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Income Effects and Trade Agreements

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Abstract

This paper considers trade agreements in a sufficiently general framework to encompass both imperfectly competitive market structures and income effects in government objectives. We show that governments choose globally efficient policies if they act as if they do not value the impact of their policies on their terms of trade. The results confirm that additional international externalities that arise in imperfectly competitive settings are the result of government failure to equate markups between sectors with domestic policies, not demand-side factors.

JEL: F12, F13, F15

Keywords: trade agreements, income effects, non-homothetic preferences

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Jövedelmi hatások és kereskedelmi egyezmények

David R. DeRemer

Összefoglaló

A tanulmány a kereskedelmi egyezményeket vizsgálja egy olyan általános modellkeretben, amelybe egyszerre illeszthetők be a nem tökéletesen versenyző piacszerkezetek és a kormányzati célfüggvényben jelentkező jövedelmi hatások is. A tanulmány megmutatja, hogy a kormányok globálisan hatékony politikát folytatnak, ha úgy viselkednek, mintha figyelmen kívül hagynák a politikájuk hatását cserearányaikra. Az eredmények megerősítik, hogy a nem tökéletes verseny esetén felmerülő pótlólagos nemzetközi externáliák abból származnak, hogy a kormányzat nem képes a haszonkulcsok szektorok közötti kiegyenlítésére, és nem pedig keresletoldali tényezőkből.

JEL: F12, F13, F15

Tárgyszavak: kereskedelmi egyezmények, jövedelmi hatás, nem homotetikus preferenciák

Income Effects and Trade Agreements

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June 2016

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This paper considers trade agreements in a sufficiently general framework to encompass both imperfectly competitive market structures and income effects in government objectives. We show that governments choose globally efficient policies if they act as if they do not value the impact of their policies on their terms of trade. The results confirm that additional international externalities that arise in imperfectly competitive settings are the result of government failure to equate markups between sectors with domestic policies, not demand-side factors.

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1 Introduction

For explaining patterns of trade related to good quality, demand-side explanations have proven essential. The Linder (1961) hypothesis first posits that consumers of similar incomes consume similar goods and specialize in producing goods that they consume. As more disaggregated data becomes available, the Linder hypothesis is confirmed empirically in higher-income nations specializing in higher-quality goods (e.g. Hallak, 2010; Dingel, 2015), and recent theory can explain these patterns (Fajgelbaum, Grossman, and Helpman, 2011).

The focus of this paper is whether demand-side theories for trade patterns carry any new implications for the theories of commercial policy and trade agreements. We discuss here two reasons why this is a worthwhile area of exploration.

First, we observe considerable differences in trade institutions in how they manage trade between similar countries, in comparison to trade between developed and developing countries. Developed countries granting unilateral market access to developing countries (the generalized system of preferences) has been central to the multilateral trading system since the 1960s, despite the questionable institutional efficiency of these policies which violate both the principles of reciprocity and nondiscrimination (Bagwell and Staiger, 2014). More recently, many developing countries who had received nonreciprocal market access to the European market have been obligated by the World Trade Organization (WTO) to open their markets reciprocally. The survey of Ornelas (2016) suggests there is neither positive nor normative theory to explain such "special and differential treatment" for developing nations. Theory in which per-capita income leads to differences in trade patterns then seems a natural place for beginning to understand such trade rules.

Second, an open question in the trade agreement literature is whether income effects matter for the international externalities that trade agreements that need to address. Ossa (2011) shows that when consumers have Cobb-Douglas preferences and firms are monopolistically competitive, then there is a firm delocation or production relocation externality in import tariff choices that trade institutions need to solve. Bagwell and Staiger (2012a, 2012b, 2015) observe in various imperfectly competitive frameworks, that if nations have both import policies and export policies, then the only problem for trade agreements remains terms-of-trade manipulation, just like in the canonical perfectly competitive model. A key distinction however is that Bagwell and Staiger derive their results using quasilinear consumer preferences. Maggi (2014) hypothesizes that the absence of income effects is essential to their results, though Bagwell and Staiger (2016) question this claim. This paper

in turn attempts a general analysis of whether such income effects matter for trade policy externalities.

