Trade Agreement with Cross-Border Unbundling

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Abstract

Does offshoring of intermediate inputs introduce a new reason for trade policy intervention and change the role and design of trade agreement? This paper revisits the role and design of trade agreement in a theoretical framework that considers the firm's global production operations and input procurements subject to trade costs, inclusive of trade policy interventions by governments. The paper highlights an interrelationship between market-clearing prices of final goods and the associated domestic and foreign inputs through production linkage, which gives a novel feature to the role of trade agreement beyond the conventional market-access argument associated with the terms-of-trade theory. In particular, the local price externality arises in the sense that foreign government manipulates the local equilibrium price for home domestic inputs by unilaterally opening up the market access for final goods to its advantage. To achieve globally efficient outcomes through trade agreement, we propose to specify the market access using the trade-weighted terms of trade and to coordinate in changing the value-added created from trade between countries in a reciprocal manner.

1 Introduction

As cross-border unbundling of production processes becomes pervasive, does offshoring of intermediate inputs introduce a new reason for trade policy intervention and change the role and design of trade agreement? This paper revisits the role and design of trade agreement in a theoretical framework that considers the firm's global production operations and input procurements subject to trade costs, inclusive of trade barriers. The firm's production location and input sourcing decision potentially depends on a combination of trade costs imposed on different stages of production. In the meantime, a government would choose a combination of trade policy instruments, taking into consideration its influence on the firm's decision on how much of intermediate inputs to source domestically and import from abroad and further on whether to shift the production base.

The paper is closely related to an applied-theoretical literature on trade agreements along the lines of Antràs and Staiger (2012a, b), by exploring the role of trade agreement

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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. While Antràs and Staiger (2012a, b) feature the change in international price determination as a result of offshoring, the current paper aims to contribute to the literature by highlighting an interrelationship between market-clearing prices of the final goods and the associated domestic and foreign inputs through production linkage, which gives a novel feature to the role of trade agreement beyond the conventional market-access argument.

To do so, we consider a simple two-country framework in which the final-good producer located in the home country imports foreign intermediate inputs, to assemble them, combined with domestically-sourced inputs, into final goods, some of which then are domestically consumed and the rest exported back to the foreign country. In this setting, noncooperative trade policies chosen by each government so as to maximize its own national welfare are globally inefficient. Although the terms-of-trade consequences of noncooperative trade policy choices represent one source of inefficiencies, the interrelationship between market-clearing prices through production linkage gives rise to additional source of inefficiencies — the local price externality that foreign government manipulates the local equilibrium price for home domestic inputs by unilaterally opening up the market access for final goods to its advantage. We argue that trade agreement must be designed to solve inefficiencies arising in noncooperative policy choices not only because of terms-of-trade manipulation but due to the novel local price externality. In other words, the potential of trade agreement to solve the inefficiencies would be called for beyond the conventional market-access argument.

Then we propose to re-define the terms of trade as a trade-weighted version in the prevalence of cross-border unbundling. Specifying the market access based on this trade-weighted terms of trade enables us to eliminate inefficiencies arising due to the local price externality because a government is no longer able to change market access in a way that improves the trade-weighted terms of trade. Holding the trade-weighted terms of trade substantially means that the foreign government cannot use trade policies to deteriorate what the home country can earn from trade, that is, the home value-added exports, to its advantage. We also discuss how globally efficient outcomes can be achieved through trade agreement in a reciprocal manner by using the trade-weighted terms of trade.

The remainder of the paper proceeds as follows: the next section sets up a basic model to be used throughout the paper to analyze the role and design of trade agreement with cross-border unbundling. Also, we identify the global efficiency frontier and show that noncooperative trade policies are globally inefficient. Section 3 examines the changing role of trade agreement in the presence of cross-border unbundling. We reveal that the conventional market-access focus alone is unlikely to deliver globally efficient outcomes and that trade agreement must be designed to solve inefficiencies arising in noncooperative policy choices beyond the terms-of-trade externality. Section 4 examines the design feature of trade agreement by proposing an alternative definition of the terms of trade relevant to the presence of cross-border unbundling and discusses how globally efficient outcomes can be achieved through trade agreement in a reciprocal manner. And section 5 concludes the paper by discussing the way forward for future research.

2 The basic model

This section lays out a two-country model to be used to analyze the role of trade agreement with cross-border unbundling of production. We highlight an interrelationship between market-clearing prices of the final goods and the associated domestic and foreign inputs through production linkage, which as we will argue in the next section, gives a novel feature to the role of trade agreement in the presence of cross-border unbundling. After describing the economic environment of the model, we derive the global efficiency conditions to maximize the world aggregate welfare and then show that noncooperative trade policies chosen by each government so as to maximize its own national welfare in the Nash equilibrium are globally inefficient. A part of the Nash inefficiencies does not disappear even in a hypothetical setting in which governments were not motivated by the terms-of-trade implications of trade policy choices.

2.1 The economic environment

We consider a simple model of trade agreement with cross-border unbundling between two countries, Home (labeled with "H") and Foreign ("F"). We simplify the analysis by holding the location of the final assembly plant to be in the home country.[1] The home country imports intermediate inputs to assemble them, combined with domestically-sourced inputs, into homogeneous final goods, which are then exported to the foreign country. Consumer preferences are identical in the two countries and are represented by the utility function

$$U^j = c_0^j + u(c_1^j),$$

where c_i^j denotes consumption of good $i \in \{0,1\}$ in country $j \in \{H,F\}$, and $u' > 0$ and $u'' < 0$. Good 0, which we take to be the numeraire, is assumed to be costlessly traded and always consumed in positive amounts in both countries. We normalize the price of the numeraire good to unity. Let p_1^j denote the local price of good 1 in country j. We assume that there is a measure $(1-\theta)$ of consumers in the home country with the demand for good 1 represented by the demand function, $d(p_1^H)$, and a measure θ of consumers in F with a symmetric demand function, $d(p_1^F)$.

The final good 1 is manufactured in the home country, using domestically-sourced inputs together with inputs imported from the foreign country. Let x_j denote the amount of inputs sourced from country $j \in \{H,F\}$. The final good 1 is produced according to the strictly concave production function

$$y_1 = y(x_H, x_F),$$

where $y(0,0) = 0$ and the partial derivative $y_{x_j} > 0$. We assume that final goods are supplied under conditions of perfect competition. Let $p_{x_j}^H$ denote the home local price of inputs sourced from j. It follows from the first-order conditions for the final-good producer's profit maximization that

$$p_1^H = p_{x_j}^H \left(y_{x_j}\right)^{-1}, \qquad \forall j,$$

[1] We will discuss later what if the assembly's location is endogenously determined by the trade policy intervention.

which implicitly define the derived demand for home and foreign inputs, $x_H^D\left(p_1^H, p_{x_H}^H, p_{x_F}^H\right)$ and $x_F^D\left(p_1^H, p_{x_H}^H, p_{x_F}^H\right)$. The associated profit-maximizing quantity of competitive supply for the final goods is then given by

$$y_1 = y(x_H^D\left(p_1^H, p_{x_H}^H, p_{x_F}^H\right), x_F^D\left(p_1^H, p_{x_H}^H, p_{x_F}^H\right)) \equiv y(p_1^H, p_{x_H}^H, p_{x_F}^H).$$

Let $\widehat{x_j^D}\left(p_{x_H}^H, p_{x_F}^H, y(p_1^H, p_{x_H}^H, p_{x_F}^H)\right)$ be the cost-minimizing amount of inputs sourced from j, which is identical to the profit-maximizing amount. We assume that both domestic and imported inputs are normal production factors for the final goods, i.e., $\frac{\partial \widehat{x_j^D}}{\partial y} > 0$, $\forall j$. And there is some degree of substitutability in production between domestic and imported inputs such that $\frac{\partial x_j^D}{\partial p_{x_k}^H} = \frac{\partial \widehat{x_j^D}}{\partial p_{x_k}^H} + \frac{\partial \widehat{x_j^D}}{\partial y}\frac{\partial y}{\partial p_{x_k}^H} > 0$, $\forall j \neq k \in \{H, F\}$, where the first term on the right-hand side corresponds to a substitution effect and is positive while the second term corresponds to the output effect and is negative.

Also, we assume that country-specific inputs are competitively supplied in country j, according to the supply curve represented by the increasing function

$$x_j^S \equiv x_j^S\left(p_{x_j}^j\right).$$

We introduce trade policies into the model as a component of trade costs charged as fixed amount per quantity, which apply only to cross-border transactions. Trade costs on final goods, shipped from the home to foreign country are given by $t_1 = \tau_1^H + \tau_1^F + \mu_1$, where τ_1^H is the home export tax (if positive) or subsidy (if negative), τ_1^F is the foreign import tariff (if positive) or subsidy (if negative), and $\mu_1 > 0$ is any exogenous transport cost. For each unit of imported inputs, the final-good producer incurs cross-border sourcing costs of t_x, unlike the domestic sourcing. t_x also consists of three components: $t_x = \tau_x^H + \tau_x^F + \mu_x$, where τ_x^H is home import tariff or subsidy, τ_x^F is foreign export tax or subsidy, and $\mu_x > 0$ is any exogenous transport cost. In what follows, we assume that t_1 and t_x are not so high as to prohibit trade.

Local prices in each country must obey the following arbitrage condition:

$$\begin{aligned} p_1^F &= p_1^H + \tau_1^H + \tau_1^F + \mu_1; \\ p_{x_F}^H &= p_{x_F}^F + \tau_x^H + \tau_x^F + \mu_x. \end{aligned}$$

Let p_1^W and $p_{x_F}^W$ denote the world price for final goods and foreign inputs, respectively. Given the arbitrage condition, we implicitly define the world prices and express local prices as functions of the world prices and the country's own trade policies as follows:[2]

$$\begin{aligned} p_1^H &= p_1^W - \tau_1^H \equiv p_1^H\left(\tau_1^H, p_1^W\right); \\ p_1^F &= p_1^W + \mu_1 + \tau_1^F \equiv p_1^F\left(\tau_1^F, p_1^W\right); \\ p_{x_F}^H &= p_{x_F}^W + \mu_x + \tau_x^H \equiv p_{x_F}^H\left(\tau_x^H, p_{x_F}^W\right); \\ p_{x_F}^F &= p_{x_F}^W - \tau_x^F \equiv p_{x_F}^F\left(\tau_x^F, p_{x_F}^W\right). \end{aligned}$$

[2] We here think of the world price as the price that prevails after the export policy is applied but before the import policy is imposed.

Using this definition of the world prices, we can express the market-clearing conditions for final goods, home inputs, and foreign inputs, as functions of the world prices and trade policies:

$$\theta d(p_1^F\left(\tau_1^F, p_1^W\right)) = y(p_1^H\left(\tau_1^H, p_1^W\right), p_{x_H}^H, p_{x_F}^H\left(\tau_x^H, p_{x_F}^W\right)) - (1-\theta)d(p_1^H\left(\tau_1^H, p_1^W\right));$$

$$x_H^D\left(p_1^H\left(\tau_1^H, p_1^W\right), p_{x_H}^H, p_{x_F}^H\left(\tau_x^H, p_{x_F}^W\right)\right) = x_H^S\left(p_{x_H}^H\right);$$

$$x_F^D\left(p_1^H\left(\tau_1^H, p_1^W\right), p_{x_H}^H, p_{x_F}^H\left(\tau_x^H, p_{x_F}^W\right)\right) = x_F^S\left(p_{x_F}^F\left(\tau_x^F, p_{x_F}^W\right)\right).$$

We then solve these equations to determine the market-clearing prices that satisfy the above conditions, as functions of trade policies:

$$\widetilde{p}_1^W\left(\tau_1^H, \tau_1^F, \tau_x^H + \tau_x^F\right);$$
$$\widetilde{p}_{x_H}^H\left(\tau_1^H + \tau_1^F, \tau_x^H + \tau_x^F\right);$$
$$\widetilde{p}_{x_F}^W\left(\tau_1^H + \tau_1^F, \tau_x^H, \tau_x^F\right).$$

The market-clearing world price for final goods depends not only on trade policies implemented against the final goods by each country but also on the corresponding sum of trade taxes imposed on foreign inputs. In an analogous way, the market-clearing world price for foreign inputs depends on trade policies imposed on the inputs themselves and on the corresponding sum of trade taxes on final goods. In addition, since we allow for some degree of substitutability in production between domestic and imported inputs, the market-clearing price for the home domestically-sourced inputs depends crucially on the sum of taxes imposed against international trade in final goods and foreign inputs.

