of the actual carbon intensity of such imports.[22] Clearly, in this instance, a ban would not be commensurate with the domestic measure—only a tariff could be. Furthermore, neutral BCAs, unlike bans, appear within the policy space contained in the shaded region of Figure 1 and have an analytical structure that allows nontrivial comparisons in terms of their relative efficiency.

[21] Whether such endorsement extends to BCAs is discussed in another trade law paper: Colares, 2017.

[22] This point is particularly important in light of trade lawyers' and trade economists' heavy reliance on Article XX arguments when discussing BCAs (e.g., Tran, 2010 (law); Ismer and Neuhoff (2004) (applied economics)). Horn and Mavroidis (2011) remain, to date, the only trade law scholars to have offered a legal analysis supporting BCAs where Article XX(g) is scarcely mentioned. The duo uses legal interpretive techniques to support the conclusion—also correct in our view—that GATT art. II:2(a) allows tariffs equivalent to art. III:2-consistent internal taxes in the case of *u*-PPMs (*id.*; Horn and Mavroidis, 2010). Notably, they are also the first legal scholars to extensively discuss the possibility of BCA deployment for protectionist purposes (Horn and Mavroidis, 2011). Even trade law scholars who are lukewarm to BCAs—for reasons not related to efficiency—also rely heavily on GATT art. XX rationales (Pauwelyn, 2007).

This concludes our *legal* analysis of neutral BCAs under the WTO regime. Legally inclined readers may refer to Appendix A.1 for a discussion of how *Home*'s carbon taxes can be rebated on export transactions without running afoul of WTO subsidy disciplines. Appendix A.2 explains how BCAs can be compatible with MFN-neutrality (i.e., the requirement not to discriminate on the basis of national origin). As explained above, theoretical and methodological parsimony compels us to consider only neutral BCAs in the formal analysis that follows. Even if such BCAs are eventually upheld as WTO-compatible, they might still be far from optimal from domestic and global welfare standpoints.

II. Formalizing BCAs: Carbon Taxes, Import Tariffs and Trade Equilibrium

A. First Steps

We develop an economic model in which trade takes place between two large countries- *Home* and *Foreign*. Emissions of carbon are a byproduct of goods production and cause a global negative externality. Producers in *Home* face a price on carbon emissions. In contrast, *Foreign* is a non-carbon-restricting jurisdiction where producers pollute at no cost. However, *Home* may pursue a BCA in the form of tariffs on imports from *Foreign* (or export rebates if *Home* is an exporter). It should be highlighted that our analysis takes place in a second-best setting in which the first-best policy option (i.e., a country-by-country tax on carbon emissions set at the rate of marginal damage) is not politically feasible.

B. Economic Environment

1. Consumption, Production and Externalities

The number of consumers in *Home* and *Foreign* is denoted by N_H and N_F, respectively. In each country, consumers consume a numeraire good (indexed *0*), produced by labor alone, and n non-numeraire goods (indexed $1, \ldots, n$), produced using labor and a sector-specific input.[23] Individuals have identical quasilinear and additively separable preferences over the goods. Utility maximization subject to a budget constraint leads to an individual demand

[23] In both countries, we assume each sector-specific input is in inelastic supply and aggregate labor supply is also inelastic. Labor supply in each country is assumed to be large enough such that each country's equilibrium consumption of the numeraire good is positive. This ensures that the equilibrium wage rate equals 1.

function, d_i, for each good $i = 0, \ldots, n$. Let D_{Hi} and D_{Fi} denote aggregate *Home* and *Foreign* consumption demand.[24]

All goods are produced using constant-returns-to-scale technology and are sold under perfect competition. Let Y_{Hi} and Y_{Fi} denote *Home* and *Foreign* output of good *i* respectively, and let Π_{Hi} and Π_{Fi} denote the total rents accruing to the good *i*-specific input, in *Home* and *Foreign* respectively.

Carbon dioxide is released into the atmosphere during the production of the *n* non-numeraire goods. We assume carbon emissions are proportional to output but allow the emissions intensity of production to differ both by good and by location of production. Global carbon emissions from production of good *i* (denoted E_i) are:

$$E_i = \alpha_{Hi} Y_{Hi} + \alpha_{Fi} Y_{Fi}, \qquad (3)$$

where α_{Hi} and α_{Fi} are the respective *Home* and *Foreign* emissions intensities. As carbon is not a local pollutant, damage depends on the total quantity of emissions from all sources worldwide. We express per-capita damage from carbon emissions as a function of total global emissions: $v(E)$, with $E \equiv \sum_{i=1}^{n} E_i$.[25]

2. Emissions Taxes and Import Tariffs

Producers in *Home* must pay a price for emitting carbon. We represent this as an output tax on good *i*, denoted t_{Hi}.[26] Moreover, *Home* can impose a BCA in the form of tariffs on imports from *Foreign*. An import tariff on good *i* (τ_i) creates a wedge between its world price (p_i) and its domestic producer and consumer prices. An emissions tax, in contrast, imposes an added cost on production and creates a wedge between domestic producer and consumer prices. Thus, the *Home* consumer price for good *i* is $p_i + \tau_i$, while the *Home* producer price is $p_i + \tau_i$ -

[24] $D_{Hi} = N_H * d_i$; $D_{Fi} = N_F * d_i$.

[25] For purposes of the model, the damage is assumed to be the same for all individuals worldwide.

[26] Because emissions are proportional to output, with each good produced under a specific emission intensity, a tax on emissions can be represented as a good-specific tax on output. As discussed previously, this representation also applies in the case of a permit price in a cap-and-trade program: we assume each producer is a price-taker in the emissions permit market—an extension of the perfect competition assumption.

t_{Hi}. We assume the *Home* government redistributes the tax and tariff revenue uniformly to all N_H individuals.

3. Trade Equilibrium

Market clearing requires world supply to equal world demand for each good, or equivalently, *Home* imports to equal *Foreign* exports. Formally, for each good *i*:

$$D_{Hi}(p_i + \tau_i) - Y_{Hi}(p_i + \tau_i - t_{Hi}) = Y_{Fi}(p_i) - D_{Fi}(p_i) \tag{4}$$

where D_{Hi} and D_{Fi} are *Home* and *Foreign* demand functions, and Y_{Hi} and Y_{Fi} are the *Home* and *Foreign* supply functions for each good *i*.

Because *Home* is a large country, any change in taxes or tariffs affects equilibrium world prices. A marginal increase in the emissions tax, by raising *Home* production costs, has the effect of raising the equilibrium world price (p_i). In contrast, a marginal increase in the tariff lowers the world price by dampening *Home* demand. We denote these effects $\partial p_i/\partial t_{Hi} \equiv \delta_i$ and $\partial p_i/\partial \tau_i \equiv -\phi_i$. Note that δ_i and ϕ_i always lie between 0 and 1.[27]

In summary, the need for BCAs arises solely because *Home*'s environmental measure (i.e., emissions tax) raises equilibrium world prices, thereby stimulating production and emissions in *Foreign*. Conversely, the effectiveness of BCAs in curbing *Foreign* emissions stems entirely from their ability to depress world prices. Without consideration of these general equilibrium effects, an economic model of BCAs would be a non-starter.

III. Optimal Tariffs

A. Components of Welfare

[27] Appendix B.1 provides full derivations of δ_i and ϕ_i. Because δ_i lies between 0 and 1, a *ceteris paribus* marginal increase in the tax (t_{Hi}) results in a lower *Home* producer price ($p_i + \tau_i - t_{Hi}$), even after considering the effect on the world price (p_i) in equilibrium. The increase in the tax leads to a higher *Home* consumer price ($p_i + \tau_i$), however, solely through the higher world price (p_i). Similarly, because ϕ_i lies between 0 and 1, a *ceteris paribus* marginal increase in the tariff (τ_i) results in a higher *Home* producer price and consumer price.

In the economic environment just described, global welfare comprises aggregate income (i.e., labor income, rents from sector-specific input, tax and tariff revenue)[28] and consumer surplus, less the damage from emissions.

It is evident that taxes and tariffs not only affect overall global welfare, but also create winners and losers through their impact on producer and consumer prices. *Home* producers are hurt by an emissions tax, but benefit from an import tariff as the former effectively lowers the producer price, while the latter raises it. In contrast, *Foreign* producers benefit from *Home*'s emissions tax, which raises the world price, but are hurt by any import tariff imposed by *Home*. Taxes and tariffs also affect consumer surplus in both *Home* and *Foreign*. *Home* consumer surplus is reduced by both the tax and tariff as both lead to a higher consumer price.[29] *Foreign* consumer surplus is decreasing in *Home*'s tax but increasing in the tariff. Aside from these changes in consumer surplus, consumers in both *Home* and *Foreign* also benefit from any reductions in environmental damage due the tax and tariff.