We consider a model with quite general government preferences over local prices and each country's income, such that we can nest frameworks with nonhomothetic preferences and imperfect competition like Fajgelbaum, Grossman, and Helpman (2011). Governments can choose to tax or subsidize either imports or exports, but have no choices for domestic policies. Following Bagwell and Staiger (1999), governments cannot lose from terms-of-trade appreciation or benefit from terms-of-trade deterioration. There is a stronger restriction than Bagwell and Stagier (1999) in assuming that governments value trade policy only through its effects on trade tax revenue and the local prices faced by either nation.[1]

Following Bagwell and Staiger, we consider whether policies are efficiently chosen when nations choose import policies and export policies as if they did not care about the impact of their policies on their terms of trade. This is known in their literature as the *political optimum*. Starting from these policies, governments do not achieve any first-order gains from changes in local prices. They do, however, gain from changes in their terms of trade. What then remains to be shown is that governments cannot mutually benefit from further cooperation in using policy to affect world prices, holding local prices in all markets fixed.

We show in fact that the political optimum is efficient. We derive a technical result that makes it clear in this general setting that there is no further room for cooperation beyond the politically optimal policies. The ratio of first-order changes in each country's trade tax revenue will be constant in response to any small change in any world prices from the political optimum. This result reduces the several channels by which trade policy can influence welfare down to one independent channel. Proving the efficiency of politically optimal policies then becomes as straightforward as in the Bagwell and Staiger (1999) framework, which allows for only one world price.

2 Model

We construct a static, two-country model with many goods and many prices. We do not impose any specific structure on firms or consumers in the economy, other than assuming that agents' decisions are pinned down by all home and foreign prices, endowments, and net trade tax revenue in the economy. Prices here refers to both the prices consumers pay and the prices producers receive. Trade tax revenue is assumed to collected by governments and then redistributed in whatever manner they consider to be optimal. Trade tax revenue is

[1] The Bagwell and Staiger (2002) appendix imposes a similar restriction in a multi-country, many good trade policy model while addressing a distinct research question from mine.

derived from government import or export policies, which can be distinct taxes or subsidies for each good.

2.1 Government Preferences

Governments choose their trade policies to maximize welfare. The strongest assumption we make on government preferences is that governments value trade policies only through their effects on trade tax revenues or any prices faced in either nation. Government indirect utility functions are assumed to exist with the form

$$\begin{aligned} W_h &= W_h(P, T_h, T_f, \theta) \\ W_f &= W_f(P, T_h, T_f, \theta) \end{aligned}$$

where P is the vector of all home and foreign local prices, T_h and T_f are total home and foreign net trade tax revenue, respectively, and θ is a vector of endowments and all other parameters that are invariant to trade. These government utility functions are sufficiently general to allow for preferences over any distributional outcome in any economy, provided that the choices of firms and consumers are all also functions of prices, trade tax revenue, and endowments. We also assume there is a unique equilibrium in the world economy, taking government trade policies as given.

2.2 Local Prices and Trade Taxes

The vector P can be divided into subvectors:

$$P \equiv (p_h, p_h^*, r_h, r_h^*, p_f, p_f^*, r_f, r_f^*)$$

where p denotes consumer prices and r denotes prices producers receive. The h and f subscript denote nation of origin, home and foreign respectively, and the star indicates the destination is the foreign nation.

