Online Appendix: "The Cost of a Global Tariff War: *A Sufficient Statistics Approach*"

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Theoretical Appendix

A Proof of Proposition 3

The proof of Proposition 3 is conducted along the same steps those as taken earlier to prove Proposition 1. The present proof, however, departs from the baseline proof in to two key aspects. First, the optimal tariff problem (under Lemma 2) should be revised, such that the government chooses *only* import prices, which are denoted by

$$\tilde{\mathbf{P}}_{-ii} = \left\{\tilde{\mathbf{P}}_{1i}, ..., \tilde{\mathbf{P}}_{i-1i}, \tilde{\mathbf{P}}_{i+1i}, ..., \tilde{\mathbf{P}}_{Ni}\right\}.$$

The domestic price, $\tilde{P}_{ii,k} = P_{ii,k} = (1+\mu_k)a_{i,k}w_i$, should be treated as an equilibrium outcome that is pinned to the wage rate, w_i. The reason we should exclude $\tilde{\mathbf{P}}_{ii}$ from the government's policy set, is that including $\tilde{\mathbf{P}}_{ii}$ affords the government an additional ability to tackle markup distortions with domestic subsidies. That is, the problem where the government chooses $\tilde{\mathbf{P}}_i = \left\{\tilde{\mathbf{P}}_{ii}, \tilde{\mathbf{P}}_{-ii}\right\}$ affords the government more policy space than the problem where the government only chooses tariff, $\mathbf{t}_i$.

To state the above point more formally, we can first follow with the basic idea presented under Lemma 1, to formulate all equilibrium variables as a function of $\tilde{\mathbf{P}}_{-ii}$, $\mathbf{t}_{-i}$, and $\mathbf{w}$. We can, then, reformulate the optimal tariff problem as follows:

$$\max_{\tilde{\mathbf{P}}_{-ii}} \; W_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) \equiv V_i(Y_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}), \tilde{\mathbf{P}}_{-ii}, \tilde{P}_{ii}(w_i)) \quad s.t. \; (\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) \in \mathbb{F} \qquad \text{(P1-MC)}$$

The second difference is that, when solving (P1-MC), total income in country i includes income from profits. Namely,

$$Y_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) = \overline{\mu}_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) w_i \bar{L}_i + \overbrace{\sum_{j\neq i}\left[\left(\tilde{\mathrm{P}}_{ji} - \mathbf{P}_{ji}(w_j)\right)\cdot \mathrm{Q}_{ji}(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w})\right]}^{\text{tariff revenue}},$$

where $\overline{\mu}_i$ is the output-weighted average markup in economy i:[1]

$$\overline{\mu}_i(.) \equiv \frac{\sum_{n=1}^{N} \mathbf{P}_{in} \cdot \mathbf{Q}_{in}}{\sum_{n=1}^{N} \frac{\mathbf{1}}{\boldsymbol{\mu}} \odot \mathbf{P}_{in} \cdot \mathbf{Q}_{in}}, \qquad \frac{\mathbf{1}}{\boldsymbol{\mu}} \equiv \left[\frac{1}{\mu_1}, ..., \frac{1}{\mu_K}\right].$$

Note that if markups are uniform across industries $\mu_k = \mu$, then Problems (P1 or $\widetilde{\text{P1}}$) and (P1-MC) become identical. Otherwise, they are different as optimal tariffs under (P1-MC) will be chosen to both improve the terms-of-trader and (partially) correct preexisting markup distortions.

The system of F.O.C.'s underlying Problem (P1-MC) can be expressed as follows:

$$\nabla_{\tilde{\mathbf{P}}_{-ii}} W_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) = \mathbf{0}.$$

