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Optimal Trade Policy and Production Location

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September 2016

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The paper features the assembly-relocation effect and the production-chain effect to explain incentives behind the Nash trade policy intervention with cross-border un-bundling of production processes: first, a government sometimes would use an import tariff and/or export tax as a way to shift the location of the final assembly in its favor, forcing an inefficient location, so that, conditional on the assembly relocation, it can maximize its ability to manipulate the terms of trade. Second, a rise in the tariff/tax on inputs could push up the world price of the final good through the production chain.

JEL Classification: F15; F53

* I am truly grateful to my adviser Professor Robert Staiger for his guidance and encouragement. This research benefits greatly from discussions with Ralph Ossa and Alan Winters. I also thank participants at the University of Wisconsin-Madison International Brown Bag Seminar and the Stanford International Lunch Workshop for helpful comments and suggestions. This work is supported by JSPS Grant-in-Aid for Research Activity Start-up (16H07241). All errors are my own. Correspondence: obashi@toyo.jp.

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1 Introduction

As cross-border unbundling of production processes becomes pervasive, the production location potentially depends on a combination of trade costs, inclusive of trade barriers, imposed on different stages of production. Looking at the flip side of the coin, a government would choose a combination of trade policy instruments, taking into consideration its influence on the firm's decision on whether to offshore the production base and on whether and which intermediate inputs to source domestically or import from abroad. A government might care about the locations of the firm's global production activities to better exploit its market power over world prices with trade policy intervention. To understand the design and operation of trade agreements that we observe amid the growing importance of cross-border unbundling, the role of trade policies and trade agreements needs to be revisited by taking into account the potential of trade policy intervention to impact the firm's location and sourcing decision.

This paper revisits the role of trade policies in a theoretical framework considering the firm's global production operation subject to trade costs. In so doing, I aim at theoretically revealing how cross-border unbundling of production processes changes the role of trade policies and introduces a new reason for trade policy intervention, compared to a conventional model consisting only of trade in final goods. The paper is related to an applied-theoretical literature on trade agreements along the lines of Antràs and Staiger (2012a, b), by exploring the role of trade policies in a model with intermediate input trade. Antràs and Staiger highlight the potential for offshoring of customized inputs to increase the prevalence of bargaining as a mechanism for international price determination and point out that the prediction of the standard terms-of-trade theory is overturned if international prices are determined through bargaining. Although a central focus of the authors is whether offshoring introduces new rationale for a trade agreement, the current paper only studies the role of trade policies as an initial step, leaving an analysis on trade agreements for future work.

While Antràs and Staiger (2012a, b) feature the change in international price determination as a result of offshoring, this paper aims to contribute to the literature by considering the framework in which the location choice by the final-good producer depends on a combination of trade barriers imposed on different stages of production and by exploring how an interrelationship between trade barriers creates incentives for trade policy intervention. To do so, I incorporate the essence of spatial economics, i.e. a tension between agglomeration and dispersion forces in determining the locations of the firm's global production activities subject to trade costs and frictions, into a well-established literature on the role of trade policies (e.g. Bagwell and Staiger (2002)).

Specifically, I develop a simple North-South partial equilibrium model based on a model of spatial unbundling proposed by Baldwin and Venables (2013), in which a stage of production can be unbundled from adjacent stages, at a cost, to exploit comparative advantage. The unbundling costs create centripetal forces binding related stages together (i.e., agglomeration force) while international cost differences create centrifugal forces encouraging dispersed production of different stages since different stages have different factor input requirements (dispersion force). The authors show how a tension between these forces determines the location of different production stages, and compare the unbundling outcomes between two different configurations of the production process, the spider and the snake. In the spider, multiple limbs (e.g. intermediate inputs) coming together to form a body (assembly), which may be the final product itself or a key component such as a module in the auto industry. In the snake, the good moves in a sequential manner from upstream to downstream. Although most production processes can be viewed as complex mixtures of the two, the current paper builds on the spider version of the model because the spider is simpler than the snake in the sense that an intermediate input crosses borders at most twice for the spider while how many times the good crosses borders is endogenously determined by how finer the production chain is sliced for the snake.

I consider two goods, the final good that requires a range of intermediate inputs, and a numeraire good. The final-good producer sources an intermediate input only from the least-cost location. Factor costs differ between countries for each intermediate input while cross-border sourcing of inputs is costly. So, there arises the tension between the agglomeration and dispersion forces that affects the final-good producer's decision on whether and which intermediate inputs to source domestically or import from abroad. And, the final-good producer decides on where to locate the assembly plant, with a consideration to the overall costs of producing and delivering the final good to consumers.

In order to investigate the role of trade policies, this paper augments the spider model by introducing trade costs on the final good and on intermediate inputs, conditional on the location of the final assembly, separately and by decomposing trade costs into three components: North government's import tariff/subsidy (if North is importer or export tax/subsidy if exporter), South government's import tariff/subsidy (or export tax/subsidy), and any exogenous transport costs. Each government is endowed with a tariff and tax on the final good and tariffs and taxes on intermediate inputs, conditional on the location of assembly. The trade policy decision of a government alters trade costs, and as a result affects the final-good producer's location and sourcing decision. A government therefore chooses a set of tariffs/taxes, taking into consideration an interrelationship between tariffs/taxes imposed on different stages of production and its influence on the final-good producer's location and sourcing decision.

In this environment, gains from trade come from the efficient global allocation of the final assembly and the intermediate input production. I make a bold assumption that the demand for the final good is perfectly inelastic and all the demand is in North, for sake of simplicity. This assumption does help to isolate a novel inefficiency caused by trade policy intervention in my model, which is inefficiency due to the location of assembly. I first show that free trade policies are efficient. I then solve for the optimal combination of tariffs that maximizes the national welfare by endogenizing the firm's location and sourcing decision, and identify the nature of inefficiencies caused by the trade policy intervention.

In a Nash equilibrium, South government always intervenes while North selects free trade or other policies that have impact on neither North nor South's national welfare. Furthermore, South government sometimes uses a tariff and/or tax as a way to change the location of the final assembly to its advantage, forcing an inefficient location, while North never has an incentive to manipulate the location. South's Nash trade policy intervention benefits South's residents, who are entitled to the export tax revenue, at the expense of North's consumers, who face a higher price of the final good, compared to the efficient, free trade benchmark. In addition, inefficiencies caused by the Nash trade policy intervention imply the potential of a trade agreement to offer governments a means of escape from a

Prisoners' Dilemma.

Although the asymmetry itself is an artifact of the final-good demand assumption, the paper features two effects to explain incentives behind the Nash trade policy intervention. First, a government sometimes uses a tariff/tax as a way to shift the location of the final assembly in its favor, forcing an inefficient location, so that, conditional on the resulting location, it can maximize its ability to manipulate the terms of trade. The effect of trade policy intervention on the final-good producer's optimal location choice is what I call *the assembly-relocation effect*. Second, a rise in the tariff/tax on intermediate inputs could push up the world price of the final good through the production chain, which is what I call *the production-chain effect*.

The assembly-relocation motive for trade policy intervention is related to the literature featuring the firm-delocation effect, according to which an import tariff or export subsidy can benefit consumers in the intervening country as foreign firms are delocated to the home market and the domestic price falls through enhanced competition, in imperfectly competitive environments (Venables (1985, 1987)). More recently, Ossa (2011) and Bagwell and Staiger (2015) study the role of trade agreements with the firm-delocation motive for trade policy intervention. Although the current paper does not consider ins and outs of firms due to the profit-shifting from country to another, it shares with the literature the idea that the trade policy intervention potentially affects the production location.

The remainder of the paper proceeds as follows: the next section sets up a basic model and clarifies the final-good producer's location choice from the perspective of governments. Section 3 studies reasons for trade policy intervention, and section 4 solves for Nash equilibrium trade policies and identifies the nature of the Nash trade policy distortions. Section 5 concludes by discussing the way forward for future research.

2 Basic model

My basic model builds on the spider version of the Baldwin and Venables (2013)'s model. Baldwin and Venables consider a world of two countries, where the single final product requires a range of intermediate inputs that can be produced in either country. Factor costs differ between countries for each intermediate input while cross-border sourcing of inputs is costly. So a tension arises between unbundling production to reduce factor costs (i.e., dispersion force) and bundling it to reduce cross-border sourcing costs (i.e., agglomeration force).

To investigate the role of trade policies in the spider model, I consider trade cost on the final good and trade costs on intermediate inputs, conditional on the location of the final assembly plant, separately.[1] And I introduce import tariffs and export taxes (or subsidies) as a component of trade costs. To close the model, I explicitly consider a numeraire good and assume a single factor of production, say, labor, which is mobile across sectors within a country. Each unit of the numeraire good requires one unit of labor in either country.

[1]While Baldwin and Venables (2013) assume that per-unit trade cost on the final good is proportional to that on intermediate inputs, I assume that they are independent to each other. In addition, unlike Baldwin and Venables, I assume that trade cost on intermediate inputs depends on the direction of trade flows, i.e. the location of the final assembly plant.

Because the numeraire good is freely traded and its world price is normalized to one, the competitive wage rate equals one.

After describing the set-up of the model, section 2.2 looks into the final-good producer's location choice from the perspective of governments and shows how an interrelationship between tariffs/taxes imposed on different stages of production plays a role when a government chooses a set of tariffs/taxes while having the location of the final assembly in its favor. Before solving for quilibrium response trade policies, section 2.3 shows that free trade policies are efficient and overviews the nature of the gains from trade and the efficient pattern of production and trade.

2.1 Set-up

Preferences There are two countries, North and South. Residents of each country share identical additively separatable preferences. For sake of simplicity, I assume that all demand for the final good is in North.[2] Each individual in North maximizes a utility function of the form: $U(x_0, x_1) = x_0 + u(x_1)$, where x_0 is consumption of the numeraire good and x_1 is consumption of the final good. I denote by p_1 the domestic price of the final good that the consumer in North faces. The consumer has unit demand for the final good and devotes the remainder of his total spending of m to the numeraire good, thereby attaining the utility level:

$$V(p_1, m) = m + v(p_1), \tag{1}$$

where $v(p_1)$ is the consumer surplus enjoyed on the final good.[3][4] Each individual in South, on the other hand, devotes all of his spending of m^* to the numeraire good:

$$U^*(x_0^*) = x_0^* = m^* = V^*(m^*). \tag{2}$$

Technology Each unit of intermediate input $z \in Z$ is produced using one unit of labor in North or $b(z)$ unit of labor in South. $b(z)$ is uniformly distributed on $[\underline{b}, \bar{b}]$, where $0 < \underline{b} < 1 < \bar{b}$.[5] And one unit of each input is assembled into one unit of the final good, using $a > 0$ units of labor in North or $a^* > 0$ units of labor in South.

Tariffs/taxes are introduced as a component of trade costs charged as fixed amount per quantity, which apply only to cross-border transactions. Without loss of generality, as defined below, I focus on studying the implications of import tariffs and export taxes, unless otherwise noted, because the national welfare-maximizing governments will not unilaterally choose to implement import or export subsidies in an interesting way in my model. Trade costs on the final good, shipped from South to North, are given by $t_1 = \tau_1 + \tau_1^* + \mu_1$, where $\tau_1 \geq 0$ is North government's import tariff, $\tau_1^* \geq 0$ is South government's export tax, and $\mu_1 > 0$ is any exogenous transport cost. For all intermediate inputs, the final-good producer incurs equal costs of cross-border sourcing, t_{2L}, conditional on the location of the

[2] I employ this unrealistic but useful assumption because allowing the final-good demand in both countries will not introduce any additional reason for trade policy intervention.