The problem of leakage arises when *Home* imposes an emissions tax that is not accompanied by a tariff on *Home* imports. While the tax has the effect of lowering *Home* production, it also raises the world price, thus leading to an increase in *Foreign* production of good *i* equal to $\delta_i * (\partial Y_{Fi}/\partial p_i)$. The increase in emissions from higher *Foreign* production may exceed the reductions due to lower *Home* production and possibly lead to a net increase in total global emissions, depending on differences in emissions intensities in *Foreign* and *Home*.

The efficiency consequences of import tariffs are also salient. While tariffs raise revenue, combat *Foreign* emissions and benefit *Home* producers, they also create deadweight loss by distorting consumption decisions. While taxes (t_{Hi}) correct for a negative externality by precisely targeting it at its source (i.e. supply), tariffs (τ_i) take aim at supply and demand equally.[30] Deadweight loss arises due to a distortion in the consumer price signal, even though the externality is entirely on the supply side. In short, tariffs are an imperfect policy instrument

[28] The same setup applies if instead of an emissions tax, there exists a cap-and-trade program in *Home*. The tax revenue component would instead be revenue from permit sales.

[29] Although we do not explicitly model it, producers who purchase an intermediate good as an input to producing a final good (e.g., car manufacturers, with tires as an intermediate good) are hurt by import tariffs on the intermediate good.

[30] This is evident through the direct effect of tariffs on the *Home* consumer price.

for reducing global emissions because they target imports rather than *Foreign* production. Due to this inherent imperfection, even the most well-meaning BCAs cannot achieve the first-best outcome for maximizing global welfare; the first-best is only achieved through a uniform tax on emissions in both *Home* and *Foreign*, set at a rate equal to the marginal damage.[31] We are thus dealing with a setting where only second- or third-best policy options are viable. In the following proposition, we establish that in a setting without a worldwide emissions tax, global welfare is maximized through an emissions tax at *Home* set equal to the rate of global marginal damage, along with import tariffs that are lower than the rate of global marginal damage.

B. Maximizing Global Welfare

Proposition 1 (Second-Best Policy for Global Welfare, without *Foreign* Emissions Tax):[32]

When the only available policy instruments are an emissions tax at *Home* along with import tariffs, the second-best level of global welfare is achieved by setting taxes:

$$t_{Hi}^{**} = (N_H + N_F)\alpha_{Hi}v'(E) \tag{5}$$

and tariffs:

$$\tau_i^{**} = \frac{(N_H+N_F)\alpha_{Fi}v'(E)Y_{Fi}'(p_i)}{Y_{Fi}'(p_i)-D_{Fi}'(p_i)}, \tag{6}$$

where *v'(E)* is the marginal individual damage from emissions, $\mathrm{Y}_{\mathrm{Fi}}'(p_i) > 0$ is the slope of the *Foreign* supply curve and $D_{\mathrm{Fi}}'(p_i) < 0$ is the slope of the *Foreign* demand curve at p_i.

While it remains optimal to tax *Home* emissions at the rate of marginal damage, the optimal import tariffs are actually less than the marginal damage.[33] The motivation for this result comes from the fact that it is production, not imports, that generates harmful emissions.

[31] Formally, the tax at *Home* should be set to $t_{Hi} = (N_H + N_F)\alpha_{Hi}v'(E)$ while the tax in *Foreign* should be set to $t_{Fi} = (N_H + N_F)\alpha_{Fi}v'(E)$.

[32] Please refer to Appendix B.2 for a proof of this proposition. Balistreri et al. (2014) provide a version of this proposition, and Markusen (1975) formalizes the theory of cross-border pollution taxation.

[33] Specifically, τ_i^{**} is equal to the marginal damage multiplied by $\frac{Y_{Fi}'(p_i)}{Y_{Fi}'(p_i)-D_{Fi}'(p_i)}$, which is less than one.

Taking aim at imports, which are a net quantity of production less consumption, generates deadweight loss by distorting consumption decisions, and, for this reason, the optimal tariffs are less than the marginal damage.

Neutrality permits higher tariffs than τ_i^{**}. If *Home* production of good *i* is subject to the carbon tax represented by t_{Hi}^{**}, neutrality allows the tariff to be as high as $(N_H + N_F)\alpha_{Fi}v'(E)$ (i.e., the global marginal damage from *Foreign* production).

We now consider a scenario where *Home* already imposes a tax on emissions at a previously determined rate, which may not equal the rate of marginal damage. This scenario represents a third-best setting where import tariffs are the only policy lever available. The situation in the EU can be conceived along these lines. The EU Emissions Trading Scheme already imposes a previously decided emissions cap that is embodied in the permit price. Given the existing policy, what are the optimal BCAs the EU should adopt? The fundamental policy determination to be made at this point is: what are the optimal import tariffs for global welfare given the preexisting tax, and do these tariffs meet the criterion of neutrality?

Proposition 2 (Optimal Tariffs for Global Welfare, Given a Preexisting Emissions Tax):[34]

If *Home* already imposes a previously determined emissions tax represented by tax rates $\hat{t}_{Hi}$ for goods $i = 1, \ldots, n$, the optimal import tariffs are:

$$\widehat{\tau_i}^{**} = \tau_i^{**} - \frac{[(N_H+N_F)\alpha_{Hi}v'(E)-\hat{t}_{Hi}](1-\phi_i)Y_{Hi}'}{\phi_{i^*}[Y_{Fi}'-D_{Fi}']}. \qquad (7)$$

The first term in $\widehat{\tau_i}^{**}$ is simply τ_i^{**}, which is already below marginal damage. Furthermore, a second term incorporating the preexisting emissions tax can bring the optimal tariffs even further below marginal damage.[35] Specifically, compared to a tax that is set at marginal damage, a tax that is set below marginal damage warrants tariffs that are even further below marginal damage. However, the tax-tariff relationship does not exactly align with neutrality. In the special case where $\hat{t}_{Hi} = (N_H + N_F)\alpha_{Hi}v'(E)$, i.e., the tax equals marginal damage, Proposition 1 establishes unambiguously that the efficient tariff is strictly less than the

[34] Please refer to Appendix B.3 for a proof of this proposition.

[35] In the case where the tax is set optimally to equal marginal damage, the second term vanishes.

highest permitted tariff under neutrality (i.e., $\frac{\hat{\tau}_i^{**}}{\alpha_{Fi}}$ is strictly less than $\frac{\hat{t}_{Hi}}{\alpha_{Hi}}$). We can characterize when this situation holds, more generally, by comparing $\frac{\hat{\tau}_i^{**}}{\alpha_{Fi}}$ with $\frac{\hat{t}_{Hi}}{\alpha_{Hi}}$ for any arbitrarily selected $\hat{t}_{Hi}$. It turns out that the key variables for this comparison are the emissions intensities and the price-responsiveness of supply and demand in *Home* and *Foreign*.

While the mathematical details can be found in Appendix B.4, we focus here on sufficient conditions under which the efficient tariff is guaranteed to be strictly less than the highest permitted tariff under neutrality. Of particular significance is the net change in global emissions due to a marginal increase in the tariff (given a fixed $\hat{t}_{Hi}$). Marginally increasing the tariff has two opposing effects on global emissions. On one hand, it leads to lower *Foreign* production, and consequently lower *Foreign* emissions, brought about through a lower world price. On the other hand, it leads to increased *Home* production and emissions. Formally, the decrease in *Foreign* emissions is $\phi_i \alpha_{Fi} Y'_{Fi}$. The increase in *Home* emissions is $(1-\phi_i)\alpha_{Hi} Y'_{Hi}$.

Proposition 3 (Sufficient Conditions to Ensure $\frac{\hat{\tau}_i^{**}}{\alpha_{Fi}} < \frac{\hat{t}_{Hi}}{\alpha_{Hi}}$):[36]

If Foreign production of good *i* is at least as emission-intensive as *Home* production of good *i* (i.e., $\alpha_{Fi} \geq \alpha_{Hi}$), and a marginal increase in the tariff on good *i* raises *Home* emissions by as much or more than it lowers *Foreign* emissions (i.e., $(1-\phi_i)\alpha_{Hi} Y'_{Hi} - \phi_i \alpha_{Fi} Y'_{Fi} \geq 0$), then $\frac{\hat{\tau}_i^{**}}{\alpha_{Fi}} < \frac{\hat{t}_{Hi}}{\alpha_{Hi}}$.

We use the term "susceptible goods" to refer to goods that always meet the conditions of Proposition 3, regardless of the level of $\hat{t}_{Hi}$.[37] Proposition 1 established that for *all* goods, the efficient tariff is below the maximum neutral tariff when $\hat{t}_{Hi}$ is set at the rate of marginal damage. However, for susceptible goods, the efficient tariff is below the maximum neutral tariff no matter where $\hat{t}_{Hi}$ is set. Although it is admittedly difficult to decisively identify a given good in the real world as "susceptible," the conditions of Proposition 3 do at least suggest some guidelines. Particularly, a good *i* is more likely to be susceptible if: (i) *Foreign* production of

[36] Please refer to Appendix B.4 for a proof of this proposition.