By differentiating the market-clearing conditions with respect to tariffs, using the local price functions of the world prices, we can confirm the equilibrium world price implications of trade policies as below:

$$\frac{\partial \widetilde{p}_1^W}{\partial \tau_1^H} > 0; \qquad \frac{\partial \widetilde{p}_1^W}{\partial \tau_1^F} < 0; \qquad \frac{\partial \widetilde{p}_1^W}{\partial \tau_1^H} - \frac{\partial \widetilde{p}_1^W}{\partial \tau_1^F} = 1; \tag{1}$$

$$\frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_x^H} < 0; \qquad \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_x^F} > 0; \qquad \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_x^F} - \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_x^H} = 1, \tag{2}$$

which show that the world price increases when the export tax is raised while it falls when the import tariff is raised, as in a standard model of trade agreement. More importantly, the cross-price effects of trade policies through production linkage are given by

$$\frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_1^H} = \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_1^F} < 0; \qquad \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_1^H} = \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_1^F} < 0. \tag{3}$$

A rise in the sum of trade taxes imposed on final goods, $(\tau_1^H + \tau_1^F)$, drives down the home local price of the final goods and has a depressing effect on the final-good output, which in turn decreases the demand for normal inputs, resulting in a fall in the market-clearing price for the inputs. That is, $\frac{\partial \widehat{x_j^D}}{\partial y}\frac{\partial y}{\partial p_1^H} > 0$, $\forall j$. Also, we have

$$\frac{\partial \widetilde{p}_1^W}{\partial \tau_x^H} = \frac{\partial \widetilde{p}_1^W}{\partial \tau_x^F} > 0; \qquad \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_x^H} = \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_x^F} > 0, \tag{4}$$

which represents the effects of the sum of trade taxes on foreign inputs, $(\tau_x^H + \tau_x^F)$, on the final-good output and on the demand for home inputs, respectively. The former is non-negative because a rise in $(\tau_x^H + \tau_x^F)$ pushes up $p_{x_F}^H$ and $\frac{\partial y}{\partial p_{x_F}^H} < 0$. The latter is positive since $\frac{\partial x_H^D}{\partial p_{x_F}^H} > 0$.

In what follows, for convenience, we express the local prices as explicit functions of the market-clearing world prices and the country's own trade policy as in the related literature:

$$\begin{aligned}
p_1^H\left(\tau_1^H, \widetilde{p}_1^W\left(\tau_1^H, \tau_1^F, \tau_x^H + \tau_x^F\right)\right) &\equiv \widetilde{p}_1^W\left(\tau_1^H, \tau_1^F, \tau_x^H + \tau_x^F\right) - \tau_1^H; \\
p_1^F\left(\tau_1^F, \widetilde{p}_1^W\left(\tau_1^H, \tau_1^F, \tau_x^H + \tau_x^F\right)\right) &\equiv \widetilde{p}_1^W\left(\tau_1^H, \tau_1^F, \tau_x^H + \tau_x^F\right) + \mu_1 + \tau_1^F; \\
p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\left(\tau_1^H + \tau_1^F, \tau_x^H, \tau_x^F\right)\right) &\equiv \widetilde{p}_{x_F}^W\left(\tau_1^H + \tau_1^F, \tau_x^H, \tau_x^F\right) + \mu_x + \tau_x^H; \\
p_{x_F}^F\left(\tau_x^F, \widetilde{p}_{x_F}^W\left(\tau_1^H + \tau_1^F, \tau_x^H, \tau_x^F\right)\right) &\equiv \widetilde{p}_{x_F}^W\left(\tau_1^H + \tau_1^F, \tau_x^H, \tau_x^F\right) - \tau_x^F.
\end{aligned}$$

Notice, however, that under our assumptions, home inputs are not traded and are sold domestically and thus the "local" market-clearing price, as derived above, is $\widetilde{p}_{x_H}^H\left(\tau_1^H + \tau_1^F, \tau_x^H + \tau_x^F\right)$, which depends not only on the home country's own trade policies but depends "directly" on the foreign trade policies in the sense that the effects of foreign policies do no pass through the world prices of the other goods.

Finally, we consider the market-clearing trade volumes that are implied by the equilibrium world prices and trade policies. Using the foreign import demand for final goods represented by M_1^F, the market-clearing trade volume of the final goods is expressed by

$$M_1^F(p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right)) \equiv \theta d\left(p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right)\right),$$

or equivalently using the home export supply represented by E_1^H,

$$\begin{aligned}
& E_1^H\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right)\right) \\
\equiv\ & y\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right)\right) - (1-\theta) d\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right)\right).
\end{aligned}$$

In an analogous manner, using the home import demand for foreign inputs represented by M_x^H, the equilibrium trade volume of foreign inputs is expressed by

$$M_x^H\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right)\right) \equiv x_F^D\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right)\right),$$

or using the foreign export supply represented by E_x^F,

$$E_x^F\left(p_{x_F}^F\left(\tau_x^F, \widetilde{p}_{x_F}^W\right)\right) \equiv x_F^S\left(p_{x_F}^F\left(\tau_x^F, \widetilde{p}_{x_F}^W\right)\right).$$

2.2 Government objectives

A government is equipped with trade policies on final goods and on inputs and use them at its disposal so as to maximize the government's payoff, i.e., the social welfare in the country. We define the measure of welfare in each country by the sum of consumer surplus, producer surplus, and tariff/tax revenue. Let $CS^j(p_1^j) \equiv \int_{p_1^j}^{\overline{p}} d(p)dp$ denote consumer surplus for final goods in country j, where $\overline{p}$ is the choke price (if any) for country j's demand for the final goods. Producer surplus for final goods in the home country is denoted by $PS_1^H(p_1^H, p_{x_H}^H, p_{x_F}^H) \equiv \int_0^{p_1^H} y(p, p_{x_H}^H, p_{x_F}^H)dp$, and that for inputs in country j is by $PS_x^j(p_{x_j}^j) \equiv \int_0^{p_{x_j}^j} x_j^S(p)\, dp$. The home welfare function may now be written as

$$\begin{aligned} W^H &= (1-\theta)CS^H\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right)\right) \\ &\quad + \gamma_1^H PS_1^H(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right)) + \gamma_x^H PS_x^H\left(\widetilde{p}_{x_H}^H\right) \\ &\quad + \left(\widetilde{p}_1^W - p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right)\right) E_1^H\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right)\right) \\ &\quad + \left(p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right) - \widetilde{p}_{x_F}^W - \mu_x\right) M_x^H\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right)\right) \\ &\equiv W^H\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_1^W, \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right), \widetilde{p}_{x_F}^W\right), \end{aligned} \tag{5}$$

where $\gamma_1^H \geq 1$ and $\gamma_x^H \geq 1$ is political weights for the final-good and input producers in H, respectively. Similarly, the foreign welfare function is written as

$$\begin{aligned} W^F &= \theta CS^F(p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right)) + \gamma_x^F PS_x^F\left(p_{x_F}^F\left(\tau_x^F, \widetilde{p}_{x_F}^W\right)\right) \\ &\quad + \left(p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right) - \widetilde{p}_1^W - \mu_1\right) M_1^F\left(p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right)\right) \\ &\quad + \left(\widetilde{p}_{x_F}^W - p_{x_F}^F\left(\tau_x^F, \widetilde{p}_{x_F}^W\right)\right) E_x^F\left(p_{x_F}^F\left(\tau_x^F, \widetilde{p}_{x_F}^W\right)\right) \\ &\equiv W^F\left(p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right), \widetilde{p}_1^W, p_{x_F}^F\left(\tau_x^F, \widetilde{p}_{x_F}^W\right), \widetilde{p}_{x_F}^W\right), \end{aligned} \tag{6}$$

where $\gamma_x^F \geq 1$ is political weight for input producers in F.

The foreign government cares about the trade policy choices of the trading partner only indirectly, through the effects that these choices have on the world prices, as in a standard model of trade agreement. However, the effects on home welfare of the foreign government's policy choices are channeled not only through the world prices of final goods and imported inputs but also through the local market-clearing price of domestic inputs, $\widetilde{p}_{x_H}^H(\tau_1^H + \tau_1^F, \tau_x^H + \tau_x^F)$, due to the production linkage.

2.3 Efficient policy choices

We are now ready to characterize efficient choices of trade policies, $(\tau_1^H, \tau_1^F, \tau_x^H, \tau_x^F)$, that maximize the world aggregate welfare $W^W = W^H + W^F$. Any efficient policy combination solves

$$\begin{aligned} \max_{\tau_1^H, \tau_1^F, \tau_x^H, \tau_x^F} \quad & W^H\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_1^W, \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right), \widetilde{p}_{x_F}^W\right) \\ & + W^F\left(p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right), \widetilde{p}_1^W, p_{x_F}^F\left(\tau_x^F, \widetilde{p}_{x_F}^W\right), \widetilde{p}_{x_F}^W\right), \end{aligned}$$

where the market-clearing prices depend on trade policy choices: $\widetilde{p}_1^W(\tau_1^H, \tau_1^F, \tau_x^H + \tau_x^F)$, $\widetilde{p}_{x_F}^W(\tau_1^H + \tau_1^F, \tau_x^H, \tau_x^F)$, and $\widetilde{p}_{x_H}^H(\tau_1^H + \tau_1^F, \tau_x^H + \tau_x^F)$. The set of efficient policy combinations, i.e., the global efficiency frontier, is jointly defined by the first-order conditions associated with the above maximization problem:

$$
\begin{aligned}
[E1] \qquad 0 &= \left[W^H_{p_1^H} + W^F_{p_1^F}\right]\frac{\partial \widetilde{p}_1^W}{\partial \tau_1^H} + \left[W^H_{p^H_{x_F}} + W^F_{p^F_{x_F}}\right]\frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau_1^H} - W^H_{p_1^H} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_1^H};\\
[E2] \qquad 0 &= \left[W^H_{p_1^H} + W^F_{p_1^F}\right]\frac{\partial \widetilde{p}_1^W}{\partial \tau_1^F} + \left[W^H_{p^H_{x_F}} + W^F_{p^F_{x_F}}\right]\frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau_1^F} + W^F_{p_1^F} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_1^F};\\
[E3] \qquad 0 &= \left[W^H_{p_1^H} + W^F_{p_1^F}\right]\frac{\partial \widetilde{p}_1^W}{\partial \tau_x^H} + \left[W^H_{p^H_{x_F}} + W^F_{p^F_{x_F}}\right]\frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau_x^H} + W^H_{p^H_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_x^H};\\
[E4] \qquad 0 &= \left[W^H_{p_1^H} + W^F_{p_1^F}\right]\frac{\partial \widetilde{p}_1^W}{\partial \tau_x^F} + \left[W^H_{p^H_{x_F}} + W^F_{p^F_{x_F}}\right]\frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau_x^F} - W^F_{p^F_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_x^F},
\end{aligned}
$$

where W^j_p represents the partial derivative of country j's welfare with respect to price p.

Using (1) and (3), it can be shown that $[E1]$ and $[E2]$ are identical. Assuming that the world aggregate welfare is strictly concave with respect to tariff/tax, the pair of first-order conditions therefore determine the sum of home and foreign taxes imposed on trade in final goods, $\left(\tau_1^H + \tau_1^F\right)$, that is consistent with the global efficiency. Also, it follows from (2) and (4) that $[E3]$ and $[E4]$ are identical and, given our assumption that the world aggregate welfare is strictly concave, determine the globally efficient sum of taxes on trade in foreign inputs, $\left(\tau_x^H + \tau_x^F\right)$. Since the world aggregate welfare, at given local prices, is independent of world prices, the global efficiency imposes requirements only on local prices, which in turn depend only on the sum of trade taxes by construction. This is a standard property.