[3] Willingness to pay is assumed to be sufficiently higher than or equal to p_1.

[4] Introducing linear demand for the final good does not qualitatively change the following results.

[5] Unlike Baldwin and Venables (2013), I proceed without making an assumption about the average cost of producing inputs in South, $\frac{\underline{b}+\bar{b}}{2}$, relative to that in North, which equals one.

final assembly, $L = \{N, S\}$. t_{2L} also consists of three components: $t_{2L} = \tau_{2L} + \tau^*_{2L} + \mu_2$, where $\tau_{2L} \geq 0$ is North's import tariff (if $L = N$) or export tax (if $L = S$), $\tau^*_{2L} \geq 0$ is South's export tax (if $L = N$) or import tariff (if $L = S$), and $\mu_2 > 0$ is any exogenous cost regardless of the direction of trade flows.

The final-good producer's sourcing decision The final-good producer sources an intermediate input only from the location in which the input can be produced and shipped to the assembly plant at the lowest cost. When the assembly is undertaken in North, $L = N$, $b_N = \max\{1 - t_{2N}, \underline{b}\}$ is the marginal good that defines the lowest-cost locations of inputs. $\left[b_N, \overline{b}\right]$ is a set of inputs produced less costly in North domestically while $[\underline{b}, b_N)$ is a set of those produced and delivered less costly from South. As long as the input that South has the most comparative advantage is produced and delivered less costly from South, $1 > \underline{b} + t_{2N}$, the final-good producer imports $[\underline{b}, 1 - t_{2N})$ of inputs from South while sourcing $\left[1 - t_{2N}, \overline{b}\right]$ domestically. But otherwise $b_N = \underline{b}$, and the final-good producer sources all inputs, $\left[\underline{b}, \overline{b}\right]$, domestically. Similarly, when $L = S$, $b_S = \min\left\{1 + t_{2S}, \overline{b}\right\}$ is the marginal good.

The costly cross-border sourcing implies that there is a tension between the agglomeration and dispersion forces that affects the final good producer's decision on whether and which intermediate inputs to source domestically or import from abroad. As t_{2N} (or t_{2S}) rises, a set of inputs produced in North (South) regardless of the location of assembly, $[\underline{b}, b_N)$ ($\left(b_S, \overline{b}\right]$), will shrink while a set of those produced in the same country as the assembly's location, $[b_N, b_S]$, will expand: less inputs will be produced in line with the comparative advantage while more inputs will be produced in proximity to the assembly plant.

By explicitly considering trade policies of governments, the overall production costs, $c_L(\tau_{2L}, \tau^*_{2L})$, conditional on the location of assembly, $L = \{N, S\}$, are

$$c_N(\tau_{2N}, \tau^*_{2N}) = a + \overline{b} - b_N + (b_N - \underline{b})\left(\frac{b_N + \underline{b}}{2} + \tau_{2N} + \tau^*_{2N} + \mu_2\right); \tag{3}$$

$$c_S(\tau_{2S}, \tau^*_{2S}) = a^* + \left(\overline{b} - b_S\right)(1 + \tau_{2S} + \tau^*_{2S} + \mu_2) + (b_S - \underline{b})\frac{b_S + \underline{b}}{2}, \tag{4}$$

where $b_N = \max\{1 - \tau_{2N} - \tau^*_{2N} - \mu_2, \underline{b}\}$ and $b_S = \min\left\{1 + \tau_{2S} + \tau^*_{2S} + \mu_2, \overline{b}\right\}$.

The final-good producer's location decision The final-good producer decides on where to locate an assembly plant so as to minimize the (per-unit) overall production costs, (3) and (4), with a consideration to trade costs on the final good:

$$L(\tau_1, \tau_{2N}, \tau_{2S}, \tau^*_1, \tau^*_{2N}, \tau^*_{2S}) = \begin{cases} N & \text{if} \quad c_N(\tau_{2N}, \tau^*_{2N}) \leq c_S(\tau_{2S}, \tau^*_{2S}) + \tau_1 + \tau^*_1 + \mu_1 \\ S & \quad\quad \text{otherwise.} \end{cases} \tag{5}$$

Pricing of the final good Suppose that the final good is produced in the perfectly competitive industry.[6] The factory gate price is always set equal to the (per-unit) overall

[6] Under the perfectly inelastic demand assumption about the final good, alternative market structure will not change the following results as long as the final-good producer is owned by residents in North, who are entitled to profits produced from the assembly regardless of the location of assembly, because the surplus will be simply transferred from North's consumers to the final-good producer.

production costs, yielding zero profits, and the domestic price of the final good in North is

$$p_1(\tau_1, \tau_{2N}, \tau_{2S}, \tau_1^*, \tau_{2N}^*, \tau_{2S}^* \,|L) = \begin{cases} c_N(\tau_{2N}, \tau_{2N}^*) & \text{if} \quad L = N \\ c_S(\tau_{2S}, \tau_{2S}^*) + \tau_1 + \tau_1^* + \mu_1 & \text{if} \quad L = S. \end{cases} \tag{6}$$

National welfare I normalize the total population of each country to one. Since wages are unity, the total labor income from all the production activities undertaken in North (or South) equals the fixed aggregate labor supply of l (l^*).[7] In addition to labor income, I assume that revenue raised from import tariff or export tax, $R(\tau_1, \tau_{2N}, \tau_{2S}, \tau_1^*, \tau_{2N}^*, \tau_{2S}^* \,|L)$ (or $R^*(\cdot\,|L)$), is redistributed to residents in North (South).[8] Under the perfect competition assumption about the final good, there are zero profits that individuals are also entitled to.[9] Then I can define North and South's national welfare as the (sum of) individual utility (1) and (2), respectively. Governments choose a set of tariffs/taxes to maximize the national welfare:

$$\boldsymbol{\tau} \equiv (\tau_1, \tau_{2N}, \tau_{2S}) = \arg\max_{\boldsymbol{\tau}} \quad W(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L(\boldsymbol{\tau}, \boldsymbol{\tau}^*)),$$

with

$$W(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L(\boldsymbol{\tau}, \boldsymbol{\tau}^*)) = l + R(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L(\boldsymbol{\tau}, \boldsymbol{\tau}^*)) + v(p_1(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L(\boldsymbol{\tau}, \boldsymbol{\tau}^*)))$$

$$R(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L) = \begin{cases} \tau_{2N}(b_N - \underline{b}) & \text{if} \quad L = N \\ \tau_1 + \tau_{2S}\left(\overline{b} - b_S\right) & \text{if} \quad L = S; \end{cases}$$

$$\boldsymbol{\tau}^* \equiv (\tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = \arg\max_{\boldsymbol{\tau}^*} \quad W^*(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L(\boldsymbol{\tau}, \boldsymbol{\tau}^*)),$$

with

$$W^*(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L(\boldsymbol{\tau}, \boldsymbol{\tau}^*)) = l^* + R^*(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L(\boldsymbol{\tau}, \boldsymbol{\tau}^*))$$

$$R^*(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L) = \begin{cases} \tau_{2N}^*(b_N - \underline{b}) & \text{if} \quad L = N \\ \tau_1^* + \tau_{2S}^*\left(\overline{b} - b_S\right) & \text{if} \quad L = S, \end{cases}$$

where $L(\boldsymbol{\tau}, \boldsymbol{\tau}^*) = \{N, S\}$ is the cost-minimizing location of the final assembly, as defined in (5); $p_1(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|L)$ is the domestic price of the final good in North, as defined in (6).

Our interest is in solving for an optimal set of tariffs/taxes that are unilaterally chosen by governments and in identifying the nature of inefficiencies caused by the Nash trade policy intervention. In what follows, I assume that exogenous transport costs are not prohibitively high in the sense that implementing an import or export subsidy is not only the way to allow the assembly to be undertaken in South, $\mu_1 \in \left(0,\, a - a^* + 2\beta\mu_2 + \frac{1}{2}(1 - \underline{b} - \mu_2)^2\right)$, where $\beta \equiv 1 - \frac{\underline{b}+\overline{b}}{2}$, and also in the sense that some of intermediate inputs are imported from one country to the other under free trade policies, $\mu_2 \in \left(0,\, \min\left\{1 - \underline{b}, \overline{b} - 1\right\}\right)$.

[7] I assume that the aggregate labor supply in each country is sufficiently large to ensure positive output of the numeraire good.

[8] In the case of export or import subsidy, this can be interpreted as the expenditure owed by residents.

[9] Since the perfect competition assumption implies zero profits anyway, I proceed without making an assumption about whether the final-good producer is owned by residents in North or South.

2.2 Endogenous location of assembly

This subsection looks into the final-good producer's location choice of $L(\tau_1, \tau_{2N}, \tau_{2S}, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = \{N, S\}$ from the perspective of governments. In so doing, the subsection will help the reader better understand how the model works and what an interrelationship between tariffs/taxes faced by governments is when choosing a set of tariffs/taxes while having the location of the final assembly favorable.

Below, I rewrite the cost-minimizing location decision (5) in terms of aggregate barriers to trade in the final good, $\tau_1 + \tau_1^* \equiv \tau_1^W$, and those for intermediate inputs, $\tau_{2N} + \tau_{2N}^* \equiv \tau_{2N}^W$ and $\tau_{2S} + \tau_{2S}^* \equiv \tau_{2S}^W$. As long as $\tau_{2N}^W \in (0,\, 1 - \underline{b} - \mu_2)$ and $\tau_{2S}^W \in \left(0,\, \overline{b} - 1 - \mu_2\right)$ such that the final-good producer sources some of inputs domestically and imports other inputs from abroad, (5) is rewritten as

$$L\left(\tau_1^W, \tau_{2N}^W, \tau_{2S}^W\right) = \begin{cases} N & \text{if} \quad \tau_1^W \geq a - a^* - \mu_1 + \beta\left(\overline{b} - \underline{b}\right) - \frac{1}{2}\left(1 - \underline{b} - \mu_2 - \tau_{2N}^W\right)^2 \\ & \qquad +\frac{1}{2}\left(\overline{b} - 1 - \mu_2 - \tau_{2S}^W\right)^2 \\ S & \quad \text{otherwise,} \end{cases} \tag{7}$$

where $\beta \equiv 1 - \frac{\underline{b}+\overline{b}}{2}$ is the difference in the average cost of producing inputs between North and South.

The cost-minimizing location pattern as a function of aggregate trade barriers is visually summarized in Figure 1. When governments select free trade policies, $\tau_1^W = \tau_{2N}^W = \tau_{2S}^W = 0$, given some (positive) exogenous transport costs, the cost-minimizing location will be North or South depending on the comparative advantage in the assembly, captured by $(a - a^*)$, and the (average) cost advantage in the input production, captured by β :[10]

$$L(0,0,0) = \begin{cases} N & \text{if} \quad 0 \geq a - a^* - \mu_1 + 2\beta\mu_2 \\ S & \quad \text{otherwise.} \end{cases}$$

Generally, a critical value of τ_1^W that determines the cost-minimizing location depends on both τ_{2N}^W and τ_{2S}^W.[11] This implies that, when a government prefers having the assembly plant located in North, it might raise τ_1^W and/or τ_{2S}^W high enough to have the location favorable while targeting an optimal level of τ_{2N}^W. When a government prefers having the assembly located in South, an interrelationship between tariffs plays a crucial role in targeting an optimal combination of τ_1^W and τ_{2S}^W as well as in having the location favorable. On the one hand, τ_1^W will need to be decreased to increase τ_{2S}^W and vice versa, without shifting the assembly out of South. On the other hand, a rise in τ_{2N}^W will create new room for τ_1^W and τ_{2S}^W to be raised while keeping the assembly in South.