[37] It should be emphasized that Proposition 3 outlines *sufficient* conditions to ensure $\frac{\hat{\tau}_i^{**}}{\alpha_{Fi}} < \frac{\hat{t}_{Hi}}{\alpha_{Hi}}$. As shown in Appendix B.4, the necessary conditions are weaker than those in Proposition 3.

good i is at least as emission intensive as *Home* production of good i ; and (ii) the *Home* supply of good i is much more responsive to price than the *Foreign* supply of good i (i.e., $Y'_{Hi} > Y'_{Fi}$). Susceptible goods are of particular concern from a policy standpoint. For these goods, regardless of the *Home* emissions tax, NT-neutrality will not foreclose tariffs set at above the economically efficient level.

Figure 2 (see below) graphically displays Equation (7) for a susceptible good. The solid diagonal curve depicts the optimal tariffs and it must go through the coordinate:

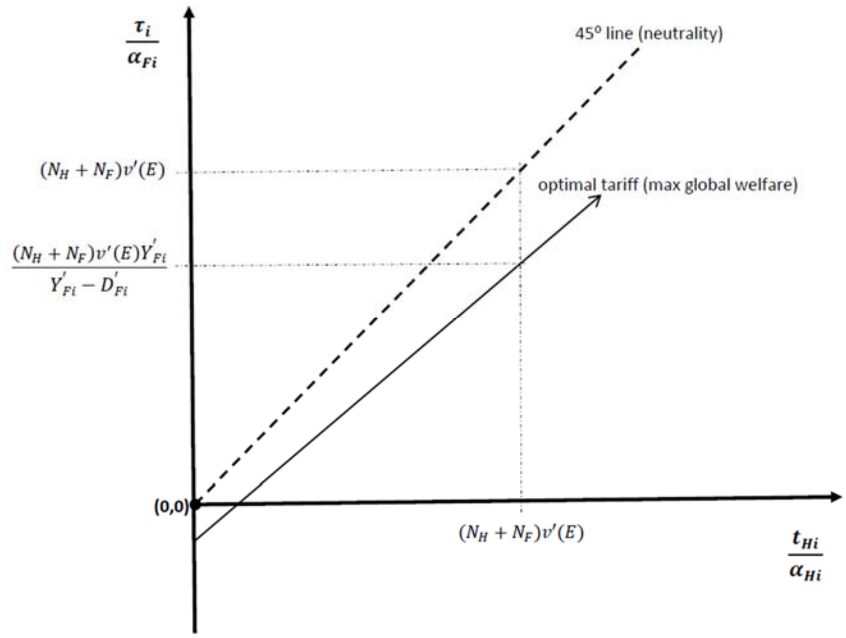
$$\left((N_H + N_F)v'(E), \frac{(N_H+N_F)v'(E)Y'_{Fi}}{Y'_{Fi}-D'_{Fi}}\right), \tag{8}$$

which corresponds to the second-best outcome from Proposition 1.[38] As in Figure 1, we have used carbon emissions as the measuring unit; hence the horizontal and vertical axes are $\frac{t_{Hi}}{\alpha_{Hi}}$ and $\frac{\tau_i}{\alpha_{Fi}}$ respectively. The 45-degree line demarcates the highest possible import tariff that satisfies neutrality for any given tax at *Home*. For susceptible goods, the maximum neutral tariff always exceeds the optimal tariff, regardless of the *Home* tax level.[39] The upshot is that neutral, WTO-consistent BCAs do allow a range of economically inefficient BCAs. This is of particular concern because neutral BCAs can further protectionist motives under the cloak of legality.

Figure 2: Optimal and Neutral Tariffs as Function of *Home* Emissions Tax (Susceptible Goods)

[38] Equation (7) does not stipulate that optimal tariffs ($\hat{\tau}_i^{**}$) will be linear in $\hat{t}_{Hi}$. The linearity in Figure 2 is for illustrative purposes only.

[39] Although it may appear counterintuitive, the optimal tariff for a susceptible good is actually negative when *Home* imposes no emissions tax ($\hat{t}_{Hi}$). This is reflected in the negative vertical intercept of the optimal tariff curve and is due to the fact that for a susceptible good, a marginal increase in the tariff (weakly) raises global emissions.



IV. Extensions

Our basic model has characterized the globally optimal environmental policies under the constraint that policy action is undertaken unilaterally by *Home*. In this section, we explore the implications of relaxing these conditions.[40] In particular, we consider cases in which: (a) the government in *Foreign* also levies an emissions tax; (b) *Foreign* producers respond to *Home*'s BCA by adopting less emission-intensive technologies; and (c) the *Home* government sets BCAs with objectives other than global welfare.

In Section IV.A, we demonstrate that should the government in *Foreign* also levy an emissions tax, the same kind of divergence between neutral and efficient BCAs would remain. In Section IV.B, where we allow *Foreign* producers to adopt less emission-intensive technologies in response to *Home*'s BCA, our model produces theoretically ambiguous results: an increase in *Home*'s BCA does not necessarily encourage adoption of such technologies. Finally, in Section IV.C, we show that where the *Home* government sets BCAs with objectives other than global welfare, neutral BCAs may be driven by protectionist motives. In particular, neutral BCAs may reflect *Home*'s exploitation of market power to increase its own aggregate

[40] Note that our model does not consider repeated interactions among economic agents in a multi-period setting. Thus, our results may not represent a long-run equilibrium. Nevertheless, the extensions in this section are meant to shed light on possible reactions to BCAs by various economic agents.

welfare at the expense of *Foreign*'s welfare. Furthermore, rent-seeking pressures from organized industries may lead to further deviations from economic efficiency.

A. Emissions Tax in *Foreign*

Suppose that *Foreign* has its own emissions tax, represented by tax rates t_{Fi} for goods $i = 1, \ldots, n$. Without loss of generality, suppose *Foreign*'s emissions tax is still lower than *Home*'s. In this case, neutrality stipulates that the carbon content of imported goods cannot be taxed at a higher rate than the difference between the *Home* and *Foreign* tax rates. Formally, a tariff, τ_i, qualifies as neutral if:[41]

$$\frac{\tau_i}{\alpha_{Fi}} \leq \frac{t_{Hi}}{\alpha_{Hi}} - \frac{t_{Fi}}{\alpha_{Fi}} \tag{9}$$

The divergence between neutral and efficient BCAs persists even in the more general case where *Foreign* producers are also subject to an emissions tax. Corollary 1 establishes that if *Home* taxes emissions at the rate of global marginal damage, the global optimal import tariffs continue to be lower than the neutral level.

Corollary 1 (Second-Best Policy for Global Welfare, Given *Foreign* Emissions Tax):[42]

If *Home* taxes emissions at the rate of global marginal damage (i.e., $t_{Hi} = (N_H + N_F)\alpha_{Hi}v'(E)$ for goods $i = 1, \ldots, n$), and *Foreign* has an emissions tax, represented by tax rates t_{Fi} for goods $i = 1, \ldots, n$, the optimal import tariffs are:

$$\tau_i = \frac{[(N_H+N_F)\alpha_{Fi}v'(E)-t_{Fi}]Y'_{Fi}(p_i)}{Y'_{Fi}(p_i)-D'_{Fi}(p_i)}. \tag{10}$$

Corollary 1 generalizes Proposition 1 by characterizing the optimal BCAs for an arbitrary rate of emissions taxation in *Foreign*. Even with this generalization, the optimal BCAs diverge from those permitted under the NT-principle. Specifically, NT-neutrality will permit τ_i to be set as high as $(N_H + N_F)\alpha_{Fi}v'(E) - t_{Fi}$, while Equation (10) indicates that the optimal tariff is clearly lower than this.

[41] Equation (1) thus represents a special case of Equation (9), where $t_{Fi} = 0$.

[42] Please refer to Appendix B.5 for a proof of this corollary.

B. Adoption of Cleaner Production Technologies in *Foreign*

Our basic model assumes that the emission intensities of goods produced is exogenously determined. However, one ostensible aim of BCAs is to encourage the adoption of less emission-intensive production technologies in the unregulated country (i.e., *Foreign*). Suppose *Foreign* producers of good *i* can reduce emission intensity by *r* tons per unit of output, at a cost *C(r)*, where the function *C* is increasing and convex in *r*. By construction, *Foreign* producers of good *i* are subject to a lower BCA if they reduce their emission-intensity. The lower BCA, in turn, entails their output fetching a higher price. In Appendix B.6, we solve for the profit-maximizing level of emission-intensity reduction (i.e., *r*) as a function of the BCA rate.