Looking into the global efficiency frontier, let us consider infinitesimal changes in the mix of home trade policies, τ_1^H and τ_x^H, which hold each of the world prices, $\widetilde{p}_1^W$ and $\widetilde{p}^W_{x_F}$, constant, such that

$$\frac{d\tau_x^H}{d\tau_1^H} = -\frac{\partial \widetilde{p}_1^W/\partial \tau_1^H}{\partial \widetilde{p}_1^W/\partial \tau_x^H} = -\frac{\partial \widetilde{p}^W_{x_F}/\partial \tau_1^H}{\partial \widetilde{p}^W_{x_F}/\partial \tau_x^H} < 0. \tag{7}$$

The last inequality in (7) implies that any home policy changes might not be able to improve home welfare without hurting foreign welfare. Multiplying $[E3]$ by (7) and adding it to $[E1]$ enables us to check how home policy changes that hold each world price constant at globally efficient choices of τ_1^H and τ_x^H affect the world aggregate welfare. We may restate $[E1]$ and $[E3]$ as

$$[E5] \qquad 0 = -W^H_{p_1^H} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_1^H} - \left[W^H_{p^H_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_x^H}\right]\frac{\partial \widetilde{p}^W_{x_F}/\partial \tau_1^H}{\partial \widetilde{p}^W_{x_F}/\partial \tau_x^H},$$

the right-hand side of which includes the impact on home welfare only. $[E5]$ indicates that at globally efficient choices of τ_1^H and τ_x^H, the home policy changes holding the terms of trade constant can have no first-order effect on home welfare. Because the both world prices held constant and foreign tariffs, τ_1^F and τ_x^F, are fixed, such policy changes do not affect foreign welfare. With τ_1^F and τ_x^F fixed and thus the foreign local prices, $p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right)$ and $p^F_{x_F}\left(\tau_x^F, \widetilde{p}^W_{x_F}\right)$, unchanged, such policy changes do not affect the market-clearing trade volume for final goods, $M^F(p_1^F(\cdot))$, and for inputs, $E^F\left(p^F_{x_F}(\cdot)\right)$, either.

In a similar manner, let us consider infinitesimal changes in the mix of foreign trade policies, τ_1^F and τ_x^F, which hold each of the world prices constant, such that

$$\frac{d\tau_x^F}{d\tau_1^F} = -\frac{\partial \widetilde{p}_1^W / \partial \tau_1^F}{\partial \widetilde{p}_1^W / \partial \tau_x^F} = -\frac{\partial \widetilde{p}_{x_F}^W / \partial \tau_1^F}{\partial \widetilde{p}_{x_F}^W / \partial \tau_x^F} > 0. \tag{8}$$

The last inequality in (8), combined with (3) and (4), implies that foreign policy changes that hold each world price constant might be able to improve foreign welfare while hurting home welfare through their effects on $\widetilde{p}_{x_H}^H$. Indeed, by multiplying $[E4]$ by (8) and adding it to $[E2]$, we may restate the two global efficiency conditions as

$$[E6] \qquad 0 = W_{p_1^F}^F + W_{\widetilde{p}_{x_H}^H}^H \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_1^F} + \left[W_{p_{x_F}^F}^F - W_{\widetilde{p}_{x_H}^H}^H \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_x^F} \right] \frac{\partial \widetilde{p}_{x_F}^W / \partial \tau_1^F}{\partial \widetilde{p}_{x_F}^W / \partial \tau_x^F},$$

which indicates that at globally efficient choices of τ_1^F and τ_x^F, the foreign policy changes holding the terms of trade constant affect home welfare as well as foreign welfare itself. Although the both world prices remain constant and home tariffs, τ_1^H and τ_x^H, are fixed, such policy changes affect the local market-clearing price for home domestic inputs, $\widetilde{p}_{x_H}^H(\tau_1^H + \tau_1^F, \tau_x^H + \tau_x^F)$, and thus the producer surplus for final goods and for inputs in H and the equilibrium trade volumes, $E^H\left(p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \widetilde{p}_{x_F}^W\right)\right)$ and $M^H\left(p_1^H(\cdot), \widetilde{p}_{x_H}^H, p_{x_F}^H(\cdot)\right)$.

In what follows, we are interested in checking if there arise any inefficiencies or deviations from the global efficiency frontier jointly defined by $[E1]$ to $[E6]$ when each government noncooperatively chooses trade policies.

2.4 Noncooperative policy choices

Let us consider unilateral, noncooperative trade policies chosen by each government so as to maximize its own national welfare in the Nash equilibrium. The associated first-order conditions are

$$\begin{aligned}
[N1] \qquad 0 &= \left[W_{p_1^H}^H + W_{\widetilde{p}_1^W}^H\right] \frac{\partial \widetilde{p}_1^W}{\partial \tau_1^H} + \left[W_{p_{x_F}^H}^H + W_{\widetilde{p}_{x_F}^W}^H\right] \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_1^H} - W_{p_1^H}^H + W_{\widetilde{p}_{x_H}^H}^H \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_1^H}; \\
[N2] \qquad 0 &= \left[W_{p_1^F}^F + W_{\widetilde{p}_1^W}^F\right] \frac{\partial \widetilde{p}_1^W}{\partial \tau_1^F} + \left[W_{p_{x_F}^F}^F + W_{\widetilde{p}_{x_F}^W}^F\right] \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_1^F} + W_{p_1^F}^F; \\
[N3] \qquad 0 &= \left[W_{p_1^H}^H + W_{\widetilde{p}_1^W}^H\right] \frac{\partial \widetilde{p}_1^W}{\partial \tau_x^H} + \left[W_{p_{x_F}^H}^H + W_{\widetilde{p}_{x_F}^W}^H\right] \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_x^H} + W_{p_{x_F}^H}^H + W_{\widetilde{p}_{x_H}^H}^H \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_x^H}; \\
[N4] \qquad 0 &= \left[W_{p_1^F}^F + W_{\widetilde{p}_1^W}^F\right] \frac{\partial \widetilde{p}_1^W}{\partial \tau_x^F} + \left[W_{p_{x_F}^F}^F + W_{\widetilde{p}_{x_F}^W}^F\right] \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_x^F} - W_{p_{x_F}^F}^F.
\end{aligned}$$

Notice that

$$W_{\widetilde{p}_1^W}^H = E^H = -W_{\widetilde{p}_1^W}^F = M^F > 0; \tag{9}$$

$$W_{\widetilde{p}_{x_F}^W}^F = E^F = -W_{\widetilde{p}_{x_F}^W}^H = M^H > 0, \tag{10}$$

both of which imply that, holding local prices fixed, each government achieves higher welfare when its terms of trade improve. Using (1), (3), (9), and (10), $[N1]$ and $[N2]$ can be added together to yield

$$\left[W^H_{p_1^H} + W^F_{p_1^F}\right] \frac{\partial \widetilde{p}_1^W}{\partial \tau_1^F} + \left[W^H_{p^H_{x_F}} + W^F_{p^F_{x_F}}\right] \frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau_1^F} + W^F_{p_1^F} + W^H_{\widetilde{p}^H_{x_H}} \frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_1^F} + W^H_{\widetilde{p}_1^W} = 0.$$

Comparing this with the global efficiency condition of $[E2]$, the difference is the last, additional term $W^H_{\widetilde{p}_1^W} > 0$, which means that the sum of trade taxes on final goods, $\left(\tau_1^H + \tau_1^F\right)$, employed in the Nash equilibrium is inefficiently high with respect to the globally efficient level. Also, given (2), (4), (9), and (10), adding up $[N3]$ and $[N4]$ yields

$$\left[W^H_{p_1^H} + W^F_{p_1^F}\right] \frac{\partial \widetilde{p}_1^W}{\partial \tau_x^H} + \left[W^H_{p^H_{x_F}} + W^F_{p^F_{x_F}}\right] \frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau_x^H} + W^H_{p^H_{x_F}} + W^H_{\widetilde{p}^H_{x_H}} \frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_x^H} + W^F_{\widetilde{p}^W_{x_F}} = 0.$$

The difference from $[E3]$ is the additional term $W^F_{\widetilde{p}^W_{x_F}} > 0$, which means that the sum of trade taxes on inputs, $\left(\tau_x^H + \tau_x^F\right)$, is inefficiently high under the Nash equilibrium with respect to the globally efficient level. These imply that the volume of trade in final goods and inputs is inefficiently low in light of the mix of trade policy choices that each government employs in the Nash equilibrium to deliver the chosen level of the world prices and (with the trading partner's policy choices fixed) the local prices of the partner country.

To check the global efficiency for the mix of τ_1^H and τ_x^H that home government employs in the Nash equilibrium, we multiply $[N3]$ by (7) and add it to $[N1]$ to get

$$[N5] \qquad 0 = -W^H_{p_1^H} + W^H_{\widetilde{p}^H_{x_H}} \frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_1^H} - \left[W^H_{p^H_{x_F}} + W^H_{\widetilde{p}^H_{x_H}} \frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau_x^H}\right] \frac{\partial \widetilde{p}^W_{x_F} / \partial \tau_1^H}{\partial \widetilde{p}^W_{x_F} / \partial \tau_x^H},$$

which is identical to the global efficiency condition of $[E5]$. We may conclude that the trade policy mix employed by home government in the Nash equilibrium to deliver its chosen level of the world prices, $\widetilde{p}_1^W$ and $\widetilde{p}^W_{x_F}$, and (with foreign choices of τ_1^F and τ_x^F fixed) the foreign domestic prices, $p_1^F\left(\tau_1^F, \widetilde{p}_1^W\right)$ and $p^F_{x_F}\left(\tau_x^F, \widetilde{p}^W_{x_F}\right)$, and therefore the equilibrium trade volumes, $M^F(p_1^F(\cdot))$ and $E^F\left(p^F_{x_F}(\cdot)\right)$, is globally efficient.

In contrast, as for the mix of τ_1^F and τ_x^F employed by foreign government in the Nash equilibrium, multiplying $[N4]$ by (8) and adding it to $[N2]$ yields

$$[N6] \qquad 0 = W^F_{p_1^F} + W^F_{p^F_{x_F}} \frac{\partial \widetilde{p}^W_{x_F} / \partial \tau_1^F}{\partial \widetilde{p}^W_{x_F} / \partial \tau_x^F},$$

which is different than the global efficiency condition of $[E6]$. The trade policy mix employed by foreign government in the Nash equilibrium to deliver its chosen level of each world price and (with τ_1^H and τ_x^H fixed) hence the home local prices, p_1^H and $p^H_{x_F}$, and the equilibrium trade volumes, $E^H\left(p_1^H(\cdot), \widetilde{p}^H_{x_H}, p^H_{x_F}(\cdot)\right)$ and $M^H\left(p_1^H(\cdot), \widetilde{p}^H_{x_H}, p^H_{x_F}(\cdot)\right) x^F$, is globally inefficient. This is because, as is clear from comparing $[N6]$ to $[E6]$, foreign government does not care about the indirect impact of its policy choices on home welfare that is channeled through the market-clearing price for home domestic inputs, $\widetilde{p}^H_{x_H}(\tau_1^H + \tau_1^F, \tau_x^H + \tau_x^F)$.

In short, there arise three sources of inefficiencies in the Nash equilibrium. First, the sum of trade taxes on final goods, $\left(\tau_1^H + \tau_1^F\right)$, is inefficiently high, and hence there is too little market-clearing volume of trade in final goods. Second, similarly to the above, the sum of trade taxes on inputs, $\left(\tau_x^H + \tau_x^F\right)$, is inefficiently high, and hence there is too little equilibrium input trade volume. Third, the mix of τ_1^F and τ_x^F employed by foreign government is inefficient.