[10] Note that β can be positive or negative. With no exogenous transport costs as well as no trade policy interventions, the cost-minimizing location is naturally the country that has comparative advantage in the assembly, i.e. South if $a > a^*$.

[11] When the aggregate barriers to trade in inputs are set prohibitively high, $\tau_{2N}^W \geq 1 - \underline{b} - \mu_2$ (or $\tau_{2S}^W \geq \overline{b} - 1 - \mu_2$), in the sense that the final-good producer sources all inputs domestically, the critical value of τ_1^W does not depend on τ_{2N}^W (or τ_{2S}^W).

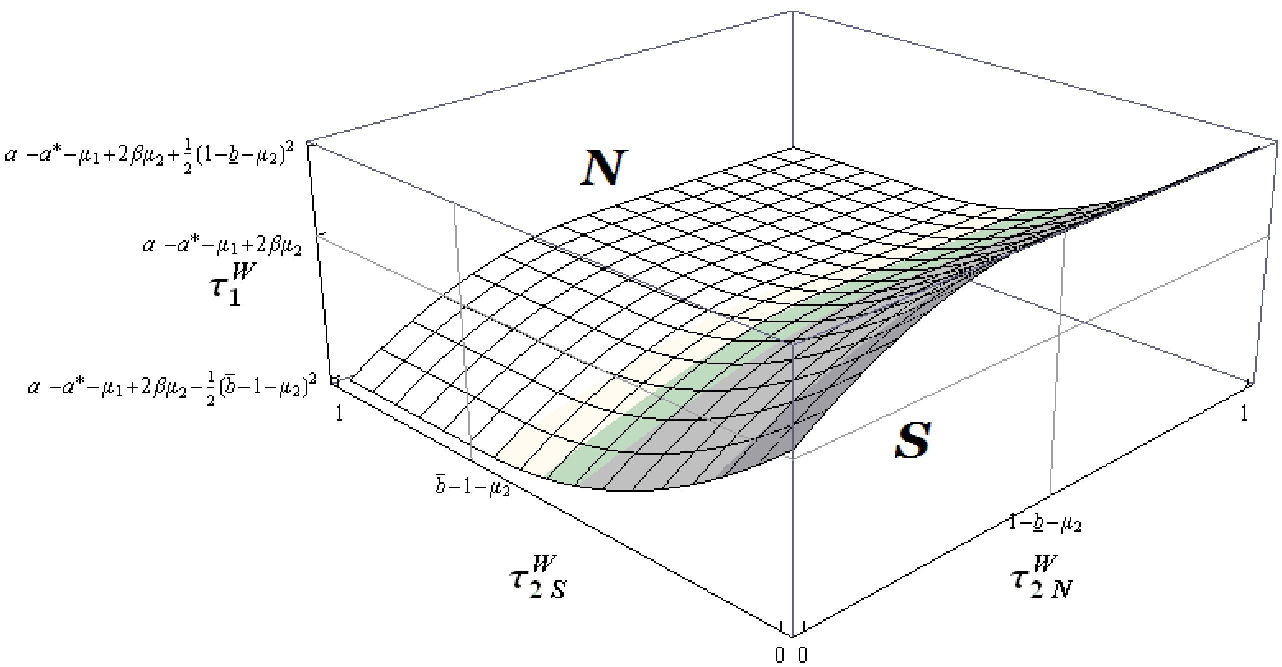

Figure 1: Assembly's location as a function of aggregate trade barriers

Notes: The vertical axis represents aggregate barriers to trade in the final good, $\tau_1 + \tau_1^* \equiv \tau_1^W$, and the two horizontal axes for inputs, $\tau_{2N} + \tau_{2N}^* \equiv \tau_{2N}^W$ and $\tau_{2S} + \tau_{2S}^* \equiv \tau_{2S}^W$. The surface represents a critical value of τ_1^W, as a function of τ_{2N}^W and τ_{2S}^W, that determines the cost-minimizing location choice by the final-good producer, $L(\tau_1^W, \tau_{2N}^W, \tau_{2S}^W) = \{N, S\}$. The cost-minimizing location is North, $L = N$, when a set of aggregate trade barriers lies on or above the surface and is South, $L = S$, otherwise.

2.3 Free trade benchmark

Before solving for Nash equilibrium trade policies, let us begin with overview of the nature of the gains from trade and the pattern of production and trade under free trade policies, which are shown to be efficient, as an initial benchmark.

The gains from trade come from the efficient global allocation of the final assembly and the intermediate input production that minimizes the (per-unit) cost of producing and delivering the final good to consumers (in North). For τ_{2L} or τ_{2L}^{*}, any deviation from zero aggregate barriers to trade in inputs will distort the efficient specialization of the input production, conditional on $L = \{N, S\}$, because the location margin for inputs is continuous. Excessive distortions in the input production may result in forcing the assembly plant out of the efficient location.

The intervention using τ_1 or τ_1^{*}, on the other hand, only induces inefficiency if it changes the location of assembly from the efficient location. In other words, under the perfectly inelastic demand assumption about the final good, there are a range of non-zero aggregate barriers to trade in the final good that merely shift a surplus within a country or from a country to another without creating the world welfare loss. Although this is an artifact of the final good demand assumption, the assumption does help to isolate the novel inefficiency in my model, which is inefficiency due to the assembly's location. The wrong location of assembly relative to the efficient location implies that the intermediate input production also will be distorted, accompanied by a wrong direction of trade flows in inputs as well as the final good. Therefore, efficient trade policies are summarized as follows:

Proposition 1 *Free trade policies,* $\tau_1 = \tau_{2N} = \tau_{2S} = \tau_1^{*} = \tau_{2N}^{*} = \tau_{2S}^{*} = 0$*, are efficient. Let* $E = \{N, S\}$ *be an efficient location of assembly, which is the cost-minimizing location under free trade policies:* $E = L(0,0,0,0,0,0)$*. As long as* $\tau_{2E} + \tau_{2E}^{*} = 0$ *and the assembly's location is not distorted from* E*, other trade policies than free trade will not create the world welfare loss and be efficient.*

Proof. See Appendix A. ■

The pattern of production and trade in the free trade benchmark is summarized as follows: first, if parameters are such that $\mu_1 \in \left[a - a^{*} + 2\beta\mu_2,\, a - a^{*} + 2\beta\mu_2 + \frac{1}{2}\left(1 - \underline{b} - \mu_2\right)^2\right)$, the efficient location of assembly is North, $E = N$, in which the final good and $\left[1 - \mu_2,\, \overline{b}\right]$ of inputs are produced. $[\underline{b},\, 1 - \mu_2)$ of inputs are produced in S. There is no trade in the final good. North is an importer of inputs and exporter of the numeraire good while South is an exporter of inputs and importer of the numeraire good. The volume of trade in inputs is $(1 - \mu_2 - \underline{b})$.

Second, if parameters are such that $\mu_1 \in (0,\, a - a^{*} + 2\beta\mu_2)$, $E = S$. $\left(1 + \mu_2,\, \overline{b}\right]$ of inputs are produced in N while the final good and $[\underline{b},\, 1 + \mu_2]$ of inputs are produced in S. North is an importer of the final good and exporter of inputs as well as the numeraire good, with South as a counterpart. The volume of trade in the final good is one and that of trade in inputs is $\left(\overline{b} - 1 - \mu_2\right)$.

3 Properties of equilibrium response trade policies

This section outlines reasons for trade policy intervention by North and South governments in the basic model. Although the paper highlights the potential of trade policy intervention to change the final-good producer's optimal location choice, the section begins by holding the location of the final assembly fixed in order to show terms-of-trade-driven incentives for trade policy intervention case by case. Then I will allow the location of assembly to be determined endogenously and will consider an incentive to use a tariff/tax as a way to manipulate the location later in the section. A government might care about the assembly's location to better exploit its market power over world prices with trade policy intervention. I call the effect of trade policy intervention on the final-good producer's optimal location choice *the assembly-relocation effect.* As discussed in section 2.2, an interrelationship between tariffs/taxes imposed on different stages of production plays a crucial role in governments' trade policy decisions.

3.1 Fixed location case

To start with, let us hold the location of assembly to abstract from the assembly-relocation effect. When the assembly is undertaken in North, $L = N$, and if the location were fixed, an effective instrument for North (or South) government is τ_{2N} (τ_{2N}^*) only as the final good is produced and consumed only in N. Below, I restrict the analysis to non-prohibitive cases where governments' trade policy choices are such that the input that South has the most comparative advantage is imported to N: $1 > \underline{b} + \tau_{2N} + \tau_{2N}^* + \mu_2$.[12] The exporter's price, the world price, and the importer's price of intermediate input z are defined as follows:

$$\begin{aligned} p_z^* &= b(z); \\ p_z^W &= b(z) + \tau_{2N}^*; \\ p_z &= b(z) + \tau_{2N}^* + \mu_2 + \tau_{2N}, \end{aligned}$$

where $b(z) \in [\underline{b}, b_N) = [\underline{b}, 1 - \tau_{2N} - \tau_{2N}^* - \mu_2)$.[13]

North, as an importer of input z, is a small country since the input is produced at the lowest-cost location. Under the assumption that one unit of each input is assembled into one unit of the final good, τ_{2N} perfectly passes through not only to the domestic price of input z but also the price of the final good. Combined with the assumption of the perfectly inelastic demand for the final good, an increase in the tariff revenue from inputs and a decrease in the consumer surplus due to the rise in the final good price will neutralize each other. In addition, τ_{2N} will distort the efficient international specialization of the input production, deteriorating the consumer surplus through a rise in the final good price:

$$\frac{\partial W\left(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,|N\right)}{\partial \tau_{2N}} = \underbrace{-\tau_{2N}}_{\text{efficiency loss}}. \tag{8}$$

Therefore, if $L = N$ were fixed, North would unilaterally select free trade policy on inputs, $\tau_{2N} = 0$.

[12] Otherwise, all inputs are sourced domestically in N, and τ_{2N} or τ_{2N}^* never affects the national welfare.

[13] The numeraire good is exported from N to S, regardless of the assembly's location.

South, as an exporter of input z, has a market power to influence the world price as long as the input is delivered to the assembly plant in N from S than domestically. The pass through of τ_{2N}^{*} to the world price is one for one. If the terms-of-trade gain outweighs the welfare loss from inefficiencies in the input production, τ_{2N}^{*} will be welfare-enhancing:[14]

$$\frac{\partial W^{*}\left(\boldsymbol{\tau},\boldsymbol{\tau}^{*}\left|N\right.\right)}{\partial\tau_{2N}^{*}}=\underbrace{\left(1-\tau_{2N}-\tau_{2N}^{*}-\mu_{2}-\underline{b}\right)}_{\text{TOT gain}}\quad\underbrace{-\tau_{2N}^{*}}_{\text{efficiency loss}}. \tag{9}$$

Therefore, if $L=N$ were fixed, given an arbitrary τ_{2N}, South would choose $\tau_{2N}^{*}=\frac{1-\underline{b}-\mu_{2}-\tau_{2N}}{2}>0$.