Somewhat counter intuitively, a higher BCA rate does not always lead to a greater reduction in emission intensity. In the particular case where *Home* starts with no BCA, a marginal increase in the BCA rate does unambiguously induce *Foreign* producers to reduce their emission intensity. However, this result does not necessarily hold if *Home* marginally increases an already high BCA rate. At a sufficiently high BCA rate, a one-unit reduction in emission intensity can be so effective in engendering a higher price that any further increase in the BCA rate may actually induce *Foreign* producers to choose a lower level of *r*.[43] This theoretical result is an environmental analogue of the well-known, backward-bending labor supply curve, where at a sufficiently high wage, an increase in the wage actually causes workers to work less.[44]

In summary, taking into account the effects on clean technology adoption in *Foreign* can provide analytical justification for a higher BCA, but only up to a point. Beyond that point, further increases in the BCA rate may even be counterproductive in promoting less emission-intensive production technologies. This effect has the potential to compound the economic inefficiencies already inherent in the highest NT-neutral BCAs.

C. Objectives other than Global Welfare

[43] Please refer to Appendix B.6 for mathematical details.

[44] This is due to the domination of the income effect over the substitution effect (Varian, 1999).

The discussion thus far has focused on optimal policies for maximizing global welfare, albeit in second- and third-best settings. We now consider how tariffs will be determined when the *Home* government is concerned with overall domestic welfare rather than global welfare.

Proposition 4 (Tariffs that Maximize *Home* Welfare, Given a Pre-existing Emissions Tax):[45]

If *Home* already imposes a previously determined emissions tax, represented by tax rates $\hat{t}_{Hi}$ for goods $i = 1, \ldots, n$, the following tariffs maximize *Home* welfare:

$$\hat{\tau}_i^* = \frac{N_H \alpha_{Fi} v'(E) Y_{Fi}'}{Y_{Fi}' - D_{Fi}'} - \frac{[N_H \alpha_{Hi} v'(E) - \hat{t}_{Hi}](1-\phi_i) Y_{Hi}'}{\phi_{i*}[Y_{Fi}' - D_{Fi}']} + \frac{p_i}{\epsilon_{Fi}^X}, \quad (11)$$

where ϵ_{Fi}^X denotes the price elasticity of *Foreign* export supply.[46]

Two important differences between $\hat{\tau}_i^{**}$ and $\hat{\tau}_i^*$ are evident. First, the initial two terms of $\hat{\tau}_i^*$, while resembling $\hat{\tau}_i^{**}$ in structure, do not include marginal environmental damage occurring in *Foreign*.[47] This occurs because the *Home* government does not take into consideration environmental damage abroad.[48] For susceptible goods, the lack of concern for *Foreign* environmental damage exerts upward pressure on tariffs (see Appendix B.7.b.)

Second, $\hat{\tau}_i^*$ includes a terms-of-trade effect, $\frac{p_i}{\epsilon_{Fi}^X}$, which is absent in $\hat{\tau}_i^{**}$ and reflects *Home*'s exercise of market power. Because *Home* is a large country whose actions affect world prices, it may set higher tariffs on all goods to increase its aggregate welfare at the expense of *Foreign* welfare.[49] Ordinarily, setting any tariff with the sole purpose of exploiting market power would violate GATT. Of course, WTO members are aware of this and might impose a BCA ostensibly to offset a domestic emission tax. As shown in the preceding section, such

---

[45] Please refer to Appendix B.7.a for a proof of Proposition 4.

[46] $\epsilon_{Fi}^X \equiv \left(\frac{\partial(Y_{Fi} - D_{Fi})}{\partial p_i}\right)\left(\frac{p_i}{(Y_{Fi} - D_{Fi})}\right)$.

[47] Formally, instead of $N_H + N_F$, $\hat{\tau}_i^*$ only contains N_H.

[48] Although we have taken the domestic emissions tax as pre-determined, the indifference to *Foreign* environmental damage would also cause *Home* to set a lower emissions tax on domestic producers. If maximizing *Home* welfare only, taxes would be set to $t_{Hi}^* = N_H \alpha_{Hi} v'(E)$ rather than $(N_H + N_F)\alpha_{Hi} v'(E)$.

[49] In the case where *Home* is a net exporter, the terms-of-trade effect drives the export subsidy lower.

protectionist motives would not be entirely curtailed by meeting the neutrality requirement, which does not always foreclose tariffs set at above economically efficient levels.

While Proposition 4 illustrates how neutral BCAs that maximize *Home* welfare can be suboptimal from the standpoint of global welfare, it is also possible that neutral BCAs can come short of maximizing *Home* welfare. This insight stems from Grossman and Helpman's 1994 work on the political economy of protectionism. In their "Protection-for-Sale" model, politically organized industries seek to influence the tariff structure via financial contributions to the *Home* government. Industries desire higher tariffs on the goods they produce but lower tariffs on other goods (Grossman and Helpman, 1994). The *Home* government, on its part, maximizes a weighted sum of domestic welfare and industry contributions. In this setting, industry lobbying creates a pattern of deviations from *Home*-welfare-maximizing tariffs, with tariffs for organized sectors pushed higher and those for unorganized sectors pushed lower.[50] In light of Grossman and Helpman's (1994) results (and basic public choice intuition), even NT-neutral BCAs might be arrived at in this manner.

In summary, where the *Home* government is concerned with domestic rather than global welfare and is subject to pressure from organized industries, tariff inefficiencies will result. The sources for these inefficiencies include: (i) the exploitation of market power to increase *Home* welfare at the expense of *Foreign* welfare; and (ii) lobbying activity of organized industries to raise tariff levels on their own goods and lower those on other goods. Taking these factors into account, there is the real possibility that BCAs for susceptible goods produced by organized industries will be set higher than the global welfare-maximizing level, while still being economically neutral. The influence of industry lobbying also generates inefficiencies even if only *Home* welfare is considered. Moreover, apart from the inefficiencies in the tariffs themselves, additional welfare loss occurs due to the wasteful use of resources in rent-seeking activity (i.e., political contributions, etc.).

Conclusion

[50] Note that these deviations follow a modified Ramsey rule, as the *Home* government seeks to minimize deadweight loss while satisfying lobby demands. Moreover, the *Home* government's relative weighting of contributions *versus* overall welfare influences the magnitude of all deviations. The more the *Home* government cares about national welfare relative to contributions, the smaller will be the deviations.

This article explores the tension between neutrality and efficiency: we used the GATT art. XX environmental exception to justify NT-neutral BCAs (a controversial *u*-PPM measure) and compared these to global welfare-maximizing BCAs. We then demonstrated through our general equilibrium model that, in certain situations, a neutral BCA might be set with little or no regard to global economic efficiency, likely in response to industry lobbying demands. Thus, NT-neutrality can afford excessive leniency in that it does not foreclose tariffs set at above the economically efficient level. Worse, resort to the GATT art. XX environmental exception would not foreclose even more trade-restrictive measures, such as non-neutral tariffs and, possibly, bans, as in *US–Shrimp/Turtle Compliance*.

Concerns about leniency notwithstanding, NT-neutrality does have the advantage of being relatively straightforward to operationalize by reference to well-articulated WTO standards (and to enforce, through Member-to-Member consultation, and, if necessary, bilateral adjudication before the WTO Dispute Settlement Body). Efficiency, though complex, can be conceptually formalized and yield important policy insights. In the real world, however, the informational requirements for evaluating BCAs on the grounds of economic efficiency might be administratively and statistically prohibitive. This imposes a challenge to policymakers who might consider BCAs: unilaterally imposed, WTO-neutral BCAs can be instrumental in paving the way to addressing carbon leakage, but they are susceptible to protectionist rent-seeking pressures. Our analysis of the relationship between these two concepts only strengthens the case for multilateral alternatives that can be effective in curbing global GHG emissions, arguably this century's greatest coordination challenge.

Appendix A

A.1. Why Rebating Taxes on Exports Is Not a Subsidy

GATT follows the "Destination Principle" of taxation, according to which goods are taxed in the country where consumption takes place.[51] This principle allows *Home*—the place of consumption—to impose adjustments to imports in order to preserve the competitive parity between domestic, taxed products and foreign, untaxed products.[52] A corollary to this principle is the exemption or remission of taxes born by products made in *Home* that are bound to *Foreign*, because consumption will take place abroad. Generally speaking, *Home*'s discretion to tax and, thus, remit taxes is an internal, sovereign prerogative.[53] However, *Home*'s discretion on how much to rebate on such outbound goods is subject to limitations under trade law.

Although preventing rebates on export transactions from becoming subsidies is a major concern in international trade law, the WTO system's approach to the use of rebates in export transactions is generally permissive (i.e., except in the case of direct taxes). For instance, note 1 of Article 1.1(ii) of the Agreement on Subsidies and Countervailing Duties ("SCM Agreement") expressly excludes export rebates (also known as "export BTAs") from the definition of "subsidy" (SCM Agreement, 1994). That is, *Home* can institute export BCAs, so long as they are less than or equivalent to the indirect taxes *Home* imposes on domestic products. By allowing *Home* to rebate such taxes on exports, the SCM reestablishes symmetry between like products made in both regulating (*Home*) and non-regulating (*Foreign*) markets.