Governments can choose ad valorem trade taxes or subsidies for all goods. Trade policies and prices are linked by the equations

$$\begin{aligned} p_{hg}^* &= (1 + t_{hg}^* + t_{fg}^* + \phi_g^*) r_{hg}^* \\ p_{fg} &= (1 + t_{hg} + t_{fg} + \phi_g) r_{fg} \end{aligned}$$

Here g indexes goods. The consumer price p^*_{hg} is for a home export to foreign, t^*_{hg} is home's export policy (positive for a tax and negative for a subsidy), t^*_{fg} is foreign's import policy, ϕ^*_g is a transport cost for exports to foreign, and r^*_{hg} is the price domestic consumers receive for exports. The notation for foreign's exports follows a similar pattern.

Net trade tax revenue is implicitly defined as the sum of each nation's trade taxes and subsidies across all goods

$$\begin{aligned} T_h &\equiv \sum\nolimits_g t^*_{hg} r^*_{hg} x^*_{hg} + \sum\nolimits_g t_{hg} r_{fg} x_{fg} \\ T_f &\equiv \sum\nolimits_g t^*_{fg} r^*_{hg} x^*_{hg} + \sum\nolimits_g t_{fg} r_{fg} x_{fg} \end{aligned}$$

where x^*_h and x_f denote home and foreign export volume, respectively. The definition is implicit because the export volumes can depend on the net trade tax revenue.

2.3 Defining Terms-of-Trade

The terms-of-trade are defined to be the world prices in between nation's borders. Formally,

$$\begin{aligned} p^w_{hg} &\equiv (1 + t^*_{hg}) r^*_{hg} \\ p^w_{fg} &\equiv (1 + t_{fg}) r_{fg} \end{aligned} \tag{1}$$

where p^w_{hg} and p^w_{fg} are the world prices of home and foreign exports, respectively, which are the producer prices augmented by the exporting nation's export policy.

Given this definition of world prices, government welfare and tariff revenue can be rewritten as a function of world prices and local prices as follows. Tariff revenue can be written as

$$\begin{aligned} T_h(P, p^w, \theta) &= \sum\nolimits_g (p^w_{hg} - r^*_{hg}) x^*_{hg} + \sum\nolimits_g (p_{fg} - p^w_{fg} - \phi_g r_{fg}) x_{fg} \\ T_f(P, p^w, \theta) &= \sum\nolimits_g (p^*_{hg} - p^w_{hg} - \phi^*_g r^*_{hg}) x^*_{hg} + \sum\nolimits_g (p^w_{fg} - r_{fg}) x_{fg} \end{aligned} \tag{2}$$

where p^w is the vector of home and foreign terms-of-trade. Writing the tariff revenue as a function of prices and endowments relies on the assumption that export policies are pinned down by local prices P, trade tax revenue, and endowments.

Government welfare can then be written as follows

$$\begin{aligned} W_h(P, p^w, \theta) &= W_h(P, T_h(P, p^w, \theta), T_f(P, p^w, \theta), \theta) \\ W_f(P, p^w, \theta) &= W_f(P, T_h(P, p^w, \theta), T_f(P, p^w, \theta), \theta) \end{aligned}$$

Having written welfare in this form, we can now introduce the assumption that governments weakly benefit from terms-of-trade improvement and weakly suffer from terms-of-trade deterioration, holding local prices fixed. More formally for home,

$$\begin{aligned} \frac{\widetilde{\partial W_h}}{\partial p_h^w} &\equiv \frac{\partial W_h}{\partial T_h}\frac{\partial T_h}{\partial p_h^w} + \frac{\partial W_f}{\partial T_f}\frac{\partial T_f}{\partial p_h^w} \geq 0 \\ \frac{\widetilde{\partial W_h}}{\partial p_f^w} &\equiv \frac{\partial W_h}{\partial T_h}\frac{\partial T_h}{\partial p_f^w} + \frac{\partial W_f}{\partial T_f}\frac{\partial T_f}{\partial p_f^w} \leq 0 \end{aligned} \tag{3}$$

Similar restrictions are assumed for the foreign nation. We also assume strict inequality for at least one element of p_h^w and p_f^w. A terms-of-trade change, holding prices fixed, amounts to a direct income transfer between nations, so this assumption rules out the possibility that any nation would use trade policy as a means to make an income transfer. This assumption could be justified on the grounds that nations have other means to make such transfers. Similar restrictions on the effects of terms-of-trade changes on welfare were made in Bagwell and Staiger (1999).