When $L=S$, and if the location were fixed, on the other hand, an effective instrument for North (or South) would be a pair of τ_1 and τ_{2S} (a pair of τ_1^{*} and τ_{2S}^{*}). Below, I restrict the analysis to governments' tariff choices such that the input that South has the least comparative advantage is imported to S: $1+\tau_{2S}+\tau_{2S}^{*}+\mu_{2}<\overline{b}$.[15] The exporter's price, the world price, and the importer's price of the final good are given by:

$$\begin{aligned} p_{1}^{*} &= c_{S}\left(\tau_{2S},\tau_{2S}^{*}\right); \\ p_{1}^{W} &= c_{S}\left(\tau_{2S},\tau_{2S}^{*}\right)+\tau_{1}^{*}; \\ p_{1} &= c_{S}\left(\tau_{2S},\tau_{2S}^{*}\right)+\tau_{1}^{*}+\mu_{1}+\tau_{1}, \end{aligned}$$

where $c_{S}\left(\tau_{2S},\tau_{2S}^{*}\right)$ is the overall production costs (4). It is noteworthy that a rise in τ_{2S} or τ_{2S}^{*} distorts the efficient specialization of the input production, and as a result, pushes up p_1^W through the production chain: $\frac{\partial p_1^W}{\partial\tau_{2S}}=\frac{\partial p_1^W}{\partial\tau_{2S}^{*}}=\overline{b}-b_S=\overline{b}-1-\tau_{2S}-\tau_{2S}^{*}-\mu_2>0$. I call this effect of τ_{2S} or τ_{2S}^{*} on p_1^W *the production-chain effect*. Meanwhile, the corresponding prices of input z are given by:

$$\begin{aligned} p_{z} &= 1; \\ p_{z}^{W} &= 1+\tau_{2S}; \\ p_{z}^{*} &= 1+\tau_{2S}+\mu_{2}+\tau_{2S}^{*}. \end{aligned}$$

North, as an importer of the final good, is a small country since the perfectly competitive factory gate price does not depend on τ_1. Under the perfectly inelastic demand assumption about the final good, τ_1 will have no impact on North's national welfare because an increase in the tariff revenue and a decrease in the consumer surplus will neutralize each other:

$$\frac{\partial W\left(\boldsymbol{\tau},\boldsymbol{\tau}^{*}\left|S\right.\right)}{\partial\tau_{1}}=0. \tag{10}$$

Therefore, North is indifferent between any levels of τ_1 unless its tariff choice changes the location.

[14] A rise in τ_{2N}^{*} will improve South's terms of trade: $\frac{\partial}{\partial\tau_{2N}^{*}}\left(\frac{p_z^W}{p_0^W}\right)=1$ where $p_0^W=1$. $\left(1-\tau_{2N}-\tau_{2N}^{*}-\mu_2-\underline{b}\right)$ is the volume of exports of inputs.

[15] Otherwise, all inputs are sourced domestically in S, and τ_{2S} or τ_{2S}^{*} never affects the national welfare.

South, as an exporter of the final good, has a market power to influence the world price. τ_1^* perfectly passes through to the world price, leading to the terms-of-trade gain:[16]

$$\frac{\partial W^*\left(\boldsymbol{\tau},\boldsymbol{\tau}^*\left|S\right.\right)}{\partial\tau_1^*}=\underbrace{1}_{\text{TOT gain}}. \tag{11}$$

Therefore, if $L=S$ were fixed, South would have an incentive to raise τ_1^* as high as possible.

North, as an exporter of input z, has a market power to influence the world price. Despite the production-chain effect, a rise in τ_{2S} will improve North's terms of trade.[17] Meanwhile, however, a rise in τ_{2S} leads to inefficiencies in the input production and the resulting rise in p_1^W will deteriorate the consumer surplus. The welfare losses always outweigh the terms-of-trade gain:[18]

$$\begin{aligned}\frac{\partial W\left(\boldsymbol{\tau},\boldsymbol{\tau}^*\left|S\right.\right)}{\partial\tau_{2S}} &= \underbrace{\left(\bar{b}-1-\tau_{2S}-\tau_{2S}^*-\mu_2\right)}_{\text{TOT gain}}\quad\underbrace{-\tau_{2S}}_{\text{efficiency loss}}\quad\underbrace{-\left(\bar{b}-1-\tau_{2S}-\tau_{2S}^*-\mu_2\right)}_{\text{decrease in CS}}\\ &= -\tau_{2S}.\end{aligned} \tag{12}$$

Therefore, if $L=S$ were fixed, North would unilaterally select $\tau_{2S}=0$, as in the case of $L=N$ fixed.

South, as an importer of input z, is a small country. Nevertheless, a rise in τ_{2S}^* will improve South's terms of trade via the production-chain effect, and thereby might be welfare-enhancing:[19]

$$\frac{\partial W^*\left(\boldsymbol{\tau},\boldsymbol{\tau}^*\left|S\right.\right)}{\partial\tau_{2S}^*}=\underbrace{\left(\bar{b}-1-\tau_{2S}-\tau_{2S}^*-\mu_2\right)}_{\text{TOT gain}}\quad\underbrace{-\tau_{2S}^*}_{\text{efficiency loss}}. \tag{13}$$

Therefore, if $L=S$ were fixed, given an arbitrary τ_{2S}, South would choose $\tau_{2S}^*=\frac{\bar{b}-1-\mu_2-\tau_{2S}}{2}>0$.

3.2 Endogenous location case

Next, let us allow the location of assembly to be determined endogenously and summarize properties of equilibrium response tariffs. In other words, in addition to the conventional, terms-of-trade-driven incentives discussed thus far, we will consider a possibility that a government might use a tariff/tax as a way to manipulate the location of the final assembly in its favor so that, conditional on that location, it can maximize its ability to manipulate the terms of trade. An equilibrium response by each country to an arbitrary trade policy vector of the other country is defined below. I use North to illustrate though a similar definition applies to South.

[16] $\frac{\partial}{\partial\tau_1^*}\left(\frac{p_1^W}{p_z^W}\right)=\frac{1}{p_z^W}>0.$

[17] $\frac{\partial}{\partial\tau_{2S}}\left(\frac{p_z^W}{p_1^W}\right)=\frac{1}{p_1^W}\left(1-\frac{\left(\bar{b}-1-\mu_2-\tau_{2S}-\tau_{2S}^*\right)p_z^W}{p_1^W}\right)>0.$

[18] $\left(\bar{b}-1-\tau_{2S}-\tau_{2S}^*-\mu_2\right)$ of the first term corresponds to the volume of input exports.

[19] $\frac{\partial}{\partial\tau_{2S}^*}\left(\frac{p_1^W}{p_z^W}\right)=\frac{\left(\bar{b}-1-\mu_2-\tau_{2S}-\tau_{2S}^*\right)}{p_z^W}>0.$

Definition 2 *Let* $\boldsymbol{\tau}^*$ *be an arbitrary trade policy vector of South government. Then a trade policy vector* $\boldsymbol{\tau}^{BR}(\boldsymbol{\tau}^*) \equiv \left(\tau_1^{BR}(\boldsymbol{\tau}^*), \tau_{2N}^{BR}(\boldsymbol{\tau}^*), \tau_{2S}^{BR}(\boldsymbol{\tau}^*)\right)$ *is an equilibrium response to* $\boldsymbol{\tau}^*$ *if*

$$\boldsymbol{\tau}^{BR}(\boldsymbol{\tau}^*) = \arg\max_{\boldsymbol{\tau}} \quad W(\boldsymbol{\tau}, \boldsymbol{\tau}^* \,| L(\boldsymbol{\tau}, \boldsymbol{\tau}^*)).$$

First, North government never has the assembly-relocation motive for trade policy intervention. This is because shifting the assembly plant away from the cost-minimizing location given any South's trade policy vector will lead to further inefficiencies in the global allocation of assembly and/or the input production. The resulting higher price of the final good ultimately will deteriorate the consumer surplus in North. Therefore, North's equilibrium response trade policies are summarized as follows:

Lemma 3 *Given any (non-prohibitive) trade policy vector of South government,* $\boldsymbol{\tau}^*$*, North unilaterally selects free trade policy on inputs, conditional on* $L(0,0,0,\tau_1^*,\tau_{2N}^*,\tau_{2S}^*) = \{N, S\}$*, and chooses the other trade policies not to shift the assembly plant away from* $L(0,0,0,\tau_1^*,\tau_{2N}^*,\tau_{2S}^*)$*. Specifically, given* $\boldsymbol{\tau}^*$ *such that* $L(0,0,0,\tau_1^*,\tau_{2N}^*,\tau_{2S}^*) = N$*, North selects* $\tau_{2N}^{BR}(\boldsymbol{\tau}^*) = 0$ *while* $\tau_1^{BR}(\boldsymbol{\tau}^*)$ *and* $\tau_{2S}^{BR}(\boldsymbol{\tau}^*)$ *will be any combination as long as* $L\left(\tau_1^{BR}, 0, \tau_{2S}^{BR}, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*\right) = L(0,0,0,\tau_1^*,\tau_{2N}^*,\tau_{2S}^*) = N$*. Similarly, given* $\boldsymbol{\tau}^*$ *such that* $L(0,0,0,\tau_1^*,\tau_{2N}^*,\tau_{2S}^*) = S$*, North selects* $\tau_{2S}^{BR}(\boldsymbol{\tau}^*) = 0$ *while choosing* $\tau_1^{BR}(\boldsymbol{\tau}^*)$ *and* $\tau_{2N}^{BR}(\boldsymbol{\tau}^*)$ *such that* $L\left(\tau_1^{BR}, \tau_{2N}^{BR}, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*\right) = L(0,0,0,\tau_1^*,\tau_{2N}^*,\tau_{2S}^*) = S$*.*

Proof. See Appendix B. ■

In contrast to North, South government sometimes will have the assembly-relocation motive for trade policy intervention. Notice that since the final good is not consumed in South, it does not adversely affect South's consumer surplus to use a tariff as a way to manipulate the location of assembly. The potential terms-of-trade consequences that South government could enjoy, conditional on the location, determine whether South will prefer having the assembly located in one location to the other. In what follows, I begin with discussion on South's preference for the location without making an assumption about where an efficient location of assembly is. Then I will identify conditions under which South would want to inefficiently shift the assembly to North or to South, and when South would want to preserve the efficient location.