A.2. BCAs and MFN-Neutrality

Besides requiring Members not to discriminate between imports and domestic products, the GATT also requires importing Members not to discriminate on the basis of national origin. Article I provides:

---

[51] The adopted 1970 GATT Working Party analysis of BTAs endorsed the application of the Destination Principle to BTAs (1970 GATT Working Party on BTAs, 1970; WTO, 1997 CTE Report).

[52] Note that paragraphs 4 and 9 of the 1970 GATT Working Party on BTAs discuss this principle, including an explanation that, to most members, "the philosophy behind the provisions was the ensuring of a certain trade neutrality."

[53] As described in Section I, we assume that *Foreign* imposes no carbon taxes or charges on similar products, whether they are produced domestically or elsewhere.

> With respect to customs duties and charges of any kind imposed on or in connection with importation or exportation . . . and with respect to all matters referred to in paragraphs 2 and 4 of Article III, any advantage, favor, privilege or immunity granted by any contracting party to any product originating in or destined for any other country shall be accorded immediately and unconditionally to the like product originating in or destined for the territories of all other contracting parties.

At the outset, we note that because our model involves only two countries—with one being a foreign country—issues regarding MFN-neutrality are naturally not specified and discussed beyond Section I (see Equation (2)). With this caveat, let us begin by first discussing how carbon-taxing Members can meet the MFN Principle when considering imports. We subsequently consider exports.

A.2.a. BCAs and MFN-Import Neutrality

Home may consider complying with its MFN obligation in two different ways. First, it may impose a BCA that, though not protectionist in intent, differentiates among imports originating from different Members (e.g., "*Foreign A*," "*Foreign B*," etc.), depending on whether and how they impose carbon taxes or charges. For instance, *Foreign A*'s adoption of taxes based on a "predominant method of production" that resemble *Home*'s could lead *Home* to charge a lower or no BCA on *Foreign A*'s imports. In contrast, *Foreign B*'s lack of carbon taxes or low taxation on much more carbon-inefficient production would justify a relatively higher BCA. Thus, any differentiation *Home* imposes on the treatment of imports from *Foreign A* and *Foreign B* would be solely based on two origin-neutral criteria: (i) their relative emission intensities; and (ii) the level of taxation (if any) that *Foreign A* and *Foreign B* imposes.

In principle, such an adjustable import BCA would be MFN-compliant. In an unappealed portion of a WTO Panel Report , panelists agreed that "conditions attached to . . . an advantage [in treatment] . . . [do] not necessarily imply that such conditions are discriminatory with respect to the origin of imported products" (Panel Report, *Canada–Certain Measures Affecting the Automotive Industry*, 2000).[54] The panel upheld the facial legality of Canada's import duty exemption to vehicles from certain Members, not others. Of course, *Canada–Autos*

[54] The final Appellate Body Report in this dispute focused solely on whether the challenged measure (i.e., Canada's duty exemption to imports from certain countries) violated the MFN Principle (Appellate Body Report, *Canada–Certain Measures Affecting the Automotive Industry*, 2000).

has great practical relevance to *Foreign A*: allowing *Home* not to tax *Foreign A*'s imports—premised, of course, on certain legitimate "conditions"—enables *Foreign A* to keep the revenue from its carbon taxation without prejudice to its exports to *Home*.

An alternative, MFN-compliant manner of administering import BCAs would have *Home* apply an across-the-board, uniform rate to all imports that compete with taxed, domestic like products. From *Home*'s perspective, such a BCA would not take into account the absence of or differences in levels of carbon taxation in *Foreign A* and *Foreign B*. Quite simply, *Home* would fix a tax based on *Home*'s predominant (domestic) method of production for each good and replicate that tax as an adjustment to imports. As indicated in Appendix A.1, upon export, *Foreign A* would rebate carbon taxes or charges imposed on its goods, while *Foreign B* could not, for doing so, would be a prohibited export subsidy. Because *Foreign A* would be disinclined to forgo its carbon tax revenue, it is likely that *Foreign A* would be motivated to negotiate an international treaty with *Home* that exempts its imports from *Home*'s tariffs based on their similar carbon stringency. *Canada–Autos* shows that the WTO system does not foreclose this type of solution.

A.2.b. BCAs and MFN-Export Neutrality

Let us now assume that *Foreign B*, in anticipation to *Home*'s collection of BCAs on *Foreign B*'s products, decides to adopt export taxes with the expectation that Home will exempt them. Assume further that in *Foreign B*'s trade with *Foreign C* —who also has no carbon tax or charge—*Foreign B* decides not to impose any export tax. Clearly, *Foreign B*'s original purpose is to capture revenue that *Home* would otherwise collect. Of course, as the discussion above (see A.2.a) explained, *Home*, the destination country, would not be under any obligation to account for *Foreign B's* taxation—*Home*'s authority under GATT to impose a BCA is premised on *Foreign B*'s non-taxation of emissions on *production*, not on its non-taxation of exports. In fact, in this scenario, *Home* might be better served by imposing a straightforward uniform rate to imports, regardless of how they are produced. That being the case, double taxation would occur, and *Foreign B*'s decision to continue taxing would be rational only if *Foreign B* valued *Home*'s loss of revenue (due to declining imports from *Foreign B*) more than *Foreign B*'s producers' loss of market share (in *Home*).

Regardless, *Foreign B*'s conduct would violate MFN-neutrality by imposing an export charge that discriminates on the basis of country of destination. This point should not be lost on protectionist, non-carbon-restricting countries.

Appendix B

B.1. Marginal Effect of Tax and Tariff on World Price

To obtain the marginal effect of an increase in t_{Hi} on p_i, we implicitly differentiate the market clearing condition:

$$D_{Hi}(p_i + \tau_i) - Y_{Hi}(p_i + \tau_i - t_{Hi}) = Y_{Fi}(p_i) - D_{Fi}(p_i), \qquad \text{(B.1)}$$

yielding:

$$\partial p_i D'_{Hi}(p_i + \tau_i) - \partial p_i Y'_{Hi}(p_i + \tau_i - t_{Hi}) + \partial t_{Hi} Y'_{Hi}(p_i + \tau_i - t_{Hi}) = \partial p_i Y'_{Fi}(p_i) - \partial p_i D'_{Fi}(p_i). \qquad \text{(B.2)}$$

Rearranging Equation (B.2), we obtain:

$$\delta_i \equiv \frac{\partial p_i}{\partial t_{Hi}} = \frac{Y'_{Hi}(p_i+\tau_i-t_{Hi})}{[Y'_{Hi}(p_i+\tau_i-t_{Hi})-D'_{Hi}(p_i+\tau_i)]+[Y'_{Fi}(p_i)-D'_{Fi}(p_i)]}. \qquad \text{(B.3)}$$

It is evident that $\delta_i \in [0,1]$.

Similarly, implicit differentiation of the market clearing condition also yields the marginal effect of an increase in τ_i on p_i:

$$-\phi_i \equiv \frac{\partial p_i}{\partial \tau_{Hi}} = \frac{-[Y'_{Hi}(p_i+\tau_i-t_{Hi})-D'_{Hi}(p_i+\tau_i)]}{[Y'_{Hi}(p_i+\tau_i-t_{Hi})-D'_{Hi}(p_i+\tau_i)]+[Y'_{Fi}(p_i)-D'_{Fi}(p_i)]}. \qquad \text{(B.4)}$$

It is evident that $\phi_i \in [0,1]$.