3 Results

If a trade agreement forces governments to act as if they do not value the rents they gain from terms-of-trade changes, then the trade policies chosen are efficient. Following Bagwell and Staiger, we define these policies to be *politically optimal*. The exposition and proof of this result proceed as follows: (1) formally define noncooperative and politically optimal tariffs, (2) establish the condition that needs to be satisfied for politically optimal tariffs to be efficient, (3) show how this condition has been satisfied by previous papers in this literature, and (4) introduce a technical result that allows for the efficiency of political optimal tariffs to be satisfied more generally.

3.1 Noncooperative and Politically Optimal Tariffs

Following Bagwell and Staiger (1999), noncooperative and political optimal tariffs are assumed to exist. We assume that nations neither desire infinite subsidies nor infinite taxes, so noncooperative solutions are in the interior of the nation's policy space. For notational convenience, have τ_h^i index home's trade policies and τ_f^j index foreign's trade policies, whether they be import or export policies. Nash policies then satisfy

$$\frac{dW_h}{d\tau_h^i} = 0 \quad \frac{dW_f}{d\tau_f^j} = 0 \quad \forall i, j$$

The derivatives of trade policies can be decomposed into their effects that operate through local prices P and the effects that operate through terms-of-trade. Define this latter residual as

$$\begin{aligned} \widetilde{\frac{dW_h}{d\tau_h^i}} &\equiv \frac{dW_h}{d\tau_h^i} - \frac{dW_h}{dP}\frac{dP}{d\tau_h^i} \quad \forall i \\ \widetilde{\frac{dW_f}{d\tau_f^j}} &\equiv \frac{dW_f}{d\tau_f^j} - \frac{dW_f}{dP}\frac{dP}{d\tau_f^j} \quad \forall j \end{aligned}$$

The Nash conditions can then be written as

$$\begin{aligned} \frac{dW_h}{dP}\frac{dP}{d\tau_h^i} + \widetilde{\frac{dW_h}{d\tau_h^i}} &= 0 \ \forall i \\ \frac{dW_f}{dP}\frac{dP}{d\tau_f^j} + \widetilde{\frac{dW_f}{d\tau_f^j}} &= 0 \ \forall j \end{aligned} \tag{4}$$

The politically optimal policies are those chosen when nation's act as if they do not value the rents they gain from terms-of-trade changes, as if $\widetilde{\frac{dW_h}{d\tau_h^i}} = \widetilde{\frac{dW_f}{d\tau_f^j}} = 0$. Thus, politically optimal policies satisfy

$$\begin{aligned} \frac{dW_h}{dP}\frac{dP}{d\tau_h^i} &= 0 \quad \forall i \\ \frac{dW_f}{dP}\frac{dP}{d\tau_f^j} &= 0 \quad \forall j \end{aligned} \tag{5}$$

3.2 Conditions for Efficiency

Having formally defined Nash and politically optimal trade policies, we can then answer the following questions: Is there any reason for a trade agreement? Are trade agreements that cause governments to choose politically optimal policies efficient?

The necessary condition for efficiency is a tangency condition between home and foreign welfare with respect to all pairings of trade policies. This condition results from the standard constrained optimization problem for one nation maximizing welfare, while preserving the other nation's level of welfare. Following Bagwell and Staiger (1999), the necessary condition is also sufficient under global concavity.

$$\frac{\frac{dW_h}{d\tau_h^i}}{\frac{dW_f}{d\tau_h^i}} = \frac{\frac{dW_h}{d\tau_f^j}}{\frac{dW_f}{d\tau_f^j}} \leq 0, \forall i, j \tag{6}$$

It is straightforward to show that the Nash policies are inefficient. Recall at Nash policies $\frac{\partial W_h}{\partial \tau_h^i} = \frac{dW_f}{d\tau_f^j} = 0$. It can be shown that $\frac{dW_h}{d\tau_f^j} \neq 0$, $\frac{\partial W_f}{\partial \tau_h^i} \neq 0$ for some i and j. In the appendix, we show that the latter result follows from the distinct effects home and foreign trade policies have on world prices. Thus, a trade agreement is necessary because noncooperative policies are not Pareto efficient.