It would be convenient to think of South government's preference for the location in the following way: as shown in (9), given any (non-prohibitive) τ_{2N}, $\tau_{2N}^* = \frac{1-\underline{b}-\mu_2-\tau_{2N}}{2}$ will attain the maximum of $W^*(\tau_{2N}, \tau_{2N}^* \,|N)$. Let

$$\overline{W}_N^*(\tau_{2N}) \equiv W^*\left(\tau_{2N}, \frac{1-\underline{b}-\mu_2-\tau_{2N}}{2} \,|N\right) = l^* + \frac{1}{4}(1-\underline{b}-\mu_2-\tau_{2N})^2.$$

South will prefer having $L = S$ than otherwise if there exists a feasible combination of τ_1^* and τ_{2S}^* that attains a higher welfare than $\overline{W}_N^*(\tau_{2N})$. This can be considered as a problem of maximizing $W^*(\tau_1, \tau_{2S}, \tau_1^*, \tau_{2S}^* \,|S)$ by choosing $\boldsymbol{\tau}^*$ subject to the location constraint that dictates the final-good producer's optimal location choice. It follows from combining (11) and (13) with the discussion in section 2.2 that South government always has an incentive to increase τ_{2N}^* as high as possible, though not yielding a terms-of-trade gain directly, to create

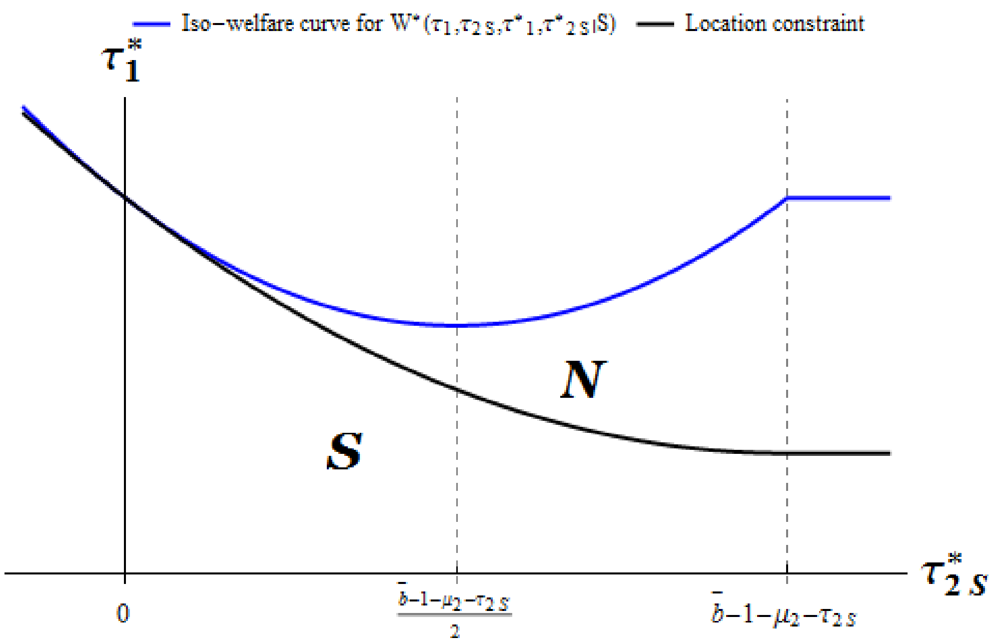

Figure 2: South's optimal trade policy when having $L = S$ is feasible and more favorable for South

Notes: The vertical axis represents South's export tax on the final good, and the horizontal axis for the import tariff on inputs shipped from N to S. The locational constraint represents a critical value that determines the cost-minimizing location choice by the final-good producer, $L(\boldsymbol{\tau}, \boldsymbol{\tau}^*) = \{N, S\}$. The cost-minimizing location is North, $L = N$, when a combination of τ_1^* and τ_{2S}^* lies on or above the constraint and is South, $L = S$, otherwise.

room for τ_1^* and τ_{2S}^* to be raised while keeping $L = S$. Thus, the maximization problem can be solved with respect to τ_1^* and τ_{2S}^*, as visualized in Figure 2.

Conditional on having $L = S$, South government will impose τ_1^* to enjoy terms-of-trade gain (see (11)). South could use τ_{2S}^*, as well as a direct instrument of τ_1^*, to manipulate the world price of the final good to its advantage via the production-chain effect (see (13)). As discussed in section 2.2, however, τ_{2S}^* will need to be decreased to increase τ_1^* without shifting the assembly out of South. As formally shown in Appendix C, the iso-welfare curve for $W^*(\cdot\,|S)$ is tangent to the location constraint at $\tau_{2S}^* = 0$, and South will end up using a direct instrument of τ_1^* exclusively in aiming at attaining a higher $W^*(\cdot\,|S)$ compared to $\overline{W}_N^*(\tau_{2N})$. Therefore, South will prefer having $L = S$ if it can choose $\tau_1^* > \frac{1}{4}\left(1 - \underline{b} - \mu_2 - \tau_{2N}\right)^2$ without shifting the assembly out of S. Otherwise, South will prefer having $L = N$, and will impose τ_{2N}^* to enjoy terms-of-trade gain while using τ_1^* and/or τ_{2S}^* only to have the assembly's location favorable.[20]

If the more favorable location for South is different from the cost-minimizing location given North's trade policy choice, South government will use a tariff/tax to change the assembly's location in its favor. Because North never has the assembly-relocation motive, as stated in Lemma 3, if the final-good producer's optimal location choice is changed as a result of South's trade policy intervention, it always implies a shift away from the efficient location.

Given that the efficient location is North, it is more likely that South will inefficiently move the assembly to South when North has a relatively less cost advantage in the intermediate input production, i.e. $\underline{b}$ and $\overline{b}$ are smaller (and β might be positive and larger), and when North has a relatively less comparative advantage in the assembly, i.e. $(a - a^*)$ is negative but close to zero (or might be positive). These conditions imply that the additional (per-unit) costs of producing and delivering the final good incurred by the final-good producer when having the assembly to be located in South is less substantial. By increasing τ_{2N}^* as high as possible, South therefore would have the assembly out of North and be able to create new room for τ_1^* to be raised in order to better exploit its market power over the world price of the final good. Similarly, given that the efficient location is South, South would want to inefficiently move the assembly to North when the additionally incurred production costs when having the assembly located in North is less substantial.

Under the perfectly inelastic demand assumption about the final good, South's national welfare does not depend directly on North's trade policy choice for the final good. Nevertheless, how much South government will be able to exploit its market power over the world price of the final good depends on North's choice of τ_1: for example, suppose that the efficient location is North, and that a sufficiently high τ_1 is chosen by North. There would

[20] In a real world, export taxes are prohibited, for example, by the US constitution. Export taxes may not be used anyway because of political lobbying by the export industry though introducing political economy in my model is beyond the scope of the present paper. Nevertheless, it would be worth noting what if South government were not allowed to impose an export tax in my model: South would use the second-best instrument, τ_{2S}^*, instead of using τ_1^* directly, i.e. $\tau_1^{*BR} = 0$ and $\tau_{2S}^{*BR} > 0$, in aiming at attaining a higher welfare while having $L = S$ in its favor. Notice that South would not be able to raise τ_{2N}^*, even if needed to have $L = S$. When having $L = N$ is more favorable for South, on the other hand, South would choose $\tau_{2N}^{*BR} = 0$, and would use $\tau_{2S}^{*BR} > 0$ if needed to have $L = N$. Thus, τ_{2S}^* would be the only instrument that South unilaterally uses, and the assembly-relocation effect of tariff intervention would arise only when $E = S$.

be little room for τ_1^* to be raised while having the assembly located in South. If this is the case, South will probably prefer preserving the efficient location of assembly so that it can manipulate its terms of trade as best it can, by imposing τ_{2N}^* instead of increasing τ_1^*.

Lemma 4 *Given any (non-prohibitive) trade policy vector of North government, $\boldsymbol{\tau}$, South always intervenes. Moreover, South sometimes will have the assembly-relocation motive for trade policy intervention, so that, conditional on the resulting location, it can maximize its ability to manipulate the terms of trade. South will prefer having $L = S$ if it can choose $\tau_1^* > \frac{1}{4}\left(1 - \underline{b} - \mu_2 - \tau_{2N}\right)^2$, while choosing $\tau_{2S}^{*BR}(\boldsymbol{\tau}) = 0$ and setting $\tau_{2N}^{*BR}(\boldsymbol{\tau}) \geq 1 - \underline{b} - \mu_2 - \tau_{2N}$ prohibitively high, without shifting the assembly plant out of S. Otherwise, South will prefer having $L = N$ and will choose $\tau_{2N}^{*BR}(\boldsymbol{\tau}) = \frac{1-\underline{b}-\mu_2-\tau_{2N}}{2}$, while using $\tau_1^{*BR}(\boldsymbol{\tau}) \neq 0$ and/or $\tau_{2S}^{*BR}(\boldsymbol{\tau}) \neq 0$ if needed to have $L = N$.*

Proof. See Appendix C. ■

4 Nash equilibrium trade policies

This section solves for Nash equilibrium trade policies in the basic model and identifies the nature of Nash trade policy distortions by comparing the pattern of production and trade under Nash equilibrium with the efficient levels. With Lemmas 3 and 4 regarding the properties of equilibrium response trade policies, we are ready to define and solve for a Nash equilibrium:

Definition 5 *A Nash equilibrium consists of trade policy choices of North and South governments such that $\boldsymbol{\tau}^{NE} \equiv \left(\tau_1^{NE}, \tau_{2N}^{NE}, \tau_{2S}^{NE}\right)$ is the equilibrium response to $\boldsymbol{\tau}^{*NE} \equiv \left(\tau_1^{*NE}, \tau_{2N}^{*NE}, \tau_{2S}^{*NE}\right)$ and $\boldsymbol{\tau}^{*NE}$ is the equilibrium response to $\boldsymbol{\tau}^{NE}$.*

In a Nash equilibrium, South government always intervenes while North selects free trade or other policies that are equivalent to free trade in the sense that they are not driven by a beggar-thy-neighbor motive and that they have an impact on neither North nor South's national welfare. Furthermore, South can sometimes beneficially use its tariff/tax to force an inefficient location, via the assembly-relocation effect, so that it can better exploit its market power over world prices with trade policy intervention, while manipulating the location is always not beneficial to North.

There are three types of qualitatively different Nash equilibria, in terms of the nature of distortions caused by South government's Nash trade policy intervention. Nash equilibrium outcome depends on a set of parameter values regarding the comparative advantage in the final assembly, the (average) cost advantage of the intermediate input production, and exogenous transport costs. Nevertheless, for all the following three types, South's Nash trade policy intervention benefits South's residents, who are entitled to the revenue raised from export tax, $\tau_1^{*NE} > 0$ or $\tau_{2N}^{*NE} > 0$, at the expense of North's consumers, who face a higher price of the final good, compared to the efficient, free trade benchmark. The world price of the final good is pushed up not only due directly to a rise in τ_1^*, but because of the distortions from the efficient global allocation of assembly and/or the input production.

In the first type of Nash equilibria, South government's trade policy intervention leads to a simple shift of surplus from North to South in a lump-sum fashion without creating the world welfare loss. This type is realized only when the efficient location of assembly is South, $E = S$. South enjoys terms-of-trade gain on the final good by choosing $\tau_{2S}^{*NE} = 0$ and setting $\tau_1^{*NE} > \frac{1}{4}\left(1 - \underline{b} - \mu_2\right)^2$ as high as possible while leaving the location the same as E. Meanwhile, South chooses a prohibitively high $\tau_{2N}^{*NE} \geq 1 - \underline{b} - \mu_2 > 0$, though τ_{2N}^* will not yield a terms-of-trade gain directly, in order to create room for τ_1^* to be raised fully. It follows that there is no distortion in the pattern of production and trade in the final good or in inputs.

In the second type of Nash equilibria, South government's trade policy intervention is traced only to distortions from the efficient specialization of the input production. This type is realized only when $E = N$. South enjoys terms-of-trade gain on inputs by choosing $\tau_{2N}^{*NE} = \frac{1-\underline{b}-\mu_2}{2} > 0$. Meanwhile, South will use $\tau_1^{*NE} \neq 0$ and/or $\tau_{2S}^{*NE} \neq 0$ if needed to have the location the same as E. The amount of production of inputs increases by τ_{2N}^{*NE} in the (efficient) location of assembly while it decreases by τ_{2N}^{*NE} in the other country, compared to the free trade benchmark. As a result, the volume of trade in inputs becomes low relative to the efficient level.

In the third type of Nash equilibria, South government's trade policy intervention is traced to distortions from the efficient location of assembly as well as the efficient specialization of the input production. South forces an inefficient location via the assembly-relocation effect so that, conditional on that location, it can maximize its ability to manipulate the terms of trade. A wrong location of assembly implies an inefficient allocation of the input production, which is accompanied by the wrong direction of trade flows.