B.2. Proof of Proposition 1

Individuals have identical quasilinear and additively separable preferences over the goods. Letting c_i denote consumption of good i, individual utility from consumption is:

$$u(c_0, \ldots, c_n) = c_0 + \sum_{i=1}^{n} u_i(c_i), \qquad \text{(B.5)}$$

where each function u_i is strictly increasing and concave in its argument. Utility maximization subject to a budget constraint leads to an individual demand function, d_i, for each good $i = 0, \ldots, n$.[55]

Table B.1 summarizes the components of global welfare as a function of taxes and tariffs:

Table B.1: Components of Global Welfare

Home Labor Income	L_H
Foreign Labor Income	L_F
Home Rents from Sector-Specific Inputs	$\sum_{i=1}^{n} \Pi_{Hi}(p_i + \tau_i - t_{Hi})$
Foreign Rents from Sector-Specific Inputs	$\sum_{i=1}^{n} \Pi_{Fi}(p_i)$
Home Tax Revenue	$\sum_{i=1}^{n} t_{Hi} Y_{Hi}(p_i + \tau_i - t_{Hi})$
Home Tariff Revenue	$\sum_{i=1}^{n} \tau_i * (D_{Hi}(p_i + \tau_i) - Y_{Hi}(p_i + \tau_i - t_{Hi}))$
Home Consumer Surplus	$N_H \sum_{i=1}^{n} [u_i(d_i(p_i + \tau_i) - (p_i + \tau_i) d_i(p_i + \tau_i)]$
Foreign Consumer Surplus	$N_F \sum_{i=1}^{n} [u_i(d_i(p_i)) - p_i d_i(p_i)]$
(less) Global Damage from Emissions	$(N_H + N_F) v(E)$

When the only available policy options are an emissions tax at *Home* along with tariffs on imports from *Foreign*, global welfare is maximized by solving the following problem:

$$Max_{\{t_{Hi},\tau_i\}_{i=1}^{n}} L_H + L_F + \sum_{i=1}^{n} [\Pi_{Hi} + \Pi_{Fi} + t_{Hi} Y_{Hi} + \tau_i * (D_{Hi} - Y_{Hi})] + \sum_{i=1}^{n} [N_H [u_i - (p_i + \tau_i) d_i] + N_F [u_i - p_i d_i]] - (N_H + N_F) v(E)]. \quad \text{(B.6)}$$

After applying the Envelope Theorem and Hotelling's Lemma[56], the first order conditions with respect to $\{t_{Hi}\}_{i=1}^{n}$ can be expressed as:

$$t_{Hi}(\delta_i - 1) Y'_{Hi} + \tau_i [\delta_i D'_{Hi} - (\delta_i - 1) Y'_{Hi}] = (N_H + N_F) v'(E) [(\delta_i - 1) \alpha_{Hi} Y'_{Hi} + \delta_i \alpha_{Fi} Y'_{Fi}] \; \forall \, i \in \{1, \ldots, n\}, \quad \text{(B.7)}$$

[55] Under quasilinear utility, demand for any non-numeraire good depends only on its own price (including any tariff), and all residual income is spent on the numeraire good. No consumer surplus is derived from the numeraire good.

[56] The first order condition from utility maximization is that $u'_i(d_i(p_i + \tau_i)) = p_i + \tau_i \; \forall \, i \in \{1, \ldots, n\}$. Hotelling's Lemma refers to the result that the supply function (Y_{Hi} or Y_{Fi}) is the first derivative of the profit function, i.e. $Y_{Hi} = \Pi'_{Hi}$ and $Y_{Fi} = \Pi'_{Fi} \; \forall \, i \in 1, \ldots, n$.

and the first order conditions with respect to $\{\tau_i\}_{i=1}^{n}$ can be expressed as:

$$t_{Hi}(1-\phi_i)Y'_{Hi} + \tau_i(1-\phi_i)[D'_{Hi} - Y'_{Hi}] = (N_H + N_F)v'(E)[(1-\phi_i)\alpha_{Hi}Y'_{Hi} - \phi_i\alpha_{Fi}Y'_{Fi}] \ \forall\, i \in \{1, \ldots, n\}. \quad \text{(B.8)}$$

Let $X_{Fi} \equiv Y_{Fi} - D_{Fi}$ denote *Foreign* export supply of good *i*.[57] Noting that $\delta_i D'_{Hi} - (\delta_i - 1)Y'_{Hi} = \delta_i(Y'_{Fi} - D'_{Fi})$ and $(1-\phi_i)[D'_{Hi} - Y'_{Hi}] = \phi_i[D'_{Fi} - Y'_{Fi}]$, we simultaneously solve the *n* pairs of first order conditions to obtain the optimal taxes:

$$t_{Hi}^{**} = (N_H + N_F)\alpha_{Hi}v'(E) \ \forall\, i \in \{1, \ldots, n\}, \quad \text{(B.9)}$$

and tariffs:

$$\tau_i^{**} = \frac{(N_H+N_F)\alpha_{Fi}v'(E)Y'_{Fi}(p_i)}{Y'_{Fi}(p_i) - D'_{Fi}(p_i)} = \frac{(N_H+N_F)\alpha_{Fi}v'(E)\epsilon_{Fi}^{Y}}{x_{Fi}\epsilon_{Fi}^{X}} \ \forall\, i \in \{1, \ldots, n\}. \quad \text{(B.10)}$$

where $x_{Fi} \equiv \frac{X_{Fi}}{Y_{Fi}}$ is the *Foreign* export to output ratio, $\epsilon_{Fi}^{Y} \equiv \left(\frac{\partial Y_{Fi}}{\partial p_i}\right)\left(\frac{p_i}{Y_{Fi}}\right)$ is the price elasticity of *Foreign* output and $\epsilon_{Fi}^{X} \equiv \left(\frac{\partial X_{Fi}}{\partial p_i}\right)\left(\frac{p_i}{X_{Fi}}\right)$ is the price elasticity of *Foreign* export supply.[58]

The tariffs follow a modified Ramsey rule, i.e., all else equal, goods that have lower export supply or import demand elasticity (in absolute value) will have higher optimal tariffs, as the deadweight loss from tariffs on such goods is relatively lower. Proposition 1 also stipulates, all else equal, a higher tariff on goods whose *Foreign* production is more responsive to price changes. Because tariffs curtail *Foreign* production and emissions by lowering the world price of a good, it is economically efficient to impose higher tariffs on goods whose *Foreign* output responds to price more strongly.

B.3. Proof of Proposition 2

Suppose the emissions tax at Home is pre-determined (represented by tax rates $\hat{t}_{Hi}$ for goods $i = 1, \ldots, n$), and the only available policy choices are tariffs on imports from *Foreign*. Global welfare is maximized by solving the following problem:

$$Max_{\{\tau_i\}_{i=1}^{n}} L_H + L_F + \sum_{i=1}^{n}[\Pi_{Hi} + \Pi_{Fi} + \hat{t}_{Hi}Y_{Hi} + \tau_i * (D_{Hi} - Y_{Hi})] + \sum_{i=1}^{n}[N_H[u_i - (p_i + \tau_i)d_i] + N_F[u_i - p_i d_i]] - (N_H + N_F)v(E)]. \quad \text{(B.11)}$$

[57] X_{Fi} would represent *Foreign* import demand if negative.

[58] This would be the elasticity of import demand if *Foreign* is a net importer and would take on a negative value.

After applying the Envelope Theorem and Hotelling's Lemma, the first order conditions with respect to $\{\tau_i\}_{i=1}^{n}$ can be expressed as:

$$\hat{t}_{Hi}(1-\phi_i)Y'_{Hi} + \tau_i(1-\phi_i)[D'_{Hi} - Y'_{Hi}] = (N_H + N_F)v'(E)[(1-\phi_i)\alpha_{Hi}Y'_{Hi} - \phi_i\alpha_{Fi}Y'_{Fi}] \ \forall\, i \in \{1, \ldots, n\}. \quad \text{(B.12)}$$

Noting that $(1-\phi_i)[D'_{Hi} - Y'_{Hi}] = \phi_i[D'_{Fi} - Y'_{Fi}]$, Equation (B.12) can be rearranged to yield the optimal tariffs:

$$\widehat{\tau_i}^{**} = \tau_i^{**} - \frac{[(N_H+N_F)\alpha_{Hi}v'(E) - \hat{t}_{Hi}](1-\phi_i)Y'_{Hi}}{\phi_i * [Y'_{Fi} - D'_{Fi}]} \ \forall\, i \in \{1, \ldots, n\}. \quad \text{(B.13)}$$

B.4. Proof of Proposition 3

Rearranging the expression for $\widehat{\tau_i}^{**}$ contained in Equation (B.13), we find that the efficient tariff is strictly less than the highest permitted tariff under neutrality if:

$$\frac{(N_H+N_F)v'(E)[\phi_i\alpha_{Fi}Y'_{Fi} - (1-\phi_i)\alpha_{Hi}Y'_{Hi}]}{\alpha_{Fi} * \phi_i * [Y'_{Fi} - D'_{Fi}]} + \frac{\hat{t}_{Hi}Y'_{Hi}}{\alpha_{Fi} * [Y'_{Hi} - D'_{Hi}]} < \frac{\hat{t}_{Hi}}{\alpha_{Hi}}. \quad \text{(B.14)}$$

While the left-hand side of Equation (B.14) is not generally lower than the right-hand side, we can characterize conditions under which it would be unambiguously lower. Suppose *Foreign* production of good *i* is at least as emission-intensive as *Home* production of good *i* (i.e., $\alpha_{Fi} \geq \alpha_{Hi}$). This guarantees that the second term of the left-hand side is strictly less than or equal to the right-hand side (i.e., $\frac{\hat{t}_{Hi}Y'_{Hi}}{\alpha_{Fi} * [Y'_{Hi} - D'_{Hi}]} < \frac{\hat{t}_{Hi}}{\alpha_{Hi}}$). Turning to the first term of the left-hand side, we see that its sign depends on the sign of $\phi_i\alpha_{Fi}Y'_{Fi} - (1-\phi_i)\alpha_{Hi}Y'_{Hi}$, which is the net decrease in global emissions due to a marginal increase in the tariff.[59] If a marginal increase in the tariff raises *Home* emissions more than it lowers *Foreign* emissions, then the first term will be negative. Thus, in the case where the second left-hand-side-term is less than or equal to $\frac{\hat{t}_{Hi}}{\alpha_{Hi}}$, and the first term is negative, the entire left-hand side is less than the right-side side, which means the efficient tariff is unambiguously less than the highest permitted tariff under neutrality.

