The economics of trade agreements in the linear Cournot delocation model

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1. Introduction

The treatment of export subsidies in trade agreements is puzzling. It is often observed that export subsidies distort market forces and lead to inefficient patterns of trade, and that the use of export subsidies should be restricted by international agreement for this reason. Formulating this position, however, has proven to be surprisingly elusive. In fact, formal arguments for the treatment of export subsidies in trade agreements point to a starkly different conclusion: rather than restrain export subsidies, international agreements should, if any-thing, encourage them. At a basic level, this conclusion reflects the trade-volume-expanding nature of export subsidies, which generally aligns these policies with the purpose of a trade agreement.

In practice, the treatment of export subsidies is also complex, and has evolved over time from the early years of the General Agreement on Tariffs and Trade (GATT) to the creation of GATT’s successor, the World Trade Organization (WTO). In the early GATT era, a permissive stance was taken on export subsidies, amounting to little more than reporting requirements. Over time GATT restrictions on the use of export subsidies were progressively tightened, and during the final GATT negotiation round (the Uruguay Round) in which the WTO was created, a more comprehensive approach to subsidies was introduced in the Agreement on Subsidies and Countervailing Measures (the SCM Agreement) which includes a prohibition on the use of export subsidies.

Theoretical attempts to understand and interpret the treatment of export subsidies in trade agreements face two challenges. A first challenge is to find situations in which a government actually would be tempted to use an export subsidy. A second challenge is to show that a ceiling on export subsidies would then be beneficial for the negotiating governments. The first step has been taken in the distinct literatures on strategic trade policy and on the political economy of trade policy. The second step is especially perplexing. To be sure, for the models developed in these literatures, the governments of exporting countries could enjoy mutual gains from an agreement to impose ceilings on export subsidies. But once importing-country welfare is considered, mutual gains for the negotiating governments would require that exporting countries face floors on export subsidies. Therefore, the existing theories imply a provocative interpretation of GATT/ WTO efforts to reign in export subsidies: these efforts represent an...
inefficient victory for exporting governments that comes at the expense of importing governments.

In this paper, we demonstrate that it is possible to develop a formal treatment of export subsidies in trade agreements in which a more benign interpretation of the GATT/WTO efforts to reign in export subsidies emerges. And we suggest that the gradual tightening of restraints on export subsidies that has occurred in the GATT/WTO may be interpreted as deriving naturally from the gradual reduction in import barriers that member countries have negotiated. To make these points, we adopt the Cournot delocation model first introduced by Venables (1985). Venables shows that, if countries start at global free trade (i.e., if each country sets its import and export policy at free trade), then a country gains by introducing a small export subsidy and its trading partner loses. Assuming that countries start at global free trade, Venables also shows that a country gains, and its trading partner again loses, when the country imposes a small import tariff.

Venables does not characterize the Nash equilibrium in import and export policies, though, and so does not address the first step mentioned above, namely, confirming that a government actually would use an export subsidy. As well, he does not consider efficiency, and so does not assess the second step mentioned above, namely, confirming that negotiated restraints on export subsidies could lead to mutual gains for the negotiating governments. We focus on a linear model and address both steps, and thereby advance the understanding of the linear Cournot delocation model at the same time that we provide a potential efficiency-enhancing interpretation for WTO rules on export subsidies.

More specifically, we consider trade policies and agreements in the linear Cournot delocation model. In this model, two countries trade a given homogeneous good subject to trade costs. The markets are segmented and firms compete as Cournot competitors, leading to the possibility of two-way trade in identical products. This model exhibits a firm-delocation effect, whereby a higher trade cost along one channel of trade increases the number of firms in the importing country and decreases the number of firms in the exporting country. And as Venables (1985) emphasizes, by altering the intensity of Cournot competition across markets, the firm-delocation effect can give rise to novel reasons for unilateral trade policy intervention.

We first offer a thorough analysis of the manner in which prices and trade volumes respond to changes in trade costs such as a change in an import or export tax. Following Venables (1985), we then show that, starting at global free trade, the introduction of a small import tariff or export subsidy generates a welfare gain for the intervening country and a welfare loss for its trading partner. For symmetric policies, we also establish that an efficient set of trade policies in this model entails a net trade tax of zero along each channel of trade; for example, countries achieve an efficient outcome under global free trade. Viewed together, these findings suggest a potential efficiency-enhancing interpretation for WTO rules, which place ceilings on import tariffs and export subsidies.

We show, however, that this interpretation is subtle. In particular, we also consider the Nash equilibrium in trade policies, and we find that export taxes are used in the Nash equilibrium, in addition to import tariffs. Thus, if the trade policies of countries are sufficiently close to their non-cooperative levels, then a ceiling on export subsidies by itself would be meaningless.

The finding that Nash policies involve export taxes arises as well in traditional models that feature perfectly competitive markets; however, it is perhaps unexpected in the Cournot delocation model, given that the optimal export-policy departure from global free trade involves the introduction of an export subsidy. To interpret our characterization of the Nash equilibrium, we show that, if a country's trade policies start at free trade, then that country could gain by introducing a small import tariff combined with a small export tax, where these policy changes are set so as to maintain the free-trade price in the intervening country. This unilateral variation leaves unaltered the level of consumer surplus in the intervening country while giving it greater tariff revenue. We provide further interpretation of the Nash equilibrium by showing that, if a country's trade policies start in the neighborhood of free trade, then a novel tariff-complementarity effect exists, whereby the country's import and export tariffs exert a complementary effect on its tariff revenue.

With these results in place, we may then understand why a country is unlikely to use an export subsidy when it is already imposing a significant import tariff. Intuitively, an import tariff induces entry by firms in the intervening country via the firm-delocation effect, which ultimately increases exports and raises the cost of an export-subsidy program. Moreover, we may also understand why, in the presence of a significant import tariff, an export tax begins to look appealing: by inducing entry of firms in the intervening country's trading partner, the firm-delocation effect that is associated with the export tax raises the volume of imports on which the import tariff is applied, thereby enhancing the revenue benefits of the import tariff.

In the Nash equilibrium, therefore, an export tax is used in conjunction with an import tariff. If a tight ceiling on import tariffs is imposed, however, then a country may be tempted to use an export subsidy. From this perspective, we may speculate that the imposition over time in the WTO of tighter restrictions on the use of export subsidies may ultimately be explained by the success that this institution has had over time in facilitating negotiations leading to tighter ceilings on import tariffs by member countries. We thus provide a subtle and potentially rich interpretation of the treatment of export subsidies in the WTO.

To further develop this interpretation, we provide two results concerning the liberalization path from the Nash equilibrium to the efficiency frontier. First, starting at the Nash equilibrium, we show that the welfare of each country is sure to increase if governments agree to small and symmetric reductions in import tariffs, export tariffs, or import and export tariffs. As we note, a surprising feature of our analysis is that countries can achieve mutual gains by exchanging small reductions in export tariffs, even though the trading partner receives a terms-of-trade loss when a country reduces its export tariff. Second, we characterize the properties of any symmetric agreement on import tariffs that achieves efficiency, when governments face no restrictions on the use of export policies. This second characterization is motivated by the fact that export subsidies were largely unregulated in GATT. We find that any such agreement must entail a positive import tariff that is offset exactly by a positive export subsidy, so that the total trade tax is zero. Starting at such an agreement, if governments were to pursue a subsequent agreement that prohibited the use of export subsidies, then efficiency would be maintained if subsequent agreement also resulted in a reduction of import tariffs to the free-trade level. While our model does not imply a preference for one path of liberalization to the efficiency frontier over another, these two results together suggest that an initial emphasis on cutting import tariffs, the subsequent emergence of export subsidies, and a final effort to ban export subsidies while further reducing tariffs is compatible with efficiency.

From a policy perspective, our findings thus suggest that the linear Cournot delocation model can offer interpretations of some of the central features of the GATT/WTO treatment of export subsidies that are puzzling when viewed from the standard models of the existing literature. This model, however, is quite special along a number of dimensions, and a question raised by our findings is therefore the extent to which the model is empirically relevant in the context of real-world export policy. While it is beyond the scope of our paper to answer this question, in the conclusion we mention several points that may be relevant in providing an eventual answer.

The rest of the paper proceeds as follows. In Section 2 we develop the linear Cournot delocation model. Section 3 then characterizes unilateral and efficient trade policies, while Section 4 characterizes the Nash equilibrium trade policies. In Section 5 we interpret these
2. Cournot delocation model

In this section, we develop a model of two countries that trade a given homogeneous good, where the markets are segmented and firms compete as Cournot competitors. We begin by analyzing the model in a “short-run” setting in which the number of firms is fixed in each country. We then allow for endogenous entry and exit and thus adopt a “long-run” orientation. We present short- and long-run comparative statics results. In later sections, we use this model to analyze trade policies.

2.1. Basic assumptions

We focus on a good that is produced and consumed in both a domestic or home country and in a foreign country, and we use asterisks (*) to denote foreign-country variables. The respective markets are segmented, and so prices may differ across the two markets. The firms compete in a Cournot fashion. As is well known, in this setting, two-way (intra-industry) trade may occur.

We assume that demand and cost functions are linear. With the domestic price denoted as \( P \) and the foreign price denoted as \( P^* \), the inverse domestic and foreign demand functions are then given by \( P(Q) = 1 - Q \) and \( P^*(Q^*) = 1 - Q^* \), respectively, where \( Q \) denotes the units of the good supplied to the domestic market and \( Q^* \) denotes the units of the good supplied to the foreign market. Whether a firm is located in the domestic or foreign market, the firm has a constant marginal cost of production, \( c \), where \( 1 > c \geq 0 \). Each firm also incurs a fixed cost \( F > 0 \) upon entry. We assume that the fixed cost is never so large as to preclude entry by more than one firm.

Finally, when a domestic firm exports output to the foreign market, it incurs a per-unit trade cost of \( \tau^* > 0 \); likewise, when a foreign firm exports output to the domestic market, it incurs a per-unit trade cost of \( \tau > 0 \). As discussed further in the next section, the trade cost facing any firm is the sum of the specific export tariff that its own country imposes, the specific import tariff that the other country imposes, and the per-unit transport cost, \( \phi > 0 \). Throughout we assume that these trade costs are non-prohibitive.

2.2. Short-run analysis

We first present our short-run analysis, where the number of firms in each country is taken as fixed. Let \( n_i \) be the number of home firms and \( n_f \) be the number of foreign firms.

We begin by considering the output choices of some home firm \( i \). Let \( q_{ih} \) be the output for home firm \( i \) that is sold in the home market, \( q_{if} \) be the output of each other home firm for sales in the home market, and \( q_{ih}^* \) be the output of each foreign firm for sales in the home market. Similarly, let \( q_{if}^* \) be the output for home firm \( i \) that is sold in the foreign market, \( q_{if}^* \) be the output of each other home firm for sales in the foreign market, and \( q_{if}^* \) be the output of each foreign firm for sales in the foreign market. We may now define the short-run profit function for home firm \( i \) as

\[
\pi_i^h = \left[ P\left(q_{ih} + (n_h-1)q_{if} + n_f q_{if}^*\right) - c\right] q_{ih}^* + \left[ P\left(q_{ih}^* + (n_h-1)q_{ih} + n_f q_{if}^*\right) - (c + \tau^*)\right] q_{ih}^* - F. \tag{1}
\]

Recall that \( \tau^*>0 \) denotes the total trade cost expressed in specific (per-unit) terms for sales of domestic firms in the foreign market.

A domestic firm chooses \( q_{ih}^* \) and \( q_{if}^* \) to maximize its short-run profit. Using Eq. (1), the first-order conditions for profit maximization are given by

\[
P\left(q_{ih} + (n_h-1)q_{if} + n_f q_{if}^*\right) - c = q_{ih}^* \left. \right|_{\tau^*} = q_{ih}^* \left. \right|_{\tau^*} \quad \text{and} \quad P\left(q_{ih}^* + (n_h-1)q_{ih} + n_f q_{if}^*\right) - (c + \tau) = q_{ih}^* \left. \right|_{\tau} = q_{ih}^* \left. \right|_{\tau},
\]

from which the short-run reaction functions for firm \( i \), \( q_{ih}^*\left(q_{if}, q_{if}^*, n_h, n_f\right) \) and \( q_{ih}^*\left(q_{if}, q_{if}^*, n_h, n_f, \tau^*\right) \), may be derived. Imposing within-country symmetry by setting \( q_i = q_f \) and \( q_i^* = q^*_f \), we can derive home-firm reaction functions, which may be represented as \( q_{ih}^*\left(q_{if}, n_h, n_f, \tau\right) \) and \( q_{ih}^*\left(q_{if}, n_h, n_f, \tau^\ast\right) \).