When South government forces the assembly plant out of $E = N$ to shift it to S, it raises τ_{2N}^*. As in the first type, to have $L = S$, South ends up choosing a prohibitively high $\tau_{2N}^{*NE} \geq 1 - \underline{b} - \mu_2$ to raise τ_1^* fully and to enjoy the terms-of-trade gain on the final good. Note that a set of Nash equilibrium trade policies is seemingly the same as the first type, but have different welfare implications as the efficient location is different than the first type. The input production increases by $2\mu_2 > 0$ in the Nash location of assembly while it decreases by $2\mu_2$ in the efficient location of assembly, compared to the free trade benchmark.[21] The final good is traded against the efficient level of zero though it is in the wrong direction. A change in the input trade volume relative to the efficient level is -2β, which may be positive or negative.[22] It is noteworthy that the Nash trade volume will be higher than the efficient level when North has cost advantage in the input production, $\beta < 0$, though the flow is in the wrong direction.

When South government forces the assembly out of $E = S$ to shift it to N, on the other hand, it uses τ_1^* and/or τ_{2S}^*. Again, a set of Nash equilibrium trade policies is seemingly the same as the second type, but have different welfare implications. The input production increases by $2\mu_2 + \tau_{2N}^{*NE} > 0$ in the Nash location of assembly while it decreases by $2\mu_2 + \tau_{2N}^{*NE}$ in the efficient location of assembly, compared to the free trade benchmark.[23] While the final

[21] The input production in the Nash Location of S changes from $(1 - \mu_2 - \underline{b})$ to $(1 + \mu_2 - \underline{b})$ while the production in the efficient location of N changes from $\left(\bar{b} - 1 + \mu_2\right)$ to $\left(\bar{b} - 1 - \mu_2\right)$.

[22] The input trade volume changes from $(1 - \mu_2 - \underline{b})$ to $\left(\bar{b} - 1 - \mu_2\right)$.

[23] The input production in the Nash Location of N changes from $\left(\bar{b} - 1 - \mu_2\right)$ to $\left(\bar{b} - 1 + \mu_2 + \tau_{2N}^*\right)$ while the production in the efficient location of S changes from $(1 + \mu_2 - \underline{b})$ to $(1 - \mu_2 - \tau_{2N}^* - \underline{b})$.

good is no longer traded, the input trade volume may become higher than the efficient level: a change in the input trade volume, $2\beta - \frac{1-\underline{b}-\mu_2}{2}$, may be positive, when South has greater cost advantage in the input production, $\beta > 0$.[24] In either case of the shift away from an efficient location, the assembly-relocation effect of trade policy intervention results in trade-pattern reversal from efficient to Nash, and the Nash trade volume is not necessarily low relative to the efficient level.

Proposition 6 *In a Nash equilibrium, while North government selects free trade or other equivalent trade policies, South always intervenes and sometimes will have the assembly-relocation motive for trade policy intervention. South's Nash trade policy intervention will not create the world welfare loss in one case, but will cause distortions from the efficient global allocation of the final assembly and/or the intermediate input production in the other cases.*

Proof. Follows from Lemmas 3 and 4. See Appendix D for the details of Nash equilibrium tariffs. ■

5 Conclusion

This paper considered the national welfare-maximizing combination of trade policy instruments imposed on different stages of production, by endogenizing the firm's location and sourcing decision, and identified the nature of inefficiencies caused by the trade policy intervention. Using a simple model of cross-border unbundling subject to trade costs on the final good and on intermediate inputs, the paper highlighted the novel inefficiency due to the location of the final assembly and the assembly-relocation motive for trade policy intervention. A government sometimes uses an import tariff and/or export tax as a way to manipulate the location of assembly in its favor, forcing an inefficient location, so that, conditional on the resulting location, it can better exploit its market power over world prices with trade policy intervention. In addition, the paper featured the production-chain effect to explain incentives behind the trade policy intervention. A rise in the tariff/tax on inputs could push up the world price of the final good through the production chain.

My basic model laid out in this paper focuses on a very simple setting in which the demand for the final good is perfectly inelastic and all the demand is in North. This assumption for simplicity is not realistic but does help to highlight the assembly-relocation motive for trade policy intervention. If we allow the final-good demand in South as well as North, though keeping the perfectly inelastic demand assumption, the cost-minimizing location choice by the final-good producer depends on trade cost on the final good shipped from North to South as well. In this setting, North government will no longer cause no distortion: any country whose share in the world population, i.e. the share in the world (fixed) demand for the final good, is θ, where $0 \leq \theta < 1$, would always intervene, causing distortions from the efficient global allocation of the final assembly and/or the intermediate input production.

To be more precise, in a Nash equilibrium, one country will raise the export tax on intermediate inputs and/or import tariff on the final good so that it can create room for the

[24] The input trade volume changes from $(\bar{b} - 1 - \mu_2)$ to $(1 - \mu_2 - \tau_{2N}^{*} - \underline{b})$.

export tax on the final good to be raised to enjoy the terms-of-trade gain from the final good, having the final assembly plant located in that country. By raising the tariff/tax prohibitively high, a country sometimes forces an inefficient location via the assembly-relocation effect. Meanwhile, the other country imposes the export tax on inputs to enjoy the terms-of-trade gain from inputs. Thus, though a Nash equilibrium will be inefficient for any parameter values, allowing the final-good demand in both countries will not introduce any additional reason for trade policy intervention.

As long as we stick with a small country case, the above pattern of Nash trade policy intervention arises even if we consider a general demand function for the final good. Note that, in the perfectly inelastic demand case, the higher the export tax on the final good is raised without shifting the final assembly plant away from home, the larger terms-of-trade gain from the final good the country can enjoy. In the general demand case, on the other hand, there is an optimal level of the export tax imposed on the final good. Suppose if a country is unconstrained by the location of assembly which remains at home, then the country will use the optimal export tax alone on the final good to manipulate the terms of trade, with no intervention on intermediate inputs. But if this optimum would lead the assembly to move to the other country, then the country may put a higher export tax on inputs so that it can stop the assembly relocation and continue to impose its unconstrained optimal export tax on the final good. If even with a prohibitively high export tax on inputs the assembly would move to the other country under the optimal final-good export tax, then the country will give up on keeping the assembly at home, let it move to the other country, and use the export tax on inputs to manipulate its terms of trade as best it can. Still, generalizing the demand structure does not yield any additional reason for trade policy intervention.

Importantly, my theoretical analysis sheds light on the national welfare-maximizing government's incentives for imposing the export tax on intermediate inputs (i) to enjoy terms-of-trade gains or (ii) to attract the final assembly plant to that country in order to maximize its ability to enjoy terms-of-trade gains, conditional on the assembly relocation. To the best of my knowledge, the assembly-relocation motive had not yet been theoretically studied, and, even for the terms-of-trade motive (the theoretical study of which is going back to Just, Schmitz, and Zilberman (1979)), there remains an ample room for theory-based empirical research on discerning the reasons for imposing export restrictions. There are also previous theoretical studies focusing on the profit-shifting motive of export taxes (Eaton and Grossman (1986), Rodrik (1989), and Bernhofen (1997)), which is not considered in the current paper though.

Export restrictions have recently been increasingly used as trade policy instrument not only on natural resources and agricultural and food products, but also on industrial raw and semi-processed materials. Export taxes have been imposed by 65 out of the 128 countries reviewed by the WTO since 2003 (Kim (2010)), and they are primarily used by large emerging economies such as Argentina, Brazil, China, India, and Russian Federation (Solleder (2013)).

For example, the WTO panels on China's export restrictions on rare earths, tungsten, and molybdenum (which are raw materials used in the production of various kinds of electronic goods) requested by the US (DS431), EU (DS432), and Japan (DS433) are still vivid in our mind. In relation to this, Chinese government drastically decreased its export ceiling on rare earths in July 2010, and applied stricter customs clearance procedures in September 2010, leading to a de facto embargo on the rare-earth exports to Japan. These China's protectionist measures prompted rare-earth magnet (which is produced from rare earths) manufacturers (e.g., TDK Corporation, Hitachi Metals Ltd., Shin-Etsu Chemical Co., Ltd.) based in Japan to relocate their factories to China. In August 2012, Japanese government introduced non-automatic license requirement to exports of rare-earth magnets, their manufacturing equipment, and associated parts and components, seemingly in an attempt to stem a wave of the production relocation to China. This China-Japan export restriction-nexus trade war shocked the Japanese industry.[25]

Given the increasing prevalence of export restrictions, future studies are awaited to extend the basic model of cross-border unbundling presented in this paper to derive theoretical predictions regarding reasons for export restrictions on intermediate inputs to be emprically examined. In addition, to mitigate inefficiencies caused by the export restriction-nexus trade war, we would need to investigate how the rules of trade agreements on export restrictions should be designed. In a real world, the GATT/WTO provides a general prohibition on quantitative export restrictions but the broad and, at times, ambiguous exceptions somewhat vitiate the ban. Moreover, export taxes are not explicitly forbidden in the GATT/WTO. Meanwhile, Korinek and Bartos (2012) found that, out of the sample of 93 regional trade agreements that they carefully surveyed, 66 agreements include explicit disciplines on export taxes beyond the GATT/WTO provisions. They also found that 15 out of 93 agreements contain stronger language than the GATT/WTO quantitative export restriction disciplines. These findings can be interpreted as suggesting a need for improving the rules on export restrictions at the level of the WTO. A current struggle of the WTO appears to imply that its traditional focus on import tariffs and market access, i.e., shallow integration, would be of limited effectiveness for further multilateral liberalization. To go beyond the shallow integration, we would need to reconsider how to effectively let governments bargain to efficient trade policy choices including export restrictions.

A Proof of Proposition 1

To show that free trade policies are efficient, I first solve the social planner's problem in terms of aggregate tariffs, $\boldsymbol{\tau}^W \equiv \left(\tau_1^W, \tau_{2N}^W, \tau_{2S}^W\right)$, by holding the location of assembly fixed. Then I show that the planner has no incentive to use tariffs as a way to change the assembly's location.

The social planner chooses a set of aggregate tariffs to maximize the world welfare:

$$\boldsymbol{\tau}^W \equiv \left(\tau_1^W, \tau_{2N}^W, \tau_{2S}^W\right) = \arg\max_{\boldsymbol{\tau}^W} W^W \left(\boldsymbol{\tau}^W \left| L\left(\boldsymbol{\tau}^W\right)\right.\right),$$

with

$$W^W \left(\tau_{2N}^W \left| N\right.\right) = l^W + \tau_{2N}^W \left(b_N - \underline{b}\right) + v\left(p_1\left(\tau_{2N}^W \left| N\right.\right)\right);$$

$$W^W \left(\tau_1^W, \tau_{2S}^W \left| S\right.\right) = l^W + \tau_1^W + \tau_{2S}^W \left(\overline{b} - b_S\right) + v\left(p_1\left(\tau_1^W, \tau_{2S}^W \left| S\right.\right)\right),$$

[25] For more anecdotal facts about the firm's relocation of production site to circumvent export restrictions imposed on intermediate inputs, i.e., export-restriction jumping investments, see WTO (2010, 2014).

where $l^W \equiv l + l^*$, $b_N = \max\left\{1 - \tau_{2N}^W - \mu_2,\, \underline{b}\right\}$, and $b_S = \min\left\{1 + \tau_{2S}^W + \mu_2,\, \overline{b}\right\}$. Holding the assembly's location fixed and taking partial derivatives with respect to tariffs, we have

$$\frac{\partial W^W\left(\cdot\,|N\right)}{\partial \tau_{2N}^W} = -\tau_{2N}^W;$$

$$\frac{\partial W^W\left(\cdot\,|S\right)}{\partial \tau_1^W} = 0;$$

$$\frac{\partial W^W\left(\cdot\,|S\right)}{\partial \tau_{2S}^W} = -\tau_{2S}^W.$$

As long as the location is unchanged, τ_1^W has no impact on W^W, and $\tau_{2N}^W = 0$ and $\tau_{2S}^W = 0$ attains the maximum of $W^W\left(\cdot\,|N\right)$ and $W^W\left(\cdot\,|S\right)$, respectively.