To analyze the above system, I will use the same partial derivative notation presented in *Section A* of the main appendix. Invoking the chain rule, the F.O.C. for $\tilde{P}_{ji,k} \in \tilde{\mathbf{P}}_{-ii}$ can be expressed as follows

$$\begin{aligned}
\frac{\mathrm{d} W_i}{\mathrm{d} \ln \tilde{P}_{ji,k}} &= \frac{\partial V_i(.)}{\partial \ln \tilde{P}_{ji,k}} + \frac{\partial V_i(.)}{\partial Y_i} \left(\frac{\partial Y_i}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}} + \left(\frac{\partial W_i(.)}{\partial \ln \mathbf{w}}\right)_{\tilde{\mathbf{P}}_{-ii}} \cdot \frac{\mathrm{d} \ln \mathbf{w}}{\mathrm{d} \ln \tilde{P}_{ji,k}}. \\
&= \frac{\partial V_i}{\partial Y_i} \left(\frac{\partial V_i(.)}{\partial \ln \tilde{P}_{ji,k}} \left(\frac{\partial V_i}{\partial Y_i}\right)^{-1} + \left(\frac{\partial Y_i}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}} + \left(\frac{\partial W_i(.)}{\partial \ln \mathbf{w}}\right)_{\tilde{\mathbf{P}}_{-ii}} \cdot \frac{\mathrm{d} \ln \mathbf{w}}{\mathrm{d} \ln \tilde{P}_{ji,k}} \left(\frac{\partial V_i}{\partial Y_i}\right)^{-1} \right) = 0
\end{aligned}$$

The above F.O.C., like the one analyzed in *Section A* of the main appendix, features three different terms: (i) $\frac{\partial V_i(.)}{\partial \ln \tilde{P}_{ji,k}}$, which accounts for direct price effect; (ii) $\left(\frac{\partial Y_i}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}}$, which accounts for direct income effects holding $\mathbf{w}$, $\tilde{\mathbf{P}}_{-ii} - \{\tilde{P}_{ji,k}\}$, and $\mathbf{t}_{-i}$ fixed; and (iii) $\left(\frac{\partial W_i(.)}{\partial \ln \mathbf{w}}\right)_{\tilde{\mathbf{P}}_{-ii}} \cdot \frac{\mathrm{d} \ln \mathbf{w}}{\mathrm{d} \ln \tilde{P}_{ji,k}}$, which accounts for general equilibrium wage effects holding $\tilde{\mathbf{P}}_{-ii}$ (and also $\mathbf{t}_{-i}$) fixed.

The direct price effects can be characterized by consumer-side envelope conditions that drive from the optimality of demand:

$$\text{[Roy's identity]} \qquad \frac{\partial V_i(.)}{\partial \ln \tilde{P}_{ji,k}} \left(\frac{\partial V_i}{\partial Y_i}\right)^{-1} = -\tilde{P}_{ji,k} Q_{ji,k}. \tag{1}$$

Direct income effects have to take into account effect on both profits and tax revenues. Using vector operations ($\mathbf{a} \cdot \mathbf{b} = \sum_i a_i b_i$ and $\mathbf{a} \odot \mathbf{b} = [a_i b_i]_i$), we can characterize the direct income effects as follows:

$$\left(\frac{\partial Y_i}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}} = \left(\frac{\partial \overline{\mu}_i}{\partial \tilde{P}_{ji,k}}\right)_{\mathbf{w}} w_i \bar{L}_i \;+\; \tilde{P}_{ji,k} Q_{ji,k} + \left(\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii}\right) \cdot \left(\frac{\partial \ln \mathbf{Q}_{-ii}}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}}$$

[1] Note that for any two vectors $\mathbf{a}$ and $\mathbf{b}$ of similar length, the inner product operates as $\mathbf{a} \cdot \mathbf{b} = \sum_i a_i b_i$, while the element-wise product operates as $\mathbf{a} \odot \mathbf{b} = [a_i b_i]_i$.

$$= \left(\frac{\partial \bar{\mu}_i}{\partial \tilde{P}_{ji,k}}\right)_{\mathbf{w}} w_i \bar{L}_i + \tilde{P}_{ji,k} Q_{ji,k} + (\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii}) \odot \mathbf{Q}_{-ii} \cdot \left[\boldsymbol{\varepsilon}_{-ii}^{(ji,k)} + \boldsymbol{\eta}_{-ii}\left(\frac{\partial Y_i}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}}\right], \quad (2)$$

where the second line derives from the definition of Marshallian demand elasticities (refer to *Section A* of the main appendix for details). The direct effect on profits, in the above equation, can be also specified as follows:

$$\left(\frac{\partial \bar{\mu}_i}{\partial \tilde{P}_{ji,k}}\right)_{\mathbf{w}} w_i \bar{L}_i = \left(\frac{\partial}{\partial \ln \tilde{P}_{ij,k}} \frac{\sum_n \mathbf{P}_{in} \cdot \mathbf{Q}_{in}}{\sum \frac{\mathbf{1}}{\boldsymbol{\mu}} \odot \mathbf{P}_{in} \cdot \mathbf{Q}_{in}}\right)_{\mathbf{w}} w_i \bar{L}_i = \left(\mathbf{1} - \frac{\bar{\mu}_i}{\boldsymbol{\mu}}\right) \odot \mathbf{P}_{ii} \odot \mathbf{Q}_{ii} \cdot \left[\boldsymbol{\varepsilon}_{ii}^{(ji,k)} + \boldsymbol{\eta}_{ii}\left(\frac{\partial Y_i}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}}\right]. \quad (3)$$

Finally, general equilibrium wage effects can be characterized by applying the Implicit Function Theorem to the balanced trade condition, $\mathrm{T}_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w})$. This application yields the following expression:

$$\left(\frac{\partial W_i(.)}{\partial \ln \mathbf{w}}\right)_{\tilde{\mathbf{P}}_{-ii}} \cdot \frac{\mathrm{d} \ln \mathbf{w}}{\mathrm{d} \ln \tilde{P}_{ji,k}} \left(\frac{\partial V_i}{\partial Y_i}\right)^{-1} = -\bar{\tau}_i \left[\mathbf{P}_{-ii} \cdot \left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}}\right] = -\bar{\tau}_i \left(\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii}\right) \odot \mathbf{Q}_{-ii} \cdot \left[\boldsymbol{\varepsilon}_{-ii}^{(ji,k)} + \boldsymbol{\eta}_{-ii}\left(\frac{\partial \ln Y_i}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}}\right], \quad (4)$$

where $\bar{\tau}_i \equiv \frac{\frac{\partial W_i(.)/\partial \ln w_i}{\partial V_i(.)/\partial Y_i}}{(\partial \mathrm{T}_i(.)/\partial \ln w_i)_{\mathbf{w}_{-i}}}$ (see *Section A* of the main appendix for the specific details underlying this step). Combining Equations 1, 2, 3, and 4 yields the following F.O.C. w.r.t. $\tilde{P}_{ji,k} \in \tilde{\mathbf{P}}_i$,

$$\left(\mathbf{1} - \frac{\bar{\mu}_i}{\boldsymbol{\mu}}\right) \odot \mathbf{P}_{ii} \odot \mathbf{Q}_{ii} \cdot \boldsymbol{\varepsilon}_{ii}^{(ji,k)} + \left(\tilde{\mathbf{P}}_{-ii} - (1+\bar{\tau}_i)\mathbf{P}_{-ii}\right) \odot \mathbf{Q}_{-ii} \cdot \boldsymbol{\varepsilon}_{-ii}^{(ji,k)} + \Delta_i(\boldsymbol{\mu}) \frac{\partial Y_i}{\partial \ln \tilde{P}_{ij,k}} = 0, \quad (5)$$

where $\Delta_i(\boldsymbol{\mu})$ is a uniform scalar term that regulates the circular nature of the income effects:

$$\Delta_i(\boldsymbol{\mu}) = \left(\mathbf{1} - \frac{\bar{\mu}_i}{\boldsymbol{\mu}}\right) \odot \mathbf{P}_{ii} \odot \mathbf{Q}_{ii} \cdot \boldsymbol{\eta}_{ii} + \left(\tilde{\mathbf{P}}_{-ii} - (1+\bar{\tau}_i)\mathbf{P}_{-ii}\right) \odot \mathbf{Q}_{-ii} \cdot \boldsymbol{\eta}_{-ii}.$$

