



Full length articles

A theory of economic sanctions as terms-of-trade manipulation[☆]John Sturm Becko^{*}

Massachusetts Institute of Technology, 50 Memorial Drive, Cambridge, 02142, MA, USA



ARTICLE INFO

JEL classification:

F51
F13
H21

Keywords:

International trade sanctions
Trade policy
Terms-of-trade manipulation

ABSTRACT

How can a country design economic sanctions to maximize their economic cost to the sanctioned country at the lowest cost to the sanctioner? I consider this problem from the perspective of international trade and draw a close connection between trade restrictions as economic sanctions and trade restrictions as terms-of-trade manipulation. This connection has useful implications for the design of trade taxes as sanctions: Small sanctions increase welfare in the sanctioning country. Sanctions target the same goods as terms-of-trade manipulation. Sanctions ignore elasticities of demand and supply in the sanctioning country.

1. Introduction

Many countries, including the U.S. and members of the E.U., have recently imposed severe economic sanctions on Russia in response to its invasion of Ukraine. Although some of these sanctions are financial in nature – freezing Russian assets or preventing financial transactions – others directly restrict international trade.¹ How can these trade restrictions be designed so as to achieve their aims at limited cost to the sanctioning countries?

A vast literature on sanction design has addressed this question, but seldom from a purely economic standpoint. One strand of this literature compiles detailed case studies and, more recently, comprehensive databases that emphasize the institutional context of successful and unsuccessful historical sanctions (see [Hufbauer et al., 1990](#); [Pape, 1997](#); [Felbermayr et al., 2020](#); [Demena et al., 2021](#)). Other research such as [Førland \(1991\)](#) and [Cortright et al. \(2002\)](#) considers how sanctions should target particular “strategic” goods – such as arms used to wage war or technology that may contribute to future military power – or particular actors in positions of political power. Yet another focus is on how sanctions shape the game-theoretic interactions among nation states and within them, between ruling elites and regular citizens (see [Eaton and Engers, 1992](#); [Morgan and Bapat, 2003](#); [Baliga and Sjöström, 2022](#)).

In contrast to this literature, I take a canonical economic perspective, asking what restrictions on international trade maximize the economic cost to a sanctioned country at the lowest cost to the sanctioning country.² While new to the academic literature, this economic lens is evident in the language of policymakers:

“We’ve intentionally scoped our sanctions to deliver severe impact on the Russian economy while minimizing the cost to the U.S., as well as our Allies and partners.”

— U.S. Deputy N.E.C. Director Daleep Singh, February 24, 2022 (see [The White House, 2022](#))

[☆] This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

^{*} Correspondence to: Princeton University, 20 Washington Road, Princeton, 08540, NJ, USA.

E-mail address: johnsbecko@gmail.com.

¹ This includes bans on commodity trade in various sectors, such as energy, transport, and technology, as well as bans on intertemporal trade in the form of limitations on lending to sanctioned Russian individuals.

² I take this objective of sanctions as given and do not evaluate their ethical or geopolitical foundations. These are important and extensively studied topics in their own right.

This framing allows me to draw on ideas from the optimal tariff literature and shed new light on the question of sanction design. In particular, I connect to the well-studied case of pure terms-of-trade manipulation, wherein a country places no weight – positive or negative – on foreign welfare and so sets tariffs to maximize its own welfare. My main result shows that optimal trade taxes as sanctions, t_k , bear a striking resemblance to optimal trade taxes as terms-of-trade manipulation, t_k^{ToT} :

$$t_k = (1 - \lambda^F) t_k^{\text{ToT}},$$

where t_k and t_k^{ToT} are the ad-valorem import tariffs or export subsidies on a good k , and where λ^F is a measure of a sanctioning country's willingness to pay for economic welfare in the sanctioned country (negative in the case of sanctions). When the sanctioning country is willing to incur economic losses at home in order to impose economic costs in the sanctioned country – so that $\lambda^F < 0$ – sanctions target the same goods as pure terms of trade manipulation but simply increase in intensity.³

At the heart of this result is a well-known observation about the foreign welfare effects of domestic trade taxes: In simple neoclassical settings, domestic trade taxes affect foreign welfare only through effects on its terms of trade. Since foreign terms of trade are simply the negative of domestic terms of trade, two of the effects that one might have expected to influence sanction design – domestic terms of trade and foreign welfare – are in fact proportional to one another. Therefore, optimal sanctions simply balance domestic terms of trade against inefficiencies stemming from the wedge between domestic and world prices, like standard unilateral trade taxes, but with different weights that account for the sanctioning motive.

This insight leads to three broad lessons for optimal sanction design. I focus these lessons on the case where sanctions take the form of simple, linear trade taxes (import tariffs and export taxes), as I show that linear taxes can implement the same allocations as more complex instruments such as price caps and quotas.

1. Starting from near free trade, weak enough sanctions *improve* the welfare of the sanctioning country. More severe sanctions come at a cost to the sanctioning country.
2. Optimal trade taxes as sanctions target the same goods as trade taxes as terms-of-trade manipulation – typically using higher taxes on goods that the sanctioned country supplies or demands inelastically – but with potentially higher tax rates.
3. Optimal trade taxes as sanctions do not depend on domestic elasticities of demand for imports or supply of exports.

While simple, these lessons are novel to the literature on economic sanctions and have direct policy relevance.

I develop these ideas in a benchmark neoclassical model. In the model, two countries – a sanctioning country and a sanctioned country – each contain a representative household and firm. Markets are competitive. Whereas the sanctioned country engages in free trade, the sanctioning country may impose a general form of trade sanctions.

My main result characterizes the sanctions that trace out the frontier of sanctioner–sanctionee utilities, therefore characterizing how the sanctioner can reduce welfare in the sanctioned country at the least economic cost to itself. Notably, this result and the lessons that follow from it apply to all points on this frontier; they do not require taking a stance on one's preferred severity of sanctions.⁴

After presenting my main result and its implications, I study its robustness in several extensions. Most importantly, I consider the case where the sanctioned country also imposes optimal sanctions. This extension leads to a novel characterization of bilateral trade policy during trade wars. I also discuss the robustness of my results to the presence of multiple sanctioning countries and “neutral” third-party countries.

To the best of my knowledge, this paper provides the first general analysis of optimal sanction design from the perspective of international trade theory. Other research and indeed practice has emphasized that sanctions should target goods that a sanctioned country demands inelastically – particularly bottleneck inputs – but typically in the context of “strategic” political or military goods rather than economic welfare (e.g., [Førland, 1991](#)). In emphasizing terms-of-trade manipulation, I build on an idea dating back to at least ([Mill, 1844](#)).⁵ Importantly, [Meade \(1955\)](#) provides a formula for optimal tariffs when non-zero weight is placed on a trading partner, and [Osgood \(1957\)](#) interprets the case of negative foreign weight as an “optimum warfare” tariff. However, these early works only study the case of two goods and so overlook the main idea of my result—that the *relative* trade taxes on different goods are invariant to the weight on foreign welfare.⁶ While I mainly study competitive markets, work by [Gros \(2022\)](#) posted after the first draft of this paper has considered how sanction design can account for foreign monopoly power.

More broadly, this paper is part of a quickly growing literature that studies the design and potential effects of sanctions in the context of Russia's invasion of Ukraine. [Bachmann et al. \(2022\)](#) and related works use semi-structural models to predict the economic cost to European countries of a full embargo on imports of Russian energy goods (e.g., [Baqae et al., 2022](#); [Berger et al., 2022](#)). Others such as [Hausmann \(2022\)](#) and [Chaney et al. \(2022\)](#) have called for tariffs on imports as a way to inflict economic damage on Russia at lower cost to sanctioning countries.⁷ I study the question of which goods it is most efficient to target with these trade

³ It is worth noting that were $1 + t_k$ proportional to $1 + t_k^{\text{ToT}}$, then changing the constant of proportionality would have no real effect, by Lerner symmetry. However, the formulation above has non-neutral effects, even cutting off trade entirely for negative enough λ^F .

⁴ I use the word “optimal” to refer to any point on this frontier.

⁵ See [de V. Graaff \(1949\)](#) for a review of early work and [Dixit \(1985\)](#) for a modern treatment. More recent contributions such as [Costinot et al. \(2014\)](#), [Costinot et al. \(2015, 2020\)](#) have studied terms-of-trade manipulation in models that microfound a foreign country's demand system using models of Ricardian trade, fixed costs of exporting, and dynamic substitution.

⁶ A model must include at least three goods (not two) in order to consider the ratios of trade taxes on different goods, since by Lerner symmetry one good is always effectively untaxed.

⁷ More indirectly related are several papers that study the implications of financial sanctions and the financial implications of sanctions in general (see [Itskhoki and Mukhin, 2022](#); [Lorenzoni and Werning, 2022](#); [Bianchi and Sosa-Padilla, 2024](#)).

restrictions. My theoretical analysis complements several contemporaneous quantitative analyses of optimal sanction design, such as [de Souza et al. \(2023\)](#), [Chowdhry et al. \(2023\)](#), and [Hausmann et al. \(2024\)](#).

2. Benchmark two country trade model

I consider a competitive world economy with two countries, Home ($i = H$) and Foreign ($i = F$), and many goods $k \in K$. In order to set aside redistributive concerns and focus my analysis, I assume each country contains a representative household and a representative firm. Foreign engages in free trade. Home sets import tariffs and export taxes, and it rebates revenues lump-sum.

Goods are traded between countries at world prices p . Households and firms within each country i trade at domestic prices q^i . Foreign domestic prices are equal to world prices. Home domestic prices differ from world prices by ad-valorem trade taxes $t(x^F)$, which may in general depend on Foreign's net exports x_k^F of each good k . The quantity-dependence of taxes allows us to nest quantity restrictions (e.g. prohibitive tariffs once imports cross a threshold) and price caps (e.g. export subsidies that adjust in order to hold prices fixed).

$$q_k^F = p_k \quad \text{and} \quad q_k^H = p_k(1 + t_k(x^F)). \quad (1)$$

A positive tax t_k corresponds to a tariff if Home imports k and an export subsidy if Home exports k .

In each country i , a representative household chooses net consumption c^i to maximize utility V^i derived from a utility function $u^i(\cdot)$ subject to a budget constraint.⁸ The household owns the profits π^i of domestic firms and receives a lump-sum transfer T^i .

$$V^i = u^i(c^i) \quad \text{and} \quad c^i \in \arg \max_{c \in \mathbb{R}^K} u^i(c) \quad \text{s.t.} \quad q^i \cdot c \leq \pi^i + T^i. \quad (2)$$

In each country i , a representative firm chooses net output y^i to maximize profits π^i subject to a production frontier $G^i(y^i) \leq 0$.

$$\pi^i = q^i \cdot y^i \quad \text{and} \quad y^i \in \arg \max_{y \in \mathbb{R}^K} q^i \cdot y \quad \text{s.t.} \quad G^i(y) \leq 0. \quad (3)$$

Each country i has net exports x^i equal to the difference between its production and consumption and, globally, markets clear.

$$x^i = y^i - c^i \quad \text{and} \quad x^i + x^{-i} = 0. \quad (4)$$

Foreign has no taxes or transfers. Home rebates trade tax revenues with a lump-sum transfer T^H in order to maintain budget balance.

$$T^F = 0 \quad \text{and} \quad T^H = - \sum_{k \in K} p_k t_k(x^F) x_k^H. \quad (5)$$

3. Designing economic sanctions

I now present my main theoretical result – a formal characterization of optimal economic sanctions – before turning to several practical takeaways for sanction design.

3.1. The Home–Foreign welfare frontier

My main result studies trade policies that are optimal in the sense that they implement an extremal point in the set of feasible Home and Foreign welfares.

Formally, I define the set of utility profiles $\mathcal{V}$ implementable with (quantity-dependent) Home trade taxes as

$$\mathcal{V} \equiv \left\{ (V^H, V^F) \mid \text{there exist quantity-dependent taxes } t(\cdot) : \mathbb{R}^K \rightarrow \mathbb{R}^K \text{ and a trade equilibrium at taxes } t(\cdot) \text{ that achieves household utilities } (V^H, V^F) \right\}. \quad (6)$$

A natural question is whether quantity restrictions or price caps – in general, quantity-dependent taxes – ever allow Home to implement utility profiles that it cannot implement with linear taxes. The following lemma clarifies that this is not the case: linear taxes are sufficient.

Lemma 1. *Linear Home trade taxes can implement any utility profile implementable with quantity-dependent Home trade taxes, i.e. all of $\mathcal{V}$.*

The idea behind this result is basic: In any equilibrium with quantity-dependent taxes, each price-taking household and firm still acts as if taxes are fixed. So it suffices to use linear trade taxes equal to the difference between these price vectors in Home and Foreign. This relies on perfect information on the part of the planner and perfect competition; instruments such as price caps or “autarky threats” can dominate linear taxes when these assumptions fail (e.g., see [Weitzman, 1974](#); [Baron and Myerson, 1982](#)).

⁸ I impose standard regularity conditions on utility functions and production frontiers in [Appendix B](#).