Consider next the output choices of some foreign firm \( i \). Let \( q_{if}^* \) denote the output of foreign firm \( i \) for sales in the foreign market and \( q_{if}^* \) denote the output of foreign firm \( i \) for sales in the home market. The short-run profit function for foreign firm \( i \) is then defined as

\[
\pi_i^f = \left[ P\left(q_{if} + (n_f-1)q_{if} + n_h q_{ih}^*\right) - c\right] q_{if}^* + \left[ P\left(q_{if}^* + (n_f-1)q_{if} + n_h q_{ih}^*\right) - (c + \tau)\right] q_{if}^* - F. \tag{3}
\]

Similarly, let \( q_{ih}^* \) be the output of each foreign firm for sales in the foreign market, and \( q_{if}^* \) be the output of each foreign firm for sales in the foreign market. We may now define the short-run profit function for foreign firm \( i \) as

\[
\pi_i^f = \left[ P\left(q_{if} + (n_f-1)q_{if} + n_h q_{ih}^*\right) - c\right] q_{if}^* + \left[ P\left(q_{if}^* + (n_f-1)q_{if} + n_h q_{ih}^*\right) - (c + \tau^*)\right] q_{if}^* - F. \tag{4}
\]

As above, we may now derive the short-run reaction functions for foreign firm \( i \), impose within-country symmetry by setting \( q_i^* = q_f^* \) and \( q_i = q_f \), and thus derive the foreign-firm reaction functions, \( q_{if}^*\left(q_{ih}, n_h, n_f\right) \) and \( q_{if}^*\left(q_{ih}, n_h, n_f, \tau^*\right) \).

We may now solve for the Cournot–Nash equilibrium quantities in each of the two (segmented) markets. For the home market, we find

\[
q_{ih}^N\left(n_h, n_f, \tau\right) = \frac{1-c-\tau n_f}{1+n_h+n_f} \quad : \quad q_{ih}^N\left(n_h, n_f, \tau\right) = \frac{1-c-\tau(1+n_h)}{1+n_h+n_f}. \tag{5}
\]

As expected, each home (foreign) firm produces more in the domestic market when its marginal cost of production is lower, the trade cost facing foreign firms is higher (lower), and the number of domestic or foreign firms is lower. Letting the aggregate Cournot–Nash quantity in the home market be expressed as \( Q^N\equiv n_h q_{ih}^N + n_f q_{ih}^N \), it then follows from Eq. (5) that

\[
Q^N\left(n_h, n_f, \tau\right) = \frac{\left(n_h + n_f\right)(1-c)-\tau n_f}{1+n_h+n_f}, \quad \text{and} \quad P^N\left(n_h, n_f, \tau\right)\equiv 1-Q^N\left(n_h, n_f, \tau\right) = \frac{1+c n_h + (c + \tau)n_f}{1+n_h+n_f}. \tag{6}
\]

The Cournot output (price) in the domestic market decreases (increases) with the trade cost, \( \tau \), and increases (decreases) with the numbers of domestic and foreign firms, \( n_h \) and \( n_f \).

\[5\] The home- and foreign-firm reaction functions have the following explicit forms:

\[
q_{ih}^*\left(q_{if}, n_h, n_f\right) = \left(1 - n_f q_f - c\right)/(n_h + 1), q_{ih}^*\left(q_{if}, n_h, n_f, \tau\right) = \left(1 - n_f \tau q_f - c\right)/(n_h + 1), q_{ih}^*\left(q_{if}, n_h, n_f, \tau\right) = \left(1 - n_f \tau q_f - c\right)/(n_h + 1), q_{if}^*\left(q_{ih}, n_h, n_f\right) = \left(1 - n_h q_h - c\right)/(n_f + 1) \] and \( q_{if}^*\left(q_{ih}, n_h, n_f, \tau\right) = \left(1 - n_h q_h - c\right)/(n_f + 1). \]
Likewise, for the foreign market, we find

\[
q_f^N(n_h, n_f, \tau^*) = \frac{1 - c + \tau^*}{1 + n_h + n_f}, \quad q_h^N(n_h, n_f, \tau^*) = \frac{1 - c - \tau^* (1 + n_f)}{1 + n_h + n_f}.
\]

(7)

Letting the aggregate Cournot–Nash quantity in the foreign market be expressed as \(Q^N = n_o + n_f q_f^N\), we have from (7) that

\[
Q^N(n_h, n_f, \tau^*) = \frac{(n_h + n_f)(1 - c - \tau^*)}{1 + n_h + n_f}
\]

\[\begin{align*}
p^N(n_h, n_f, \tau^*) & = 1 - Q^N(n_h, n_f, \tau^*) = \frac{1 + c n_f + (c + \tau^*) n_h}{1 + n_h + n_f}.
\end{align*}\]

(8)

Thus, the Cournot output (price) in the foreign market decreases (increases) with the trade cost, \(\tau^*\), and increases (decreases) with the numbers of domestic and foreign firms, \(n_h\) and \(n_f\).

Finally, the Cournot–Nash quantities from Eqs. (5) and (7) may be plugged into the domestic-firm profit expression found in Eq. (1) to define the short-run maximized profit of a home firm:

\[
\Pi^h(n_h, n_f, \tau^*, \tau) \equiv [p^h(n_h, n_f, \tau) - c] q^h(n_h, n_f, \tau) + [p^N(n_h, n_f, \tau) - (c + \tau^*)] q^N(n_h, n_f, \tau^*) - F.
\]

Using the first-order condition for profit maximization in Eq. (2), we may simplify and write

\[
\Pi^h(n_h, n_f, \tau^*, \tau) = \left( q^h(n_h, n_f, \tau) \right)^2 + \left( q^N(n_h, n_f, \tau^*) \right)^2 - F.
\]

Similarly, using Eqs. (5), (7) and (3), we find that the short-run maximized profit of a foreign firm is

\[
\Pi^f(n_h, n_f, \tau^*, \tau) \equiv [p^h(n_h, n_f, \tau) - c] q^h(n_h, n_f, \tau) + [p^N(n_h, n_f, \tau) - (c + \tau^*)] q^N(n_h, n_f, \tau^*) - F.
\]

Using the first-order conditions for profit maximization in Eq. (4), we may again simplify and write

\[
\Pi^f(n_h, n_f, \tau^*, \tau) = \left( q^h(n_h, n_f, \tau) \right)^2 + \left( q^N(n_h, n_f, \tau^*) \right)^2 - F.
\]

We complete our short-run analysis of the model by considering comparative statics properties for the maximized profit functions. These properties are essential below, when we analyze the long-run implications of changes in trade policies. For a home firm, we find that

\[
\begin{align*}
\frac{\partial \Pi^h}{\partial \tau} & = 2 \frac{\partial q^h}{\partial \tau} > 0, \\
\frac{\partial \Pi^h}{\partial \tau^*} & = 2 q^h \frac{\partial \Pi^h}{\partial \tau} < 0,
\end{align*}
\]

(9)

where for notational simplicity we suppress functional dependencies on the right-hand side of these expressions. Thus, an increase in the trade cost \(\tau\) confronts foreign exporters generates an increase in profit for a home firm, whereas an increase in the trade cost \(\tau^*\) that a home firm faces when exporting results in a decrease in profit for a home firm. Turning now to the effect on a home firm's profit of changes in the numbers of firms, we find

\[
\begin{align*}
\frac{\partial \Pi^h}{\partial n_h} & = 2 q^h \frac{\partial \Pi^h}{\partial n_h} < 0, \\
\frac{\partial \Pi^h}{\partial n_f} & = 2 q^h \frac{\partial \Pi^h}{\partial n_f} < 0.
\end{align*}
\]

(10)

Thus, home firm profit falls when there is an increase in the number of domestic or foreign firms.

Similarly, for a foreign firm, we find that

\[
\begin{align*}
\frac{\partial \Pi^f}{\partial \tau} & = 2 q^f \frac{\partial \Pi^f}{\partial \tau} < 0, \\
\frac{\partial \Pi^f}{\partial \tau^*} & = 2 q^f \frac{\partial \Pi^f}{\partial \tau^*} > 0,
\end{align*}
\]

(11)

and

\[
\begin{align*}
\frac{\partial \Pi^f}{\partial n_h} & = 2 q^f \frac{\partial \Pi^f}{\partial n_h} < 0, \\
\frac{\partial \Pi^f}{\partial n_f} & = 2 q^f \frac{\partial \Pi^f}{\partial n_f} < 0.
\end{align*}
\]

(12)

These findings may be interpreted in an analogous fashion.

2.3. Long-run analysis and the firm-delocation effect

Thus far we have assumed that the numbers of domestic and foreign firms are fixed. A short-run modeling framework is appropriate for understanding how trade policies may shift profits between domestic and foreign firms, and indeed much of the strategic-trade literature employs this framework. In this paper, however, we are interested in the long-run effects of trade policy. We are therefore led to consider how trade policies may change the numbers of domestic and foreign firms as well as the outputs of individual firms. To this end, we now shift our focus to the long run and use the short-run analysis above to define and analyze the long-run industry equilibrium.

The key feature of the long-run analysis is that the numbers of domestic and foreign firms are endogenously determined by free-entry conditions. We thus now define the free-entry numbers of firms, \(n^h_0(\tau^*, \tau)\) and \(n^f_0(\tau^*, \tau)\), as the solutions to the free-entry conditions:

\[
I^h_0(n_h, n_f, \tau^*, \tau) = 0 = I^f_0(n_h, n_f, \tau^*, \tau).
\]

(13)

In all of our subsequent analysis, we assume that the numbers of domestic and foreign firms adjust to ensure that the free-entry conditions captured in Eq. (13) are satisfied.

We can analyze \(n^h_0(\tau^*, \tau)\) and \(n^f_0(\tau^*, \tau)\) as the solutions to the 2×2 system in Eq. (13). This system has the following Jacobian determinant, where the final expression is derived using Eqs. (10) and (12):

\[
| J | = \frac{\partial \Pi^h}{\partial n_h} \frac{\partial \Pi^f}{\partial n_f} - \frac{\partial \Pi^h}{\partial n_f} \frac{\partial \Pi^f}{\partial n_h} = \frac{2}{(1 + n_h + n_f)^2} \left[ q^h q^f - n^h_0 n^f_0 \right]^2 > 0.
\]

(14)
The inequality in Eq. (14) is important and follows since
\[ q_h^N - q_h^N = \tau^* + n_f(\tau + \tau^*) > 0, \quad \text{and} \]
\[ q_h^N - q_f^N = \tau^* + n_h(\tau + \tau^*) > 0 \] 
(15)
under our assumption that \( \tau > 0 \) and \( \tau^* > 0 \). The inequalities featured in Eq. (15) capture a local-market bias in firm sales: each firm produces more for sales in its local market than for export, when trade costs are positive. Given that the firms are otherwise symmetric, this means as well that each firm sells more in its local market than do firms that export into this market: \( q_h^N - q_h^N = \tau > 0 \), and \( q_h^N - q_h^N = \tau^* > 0 \). As will become clear below, the local-market bias in firm sales plays a critical role in determining the long-run implications of trade policies.

We next conduct long-run comparative statics on the numbers of domestic and foreign firms. Using the signs for partial derivatives of maximized profit functions as derived above in Eqs. (9)-(12), along with the sign of the Jacobian as given in Eq. (14), it can be confirmed that \( n_h^N(\tau^*, \tau) \) is decreasing in \( \tau^* \) and increasing in \( \tau \) and that \( n_f^N(\tau^*, \tau) \) is increasing in \( \tau^* \) and decreasing in \( \tau \). Thus, we observe the presence of a firm-deletion effect: a higher trade cost along one channel increases the numbers of firms in the importing country and decreases the number of firms in the exporting country.