2.5 Political-optimum policy choices

Next, following Bagwell and Staiger (1999), we consider a hypothetical situation called the political optimum that governments were not motivated by the impact of their tariff choices on the world prices, i.e., $W^H_{\widetilde{p}^W_1} = W^F_{\widetilde{p}^W_1} = W^H_{\widetilde{p}^W_{x_F}} = W^F_{\widetilde{p}^W_{x_F}} = 0$. We then identify the tariffs that would be chosen noncooperatively by governments with these hypothetical preferences. Using the Nash conditions $[N1]$ to $[N4]$, it is straightforward that the following conditions jointly define the political optimum:

$$
\begin{aligned}
&[PO1] \qquad 0 = W^H_{p^H_1}\frac{\partial \widetilde{p}^W_1}{\partial \tau^H_1} + W^H_{p^H_{x_F}}\frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau^H_1} - W^H_{p^H_1} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau^H_1};\\
&[PO2] \qquad 0 = W^F_{p^F_1}\frac{\partial \widetilde{p}^W_1}{\partial \tau^F_1} + W^F_{p^F_{x_F}}\frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau^F_1} + W^F_{p^F_1};\\
&[PO3] \qquad 0 = W^H_{p^H_1}\frac{\partial \widetilde{p}^W_1}{\partial \tau^H_x} + W^H_{p^H_{x_F}}\frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau^H_x} + W^H_{p^H_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau^H_x};\\
&[PO4] \qquad 0 = W^F_{p^F_1}\frac{\partial \widetilde{p}^W_1}{\partial \tau^F_x} + W^F_{p^F_{x_F}}\frac{\partial \widetilde{p}^W_{x_F}}{\partial \tau^F_x} - W^F_{p^F_{x_F}}.
\end{aligned}
$$

Given (1) and (3), adding up $[PO1]$ and $[PO2]$ yields what is identical to the global efficiency condition of $[E1]$ or $[E2]$, which implies that the sum of trade taxes on final goods, $\left(\tau^H_1 + \tau^F_1\right)$, is globally efficient under the political optimum. The efficiency holds regardless of whether or not governments are motivated by political economy concerns, i.e., regardless of the size of γ's. Also, it follows from (2) and (4) that the sum of $[PO3]$ and $[PO4]$ is identical to $[E3]$ or $[E4]$, which implies that the sum of trade taxes on inputs, $\left(\tau^H_x + \tau^F_x\right)$, is globally efficient under the political optimum, irrespective of the political economy concerns.

To check the global efficiency for the mix of τ^H_1 and τ^H_x that home government employs under the political optimum, we multiply $[PO3]$ by (7) and add it to $[PO1]$ to get

$$[PO5] \qquad 0 = -W^H_{p^H_1} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau^H_1} - \left[W^H_{p^H_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau^H_x}\right]\frac{\partial \widetilde{p}^W_{x_F}/\partial \tau^H_1}{\partial \widetilde{p}^W_{x_F}/\partial \tau^H_x},$$

which is identical to the global efficiency condition of $[E5]$ (and the Nash condition of $[N5]$). The trade policy mix employed by home government under the political optimum is globally efficient.

However, by multiplying $[PO4]$ by (8) and adding it to $[PO2]$, we have

$$[PO6] \qquad 0 = W^F_{p^F_1} + W^F_{p^F_{x_F}}\frac{\partial \widetilde{p}^W_{x_F}/\partial \tau^F_1}{\partial \widetilde{p}^W_{x_F}/\partial \tau^F_x},$$

which is different than $[E6]$ (but is identical to $[N6]$) and implies that the mix of τ^F_1 and τ^F_x that foreign government employs under the political optimum is globally inefficient. The difference between $[PO6]$ and $[E6]$ means that the inefficiency arises in noncooperative policy choices even if foreign (as well as home) government is not motivated by the terms-of-trade implications of its policy choices. Combined with the identity of $[PO6]$ and $[N6]$, the difference between $[PO6]$ and $[E6]$ further implies that the policy mix unilaterally chosen by foreign government is globally inefficient not only due to the terms-of-trade externality but because foreign government does not internalize the impact of its policy choices on home welfare through affecting the equilibrium price for home domestic inputs, $\widetilde{p}^{H}_{x_H}(\tau_1^H + \tau_1^F, \tau_x^H + \tau_x^F)$. Recall that the home inputs are not traded and are sold domestically but that its equilibrium price depends not only on home policies but also depends directly on foreign policies due to the production linkage with the traded final goods and foreign (imported) inputs.

In summary, although the sum of trade taxes on final goods, $\left(\tau_1^H + \tau_1^F\right)$, and the sum of trade taxes on inputs, $\left(\tau_x^H + \tau_x^F\right)$, are both inefficiently high in the Nash equilibrium and the Nash levels of trade volumes are too low, these Nash inefficiencies disappear under the political optimum. This first finding suggests that governments would be able to expand the trade volume, i.e., secure additional market access, for final goods and for inputs to globally efficient level through a trade agreement as in the conventional market-access argument associated with the terms-of-trade theory in the related literature. Nevertheless, the mix of τ_1^F and τ_x^F that foreign government employs under the political optimum still remains inefficient as in the Nash equilibrium. We may interpret the latter finding to mean that, although the terms-of-trade consequences of noncooperative trade policy choices represent one source of inefficiencies, the standard terms-of-trade theory is not completely applicable to our model of trade agreement with cross-border unbundling.

The key findings of this section are summarized as follows:

Proposition 1 *In the presence of cross-border unbundling, noncooperative trade policy choices are not globally efficient not only because of terms-of-trade manipulation but due to local price externality for the home domestically-sourced inputs. Specifically, (i) the Nash trade policies are not globally efficient. Both the sum of trade taxes on final goods and the sum of trade taxes on inputs are too high and the Nash trade volumes are too low. (ii) The politically optimal trade policy mix chosen by foreign government is not globally efficient.*

3 Role of trade agreement

Using our model of trade agreement with cross-border unbundling, this section highlights that with the prevalence of cross-border unbundling, the potential of trade agreement to solve inefficiencies arising in the noncooperative policy choices would be called for beyond the conventional market-access argument.

3.1 Market access in a conventional sense

Bagwell and Staiger (2001a) defines the market access with which a country provides its trading partner by the volume of imports it would accept at a particular world price. As Bagwell and Staiger (2001a) emphasizes, it is well known that in the models of trade agreement featuring terms-of-trade externality, trade policy adjustments by one country that maintain the market access defined as above do not alter the equilibrium world prices or trade volumes, and hence cannot affect the trading partner's welfare. In our model of trade agreement with cross-border unbundling, however, we argue that the conventional market-access focus alone is unlikely to deliver globally efficient outcomes. Specifically, the foreign government of country F, from which inputs are exported to the final-good assembly plant located in country H and the final goods are subsequently exported back to F, may later adjust tariff policies unilaterally, so long as the adjustment does not violate the market access commitment, to its advantage.

Applying the conventional definition of market access associated with the terms-of-trade theory to our model, the foreign market access for final goods afforded for the trade counterpart H and the home market access for foreign inputs afforded for the trade counterpart F, given a particular set of world prices, $\overline{p}_1^W$ and $\overline{p}_{x_F}^W$, are defined as

$$\begin{aligned} m_1 &\equiv M_1^F(p_1^F\left(\tau_1^F, \overline{p}_1^W\right)); \\ m_x &\equiv M_x^H\left(p_1^H\left(\tau_1^H, \overline{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\tau_x^H, \overline{p}_{x_F}^W\right)\right). \end{aligned}$$

The foreign market access for final goods, m_1, depends solely on the local price of their own, p_1^F, as usual. But the home market access for inputs, m_x, depends not only on the local price of inputs themselves, $p_{x_F}^H$, but also on the local price of final goods, p_1^H, and on the local (market-clearing) price for home domestic inputs, $\widetilde{p}_{x_H}^H$, through production linkage.

Suppose that home and foreign governments negotiate over the levels of their tariffs and commit to the market access levels implied by the agreed tariffs, $\left(\overline{\tau}_1^H, \overline{\tau}_1^F, \overline{\tau}_x^H, \overline{\tau}_x^F\right)$, and the corresponding world prices, $\left(\overline{p}_1^W, \overline{p}_{x_F}^W\right)$. A country importing a particular good maintains the committed level of market access afforded for the trading partner while the counterpart country exporting the good should not limit the export volume below the market access level. In line with the approach taken by Antràs and Staiger (2012), let us consider the case in which negotiation reaches to the efficient trade volume for final goods and for inputs and the market access levels are set equal to the efficient trade volumes: $m_1 = m_1^E$ and $m_x = m_x^E$. We will show that such negotiation outcome may not be lasting as efficient once the possibility of foreign government's subsequent unilateral policy adjustments is taken into consideration.

Before turning to the foreign government's incentive for unilateral policy adjustments, we first explore the possibility of adjustments by the home government of country H, where the final-good producer is located and imports foreign inputs to assemble them, combined with domestically-sourced inputs, into the final goods to be sold domestically and exported (back) to country F. As summarized in proposition 1, home government only has terms-of-trade-driven incentives for trade policy intervention. Thus, home government may make adjustments to its once-agreed choices of $\left(\overline{\tau}_1^H, \overline{\tau}_x^H\right)$ only so long as the adjustments neither alter the world prices of final goods and foreign inputs nor change trade volumes from the efficient levels. Holding each world price unaltered from $\left(\overline{p}_1^W, \overline{p}_{x_F}^W\right)$, home government could slightly increase τ_1^H and decrease τ_x^H simultaneously (recall (7)). An unilateral rise of τ_1^H in combination with a decline of τ_x^H that leaves each world price unaltered implies a lower home local price of p_1^H while the home export supply curve shift out in the world market for final goods. Meanwhile, for foreign inputs, home local price of $p_{x_F}^H$ becomes lower while the home import demand curve shifts in. Such unilateral policy adjustments do not alter trade volumes, resulting in no impact on foreign welfare. We can easily show that similar adjustments in the opposite direction also cannot affect foreign welfare. Therefore, even if home government makes unilateral policy adjustments, it merely causes internal surplus shift within the home country.

We next point to the possibility that foreign government unilaterally makes adjustments to its once-agreed choices of $\left(\overline{\tau}_1^F, \overline{\tau}_x^F\right)$. Given the market access commitment, foreign government may make unilateral policy adjustments only so long as the adjustments do not alter the world prices from $\left(\overline{p}_1^W, \overline{p}_{x_F}^W\right)$. Holding each world price constant, foreign government might alter τ_1^F and τ_x^F in coordination to the same direction (recall (8)). But foreign government will never increase τ_1^F, (with $\overline{p}_1^W$ unchanged) accompanied by a rise in foreign local price of p_1^F, which dampens the import demand for final goods and thus country F is no longer able to maintain the market access. So the only remaining option is to decrease both τ_1^F and τ_x^F. Lowering τ_1^F pushes up $\widetilde{p}_1^W$ and (given $\overline{\tau}_1^H$ fixed) increases p_1^H, which induces an increase in the demand for the associated inputs, i.e., $\frac{\partial \widehat{x_F^D}}{\partial y} \frac{\partial y}{\partial p_1^H} \frac{\partial \widetilde{p}_1^W}{\partial \tau_1^F} < 0$, leading to a rise in $\widetilde{p}_{x_F}^W$. Meanwhile, lowering τ_x^F pushes down $\widetilde{p}_{x_F}^W$ and (given $\overline{\tau}_x^H$ fixed) decreases the home local price of $p_{x_F}^H$, which increases the final-good output, i.e., $\frac{\partial y}{\partial p_{x_F}^H} \frac{\partial \widetilde{p}_{x_F}^W}{\partial \tau_x^F} < 0$, leading to a decline in $\widetilde{p}_1^W$. These effects on $\widetilde{p}_1^W$ and $\widetilde{p}_{x_F}^W$ offset each other so as to result in leaving the world prices unaltered from $\left(\overline{p}_1^W, \overline{p}_{x_F}^W\right)$.

Notice that, by lowering τ_1^F and responding to the induced import demand, foreign government can open up the market for final goods more to its trade counterpart H without violating (the lower bound of) the market access constraint. The decline of τ_1^F in combination with the decline of τ_x^F that leaves $\overline{p}_1^W$ unaltered results in a situation that the home export supply curve shifts out in the world market for final goods. Meanwhile, the sum of trade taxes $\left(\overline{\tau}_1^H + \tau_1^F\right)$ is decreased by a lower τ_1^F, leading to an increase in the equilibrium trade volume for final goods, i.e., $M_1^F\left(p_1^F\left(\tau_1^F, \overline{p}_1^W\right)\right) = E_1^H\left(p_1^H\left(\overline{\tau}_1^H, \overline{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\overline{\tau}_x^H, \overline{p}_{x_F}^W\right)\right) > m_1^E$, though $\overline{p}_1^W$ remains unaltered. On the other hand, the decline of τ_x^F in combination with the decline of τ_1^F that leaves $\overline{p}_{x_F}^W$ unchanged results in a situation that the home import demand curve shifts out in the world market for foreign inputs. The sum of trade taxes $\left(\overline{\tau}_x^H + \tau_x^F\right)$ is decreased by a lower τ_x^F, leading to an increase in the equilibrium trade volume for inputs, i.e., $M_x^H\left(p_1^H\left(\overline{\tau}_1^H, \overline{p}_1^W\right), \widetilde{p}_{x_H}^H, p_{x_F}^H\left(\overline{\tau}_x^H, \overline{p}_{x_F}^W\right)\right) = E_x^F\left(p_{x_F}^F\left(\tau_x^F, \overline{p}_{x_F}^W\right)\right) > m_x^E$, though $\overline{p}_{x_F}^W$ remains unaltered.