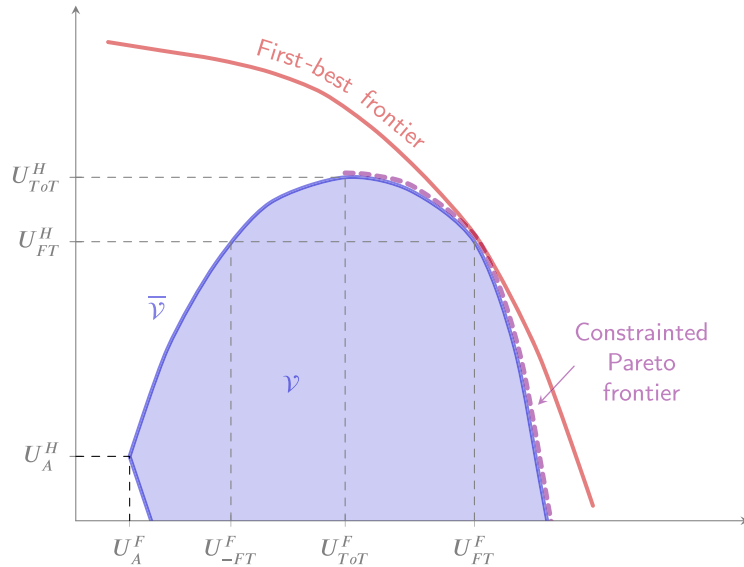


Fig. 1. The set $\mathcal{V}$ of Home–Foreign welfare profiles implementable with Home trade policies and its frontier $\bar{\mathcal{V}}$. The implementable frontier intersects the first-best frontier when Home engages in free trade (FT) and overlaps with the constrained Pareto frontier when Home does not sanction Foreign at a cost to its own welfare. It contains standard terms-of-trade manipulation (ToT) as well as autarky (A). Starting from free trade, Home can reduce Foreign welfare to U_{-FT}^F without reducing its own welfare.

Nevertheless, I now narrow my focus to linear taxes for the remainder of the paper. This in mind, I denote trade taxes simply by $\tau \in \mathbb{R}^K$.

Moving toward optimal policy, I now consider a generalization of $\mathcal{V}$'s Pareto frontier: the set of points $\bar{\mathcal{V}}$ in $\mathcal{V}$ that are extremal in either the positive- or negative-utility directions:

$$\bar{\mathcal{V}} \equiv \left\{ (V^H, V^F) \in \mathcal{V} \mid \text{there exist "welfare signs" } s^H, s^F \in \{-1, 1\} \text{ such that for all } (\tilde{V}^H, \tilde{V}^F) \in \mathcal{V}, \right. \\ \left. \text{if } s^i \tilde{V}^i > s^i V^i \text{ for some } i \in \{H, F\}, \text{ then } s^j \tilde{V}^j < s^j V^j \text{ for some } j \in \{H, F\} \right\} \quad (7)$$

Note that the *implementable frontier* $\bar{\mathcal{V}}$ lies inside of the *first-best* frontier, i.e. the set of extremal utility profiles that are feasible subject to only preferences and technology.

Fig. 1 depicts $\mathcal{V}$ and $\bar{\mathcal{V}}$. The red line traces the first-best Pareto frontier, whereas the purple line traces the Pareto frontier of $\mathcal{V}$, i.e. the subset of $\bar{\mathcal{V}}$ corresponding to $s^H = s^F = 1$. $\mathcal{V}$ lies within the first-best Pareto frontier, since trade taxes are distortionary; the two intersect only when trade taxes are set to zero. The figure notes Home and Foreign welfare at autarky ("A"), at free trade ("FT"), and at the level of Home tariffs that maximizes Home welfare by optimally manipulating Home's terms of trade ("ToT"). As long as there is non-zero trade and Foreign's supply of exports and demand for imports are not perfectly elastic, there is scope for such manipulation, so that Home can make itself better off than under free trade and make Foreign worse off.

3.2. Optimal economic sanctions

My main result characterizes the trade taxes that implement the extremal points $\bar{\mathcal{V}}$ of the set of implementable utilities. In doing so, I describe the sanctions that are efficient in the sense that they reduce Foreign welfare to any given level at the lowest welfare cost to Home.

As in the case of pure terms-of-trade manipulation, a key object in this characterization is Foreign's inverse net export supply curve, $p(x^F)$, which specifies world prices as a function of Foreign's net exports.⁹ Foreign's supply curve affects Home's tax design problem through *terms-of-trade elasticities* Σ_k^F that, at a given level of Foreign net exports x^F , capture the total appreciation of Foreign's net exports resulting from a small change in the value of its net exports of good k :¹⁰

$$\Sigma_k^F \equiv \sum_{\ell \in K} \frac{x_\ell^F}{p_k(x^F)} \frac{dp_\ell(x^F)}{dx_k^F}. \quad (8)$$

⁹ Formally, one may take $p(\cdot)$ to be any differentiable function $\mathbb{R}^K \rightarrow \mathbb{R}^K$ such that at all x , $p(x) \propto -V_x^F(x)$, where $V^F(x) \equiv \max_c u^F(c)$ s.t. $G^F(c+x) \leq 0$. **Lemma 4** in **Appendix C.2** validates this definition by showing $p \propto -V^F(x^F)$ in any equilibrium.

¹⁰ Since $p(x^F) \propto -V_x^F(x^F)$, Σ_k^F can be written as $\sum_{\ell \in K} \frac{d \log p_\ell(x^F)}{d \log |x^F|}$ by the symmetry of second derivatives. This cross-elasticity representation is perhaps more elegant, but obscures the economic mechanism.

The formal statement of the result uses a weak regularity condition on these elasticities.¹¹

Assumption 1. At any non-zero level of Foreign exports $x^F \neq 0$ that satisfies trade balance – i.e. $p(x^F) \cdot x^F = 0$ – there exist goods $k, \ell \in K$ such that additional net exports of k cause Foreign's total existing net exports to appreciate – i.e. $\Sigma_k^i \geq 0$ – and additional net exports of ℓ cause them to depreciate – i.e. $\Sigma_\ell^i \leq 0$ – with strictness in at least one case.

For typical preference specifications, one may take k to be any good Foreign exports and ℓ to be any good Foreign imports: An increase in exports of k moves Foreign sellers up their supply curve, pushing up prices and improving Foreign terms of trade, whereas an increase in net exports of ℓ – i.e. a decrease in imports – moves Foreign buyers up their demand curve, pushing up prices and worsening Foreign terms of trade.

Aside from Foreign's terms-of-trade elasticities, my main result emphasizes one other key statistic that shapes Home's optimal trade taxes. Namely, given any equilibrium, I denote by λ^F the shadow cost of Foreign welfare in units of Home welfare. As Home may set its taxes freely, I interpret λ^F as Home's marginal *willingness to pay* for Foreign welfare. In order to compare units of welfare across Home and Foreign, I measure welfare in terms of the utility each country's representative consumer derives from the marginal consumption of a particular bundle of goods $x^* \gg 0$, in the direction of which Foreign's terms of trade neither appreciate neither depreciate to first order.¹² λ^F is how many units of x^* one would have to give to H per unit of x^* one takes from F in order to move along the extremal frontier $\bar{V}$.

Theorem 1. At any point in the set $\bar{V}$ except autarky, trade taxes are, up to Lerner symmetry,¹³ given by

$$t_k = (1 - \lambda^F) \Sigma_k^F. \quad (9)$$

Theorem 1 nests the well known cases of free trade, which is optimal for a global planner with no redistributive preference across countries ($\lambda^F = 1$), and full terms-of-trade manipulation, which is optimal for a purely self-interested Home planner ($\lambda^F = 0$). It shows that, surprisingly, optimal trade taxes at any point on the implementable frontier $\bar{V}$ have the same structure as those that implement full terms-of-trade manipulation. The only difference is in the weight they place on the terms-of-trade elasticity Σ_k^F .

To understand the logic behind this result, consider the Home and Foreign welfare effects of a change in Home's trade policies that marginally increases Home's net exports of a good k . First, households in each country i experience a direct welfare change proportional to the price decrease of their consumption bundle, i.e. $-c^i \cdot dq^i$. Second, firms (and therefore the households that own them) experience a change in profits proportional to the price increase of their output bundle, i.e. $y^i \cdot dq^i$. In Home, there is a third effect: the change in government tariff revenue. This is equal to the change in the tariffs applied to Home's existing net exports, i.e. $x^H \cdot (dp - dq^H)$, plus the change in net exports at Home's existing tariffs, i.e. $dx_k^H (p_k - q_k^H)$.

Combining these terms using the market clearing condition $x^i = y^i - c^i$, the total welfare effects of Home's change in trade policy are:

$$dV^H = -p_k t_k dx_k^H + x^H \cdot dp \quad \text{and} \quad dV^F = x^F \cdot dp = -x^H \cdot dp. \quad (10)$$

In other words, Home's change in welfare is equal to appreciation of its existing net exports less the export subsidies it pays on the marginal unit of exports. In particular, the distribution of policy impacts on Home households, firms, and the government is irrelevant because households own firms and the government rebates tax revenues lump-sum. On the other hand, Foreign's change in welfare is equal to the appreciation of its existing net exports, which by trade balance is the same as the depreciation of Home's existing net exports. Intuitively, this terms-of-trade effect simply represents a transfer between Home and Foreign. By contrast, the tariff revenue effect – corresponding to additional exports of a subsidized product – represents a deadweight loss. Home's optimal policy, which ensures that the net effect $dV^H + \lambda^F dV^F$ is zero, balances this deadweight loss (the left-hand side of (9)) against the value Home places on the transfer (the right-hand side). [Fig. 2](#) uses a supply-and-demand diagram to illustrate these tradeoffs graphically in a simple, quasilinear example.

The essential step in this reasoning is to recognize that two seemingly distinct motives for trade taxes – manipulating Home's terms of trade and making Foreign worse (or better) off – are in fact two sides of the same coin. On one hand, the terms-of-trade manipulation motive encourages Home to artificially restrict trade when doing so lowers (raises) the import (export) prices it faces on the world market, *so that its net exports appreciate*. On the other hand, the first-order welfare loss to Foreign from any trade restriction is – by the envelope theorem – proportional to the *depreciation of its net exports*. So trade taxes as terms-of-trade manipulation seek to appreciate Home's terms of trade, whereas trade taxes as sanctions seek to depreciate Foreign's terms of trade.

Remark. **Theorem 1** can be reinterpreted as a manifestation of the (Diamond and Mirrlees, 1971) expression for optimal commodity taxes with a single household. The main idea behind this interpretation is to recast Home's sanction design problem as choosing a vector of world prices that minimizes (or maximizes) Foreign welfare subject to the constraint that Home welfare – conditional on having net exports equal to Foreign's net imports at those prices – is sufficiently high. If one refers to the Foreign net imports consistent with sufficiently high Home welfare as those which are “technologically feasible”, then this is the dual version of a

¹¹ It also uses three standard and purely technical assumptions that I accordingly relegate to [Appendix B](#).

¹² Under [Assumption 1](#), such a bundle always exists.

¹³ It is well known that for any equilibrium with trade taxes t and any $\kappa > 0$, there is an equivalent equilibrium with trade taxes t' given by $1 + t'_k = \kappa(1 + t_k)$ (see [Lerner, 1936](#); [Costinot and Werning, 2019](#)).

standard commodity taxation problem—except with potentially negative welfare weight on the consumer (i.e. Foreign) and without transfers that rebate tax revenues (as these accrue to Home). Let p denote consumer (i.e. Foreign) prices, q^H denote firm (i.e. Home) prices, $t_k = (q_k^H - p_k)/p_k$ denote the wedge between firm and consumer prices for each good k , and λ^F denote the shadow price of consumer welfare relative to the resource constraint (Foreign welfare relative to Home). The standard formula for optimal commodity taxes – essentially the first-order condition for prices p – then implies the first equation below:

$$\lambda^F - 1 = \sum_{\ell \in K} (-t_\ell) \frac{d \log |x_\ell^F|}{d \log p_\ell} \iff t_k = (1 - \lambda^F) \sum_{\ell \in K} \frac{d \log p_\ell}{d \log |x_\ell^F|}, \quad (11)$$

where the equivalence is simply linear algebra. The second equation in (11) is equivalent to (9) since – as $p(x^F) \propto -V^F(x^F)$ (see Footnote 9) – we have $dp_\ell(x^F)/dx_k^F = dp_k(x^F)/dx_\ell^F$ by Hessian symmetry.

3.3. Lessons for sanction design

The characterization of Section 3.2 has three useful lessons for sanction design.

The first lesson is apparent simply from the setup of the sanction design problem, as represented in Fig. 1.

Lesson 1. *Starting from any extremal point between free trade and full terms-of-trade manipulation, Home can impose a welfare loss on Foreign while increasing its own welfare.*

In other words, if Home initially does not engage in full terms-of-trade manipulation – for instance because of a free trade agreement – then imposing sanctions can actually make it better off.¹⁴ For example, suppose Home is initially in free trade, so that it achieves welfare U_{FT}^H in the figure. Home can reduce Foreign welfare to $U_{ToT}^F < U_{FT}^F$ while strictly increasing its own welfare, and can reduce Foreign welfare further, to $U_{-FT}^F < U_{ToT}^F$, before Home is worse off than under free trade.

The remaining two lessons are applications of my main result, Theorem 1. For simplicity, I present these lessons in the special case where Foreign's net export supply curve has constant elasticities Σ_k^F and then discuss their robustness.

To begin, note that, while the level of trade taxes depends on the point in $\bar{V}$ they implement – i.e. on the severity of sanctions – Theorem 1 implies that the ratio of trade taxes on any two goods is invariant.

Lesson 2. *Trade taxes as sanctions target the same goods as do trade taxes as terms-of-trade manipulation – generally using higher taxes on goods that Foreign demands or supplies inelastically – just with higher tax levels.*

In other words, to the extent that Foreign elasticities do not depend on trade taxes, one may design sanctions by simply scaling up any preexisting trade taxes that lie along the efficient frontier.