For future use, we require explicit expressions for the firm-deletion effects associated with changes in trade policies. In particular, we find that a change in the trade cost that affects foreign exports induces the following changes in the numbers of domestic and foreign firms:
\[ \frac{\partial n_h^N}{\partial \tau} = \left[ q_h^N n_h^N \left( \left( q_h^N \right)^2 + \left( q_f^N \right)^2 \right) + q_h^N \left( 1 + n_h^N \right) \left( q_h^N q_f^N + q_h^N q_f^N \right) \right] > 0 \]
\[ \frac{\partial n_f^N}{\partial \tau} = -\left[ q_f^N \left( 1 + n_h^N \right) \left( \left( q_h^N \right)^2 + \left( q_f^N \right)^2 \right) + q_f^N n_h^N \left( q_h^N q_f^N + q_h^N q_f^N \right) \right] < 0, \] 
(16)
where we suppress notational dependencies. Similarly, a change in the trade cost that affects domestic exports results in the following changes in the numbers of domestic and foreign firms:
\[ \frac{\partial n_h^N}{\partial \tau} = -\left[ q_h^N \left( 1 + n_f^N \right) \left( \left( q_h^N \right)^2 + \left( q_f^N \right)^2 \right) + q_n^N n_h^N \left( q_h^N q_f^N + q_h^N q_f^N \right) \right] < 0 \]
\[ \frac{\partial n_f^N}{\partial \tau} = \left[ q_f^N n_h^N \left( \left( q_h^N \right)^2 + \left( q_f^N \right)^2 \right) + q_f^N \left( 1 + n_f^N \right) \left( q_h^N q_f^N + q_h^N q_f^N \right) \right] > 0. \]
(17)
These explicit expressions confirm what was previously indicated: an increase in the trade cost along any one channel of trade causes a decrease in the number of firms in the exporting country and an increase in the number of firms in the importing country.

Finally, we define the following long-run price and quantity functions. It is apparent that the long-run prices are ultimately functions of the trade costs:
\[ P^N(\tau^*, \tau) \equiv \frac{\partial P^N}{\partial \tau^*} \]
\[ P^N(\tau^*, \tau) \equiv \frac{\partial P^N}{\partial \tau} \]
Similarly, the long-run outputs of domestic and foreign firms in the domestic market are ultimately determined by the underlying trade costs:
\[ \bar{q}^N(\tau^*, \tau) \equiv \frac{\partial \bar{q}^N}{\partial \tau^*} \]
\[ \bar{q}^N(\tau^*, \tau) \equiv \frac{\partial \bar{q}^N}{\partial \tau} \]
The long-run outputs of domestic and foreign firms in the foreign market are similarly characterized:
\[ n_f^N(\tau^*, \tau) \equiv \frac{\partial n_f^N}{\partial \tau^*} \]
\[ n_f^N(\tau^*, \tau) \equiv \frac{\partial n_f^N}{\partial \tau} \]
These definitions identify the precise channels through which trade costs alter long-run prices and quantities. Our next step is to characterize the overall effect that a change in a trade cost has on long-run prices and trade volumes.

2.4. Long-run comparative statics on prices

The comparative statics results for prices reflect the firm-deletion effect. Observe that
\[ \frac{\partial P^N(\tau^*, \tau)}{\partial \tau} = p^N \frac{\partial Q^N}{\partial \tau} \left[ \frac{\partial Q^N}{\partial n_h^N} \frac{\partial n_h^N}{\partial \tau} + \frac{\partial Q^N}{\partial n_f^N} \frac{\partial n_f^N}{\partial \tau} + \frac{\partial Q^N}{\partial \tau} \right]. \]
(18)
Using Eqs. (6) and (16), we find that
\[ \frac{\partial P^N(\tau^*, \tau)}{\partial \tau} = -\bar{q}^N \left( \frac{\partial \bar{q}^N}{\partial \tau} \right) < 0, \] 
where the inequality uses the fact that Eq. (14) holds in particular at the free-entry values for the numbers of domestic and foreign firms under our assumption that \( \tau > 0 \) and \( \tau^* > 0 \). In other words, we see from Eq. (18) that long-run prices in this model behave in a surprising manner and in fact exhibit the Metzler paradox: a higher import tariff (or a higher foreign export tariff) induces so much domestic entry that the local domestic price actually falls.

Next, consider the effect on \( P^N \) of an increase in \( \tau^* \). We have
\[ \frac{\partial P^N(\tau^*, \tau)}{\partial \tau^*} = p^N \left( \frac{\partial Q^N}{\partial \tau^*} \right) \left[ \frac{\partial Q^N}{\partial n_h^N} \frac{\partial n_h^N}{\partial \tau^*} + \frac{\partial Q^N}{\partial n_f^N} \frac{\partial n_f^N}{\partial \tau^*} + \frac{\partial Q^N}{\partial \tau^*} \right]. \]
Using (6), (17) and (14), it follows that
\[ \frac{\partial P^N(\tau^*, \tau)}{\partial \tau^*} = \frac{\bar{q}^N \left( \frac{\partial \bar{q}^N}{\partial \tau^*} \right)}{\bar{q}^N \left( \frac{\partial \bar{q}^N}{\partial \tau^*} \right)} > 0 \]
(19)
under our assumption that \( \tau > 0 \) and \( \tau^* > 0 \). Thus, according to Eq. (19), when domestic firms incur a higher trade cost as exporters, exit in the domestic country occurs to such a degree that the domestic price actually rises.

Of course, exactly analogous results hold for the price in the foreign country. In particular, employing Eqs. (8), (16), (17), (14) and our assumption that \( \tau > 0 \) and \( \tau^* > 0 \), and proceeding as above, we find that
\[ \frac{\partial P^N(\tau^*, \tau)}{\partial \tau^*} = \frac{-\bar{q}^N \left( \frac{\partial \bar{q}^N}{\partial \tau^*} \right)}{\bar{q}^N \left( \frac{\partial \bar{q}^N}{\partial \tau^*} \right)} < 0 \] 
(20)
\[
\frac{\partial \bar{p}_h^{N}(\tau^*, \tau)}{\partial \tau} = \frac{\bar{q}_h^{N}(\tau^*, \tau)_f}{q_h^{N}\bar{q}_f^{N} - q_h^{N}q_f^{N} > 0.}
\] (21)

The price effects of trade taxes described by Eq. (18) through (21) represent the most striking implication of the firm-delocation effect, but they are not by themselves enough to determine the impact of trade taxes on welfare. In order to determine that, we need to know as well how trade taxes impact trade volumes. We turn to this issue next.

2.5. Long-run comparative statics on trade volumes

Trade taxes impact trade volumes in this model through two channels: they affect the export sales per firm in a given country, and they affect the number of firms located in that country. We have already derived expressions for the second channel. What remains is to derive expressions for the first channel, so that we may then evaluate the impact of trade taxes on trade volumes.

Notice that, for a given market and any given numbers of domestic and foreign firms, and using the linear structure of our model, the first-order conditions (2) and (4) for profit maximization imply that a firm’s best-response and thus Cournot–Nash quantity must equal the effective markup for the firm in that market. Therefore, we may use our knowledge of how long-run prices vary with trade costs, as captured in Eqs. (18)–(21), to deduce how long-run firm quantities vary with trade costs.

Consider, then, export sales per home firm, \(q_h^{N}(\tau^*, \tau)\). We know from Eq. (2) that, for given trade costs and numbers of firms, \(P(Q_h^{N}) - (\tau^* + \tau^*) = \bar{q}_h^{N}\). This relationship must hold in particular at the free-entry numbers of firms; thus, \(P_h^{N}(\tau^*, \tau) - (\tau^* + \tau^*) = \bar{q}_h^{N}(\tau^*, \tau)\). Using Eqs. (21) and (20), we may therefore conclude that

\[
\frac{\partial \bar{q}_h^{N}(\tau^*, \tau)}{\partial \tau} = \frac{\partial \bar{p}_h^{N}(\tau^*, \tau)}{\partial \tau} = \frac{\bar{q}_f^{N}(\tau^*, \tau)_f}{q_h^{N}\bar{q}_f^{N} - q_h^{N}q_f^{N} > 0.}
\] (22)

Thus, when the trade cost imposed on foreign exports rises, domestic entry and foreign exit occur. The foreign exit is sufficiently intense that the price of foreign exports actually rises, with the result that each domestic firm now exports more. Likewise, when the trade cost imposed on domestic exports rises, foreign entry is unleashed to such an extent that the price in the foreign market falls. With domestic firms now receiving a lower effective markup on exports, both because of the higher trade cost and the lower foreign market price, domestic firms export less.

Of course, similar findings obtain for the export sales per foreign firm \(q_f^{N}(\tau^*, \tau)\). For given trade costs and numbers of firms, we know from Eq. (4) that \(P(Q_f^{N}) - (\tau^* + \tau^*) = \bar{q}_f^{N}\). Evaluating at the free-entry numbers of firms, we thus have that \(P_f^{N}(\tau^*, \tau) - (\tau^* + \tau^*) = \bar{q}_f^{N}(\tau^*, \tau)\). Using Eqs. (18) and (19), we may therefore conclude that

\[
\frac{\partial \bar{q}_f^{N}(\tau^*, \tau)}{\partial \tau} = \frac{\partial \bar{p}_f^{N}(\tau^*, \tau)}{\partial \tau} = \frac{-\bar{q}_h^{N}(\tau^*, \tau)_h}{q_h^{N}\bar{q}_f^{N} - q_h^{N}q_f^{N} < 0.}
\] (23)

Thus, when the trade cost imposed on foreign exports is increased, domestic entry occurs and the domestic price falls. Due to the reduced domestic price as well as the direct cost of the higher trade cost, each foreign firm reduces its exports to the domestic market. When the trade cost imposed on domestic exports is increased, domestic exit occurs, the domestic price rises, and so each foreign firm exports more to the domestic market.

Armed with Eqs. (22) and (23) as well as Eqs. (16) and (17) from above, we may now turn to the final task of this section and consider how long-run trade volumes vary with trade costs. As noted above, an understanding of the relationship between export volumes and trade costs is needed to determine the impact of trade taxes on welfare, which is in turn important for subsequent sections, when we consider the determination of unilateral, efficient and Nash trade policies.

To begin, we define the home country’s export volume as

\[ E_h^{N}(\tau^*, \tau) \equiv n_h^{N}(\tau^*, \tau)\bar{q}_h^{N}(\tau^*, \tau). \] (24)

Now consider how the domestic export volume varies with the trade cost that confronts foreign exports. Using Eq. (24), we have that

\[ \frac{\partial E_h^{N}(\tau^*, \tau)}{\partial \tau} = n_h^{N}(\tau^*, \tau) \frac{\partial \bar{q}_h^{N}(\tau^*, \tau)}{\partial \tau} + \bar{q}_h^{N}(\tau^*, \tau) \frac{\partial n_h^{N}(\tau^*, \tau)}{\partial \tau} > 0, \] (25)

where the inequality follows from Eqs. (22) and (16). Thus, if foreign exporters confront a higher trade cost, then the number of domestic firms, the export sales of each domestic firm and thus the volume of domestic exports must rise. Next, consider how the domestic export volume varies with the trade cost that confronts domestic exports. Referring to Eq. (24), we see that

\[ \frac{\partial E_h^{N}(\tau^*, \tau)}{\partial \tau} = n_h^{N}(\tau^*, \tau) \frac{\partial \bar{q}_h^{N}(\tau^*, \tau)}{\partial \tau} + \bar{q}_h^{N}(\tau^*, \tau) \frac{\partial n_h^{N}(\tau^*, \tau)}{\partial \tau} < 0, \]

where the inequality follows from Eqs. (22) and (17). Thus, if the trade cost that faces domestic exporters increases, then the number of domestic firms, the export volume of each domestic firm and thus the volume of domestic exports must fall.