Foreign government would make such unilateral policy adjustments, accompanied by the unilateral opening up of the market access for final goods, causing surplus shift to country F from the trade counterpart H. To see this, let us consider the impact on the home and foreign welfare of the foreign tariff policy changes in turn. Let dW^F be a change in foreign welfare implied by the policy changes of $d\tau_1^F < 0$ and $d\tau_x^F < 0$ that do not alter world prices of $\left(\overline{p}_1^W, \overline{p}_{x_F}^W\right)$.

$$\begin{aligned} dW^F &= d\tau_1^F\left[\theta\frac{dCS^F(p_1^F)}{dp_1^F} + \frac{dTR_1^F(\tau_1^F)}{d\tau_1^F}\right] + d\tau_x^F\left[-\gamma_x^F\frac{dPS_x^F(p_{x_F}^F)}{dp_{x_F}^F} + \frac{dTR_x^F(\tau_x^F)}{d\tau_x^F}\right] \quad (11) \\ &= d\tau_1^F\left[\tau_1^F M_1^{F\prime}(p_1^F)\right] + d\tau_x^F\left[\left(1-\gamma_x^F\right)E_x^F\left(p_{x_F}^F\right) - \tau_x^F E_x^{F\prime}\left(p_{x_F}^F\right)\right], \end{aligned}$$

where $TR_1^F(\tau_1^F) = \tau_1^F M_1^F\left(p_1^F(\tau_1^F, \overline{p}_1^W)\right)$ is import tariff revenue from (or import subsidy expenditure for) final goods and $TR_x^F(\tau_x^F) = \tau_x^F E_x^F\left(p_{x_F}^F\left(\tau_x^F, \overline{p}_{x_F}^W\right)\right)$ is export tax revenue from (or export subsidy expenditure for) inputs. The declined local price of p_1^F benefits foreign consumers while the raised local price of $p_{x_F}^F$ benefits foreign input suppliers. Overall, dW^F is (weakly) positive if $\tau_1^F = \tau_x^F = 0$. And more importantly, dW^F is strictly greater than zero if $\tau_1^F > 0$ (import tariff) and $\tau_x^F \geq 0$ (export tax) or if $\tau_1^F \geq 0$ and $\tau_x^F > 0$, regardless of the political weight of γ_x^F put on input suppliers. In the case of $\tau_1^F < 0$ (import subsidy) or $\tau_x^F < 0$ (export subsidy), we observe that $dW^F > 0$ if and only if

$$\gamma_x^F - 1 > \frac{1}{E_x^F}\left[\tau_1^F M_1^{F\prime}\frac{d\tau_1^F}{d\tau_x^F} - \tau_x^F E_x^{F\prime}\right],$$

where the right-hand side could be positive but negligibly small. The above inequality is highly likely to hold if $\gamma_x^F > 1$, i.e., if foreign government is motivated by the political economy pressure from input suppliers. Thus, foreign government sometimes would have an incentive to unilaterally make adjustments to its once-agreed policy mix, without violating the market access commitment, in its favor.

The corresponding change in home welfare is given by

$$dW^H = \left[d\tau_1^F \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_1^F} + d\tau_x^F \frac{\partial \widetilde{p}_{x_H}^H}{\partial \tau_x^F}\right] W_{\widetilde{p}_{x_H}^H}^H \tag{12}$$

with

$$\begin{aligned} W_{\widetilde{p}_{x_H}^H}^H &= \gamma_1^H \frac{\partial PS_1^H\left(p_1^H, \widetilde{p}_{x_H}^H, p_{x_F}^H\right)}{\partial \widetilde{p}_{x_H}^H} + \gamma_x^H \frac{dPS_x^H(\widetilde{p}_{x_H}^H)}{d\widetilde{p}_{x_H}^H} \\ &\quad + \overline{\tau}_1^H \frac{\partial E_1^H\left(p_1^H, \widetilde{p}_{x_H}^H, p_{x_F}^H\right)}{\partial \widetilde{p}_{x_H}^H} + \overline{\tau}_x^H \frac{\partial M_x^H\left(p_1^H, \widetilde{p}_{x_H}^H, p_{x_F}^H\right)}{\partial \widetilde{p}_{x_H}^H} \\ &= x_H^D\left(\gamma_x^H - \gamma_1^H\right) + \overline{\tau}_1^H \frac{\partial y}{\partial \widetilde{p}_{x_H}^H} + \overline{\tau}_x^H \frac{\partial x_F^D}{\partial \widetilde{p}_{x_H}^H}. \end{aligned}$$

Recall that given $\left(\overline{\tau}_1^H, \overline{\tau}_x^H\right)$, with $\left(\overline{p}_1^W, \overline{p}_{x_F}^W\right)$ held unaltered, home local prices, p_1^H and $p_{x_F}^H$, remain unaltered, and that the foreign policy changes of $d\tau_1^F < 0$ and $d\tau_x^F < 0$ therefore pass only through the equilibrium price for home domestic inputs, $\widetilde{p}_{x_H}^H(\overline{\tau}_1^H + \tau_1^F, \overline{\tau}_x^H + \tau_x^F)$, to home welfare. The terms in the square bracket in (12) represent the overall impact of the foreign policy changes on $\widetilde{p}_{x_H}^H$. It follows from (3) and (4) that the first term in the bracket is positive while the second term is negative. Combined these together, as long as the "overall" output expansion effect through $d\tau_1^F < 0$ as well as $d\tau_x^F < 0$ outweighs the substitution effect from home to foreign inputs, the foreign policy changes would induce a net increase in the demand for home inputs, pushing up $\widetilde{p}_{x_H}^H$.[3][4]

Given this observation, $dW^H < 0$ if and only if

$$\gamma_1^H - \gamma_x^H > \frac{1}{x_H^D}\left[\overline{\tau}_1^H \frac{\partial y}{\partial \widetilde{p}_{x_H}^H} + \overline{\tau}_x^H \frac{\partial x_F^D}{\partial \widetilde{p}_{x_H}^H}\right],$$

[3] If the production function has constant returns to scale, then only $\tilde{p}_{x_H}^H$ will not change while p_1^H and $p_{x_F}^H$ are unchanged, resulting in $dW^H = 0$.

[4] We presume somewhat limited degree of imperfect substitution between home and foreign inputs. In the empirical trade literature on home bias, Blonigen and Wilson (1999), for example, estimates the (constant) elasticity of substitution between the US domestic and foreign goods in consumption, i.e., Armington elasticities, to be on average 0.81 though with standard deviation across 146 sectors of 0.63. We deem the imperfect substitution between home and foreign inputs in production (in our model) to be comparable in magnitude to the Armington estimates.

which would hold if $\overline{\tau}_1^H > 0$ (export tax) and $\overline{\tau}_x^H < 0$ (import subsidy), as long as there is equal political weight put on the final-good producers and on input suppliers, i.e., $\gamma_1^H = \gamma_x^H$. Even in the case of other trade policy instruments employed by home government, the inequality is highly likely to hold if home government is relatively more motivated by political economic concerns regarding the final-good producers, i.e., $\gamma_1^H > \gamma_x^H$.

In short, foreign government sometimes can achieve higher welfare by making unilateral adjustments to its once-agreed tariff choices while opening up the market access afforded for the trade counterpart but without altering the equilibrium world prices. As the import tariff (subsidy) on final goods is reduced (raised), country F demands more imports of the final goods. The final-good producer in country H responds to the increased final-good demand by expanding input procurement. Meanwhile, as the export tax (subsidy) on inputs is reduced (raised), the foreign input suppliers are willing to export more inputs, which are absorbed by the increased import demand by the final-good producers in H. Although such simultaneous tariff changes affect the world prices of final goods and foreign inputs, their effects balance out, leaving each world price unaltered from the level implied by the agreed tariffs. Nevertheless, in response to the increased volume of trade in final goods and foreign inputs, the imperfect substitution between domestic and imported inputs leads to a rise in the local equilibrium price of home domestic inputs. As a consequence, foreign government sometimes will shift the cost of its unilateral policy changes onto the trading partner to its advantage, without violating the market access commitment.

Such possible beggar-thy-neighbor effect caused by unilateral policy adjustments suggests that the role and design of trade agreement should be revisited beyond the conventional market access argument. To achieve globally efficient outcomes in the presence of cross-border unbundling, trade agreement must be designed to solve inefficiencies arising in the noncooperative policy choices even without terms-of-trade externality. Recall the difference between $[PO6]$ and $[E6]$ shown in the previous section. Specifically, trade agreement is expected to solve inefficiencies arising due to the local price externality that foreign government manipulates the local equilibrium price for home domestic inputs by unilaterally opening up the market access for final goods.

Proposition 2 *To achieve globally efficient outcomes in the presence of cross-border unbundling, trade agreement requires governments to agree to constraints on trade policies that extend beyond the conventional market access commitment. In particular, trade agreement must be designed to force foreign government to internalize the local price externality for home domestic inputs.*

3.2 What if home imports are fixed to the market access level?

This subsection continues to consider the possibility that foreign government unilaterally makes adjustments to its once-agreed choices of $\left(\overline{\tau}_1^F, \overline{\tau}_x^F\right)$, but examines possible outcomes in the case in which the market access commitment imposes the lower boundary of trade volume given a particular set of world prices. In other words, while foreign government can unilaterally open up the market access for final goods without violating (the lower bound of) the market access commitment as in the previous subsection, we suppose that home government is allowed to intervene to prevent imports of foreign inputs to increase beyond the market access level as long as each world price remains unaltered. Specifically, we consider a hypothetical situation that the volume of home imports of foreign inputs is held fixed by import quota at the efficient home market access level of m_x^E. Such import quota implies that the equilibrium volume of trade in foreign inputs remains constant even though the foreign input suppliers are willing to export more inputs as $p_{x_F}^F$ becomes higher due to the reduction in τ_x^F. In the meantime, the reduction in τ_1^F expands trade in final goods and induces an increase in the demand for the associated inputs. As a result, the increased quantity of input procurement is biased toward home domestic inputs, putting upward pressure on $\widetilde{p}_{x_H}^H$.

Even if the import quota is introduced as an extra instrument to home trade policies, foreign government still sometimes would have an incentive to unilaterally make policy changes such that $d\tau_1^F < 0$ and $d\tau_x^F < 0$ and open up the market access for final goods to its advantage, while neither altering the world prices nor violating (the lower bound of) the market access commitment. To see this, the change in foreign welfare (11) can be rewritten as

$$dW^F = d\tau_1^F \left[\tau_1^F M_1^{F\prime}(p_1^F)\right] + d\tau_x^F \left[\left(1-\gamma_x^F\right) m_x^E\right].$$

And $dW^F > 0$ if and only if

$$\gamma_x^F - 1 > \frac{1}{m_x^E}\left[\tau_1^F M_1^{F\prime}\frac{d\tau_1^F}{d\tau_x^F}\right],$$

which always holds as long as $\tau_1^F > 0$, regardless of the political weight of γ_x^F put on input suppliers. Otherwise, the right-hand side could be positive but negligibly small, and thereby the above inequality is highly likely to hold if foreign government is motivated by the political economy pressure of $\gamma_x^F > 1$ from input suppliers.