[59] Marginally increasing the tariff has two opposing effects on global emissions. On one hand, it leads to lower *Foreign* production, and consequently lower *Foreign* emissions, brought about through a lower world price. On the other hand, it leads to increased *Home* production and emissions. Formally, the decrease in *Foreign* emissions is $\phi_i\alpha_{Fi}Y'_{Fi}$. The increase in *Home* emissions is $(1-\phi_i)\alpha_{Hi}Y'_{Hi}$.

B.5. Proof of Corollary 1

Suppose *Foreign* producers face a pre-determined emissions tax represented by tax rates t_{Fi} for goods *i=1, . . ., n*. If the only available policy levers are an emissions tax at *Home* along with tariffs on imports from *Foreign*, global welfare is maximized by solving the following problem:

$$Max_{\{t_{Hi},\tau_i\}_{i=1}^n} L_H + L_F + \sum_{i=1}^n [\Pi_{Hi} + \Pi_{Fi} + t_{Hi}Y_{Hi} + t_{Fi}Y_{Fi} + \tau_i * (D_{Hi} - Y_{Hi})] + \sum_{i=1}^n [N_H[u_i - (p_i + \tau_i)d_i] + N_F[u_i - p_i d_i]] - (N_H + N_F)v(E)] \quad \text{(B.15)}$$

After applying the Envelope Theorem and Hotelling's Lemma,the first order conditions with respect to $\{t_{Hi}\}_{i=1}^n$ can be expressed as:

$$t_{Hi}(\delta_i - 1)Y'_{Hi} + \tau_i[\delta_i D'_{Hi} - (\delta_i - 1)Y'_{Hi}] = (N_H + N_F)v'(E)[(\delta_i - 1)\alpha_{Hi}Y'_{Hi} + \delta_i \alpha_{Fi} Y'_{Fi}] - t_{Fi}\delta_i Y'_{Fi} \; \forall \, i \in \{1, . . ., n\}, \quad \text{(B.16)}$$

and the first order conditions with respect to $\{\tau_i\}_{i=1}^n$ can be expressed as:

$$t_{Hi}(1 - \phi_i)Y'_{Hi} + \tau_i(1 - \phi_i)[D'_{Hi} - Y'_{Hi}] = (N_H + N_F)v'(E)[(1 - \phi_i)\alpha_{Hi}Y'_{Hi} - \phi_i \alpha_{Fi} Y'_{Fi}] + t_{Fi}\phi_i Y'_{Fi} \; \forall \, i \in \{1, . . ., n\}. \quad \text{(B.17)}$$

Noting that $\delta_i D'_{Hi} - (\delta_i - 1)Y'_{Hi} = \delta_i(Y'_{Fi} - D'_{Fi})$ and $(1 - \phi_i)[D'_{Hi} - Y'_{Hi}] = \phi_i[D'_{Fi} - Y'_{Fi}]$, we simultaneously solve the *n* pairs of first order conditions to obtain the optimal taxes:

$$t_{Hi} = (N_H + N_F)\alpha_{Hi}v'(E) \; \forall \, i \in \{1, . . ., n\}, \quad \text{(B.18)}$$

and tariffs:

$$\tau_i = \frac{[(N_H+N_F)\alpha_{Fi}v'(E) - t_{Fi}]Y'_{Fi}(p_i)}{Y'_{Fi}(p_i) - D'_{Fi}(p_i)} = \frac{[(N_H+N_F)\alpha_{Fi}v'(E) - t_{Fi}]\epsilon^Y_{Fi}}{x_{Fi}\epsilon^X_{Fi}} \; \forall \, i \in \{1, . . ., n\}. \quad \text{(B.19)}$$

In the special case where Foreign has an emissions tax of zero (i.e., $t_{Fi} = 0 \; for \; i \in \{1, . . ., n\}$), the result is identical to that of Proposition 1.

B.6. Profit-maximizing Emission Intensity Reduction in *Foreign*

Let $\overline{\alpha_{Fi}}$ denote the baseline emission-intensity of good *i* production in *Foreign*. Suppose *Foreign* producers of good *i* can reduce emission intensity below this baseline rate by *r* tons per unit of output, at a cost *C(r)*, where the function *C* is increasing and convex in *r*. The emission-intensity of *Foreign* production of good is thus $\alpha_{Fi} \equiv \overline{\alpha_{Fi}} - r$.

Home imposes a BCA on imports from *Foreign*, represented by good-specific tariffs $\tau_i \; for \; i \in \{1, \ldots, n\}$. The good-specific tariff τ_i can expressed in terms of an undifferentiated BCA rate (τ), multiplied by good *i*'s emissions intensity of production in *Foreign* (α_{Fi}). Formally, imports of good *i* from *Foreign* ultimately face a tariff of $\tau_i \equiv \tau\alpha_{Fi} \equiv \tau(\overline{\alpha_{Fi}} - r)$.

Foreign producers benefit from emission-intensity reductions *via* lower tariffs.[60] However, reduction in emissions intensity are costly. This trade-off is captured in the following problem, where producers of good *i* choose a profit-maximizing level of emission-intensity reduction:

$$Max_r \; \Pi_{Fi}(p_i) - C(r). \tag{B.20}$$

After applying Hotelling's Lemma, the first order condition with respect to r can be expressed as:

$$Y_{Fi} * \phi_i * \tau = C'(r). \tag{B.21}$$

The effect of an increase in the BCA rate (τ) on emission-intensity reduction (*r*) can be obtained by implicitly differentiating Equation (B.21):

$$\frac{\partial r}{\partial \tau} = \frac{\left(\frac{\overline{\alpha_{Fi}} - r}{\tau}\right)\left[Y'_{Fi}\phi_i^2\tau^2 + Y_{Fi}\left(\frac{\partial \phi_i}{\partial r}\right)\tau - \frac{C'(r)}{\overline{\alpha_{Fi}} - r}\right]}{\left[Y'_{Fi}\phi_i^2\tau^2 + Y_{Fi}\left(\frac{\partial \phi_i}{\partial r}\right)\tau - C''(r)\right]}. \tag{B.22}$$

By the second order sufficient condition of the profit-maximization problem, the denominator of Equation (B.22) is unambiguously negative. However, the sign of the numerator is ambiguous. This means that it is impossible to generally characterize whether an increase in the BCA rate leads to more emission-intensity reduction.

In the limiting case where τ tends to zero, a marginal increase in τ will cause an unboundedly large increase in *r*.[61] However for a sufficiently large τ, the numerator of Equation (B.22) can be positive, implying that a marginal increase in τ leads to a decrease in *r*.

B.7. Proof of Proposition 4

[60] The lower tariffs entail the output of *Foreign* producers fetching a higher price.

[61] This is because the denominator of Equation (B.22) is unambiguously negative, and *C'(r)* is positive.

B.7.a. Tariffs that Maximize Overall *Home* Welfare

Suppose the emissions tax at *Home* is pre-determined (represented by tax rates $\hat{t}_{Hi}$ for goods $i = 1, \ldots, n$) and the only available policy choices are tariffs on imports from *Foreign*. *Home* welfare is maximized by solving the following problem:

$$Max_{\{\tau_i\}_{i=1}^{n}} L_H + \sum_{i=1}^{n}\left[\Pi_{Hi} + \hat{t}_{Hi}Y_{Hi} + \tau_i * (D_{Hi} - Y_{Hi}) - N_H[u_i - (p_i + \tau_i)d_i]\right] - N_H v(E) \quad \text{(B.23)}$$

(see Table B.1 for a description of the components of welfare.)