We can similarly derive long-run comparative statics findings for foreign export volumes. Defining the foreign country’s export volume as

\[ E_f^{N}(\tau^*, \tau) \equiv n_f^{N}(\tau^*, \tau)\bar{q}_f^{N}(\tau^*, \tau), \] (26)

we then have

\[ \frac{\partial E_f^{N}(\tau^*, \tau)}{\partial \tau} = n_f^{N}(\tau^*, \tau) \frac{\partial \bar{q}_f^{N}(\tau^*, \tau)}{\partial \tau} + \bar{q}_f^{N}(\tau^*, \tau) \frac{\partial n_f^{N}(\tau^*, \tau)}{\partial \tau} > 0, \] (27)

where the inequality follows from Eqs. (23) and (17). Finally, we consider how foreign export volume varies with the trade cost that foreign exporters incur. We thus compute

\[ \frac{\partial E_f^{N}(\tau^*, \tau)}{\partial \tau} = n_f^{N}(\tau^*, \tau) \frac{\partial \bar{q}_f^{N}(\tau^*, \tau)}{\partial \tau} + \bar{q}_f^{N}(\tau^*, \tau) \frac{\partial n_f^{N}(\tau^*, \tau)}{\partial \tau} < 0, \]

where the inequality uses Eqs. (23) and (16). Thus, foreign export volume increases when the trade cost facing domestic exports rises and decreases when the trade cost facing foreign exports rises.

For general tariff pairs \((\tau^*, \tau)\), we derive explicit expressions for long-run comparative statics of export volumes in the Appendix. A case of particular interest arises when \(\tau = \tau^*\) so that trade policies are symmetric across markets. At a symmetric point, we have that \(\bar{q}_h^{N} = \bar{q}_f^{N}, \bar{q}_f^{N} = \bar{q}_h^{N}\) and \(n_h^{N} = n_f^{N}\). Under symmetry, we may thus express all magnitudes in terms of domestic variables and derive...
simpler expressions. In particular, at a symmetric point, we may simplify Eqs. (50) and (52) from the Appendix to find that:

$$\frac{\partial E^{N}(\tau', \tau)}{\partial \tau} = \frac{\partial E^{N}(\tau', \tau)}{\partial \tau}$$

$$\equiv \frac{2q_{h}^{N} q_{h}^{N} (q_{h}^{N})^{2} + (q_{h}^{N})^{2}}{(q_{h}^{N})^{2} - (q_{h}^{N})^{2}} > 0. \quad (28)$$

Likewise, at a symmetric point, we may simplify Eqs. (51) and (53) from the Appendix to get:

$$\frac{\partial E^{E}(\tau', \tau)}{\partial \tau} = \frac{\partial E^{E}(\tau', \tau)}{\partial \tau}$$

$$= - \frac{\left( (q_{h}^{N})^{2} + (q_{h}^{N})^{2} \right) \left( q_{h}^{N} (q_{h}^{N})^{2} + (q_{h}^{N})^{2} \right) + (q_{h}^{N})^{2}}{(q_{h}^{N})^{2} - (q_{h}^{N})^{2}} < 0. \quad (29)$$

Note that Eq. (15) yields $q_{h}^{N} - q_{h}^{N} = \tau$ at a symmetric point, and so $q_{h}^{N} - q_{h}^{N} > 0$ given that $\tau > 0$.

3. Unilateral and efficient trade policies

With the key properties of the Cournot delocation model now developed, we are ready to consider the determination of trade policies. We begin by defining national welfare. Following Venables (1985), we then ask whether a country could gain by introducing a slight departure from free trade in exactly one of its trade policies. A country always gains from introducing a slight import tariff, provided only that the other country’s trade policies are such that in each market the trade cost is positive and trade is not prohibited. Further, a country gains by introducing a small export subsidy, if all other policies in both countries are set at free trade. Finally, the introduction of an import tariff or an export subsidy also leads to a reduction in the welfare of the other country, if all policies in both countries are initially set at the free-trade level. We also establish novel findings regarding the efficiency frontier. For symmetric policies, we show that free-trade policies (i.e., $\tau = \tau' = \phi$) are efficient policies in the linear model studied here. In addition, we find that, when all policies in both countries are initially at free trade, the unilateral introduction of a small import tariff or export subsidy by one country must result in a less efficient outcome.

3.1. Welfare functions

With $\phi > 0$ representing the transport cost, we let $\tau = \phi + t_{b} + t_{f}$ denote the total trade cost imposed on foreign exports, where $t_{b}$ is the (specific) domestic import tariff and $t_{f}$ is the (specific) foreign export tariff. Likewise, the total trade cost imposed on domestic exports is $\tau' = \phi + t_{b}' + t_{f}'$, where $t_{b}'$ is the (specific) domestic export tariff and $t_{f}'$ is the (specific) foreign import tariff.

When evaluating trade policies, we assume that the domestic and foreign governments maximize their respective long-run national incomes. In the long run, profits are driven to zero, and national income is simply the sum of consumer surplus and net tariff revenue. Letting $CS(\bar{P}^{N}(\tau', \tau))$ denote domestic consumer surplus in the long-run equilibrium, the domestic government thus maximizes

$$G(\tau', \tau, t_{b}, t_{f}) = CS(\bar{P}^{N}(\tau', \tau)) + t_{b} n_{N}(\tau', \tau) q_{h}^{N}(\tau', \tau) + t_{f} n_{N}(\tau', \tau) q_{h}^{N}(\tau', \tau)$$

$$= CS(\bar{P}^{N}(\tau', \tau)) + t_{b} E^{N}(\tau', \tau) + t_{f} E^{N}(\tau', \tau).$$

where

$$CS(\bar{P}^{N}(\tau', \tau)) = -D(\bar{P}^{N}(\tau', \tau)) \equiv (1 - \bar{P}^{N}(\tau', \tau)).$$

Similarly, letting $CS(\bar{P}^{N}(\tau', \tau))$ denote foreign consumer surplus, the foreign government maximizes

$$G(\tau', \tau, t_{b}, t_{f}) = CS(\bar{P}^{N}(\tau', \tau)) + t_{f} n_{N}(\tau', \tau) q_{h}^{N}(\tau', \tau) + t_{f} n_{N}(\tau', \tau) q_{h}^{N}(\tau', \tau)$$

$$= CS(\bar{P}^{N}(\tau', \tau)) + t_{f} E^{N}(\tau', \tau).$$

where

$$CS(\bar{P}^{N}(\tau', \tau)) = -D(\bar{P}^{N}(\tau', \tau)) \equiv (1 - \bar{P}^{N}(\tau', \tau)).$$

3.2. Introduction of a small import tariff

Now let us suppose that the domestic country initially adopts free trade with its import and export tariffs. With respect to foreign trade policies, we assume for the moment only that the foreign government’s trade policies are such that the trade cost is positive (i.e., $\tau > 0$) and trade is not prohibited (i.e., $E^{N}(\tau', \tau) > 0$). From this starting point, would the domestic government gain by slightly increasing its import tariff? To answer this question, we use Eq. (30) and compute

$$\frac{dG}{dt_{b}} = -D(\bar{P}^{N}(\tau', \tau)) \frac{\partial E^{N}(\tau', \tau)}{\partial \tau} + t_{b} \left( \frac{\partial E^{N}(\tau', \tau)}{\partial \tau} \right),$$

Under our supposition that the domestic country initially adopts a free-trade policy with respect to its import and export tariffs, the last two terms in Eq. (32) disappear. We may thus rewrite Eq. (32) as

$$\frac{dG}{dt_{b}} = -D(\bar{P}^{N}(\tau', \tau)) \frac{\partial E^{N}(\tau', \tau)}{\partial \tau} + E^{N}(\tau', \tau) > 0, \quad (33)$$

where the inequality follows since $D(\bar{P}^{N}(\tau', \tau)) > 0$, $E^{N}(\tau', \tau) > 0$ under our assumption that trade is not prohibited, and $\partial E^{N}(\tau', \tau)/\partial \tau < 0$ by Eq. (18) under our assumption that trade costs are positive. Thus, with the firm-delocation effect giving $\partial E^{N}(\tau', \tau)/\partial \tau < 0$, we see that a positive import tariff is optimal for the domestic country. Intuitively, the import tariff generates domestic entry and thus a lower domestic price, which raises consumer surplus. As well, a positive import tariff raises tariff revenue relative to the free-trade benchmark.

Using Eq. (31) we now consider the impact of a small domestic import tariff on the foreign country:

$$\frac{dG}{dt_{b}} = -D(\bar{P}^{N}(\tau', \tau)) \frac{\partial E^{N}(\tau', \tau)}{\partial \tau} + t_{f} \left( \frac{\partial E^{N}(\tau', \tau)}{\partial \tau} \right) + t_{f} \left( \frac{\partial E^{N}(\tau', \tau)}{\partial \tau} \right).$$

(34)

If we suppose that the foreign country also initially adopts a free-trade policy with respect to its import and export tariffs, then the last two terms in (34) disappear. We may then rewrite Eq. (34) as

$$\frac{dG}{dt_{b}} = -D(\bar{P}^{N}(\tau', \tau)) \frac{\partial E^{N}(\tau', \tau)}{\partial \tau} < 0, \quad (35)$$

where the inequality follows at global free trade, since under these policies $D(\bar{P}^{N}(\tau', \tau)) > 0$ and trade costs are positive so that $\partial E^{N}(\tau', \tau)/\partial \tau > 0$ by (21). The latter effect is simply the firm-delocation effect: a higher domestic import tariff causes exit in the
foreign country to such a degree that the foreign price increases. In other words, starting with all policies in both countries set at free trade, the introduction of a small domestic import tariff raises the foreign price and thus harms foreign welfare by reducing foreign consumer surplus.

Following Venables (1985), we may conclude as follows:

**Proposition 1.** If both countries initially adopt a policy of free trade with respect to their imports and exports, then the introduction of a small import tariff by the domestic government generates a welfare gain for the foreign country and a welfare loss for the domestic country.

Similarly, the introduction of a small import tariff by the foreign government generates a welfare gain for the foreign country and a welfare loss for the domestic country.

3.3. Introduction of a small export subsidy

We consider next the introduction of a small export subsidy, whose effect is that of a small export tariff once the sign of the effect is reversed. Using Eq. (30), we compute that

\[
\frac{dG^*}{dt} = -D \left( \frac{\partial G^*}{\partial \tau^*} \right) \frac{\partial P^N}{\partial \tau^*} + E^N(\tau^*, \tau) + \frac{\partial E^N}{\partial \tau^*}.
\]

(36)

If the domestic country starts at free trade with respect to its import and export policies, we thus find that the last two terms in Eq. (36) again disappear, and so we get

\[
\frac{dG^*}{dt} = -D \left( \frac{\partial G^*}{\partial \tau^*} \right) \frac{\partial P^N}{\partial \tau^*} + E^N(\tau^*, \tau).
\]

(37)

Assuming that the foreign trade policies are nonprohibitive and such that trade costs are positive, we have that \( D \left( \frac{\partial P}{\partial \tau} \right) > 0, \frac{\partial P^N}{\partial \tau^*} > 0 \) by (19), and \( E^N(\tau^*, \tau) > 0 \). Referring to Eq. (37), we thus see that the introduction of a small export tariff has competing effects on domestic welfare: the export tariff induces exit and thereby a higher domestic price, which reduces consumer surplus, but it also generates additional tariff revenue relative to the free-trade benchmark.

To sign the expression in Eq. (37), we use \( D \left( \frac{\partial P}{\partial \tau} \right) = m_n q^N + n_n q^N \), Eqs. (24) and (19) and find that, at free-trade domestic policies,

\[
\frac{dG^*}{dt} = -n_n \frac{q^N}{q^N} \left( \frac{n_n q^N}{q^N} + \frac{m_n q^N}{q^N} \right) < 0,
\]

where the inequality follows under our assumptions that \( \tau > 0 \) and \( \tau^* > 0 \). Thus, starting from free-trade domestic policies and so long as the trade policies of the foreign country are non-prohibitive and such that trade costs are positive, the domestic government gains when it introduces a small export subsidy. In this model, therefore, when a small export subsidy is introduced, the benefit to domestic consumers of a lower domestic price (due to the firm-delocation effect) exceeds the loss in tariff revenue.