For example, suppose Foreign exports gas with a constant elasticity $1/\sigma_g$, exports oil with a constant elasticity $1/\sigma_o$, and imports a quasilinear numeraire good:

$$u^F(c_g, c_o, c_n) = -k_g(-c_g)^{1+\sigma_g} - k_o(-c_o)^{1+\sigma_o} + c_n, \quad (12)$$

Moreover, suppose Foreign has no ability to transform these goods, i.e. its technology is one-to-one in each good. Note that this implies Foreign has terms-of-trade elasticities $\Sigma_g^F = \sigma_g$, $\Sigma_o^F = \sigma_o$, and $\Sigma_n^F = 0$.

In this setting, it is well known that – taking the numeraire good to be untaxed – Home's optimal tariffs for terms-of-trade manipulation are simply equal to each good's inverse supply elasticity: $t_g = \sigma_g$, $t_o = \sigma_o$. According to Theorem 1, Home's optimal tariffs as sanctions are simply reweighted to $t_g = (1 - \lambda^F)\sigma_g$, $t_o = (1 - \lambda^F)\sigma_o$, where λ^F is Home's willingness to pay for a transfer of the numeraire to Foreign (negative in the case of sanctions). Notably, the ratio of Home's tariff on gas relative to oil is invariant to the severity of the sanctions.

An important caveat concerns the case where Foreign's elasticities are variable in the quantities it trades. In this general case, trade taxes as sanctions need not target the same goods as trade taxes as terms-of-trade manipulation because – by imposing greater trade restrictions – sanctions move the Foreign's net exports to a new level at which they may have different elasticities. Evaluating (9) at this different point therefore can result in a different pattern of trade taxes across goods. The fixed-point nature of the optimal sanctions – with taxes that depend on elasticities and elasticities that depend on taxes – may also make them harder to implement in economies with highly variable elasticities.

Another key implication of Theorem 1 is that Home elasticities only affect the design of its sanction policy insofar as they affect its willingness to trade off Home and Foreign welfare.

Lesson 3. *Given Home's willingness to pay for welfare in Foreign, λ^F , its optimal trade taxes only depend on Foreign elasticities. In particular, Home elasticities are irrelevant.¹⁵*

¹⁴ Of course, this observation breaks down if Foreign retaliates with tariffs of its own.

¹⁵ In the general case where Foreign's elasticities depend on the quantity of its net exports, Home elasticities can – as discussed above – play an indirect role by determining the point at which Foreign's supply elasticities are evaluated.

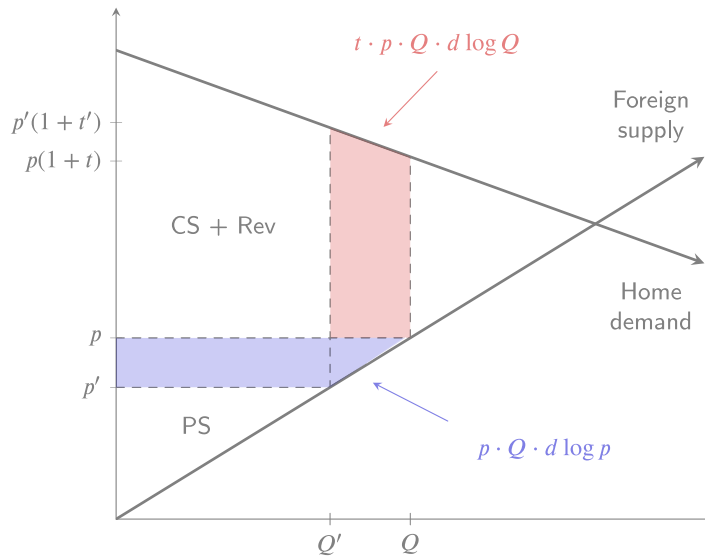


Fig. 2. Changes in Home and Foreign welfare resulting from an increase in Home import tariff. Blue region: Reduction in price of inframarginal units, i.e. transfer from Foreign to Home. Red region: Loss of tariff revenue from marginal units, i.e. increased deadweight loss. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

For example, Home need not avoid tariffs that raise import prices in sectors away from which it cannot easily substitute, such as natural gas.

Fig. 2 illustrates the irrelevance of Home elasticities in an elementary example of a single import market. Any small increase in Home's import tariff reduces Foreign producer surplus by the reduction in price of Foreign's inframarginal exports. At the same time, it increases Home surplus – which is the sum of consumer surplus and tariff revenue – by the amount lost in producer surplus minus the reduction in quantity traded at the existing tariff level.

$$d(PS) = p \cdot Q \cdot d \log p \quad \text{and} \quad d(CS + Rev) = -d(PS) + \underbrace{t \cdot p \cdot Q \cdot d \log Q}_{\epsilon^S \cdot d \log p} \quad (13)$$

where here I have noted that the change in world prices and quantities are related by the elasticity of Foreign's export supply, ϵ^S . Although Home's elasticity of demand does impact the change in world price, this change affects both Home and Foreign surplus proportionately. It therefore drops out of any determination of whether taxes are set optimally—i.e. whether the two terms balance one another, given some weight on Foreign relative to Home surplus. Notably, the change in Home's domestic price is irrelevant for Home surplus conditional on the world price, provided Home can redistribute tax revenue frictionlessly. It is important to note that domestic elasticities do factor into the *welfare impacts* of optimal sanctions, in both Home and Foreign. I discuss this topic briefly in Appendix A.

While Home's elasticities are irrelevant to its trade taxes *taking as given* its willingness λ^F to pay for Foreign welfare, they can play a role in determining this willingness. To see this, suppose – for the sake of illustration – that Home is less willing to pay for damage to Foreign once its own welfare is 1% below its level under free trade. If Home's net export demands are extremely elastic, then, since this implies it experiences very little gains from trade to start with, sanctions will never decrease Home welfare by enough to reduce its willingness to engage in them. However, if Home's net export demands are less elastic, then large enough sanctions may reduce Home's welfare by more than 1%, reducing its willingness to pay for further reductions in Foreign welfare and resulting in smaller sanctions than in the extremely-elastic case.

4. Extensions

So far, I have abstracted from many salient features of reality, including the existence of foreign trade taxes, distributional impacts of sanctions, “neutral” third-party countries, and the presence of multiple sanctioning countries. I explore these issues below.

4.1. Foreign trade taxes

I have so far assumed that Foreign's economy is efficient. This assumption plays a key role in Theorem 1 by ensuring that the effects of trade restrictions on Foreign welfare is proportional to their effects on Home terms of trade.

I now allow for Foreign distortions in the form of ad-valorem trade taxes t^F that place a wedge between Foreign domestic prices q^F and world prices.¹⁶ Foreign tax revenues are rebated lump sum. I denote Home trade taxes by t^H .

Analogously to the case without Foreign taxes, let $\mathcal{V}^i(t^{-i})$ denote the set of utility profiles implementable with some (possibly quantity-dependent) trade taxes in i , holding fixed ad-valorem taxes t^{-i} in $-i$. Let $\bar{\mathcal{V}}^i(t^{-i})$ denote the extremal points of $\mathcal{V}^i(t^{-i})$. As before, I denote Foreign terms-of-trade elasticities by Σ_k^F ; I analogously denote Home's terms-of-trade elasticities by Σ_k^H .¹⁷ Finally, for any country $i \in \{H, F\}$ and any good $k \in K$, I denote by λ_k^i country $-i$'s marginal willingness to pay for welfare in i , in units of good k . More formally, λ_k^i is how many units of k one would have to give to i per unit one takes from $-i$ in order to move along the extremal frontier $\bar{\mathcal{V}}^i(t^{-i})$.

My next result shows that – in the presence of Foreign trade taxes – Home trade taxes as sanctions take a similar form to the baseline case, but restrict trade by more in goods that generate Foreign tax revenue.

Theorem 1'. Fix any ad-valorem trade taxes t^F in Foreign and consider any point in $\bar{\mathcal{V}}^H(t^F)$ at which $1 + t^F \not\propto 1 + \Sigma^F$. For all goods k, ℓ such that $\Sigma_\ell^F \neq -1$, Home trade taxes satisfy

$$\frac{1 + t_k^H}{1 + t_\ell^H} = \lambda_\ell^F \frac{1 + t_k^F}{1 + t_\ell^F} + (1 - \lambda_\ell^F) \frac{1 + \Sigma_k^F}{1 + \Sigma_\ell^F}. \quad (14)$$

When there are no Foreign taxes, one can verify that (14) coincides with (9). More generally, Theorem 1' says that – in addition to restricting trade in goods that appreciate Home's net exports (when $\lambda_\ell^F < 1$) – Home also restricts trade in goods that generate Foreign tax revenue (when $\lambda_\ell^F < 0$). Intuitively, Foreign trade taxes may place a wedge between, for example, an export's true market price and the price faced by households and firms, implying that Foreign exports of taxed goods are inefficiently low. To the extent Home is willing to pay to reduce Foreign welfare, it should further restrict trade in such goods, "loading onto" this wedge. For example, if k is a Home import and Home is willing to pay to reduce Foreign welfare $\lambda_\ell^F < 0$, then Home uses a larger import tariff t_k^H on k the larger is Foreign's export tax on k —i.e. the more negative is t_k^F .

While I have modeled Foreign distortions as trade taxes, similar results would apply to other distortions. For example, suppose that Foreign exporters have market power, charging a markup over their costs. Like a Foreign export tax, a Foreign export markup incentivizes Home – to the extent Home places negative weight on Foreign welfare – to import fewer marked-up goods, since doing so exacerbates the markup-induced wedge in Foreign's economy.

Theorem 1' also allows me to characterize the stable outcomes of trade wars, by assuming that trade taxes in each country are given by (14), holding ad-valorem taxes in the other country as given.¹⁸

Corollary 1 (Nash Sanctions). Suppose each country $i = H, F$ sets efficient trade taxes as sanctions taking as given ad-valorem trade taxes in the other country $-i$, i.e. $(V^H, V^F) \in \bar{\mathcal{V}}^H(t^F), \bar{\mathcal{V}}^F(t^H)$. If $1 + t^F \not\propto 1 + \Sigma^F$ and $1 + t^H \not\propto 1 + \Sigma^H$, then for any goods $k, \ell \in K$ with $-\lambda_\ell^i \lambda_\ell^i, \Sigma_\ell^i, \Sigma_\ell^{-i} \neq -1$, taxes satisfy

$$\frac{1 + t_k^i}{1 + t_\ell^i} = \frac{1 + \Sigma_k^{-i}}{1 + \Sigma_\ell^{-i}} - \frac{\lambda_\ell^{-i}(1 - \lambda_\ell^i)}{1 - \lambda_\ell^{-i} \lambda_\ell^i} \left(\frac{1 + \Sigma_k^{-i}}{1 + \Sigma_\ell^{-i}} - \frac{1 + \Sigma_k^i}{1 + \Sigma_\ell^i} \right). \quad (15)$$

To illustrate the main idea behind this result, consider the typical case in trade conflicts, where Home and Foreign place negative value on each other's welfare but each value increases in their own welfare more than decreases in the other's welfare. That is, $\lambda_\ell^F, \lambda_\ell^H \in (-1, 0)$. For simplicity, suppose ℓ is an untaxed numeraire that both countries trade perfectly elastically,¹⁹ and suppose additional net exports of k from Foreign appreciate Foreign's terms of trade (as for a typical export) and additional net imports of k from Home depreciate Home's terms of trade (as for a typical import). That is, $t_\ell^H = t_\ell^F = 0$, $\Sigma_\ell^F = \Sigma_\ell^H = 0$, $\Sigma_k^F > 0$, and $\Sigma_k^H < 0$. Take all elasticities to be constant.

Under these assumptions, Eq. (15) simplifies to

$$t_k^i = \Sigma_k^{-i} - \frac{\lambda_\ell^{-i}(1 - \lambda_\ell^i)}{1 - \lambda_\ell^{-i} \lambda_\ell^i} (\Sigma_k^{-i} - \Sigma_k^i). \quad (16)$$

This implies that Home uses positive import tariffs ($t_k^F > 0$) and Foreign uses a positive export tax ($t_k^F < 0$). As in the case where each country ignores the other's sanctions, each country's trade taxes are decreasing in the other's elasticity of supply or demand and increasing in its own willingness to pay to reduce welfare in the other country. However, each country's trade taxes now also

¹⁶ The assumption that Foreign holds fixed its ad-valorem taxes does affect my results since it impacts Foreign's terms-of-trade elasticities. One could derive complementary results for the case of fixed specific taxes.

¹⁷ As before, these terms of trade elasticities measure the appreciation of i 's exports at world prices due to a small change in net exports of a good k . However, world prices are no longer equal to i 's domestic prices due to the presence of trade taxes. Formally, I define $\Sigma_k^i = \sum_{\ell \in K} \frac{x_\ell^i}{q_k^i(x^i)} \frac{1+t_\ell^i}{1+t_k^i} \frac{dq_\ell^i(x^i)}{dx_k^i}$ for any country- i inverse net export supply function $q^i(x^i) \propto -V_{x^i}^i(x^i)$, and I require that Assumption 1 applies to i 's net export demand system.

¹⁸ This exercise is similar in spirit to that of Ossa (2014) and Lashkaripour (2021), who study optimal tariffs in the presence of domestic distortions when either all countries behave unilaterally or all countries behave cooperatively. I consider the case where countries place arbitrary weights on each other's welfare and distortions arise from trade taxes themselves.