Next, I check whether the planner has an incentive to use $\boldsymbol{\tau}^W$ as a way to change L from the efficient location to another, in an attempt to maximize W^W. Without loss of generality, suppose if the planner were to initially chooses $\tau_1^W = \tau_{2N}^W = \tau_{2S}^W = 0$, which would attain the world welfare, conditional on the assembly's location, as follows:

$$\overline{W}_N^W \equiv W^W\left(0\,|N\right) = l^W + v\left(p_1\left(0\,|N\right)\right);$$

$$\overline{W}_S^W \equiv W^W\left(0, 0\,|S\right) = l^W + v\left(p_1\left(0, 0\,|S\right)\right).$$

Comparing $\overline{W}_N^W$ with $\overline{W}_S^W$, we have

$$\begin{array}{ll} \overline{W}_N^W \geq \overline{W}_S^W & \text{iff} \quad 0 \geq a - a^* - \mu_1 + 2\beta\mu_2; \\ \overline{W}_N^W < \overline{W}_S^W & \quad\;\;\;\text{otherwise,} \end{array}$$

where the inequalities on the right-hand side exactly correspond to the final-good producer's cost-minimizing location decision (7) for $L\left(0, 0, 0\right) = \{N,\, S\}$. That is,

$$\begin{array}{ll} \overline{W}_N^W \geq \overline{W}_S^W & \text{iff} \quad L\left(0, 0, 0\right) = N; \\ \overline{W}_N^W < \overline{W}_S^W & \text{iff} \quad L\left(0, 0, 0\right) = S, \end{array}$$

which indicates that the planner has no incentive to use $\boldsymbol{\tau}^W$ to force the assembly plant away from $L\left(0, 0, 0\right)$.

Therefore, $\tau_1^W = \tau_{2N}^W = \tau_{2S}^W = 0$ is efficient. Let $E = \{N,\, S\}$ be an efficient location of assembly: $E = L\left(0, 0, 0\right)$. Let $I = \{N,\, S\}$ be the other location than the efficient location of E. As long as $\tau_{2E}^W = 0$ and the location is not distorted from E, any combination of τ_1^W and τ_{2I}^W will not create the world welfare loss and be efficient.

B Proof of Lemma 3

If the location of assembly were fixed, North government would not have the terms-of-trade-driven incentives for trade policy intervention, as shown in (8), (10), and (12). In addition to this result, even after allowing the location to be determined endogenously, North never has the assembly-relocation motive for trade policy intervention to maximize its ability to manipulate the terms of trade, conditional on the resulting location. To be more precise, I want to show that North has no incentive to use $\boldsymbol{\tau}$ as a way to have the assembly plant away from the cost-minimizing location given any $\boldsymbol{\tau}^*$.

Suppose if North were to initially choose $\tau_1 = 0$, without loss of generality. Note that, as shown in the text, North is indifferent between any levels of τ_1 unless its tariff choice changes the assembly's location. Then, $\tau_{2N} = 0$ and $\tau_{2S} = 0$ would attain the maximum of the national welfare, conditional on the location, $W(\tau_{2N}, \tau_{2N}^* |N)$ and $W(\tau_1, \tau_{2S}, \tau_1^*, \tau_{2S}^* |S)$, respectively:

$$\overline{W}_N \equiv W(0, \tau_{2N}^* |N) = l + R(0, \tau_{2N}^* |N) + v(p_1(0, \tau_{2N}^* |N));$$
$$\overline{W}_S \equiv W(0, 0, \tau_1^*, \tau_{2S}^* |S) = l + R(0, 0, \tau_1^*, \tau_{2S}^* |S) + v(p_1(0, 0, \tau_1^*, \tau_{2S}^* |S)).$$

Comparing $\overline{W}_N$ with $\overline{W}_S$, we have

$$\begin{array}{lll} \overline{W}_N \geq \overline{W}_S & \text{iff} & p_1(0, \tau_{2N}^* |N) \leq p_1(0, 0, \tau_1^*, \tau_{2S}^* |S); \\ \overline{W}_N < \overline{W}_S & & \text{otherwise,} \end{array}$$

where the inequalities on the right-hand side correspond to the final-good producer's cost-minimizing location decision (5) for $L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = \{N, S\}$. That is,

$$\begin{array}{lll} \overline{W}_N \geq \overline{W}_S & \text{iff} & L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = N; \\ \overline{W}_N < \overline{W}_S & \text{iff} & L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = S, \end{array}$$

which indicates that North has no incentive to use $\boldsymbol{\tau}$ to shift the assembly away from $L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*)$.

Hence, given any non-prohibitive $\boldsymbol{\tau}^*$, North unilaterally selects free trade policy on inputs, conditional on $L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = \{N, S\}$, and chooses the other tariffs not to shift the assembly away from $L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*)$. Specifically, given an arbitrary (non-prohibitive) $\boldsymbol{\tau}^*$ such that $L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = N$, North selects $\tau_{2N}^{BR}(\boldsymbol{\tau}^*) = 0$. Meanwhile, because τ_1 and τ_{2S} would have no impact on the national welfare if $L = N$ were fixed, North is indifferent between any combinations of τ_1 and τ_{2S} unless its tariff choice changes the location. Thus, North chooses $\tau_1^{BR}(\boldsymbol{\tau}^*)$ and $\tau_{2S}^{BR}(\boldsymbol{\tau}^*)$ such that $L\left(\tau_1^{BR}, 0, \tau_{2S}^{BR}, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*\right) = L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = N$. Similarly, given an arbitrary (non-prohibitive) $\boldsymbol{\tau}^*$ such that $L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = S$, North selects $\tau_{2S}^{BR}(\boldsymbol{\tau}^*) = 0$ while $\tau_1^{BR}(\boldsymbol{\tau}^*)$ and $\tau_{2N}^{BR}(\boldsymbol{\tau}^*)$ will be any combination such that $L\left(\tau_1^{BR}, \tau_{2N}^{BR}, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*\right) = L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = S$.

C Proof of Lemma 4

Conditional on having $L = S$, it follows from (11) and (13) that South government could use τ_1^* directly and τ_{2S}^* via the production-chain effect to manipulate p_1^W to its advantage. However, I want to show that South will end up using a direct instrument of τ_1^* exclusively and choosing $\tau_{2S}^{*BR}(\boldsymbol{\tau}) = 0$, while setting $\tau_{2N}^{*BR}(\boldsymbol{\tau}) \geq 1 - \underline{b} - \mu_2 - \tau_{2N}$ prohibitively high.

South will prefer having $L = S$ than otherwise if there exists a feasible combination of τ_1^* and τ_{2S}^* that attains a higher welfare than $\overline{W}_N^*(\tau_{2N})$, with

$$\overline{W}_N^*(\tau_{2N}) \equiv W^*\left(\tau_{2N}, \tau_{2N}^* = \frac{1 - \underline{b} - \mu_2 - \tau_{2N}}{2} |N\right) = l^* + \frac{1}{4}(1 - \underline{b} - \mu_2 - \tau_{2N})^2,$$

where τ_{2N}^* is set the optimal level conditional on having $L = N$ (see (9)). When having $L = S$ is more favorable for South, given any (non-prohibitive) $\boldsymbol{\tau}$, South will set $\tau_{2N}^{*BR}(\boldsymbol{\tau}) \geq 1 - \underline{b} - \mu_2 - \tau_{2N}$ prohibitively high (recall the discussion in section 2.2) and will target an optimal combination of τ_1^* and τ_{2S}^* to attain a higher welfare than $\overline{W}_N^*(\tau_{2N})$, subject to the location constraint that dictates the final-good producer's location choice:

$$
\begin{aligned}
&\max_{\tau_1^*, \tau_{2S}^*} \quad W^*\left(\tau_1, \tau_{2S}, \tau_1^*, \tau_{2S}^* \,|S\right) \\
&\text{s.t.} \qquad \tau_1^* < a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) + \tfrac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S} - \tau_{2S}^*\right)^2 - \tau_1,
\end{aligned}
$$

with

$$
W^*\left(\cdot\,|S\right) = l^* + \tau_1^* + \tau_{2S}^*\left(\bar{b} - 1 - \mu_2 - \tau_{2S} - \tau_{2S}^*\right).
$$

In the τ_{2S}^*-τ_1^* plane, the iso-welfare curve for $W^*\left(\cdot\,|S\right)$ has a slope of $-\left(\bar{b} - 1 - \mu_2 - \tau_{2S} - 2\tau_{2S}^*\right)$ while the location constraint has a slope of $-\left(\bar{b} - 1 - \mu_2 - \tau_{2S} - \tau_{2S}^*\right)$. Thus, as visualized in Figure 2, the iso-welfare curve is tangent to the location constraint at $\tau_{2S}^* = 0$, which implies that South will end up using τ_1^* exclusively.

Hence, South will be able to attain a higher $W^*\left(\cdot\,|S\right)$ than $\overline{W}_N^*(\tau_{2N})$ if it can choose $\tau_1^* > \frac{1}{4}\left(1 - \underline{b} - \mu_2 - \tau_{2N}\right)^2$, while choosing $\tau_{2S}^{*BR}(\boldsymbol{\tau}) = 0$ and $\tau_{2N}^{*BR}(\boldsymbol{\tau}) \geq 1 - \underline{b} - \mu_2 - \tau_{2N}$, without shifting the assembly away from S. Otherwise, South will instead choose $\tau_{2N}^{*BR}(\boldsymbol{\tau}) = \frac{1 - \underline{b} - \mu_2 - \tau_{2N}}{2}$, while using $\tau_1^{*BR}(\boldsymbol{\tau}) \neq 0$ and/or $\tau_{2S}^{*BR}(\boldsymbol{\tau}) \neq 0$ if needed to have $L = N$ in its favor.

In addition, by a similar argument to Appendix B, we can show that South government sometimes has an incentive to use $\boldsymbol{\tau}^*$ as a way to shift the assembly plant away from the cost-minimizing location given $\boldsymbol{\tau}$. First, given $\boldsymbol{\tau}$ (and parameters) such that

$$
\tau_1 \geq a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) - \frac{1}{4}\left(1 - \underline{b} - \mu_2 - \tau_{2N}\right)^2 + \frac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S}\right)^2,
$$

South prefers having the same location as $L(\tau_1, \tau_{2N}, \tau_{2S}, 0, 0, 0) = N$ and has no incentive to use $\boldsymbol{\tau}^*$ to manipulate the location. Also, given $\boldsymbol{\tau}$ such that

$$
\tau_1 < a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) - \frac{1}{2}\left(1 - \underline{b} - \mu_2 - \tau_{2N}\right)^2 + \frac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S}\right)^2,
$$

South prefers not to deviate from $L(\tau_1, \tau_{2N}, \tau_{2S}, 0, 0, 0) = S$. Second, given $\boldsymbol{\tau}$ such that

$$
\begin{aligned}
\tau_1 \quad \in \quad & \Bigg[a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) - \frac{1}{2}\left(1 - \underline{b} - \mu_2 - \tau_{2N}\right)^2 + \frac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S}\right)^2, \\
& a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) - \frac{1}{4}\left(1 - \underline{b} - \mu_2 - \tau_{2N}\right)^2 + \frac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S}\right)^2\Bigg),
\end{aligned}
$$

South prefers changing the location from $L(\tau_1, \tau_{2N}, \tau_{2S}, 0, 0, 0) = N$ to S and does use $\boldsymbol{\tau}^*$ to manipulate the location. One thing to note here is that South will use $\boldsymbol{\tau}^*$ to force an inefficient location of N, given $E = L(0, 0, 0, 0, 0, 0) = S$, only if North chooses $\boldsymbol{\tau}$ such that $L(\tau_1, \tau_{2N}, \tau_{2S}, 0, 0, 0) = N$ and South chooses $\boldsymbol{\tau}^*$ such that $L(0, 0, 0, \tau_1^*, \tau_{2N}^*, \tau_{2S}^*) = N$.