The tariffs that maximize *Home* welfare are:

$$\hat{\tau}_i^* = \frac{\alpha_{Fi}N_H v'(E)Y'_{Fi}}{Y'_{Fi}-D'_{Fi}} - \frac{[N_H v'(E)\alpha_{Hi}-\hat{t}_{Hi}](1-\phi_i)Y'_{Hi}}{\phi_i*[Y'_{Fi}-D'_{Fi}]} + \frac{p_i}{\epsilon^X_{Fi}} \;\forall\, i \in \{1, \ldots, n\}. \quad \text{(B.24)}$$

B.7.b. Comparing Tariffs that Maximize Home Welfare with Tariffs that Maximize Global Welfare

The first two terms of $\hat{\tau}_i^*$ can be rearranged to yield:

$$\frac{N_H v'(E)[\phi_i\alpha_{Fi}Y'_{Fi}-(1-\phi_i)\alpha_{Hi}Y'_{Hi}]}{\phi_i*[Y'_{Fi}-D'_{Fi}]} + \frac{\hat{t}_{Hi}Y'_{Hi}}{[Y'_{Hi}-D'_{Hi}]}\,, \quad \text{(B.25)}$$

while $\hat{\tau}_i^{**}$ can be expressed as:

$$\hat{\tau}_i^{**} = \frac{(N_H+N_F)v'(E)[\phi_i\alpha_{Fi}Y'_{Fi}-(1-\phi_i)\alpha_{Hi}Y'_{Hi}]}{\phi_i*[Y'_{Fi}-D'_{Fi}]} + \frac{\hat{t}_{Hi}Y'_{Hi}}{[Y'_{Hi}-D'_{Hi}]} \quad \text{(B.26)}$$

It can be seen that if good *i* is a susceptible good (i.e., if $\phi_i\alpha_{Fi}Y'_{Fi} - (1-\phi_i)\alpha_{Hi}Y'_{Hi} < 0$), then the first two terms of $\hat{\tau}_i^*$ together exceed $\hat{\tau}_i^{**}$.

References

Agreement on Subsidies and Countervailing Measures, 15 Apr. 1994, Marrakesh Agreement Establishing the World Trade Organization, Legal Instruments–Results of the Uruguay Round, 1867 U.N.T.S. 14.

American Clean Energy and Security Act, H.R. 2454, 111th Cong., §§ 766-67 & 782(e)(1) (2009).

Appellate Body Report, *United States–Import Prohibition of Certain Shrimp and Shrimp Products*, ¶ 162, WT/DS58/AB/R (Oct. 12, 1998).

Appellate Body Report, *Canada–Certain Measures Affecting the Automotive Industry*, ¶ 78, WT/DS139/AB/R, WT/DS142/AB/R (May 31, 2000).

Appellate Body Report, *United States–Import Prohibition of Certain Shrimp and Shrimp Products (Recourse to Article 21.5 by Malaysia)*, ¶¶ 153, 136, WT/DS58/AB/RW (Nov. 21, 2001).

Appellate Body Report, *India–Additional and Extra-Additional Duties on Imports from the United States*, WT/DS360/AB/R (Oct. 20, 2008).

Balistreri, Edward, Daniel Kaffine, and Hidemichi Yonezawa. 2014. "Optimal Environmental Border Adjustments Under the General Agreement on Tariffs and Trade," *Col. Sch. of Mines Division of Bus. & Econ., Working Paper No. 2014-03*.

De Cendra, Javier. 2006. "Can emissions trading schemes be coupled with border tax adjustments? An Analysis vis-à-vis WTO Law," 15(2) *Review of European Community & International Environmental Law* 131, 143.

Colares, Juscelino F. 2013. "Paths to Carbon Stabilization: How Foreign Carbon-Restricting Reforms Will Affect U.S. Industry, Climate Policy and the Prospects of a Binding Emission Reduction Treaty," 47(2) *Journal of World Trade* 281, 289 n.41 & 327.

Colares, Juscelino F. 2017. "A Qualified Legal Argument for Lower-Cost, Neutral Border Adjustment Tariffs to Help Address Paris Agreement Coordination Problems" (on file with author).

Council Directive 2009/29, 2009 O.J. 5 (EC).

GATT Analytical Index 1, 86. Available at: https://www.wto.org/english/res_e/booksp_e/gatt_ai_e/gatt_ai_e.htm (accessed May 17, 2017).

General Agreement on Tariffs and Trade, Oct. 30, 1947, 61 Stat. A-11, 55 U.N.T.S. 194.

General Agreement on Tariffs and Trade 1994, Apr. 15, 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 1A, Legal Instruments—Results of the Uruguay Round, 33 I.L.M. 1125.

Grossman, Gene and Elhanan Helpman. 1994. "Protection for Sale," 84(4) *American Economic Review* 833-850.

Her Majesty's Treasury. 2016. "Stern Review on the Economics of Climate Change," HM Treasury 30, 338.

Horn, Henrik. 2006. "National Treatment in the GATT," 96 American Economic Review 1, 394.

Horn, Henrik and Petros Mavroidis. 2010. "Climate Change and the WTO: Legal Issues Concerning Border Tax Adjustments," 53(1) *Japanese Yearbook of International Law* 19, 32.

Horn, Henrik and Petros Mavroidis. 2011. "To B(TA) or Not to B(TA)? On the Legality and Desirability of Border Tax Adjustments from a Trade Perspective," 34(11) The World Economy 1911, 1913-14, 1919, 1927, 1932-35.

Howse, Robert L. and Antonia Eliason. 2008. "Domestic and International Strategies to Address Climate Change: An Overview of the WTO Legal Issues," in Thomas Cottier, Olga Nartova and Sadeq E.

Bigdeli, eds., *International Trade Regulation and the Mitigation of Climate Change: World Trade Forum*, 48. New York, NY: Cambridge University Press.

Ismer, Roland and Karsten Neuhoff. 2004. "Border Tax Adjustments: A Feasible way to Address Nonparticipation in Emission Trading," Cambridge Working Papers in Economics, Working Paper No. 36, 2004 (applied economics) 11, 18-23..

Markusen, James. 1975. "International Externalities and Optimal Tax Structures," 5 *Journal of International Economics* 1, 15-29.

Panel Report, *United States–Import Prohibition of Certain Shrimp and Shrimp Products*, ¶ 2.7, WT/DS58/R (May. 15, 1998).

Panel Report, *Canada–Certain Measures Affecting the Automotive Industry*, ¶¶ 10.24 & 10.29, WT/DS139/R, WT/DS142/R (Feb. 11, 2000).

Pauwelyn, Joost. 2007. "US Federal Climate Policy and Competitiveness Concerns: the Limits and Options of International Trade Law," Nicholas Institute for Environmental Policy Studies, Duke University 2, 17, 19, 20 and 33-44.

Poterba, James M. and Julio J. Rotemberg. 1995. "Environmental Taxes on Intermediate and Final Goods When Both Can Be Imported," 2 *International Tax and Public Finance* 221, 222.

Report of the Panel, *United States–Prohibition of Imports of Tuna and Tuna Products from Canada*, GATT B.I.S.D. 29S/91 (Feb. 22, 1982).

Report of the Panel, *United States–Taxes on Petroleum and Certain Imported Substances*, GATT B.I.S.D 34S/136 (Jun. 17, 1987).

Report of the Panel, *United States–Restrictions on Imports of Tuna*, GATT B.I.S.D. 39S/155 (Sep. 03, 1991).

Roessler, Frieder. 2003. "Beyond the Ostensible, A Tribute to Professor Robert Hudec's Insights on the Determination of the Likeness of Products Under the National Treatment Provisions of the GATT," 37 *Journal of World Trade* 771, 775.

Sindico, Francesco. 2008. "The EU and Carbon Leakage: How to Reconcile Border Adjustments with the WTO?," 17(6) *European Energy and Environmental Law Review* 328, 339.

Stavins, Robert. 2014. "Local Costs and Global Benefits," 31 *Environmental Forum* 5, 14.

Tollison, Robert. 1982. "Rent-Seeking: A Survey," 35 *Kyklos* 575, 577.

Tran, Christopher. 2010. "Using GATT, Art XX to Justify Climate Change Measures in Claims Under the WTO Agreements," 27(5) *Environmental and Planning Law Journal* 346, 349, 350.

Understanding on Rules and Procedures Governing the Settlement of Disputes, 15 April 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 2, Legal Instruments—Results of the Uruguay Round, 33 I.L.M. 1125.

Varian, Hal. 1999. *Intermediate Microeconomics: A Modern Approach* 174. New York, NY: W. W.

Norton & Company.

Veel, Paul-Erik. 2009. "Carbon Tariffs and the WTO: An Evaluation of Feasible Policies," 12 *Journal of International Economic Law* 749, 751.

Winchester, Niven, Sergei Paltsev and John M. Reilly. 2011. "Will Border Carbon Adjustment Work?," 11 *Berkeley Electronic Journal of Economic Analysis & Policy* 1, 12.

WTO. 1997. Report of the Committee on Trade and the Environment, Taxes and Charges for Environmental Purposes–Border Tax Adjustment, WT/CTE/W/47 (May 2, 1997).

WTO-UNEP. 2009. "Trade and Climate Change: A Report by the United Nations Environment Programme and the World Trade Organization," Ludivine Tamiotti, ed., 1-166. UNEP Earthprint. Available at: https://www.wto.org/english/res_e/booksp_e/trade_climate_change_e.pdf (accessed May 15, 2017).

Zhang, Zhong X. and Lucas Assunção. 2004. "Domestic Climate Policies and the WTO," 27 *The World Economy* 359, 380.

1970 GATT Working Party on Border Tax Adjustments, GATT B.I.S.D. 18S/97 (Dec. 2, 1970).