¹⁹ While this assumption simplifies the exposition, it is not necessary in order to draw qualitative insights from (15). Similar results apply to the relative trade taxes (in Home and Foreign) across any two goods k and ℓ for which $\Sigma_k^F < \Sigma_\ell^F$ and $\Sigma_k^H > \Sigma_\ell^H$.

depend on – and in particular are decreasing in – its own domestic elasticities. This reflects each country's i desire to reduce the other's welfare by loading onto the wedge created by the $-i$'s restrictions, which are more severe when i 's own elasticities are lower. As $-i$ responds to i 's response to $-i$'s taxes and so on, this motive generates a multiplier represented by the term $1 - \lambda_{\ell}^{-i} \lambda_{\ell}^i$ in (15). A similar mechanism implies that each country i imposes more severe sanctions when the other country $-i$ is more willing to pay for welfare reductions in i .

Two other remarks are useful in interpreting Corollary 1. For concreteness, these remarks set $i = H$ and $-i = F$.

1. If F values welfare equally in its own country and in H (i.e. $\lambda_{\ell}^H = 1$), then – counterintuitively – H 's trade taxes do not depend on its own willingness to pay for welfare in F (at least to the extent that elasticities are constant). The mechanism behind this fact is as follows: As H places more negative weight on welfare in F , it imposes more severe sanctions on F . However F , valuing welfare in H , sees H 's trade restrictions as an opportunity to restore efficiency and does this by subsidizing the trade that H has sanctioned. Finally, H recognizes that these subsidies are costly for F and, seeking to reduce F 's welfare, weakens its own trade restrictions so as to induce more costly subsidization by F . When $\lambda_{\ell}^H = 1$, this countervailing force against H 's trade restrictions exactly offsets its original sanctioning motive.
2. The multiplier term $1 - \lambda_{\ell}^F \lambda_{\ell}^H$ might give the false impression that, when each country values reductions in the other's welfare more than increases in its own welfare (i.e. $\lambda_{\ell}^F, \lambda_{\ell}^H < -1$), only autarky is consistent with Nash sanctions. In fact, there exist cases where H subsidizes trade because it can reduce F 's welfare more efficiently by (a) promoting trade that is welfare-reducing for F , due to F 's trade subsidies, than by (b) restricting trade to manipulate terms of trade; and where F subsidizes trade for the symmetric reason.

4.2. Many countries

The model studied above assumes there is a single sanctioning country and a single sanctioned country. It therefore abstracts from salient questions concerning (a) the desire of a sanctioner to damage a sanctioned country without harming others and (b) the role of international coordination in sanction design.

4.2.1. Many non-sanctioning countries

A key consideration in sanction design is how a country can design sanctions taking into account its desire to avoid harming a third country. A related concern is that one might like to harm the leaders of Foreign but not its average citizens.²⁰

One may incorporate these considerations into the model described above by assuming the (finite) set of countries I includes many foreign countries $i \neq H$. I assume that each foreign country engages in free trade and that there exists an aggregate foreign inverse net export demand curve $p(x^F)$, which specifies world prices as a continuously differentiable function of the sum of foreign net exports $x^F = \sum_{i \neq H} x^i$. I also assume each country has uniquely defined net export supply $x^i(x^F)$ as a function of these prices—and therefore as a function of aggregate foreign exports.²¹ Analogously to the two-country case, I let $\mathcal{V}$ denote the set of all-country welfare profiles that Home can implement with some trade taxes, and I let $\bar{\mathcal{V}}$ denote its extremal frontier.

In this many-country environment, changes in Home net exports can have different impacts on different foreign countries. Concretely, I denote by Σ_k^i the terms-of-trade elasticity of each foreign country i with respect to good k , holding fixed the net exports of other foreign countries, and by Σ_k^F the aggregate foreign terms-of-trade elasticity:

$$\Sigma_k^i = \sum_{\ell \in K} \frac{x_{\ell}^i(x^F)}{p_k(x^F)} \frac{dp_{\ell} \left(\sum_{i' \neq H} x^{i'} \right)}{dx_k^i} \Big|_{x^{i'} = x^{i'}(x^F)}, \quad \Sigma_k^F = \sum_{i \neq H} \Sigma_k^i. \quad (17)$$

Aside from terms-of-trade elasticities, the result below emphasizes the role of Home's willingness to pay, λ^i , for transfers to each individual foreign country $i \neq H$. Formally, λ^i is how many units of a particular bundle $x^* > 0$ one would have to give H per unit of x^* one takes from i in order to move along the extremal frontier $\bar{\mathcal{V}}$.²²

A slightly modified version of Theorem 1 carries over to this case:

Theorem 1''. *At any point in the set $\bar{\mathcal{V}}$ at which no country is in autarky, trade taxes are, up to Lerner symmetry, given by*

$$t_k = (1 - \mathbb{E}[\lambda^i]) \Sigma_k^F - (|I| - 1) \text{Cov}[\lambda^i, \Sigma_k^i], \quad (18)$$

where $\mathbb{E}$ and Cov compute unweighted moments over all foreign countries i .

²⁰ If one abstracts away from taxes within Foreign, one can interpret the many foreign countries in the model below as many household groups within a single foreign country. Each country's representative firm corresponds to those owned by its associated household group.

²¹ In Assumption 1', I provide formal statements of these assumptions and regularity conditions required for the result below.

²² This bundle, whose existence is guaranteed by Assumption 1' in Assumption 1', is distinguished by the property that marginal changes in Home net exports in the direction of x^* have no terms of trade effects on any country.

The presence of multiple foreign countries affects Home's trade taxes through the covariance term in (18). This term reflects the alignment of Home's redistributive preferences across foreign countries with the terms of trade effects induced by its restriction or promotion of trade in the goods k . Intuitively, Theorem 1'' says that Home should restrict trade by more in goods whose marginal imports or exports *disproportionately* appreciate the terms of trade of countries that Home wishes to sanction (i.e. that have lower/more negative λ^i .)

An illustrative special case is when Home wishes to sanction a particular foreign country i but is indifferent to welfare impacts on other “bystander countries” j , i.e. $\lambda^j = 0$. In this case, (18) simplifies to $t_k = (1 - \lambda^i)\Sigma_k^i$. This formula is similar to the baseline case in Theorem 1, but differs because its terms-of-trade elasticity Σ_k^i reflects changes in world prices in an economy with many foreign countries. Typically, substitution among these countries results in lower terms-of-trade elasticities, limiting the effectiveness of Home sanctions directed at i . Recent work by Hausmann (2022) considers sanction design in an environment that explicitly models and quantifies a sanctioned country's ability to trade with bystanders.

This result also speaks to the relevant case where goods are indexed by their origin or destination country and Home can tax such goods differentially. In such cases the covariance term in (18) can capture, for example, the fact that Home's tariffs on imports from a sanctioned exporter cause the exports of its allies to appreciate, which Home values. However, it does not consider the case where Home is constrained to engage in free trade with non-sanctioned foreign countries, for example due to free trade agreements. Sturm (2023) studies this case.

4.2.2. Many sanctioning countries

In practice, sanctions not only affect multiple countries, but also are imposed by multiple coordinating countries, and – as in the case of EU oil and gas sanctions on Russia – the incidence of welfare impacts among these countries and their citizens is a hotly debated topic.²³

Suppose there are multiple home countries $i \in I \setminus \{F\}$, each facing potentially distinct domestic prices q^i . These prices differ from the world prices faced by Foreign, $p = q^F$, by ad-valorem trade taxes t^i . Importantly, I allow for international transfers among home countries, so that the net transfers T^i received by home countries $i \neq F$ are constrained only by a single, common budget balance condition,

$$\sum_{i \neq F} T^i = - \sum_{i \neq F} \sum_{k \in K} p_k t_k^i x_k^i. \quad (19)$$

Analogously to the two-country case, I let $\mathcal{V}$ denote the set of all-country welfare profiles that the home countries can implement with some trade taxes and some transfers, and I let $\bar{\mathcal{V}}$ denote its extremal frontier. I restrict attention to the sub-frontier $\bar{\mathcal{V}}^+$ in which not all home countries can be made better off while Foreign welfare is held fixed.²⁴

Theorem 1 carries over to this case without modification, now additionally implying that all home countries impose the same trade taxes as one another vis-a-vis Foreign and trade freely among themselves.

Theorem 1'''. *At any point in the set $\bar{\mathcal{V}}^+$ at which Foreign is not autarky, all home countries $i \neq F$ use the same trade taxes $t^i = t$ up to Lerner symmetry—and so engage in free trade among themselves. These taxes are given by Eq. (9) for some constant λ^F .*

Intuitively, the existence of international transfers among home countries makes it possible to compensate the winners and losers from sanction policies that may affect home countries differentially. Trade taxes can therefore be designed so as to shift Foreign welfare at the least cost to home countries' overall welfare, as in the baseline with a single home country.

5. Conclusion

I have characterized the trade taxes that trace out the extremal frontier of Home and Foreign utilities in a benchmark neoclassical model—in other words, optimal trade sanctions. This characterization has several useful implications for sanction design.

These lessons are as follows: First, in the absence of retaliation, weak enough sanctions actually improve the welfare of a sanctioning country. Second, optimal trade taxes as sanctions target the same goods as trade taxes as terms-of-trade manipulation, namely those whose restriction causes the sanctioner's terms of trade to appreciate. Third, the relative magnitudes of trade taxes on different goods do not depend on any features of the domestic economy.

While I began by establishing these lessons in a stylized model, I have also shown that they extend naturally to more general settings. In the presence of Foreign trade taxes, Home has an additional motive for trade restrictions: to deprive Foreign of tariff and export tax revenue. Considering the simultaneous design of these Foreign trade taxes allows me to make concrete predictions about the structure of trade wars. In the presence of multiple foreign countries or multiple households within a single foreign country, Home uses more severe sanctions on goods whose restriction disproportionately worsens the terms of trade of countries or households whose welfare Home values less. Coordinating home countries trade freely among themselves and impose the same sanctions on Foreign, with these sanctions given by the same formula as the one-home-country case.

²³ Although the model below focuses on many home countries, it can also be interpreted to apply to many households within a single home country. In this case it is more natural to restrict all home countries/households to use the same trade taxes, which (I show below) happens to be optimal anyways.

²⁴ Formally, $\bar{\mathcal{V}}^+ \equiv \{(V^i)_{i \in I} \in \mathcal{V} \mid \exists (s^i)_{i \in I} \in \{-1, 1\}^I \text{ s.t. (a) } \forall i \neq F, s^i = 1 \text{ and (b) } \forall (V^i)_{i \in I} \in \mathcal{V}, \text{ if } s^i \tilde{V}^i > s^i V^i \text{ for some } i \in I, \text{ then } s^j \tilde{V}^j < s^j V^j \text{ for some } j \in I\}$.

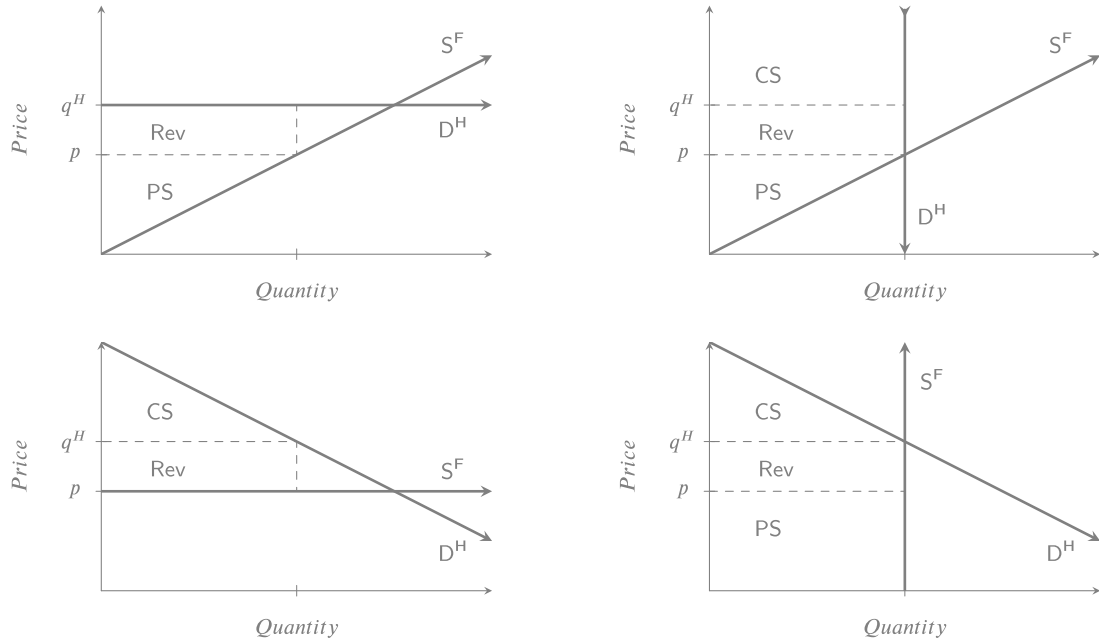


Fig. 3. Home consumer surplus, Home tariff revenue, and Foreign producer surplus under four extremal assumptions about supply and demand elasticities.

Acknowledgments

I am indebted to Iván Werning for his encouragement and guidance. I thank Daron Acemoglu, Sandeep Baliga, Peter van BERGEIJK, Arnaud Costinot, Jonathan Dingel, Joel Flynn, Bård Harstad, Ricardo Hausmann, Oliver Kooi, Rodney Ludema, Kai Menzel, Clifton Morgan, Daniel O'Connor, Jan Schmitz, Joseph Stiglitz, Constantinos Syropoulos, André Sztutman, and two anonymous referees for their comments.