Substituting in the definition of political optimal tariffs (5) yields the following condition for the efficiency of political optimal tariffs.

$$\frac{\widetilde{\frac{dW_h}{d\tau_h^i}}}{\widetilde{\frac{dW_f}{d\tau_h^i}}} = \frac{\widetilde{\frac{dW_h}{d\tau_f^j}}}{\widetilde{\frac{dW_f}{d\tau_f^j}}} \leq 0, \forall i, j \tag{7}$$

This condition is equivalent to the statement that there is no combination of small trade policies that can alter world prices, holding local prices fixed, in a manner that makes both nations better off. If this condition holds, nations have no reason to negotiate once they have reached the political optimum.

3.3 Special Cases From Prior Literature

For sake of comparison, we show how that condition (7) is satisfied in prior literature by stronger assumptions than we have imposed..

In Bagwell and Staiger (1999), international externalities influence welfare through one world relative price, whose movements shift each government's welfare in opposite directions. Thus, mutually beneficial gains through negotiations over this one world relative price are impossible. More formally, (7) can be rewritten as

$$\frac{\left(\frac{\partial W_h}{\partial p^w}\right)\left[\frac{dp^w}{d\tau_h^i}\right]}{\left(\left(\frac{\partial W_f}{\partial p^w}\right)\right)\left[\frac{dp^w}{d\tau_h^i}\right]} = \frac{\left(\frac{\partial W_h}{\partial p^w}\right)\left[\left[\frac{dp^w}{\partial \tau_f^j}\right]\right]}{\left(\left(\frac{\partial W_f}{\partial p^w}\right)\right)\left[\left[\frac{dp^w}{d\tau_f^j}\right]\right]} \leq 0,\ \forall i, \tag{8}$$

Terms with like brackets and parentheses cancel, so the equality condition above holds. The inequality condition follows from the assumption that shifts in terms of trade move each nation's welfare in opposite directions: $\left(\frac{\partial W_h}{\partial p^w}\right)\left(\frac{\partial W_f}{\partial p^w}\right) < 0$.

In Bagwell and Staiger (2012a, 2012b, 2015), income effects on demand are assumed away. Holding local prices fixed, net trade tax revenue and all other consumption choices are fixed, so negotiations over world-prices amount to zero-sum shifts in trade tax revenue between nations. This can be seen by summing the equations from (2) and observing that $\frac{\partial T_h}{\partial p^w} + \frac{\partial T_f}{\partial p^w} = 0$. The condition (7) then obviously holds because the ratios in (8) each reduce to -1.

In our more general framework, the satisfaction of (7) is not obvious because trade policies on many goods offer many world price channels for influencing welfare. Prior literature does not rule out the possibility that there exists some shift in world prices that could lead to mutually beneficial gains, thus leaving nations with room to negotiate from the politically optimal policies.

3.4 Proving Efficiency

To show the efficiency of politically optimal tariffs holds more generally, we provide a technical result that makes it obvious in our general setting that there is no further room for cooperation beyond the politically optimal policies. We show that the ratio of first-order changes in each country's trade tax revenue will be constant in response to any small change of any world prices. This result reduces the several channels by which trade policy can influence welfare down to one independent channel.