Moreover, foreign government sometimes will shift the cost of its unilateral policy changes onto the trade counterpart H, leading to a beggar-thy-neighbor effect. As for the corresponding change in home welfare, the value in the square bracket of (12) is strictly positive since the home-biased input procurement puts upward pressure on $\widetilde{p}_{x_H}^H$. Thus, $dW^H < 0$ if and only if

$$\gamma_1^H - \gamma_x^H > \frac{1}{x_H^D}\left[\overline{\tau}_1^H \frac{\partial y}{\partial \widetilde{p}_{x_H}^H}\right],$$

which would hold if $\overline{\tau}_1^H > 0$ (export tax), as long as there is equal political weight of $\gamma_1^H = \gamma_x^H$ put on the final-good producers and on input suppliers. Even in the case of other trade policy instruments employed by home government, the inequality is highly likely to hold if home government is motivated more by political economy pressure from the final-good producers such that $\gamma_1^H > \gamma_x^H$.

Hence, even if the market access commitment imposes the lower boundary of trade volume as if the home import quota on foreign inputs is permitted as an extra policy instrument, it is unlikely to deliver globally efficient outcomes. This is because the foreign government's subsequent unilateral policy adjustments to the once-agreed tariffs induce inefficiently home-biased input procurement, benefiting foreign welfare at the cost of home welfare. Such a beggar-thy-neighbor effect possibly occurs unless the unilateral opening up of the market access is prohibited. Thus, to reach the globally efficient outcomes, an immediate answer is to have both parties (exporters and importers) involved in trade of a particular final product and its associated inputs to fix the trade volumes to the market access levels. Although the direct quantitative restrictions are unrealistic, trade agreement could be designed so as to indirectly force the both parties not to decrease or even increase the trade volumes given the unaltered world prices.

Proposition 3 *To achieve globally efficient outcomes in the presence of cross-border unbundling, trade agreement must be designed so that government will not restrict or promote exports and imports to its advantage.*

3.3 In relation to the missing instrument argument

In our model of trade agreement with cross-border unbundling of production, foreign government shifts the cost of its unilateral policy adjustments onto the trading partner, and such surplus shift is passed through the "local" equilibrium price for the home domestically-produced inputs. Some may promptly interpret this result as a variant of local price externality arising in the setting where some trade policy instrument is restricted to be used or is missing. So-called missing instrument problem, as extensively discussed in Bagwell and Staiger (2016), usually takes a form that a trade policy instrument, say tariff, employed by one country on a particular product imported from the trade counterpart is not subject to trade negotiations between the countries because the product is not naturally imported by assumption. But upon the negotiation result, the importer country would use this import tariff beyond the negotiated tariffs to manipulate the world prices, or the terms of trade, in its favor.

In our model, however, foreign government uses the negotiated tariffs to manipulate the local equilibrium price for home domestic inputs to its advantage but without altering the equilibrium world prices of traded goods whose tariffs are subject to negotiation. Also, we do not consider any possible trade policy intervention on home domestic inputs because by assumption they are not imported from any trading partner, which is the foreign country in our simple two-country setting. Thus, our discussions in the previous subsections cannot be interpreted as a variant of the missing instrument problem.

4 Design of trade agreement

Given the findings from our analysis based on the conventional market access argument, this section proposes an alternative definition of the terms of trade for trade agreement in the prevalence of cross-border unbundling. We will show that specifying the market access using the alternative terms-of-trade definition eliminates inefficiencies arising due to the local price externality in noncooperative policy choices. That is, by using this alternative terms of trade, the Nash inefficiencies can be traced only to the terms-of-trade manipulation, which suggests that the conventional market access argument or like might work accordingly to achieve globally efficient outcomes through trade agreement.

4.1 Trade-weighted terms of trade

As summarized in proposition 3, an alternative definition of the terms of trade should work ideally with the market access constraint so that each government cannot change market access in a way that improves the alternative terms of trade. More specifically, infinitesimal changes in the mix of trade policies chosen by one government that hold the alternative terms of trade constant should not affect the welfare of the other country at globally efficient choices. Consequently, the alternative terms of trade would yield the identity of $[E6]$ and $[N6]$, in addition to the identity of $[E5]$ and $[N5]$. The policy mix unilaterally chosen by foreign (as well as home) government would become globally efficient unlike what we found based on the conventional terms of trade in section 2.

To have $[E6]$ to be identical with $[N6]$, we can easily show that the infinitesimal changes in the mix of foreign trade policies, $d\tau_1^F$ and $d\tau_x^F$, should satisfy

$$\frac{d\tau_x^F}{d\tau_1^F} = -\frac{([E2]-[N2])}{([E4]-[N4])} = -\frac{\partial W^H/\partial \tau_1^F}{\partial W^H/\partial \tau_x^F}.$$

As long as home government is not motivated by political economy concerns, i.e., $\gamma_1^H = \gamma_x^H = 1$, we have

$$\begin{aligned}
\frac{\partial W^H}{\partial \tau_1^F} &= \frac{\partial}{\partial \tau_1^F}\left[\widetilde{p}_1^W E_1^H - \widetilde{p}_{x_F}^W M_x^H\right] - \left[p_1^H \frac{\partial E_1^H}{\partial \tau_1^F} - p_{x_F}^H \frac{\partial M_x^H}{\partial \tau_1^F}\right]; \\
\frac{\partial W^H}{\partial \tau_x^F} &= \frac{\partial}{\partial \tau_x^F}\left[\widetilde{p}_1^W E_1^H - \widetilde{p}_{x_F}^W M_x^H\right] - \left[p_1^H \frac{\partial E_1^H}{\partial \tau_x^F} - p_{x_F}^H \frac{\partial M_x^H}{\partial \tau_x^F}\right],
\end{aligned}$$

which suggests that the trade-weighted terms of trade, $\frac{E_1^H \widetilde{p}_1^W}{M_x^H \widetilde{p}_{x_F}^W}$, might be a candidate for the alternative terms of trade as we will confirm below.

Let $\frac{E_1^H}{E_1^H+M_x^H}\widetilde{p}_1^W = (1-s)\,\widetilde{p}_1^W \equiv \widetilde{\rho}_1^W$ and $\frac{M_x^H}{E_1^H+M_x^H}\widetilde{p}_{x_F}^W = s\widetilde{p}_{x_F}^W \equiv \widetilde{\rho}_{x_F}^W$, where s is the ratio of imports of intermediate inputs to the sum of trade in the final goods and the inputs themselves that are linked through production chain. Notice that $\widetilde{p}_1^W(\tau_1^H, \tau_1^F, \tau_x^H + \tau_x^F)$ and $\widetilde{p}_{x_F}^W(\tau_1^H + \tau_1^F, \tau_x^H, \tau_x^F)$ and that we can express trade volumes directly as functions of the sum of trade taxes, $E_1^H\left(\tau_1^H+\tau_1^F, \tau_x^H+\tau_x^F\right)$ and $M_x^H\left(\tau_1^H+\tau_1^F, \tau_x^H+\tau_x^F\right)$. Thus, the trade-weighted world prices depend on trade policies implemented against final goods and foreign inputs: $\widetilde{\rho}_1^W\left(\tau_1^H, \tau_1^F, \tau_x^H+\tau_x^F\right)$ and $\widetilde{\rho}_{x_F}^W\left(\tau_1^H+\tau_1^F, \tau_x^H, \tau_x^F\right)$. Home local prices for final goods and imported foreign inputs can be expressed as functions of $\widetilde{\rho}_1^W$ and $\widetilde{\rho}_{x_F}^W$ and home own trade policies as follows:

$$\begin{aligned}
p_1^H\left(\tau_1^H, \widetilde{p}_1^W\right) &= p_1^H\left(\tau_1^H, \frac{\widetilde{\rho}_1^W}{E_1^H\left(p_1^H\left(\tau_1^H, \frac{\widetilde{\rho}_1^W}{1-s}\right), \widetilde{p}_{x_H}^H\left(\tau_1^H, \frac{\widetilde{\rho}_1^W}{1-s}, \tau_x^H, \frac{\widetilde{\rho}_{x_F}^W}{s}\right), p_{x_F}^H\left(\tau_x^H, \frac{\widetilde{\rho}_{x_F}^W}{s}\right)\right)}\right) \\
&= p_1^H\left(\tau_1^H, \frac{\widetilde{\rho}_1^W}{E_1^H\left(\tau_1^H, \tau_x^H, \widetilde{\rho}_1^W, \widetilde{\rho}_{x_F}^W\right)}\right) \\
&= p_1^H\left(\tau_1^H, \tau_x^H, \widetilde{\rho}_1^W, \widetilde{\rho}_{x_F}^W\right);
\end{aligned}$$

$$
\begin{aligned}
p^H_{x_F}\left(\tau^H_x, \widetilde{p}^W_{x_F}\right) &= p^H_{x_F}\left(\tau^H_x, \frac{\widetilde{\rho}^W_{x_F}}{M^H_x\left(p^H_1\left(\tau^H_1, \frac{\widetilde{\rho}^W_1}{1-s}\right), \widetilde{p}^H_{x_H}\left(\tau^H_1, \frac{\widetilde{\rho}^W_1}{1-s}, \tau^H_x, \frac{\widetilde{\rho}^W_{x_F}}{s}\right), p^H_{x_F}\left(\tau^H_x, \frac{\widetilde{\rho}^W_{x_F}}{s}\right)\right)}\right) \\
&= p^H_{x_F}\left(\tau^H_x, \frac{\widetilde{\rho}^W_{x_F}}{M^H_x\left(\tau^H_1, \tau^H_x, \widetilde{\rho}^W_1, \widetilde{\rho}^W_{x_F}\right)}\right) \\
&= p^H_{x_F}\left(\tau^H_1, \tau^H_x, \widetilde{\rho}^W_1, \widetilde{\rho}^W_{x_F}\right).
\end{aligned}
$$

And the home local equilibrium price of domestic inputs also can be expressed as a function of $\widetilde{\rho}^W_1$ and $\widetilde{\rho}^W_{x_F}$ and home own policies: $\widetilde{p}^H_{x_H}\left(\tau^H_1, \tau^H_x, \widetilde{\rho}^W_1, \widetilde{\rho}^W_{x_F}\right)$.

The home welfare function (5) is now rewritten as

$$
\begin{aligned}
W^H &= (1-\theta)CS^H\left(p^H_1\right) + \gamma^H_1 PS^H_1(p^H_1, \widetilde{p}^H_{x_H}, p^H_{x_F}) + \gamma^H_x PS^H_x\left(\widetilde{p}^H_{x_H}\right) \\
&\quad + \left(E^H_1 + M^H_x\right)\left[\widetilde{\rho}^W_1 - \widetilde{\rho}^W_{x_F}\right] - \left[p^H_1 E^H_1\left(p^H_1, \widetilde{p}^H_{x_H}, p^H_{x_F}\right) - \left(p^H_{x_F} - \mu_x\right) M^H_x\left(p^H_1, \widetilde{p}^H_{x_H}, p^H_{x_F}\right)\right] \\
&\equiv W^H\left(p^H_1\left(\tau^H_1, \tau^H_x, \widetilde{\rho}^W_1, \widetilde{\rho}^W_{x_F}\right), \widetilde{\rho}^W_1, \widetilde{p}^H_{x_H}\left(\tau^H_1, \tau^H_x, \widetilde{\rho}^W_1, \widetilde{\rho}^W_{x_F}\right), p^H_{x_F}\left(\tau^H_1, \tau^H_x, \widetilde{\rho}^W_1, \widetilde{\rho}^W_{x_F}\right), \widetilde{\rho}^W_{x_F}\right),
\end{aligned}
$$

The effects on home welfare of the foreign government's policy choices are now channeled only through $\widetilde{\rho}^W_1$ and $\widetilde{\rho}^W_{x_F}$, or the trade-weighted terms of trade. Similarly, using $\widetilde{\rho}^W_1 = (1-s)\,\widetilde{p}^W_1 = \frac{M^F_1}{M^F_1+E^F_x}\widetilde{p}^W_1$ and $\widetilde{\rho}^W_{x_F} = s\widetilde{p}^W_{x_F} = \frac{E^F_x}{M^F_1+E^F_x}\widetilde{p}^W_{x_F}$, the foreign welfare function (6) is rewritten as

$$
\begin{aligned}
W^F &= \theta CS^F(p^F_1) + \gamma^F_x PS^F_x\left(p^F_{x_F}\right) \\
&\quad + \left(M^F_1 + E^F_x\right)\left[\widetilde{\rho}^W_{x_F} - \widetilde{\rho}^W_1\right] - \left[p^F_{x_F} E^F_x\left(p^F_{x_F}\right) - \left(p^F_1 - \mu_1\right) M^F_1\left(p^F_1\right)\right] \\
&\equiv W^F\left(p^F_1\left(\tau^F_1, \widetilde{\rho}^W_1\right), \widetilde{\rho}^W_1, p^F_{x_F}\left(\tau^F_x, \widetilde{\rho}^W_{x_F}\right), \widetilde{\rho}^W_{x_F}\right),
\end{aligned}
$$

which depends on the home government's policy choices only indirectly, through $\widetilde{\rho}^W_1$ and $\widetilde{\rho}^W_{x_F}$.