D Details of Nash equilibrium trade policies (Proposition 6)

It follows from Lemmas 3 and 4 that North and South governments will end up with either of the following two multiple Nash equilibria, (i) or (ii), depending on parameter values as discussed in the end of this appendix:

(i) $L\left(\boldsymbol{\tau}^{NE}, \boldsymbol{\tau}^{*NE}\right) = N$ such that

$$\begin{aligned}
\tau_1^{NE} &\geq \max\left\{a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{4}\left(1 - \underline{b} - \mu_2\right)^2,\right. \\
&\quad \left. a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) - \frac{1}{8}\left(1 - \underline{b} - \mu_2\right)^2 + \frac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S}^{NE} - \tau_{2S}^{*NE}\right)^2 - \tau_1^{*NE}\right\}; \\
\tau_{2N}^{NE} &= 0; \\
\tau_{2S}^{NE} &= \text{can be any (non-prohibitive) value as long as the above inequality for } \tau_1^{NE} \text{ holds;} \\
\tau_1^{*NE} &\geq a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) - \frac{1}{8}\left(1 - \underline{b} - \mu_2\right)^2 + \frac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S}^{*NE}\right)^2 \\
\tau_{2N}^{*NE} &= \frac{1 - \underline{b} - \mu_2}{2} > 0; \\
\tau_{2S}^{*NE} &= \text{can be any (non-prohibitive) value as long as the above inequality for } \tau_1^{*NE} \text{ holds.}
\end{aligned}$$

(ii) $L\left(\boldsymbol{\tau}^{NE}, \boldsymbol{\tau}^{*NE}\right) = S$ such that

$$\begin{aligned}
\tau_1^{NE} &< a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{2}\left(1 - \underline{b} - \mu_2\right)^2 - \tau_1^{*NE}; \\
\tau_{2N}^{NE} &\geq 1 - \underline{b} - \mu_2 - \tau_{2N}^{*NE}; \\
\tau_{2S}^{NE} &= 0; \\
\tau_1^{*NE} &\in \left(\frac{1}{4}\left(1 - \underline{b} - \mu_2\right)^2, a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{2}\left(1 - \underline{b} - \mu_2\right)^2\right); \\
\tau_{2N}^{*NE} &\geq 1 - \underline{b} - \mu_2 > 0; \\
\tau_{2S}^{*NE} &= 0.
\end{aligned}$$

In what follows, I want to show how I derived these conditions for Nash equilibrium trade policies. In this appendix, I do not limit the analysis to import tariffs and export taxes. Nevertheless, in a Nash equilibrium, neither North nor South will choose to implement import or export subsidies by a beggar-thy-neighbor motive, affecting North or South's national welfare.

First, since North never has an incentive to have the assembly plant out of $L\left(0, 0, 0, \tau_1^{*NE}, \tau_{2N}^{*NE}, \tau_{2S}^{*NE}\right)$, a Nash equilibrium falling into (i) corresponds to a case where South prefers having $L = N$. It immediately follows that $\tau_{2N}^{NE} = 0$ and $\tau_{2N}^{*NE} = \frac{1 - \underline{b} - \mu_2}{2}$. For the other tariffs to constitute a Nash equilibrium, it follows from Lemma 3 that it should hold that

$$L\left(\tau_1^{NE}, 0, \tau_{2S}^{NE}, \tau_1^{*NE}, \frac{1 - \underline{b} - \mu_2}{2}, \tau_{2S}^{*NE}\right) = L\left(0, 0, 0, \tau_1^{*NE}, \frac{1 - \underline{b} - \mu_2}{2}, \tau_{2S}^{*NE}\right) = N.$$

Below, I limit the analysis to non-prohibitive τ_{2S}'s and τ_{2S}^{*}'s, without loss of generality. The second equality of the above equation implies that a combination of τ_1^{*NE} and τ_{2S}^{*NE} should satisfy

$$\tau_1^{*NE} \geq a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) - \frac{1}{8}\left(1 - \underline{b} - \mu_2\right)^2 + \frac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S}^{*NE}\right)^2,$$

while the first equality implies that a combination of τ_1^{NE} and τ_{2S}^{NE} should satisfy

$$\tau_1^{NE} \geq a - a^* - \mu_1 + \beta\left(\bar{b} - \underline{b}\right) - \frac{1}{8}\left(1 - \underline{b} - \mu_2\right)^2 + \frac{1}{2}\left(\bar{b} - 1 - \mu_2 - \tau_{2S}^{NE} - \tau_{2S}^{*NE}\right)^2 - \tau_1^{*NE}.$$

Also, to ensure that South prefers having $L = N$, Lemma 4 suggests that it should hold that

$$W^*\left(\tau_1^{NE}, 0, \tau_{2S}^{NE}, \tau_1^{*NE}, \frac{1 - \underline{b} - \mu_2}{2}, \tau_{2S}^{*NE} \,|N\right) > W^*\left(\tau_1^{NE}, 0, 0, \overline{\tau}_1^*, 1 - \underline{b} - \mu_2, 0 \,|S\right),$$

where $\overline{\tau}_1^* = a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{2}\left(1 - \underline{b} - \mu_2\right)^2 - \tau_1^{NE} - \varepsilon$, with sufficiently small $\varepsilon > 0$, is the highest possible τ_1^* that South could choose, if it shifts the assembly from N to S, conditional on that North would instead choose $\tau_{2S} = 0$ while leaving τ_1^{NE} and $\tau_{2N}^{NE} = 0$ unchanged. The above inequality can be rewritten as $\frac{1}{4}\left(1 - \underline{b} - \mu_2\right)^2 > \overline{\tau}_1^*$, that is, τ_1^{NE} should satisfy

$$\tau_1^{NE} \geq a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{4}\left(1 - \underline{b} - \mu_2\right)^2.$$

Next, a Nash equilibrium falling into (ii) corresponds to a case where South prefers having $L = S$. It immediately follows that $\tau_{2S}^{NE} = 0$ and $\tau_{2S}^{*NE} = 0$. Because, given any τ_{2N}, South always has an incentive to raise τ_{2N}^* as high as possible, Lemma 4 suggests that $\tau_{2N}^{*NE} \geq 1 - \underline{b} - \mu_2$ and $\tau_{2N}^{NE} \geq 1 - \underline{b} - \mu_2 - \tau_{2N}^{*NE}$. Below, I limit the analysis to non-prohibitive τ_{2N}'s, without loss of generality. For the other tariffs to constitute a Nash equilibrium, it follows from Lemma 3 that

$$L\left(\tau_1^{NE}, \tau_{2N}^{NE}, 0, \tau_1^{*NE}, 1 - \underline{b} - \mu_2, 0\right) = L\left(0, 0, 0, \tau_1^{*NE}, 1 - \underline{b} - \mu_2, 0\right) = S,$$

which implies that τ_1^{*NE} should satisfy

$$\tau_1^{*NE} < a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{2}\left(1 - \underline{b} - \mu_2\right)^2,$$

while τ_1^{NE} should satisfy

$$\tau_1^{NE} < a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{2}\left(1 - \underline{b} - \mu_2\right)^2 - \tau_1^{*NE}.$$

Also, to ensure that South prefers having $L = S$, Lemma 4 suggests that it should hold that

$$W^*\left(\tau_1^{NE}, \tau_{2N}^{NE}, 0, \tau_1^{*NE}, 1 - \underline{b} - \mu_2, 0 \,|S\right) > W^*\left(\tau_1^{NE}, 0, 0, \widetilde{\tau}_1^*, \frac{1 - \underline{b} - \mu_2}{2}, \widetilde{\tau}_{2S}^* \,|N\right),$$

which is rewritten as $\tau_1^{*NE} > \frac{1}{4}\left(1-\underline{b}-\mu_2\right)^2$, where $\widetilde{\tau}_1^* \geq a - a^* - \mu_1 + \beta\left(\overline{b}-\underline{b}\right) - \frac{1}{8}\left(1-\underline{b}-\mu_2\right)^2 + \frac{1}{2}\left(\overline{b}-1-\mu_2-\widetilde{\tau}_{2S}^*\right)^2 - \tau_1^{NE}$. Therefore, combined with the above, another inequality for τ_1^{*NE}, we have

$$\tau_1^{*NE} \in \left(\frac{1}{4}\left(1-\underline{b}-\mu_2\right)^2, \, a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{2}\left(1-\underline{b}-\mu_2\right)^2\right).$$

There are a few things to note about how the Nash equilibrium outcome depends on parameter values: first, if parameters are such that $\mu_1 \in \left(0, \, a - a^* + 2\beta\mu_2 + \frac{1}{4}\left(1-\underline{b}-\mu_2\right)^2\right)$, North and South will end up with either (i) or (ii), but not both. Since the above condition in terms of μ_1 implies that an efficient location may be N or S, South will keep an efficient location or will force an inefficient location, depending on the Nash location outcome, N for (i) or S for (ii), relative to an efficient location. In other words, the shift away from an efficient location would arise in either direction, $E = N$ to $L\left(\boldsymbol{\tau}^{NE}, \boldsymbol{\tau}^{*NE}\right) = S$ or $E = S$ to $L\left(\boldsymbol{\tau}^{NE}, \boldsymbol{\tau}^{*NE}\right) = N$.

One other thing to note here is that South always prefers having the assembly located in one location to the other, by construction. Suppose if South were to choose $\tau_1^* = \frac{1}{4}\left(1-\underline{b}-\mu_2\right)^2$, while having $L = S$. Then, South would enjoy exactly the same level of the terms-of-trade gain as the level that it would attain if it were to have $L = N$ instead. Notice, however, that South would always be able to increase τ_1^* a little bit higher than $\frac{1}{4}\left(1-\underline{b}-\mu_2\right)^2$ and, as a result, would strictly prefer having $L = S$ to otherwise.

It is also noteworthy that how much South could raise τ_1^* without shifting the assembly out of S depends on North's choice of τ_1, as well as on parameter values. Given a sufficiently high τ_1 such that

$$\tau_1 \in \left[a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{4}\left(1-\underline{b}-\mu_2\right)^2, \, a - a^* - \mu_1 + 2\beta\mu_2 + \frac{1}{2}\left(1-\underline{b}-\mu_2\right)^2\right),$$

South always prefers having $L = N$ and the Nash equilibrium outcome will never fall into (ii), even if μ_1 satisfies the above condition.

Lastly, if $\mu_1 \in \left[a - a^* + 2\beta\mu_2 + \frac{1}{4}\left(1-\underline{b}-\mu_2\right)^2, \, a - a^* + 2\beta\mu_2 + \frac{1}{2}\left(1-\underline{b}-\mu_2\right)^2\right)$, which implies that $E = N$, South always prefers having $L = N$ and and the Nash equilibrium outcome will fall into (i).

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