The result derives from the observation that the sum of tariff revenue has no dependence on world prices:

$$T_h + T_f = \sum\nolimits_g (p^*_{hg} - r^*_{hg}(1+\phi^*_g)) x^*_{hg}(P, T_h, T_f, \theta) + \sum\nolimits_g (p_{fg} - r_{fg}(1+\phi_g)) x_{fg}(P, T_h, T_f, \theta) \tag{9}$$

Consider any linear combination of world prices determined by a real constant vector c. Implicitly differentiating this expression with respect to any linear combination $c'p^w$, while

holding local prices fixed, yields the same result for any choice of c.[2]

$$\widetilde{\frac{dT_f}{dT_h}} \equiv \frac{\frac{\partial T_f}{\partial c' p^w}}{\frac{\partial T_h}{\partial c' p^w}} \quad \forall c \tag{10}$$

This result implies that any trade policy, holding local prices fixed, must affect home and foreign tariff revenue by the same proportion. Formally,

$$\widetilde{\frac{\partial T_f}{\partial \tau}} = \widetilde{\frac{dT_f}{dT_h}} \widetilde{\frac{\partial T_h}{\partial \tau}} \quad \forall \tau$$

Using this result, the effect of trade taxes on welfare through world prices can be decomposed as follows

$$\widetilde{\frac{\partial W_h}{\partial \tau}} \equiv \frac{\partial W_h}{\partial T_h} \widetilde{\frac{\partial T_h}{\partial \tau}} + \frac{\partial W_h}{\partial T_f} \widetilde{\frac{\partial T_f}{\partial \tau}} = \left(\frac{\partial W_h}{\partial T_h} + \frac{\partial W_h}{\partial T_f} \widetilde{\frac{dT_f}{dT_h}} \right) \widetilde{\frac{\partial T_h}{\partial \tau}}$$

This expression implies that at the political optimum, home and foreign tariff revenue are linearly dependent channels through which trade policy influences welfare. Thus, the many channels by which trade policy can influence welfare have been reduced to one. Rewriting (7) using the last expression yields

$$\frac{\left(\frac{\partial W_h}{\partial T_h} + \frac{\partial W_h}{\partial T_f} \widetilde{\frac{dT_f}{dT_h}} \right) \left[\widetilde{\frac{\partial T_h}{\partial \tau_h^i}} \right]}{\left(\left(\frac{\partial W_f}{\partial T_h} + \frac{\partial W_f}{\partial T_f} \widetilde{\frac{dT_f}{dT_h}} \right) \right) \left[\widetilde{\frac{\partial T_h}{\partial \tau_h^i}} \right]} = \frac{\left(\frac{\partial W_h}{\partial T_h} + \frac{\partial W_h}{\partial T_f} \widetilde{\frac{dT_f}{dT_h}} \right) \left[\left[\widetilde{\frac{\partial T_h}{\partial \tau_f^j}} \right] \right]}{\left(\left(\frac{\partial W_f}{\partial T_h} + \frac{\partial W_f}{\partial T_f} \widetilde{\frac{dT_f}{dT_h}} \right) \right) \left[\left[\widetilde{\frac{\partial T_h}{\partial \tau_f^j}} \right] \right]} \quad \forall i, j \tag{11}$$

Again, the terms in like brackets cancel, and the equality condition of (7) holds. we must still show that the inequality condition of (7) holds. We show in the appendix that the inequality condition follows from the technical condition we derived (10) and the assumed effect of terms-of-trade on welfare (3).

Thus, we have shown that (7) holds generally in our model, and politically optimal tariffs are indeed always efficient. This completes the proof that an agreement is efficient if countries act as if they do not value the rent-shifting from terms-of-trade.

Proposition 1 *The political optimum is efficient when countries negotiate over import and export policies.*

[2]The appendix contains a more detailed version of all derivations in this subsection.

4 Conclusion

The preceding result establishes that income effects alone do not create a new fundamental problem for trade agreements. While this is an important, it is not the final world on the relevance of income effects for trade agreements. For example, the analysis here effectively assumes that nations have sufficient policy space in import and export policies. If governments have limitations on their policy space, the resulting international externalities that have been shown to emerge due to resulting intersectoral misallocations (e.g. between the perfectly competitive outside sector and monopolistically competitive sector in Ossa, 2011) could then interact further with income effects in explaining the observed trade institutions. Another setting to consider would be whether income effects matter in settings with global values chains and prices determined by bilateral bargaining (e.g. Antras and Stagier, 2012).