We turn next to consider the implications of a small export tariff for the foreign country. To this end, we use Eq. (31) and compute

\[
\frac{dG^*}{dt} = -D \left( \frac{\partial G^*}{\partial \tau^*} \right) \frac{\partial P^N}{\partial \tau^*} + E^N(\tau^*, \tau) + \frac{\partial E^N}{\partial \tau^*}.
\]

(38)

If we now suppose that the foreign country also initially adopts a free-trade policy with respect to its import and export tariffs, then the last two terms in Eq. (38) disappear. Under this supposition, we may rewrite Eq. (38) as

\[
\frac{dG^*}{dt} = -D \left( \frac{\partial G^*}{\partial \tau^*} \right) \frac{\partial P^N}{\partial \tau^*} > 0,
\]

(39)

where the inequality in Eq. (39) follows at global free trade since then \( D \left( \frac{\partial P}{\partial \tau} \right) > 0 \) and trade costs are positive so that \( \frac{\partial P^N(\tau^*, \tau)}{\partial \tau^*} < 0 \) by Eq. (20). The latter effect is again the firm-delocation effect: a higher domestic export tariff induces sufficient entry in the foreign country that the foreign price falls and foreign consumer welfare rises. Equivalently, starting at global free trade, the introduction of a small export subsidy by the domestic country results in a reduction in the welfare of the foreign country, since it induces foreign exit and thereby a higher foreign price and thus lower foreign consumer surplus.

Following Venables (1985), we may conclude as follows:

**Proposition 2.** If both countries initially adopt free-trade policies with respect to their imports and exports, then the introduction of a small export subsidy by the domestic government generates a welfare gain for the foreign country and a welfare loss for the domestic country.

3.4. Efficient trade policies

We next consider efficient trade policies. Since governments have sufficient policy instruments in this model to effect transfers (i.e., to shift tariff revenue without altering consumer prices), efficient policies are those which maximize joint welfare, \( G + G^* \). A key observation is that joint welfare ultimately depends only on the total trade costs, \( \tau \) and \( \tau^* \). To see this, note that

\[
J(\tau, \tau^*) = G(\tau, \tau^*, \tau^*; \nu_0^*, \nu_0) + G^*(\tau^*, \tau^*, \tau; \nu_0^*, \nu_0^*) \equiv CS \left( \frac{\partial P}{\partial \tau} \right) + \frac{\partial E^N}{\partial \tau} + \frac{\partial E^N}{\partial \tau^*} + \left( \tau - \phi \right) E^N(\tau, \tau^*) + \left( \tau^* - \phi \right) E^N(\tau^*, \tau).
\]

To characterize the efficient total trade tax, we differentiate joint welfare with respect to \( \tau \) and express the associated first-order condition for efficiency as

\[
\frac{\partial J}{\partial \tau} = -D \left( \frac{\partial G}{\partial \tau} \right) \frac{\partial P^N}{\partial \tau} + E^N(\tau, \tau^*) - D \left( \frac{\partial G^*}{\partial \tau^*} \right) \frac{\partial P^N}{\partial \tau^*} + \left( \tau - \phi \right) E^N(\tau, \tau^*) + \left( \tau^* - \phi \right) E^N(\tau^*, \tau) = 0.
\]

(40)
where the first equality follows easily from the definition of joint welfare. As we show in the Appendix, at symmetric policies (\(\tau = \tau^*\)), we may use (18), (21), (26), (28) and (29) to establish that the following properties hold: the first line in Eq. (40) is zero, and the second line is zero if and only if \(\tau = \tau^* = \phi\). Of course, exactly analogous results hold when joint welfare is differentiated with respect to \(\tau^*\).

Building on these findings, we establish in the Appendix the following proposition:

**Proposition 3.** (a) For symmetric policies, the efficiency frontier is characterized by combinations of trade policies that deliver zero trade taxes on all trade (i.e., \(\tau = \tau^* = \phi\)); in particular, global free trade (\(t_h = t_r^* = t_i^* = t_f^* = t_r^f = t_i^f = 0\)) is efficient. (b) Starting at global free trade, any small symmetric or asymmetric adjustment in policies must lower efficiency.

With respect to part (a) of Proposition 3, it is important to emphasize that a continuum of symmetric policies deliver zero trade taxes on all trade (i.e., \(\tau = \tau^* = \phi\)). Global free trade is one such set of policies, but a trade tax of zero on all trade is also achieved when, along any one trade channel, any subsidy offered by one country is exactly offset by a tariff from the other country. Part (b) of Proposition 3 follows since, as we show in the Appendix, symmetric policies with \(\tau = \tau^* = \phi\) satisfy second-order conditions with respect to small symmetric and asymmetric policy changes. Thus, starting at global free trade, small asymmetric policy adjustments such as those considered in Propositions 1 and 2 must lower efficiency.

### 4. Nash trade policies

At this point, we know that, starting at global free trade, each country has a unilateral incentive to impose an import tariff and an export subsidy, even though such a unilateral policy change lowers efficiency. These findings thus provide one perspective as to why governments might seek an agreement under which ceilings are imposed on import tariffs and export subsidies. We next consider the Nash equilibrium in trade policies, and we show that governments use import and export tariffs in a Nash equilibrium. This result is novel to the literature and provides a richer perspective on the treatment of import tariffs and export subsidies in trade agreements. In particular, an efficiency enhancing trade agreement would place a ceiling on export subsidies only once import tariffs have been reduced through negotiations to a level that is sufficiently close to free trade. As explained in the Introduction, this richer perspective thus provides one interpretation of the introduction of the SCM Agreement into the WTO in 1995, after the completion of several earlier negotiation rounds that led to substantial reductions in import tariffs.

To characterize Nash equilibrium trade policies in the Cournot delocation model, we are led to consider the tariff reaction functions for the domestic and foreign countries, respectively. The domestic first-order conditions for \(t_h\) and \(t_r\) are given by \(dC/dt_h = 0\) and \(dC/dt_r = 0\), respectively, and may be analyzed using Eqs. (32) and (36) above. Furthermore, since the two countries are symmetric, we may focus on a symmetric Nash equilibrium, in which the domestic Nash import tariff equals the foreign Nash import tariff, and the domestic Nash export tariff equals the foreign Nash export tariff. Thus, we can focus on the domestic tariff reaction functions and the determination of the domestic Nash import tariff, \(t_h^N\), and Nash export tariff, \(t_r^N\).

To this end, we first use Eqs. (32) and (36) and subtract the domestic first-order condition for \(t_h\) from the domestic first-order condition for \(t_r\). This yields

\[
0 = \frac{dG}{dt_h} \frac{dG}{dt_r} = D \left[ \frac{\partial \tilde{P}_N(\tau^*, \tau)}{\partial \tau^*} - \frac{\partial \tilde{P}_N(\tau^*, \tau)}{\partial \tau} \right]
\]

(41)

where we use symmetry to impose \(E_N(\tau^*, \tau) = E_N(\tau^*, \tau), \partial E_N(\tau^*, \tau)/\partial \tau^* = \partial E_N(\tau^*, \tau)/\partial \tau = \partial E_N(\tau^*, \tau)/\partial \tau^* + \partial E_N(\tau^*, \tau)/\partial \tau\). In the Appendix, we use Eqs. (15), (18), (19), (28) and (29) to simplify and sign the bracketed terms in Eq. (41) at a symmetric point. The resulting expressions (57) and (58) in the Appendix permit us to use our “subtraction” Eq. (41) to conclude that, at a symmetric Nash equilibrium,

\[
t_h^N - t_r^N = \frac{n_h^N \left[ q_h^N + \tilde{q}_h^N \right] q_h^N + \tilde{q}_h^N \right] + \left( \frac{\tilde{q}_h^N}{\tilde{q}_h^N} \right)^2.
\]

(42)

Importantly, Eq. (42) confirms that \(n_h^N > n_r^N\), provided that \(\tilde{q}_h^N < \tilde{q}_h^N = \tau > 0\). In other words, the domestic import tariff is greater than the domestic export tariff precisely because of the local-market bias in firm sales.

Our next step is to use Eqs. (32) and (36) and add the domestic first-order condition for \(t_h\) to the domestic first-order condition for \(t_r\). We obtain

\[
0 = \frac{dG}{dt_h} \frac{dG}{dt_r} = -D \left[ \frac{\partial \tilde{P}_N(\tau^*, \tau)}{\partial \tau^*} + \frac{\partial \tilde{P}_N(\tau^*, \tau)}{\partial \tau} \right]
\]

(43)

where we use symmetry to impose \(E_N(\tau^*, \tau) = E_N(\tau^*, \tau), \partial E_N(\tau^*, \tau)/\partial \tau^* = \partial E_N(\tau^*, \tau)/\partial \tau = \partial E_N(\tau^*, \tau)/\partial \tau^* + \partial E_N(\tau^*, \tau)/\partial \tau\). In the Appendix, we use Eqs. (15), (18), (19), (28) and (29) to simplify and sign the bracketed terms in Eq. (43) at a symmetric point. The resulting expressions (59) and (60) in the Appendix permit us to use our “addition” Eq. (43) to conclude that, at a symmetric Nash equilibrium,

\[
t_h^N + t_r^N = \frac{n_h^N q_h^N q_h^N q_h^N q_h^N + \tilde{q}_h^N \left( \frac{\tilde{q}_h^N}{\tilde{q}_h^N} \right)^2 + \left( \frac{\tilde{q}_h^N}{\tilde{q}_h^N} \right)^2}{n_h^N \left( \frac{\tilde{q}_h^N}{\tilde{q}_h^N} \right)^2 + \left( \frac{\tilde{q}_h^N}{\tilde{q}_h^N} \right)^2} > 0.
\]

(44)

Importantly, Eq. (44) indicates that, at the symmetric Nash equilibrium, the total trade tax and thus the total trade cost is positive: \(\tau^N = \tau^N > 0\), where the symmetric Nash equilibrium total tariff satisfies \(\tilde{\tau} = t_h^N + t_r^N\).

At this point, we may add Eqs. (42) and (44) to obtain

\[
t_h^N = \frac{n_h^N \left[ q_h^N + \tilde{q}_h^N \right] q_h^N + \tilde{q}_h^N \right] + \left( \frac{\tilde{q}_h^N}{\tilde{q}_h^N} \right)^2 > 0.
\]

(45)

This implicit equation tells us that the Nash import tariff must be positive. Using Eqs. (44) and (45) and simplifying, we may now recover the Nash export policy as

\[
t_r^N = \frac{n_h^N \left( q_h^N \right)^2 \left( q_h^N + \tilde{q}_h^N \right)}{n_h^N \left( q_h^N \right)^2 + \left( \tilde{q}_h^N \right)^2} > 0.
\]

(46)
This implicit equation tells us that the Nash export tariff must be positive as well.

We may now conclude as follows:

**Proposition 4.** In a symmetric Nash equilibrium in trade policies, the Nash import and export tariffs are both positive, with the Nash import tariff being the larger of the two.

Comparing Propositions 3(a) and 4, we see immediately that Nash trade policies are inefficient in the linear Cournot delocation model. In particular, using the fact that \( \tau \) and \( \tau^* \) take symmetric values in both the efficient free-trade benchmark and the Nash equilibrium, we may conclude that too little trade occurs under Nash trade policies.

It is also interesting to compare our characterization in Proposition 4 of the Nash equilibrium trade policies with Propositions 1 and 2 of the previous section, where we show that a country can gain by unilaterally departing from global free trade and introducing a small import tariff or a small export subsidy. Viewed from this perspective, our finding of a positive Nash import tariff is perhaps not surprising. Our finding of a positive Nash export tariff, however, is more surprising. How can we reconcile the gain that a country experiences when departing from global free trade and introducing a small export subsidy with the finding that the Nash equilibrium entails an export tariff? We address this question in the next section.

5. Interpretation of trade policy findings

In this section, we provide two new propositions and offer an interpretation of our trade policy findings. In particular, we explain why the Nash equilibrium export policy is an export tariff, even though at global free trade a country gains from a small unilateral export subsidy.

When choosing its trade policy, a government seeks to maximize the sum of consumer surplus and tariff revenue. Consumer surplus is governed by the consumption price. Focusing for simplicity on the domestic country, consider then the iso-price relationship \( P^N(\tau, \tau) = k \), for some initial value \( k \). We can think of this relationship as generating an iso-price tariff function, \( \tau(\tau, k) \), which has positive slope.