Declaration of competing interest

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

Appendix A. Taxonomy of trade taxes' welfare impacts

In general, the welfare impacts of trade taxes depend on the full demand systems of Home and Foreign. However, the main ideas can be illustrated by considering four cases of an elementary supply and demand diagram. The diagrams in Fig. 3 depict the market for a good that Home imports from Foreign under a tariff, in the extremal cases of perfectly elastic demand (top left), perfectly inelastic demand (top right), perfectly elastic supply (bottom left), and perfectly inelastic supply (bottom right).

Each of these four extremal cases corresponds to its own stark set of implications for the welfare impacts of tariffs. If Home demand is perfectly elastic, then its consumers experience no gains from trade and tariffs simply trade off revenue maximization against Foreign welfare. If instead Home demand is perfectly inelastic, then changes in tariffs simply transfer inframarginal dollars between Home consumer surplus and Home tax revenue. If Foreign supply is perfectly elastic, then all surplus is Home surplus, so tariffs should simply maximize aggregate surplus—i.e. be set equal to zero. If Foreign supply is instead perfectly inelastic, then changes in tariffs simply transfer inframarginal dollars between Foreign producer surplus and Home tax revenue.

While considered above for the case of Home imports, one may easily verify that the same ideas apply to the case of Home exports.

Appendix B. Regularity conditions

I impose mild regularity conditions on preferences, production frontiers, and the relationship between them.

Assumption 2. The utility function $u^i(\cdot)$ of each country $i \in \{H, F\}$ is twice continuously differentiable, strictly concave, and is always increasing to first order in at least one good.²⁵

Assumption 3. The production frontier $G^i(\cdot)$ of each country $i \in \{H, F\}$ is twice continuously differentiable, weakly convex, and increasing to first order in all goods.²⁶

Assumption 4. For $i \in \{H, F\}$, utility u^i and the production frontier G^i satisfy the following:

- For all x , there exists $c_x^* \in \mathbb{R}^K$ and $d_x > 0$ such that (a) $G^i(c_x^* + x) \leq 0$ and (b) for all $c \notin B_{d_x}(0)$ satisfying $G^i(c + x) \leq 0$, $u^i(c) < u^i(c_x^*)$.
- For any $c, y \in \mathbb{R}^K$, there exists $k \in K$ with $u_{c_k}^i(c) > 0$ such that the $K \times K$ matrix

$$\left[\frac{d}{dc} \left(\frac{u_{c-k}^i(c)}{u_{c_k}^i(c)} \right) - \frac{d}{dy} \left(\frac{G_{y-k}^i(y)}{G_{y_k}^i(y)} \right), G_{y_k}^i(y) \right] \quad (20)$$

has full rank.

The first part of [Assumption 4](#) ensures that, conditional on any level of net exports, there exists a welfare maximizing level of domestic consumption. The second part ensures that this consumption level is continuously differentiable in net exports. It is easy to verify that these conditions hold in simple examples such as additive, CES, quasilinear consumption preferences and linear production.

Next, for $i \in \{H, F\}$, define a country's highest possible level of welfare given net exports x^i as

$$V^i(x^i) = \max_{y \in \mathbb{R}^K} u^i(y - x^i) \quad \text{s.t.} \quad G^i(y) \leq 0. \quad (21)$$

[Assumptions 2, 3, and 4](#) allow me to characterize $V^i(\cdot)$.

Lemma 2. For all $i \in \{H, F\}$, $V^i(\cdot)$ is well defined, twice continuously differentiable, and, for all $x^i \in \mathbb{R}^K$, satisfies $V_x^i(x^i) = -u^i(y^i(x^i) - x^i) \propto -G_y^i(y^i(x^i)) \ll 0$, where $y^i(x^i)$ is the (unique and continuously differentiable) solution to [\(21\)](#).

A second useful lemma connects this characterization to equilibrium outcomes.

Lemma 3. In any trade equilibrium in which a country i has net exports x^i , i has production y^i equal to the unique solution of [\(21\)](#) defined in [Lemma 2](#), $y^i(x^i)$, as well as domestic prices $q^i \gg 0$ proportional to both $G_y^i(y^i(x^i))$ and $u^i(y^i(x^i) - x^i)$.

Appendix C. Proofs of main results

Below, I prove the paper's main results. I relegate the proofs of several supporting lemmas to [Appendix D](#).

C.1. Proof of [Lemma 1](#)

I state and prove a generalized version of [Lemma 1](#) that covers the case with fixed ad-valorem Foreign trade taxes t^F studied in [Section 4.1](#).

Lemma 1'. Fix any ad-valorem Foreign trade taxes $t^F \gg -1$. Linear Home trade taxes can implement any utility profile implementable with quantity-dependent Home trade taxes, i.e. all of $\mathcal{V}^H(t^F)$.

Proof. Consider any equilibrium with quantity-dependent Home trade taxes $t^H(\cdot)$; prices p , $q^F = p(1 + t^F)$, and q^H ; exports x^H and x^F ; production y^H and y^F , consumption c^H and c^F ; and transfers T^F and T^H .

Let linear Home taxes $\tilde{t}^H$ be given by $\tilde{t}^H = t^H(x^F)$. It follows immediately from the equilibrium conditions that the same prices, exports, production, consumption, and transfers are an equilibrium with linear taxes $\tilde{t}^H$.

C.2. Proof of [Theorem 1](#) and [1'](#)

I begin with a simple characterization of the set of implementable utilities. To cover both [Theorems 1](#) and [1'](#), I provide a characterization that allows for zero or non-zero Foreign trade taxes.

Lemma 4. For any $t^F \gg -1$,

$$\mathcal{V}^H(t^F) = \tilde{\mathcal{V}}^H(t^F) \equiv \left\{ (V^H(x), V^F(-x)) \in \mathbb{R}^{\{H,F\}} \mid x \in \mathbb{R}^K, \sum_{k \in K} \frac{V_{x_k}^F(-x)}{1 + t_k^F} x_k = 0 \right\}. \quad (22)$$

²⁵ That is, for all $c \in \mathbb{R}^K$, there exists $k \in K$ such that $u_{c_k}^i(c) > 0$.

²⁶ That is, for all $y \in \mathbb{R}^K$, $G_y^i(y) \gg 0$.

Intuitively, each country achieves the highest possible utility *given* its net exports—the only distortions in the economy are trade taxes that determine what these net exports are. However, Home is constrained to choose a level of net exports consistent with trade balance. The interesting part of Home's problem is that it has some flexibility in the way it achieves trade balance, since it can move world prices by shifting exports (note that $V_{x_k}^F(x^F)/(1+t_k^F) \propto -p_k$ by the envelope theorem).

I now proceed to prove [Theorems 1](#) and [1'](#). As they contain many of the same steps, I prove them together, delineating between the two cases when necessary.

Proof of [Theorem 1](#) and [1'](#).

Given any t^F (possibly $t^F = 0$), fix any point (V^H, V^F) in $\bar{V}^H(t^F)$; if no such points exist, the theorems hold vacuously. For $i \in \{H, F\}$, let p, q^i, t^H, x^i denote the levels of world, Home, and Foreign prices; Home taxes; and Home and Foreign net exports in some equilibrium that implements (V^H, V^F) . Note that, since $q^F = p(1+t^F) \gg 0$ by [Lemmas 2](#) and [3](#), $t^F \gg -1$. By [Lemma 4](#), there exist $s^H, s^F \in \{-1, 1\}$ such that

$$x^H \in \arg \max_{x \in \mathbb{R}^K} s^H V^H(x) \quad \text{s.t.} \quad s^F V^F(-x) \geq s^F V^F \quad \text{and} \quad \sum_{k \in K} \frac{V_{x_k}^F(-x)}{1+t_k^F} x_k = 0. \quad (23)$$

I now claim (23) admits a first order condition in terms of Lagrange multipliers. This follows from the differentiability of its objective and the continuous differentiability of its constraints (established in [Lemma 2](#)), so long as the Jacobians of its constraints are linearly independent at x^H . Noting that – by [Lemmas 2](#) and [3](#) – there exist $\gamma^i > 0$ such that $-V_x^i(x^i) = \gamma^i q^i$ for $i \in \{H, F\}$, we have that these Jacobians are, respectively,

$$\begin{aligned} -s^F V_x^F(x^F) &= s^F \gamma^F (q^F)^T \quad \text{and} \\ \sum_{k \in K} \left[\frac{V_{x_k}^F(x^F)}{1+t_k^F} + \sum_{\ell \in K} \frac{x_\ell^F V_{x_\ell, x_k}^F(x^F)}{1+t_\ell^F} \right] \hat{e}_k^T &= -\gamma^F \sum_{k \in K} p_k \left[1 + \frac{\sum_{\ell \in K} x_\ell^F V_{x_\ell, x_k}^F(x^F)/(1+t_\ell^F)}{V_x^F(x^F)/(1+t_k^F)} \right] \hat{e}_k^T, \end{aligned} \quad (24)$$

where I have used the equilibrium conditions $x^F = -x^H$ and $q^F = p(1+t^F)$. Note that for any differentiable function $p(\cdot)$ that satisfies $-p_k(x) \propto V_{x_k}^F(x)/(1+t_k^F)$ for all $x \in \mathbb{R}^K$ and $k \in K$ – i.e. for some positive, differentiable scalar function $f(\cdot)$, $p_k(x) = -f(x)V_{x_k}^F(x)/(1+t_k^F)$ for all $k \in K$ – we have $\frac{\sum_{\ell \in K} x_\ell^F V_{x_\ell, x_k}^F(x^F)/(1+t_\ell^F)}{V_x^F(x^F)/(1+t_k^F)} = \sum_{\ell \in K} x_\ell^F \frac{d}{dx_k} p_\ell(x^F)/p_k(x^F) = \Sigma_k^F$ because $\sum_{k \in K} \frac{V_{x_k}^F(x^F)}{1+t_k^F} x_k^F = 0$.

- In the case of [Theorem 1](#), $q^F = p$. In order to establish the linear independence of the two Jacobians in (24), it suffices to show that $\{p_k \Sigma_k^F\}$ is not proportional to $\{p_k\}$. Note that $p \gg 0$ by [Lemma 2](#). Linear independence therefore follows from [Assumption 1](#), which ensures that if – as the theorem assumes – the economy is not in autarky, then $\{p_k \Sigma_k^F\}$ is non-zero and has a weakly positive entry and a weakly negative entry.
- In the case of [Theorem 1'](#), we wish to show that $\{q_k^F\} = \{p_k(1+t_k^F)\}$ is not proportional to $\{p_k(1+\Sigma_k^F)\}$. Given that $p \gg 0$ – a consequence of the fact that, by [Lemma 2](#), $q^H \gg 0$ – this is equivalent to the condition that $1+t_k^F \not\propto 1+\Sigma_k^F$, which the Theorem statement assumes.

There therefore exist $\mu^H = s^H, \mu^F, \phi \in \mathbb{R}$ such that

$$\begin{aligned} 0 &= \mu^H V_x^H(x^H) - \mu^F V_x^F(-x^H) - \phi \frac{d}{dx} \bigg|_{x=x^H} \left(\sum_{k \in K} \frac{V_{x_k}^F(-x)}{1+t_k^F} x_k \right) \\ \mu^H \gamma^H q_k^H &= \mu^F \gamma^F q_k^F + \phi \gamma^F p_k [1 + \Sigma_k^F] \\ 1+t_k^H &= \frac{\mu^F \gamma^F + \phi \gamma^F}{\mu^H \gamma^H} + \frac{\mu^F \gamma^F}{\mu^H \gamma^H} t_k^F + \frac{\phi \gamma^F}{\mu^H \gamma^H} \Sigma_k^F \quad \text{for all } k \in K. \end{aligned} \quad (25)$$

Above, the second equality follows from the Jacobian computations in and below (24) and the third equality follows from dividing by $\mu^H \gamma^H p_k$, which I have already argued is non-zero.

The remainder of the proof rearranges the last line of (25) into two different forms used in [Theorem 1](#) and [Theorem 1'](#), respectively.

- Assume $t^F = 0$. By [Assumption 1](#), take $\ell, \ell' \in K$ such that $(x^F)^T V_{xx}^F(x^F) \leq 0$ and $(x^F)^T V_{xx}^F(x^F) \geq 0$. Then there exist $\alpha_\ell, \alpha_{\ell'} \geq 0$, not both zero, such that for $x^* = \alpha_\ell \hat{e}_\ell + \alpha_{\ell'} \hat{e}_{\ell'}$, $(x^F)^T V_{xx}^F(x^F) \cdot x^* = 0$. (25) then implies

$$\mu^H V_x^H(x^H) \cdot x^* = (\mu^F + \phi) V_x^F(x^F) \cdot x^*. \quad (26)$$

Plugging (26) into the last line of (25) implies

$$1+t_k = \underbrace{\frac{\gamma^F/(V_x^F(x^F) \cdot x^*)}{\gamma^H/(V_x^H(x^H) \cdot x^*)}}_{>0} \left(1 + \left(1 - \frac{\mu^F V_x^F(x^F) \cdot x^*}{\mu^H V_x^H(x^H) \cdot x^*} \right) \Sigma_k^F \right). \quad (27)$$

where the “ > 0 ” claim follows from that $V_x^i(x^i) \ll 0$ and $\gamma^i > 0$ for $i = H, F$, and that $x^* > 0$. Defining $\lambda^F \equiv (\mu^F V_x^F(x^F) \cdot x^*)/(\mu^H V_x^H(x^H) \cdot x^*)$ completes the proof.