A Appendix

Lemma 1 *Nash policies are inefficient..*

Proof. Given efficiency condition (6), and Nash conditions $\frac{dW_h}{d\tau_h^i} = \frac{dW_f}{d\tau_f^j} = 0$, it remains to be shown that $\frac{dW_h}{d\tau_f^j} \neq 0$ or $\frac{\partial W_f}{\partial \tau_h^i} \neq 0$. We focus on $\frac{dW_f}{d\tau_h^j} \neq 0$. Choose good index g such that $\widetilde{\frac{\partial W_f}{\partial p_{hg}^w}} < 0$, where g exists by assumption, τ_h^g is an export policy, and τ_f^g is an import policy imposed on the same good. Then $\frac{dW_f}{dP}\frac{dP}{d\tau_h^g} = \frac{dW_f}{dP}\frac{dP}{d\tau_f^g}$ because the derivatives on price only depend on the sum $\tau_h^g + \tau_f^g$. This result and the Nash condition $\frac{dW_f}{d\tau_h^g} = \frac{dW_f}{dP}\frac{dP}{d\tau_f^g} + \widetilde{\frac{dW_f}{d\tau_f^g}} = 0$ then imply that $\frac{dW_f}{dP}\frac{dP}{d\tau_h^g} = -\widetilde{\frac{dW_f}{d\tau_f^g}}$. Combing these equalities yields:

$$\frac{dW_f}{d\tau_h^g} = \frac{dW_f}{dP}\frac{dP}{d\tau_h^g} + \widetilde{\frac{dW_f}{d\tau_h^g}} = \widetilde{\frac{dW_f}{d\tau_h^g}} - \widetilde{\frac{dW_f}{d\tau_f^g}}$$

Now consider the world price p_i^w. The derivative $\frac{dp_{hg}^w}{d\tau_h^g} = (1+\tau_h^g)\frac{dr_{hg}^*}{d\tau_h^g} + r_{hg}^*$, while $\frac{dp_{hg}^w}{d\tau_f^g} = (1+\tau_h^g)\frac{dr_{hg}^*}{d\tau_h^g}$, and thus $\frac{dp_{hg}^w}{d\tau_h^g} - \frac{dp_{hg}^w}{d\tau_h^g} = r_{hg}^*$. Finally,

$$\frac{dW_f}{d\tau_f^g} = \widetilde{\frac{dW_f}{d\tau_h^g}} - \widetilde{\frac{dW_f}{d\tau_f^g}} = \widetilde{\frac{\partial W_f}{\partial p_{hg}^w}} r_{hg}^* < 0$$

where $\widetilde{\frac{\partial W_f}{\partial p_{hg}^w}} < 0$ by assumption. All other effects of welfare on $\widetilde{\frac{dW_f}{d\tau_h^g}}$ and $\widetilde{\frac{dW_f}{d\tau_f^g}}$ cancel because other trade policies affect world prices only through their sum. Thus, $\frac{dW_f}{d\tau_h^g} \neq 0$. ■

Lemma 2 $\frac{\frac{\partial T_f}{\partial c' p^w}}{\frac{\partial T_h}{\partial c' p^w}}$ *is constant* $\left(\equiv \frac{\widetilde{dT_f}}{dT_h}\right)$ *for all real vectors* c.