In particular, using Eqs. (18) and (19), we find that

\[
\frac{\partial \tau}{\partial \tau} = - \frac{\partial P^N(\tau, \tau)}{\partial \tau} \frac{\partial \tau}{\partial \tau} = \frac{\partial q_1}{\partial q_N} < 1, \tag{47}
\]

where by Eq. (15) the inequality holds under our assumption that \( \tau \) and \( \tau^* \) are positive. An interesting observation is that a government can adjust its import and export tariffs along the upward-sloping iso-price tariff function, \( \tau(\tau, k) \), without impacting the surplus that its consumers enjoy on the associated good. In particular, there exists a tariff-revenue-maximizing way of delivering any given local price and thus consumer surplus.

Suppose that the foreign government has selected a pair of tariffs, \( t_f \) and \( t_f^* \), which along with an initial pair of domestic tariffs, \( t_h \) and \( t_h^* \), generate values \( \tau \) and \( \tau^* \) and thereby a domestic local price \( P^N(\tau, \tau) = k \). Building on the observation made above, we may now ask which pair of domestic tariffs maximizes domestic welfare revenue, when the local price is taken as fixed. The associated program is

\[
\max_{t_h, t_f} \text{TR} \left( t_h, t_f, t_h^*, t_f^* \right) = t_h E^N(\tau, \tau) + t_f E^N(\tau, \tau)
\]

subject to \( P^N(\tau, \tau) = k \), \( \tau = t_h + t_f + \phi \), \( \tau^* = t_h^* + t_f^* + \phi \)

or equivalently

\[
\max_{t_h} \text{TR} \left( t_h, t_f, t_h^*, t_f^* \right) = t_h E^N(\tau, \tau) + t_f E^N(\tau, \tau) E^N(\tau, \tau),
\]

where with \( t_f \) and \( t_f^* \) fixed the induced value for \( \tau^* (\tau, k) \) is achieved via alternative specifications for \( t_f^* \) as \( t_h \) and thereby \( \tau \) is varied. In particular, the induced value for \( t_f^* \) is \( t_h \) \( \tau = t_h + t_f + \phi \), where we suppress the dependence on \( \phi \) in the functional notation. The domestic Nash tariffs, for example, must solve this program when \( k = P^N(\tau^*, \tau^*) \).

We can write the first-order condition for this program as

\[
\frac{\text{dTR}}{\text{d}t_h} \left( t_h, t_f, t_h^*, t_f^* \right) = \frac{\partial E^N(\tau(\tau, \tau), \tau)}{\partial \tau} + t_h \frac{\partial E^N(\tau(\tau, \tau), \tau)}{\partial \tau} + t_f \frac{\partial E^N(\tau(\tau, \tau), \tau)}{\partial \tau} & = 0, \tag{48}
\]

where we utilize Eq. (47).

Suppose now that we initially place the domestic tariffs at free trade, while fixing the foreign tariffs at any non-prohibitive level consistent with positive trade costs. These policies induce a domestic free-trade price \( P^N(\tau_f + \phi, \tau_f^* + \phi) = k_0 \). Thus, at this starting point, \( t_f^* = t_h \). \( \tau_f \) and \( \phi \) a comparable amount as defined by Eq. (47) that serves to preserve the initial domestic free-trade price. The first-order condition (48) for our program, evaluated at \( t_h = 0 = t_f \), indicates that the domestic country would gain from such an adjustment, since it would enjoy an increase in tariff revenue with no change in consumer surplus. In particular, the gain in domestic tariff revenue and thus domestic welfare is \( E^N(\tau(\tau, k), \tau) + E^N(\tau(\tau, k), \tau) \frac{\partial q_1}{\partial q_N} > 0 \).

We may summarize the result of this variation as follows:

**Proposition 5.** Suppose the domestic tariffs are initially placed at free trade, with the foreign tariffs fixed at any non-prohibitive level consistent with positive trade costs. From this starting point, suppose further that the domestic government undertakes a slight increase in its import tariff while increasing its export tariff a comparable amount as defined by Eq. (47) that serves to preserve the initial domestic free-trade price. Then the domestic country enjoys a welfare gain, since its tariff revenue increases while its consumer surplus is unaltered.

It is interesting to compare this unilateral departure from free trade with those analyzed by Venables (1985) and in the previous section. As shown in Propositions 1 and 2, the introduction of a small import tariff or of a small export subsidy serves to raise domestic welfare. Notice, though, that these variations entail simultaneous changes in consumer surplus and tariff revenue. By contrast, the variation that we consider in Proposition 5 entails a simultaneous increase in the import and export tariffs that preserves consumer surplus and isolates the tariff-revenue effect.14

This discussion suggests a way to reconcile the finding that the optimal unilateral export policy is an export subsidy with the finding that the symmetric Nash equilibrium entails an export tax. As suggested by Proposition 2, let us suppose that the domestic import tariff and all foreign tariffs are initially set at free trade, and let us then place the domestic export policy at the optimal unilateral export subsidy. From here, we
can imagine a further variation in which we both raise the domestic im-
port tariff and reduce the domestic export subsidy so as to maintain the
domestic local price. If this adjustment increases tariff revenue, then we
could even end up with a preferred situation for the domestic country in
which import and export tariffs are positive. In the linear-demand case
at least, the Nash equilibrium tariffs can be understood in this way. By
considering only one policy change at a time, the variations considered by
Venables (1985) and featured in Propositions 1 and 2 do not permit such
simultaneous adjustments in import and export policies.

Proposition 5 highlights the potential value to a country of simulta-
neously making its import and export policies more restrictive.13 This
orientation suggests that a country’s import and export tariffs are at
least in some cases complementary with respect to their effects on tariff
revenue. In turn, this line of thought provides some additional intuition for
why the Nash import and export tariffs are indeed positive.

To further develop this intuition, we now formally identify a novel
tariff-complementarity effect that arises in the Cournot delocation model
of trade policy.14 In particular, recall that \( \mathcal{T} \mathcal{R}(\tau, \xi, \xi') = \xi E^N(\tau, \tau') + \xi' E^E(\tau', \tau') \). Consider now the cross derivative of domestic tariff revenue with
respect to changes in the domestic tariff instruments, \( \xi \) and \( \xi' \). We find that

\[
\frac{\partial^2 \mathcal{R}}{\partial \xi \partial \xi'} = \frac{\partial E^N}{\partial \tau} + \frac{\partial E^N}{\partial \tau'} + \xi \frac{\partial^2 E^E}{\partial \tau \partial \tau'} + \xi' \frac{\partial^2 E^N}{\partial \tau \partial \tau'}. \tag{49}
\]

Using Eqs. (25) and (27), and assuming that foreign tariffs are non-
prohibitive and such that trade costs are positive, we know that
\( \frac{\partial E^E}{\partial \tau} > 0 \) and \( \frac{\partial E^E}{\partial \tau'} > 0 \). Thus, at least in the neighborhood of domes-
tic free trade, we have from Eq. (49) that there exists a clear tariff-
complementarity effect: \( \frac{\partial \mathcal{R}}{\partial \xi} \frac{\partial \mathcal{R}}{\partial \xi'} > 0 \) when \( \xi = 0 = \xi' \).

We now summarize our finding to this point as regards the tariff-
complementarity effect:

**Proposition 6.** For domestic tariffs sufficiently close to free trade, the
domestic import and export tariffs exert a complementary effect on do-
mestic tariff revenue, provided that foreign tariffs are non-prohibitive and
such that trade costs are positive.

The idea behind the tariff-complementarity effect is as follows.17 When a small export tariff, \( \xi' \), is introduced, tariff revenue is enjoyed on
those units that are exported. If a small import tariff is then intro-
duced as well, domestic entry occurs and so more domestic units are
exported. Thus, an import tariff can increase the marginal revenue of
an export tariff. Indeed, this must be the case when the export tariff
begins at free trade and is then raised. Similarly, if we were to first
introduce an import tariff, then import tariff revenue would be enjoyed
on imported units; further, the volume of imports would only grow
were an export tariff introduced as well, since the export tariff
would trigger foreign entry and thus a greater volume of foreign ex-
ports. In this way, an export tariff can increase the marginal revenue of
an import tariff. The described tariff-complementarity effect is gen-
eral (and in particular is not limited to the linear-demand setting);

\[13\] In fact, the finding reported in Proposition 5 can be strengthened so as to allow for
any initial domestic trade policies satisfying \( \xi \leq 0 \) and \( \xi' \geq 0 \), suggesting that the attrac-
tiveness of raising the restrictiveness of both import and export policies in this fashion
may be quite broad.

\[14\] The tariff-complementarity effect identified here entails a complementary rela-
tionship between a country’s import and export tariffs, for the same good. This effect is
thus distinct from previously identified tariff-complementarity effects that concern
complementary relationships between the (discriminatory) import tariffs that a coun-
try applies to different suppliers of an import good (Bagwell and Staiger, 1999b) or be-
tween the import tariffs of different countries which import a common good (Bagwell
and Staiger, 1997).

\[17\] For domestic tariffs sufficiently close to free trade, and provided that foreign tariffs are
non-prohibitive and such that trade costs are positive, we can show that domestic import
and export tariffs also exert a complementary effect on domestic welfare (i.e., \( \frac{\partial E^N}{\partial \xi} > 0 \)).

We emphasize the complementary effect that domestic tariffs exert on domestic tariff rev-
ue, in order to further develop the intuition underlying Proposition 5.

however, when tariffs begin at values differing from free trade, then
the marginal revenue associated with an initial tariff hike is deter-
mained in part by the effect of the hike on the volume of trade on
which the initial tariff is applied. A tariff hike on the other channel
can then alter marginal revenue on the initial channel by altering
the rate at which the initial tariff hike affects trade volume on the ini-
tial channel. Hence, when we begin at values differing from free trade,
new effects come into play that are associated with the cross deriva-
tives of the export volume functions.18

The tariff-complementarity effect identified in Proposition 6 pro-
vides additional intuition for the fact that both import tariffs and ex-
port tariffs are positive in a Nash equilibrium. In effect, the joint use of
import tariffs and export tariffs is attractive to governments in the lin-
ear Cournot delocation model, because a tax on trade in one direction
courages trade in the other direction on which the other trade tax
can then collect revenue.

6. Liberalization paths

In this section, we present two characterizations that offer insight
into the liberalization path from the symmetric Nash equilibrium to the
efficiency frontier. First, starting at the Nash equilibrium, we char-
acterize combinations of symmetric and small policy adjustments that
generate mutual gains for governments. Second, we characterize the
properties of any symmetric agreement on import tariffs that
achieves efficiency, when export policies are unrestricted.

Our first characterization captures paths of departure from the Nash
equilibrium that yield mutual gains.

**Proposition 7.** Starting at a symmetric Nash equilibrium in trade poli-
cies, if governments agree to small and symmetric reductions in (i) im-
port tariffs, (ii) export tariffs, or (iii) import and export tariffs, then the
welfare of each country increases.

The proof of this proposition is found in the Appendix.