2. Now consider arbitrary $t^F \gg -1$. Fixing a good $\ell \in K$, the second line of (25), the assumption that $\Sigma_\ell^F \neq -1$, and the fact that $-V_x^i(x_i) = \gamma^i q^i$ for $i \in \{H, F\}$ imply that

$$\begin{aligned} \mu^H V_{x_\ell}^H(x^H) &= \mu^F V_{x_\ell}^F(x^F) + \phi V_{x_\ell}^F(x^F) \frac{1 + \Sigma_\ell^F}{1 + t_\ell^F} \\ \phi(1 + \Sigma_\ell^F) &= \left(\frac{\mu^H V_{x_\ell}^H(x^H)}{V_{x_\ell}^F(x^F)} - \mu^F \right) (1 + t_\ell^F). \end{aligned} \quad (28)$$

By the last line of (25), the observation that $t_\ell^H > -1$ since $q^H = p(1 + t^H) \gg 0$, and the assumption that $\Sigma_\ell^F \neq -1$, we have

$$\begin{aligned} \frac{1 + t_k^H}{1 + t_\ell^H} &= \frac{\mu^F(1 + t_k^F) + \phi(1 + \Sigma_k^F)}{\mu^F(1 + t_\ell^F) + \phi(1 + \Sigma_\ell^F)} \\ &= \frac{\mu^F(1 + t_k^F) + \left(\frac{\mu^H V_{x_\ell}^H(x^H)}{V_{x_\ell}^F(x^F)} - \mu^F \right) (1 + t_\ell^F) \frac{1 + \Sigma_k^F}{1 + \Sigma_\ell^F}}{\frac{\mu^H V_{x_\ell}^H(x^H)}{V_{x_\ell}^F(x^F)} (1 + t_\ell^F)} \\ &= \lambda_\ell^F \frac{1 + t_k^F}{1 + t_\ell^F} + (1 - \lambda_\ell^F) \frac{1 + \Sigma_k^F}{1 + \Sigma_\ell^F}, \end{aligned} \quad (29)$$

where the second equality follows from plugging in for $\phi(1 + \Sigma_\ell^F)$ and the third follows from the definition $\lambda_\ell^F = \frac{\mu^F V_{x_\ell}^F(x^F)}{\mu^H V_{x_\ell}^H(x^H)}$.

C.3. Proof of Theorem 1''

In addition to the assumptions imposed in the one-foreign-country case, I now impose an additional technical assumption. Below, let $|F|$ denote the number of foreign countries.

Assumption 5. Given any Home net exports $x^H \neq 0$, the system of equations

$$0 = x^H + \sum_{i \neq H} x^i \quad \text{and, for all } i \neq H, \quad -p \propto V_x^i(x^i) \quad \text{and} \quad p \cdot x^i + \frac{p \cdot x^H}{|F|} = 0. \quad (30)$$

admits a (up to price normalization) unique solution for prices $p(-x^H)$ and the net exports $x^i(-x^H)$ of each foreign country $i \neq H$, and $p(\cdot)$ is continuously differentiable.²⁷ Moreover, for each $i \neq H$, the function

$$\tilde{V}^i(p) \equiv \max_{x^i \in \mathbb{R}^K} V^i(x) \quad \text{s.t.} \quad p \cdot x^i = 0. \quad (31)$$

is well-defined and continuously differentiable.

This assumption guarantees – albeit in a reduced form way – that world prices and foreign welfare are well-behaved functions of Home's net exports, which ensures Home's tax design problem has convenient technical properties. These properties were guaranteed with more technical assumptions on fundamentals in the two-country analysis. The last equation in (30) implies trade balance for each foreign country when Home's net exports satisfy trade balance. When Home's net exports satisfy do not satisfy trade balance, it assumes all foreign countries have equal trade surpluses or deficits. While some such assumption is necessary in order to pin down world prices, this particular assumption plays no role in Home's tax design problem, as Home is constrained to choose taxes that satisfy trade balance.

Given any x^H , I denote – for each foreign country $i \neq H$ – i 's vector of terms of trade elasticities by Σ^i , i.e. for all $k \in K$,

$$\Sigma_k^i = \sum_{\ell \in K} \frac{x_\ell^i(-x^H)}{p_k(-x^H)} \frac{dp_\ell \left(\sum_{i' \neq H} x^{i'} \right)}{dx_k^i} \Big|_{x^{i'} = x^{i'}(-x^H)}. \quad (32)$$

I denote the aggregate foreign terms of trade elasticity by $\Sigma^F \equiv \sum_{i \neq H} \Sigma^i$.

I additionally require a modified version of Assumption 1 tailored to the many-foreign-country setting.

Assumption 1'. Fix any level of Home net exports x^H at which all countries are not in autarky – i.e. $x^H \neq 0$ and for all $i \neq H$, $x^i(-x^H) \neq 0$ – and which satisfies trade balance – i.e. $p(-x^H) \cdot x^H = 0$. The foreign terms of trade vectors $\{\Sigma^i\}_{i \neq H}$ are linearly independent and do not span the unit vector $\{1_k\}_{k \in K}$, and there exists a positive vector of exports $x^* > 0$ in the direction of which no countries experience terms of trade effects, i.e. $\Sigma^i \cdot x^* = 0$ for all $i \neq H$.

²⁷ Intuitively, this system of equations has $K + |F|(K - 1) + |F| = K + |F|(K - 1)$ equations, one of which is redundant by Walras' law, and (up to price normalization) $K - 1 + |F|K$ unknowns.

This assumption – which is implied by [Assumption 1](#) in the case of a single foreign country – is a rank condition used to show the existence of Lagrange multipliers and to define Home's willingness to pay for welfare in each foreign country.

Proof of Theorem 1''. To begin note that, under [Assumption 5](#), it follows from an analogous argument to the one used to prove [Lemma 4](#) that the set $\mathcal{V}$ of implementable Home and foreign utilities $(V^i)_{i \in I}$ is equal to the set

$$\tilde{\mathcal{V}} \equiv \left\{ \left(V^H(x^H), \{V^i(x^i(-x^H))\}_{i \neq H} \right) \in \mathbb{R}^I \mid x^H \in \mathbb{R}^K, x^H \cdot p(-x^H) = 0 \right\} \quad (33)$$

Moreover, note that at all x^H satisfying $x^H \cdot p(-x^H) = 0$, the construction of $x^i(-x^H)$ implies that $x^i(-x^H) \cdot p(-x^H) = 0$ and $-V_x^i(x^i(-x^H)) \propto p(-x^H)$, so – by V^i 's concavity (a consequence of [Assumptions 2](#) and [3](#)) – Lagrangian sufficiency implies $V^i(x^i(-x^H)) = \tilde{V}^i(p(-x^H))$.

It follows that at any extremal point in $\mathcal{V}$, there exist welfare signs $\{s^i\}_{i \in I} \in \{-1, 1\}^I$ and foreign welfare levels $\{\tilde{V}^i\}_{i \neq H}$ such that Home's net exports x^H satisfy

$$x^H \in \max_{x \in \mathbb{R}^K} s^H V^H(x) \quad \text{s.t.} \quad s^i \tilde{V}^i(p(-x^H)) \geq s^i \tilde{V}^i \quad \forall i \neq H \quad \text{and} \quad x^H \cdot p(-x^H) = 0. \quad (34)$$

I now claim that this problem admits a Lagrangian first-order condition. As its objective and constraints are, by [Lemma 2](#) and [Assumption 1'](#), continuously differentiable, it suffices to show that its constraints have linearly independent Jacobians. These Jacobians are:

$$\begin{aligned} -s^i \tilde{V}_p^i(p(-x^H))^T \frac{dp(x^F)}{dx^F} \Big|_{x^F=-x^H} &= -s^i \gamma^i x^i(-x^H)^T \frac{dp(x^F)}{dx^F} \Big|_{x^F=-x^H} \\ &= \{-s^i \gamma^i p_k(-x^H) \Sigma_k^i\}_{k \in K} \\ p(-x^H) - x^H \cdot p_x(-x^H) &= \{p_k(-x^H) (1 + \Sigma_k^F)\}_{k \in K}. \end{aligned} \quad (35)$$

for some constants $\gamma^i > 0$. The first equality above follows from the envelope theorem applied to $\tilde{V}^i(p)$ and the earlier observation that $x^i(-x^H)$ solves the corresponding optimization problem at prices $p(-x^H)$. The strict positivity of γ^i follows from that utility is non-satiated, by [Assumption 2](#).

Note that (a) $p(-x^H) \gg 0$ by [Assumption 5](#) and [Lemma 2](#), (b) the Σ^i 's for countries $i \neq H$ are linearly independent by [Assumption 1'](#), and (c) $\Sigma^F = \sum_{i \neq H} \Sigma^i$. It therefore suffices – in order to establish the Jacobians' linear independence – to establish that the vectors $\{p_k(-x^H) \Sigma_k^i\}_{k \in K}$ for all $i \neq H$ cannot span $p(-x^H)$, or in other words the vectors Σ^i for $i \neq H$ cannot span the unit vector, which is assumed by [Assumption 1'](#).

I conclude that there exist constants $\mu^H \in \{-1, 1\}$, $\mu^{i \neq H}, \phi \in \mathbb{R}$ such that – letting q^H and p be Home and world prices in any equilibrium that implements $(V^i)_{i \in I}$ – the following is true for all goods $k \in K$:

$$\begin{aligned} 0 &= -\mu^H \gamma^H q_k^H - p_k \sum_{i \neq H} \mu^i \gamma^i \Sigma_k^i + \phi p_k (1 + \Sigma_k^F) \\ 1 + t_k &= - \sum_{i \neq H} \frac{\mu^i \gamma^i}{\mu^H \gamma^H} \Sigma_k^i + \frac{\phi}{\mu^H \gamma^H} (1 + \Sigma_k^F) \end{aligned} \quad (36)$$

where the first equality uses [Lemmas 2](#) and [3](#) applied to Home.

Adding the first equality of (36) across goods in proportion to their representation in the bundle $x^* > 0$ – whose existence is guaranteed by [Assumption 1'](#) – I use the fact that $\Sigma^i \cdot x^* = 0$ for all $i \neq H$ to compute

$$\frac{\phi}{\mu^H \gamma^H} = \frac{q^H \cdot x^*}{p \cdot x^*}. \quad (37)$$

Note that both the numerator and denominators above are strictly positive since $\mu^H \in \{-1, 1\}$, $\gamma^H > 0$ as established above, $p, q^H \gg 0$ by [Lemma 3](#), and $x^* > 0$ by [Assumption 1'](#). Substituting back into the second equality of (36) and defining $\lambda^i \equiv \frac{\mu^i V_x^i(x^i(-x^H)) \cdot x^*}{\mu^H V_x^H(x^H) \cdot x^*} = \frac{\mu^i \gamma^i p \cdot x^*}{\mu^H \gamma^H q^H \cdot x^*}$ for all $i \neq H$, I obtain

$$\begin{aligned} 1 + t_k &= \frac{q^H \cdot x^*}{p \cdot x^*} \left[- \sum_{i \neq H} \frac{\mu^i \gamma^i p \cdot x^*}{\mu^H \gamma^H q^H \cdot x^*} \Sigma_k^i + 1 + \Sigma_k^F \right] \\ &= \frac{q^H \cdot x^*}{p \cdot x^*} \left[1 + \Sigma_k^F - \sum_{i \neq H} \lambda^i \Sigma_k^i \right] \\ &= \frac{q^H \cdot x^*}{p \cdot x^*} [1 + (1 - \mathbb{E}[\lambda^i]) \Sigma_k^F - (|I| - 1) \text{Cov}[\lambda^i, \Sigma_k^i]] \end{aligned} \quad (38)$$

where the last line follows from the definition $\Sigma_k^F \equiv \sum_{i \neq H} \Sigma_k^i$. As I have already established that $\frac{q^H \cdot x^*}{p \cdot x^*} > 0$, this implies that taxes are – up to Lerner symmetry – as in the statement of [Theorem 1''](#).

C.4. Proof of Theorem 1'''

The equilibrium conditions with many home countries are as follows.

$$q_k^F = p_k \quad \text{and} \quad q_k^{i \neq F} = p_k(1 + t_k^i). \quad (39)$$

$$V^i = u^i(c^i) \quad \text{and} \quad c^i \in \arg \max_{c \in \mathbb{R}^K} u^i(c) \quad \text{s.t.} \quad q^i \cdot c \leq \pi^i + T^i. \quad (40)$$

$$\pi^i = q^i \cdot y^i \quad \text{and} \quad y^i \in \arg \max_{y \in \mathbb{R}^K} q^i \cdot y \quad \text{s.t.} \quad G^i(y) \leq 0. \quad (41)$$

$$x^i = y^i - c^i \quad \text{and} \quad \sum_{i \neq I} x^i = 0. \quad (42)$$

$$T^F = 0 \quad \text{and} \quad \sum_{i \neq F} T^i = - \sum_{i \neq F} \sum_{k \in K} p_k t_k^i x_k^i. \quad (43)$$

I require that Assumptions 2, 3, and 4 hold for all countries i , so that Lemmas 2 and 3 apply.

I begin with a simple characterization of the set of implementable utilities, one that adapts Lemma 4 to the many-home-country setting. I relegate the proof to Appendix D.

Lemma 4'. *The implementable set $\mathcal{V}$ satisfies*

$$\mathcal{V} = \tilde{\mathcal{V}} \equiv \left\{ \left(\left(V^j(x^j) \right)_{j \neq F}, V^F \left(- \sum_{j \neq F} x^j \right) \right) \in \mathbb{R}^I \mid x^{j \neq F} \in \mathbb{R}^K, \sum_{k \in K} V_{x_k}^F \left(- \sum_{j \neq F} x^j \right) \sum_{j \neq F} x_k^j = 0 \right\}. \quad (44)$$

I now proceed to prove Theorem 1'''.