Based on the above home and foreign welfare functions expressed as functions of $\widetilde{\rho}^W_1$ and $\widetilde{\rho}^W_{x_F}$ and local prices, the global efficiency frontier is characterized by the following conditions:

$$
\begin{aligned}
[E1]' \qquad 0 &= \left[\frac{1}{1-s}\left[W^H_{p^H_1} + W^F_{p^F_1}\right] + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_1} + W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial \widetilde{\rho}^W_1}\right]\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^H_1} \\
&\quad + \left[\frac{1}{s}\left[W^H_{p^H_{x_F}} + W^F_{p^F_{x_F}}\right] + W^H_{p^H_1}\frac{\partial p^H_1}{\partial \widetilde{\rho}^W_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_{x_F}}\right]\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^H_1} \\
&\quad - W^H_{p^H_1} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau^H_1} + W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial \tau^H_1}; \\
[E2]' \qquad 0 &= \left[\frac{1}{1-s}\left[W^H_{p^H_1} + W^F_{p^F_1}\right] + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_1} + W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial \widetilde{\rho}^W_1}\right]\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^F_1} \\
&\quad + \left[\frac{1}{s}\left[W^H_{p^H_{x_F}} + W^F_{p^F_{x_F}}\right] + W^H_{p^H_1}\frac{\partial p^H_1}{\partial \widetilde{\rho}^W_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_{x_F}}\right]\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^F_1} + W^F_{p^F_1};
\end{aligned}
$$

$$
\begin{aligned}
[E3]' \qquad 0 \;=\; & \left[\frac{1}{1-s}\left[W^H_{p^H_1}+W^F_{p^F_1}\right]+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_1}+W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial \widetilde{\rho}^W_1}\right]\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^H_x} \\
& +\left[\frac{1}{s}\left[W^H_{p^H_{x_F}}+W^F_{p^F_{x_F}}\right]+W^H_{p^H_1}\frac{\partial p^H_1}{\partial \widetilde{\rho}^W_{x_F}}+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_{x_F}}\right]\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^H_x} \\
& +W^H_{p^H_1}\frac{\partial p^H_1}{\partial \tau^H_x}+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\tau^H_x}+W^H_{p^H_{x_F}}; \\
[E4]' \qquad 0 \;=\; & \left[\frac{1}{1-s}\left[W^H_{p^H_1}+W^F_{p^F_1}\right]+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_1}+W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial \widetilde{\rho}^W_1}\right]\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^F_x} \\
& +\left[\frac{1}{s}\left[W^H_{p^H_{x_F}}+W^F_{p^F_{x_F}}\right]+W^H_{p^H_1}\frac{\partial p^H_1}{\partial \widetilde{\rho}^W_{x_F}}+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_{x_F}}\right]\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^F_x}-W^F_{p^F_{x_F}}.
\end{aligned}
$$

It follows from $\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^H_1}-\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^F_1}=1-s$ and $\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^H_1}=\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^F_1}$ that $[E1]'$ and $[E2]'$ are identical and determine the globally efficient sum of trade taxes on final goods, $\left(\tau^H_1+\tau^F_1\right)$. Also, it follows from $\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^F_x}-\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^H_x}=s$ and $\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^H_x}=\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^F_x}$ that $[E3]'$ and $[E4]'$ are identical and determine the globally efficient sum of trade taxes on foreign inputs, $\left(\tau^H_x+\tau^F_x\right)$. As for the globally efficient mix of home trade policies, τ^H_1 and τ^H_x, we multiply $[E3]'$ by $\frac{d\tau^H_x}{d\tau^H_1}=-\frac{\partial \widetilde{\rho}^W_1/\partial \tau^H_1}{\partial \widetilde{\rho}^W_1/\partial \tau^H_x}=-\frac{\partial \widetilde{\rho}^W_{x_F}/\partial \tau^H_1}{\partial \widetilde{\rho}^W_{x_F}/\partial \tau^H_x}<0$ and add it to $[E1]'$ to restate the pair of conditions as

$$
[E5]' \qquad 0=-W^H_{p^H_1}+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau^H_1}+W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial \tau^H_1}-\left[W^H_{p^H_1}\frac{\partial p^H_1}{\partial \tau^H_x}+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\tau^H_x}+W^H_{p^H_{x_F}}\right]\frac{\partial \widetilde{\rho}^W_{x_F}/\partial \tau^H_1}{\partial \widetilde{\rho}^W_{x_F}/\partial \tau^H_x}.
$$

Similarly, for the corresponding globally efficient mix of foreign policies, τ^F_1 and τ^F_x, multiplying $[E4]'$ by $\frac{d\tau^F_x}{d\tau^F_1}=-\frac{\partial \widetilde{\rho}^W_1/\partial \tau^F_1}{\partial \widetilde{\rho}^W_1/\partial \tau^F_x}=-\frac{\partial \widetilde{\rho}^W_{x_F}/\partial \tau^F_1}{\partial \widetilde{\rho}^W_{x_F}/\partial \tau^F_x}$ and adding it to $[E2]'$ yields

$$
[E6]' \qquad 0=W^F_{p^F_1}+W^F_{p^F_{x_F}}\frac{\partial \widetilde{\rho}^W_{x_F}/\partial \tau^F_1}{\partial \widetilde{\rho}^W_{x_F}/\partial \tau^F_x}.
$$

Not only $[E5]'$ but also $[E6]'$ indicates that at globally efficient policy choices, one government's policy changes holding $\widetilde{\rho}^W_1$ and $\widetilde{\rho}^W_{x_F}$ constant do not affect the welfare of the trade counterpart and even have no first-order effect on its own welfare, which is a crucial difference from $[E6]$ in section 2.

Meanwhile, noncooperative trade policies chosen by each government in the Nash equilibrium are now characterized by the following conditions:

$$
\begin{aligned}
[N1]' \qquad 0 \;=\; & \left[\frac{1}{1-s}W^H_{p^H_1}+W^H_{\widetilde{\rho}^W_1}+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_1}+W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial \widetilde{\rho}^W_1}\right]\frac{\partial \widetilde{\rho}^W_1}{\partial \tau^H_1} \\
& +\left[\frac{1}{s}W^H_{p^H_{x_F}}+W^H_{\widetilde{\rho}^W_{x_F}}+W^H_{p^H_1}\frac{\partial p^H_1}{\partial \widetilde{\rho}^W_{x_F}}+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_{x_F}}\right]\frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^H_1} \\
& -W^H_{p^H_1}+W^H_{\widetilde{p}^H_{x_H}}\frac{\partial \widetilde{p}^H_{x_H}}{\partial \tau^H_1}+W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial \tau^H_1};
\end{aligned}
$$

$$[N2]' \qquad 0 = \left[\frac{1}{1-s}W^F_{p^F_1} + W^F_{\widetilde{\rho}^W_1}\right]\frac{\partial\widetilde{\rho}^W_1}{\partial\tau^F_1} + \left[\frac{1}{s}W^F_{p^F_{x_F}} + W^F_{\widetilde{\rho}^W_{x_F}}\right]\frac{\partial\widetilde{\rho}^W_{x_F}}{\partial\tau^F_1} + W^F_{p^F_1};$$

$$[N3]' \qquad 0 = \left[\frac{1}{1-s}W^H_{p^H_1} + W^H_{\widetilde{\rho}^W_1} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial\widetilde{p}^H_{x_H}}{\partial\widetilde{\rho}^W_1} + W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial\widetilde{\rho}^W_1}\right]\frac{\partial\widetilde{\rho}^W_1}{\partial\tau^H_x}$$
$$+\left[\frac{1}{s}W^H_{p^H_{x_F}} + W^H_{\widetilde{\rho}^W_{x_F}} + W^H_{p^H_1}\frac{\partial p^H_1}{\partial\widetilde{\rho}^W_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial\widetilde{p}^H_{x_H}}{\partial\widetilde{\rho}^W_{x_F}}\right]\frac{\partial\widetilde{\rho}^W_{x_F}}{\partial\tau^H_x}$$
$$+W^H_{p^H_1}\frac{\partial p^H_1}{\partial\tau^H_x} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial\widetilde{p}^H_{x_H}}{\tau^H_x} + W^H_{p^H_{x_F}};$$

$$[N4]' \qquad 0 = \left[\frac{1}{1-s}W^F_{p^F_1} + W^F_{\widetilde{\rho}^W_1}\right]\frac{\partial\widetilde{\rho}^W_1}{\partial\tau^F_x} + \left[\frac{1}{s}W^F_{p^F_{x_F}} + W^F_{\widetilde{\rho}^W_{x_F}}\right]\frac{\partial\widetilde{\rho}^W_{x_F}}{\partial\tau^F_x} - W^F_{p^F_{x_F}},$$

which are accompanied by

$$[N5]' \qquad 0 = -W^H_{p^H_1} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial\widetilde{p}^H_{x_H}}{\partial\tau^H_1} + W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial\tau^H_1} - \left[W^H_{p^H_1}\frac{\partial p^H_1}{\partial\tau^H_x} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial\widetilde{p}^H_{x_H}}{\tau^H_x} + W^H_{p^H_{x_F}}\right]\frac{\partial\widetilde{\rho}^W_{x_F}/\partial\tau^H_1}{\partial\widetilde{\rho}^W_{x_F}/\partial\tau^H_x};$$

$$[N6]' \qquad 0 = W^F_{p^F_1} + W^F_{p^F_{x_F}}\frac{\partial\widetilde{\rho}^W_{x_F}/\partial\tau^F_1}{\partial\widetilde{\rho}^W_{x_F}/\partial\tau^F_x}.$$

By comparing Nash conditions with the global efficiency conditions, it can be seen that

$$[N1]' + [N2]' - [E2]' = (1-s)\,W^H_{\widetilde{\rho}^W_1} = E^H_1 > 0;$$
$$[N3]' + [N4]' - [E3]' = sW^F_{\widetilde{\rho}^W_{x_F}} = M^H_x > 0,$$

which means that the sum of trade taxes on final goods, $\left(\tau^H_1 + \tau^F_1\right)$, and that on inputs, $\left(\tau^H_x + \tau^F_x\right)$, employed in the Nash equilibrium is inefficiently high, respectively. We also find that $[N5]' = [E5]'$ and $[N6]' = [E6]'$, which means that the trade policy mix employed by home and foreign government in the Nash equilibrium is globally efficient, respectively. Among the three sources of Nash inefficiencies that were detected in section 2.4, the third source goes away by using the trade-weighted terms of trade. Furthermore, as we will confirm it shortly, the remaining two sources of Nash inefficiencies disappear under the political optimum.