Proposition 7 is both standard and surprising. The basic method of
proof is standard and uses the envelope theorem. Starting at the Nash
equilibrium, a small change in a country’s policies has no first-order
effect on its welfare but can generate a first-order gain in the trading partner’s welfare if the policies are adjusted in the “right” direction. In
this manner, both governments can benefit from an exchange of pol-
cy changes, where the right direction of change for any government’s
policy is that which confers a positive externality on the other gov-
ernment’s welfare. A surprising feature of the current model is that
countries can achieve mutual gains by exchanging small reductions in
export tariffs, even though the trading partner experiences a
tems-of-trade loss when a country reduces its export tariff.19

\[18\] We can show that, at a point of symmetry, \( \frac{\partial E^N}{\partial \xi} = \frac{\partial E^E}{\partial \xi} = 0 \). At a symmetric point
with positive tariffs, therefore, we see from Eq. (49) that the sign of \( \frac{\partial E^N}{\partial \xi} \) involves compet-
ing effects.

\[19\] For comparison, it is instructive to consider the classic, two-good, two-country
general equilibrium model in which markets are perfectly competitive. In that model, as
Bagwell and Staiger (1999a, 2002) discuss, if Lerner and Metzler paradoxes are ab-
sent, then mutual gains from the Nash equilibrium are achieved when policy changes
take the form of small reductions in import (or export) tariffs, so that policy changes
are in the direction that generates a terms-of-trade gain for the trading partner. But
if the Metzler paradox is present in the competitive model, then it can be shown that,
starting at the Nash equilibrium, a slight increase in a country’s import tariff generates
a positive externality for its trading partner, even though the trading partner experiences a
tems-of-trade loss. The presence of the Metzler paradox thus suggests in the compet-
itive model as well that the recipient of a positive externality suffers a terms-of-trade
loss. The competitive model with the Metzler paradox, however, leads to the counter-
factual prediction that a mutually beneficial trade agreement should be designed to
duce tariffs above their non-cooperative levels. Finally, we note that, in the Cournot
delocation model studied here, when countries achieve mutual gains by exchanging
small reductions in import tariffs, each country’s policy change is in the direction that
leads to a terms-of-trade gain for the trading partner; and more broadly, as we confirm
in Bagwell and Staiger (2009b) and discuss further below, it is still the case in this
model that the problem for a trade agreement to solve can be characterized as provid-
ing an escape from a terms-of-trade driven Prisoners’ Dilemma.
To understand this feature, let us start at the Nash equilibrium and suppose that the foreign country lowers its export tariff, \( t_d \). The reduction in \( t_d \) lowers \( t \) and thus increases the domestic local price, \( P_d(\tau, \tau) \); hence, through this indirect channel, a reduction in \( t_d \) leads to a higher world price for domestic imports, \( P_m(\tau, \tau, \tau) \equiv P_d(\tau, \tau) - \epsilon_0 \). Of course, the domestic government could similarly use a reduction in its import tariff, \( t_h \), to induce a lower value for \( t \) and alter local prices. At the Nash equilibrium, the net tariff revenue and consumer surplus benefits for the domestic government of inducing such a change in local prices must at the margin be exactly offset by the terms-of-trade loss that it would thereby induce. Notice, though, that a reduction in \( t_h \) causes a terms-of-trade loss for the domestic country (i.e., an increase in \( P_m(\tau, t^\tau, \tau) \)) through indirect and direct channels. A reduction in the foreign export tariff therefore generates a strict gain for the home country, since the domestic terms-of-trade loss is diminished in magnitude due to the absence of the direct channel. Thus, both countries can gain from reducing imports in export tariffs, despite the fact that each country is adjusting its policy in the direction that gives its trading partner a terms-of-trade loss.

We now come to our second characterization. Motivated by the history of GATT negotiations, we characterize here the policies that governments might choose if export policies were unrestricted. To state our result, we say that trade policies are strongly symmetric if \( t_f = t'_f \) and \( \tau_f = \tau'_f \) so that both countries adopt the same import and export tariffs, respectively. Our definition above of symmetric Nash equilibrium requires that policies are strongly symmetric, and we note that strongly symmetric policies are symmetric (i.e., satisfy \( \tau = \tau' \)).

**Proposition 8.** If trade policies are strongly symmetric and efficient with each government selecting its export policy to maximize the welfare of its country, then each government must select a positive import tariff and a positive export subsidy such that the total trade tax is zero.

The proof of this proposition is presented in the Appendix.

According to Proposition 8, if governments are able to achieve an efficient outcome with strongly symmetric policies when they negotiate only over import tariffs, then the resulting import tariff must be positive and the associated export policy must be an export subsidy that exactly offsets the import tariff so that the total trade tax is zero. This proposition is thus consistent with the hypothesis that GATT negotiations over import tariffs resulted in the selection of import tariffs and export subsidies, even though the Nash equilibrium entails import and export tariffs. Starting at such an efficient point, if import tariffs were further lowered to the free-trade level, then efficiency would be maintained if and only if export subsidies were also capped at the free-trade level so as to maintain a total trade tax of zero. While a move to free trade in individual policies would not alter joint welfare, we show in Bagwell and Staiger (2009b) that free trade in import and export policies is the unique “political optimum” for this model and in this respect represents a focal point on the efficiency frontier.

### 7. Conclusion

This paper contributes at two levels. First, at a theoretical level, we advance the understanding of the linear Cournot delocation model introduced by Venables (1985); in particular, we characterize and interpret Nash and efficient trade policies, and we also provide results that characterize the liberalization path. These results should be useful for future trade policy work that utilizes the linear Cournot delocation model. Second, at a policy level, our theoretical findings suggest a potential efficiency-enhancing interpretation for WTO rules on export subsidies. By contrast, as we note in the Introduction, other formal analyses of the treatment of export subsidies in trade agreements suggest that GATT/WTO efforts to reign in export subsidies may be best interpreted as an inefficient victory for exporting governments that comes at the expense of importing governments.

With regard to the policy contribution of our research, an important question is whether the Cournot delocation model offers a compelling rationale for GATT/WTO efforts to restrict export subsidies. This question is not merely academic. Many GATT/WTO disputes involve export subsidies, and some of the longest-running disputes, and largest in terms of authorized retaliation, have centered on government programs that were alleged to operate as export subsidies. So there is much at stake in assessing the “legitimacy” of the SCM’s prohibition against export subsidies.

This question is ultimately an empirical one, since it boils down to whether the Cournot delocation model, or rather any of the other models that deliver the more skeptical view of the GATT/WTO stance on export subsidies, better captures the forces that are relevant for understanding and interpreting the GATT/WTO. As a consequence, the question cannot be answered here. But we mention several points that may be relevant in providing an eventual answer.

First, we have established our results in a linear-demand version of the Cournot delocation model. This raises the obvious question of whether the efficiency-enhancing interpretation for WTO rules on export subsidies would survive with general non-linear demands. This is a subtle question, because linearity plays several roles in the model. On the one hand, in a companion paper (Bagwell and Staiger, 2009a) we establish that export subsidies have non-traditional (beneficial) terms-of-trade effects for the exporting country in the Cournot delocation model even when demands are non-linear, indicating that the essential beggar-thy-neighbor features of export subsidies that argues for their restraint is not limited to a linear-demand setting. This suggests that the main insights from the linear Cournot delocation model are likely to survive in some form with general non-linear demands. On the other hand, when demands are non-linear, global free trade may not be efficient in this setting, and so whether the prohibition of export subsidies in combination with non-negative tariffs is compatible with efficiency remains an open question. On balance, though, the assumption of linear demands does not seem to be driving the case for restraining export subsidies on efficiency grounds that arises in the Cournot delocation model. Hence, evidence that the Cournot delocation model with general non-linear demands has empirical relevance would lend support to the view of GATT/WTO export subsidy agreements that we develop here.

Second, we have adopted the Cournot version of the firm-delocation model formalized by Venables (1985), but Venables (1987) has also formalized the firm-delocation effect in a differentiated product monopolistic competition setting, a setting that has been used recently to explore features of trade agreements in Ossa (2011) and also in Bagwell and Staiger (2009a). This raises the question of whether the monopolistic competition version of the firm-delocation model might also deliver an efficiency rationale for the prohibition of export subsidies. Here the answer is no. As established in Bagwell and Staiger (2009a), in that model, as in other formal analyses of export subsidies and for the same...
reason, efficiency requires that export subsidies should, if anything, be encouraged by a trade agreement. Hence, it is the empirical relevance of the Cournot version of the delocation model that is at issue here. Third, as we have established, the model predicts export taxes in the Nash equilibrium that give way to export subsidies only once significant constraints are placed on import tariffs. The model’s relevance for interpreting the treatment of export subsidies in the GATT/WTO should then be judged in part on the prevalence of export taxes in the pre-GATT era. Here we make two observations. First, in the negotiations leading up to the creation of GATT, the United States pushed for a prohibition on export taxes (see Irwin, et al., 2008, pp. 69–70, 136); while no such prohibition was ultimately included in GATT, the U.S. effort in this regard suggests that export taxes were prevalent enough in the pre-GATT era to be an important trade policy concern. And second, the practical relevance of any prediction of export taxes must confront political realities in export sectors that would push against export taxes and for export subsidies. These political economy forces are not included in the Cournot delocation model, but could enhance significantly the empirical relevance of the model for interpreting the treatment of export subsidies in the GATT/WTO.

Finally, we emphasize that there may of course not be just one “answer” to this question: the Cournot delocation model might offer a compelling rationale for the GATT/WTO efforts to restrict the use of export subsidies in some areas (e.g., agriculture), but not in others (e.g., civil aircraft). Viewed in this light, and together with existing theories, the Cournot delocation model and the results we have established here may simply help to provide a more nuanced and complete understanding of the treatment of export subsidies in trade agreements.

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Appendix

Trade volume comparative statics

We provide here expressions for long-run comparative statics on trade volumes, when symmetry is not assumed. Using Eqs. (22) and (16), we may derive the following expression:

\[
\frac{\partial E}{\partial \tau} = \frac{n}{2} \left( q^N + q^S \right)^2 + \left( q^N \right)^2 + \left( q^S \right)^2 + \left( 1 + n \right) \left( \frac{q^N \left( q^N \right)^2 + q^N \left( q^S \right)^2}{\left( q^N \right)^2 - q^N \left( q^S \right)^2} \right) < 0.
\]

(50)

Referring to Eqs. (22) and (17), we may derive the following useful expression:

\[
\frac{\partial E}{\partial \tau} = \frac{n}{2} \left( q^N \right)^2 + \left( q^N \right)^2 + \left( q^S \right)^2 + \left( 1 + n \right) \left( \frac{q^N \left( q^N \right)^2 + q^N \left( q^S \right)^2}{\left( q^N \right)^2 - q^N \left( q^S \right)^2} \right) < 0.
\]

(51)

Using Eqs. (23) and (17), we find that

\[
\frac{\partial E}{\partial \tau} = \left( \frac{q^N \left( q^N \right)^2 + q^N \left( q^S \right)^2}{\left( q^N \right)^2 - q^N \left( q^S \right)^2} \right) > 0.
\]

(52)

Referring to Eqs. (23) and (16), we have that

\[
\frac{\partial E}{\partial \tau} = \left( \frac{q^N \left( q^N \right)^2 + q^N \left( q^S \right)^2}{\left( q^N \right)^2 - q^N \left( q^S \right)^2} \right) < 0.
\]

(53)

Proof of Proposition 3

When policies are symmetric, \( \tau = \tau^* \) and so \( q^N = q^N_h, q^S = q^N_h \) and \( n^N = n^N_h \). Using Eqs. (18) and (21), we find that, at a point of symmetry,

\[
\frac{\partial D}{\partial \tau} + \frac{\partial D}{\partial \tau^*} = \frac{q^N_h}{q^N_h + q^N_h}.
\]

(54)

At symmetric policies, we use \( D = n^N_h \left( q^N_h + q^N_h \right) = D \left( q^N \right) \), Eqs. (26) and (54) to find that

\[
-D \left( q^N \right) \left( \frac{\partial D}{\partial \tau} + \frac{\partial D}{\partial \tau^*} \right) = \frac{\partial D}{\partial \tau} = 0.
\]

We thus now express Eq. (40) as

\[
\frac{\partial \psi}{\partial \tau} = \left( \tau - \phi \right) \left( \frac{\partial E}{\partial \tau} + \frac{\partial E}{\partial \tau^*} \right).
\]

(55)

Next, we use Eqs. (28) and (29) and establish after simplification that, at a symmetric point,

\[
\frac{\partial E}{\partial \tau} + \frac{\partial E}{\partial \tau^*} = - \left( \frac{n^N_h \left( q^N_h \right)^2 + \left( q^N_h \right)^2 \left( q^N_h \right)^2}{\left( q^N_h \right)^2 + \left( q^N_h \right)^2} \right) < 0.
\]

(56)

Thus, by Eqs. (55) and (56), a policy is efficient in the symmetric class of policies only if \( \tau = \tau^* = \phi \).

Next we show that \( \tau = \tau^* = \phi \) satisfies the local second-order conditions for joint-welfare maximization with respect to all (symmetric and asymmetric) policies. Using Eq. (55) and arguing similarly for the derivative of \( F \) with respect to \( \tau \), we find that \( \frac{\partial E}{\partial \tau} = 0 = \frac{\partial E}{\partial \tau^*} \) when \( \tau = \tau^* = \phi \). The corresponding local second-order conditions hold at \( \tau = \tau^* = \phi \) when \( \tau \) and \( \tau^* \) are jointly selected if the Jacobian matrix associated with the system of first-order conditions is negative definite.