Proof of Theorem 1'''.

Fix any point $(V^i)_{i \in I} \in \bar{\mathcal{V}}^+$ and, by Lemma 4', let $(x^i)_{i \neq F}$ be the associated trade vector. The definition of $\bar{\mathcal{V}}^+$ and Lemma 4' imply that there exists $s^F \in \{-1, 1\}$ such that, for some arbitrary household $i_0 \in I \setminus \{F\}$,

$$\begin{aligned} (x^i)_{i \neq F} &\in \arg \max_{(\tilde{x}^i)_{i \neq F} \in (\mathbb{R}^K)^{I \setminus \{F\}}} V^{i_0}(\tilde{x}^{i_0}) \\ \text{s.t. } &V^i(\tilde{x}^i) \geq V^i \quad \forall i \neq i_0, F \\ &s^F V^F \left(- \sum_{i \neq F} \tilde{x}^i \right) \geq s^F V^F \\ &V_x^F \left(- \sum_{i \neq F} \tilde{x}^i \right) \cdot \sum_{i \neq F} \tilde{x}^i = 0 \end{aligned} \quad (45)$$

Note that this optimization problem can be reformulated as the combination of an outer and inner problem:

$$\begin{aligned} \max_{\tilde{x}^F \in \mathbb{R}^K} W^{i_0}(\tilde{x}^F) \quad \text{s.t.} \quad &s^F V^F(\tilde{x}^F) \geq s^F V^F \quad \text{and} \quad V_x^F(\tilde{x}^F) \cdot \tilde{x}^F = 0 \\ \text{where } W^{i_0}(\tilde{x}^F) = &\max_{(\tilde{x}^i)_{i \neq F} \in (\mathbb{R}^K)^{I \setminus \{F\}}} V^{i_0}(\tilde{x}^{i_0}) \quad \text{s.t.} \quad V^i(\tilde{x}^i) \geq V^i \quad \forall i \neq i_0, F \quad \text{and} \quad \tilde{x}^F + \sum_{i \neq F} \tilde{x}^i = 0 \end{aligned} \quad (46)$$

Eq. (45) implies that $(x^i)_{i \neq F}$ solves the inner problem in (46) while $x^F \equiv - \sum_{i \neq F} x^i$ solves the outer problem.

Focusing first on the inner problem, I consider the first-order condition of the planner's Lagrangian. The Lagrangian's multipliers exist by the problem's concavity (from Assumptions 2 and 3 and the definition of $V^i(\cdot)$.) and all associated terms are differentiable by Lemma 2. We have

$$\mu^i V_{x_k}^i(x^i) = \kappa_k \quad \text{for all } k \in K, i \neq F \quad (47)$$

for some $\mu^i \geq 0$ (with $\mu^{i_0} = 1$) and $\kappa_k \in \mathbb{R}$. Assumptions 2 and 3 imply that additional home net imports of any good strictly increase i_0 's utility, ensuring all $\kappa_k > 0$ and hence all $\mu^i > 0$. I conclude by Lemmas 2 and 3 that for all $i, j \neq F$, $\mu^i q^i \propto \mu^j q^j$. In other words, trade among home countries is free, up to Lerner symmetry.

Now turning to the outer problem, I begin by establishing two facts about the function $W^{i_0}(\cdot)$. First, the differentiability of each $V^i(\cdot)$ function (from Lemma 2) and the concavity of each $V^i(\cdot)$ function (a consequence of Assumptions 2 and 3) imply that, by the Benveniste–Scheinkman theorem, $W^{i_0}(\cdot)$ is differentiable and $W_x^{i_0}(x^F) = V_x^{i_0}(x^{i_0})$. Second, by Lemma 3 and my observations above about free trade among home countries, domestic prices q^i satisfy $q^i \propto -V_x^i(x^i) \propto -V_x^i(x^{i_0}) \propto -W_x^{i_0}(x^F)$ for all countries $i \neq F$. Armed with these facts, I return to the outer problem of (46). Note that all of the arguments used to prove Theorem 1 now also apply to this outer problem. This implies that the same tariff formula holds.

Appendix D. Proofs of supporting lemmas

Proof of Lemma 2.

First, fixing any $x^i \in \mathbb{R}^K$, I argue $V^i(x^i)$ is well defined. By Assumption 4, there exists $d_x > 0$ such that for all $y \notin B_{d_x}(x^i)$ satisfying $G^i(y) \leq 0$, $u^i(y - x^i) \leq \max_{\bar{y} \in \bar{B}_{d_x}(x^i), G^i(\bar{y} - x^i) \leq 0} u^i(\bar{y} - x^i)$, where note that the latter exists since u^i is continuous by Assumption 2 and $\bar{B}_{d_x}(x^i)$ is compact (here I have used G^i 's continuity, from Assumption 3). $V^i(x^i)$ therefore has the same value as if its definition in (21) restricts to the domain $\bar{B}_{d_x}(x^i)$. That restricted problem has a solution by the extreme value theorem, so $V^i(x^i)$ is well defined. I moreover note that – since by Assumptions 2 and 3 u^i is strictly concave and G^i is weakly convex – this solution is achieved by a unique level of production that I denote by $y^i(x^i)$.

Second, fixing any $x^i \in \mathbb{R}^K$, I argue $y^i(\cdot)$ is twice continuously differentiable at x^i . To see this first note that since (21) is a convex optimization problem with a continuously differentiable objective and constraint, there exists a Lagrange multiplier $\lambda(x^i) > 0$ such that

$$u_c^i(y^i(x^i) - x^i) = \lambda(x^i)G_y^i(y^i(x^i)) \quad \text{and} \quad G^i(y^i(x^i)) = 0. \quad (48)$$

Here, I have used that the constraint must bind since, by Assumptions 2 and 3, there exists a good $k \in K$ for which $u_{c_k}^i(y^i(x^i) - x^i) > 0$ and $G_{y_k}^i(y^i(x^i)) > 0$. Letting $k \in K$ be the good referred to in the second part of Assumption 4, (48) implies

$$\frac{u_{c-k}^i(y^i(x^i) - x^i)}{u_{c_k}^i(y^i(x^i) - x^i)} - \frac{G_{y-k}^i(y^i(x^i))}{G_{y_k}^i(y^i(x^i))} = 0 \quad \text{and} \quad G^i(y^i(x^i)) = 0, \quad (49)$$

and by the second part of Assumption 4, the $K \times K$ matrix

$$\mathcal{M}(x^i)^T = \left[\frac{d}{dc} \Big|_{c=y^i(x^i)-x^i} \left(\frac{u_{c-k}^i(c)}{u_{c_k}^i(c)} \right) - \frac{d}{dy} \Big|_{y=y^i(x^i)} \left(\frac{G_{y-k}^i(y)}{G_{y_k}^i(y)} \right), G_y^i(y^i(x^i)) \right] \quad (50)$$

is full rank. By the implicit function theorem and – from Assumptions 2 and 3 – the twice continuous differentiability of $u^i(\cdot)$ and $G^i(\cdot)$, $y^i(x^i)$ is locally continuously differentiable and

$$y_x^i(x^i) = \mathcal{M}(x^i)^{-1} \left[\frac{d}{dx^i} \Big|_{y=y^i(x^i)} \left(\frac{u_{c-k}^i(y^i - x^i)}{u_{c_k}^i(y^i - x^i)} \right), 0 \right]. \quad (51)$$

Third, fixing any $x^i \in \mathbb{R}^K$, I argue $V^i(\cdot)$ is twice continuously differentiable at x^i . Fixing any $\epsilon > 0$, I first note that since $y^i(x^i)$ is continuous, there exists $\delta > 0$ such that $y^i(\tilde{x}^i) \in \bar{B}_\epsilon(y^i(x^i))$ when $\tilde{x}^i \in B_\delta(x^i)$. So for $\tilde{x}^i \in B_\delta(x^i)$,

$$V^i(\tilde{x}^i) = \max_{y^i \in B_\epsilon(y^i(x^i)), G^i(y^i) \leq 0} u^i(y^i - \tilde{x}^i). \quad (52)$$

Since, by Assumption 2, $u^i(\cdot)$ is twice continuously differentiable, the function $u^i(y^i + x^i)$ is has a bounded Jacobian in y^i on the (compact) domain of (52) – call it $\mathcal{J}^i(x^i)$ – so the family of functions $\{u^i(y^i - \tilde{x}^i)\}_{y^i \in \mathcal{J}^i(x^i)}$ is equidifferentiable at $\tilde{x}^i = x^i$. Since $\mathcal{J}^i(x^i)$ non-empty, Theorem 3 of Milgrom and Segal (2002) implies that $V^i(\cdot)$ is differentiable at x^i – and moreover $V_x^i(x^i) = \frac{d}{dx^i} \Big|_{y=y^i(x^i)} u^i(y^i - x^i) = -u_c^i(y^i(x^i) - x^i)$ – if and only if $u_c^i(y^i(\tilde{x}^i) - x^i)$ is continuous in $\tilde{x}^i$ at $\tilde{x}^i = x^i$. Indeed, this follows from that $u_c^i(\cdot)$ and $y^i(x^i)$ are both continuous (by Assumption 2 and shown above, respectively). Note that $V_x^i(x^i) = -u_c^i(y^i(x^i) - x^i)$ implies $V^i(\cdot)$ is in fact twice continuously differentiable in x^i , since $u_c^i(\cdot)$ and $y^i(x^i)$ are both continuously differentiable (again, by Assumption 2 and shown above, respectively).

Fourth and finally, fixing any $x^i \in \mathbb{R}^K$, I argue $V_x^i(x^i) \propto -G_y^i(y^i(x^i) - x^i) \ll 0$. I have already shown (a) $V_x^i(x^i) = -u_c^i(y^i(x^i) - x^i)$ and (b) there exists $\lambda > 0$ such that $u_c^i(y^i(x^i) - x^i) = \lambda G_y^i(y^i(x^i))$. So the desired claim follows from that, by Assumption 3, $G_y^i(y^i(x^i)) \gg 0$.

Proof of Lemma 3.

By domestic market clearing, consumption in i satisfies $c^i = y^i - x^i$. Since, by Assumption 2, $u^i(\cdot)$ is non-satiated, there exists at least one good $k \in K$ with a strictly positive price $q_k^i > 0$. Firm optimization and the fact that, by Assumption 3, $G^i(\cdot)$ is increasing in all goods then implies all prices are strictly positive, i.e. $q^i \gg 0$. Moreover since, by Assumption 3, $G^i(\cdot)$ is continuously differentiable, convex, and increasing, firm optimization implies $G_y^i(y^i) \propto q^i$ and $G^i(y^i) = 0$. Similarly, since, by Assumption 2, $u^i(\cdot)$ is continuously differentiable, concave, and increasing, household optimization implies $u_y^i(c^i = y^i - x^i) \propto q^i$. Since – as argued in the proof of Lemma 2 – the constraint in (21) always binds, concavity and Lagrangian sufficiency then implies that y^F solves (21). Lemma 2 then implies that $y^F = y^F(x^F)$.

Proof of Lemma 4.

First, I claim that $\mathcal{V}^H(t^F) \subset \tilde{\mathcal{V}}^H(t^F)$. To see this, take any point $(V^H, V^F) \in \mathcal{V}^H(t^F)$ and let $(x^i)_{i \in \{H, F\}}$, y^F , and q^F be net exports, Foreign production, and Foreign prices, respectively, in any equilibrium that implements it. Note that by international goods market clearing, $x^F = -x^H$. Lemma 3 therefore implies $V^H = V^H(x^H)$ and $V^F = V^F(-x^H)$. It remains to show that $\sum_{k \in K} V_{x_k}^F(x^F)/(1 + t_k^F) \cdot (-x_k^F) = 0$. Indeed,

$$\begin{aligned} \text{const} \cdot \sum_{k \in K} V_{x_k}^F(x^F)/(1 + t_k^F) \cdot x_k^F &= \sum_{k \in K} q_k^F/(1 + t_k^F) \cdot x_k^F = p \cdot x^F = (q^F - p t^F) \cdot x^F \\ &= q^F \cdot (y^F - c^F) + T^F = \pi^F - q^F \cdot c^F + T^F = 0. \end{aligned} \quad (53)$$

Above, the first inequality follows from [Lemmas 2](#) and [3](#); the second and third follow from the equilibrium condition for prices in Foreign; the fourth follows from domestic goods market clearing in Foreign and Foreign government budget balance; the fifth follows from the definition of profits; and the sixth follows from the Foreign household budget constraint.