Noncooperative trade policies chosen by each government under the political optimum are now characterized by the following conditions:

$$[PO1]' \qquad 0 = \left[\frac{1}{1-s}W^H_{p^H_1} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial\widetilde{p}^H_{x_H}}{\partial\widetilde{\rho}^W_1} + W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial\widetilde{\rho}^W_1}\right]\frac{\partial\widetilde{\rho}^W_1}{\partial\tau^H_1}$$
$$+\left[\frac{1}{s}W^H_{p^H_{x_F}} + W^H_{p^H_1}\frac{\partial p^H_1}{\partial\widetilde{\rho}^W_{x_F}} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial\widetilde{p}^H_{x_H}}{\partial\widetilde{\rho}^W_{x_F}}\right]\frac{\partial\widetilde{\rho}^W_{x_F}}{\partial\tau^H_1}$$
$$-W^H_{p^H_1} + W^H_{\widetilde{p}^H_{x_H}}\frac{\partial\widetilde{p}^H_{x_H}}{\partial\tau^H_1} + W^H_{p^H_{x_F}}\frac{\partial p^H_{x_F}}{\partial\tau^H_1};$$

$$
\begin{aligned}
[PO2]' \qquad 0 &= \frac{1}{1-s} W^F_{p^F_1} \frac{\partial \widetilde{\rho}^W_1}{\partial \tau^F_1} + \frac{1}{s} W^F_{p^F_{x_F}} \frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^F_1} + W^F_{p^F_1}; \\
[PO3]' \qquad 0 &= \left[\frac{1}{1-s} W^H_{p^H_1} + W^H_{\widetilde{p}^H_{x_H}} \frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_1} + W^H_{p^H_{x_F}} \frac{\partial p^H_{x_F}}{\partial \widetilde{\rho}^W_1} \right] \frac{\partial \widetilde{\rho}^W_1}{\partial \tau^H_x} \\
&\quad + \left[\frac{1}{s} W^H_{p^H_{x_F}} + W^H_{p^H_1} \frac{\partial p^H_1}{\partial \widetilde{\rho}^W_{x_F}} + W^H_{\widetilde{p}^H_{x_H}} \frac{\partial \widetilde{p}^H_{x_H}}{\partial \widetilde{\rho}^W_{x_F}} \right] \frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^H_x} \\
&\quad + W^H_{p^H_1} \frac{\partial p^H_1}{\partial \tau^H_x} + W^H_{\widetilde{p}^H_{x_H}} \frac{\partial \widetilde{p}^H_{x_H}}{\tau^H_x} + W^H_{p^H_{x_F}}; \\
[PO4]' \qquad 0 &= \frac{1}{1-s} W^F_{p^F_1} \frac{\partial \widetilde{\rho}^W_1}{\partial \tau^F_x} + \frac{1}{s} W^F_{p^F_{x_F}} \frac{\partial \widetilde{\rho}^W_{x_F}}{\partial \tau^F_x} - W^F_{p^F_{x_F}}.
\end{aligned}
$$

We can easily show that $[PO1]' + [PO2]' = [E1]' = [E2]'$ and $[PO3]' + [PO4]' = [E3]' = [E4]'$, which means that the sum of trade taxes $\left(\tau^H_1 + \tau^F_1\right)$ and $\left(\tau^H_x + \tau^F_x\right)$ is globally efficient under the political optimum, respectively. That is, by using the trade-weighted terms of trade, the Nash inefficiencies can be traced only to the terms-of-trade manipulation.

4.2 Market access based on the trade-weighted terms of trade

We are now ready to specify the market access using the trade-weighted terms of trade that we proposed in the previous subsection. Given a particular set of trade-weighted world prices, $\overline{\rho}^W_1$ and $\overline{\rho}^W_{x_F}$, we may re-define the foreign market access for final goods afforded for the trade counterpart H and the home market access for foreign inputs afforded for the trade counterpart F as follows:

$$
\begin{aligned}
m_1 &\equiv M^F_1(p^F_1\left(\tau^F_1, \overline{\rho}^W_1\right)); \\
m_x &\equiv M^H_x\left(p^H_1\left(\tau^H_1, \tau^H_x, \overline{\rho}^W_1, \overline{\rho}^W_{x_F}\right), \widetilde{p}^H_{x_H}\left(\tau^H_1, \tau^H_x, \overline{\rho}^W_1, \overline{\rho}^W_{x_F}\right), p^H_{x_F}\left(\tau^H_1, \tau^H_x, \overline{\rho}^W_1, \overline{\rho}^W_{x_F}\right)\right).
\end{aligned}
$$

In line with our analysis in section 3.1, let us suppose that home and foreign governments negotiate over the levels of their tariffs and commit to the market access levels implied by the agreed tariffs, $\left(\overline{\tau}^H_1, \overline{\tau}^F_1, \overline{\tau}^H_x, \overline{\tau}^F_x\right)$, and the corresponding trade-weighted world prices, $\left(\overline{\rho}^W_1, \overline{\rho}^W_{x_F}\right)$, and that the negotiation reaches to the efficient trade volumes such that $m_1 = m^E_1$ and $m_x = m^E_x$. We will show that such trade agreement will achieve globally efficient outcomes that are lasting.

On the one hand, home government may make adjustments to its once-agreed choices of $\left(\overline{\tau}^H_1, \overline{\tau}^H_x\right)$ only so long as the adjustments do not alter the trade-weighted world prices from $\left(\overline{\rho}^W_1, \overline{\rho}^W_{x_F}\right)$. Holding each trade-weighted world price constant, home government could slightly raise τ^H_1 and lower τ^H_x simultaneously, or vice versa. Such unilateral policy adjustments, however, imply that $\widetilde{p}^W_{x_F}$ and the equilibrium trade volume for inputs, M^H_x, should remain unaltered in order to neutralize the effects of tariff changes on $\overline{\rho}^W_{x_F}$. With both $\widetilde{p}^W_{x_F}$ and M^H_x constant, the adjustments result in leaving $\widetilde{p}^W_1$ and the equilibrium trade volume for final goods, E^H_1, unaltered as well. Therefore, even if home government makes unilateral policy adjustments, it results in no impact on foreign welfare, only causing internal surplus shift within the home country.

On the other hand, foreign government may make adjustments to its once-agreed choices of $\left(\overline{\tau}_1^F, \overline{\tau}_x^F\right)$ only so long as the adjustments do not alter the trade-weighted world prices from $\left(\overline{\rho}_1^W, \overline{\rho}_{x_F}^W\right)$. Holding each trade-weighted world price constant, foreign government could lower both τ_1^F and τ_x^F simultaneously so as to unilaterally open up the market for final goods, M_1^F, while increasing the input trade volume, E_x^F. Notice that such unilateral policy adjustments leaving the trade-weighted terms of trade constant result in a lower $\widetilde{p}_1^W$ and a lower $\widetilde{p}_{x_F}^W$, which may improve or deteriorate the conventional terms of trade. In other words, what we found in section 3.1 can be interpreted as indicating that foreign government sometimes can change market access in a way that holds the conventional terms of trade constant but improves the trade-weighted terms of trade to its advantage. As long as both $\overline{\rho}_1^W$ and $\overline{\rho}_{x_F}^W$ remain constant, however, foreign government is no longer able to shift the cost of its unilateral policy changes onto the home country without violating the market access commitment. Hence, we would conclude that to achieve globally efficient outcomes in the presence of cross-border unbundling, trade agreement can be designed by specifying the market access commitment based on the trade-weighted terms of trade so that each government cannot change market access in a way that improves the trade-weighted terms of trade.

4.3 Reciprocity

So far we found that in the presence of cross-border unbundling, governments can mutually gain from a trade agreement which specifies the market access commitment based on the trade-weighted terms of trade and sets the market access levels equal to the globally efficient trade volumes. Then, how can such globally efficient outcomes be achieved through trade agreement in a reciprocal manner? In trade negotiations, it is often the case that each government views a reduction in its own tariff as a concession that is offered only if the trading partner reciprocates with another concession. The general meaning of reciprocity then refers to the balance of concessions that governments seek in the trade negotiations (Bagwell and Staiger, 2001b). Let us start by formalizing what is meant by a balance of concessions in our model of trade agreement with cross-border unbundling, in the same vein as Bagwell and Staiger (2001b). We then consider the liberalization paths that governments might follow in moving from Nash equilibrium to a globally efficient trade agreement.

We will say that a proposed set of tariffs, $\left(\tau_1^{H1}, \tau_1^{F1}, \tau_x^{H1}, \tau_x^{F1}\right)$, achieves a balance of concessions relative to an existing set of tariffs, $\left(\tau_1^{H0}, \tau_1^{F0}, \tau_x^{H0}, \tau_x^{F0}\right)$, provided that, when valued at existing trade-weighted world prices, the proposed tariff reductions together bring about equal increases in the volume of each country's exports and imports:

$$
\begin{aligned}
& \widetilde{\rho}_1^W \left(\tau_1^{H0}, \tau_1^{F0}, \tau_x^0\right) \left[E_1^H \left(\tau_1^1, \tau_x^1\right) - E_1^H \left(\tau_1^0, \tau_x^0\right)\right] \\
= \; & \widetilde{\rho}_{x_F}^W \left(\tau_1^0, \tau_x^{H0}, \tau_x^{F0}\right) \left[M_x^H \left(\tau_1^1, \tau_x^1\right) - M_x^H \left(\tau_1^0, \tau_x^0\right)\right] + M_0^H \left(\tau_1^1, \tau_x^1\right) - M_0^H \left(\tau_1^0, \tau_x^0\right),
\end{aligned}
$$

where M_0^H denotes the home country's imports of the numeraire good 0 and we simplify our notation and express trade volumes as functions of the sum of trade taxes, $\tau_1 = \tau_1^H + \tau_1^F$ and $\tau_x = \tau_x^H + \tau_x^F$. Using the requirement of balanced trade at a particular set of world prices, the reciprocity condition can be rewritten as

$$\begin{aligned}
& \left[\widetilde{p}_1^W\left(\tau_1^{H0},\tau_1^{F0},\tau_x^0\right)-\widetilde{p}_1^W\left(\tau_1^{H1},\tau_1^{F1},\tau_x^1\right)\right]E_1^H\left(\tau_1^1,\tau_x^1\right) \\
& -s(\tau_1^0,\tau_x^0)\widetilde{p}_1^W\left(\tau_1^{H0},\tau_1^{F0},\tau_x^0\right)\left[E_1^H\left(\tau_1^1,\tau_x^1\right)-E_1^H\left(\tau_1^0,\tau_x^0\right)\right] \\
= & \left[\widetilde{p}_{x_F}^W\left(\tau_1^0,\tau_x^{H0},\tau_x^{F0}\right)-\widetilde{p}_{x_F}^W\left(\tau_1^1,\tau_x^{H1},\tau_x^{F1}\right)\right]M_x^H\left(\tau_1^1,\tau_x^1\right) \\
& -\left(1-s(\tau_1^0,\tau_x^0)\right)\widetilde{p}_{x_F}^W\left(\tau_1^0,\tau_x^{H0},\tau_x^{F0}\right)\left[M_x^H\left(\tau_1^1,\tau_x^1\right)-M_x^H\left(\tau_1^0,\tau_x^0\right)\right].
\end{aligned}$$

This condition is satisfied by any set of tariff reductions that (i) leaves both world prices and trade volumes, or the trade-weighted world prices, unchanged, (ii) alters the trade-weighted world prices in a way that keeps each country's welfare unaffected by the changes in the trade-weighted world prices, or (iii) alters the trade-weighted world prices in a way that keeps the values each country can earn from trade in final goods and the associated inputs, that is, value-added exports, unaffected by the changes in the trade-weighted world prices.

With a balance of concessions defined above, as liberalization occurs from the Nash equilibrium and the sum of trade taxes, τ_1 and τ_x, is reduced, trade volumes increase and the world prices adjust so that the effects of each government's tariff reductions on the trade-weighted terms of trade will neutralize with each other. In effect, each government seeks reciprocal tariff reductions from the trading partner so as to coordinate with each other in changing value-added created from trade in final goods and the associated inputs.

5 Conclusion

This paper considered a two-country model of trade agreement with cross-border unbundling of production, in which the final-good producer imports foreign intermediate inputs, to assemble them, combined with domestically-sourced inputs, into final goods, some of which then are domestically consumed and the rest exported back to the trade counterpart. By doing so, we showed that offshoring of intermediate inputs introduces a new reason for trade policy intervention and changes the role and design of trade agreement to achieve globally efficient outcomes. As one of the sources of inefficiencies arising in the noncooperative trade policy choices, we highlighted an interrelationship between market-clearing prices of the final goods and the associated domestic and foreign inputs through production linkage. The impact of a trade policy targeting a certain product travels through the production linkage, which gives rise to the local price externality as well as the terms-of-trade externality caused by trade policy intervention. The potential of trade agreement to solve the inefficiencies would be called for beyond the conventional market-access argument. Indeed, we proposed to use the trade-weighed terms of trade to specify the market access in trade agreement with the presence of cross-border unbundling.

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