Proof. Implicitly differentiating the expression for the sum of the trade tax revenue, holding prices fixed,

$$T_h + T_f = \sum\nolimits_g (p^*_{hg} - r^*_{hg}(1+\phi^*_g))x^*_{hg}(P, T_h, T_f, \theta) + \sum\nolimits_g (p_{fg} - (1+\phi_g)r_{fg})x_{fg}(P, T_h, T_f, \theta)$$

yields

$$\begin{aligned}\frac{\partial T_f}{\partial c' p^w} + \frac{\partial T_h}{\partial c' p^w} &= \sum\nolimits_g (p^*_{hg} - r^*_{hg}(1+\phi^*_g))(\frac{\partial x^*_{hg}}{\partial T_h}\frac{\partial T_h}{\partial c' p^w} + \frac{\partial x^*_{fg}}{\partial T_f}\frac{\partial T_f}{\partial c' p^w}) + \\ &\quad \sum\nolimits_g (p_{fg} - (1+\phi_g)r_{fg})(\frac{\partial x_{hg}}{\partial T_h}\frac{\partial T_h}{\partial c' p^w} + \frac{\partial x_{fg}}{\partial T_f}\frac{\partial T_f}{\partial c' p^w})\end{aligned}$$

Thus,

$$\frac{\frac{\partial T_f}{\partial c' p^w}}{\frac{\partial T_h}{\partial c' p^w}} = -\frac{1 - \sum_g (p^*_{hg} - r^*_{hg}(1+\phi^*_g))\frac{\partial x^*_{hg}}{\partial T_h} - \sum_g (p_{fg} - (1+\phi_g)r_{fg})\frac{\partial x_{hg}}{\partial T_h}}{1 - \sum_g (p^*_{hg} - r^*_{hg}(1+\phi^*_g))\frac{\partial x^*_{fg}}{\partial T_f} - \sum_g (p_{fg} - (1+\phi_g)r_{fg})\frac{\partial x_{fg}}{\partial T_f}}$$

which does not depend on c. ■

Lemma 3 $\frac{\widetilde{\partial T_f}}{\partial \tau} = \frac{\widetilde{dT_f}}{dT_h}\frac{\widetilde{\partial T_h}}{\partial \tau} \quad \forall \tau$

Proof. By definition, $\frac{\widetilde{\partial T_h}}{\partial \tau^i_h} = \sum_g \frac{\partial T_h}{\partial p^w_g}\frac{dp^w_g}{d\tau^i_h}$ and $\frac{\widetilde{\partial T_f}}{\partial \tau^i_h} = \sum_g \frac{\partial T_f}{\partial p^w_g}\frac{dp^w_g}{d\tau^i_h}$. The previous proof implies $\frac{\partial T_h}{\partial p^w_g} = \frac{\widetilde{dT_f}}{dT_h}\frac{\partial T_f}{\partial p^w_g}$. Substitution and factoring then yields the desired result. ■

Lemma 4 $\frac{\frac{\widetilde{dW_h}}{d\tau^i_h}}{\frac{\widetilde{dW_f}}{d\tau^i_h}} \leq 0$ *always, and the inequality condition for inefficiency always holds..*

Proof. From (11), this proposition amounts to proving that

$$\left(\frac{\partial W_h}{\partial T_h} + \frac{\partial W_h}{\partial T_f}\frac{\widetilde{dT_f}}{dT_h}\right) / \left(\frac{\partial W_f}{\partial T_h} + \frac{\partial W_f}{\partial T_f}\frac{\widetilde{dT_f}}{dT_h}\right) \leq 0$$

Intuitively, there is no change in home tariffs through changes in world prices that would make both nations better off. Using (10), (3) can be rewritten as

$$\left(\frac{\partial W_h}{\partial T_h} + \frac{\partial W_h}{\partial T_f}\frac{\widetilde{dT_f}}{dT_h}\right)\frac{\partial T_h}{\partial p^w_h} \geq 0 \text{ and } \left(\frac{\partial W_f}{\partial T_h} + \frac{\partial W_f}{\partial T_f}\frac{\widetilde{dT_f}}{dT_h}\right)\frac{\partial T_h}{\partial p^w_h} \leq 0$$

The desired result follows from combining these equations. ■

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