When \( \tau = \tau^* = \phi \), and using Eqs. (29) and (28), we find that

\[
\frac{\partial \psi}{\partial \tau} = \frac{\partial E}{\partial \tau} + \frac{\partial E}{\partial \tau^*} = - \left( \frac{n^N_h \left( q^N_h \right)^2 + \left( q^N_h \right)^2 \left( q^N_h \right)^2}{\left( q^N_h \right)^2 + \left( q^N_h \right)^2} \right) < 0.
\]

Thus we may then confirm that \( \frac{\partial \psi}{\partial \tau} > 0 \), and our assumption that \( \phi > 0 \). Finally, for the class of symmetric policies, it now follows that \( \tau = \tau^* = \phi \) is efficient. This policy setting satisfies local first- and second-order conditions; furthermore, as shown in the first paragraph of this proof, the first-order conditions for efficiency cannot hold for any other symmetric policy.
Proof of Proposition 4

We provide here the additional derivations referred to in the text in proving Proposition 4. We begin with derivations leading to Eq. (42). To further simplify Eq. (41), we compute \( \partial \rho^N(\tau, \tau) / \partial \tau - \partial \rho^H(\tau, \tau) / \partial \tau \) and \( \partial E^N(\tau, \tau) / \partial \tau - \partial E^H(\tau, \tau) / \partial \tau \) at a symmetric point. Using Eqs. (19) and (18) and simplifying, we find that, at a symmetric point,

\[
\frac{\partial \rho^N(\tau, \tau)}{\partial \tau} - \frac{\partial \rho^H(\tau, \tau)}{\partial \tau} = \frac{\dot{q}_h^N - \dot{q}_h^H}{\dot{q}_h^N - \dot{q}_h^H} > 0, \tag{57}
\]

where the inequality follows since we have from Eq. (15) that \( \dot{q}_h^N - \dot{q}_h^H = \frac{\tau + \theta(\tau - \tau)}{\tau + \theta(\tau - \tau)} - \tau > 0 \) at a symmetric point, under the assumption that \( \tau > 0 \). Next, we may similarly use Eqs. (28) and (29) and establish after simplification that, at a symmetric point,

\[
\frac{\partial E^H(\tau, \tau)}{\partial \tau} - \frac{\partial E^N(\tau, \tau)}{\partial \tau} = -\frac{n^N h}{n^N h + n^H h} \left[ \frac{\ddot{q}_h^N + \dot{q}_h^N}{\dot{q}_h^N - \dot{q}_h^H} \right] \left[ \left( \dot{t}_h^N - \dot{t}_h^N \right) + \left( \dot{t}_h^N - \dot{t}_h^H \right) + \left( \dot{q}_h^N \right)^2 \right] < 0, \tag{58}
\]

where the inequality again follows at a symmetric point under our assumption that \( \tau > 0 \).

We may now return to our “subtraction” Eq. (41) and make the substitutions just derived in Eqs. (57) and (58). After making these substitutions and simplifying, we get, for a symmetric point, that

\[
\frac{dG}{dh} - \frac{dG}{dt} = \frac{dG}{dh} - \frac{dG}{dt} = \left[ \frac{n^N h}{n^N h + n^H h} \right] \left[ \left( \dot{t}_h^N - \dot{t}_h^N \right) + \left( \dot{t}_h^N - \dot{t}_h^N \right) + \left( \dot{q}_h^N \right)^2 \right] \left[ \dot{q}_h^N - \dot{q}_h^N \right]^2.
\]

From here, it is straightforward to confirm that Eq. (42) must hold at a symmetric Nash equilibrium.

We next consider derivations leading to Eq. (44). To further analyze Eq. (43), we compute \( \partial \rho^N(\tau, \tau) / \partial \tau + \partial \rho^H(\tau, \tau) / \partial \tau \) and \( \partial E^N(\tau, \tau) / \partial \tau + \partial E^H(\tau, \tau) / \partial \tau \) at a symmetric point. Using Eqs. (18) and (19) and simplifying, we find that, at a point of symmetry,

\[
\frac{\partial \rho^N(\tau, \tau)}{\partial \tau} + \frac{\partial \rho^H(\tau, \tau)}{\partial \tau} = \frac{\dot{q}_h^N}{\dot{q}_h^N + \dot{q}_h^N} > 0, \tag{59}
\]

Similarly, we may use Eqs. (28) and (29) and establish after simplification that, at a symmetric point,

\[
\frac{\partial E^H(\tau, \tau)}{\partial \tau} + \frac{\partial E^N(\tau, \tau)}{\partial \tau} = -\frac{n^N h}{n^N h + n^H h} \left[ \frac{\ddot{q}_h^N + \dot{q}_h^N}{\dot{q}_h^N + \dot{q}_h^N} \right] \left[ \left( \dot{t}_h^N - \dot{t}_h^N \right) + \left( \dot{t}_h^N - \dot{t}_h^N \right) + \left( \dot{q}_h^N \right)^2 \right] < 0. \tag{60}
\]

At this point, we may return to our “addition” Eq. (43) and make the substitutions just derived in Eqs. (59) and (60). After making these substitutions and simplifying, that, for a symmetric point, that

\[
0 = \frac{dG}{dh} + \frac{dG}{dt} = n^N h \dot{q}_h^N + \dot{t}_h^N \left[ \frac{\ddot{q}_h^N + \dot{q}_h^N}{\dot{q}_h^N + \dot{q}_h^N} \right] \left[ \left( \dot{t}_h^N - \dot{t}_h^N \right) + \left( \dot{t}_h^N - \dot{t}_h^N \right) + \left( \dot{q}_h^N \right)^2 \right].
\]

It is now direct to confirm that Eq. (44) must hold at a symmetric Nash equilibrium.

Proof of Proposition 7

In a symmetric Nash equilibrium, we have from Eqs. (32) and (36) that the domestic import and export tariffs must satisfy the following first-order conditions:

\[
\frac{dG}{dh} = -D \left( \hat{p}^N(\tau, \tau) \right) \frac{\partial \rho^N(\tau, \tau)}{\partial \tau} + E^N(\tau, \tau) + t_h \frac{\partial E^N(\tau, \tau)}{\partial \tau} = 0 \tag{61}
\]

\[
\frac{dG}{dt} = -D \left( \hat{p}^N(\tau, \tau) \right) \frac{\partial \rho^N(\tau, \tau)}{\partial \tau} + E^N(\tau, \tau) + t_h \frac{\partial E^N(\tau, \tau)}{\partial \tau} + t_h \frac{\partial E^N(\tau, \tau)}{\partial \tau} = 0 \tag{62}
\]

Thus, starting at a symmetric Nash equilibrium, a slight reduction in \( t_h \) or \( t_h \) has no first-order effect on domestic welfare. Using Eq. (30), we find that the effect on domestic welfare of small increases in foreign import and export tariffs is given by

\[
\frac{dG}{dh} = -D \left( \hat{p}^N(\tau, \tau) \right) \frac{\partial \rho^N(\tau, \tau)}{\partial \tau} + t_h \frac{\partial E^N(\tau, \tau)}{\partial \tau} + t_h \frac{\partial E^N(\tau, \tau)}{\partial \tau} \tag{63}
\]

\[
\frac{dG}{dt} = -D \left( \hat{p}^N(\tau, \tau) \right) \frac{\partial \rho^N(\tau, \tau)}{\partial \tau} + t_h \frac{\partial E^N(\tau, \tau)}{\partial \tau} + t_h \frac{\partial E^N(\tau, \tau)}{\partial \tau} \tag{64}
\]

Using Eq. (62), we may re-write Eq. (63) as

\[
\frac{dG}{dt} = -E^N(\tau, \tau) < 0 \tag{65}
\]

Similarly, using Eq. (61), we may re-write Eq. (64) as

\[
\frac{dG}{dh} = -E^N(\tau, \tau) < 0 \tag{66}
\]

It now follows from Eqs. (61), (62), (65) and (66) that, starting at a symmetric Nash equilibrium, small domestic tariff reductions that are exchanged for symmetric foreign tariff reductions are sure to raise domestic welfare. By a similar argument, such an exchange is also sure to raise foreign welfare.

Proof of Proposition 8

Suppose that policies are strongly symmetric \( (t_h = \bar{t}, t_h = \bar{t}) \) and efficient, with each government selecting its export policy to maximize its country’s welfare. Let these symmetric import and export policies be denoted as \( (\bar{t}_h = \bar{t}_h, \bar{t}_h = \bar{t}_h) \). Focusing on export policies, we know from efficiency that \( \frac{\partial G}{\partial \bar{t}_h} + \frac{\partial G}{\partial \bar{t}_h} = 0 = \frac{\partial G}{\partial \bar{t}_h} + \frac{\partial G}{\partial \bar{t}_h} \). Since each country selects its export policy in a unilaterally optimal fashion, we also know that \( \frac{\partial G}{\partial \bar{t}_h} = 0 = \frac{\partial G}{\partial \bar{t}_h} \). We thus conclude that the hypothesis of the proposition implies that policies are set such that a small change in a country’s export policy would impose no externality on the trading partner: \( \frac{\partial G}{\partial \bar{t}_h} = 0 = \frac{\partial G}{\partial \bar{t}_h} \).

From the discussion above, we know that \( \frac{\partial G}{\partial \bar{t}_h} = \frac{\partial G}{\partial \bar{t}_h} \) is necessary. Using Eqs. (36) and (38) and symmetry, we may re-write this equation as

\[
D \left( \hat{p}^N(\tau, \tau) \right) \left[ \frac{\partial \rho^N(\tau, \tau)}{\partial \tau} - \frac{\partial \rho^H(\tau, \tau)}{\partial \tau} \right] + \left( \bar{t}_h - \tilde{t}_h \right) \left[ \frac{\partial E^N(\tau, \tau)}{\partial \tau} - \frac{\partial E^H(\tau, \tau)}{\partial \tau} \right] = E^N(\tau, \tau). \tag{67}
\]
where $D \left( \tilde{P}^N (\tau^*, \tau) \right) = D \left( \tilde{P}^A (\tau^*, \tau) \right)$ by symmetry. By Proposition 3(a), we also know that efficiency implies $t_h + \tilde{t}_h = 0 = t_f + \tilde{t}_f$, so that by strong symmetry $t_h + \tilde{t}_h = 0$. We thus may re-write Eq. (67) as

$$D \left( \tilde{P}^N (\tau^*, \tau) \right) \left[ \frac{\partial \tilde{P}^N (\tau^*, \tau)}{\partial \tau} - \frac{\partial \tilde{P}^N (\tau^*, \tau)}{\partial \tau^*} \right]
+ 2 \tilde{t}_h \left[ \frac{\partial \tilde{E}^N (\tau^*, \tau)}{\partial \tau} - \frac{\partial \tilde{E}^N (\tau^*, \tau)}{\partial \tau^*} \right]
= \tilde{E}^N (\tau^*, \tau). \tag{68}$$

To examine Eq. (68), we use symmetry and market clearing to find that $D \left( \tilde{P}^N (\tau^*, \tau) \right) = n_h \left[ \tilde{q}_h^N + \tilde{q}_h^N \right]$ and $\tilde{E}^N (\tau^*, \tau) = \tilde{n}_h^N \tilde{q}_h^N$. Next, since trade policies are symmetric, $\partial \tilde{P}^N (\tau^*, \tau) / \partial \tau - \partial \tilde{P}^N (\tau^*, \tau) / \partial \tau^* = \partial \tilde{E}^N (\tau^*, \tau) / \partial \tau - \partial \tilde{E}^N (\tau^*, \tau) / \partial \tau^*$, and so we may represent these differences using Eqs. (57) and (58), respectively. Using these relationships, we may return to Eq. (68) and solve for $t_h$ as

$$t_h = -\frac{\tilde{n}_h^N \left( \tilde{q}_h^N \right)^2 + \left( \tilde{q}_h^N \right)^2}{\tilde{n}_h^N \left( \tilde{q}_h^N \right)^2 + \left( \tilde{q}_h^N \right)^2} > 0,$$

where the inequality follows from Eq. (15) using $\tau = \tau^* = \phi > 0$. It follows that $\tilde{t}_h = -\tilde{t}_h = 0$. Thus, it is necessary that $t_h = \tilde{t}_f > 0$, $\tilde{t}_h = t_f < 0$, $t_h + \tilde{t}_h = 0$ and $\tilde{t}_h + \tilde{t}_f = 0$.

References