Second, I claim that $\tilde{\mathcal{V}}^H(t^F) \subset \mathcal{V}^H(t^F)$. To see this, take any $(\tilde{V}^H, \tilde{V}^F) \in \tilde{\mathcal{V}}^H(t^F)$ and let $x \in \mathbb{R}^K$ be the corresponding vector satisfying $V^H(x) = \tilde{V}^H$, $V^F(-x) = \tilde{V}^F$, and $\sum_{k \in K} V_{x_k}^F(-x)/(1+t_k^F) \cdot x_k = 0$. It suffices to construct an equilibrium $(p, (q^i, t^i, c^i, y^i, x^i, V^i, \pi^i, T^i)_{i \in \{H, F\}})$ – where I require t^F is as exogenously given – with $V^i = \tilde{V}^i$ for $i \in \{H, F\}$. To this end, I define, for all $i \in \{H, F\}$,

$$\begin{aligned} x^H &= x, & x^F &= -x^H, & q^i &= -V_x^i(x^i), & p_k &= q_k^F/(1+t_k^F), & t_k^H &= (q_k^H - p_k)/p_k \\ V^i &= \tilde{V}^i, & T^i &= (p - q^i) \cdot x^i, & y^i &= y^i(x^i), & c^i &= y^i - x^i & \pi^i &= q^i \cdot y^i. \end{aligned} \quad (54)$$

where $y^i(x^i)$ is as in [Lemma 2](#). It remains to verify that (54) satisfies equilibrium conditions (1)–(5) except – in the case of non-zero trade taxes – with $q^F = p(1+t^F)$ and $T^F = -p t^F \cdot x^F$ rather than the Foreign parts of (1) and (5). Of these, all are immediate from the construction above except for (a) the optimality of production, (b) the optimality of consumption, and (c) the fact that welfare in each country equals V^i . I now show these in turn: (a) Since G^i is concave by [Assumption 3](#), $q^i \gg 0$ by [Lemma 2](#), and $G_y^i(y^i) \gg 0$ by [Assumption 3](#), it suffices for production optimality to show that $G^i(y^i) = 0$ and $q^i \propto G_y^i(y^i)$. The former follows from the definition of $V^i(x^i)$ in (21), given that, by [Assumptions 2](#) and [3](#), consumption utility is increasing in some good that is produce-able on the margin; the latter follows from that, by construction and [Lemma 2](#), $q^i = -V_x^i(x^i) = \kappa^i G_y^i(y^i)$ for some $\kappa^i > 0$. (b) Since, by [Assumption 2](#), u^i is non-satiated and concave, it suffices for consumption optimality to show that $u_c^i(c^i) \propto q^i$ and that $q^i \cdot c^i = \pi^i + T^i$. The former follows from [Lemma 2](#) and q^i 's definition. The latter follows from the definitions of T^i and π^i and the fact that $p \cdot x^i = \pm p \cdot x^F = \text{const} \cdot \sum_{k \in K} V_{x_k}^F(x^F)/(1+t_k^F) \cdot x_k^F = 0$. (c) By [Lemma 3](#) and the construction of consumption, the representative household of each country $i \in \{H, F\}$ experiences utility $V^i(x^i)$. Since I began the proof by supposing that $\tilde{V}^i = V^i(x^i)$, each i has welfare $\tilde{V}^i = V^i$, as desired.

Proof of [Lemma 4'](#).

First, I claim that $\mathcal{V} \subset \tilde{\mathcal{V}}$. To see this, take any point $(V^i)_{i \in I} \in \mathcal{V}$ and let $(x^i)_{i \in I}$, y^F , and q^F be net exports, Foreign production, and Foreign prices, respectively, in any equilibrium that implements it. By international goods market clearing, $x^F = -\sum_{i \neq F} x^i$. [Lemma 3](#) therefore implies $V^i = V^i(x^i)$ for all $i \neq F$ and $V^F = V^F(-\sum_{i \neq F} x^i)$. It remains to show that $\sum_{k \in K} V_{x_k}^F(x^F) \cdot (-x_k^F) = 0$. Indeed,

$$\text{const} \cdot \sum_{k \in K} V_{x_k}^F(x^F) \cdot x_k^F = q^F \cdot x^F = q^F \cdot (y^F - c^F) + T^F = \pi^F - q^F \cdot c^F + T^F = 0. \quad (55)$$

Above, the first inequality follows from [Lemmas 2](#) and [3](#); the second follows from domestic goods market clearing in Foreign and Foreign government budget balance given zero Foreign tariffs; the third follows from the definition of profits; and the fourth follows from the Foreign household budget constraint.

Second, I claim that $\tilde{\mathcal{V}} \subset \mathcal{V}$. To see this, take any $(\tilde{V}^i)_{i \in I} \in \tilde{\mathcal{V}}$ and let $(x^i)_{i \neq F} \in (\mathbb{R}^K)^{|I|-1}$ be the corresponding vector satisfying $V^i(x^i) = \tilde{V}^i$ for all $i \neq F$, $V^F(-\sum_{i \neq F} x^i) = \tilde{V}^F$, and $\sum_{k \in K} V_{x_k}^F(-\sum_{i \neq F} x^i) \sum_{i \neq F} x_k^i = 0$. It suffices to extend the home net exports profile $(x^i)_{i \neq F}$ to an equilibrium $(p, (q^i, t^i, c^i, y^i, x^i, V^i, \pi^i, T^i)_{i \in I})$ with $V^i = \tilde{V}^i$ for $i \in I$, where recall I require $t^F = T^F = 0$. To this end, I define, for all $i \in I$,

$$\begin{aligned} x^F &= -\sum_{i \neq F} x^i, & q^i &= -V_x^i(x^i), & p_k &= q_k^F, & t_k^{i \neq F} &= (q_k^i - p_k)/p_k \\ V^i &= \tilde{V}^i, & T^{i \neq F} &= -q^i \cdot x^i, & y^i &= y^i(x^i), & c^i &= y^i - x^i & \pi^i &= q^i \cdot y^i. \end{aligned} \quad (56)$$

where $y^i(x^i)$ is as in [Lemma 2](#). It remains to verify that (56) is an equilibrium. Of the equilibrium conditions in Eqs. (39)–(43), all follow simply by construction except for (a) the optimality of production, (b) the optimality of consumption, (c) home government budget balance, and (d) the fact that welfare in each country equals V^i . I now show these in turn: (a) Since G^i is concave by [Assumption 3](#), $q^i \gg 0$ by [Lemma 2](#), and $G_y^i(y^i) \gg 0$ by [Assumption 3](#), it suffices for production optimality to show that $G^i(y^i) = 0$ and $q^i \propto G_y^i(y^i)$. The former follows from the definition of $y^i(x^i)$ (see [Lemma 2](#)) given that, by [Assumptions 2](#) and [3](#), consumption utility is increasing in some good that is produce-able on the margin; the latter follows from that, by construction and [Lemma 2](#), $q^i = -V_x^i(x^i) = \kappa^i G_y^i(y^i)$ for some $\kappa^i > 0$. (b) Since, by [Assumption 2](#), u^i is non-satiated and concave, it suffices for consumption optimality to show that $u_c^i(c^i) \propto q^i$ and that $q^i \cdot c^i = \pi^i + T^i$. The former follows from [Lemma 2](#) and q^i 's definition. The latter follows from the definitions of π^i and T^i for $i \neq F$. For $i = F$, it follows from the fact that $q^F \cdot x^F = \text{const} \cdot \sum_{k \in K} V_{x_k}^F(x^F) \cdot x_k^F = 0$. (c) I have just established that $p \cdot x^F = -p \cdot \sum_{i \neq F} x^i = 0$. The definitions of t^i and T^i then imply home government budget balance. (d) By [Lemma 3](#) and the construction of consumption, the representative household of each country $i \in I$ experiences utility $V^i(x^i)$. Since I began the proof by supposing that $\tilde{V}^i = V^i(x^i)$, each i has welfare $\tilde{V}^i = V^i$, as desired.

References

- Bachmann, R., Baqaee, D., Bayer, C., Kuhn, M., Löschel, A., Moll, B., Peichl, A., Pittel, K., Schularick, M., et al., 2022. What if? The economic effects for Germany of a stop of energy imports from Russia. Technical Report, ifo Institute-Leibniz Institute for Economic Research at the University of
- Baliga, S., Sjöström, T., 2022. Optimal compellence.
- Baqaee, D., Moll, B., Landais, C., Martin, P., 2022. The economic consequences of a stop of energy imports from Russia. *Conseil d'Anal. Econom. Focus* 84.
- Baron, D.P., Myerson, R.B., 1982. Regulating a monopolist with unknown costs. *Econometrica* 911–930.

- Berger, E., Bialek, S., Garnadt, N., Grimm, V., Other, L., Salzmänn, L., Schnitzer, M., Truger, A., Volker, W., 2022. A potential sudden stop of energy imports from Russia: Effects on energy security and economic output in Germany and the EU. Working Paper.
- Bianchi, J., Sosa-Padilla, C., 2024. On wars, sanctions, and sovereign default. *J. Monetary Econ.* 141, 62–70.
- Chaney, E., Portes, R., Philippon, T., Gollier, C., 2022. Economics and politics of measures to stop financing Russian aggression against Ukraine. VoxEU URL <https://voxeu.org/article/economics-and-politics-measures-stop-financing-russian-aggression-against-ukraine>.
- Chowdhry, S., Hinz, J., Kamin, K., Wanner, J., 2023. Brothers in arms: The value of coalitions in sanctions regimes.
- Cortright, D., et al., 2002. Smart sanctions: Targeting economic statecraft. *Ethics Int. Aff.* 16 (2).
- Costinot, A., Donaldson, D., Vogel, J., Werning, I., 2015. Comparative advantage and optimal trade policy. *Q. J. Econ.* 130 (2), 659–702.
- Costinot, A., Lorenzoni, G., Werning, I., 2014. A theory of capital controls as dynamic terms-of-trade manipulation. *J. Polit. Econ.* 122 (1), 77–128.
- Costinot, A., Rodríguez-Clare, A., Werning, I., 2020. Micro to macro: Optimal trade policy with firm heterogeneity. *Econometrica* 88 (6), 2739–2776.
- Costinot, A., Werning, I., 2019. Lerner symmetry: A modern treatment. *Am. Econ. Rev.: Insights* 1 (1), 13–26.
- de Souza, G.H.B., Li, H., Mei, Y., Hu, N., 2023. (Trade) war and peace: How to impose international trade sanctions.
- de V. Graaff, J., 1949. On optimum tariff structures. *Rev. Econom. Stud.* 17 (1), 47–59.
- Demena, B.A., Reta, A.S., Jativa, G.B., Kimararungu, P.B., van Bergeijk, P.A., 2021. Publication bias of economic sanctions research: a meta-analysis of the impact of trade linkage, duration and prior relations on sanctions success. In: *Research Handbook on Economic Sanctions*. Edward Elgar Publishing, pp. 125–150.
- Diamond, P.A., Mirrlees, J.A., 1971. Optimal taxation and public production II: Tax rules. *Am. Econ. Rev.* 61 (3), 261–278.
- Dixit, A., 1985. Tax policy in open economies. In: *Handbook of Public Economics*, vol. 1, Elsevier, pp. 313–374.
- Eaton, J., Engers, M., 1992. Sanctions. *J. Polit. Econ.* 100 (5), 899–928.
- Felbermayr, G., Kirilakha, A., Syropoulos, C., Yalcin, E., Yotov, Y.V., 2020. The global sanctions data base. *Eur. Econ. Rev.* 129, 103561.
- Førland, T.E., 1991. 'Economic warfare' and 'strategic goods': A conceptual framework for analyzing COCOM. *J. Peace Res.* 28 (2), 191–204.
- Gros, D., 2022. Optimal Tariff Versus Optimal Sanction: The Case of European Gas Imports from Russia. Technical Report, Center for European Policy Studies.
- Hausmann, R., 2022. The case for a punitive tax on Russian oil. Proj. Syndicate URL <https://www.project-syndicate.org/commentary/case-for-punitive-tax-on-russian-oil-by-ricardo-hausmann-2022-02>.
- Hausmann, R., Schetter, U., Yildirim, M.A., 2024. On the design of effective sanctions: The case of bans on exports to Russia. *Econ. Policy* eiad043.
- Hufbauer, G.C., Schott, J.J., Elliott, K.A., 1990. *Economic Sanctions Reconsidered: History and Current Policy*, vol. 1, Peterson Institute.
- Itskhoki, O., Mukhin, D., 2022. Sanctions and the Exchange Rate. Technical Report, National Bureau of Economic Research.
- Lashkaripour, A., 2021. The cost of a global tariff war: A sufficient statistics approach. *J. Int. Econ.* 131, 103419.
- Lerner, A.P., 1936. The symmetry between import and export taxes. *Economica* 3 (11), 306–313.
- Lorenzoni, G., Werning, I., 2022. A Minimalist Model for the Ruble During the Russian Invasion of Ukraine. Technical Report, National Bureau of Economic Research.
- Meade, J., 1955. Trade and Welfare.
- Milgrom, P., Segal, I., 2002. Envelope theorems for arbitrary choice sets. *Econometrica* 70 (2), 583–601.
- Mill, J., 1844. Essay ii. of the influence of consumption upon production. In: *Essays on Some Unsettled Questions of Political Economy*. Parker, London.
- Morgan, T.C., Bapat, N.A., 2003. Imposing sanctions: States, firms, and economic coercion. *Int. Stud. Rev.* 5 (4), 65–79.
- Osgood, T.K., 1957. *East-West Trade Controls and Economic Warfare*. Yale University.
- Ossa, R., 2014. Trade wars and trade talks with data. *Amer. Econ. Rev.* 104 (12), 4104–4146.
- Pape, R.A., 1997. Why economic sanctions do not work. *Int. Secur.* 22 (2), 90–136.
- Sturm, J., 2023. How should sanctions account for bystander countries? AEA Pap. Proc. 113 (1).
- The White House, 2022. Press briefing by Press secretary Jen Psaki and deputy National Security Advisor for International Economics and deputy NEC director Daleep Singh, February 24, 2022. White House URL <https://www.whitehouse.gov/briefing-room/press-briefings/2022/02/24/press-briefing-by-press-secretary-jen-psaki-and-deputy-national-security-advisor-for-international-economics-and-deputy-nec-director-daleep-singh-february-24-2022/>.
- Weitzman, M.L., 1974. Prices vs. quantities. *Rev. Econom. Stud.* 41 (4), 477–491.