To solve Equation 5, we can rely on the intermediate observation that if

$$\left(\mathbf{1} - \frac{\bar{\mu}_i}{\boldsymbol{\mu}}\right) \odot \mathbf{P}_{ii} \odot \mathbf{Q}_{ii} \cdot \boldsymbol{\varepsilon}_{ii}^{(ji,k)} + \left(\tilde{\mathbf{P}}_{-ii} - (1+\bar{\tau}_i)\mathbf{P}_{-ii}\right) \odot \mathbf{Q}_{-ii} \cdot \boldsymbol{\varepsilon}_{-ii}^{(ji,k)} = 0, \quad (6)$$

then, to a first-order approximation around $\mu_k \approx \bar{\mu}_i$, $\Delta_i(\boldsymbol{\mu}) \approx 0$. So, the optimal choice of $\tilde{\mathbf{P}}_i^*$ (and the implied tariff vector) can be determined by solving Equation 6. We can further simplify this equation in three steps. First, we can invoke Cournot's aggregation, $\sum_n \mathbf{P}_{ni} \odot \mathbf{Q}_{ni} \cdot \boldsymbol{\varepsilon}_{ni}^{(ji,k)} = -\tilde{P}_{ji,k} Q_{ji,k}$, which allows us to rewrite Equation 6 as

$$\frac{\bar{\mu}_i}{\boldsymbol{\mu}} \odot \mathbf{P}_{ii} \odot \mathbf{Q}_{ii} \cdot \boldsymbol{\varepsilon}_{ii}^{(ji,k)} + (1+\bar{\tau}_i)\mathbf{P}_{-ii} \odot \mathbf{Q}_{-ii} \cdot \boldsymbol{\varepsilon}_{-ii}^{(ji,k)} + \tilde{P}_{ji,k} Q_{ji,k} = 0. \quad (7)$$

Second, by appeal/xing to the *Slutsky Equation*,[2] we can alternatively write the first two

[2] Recalling that $e_{ji,k} = \tilde{P}_{ji,k} Q_{ji,k} / Y_i$ denotes the share of expenditure on ji,k, the Slutsky equation can be

terms in the above equation in terms of $\varepsilon_{ij,k}^{(ii,g)}$. In particular,

$$\eta_{ii,g} = \eta_{ji,k} = 1 \quad \xrightarrow{\text{Slutsky Equation}} \quad P_{ii,g} Q_{ii,g} \varepsilon_{ii,g}^{(ji,k)} = \tilde{P}_{ji,g} Q_{ji,g} \varepsilon_{ji,k}^{(ii,g)}.$$

Doing so, reduces the F.O.C. specified under Equation 7 to

$$1 + \sum_{g} \frac{\mu_g}{\bar{\mu}_i} \varepsilon_{ji,k}^{(ii,g)} + \sum_{g} \sum_{n \neq i} \frac{1 + \bar{\tau}_i}{1 + t_{ni,g}} \varepsilon_{ji,k}^{(ni,g)} = 0. \tag{8}$$

Last, we can use the demand function's *homogeneity of degree zero* property, $\eta_{ji,k} + \sum_{j,g} \varepsilon_{ji,k}^{(ji,g)} = 1 + \sum_{j,g} \varepsilon_{ji,k}^{(ji,g)} = 0$, to rewrite Equation 8 as follows

$$\sum_{g} \left(1 - \frac{\mu_g}{\bar{\mu}_i}\right) \varepsilon_{ji,k}^{(ii,g)} + \sum_{g} \sum_{n \neq i} \left(1 - \frac{1 + \bar{\tau}_i}{1 + t_{ni,g}}\right) \varepsilon_{ji,k}^{(ni,g)} = 0.$$

The above equation, which should hold for all $ji,k \neq ii,k$ specifies a system of necessary conditions for the optimality of country i's tariffs. We can express this system using matrix algebra as

$$\underbrace{\begin{bmatrix} \varepsilon_{1i,1}^{(ii,1)} & \cdots & \varepsilon_{Ni,K}^{(ii,1)} \\ \vdots & \ddots & \vdots \\ \varepsilon_{1i,1}^{(ii,K)} & \cdots & \varepsilon_{Ni,K}^{(ii,K)} \end{bmatrix}}_{\mathbf{E}_{-ii}^{(ii)}} \begin{bmatrix} 1 - \frac{\mu_1}{\bar{\mu}_i} \\ \vdots \\ 1 - \frac{\mu_K}{\bar{\mu}_i} \end{bmatrix} + \underbrace{\begin{bmatrix} \varepsilon_{1i,1}^{(1i,1)} & \cdots & \varepsilon_{i-1i,k}^{(1i,1)} & \varepsilon_{i+1i,k}^{(1i,1)} & \cdots & \varepsilon_{Ni,K}^{(1i,1)} \\ \vdots & \ddots & & & \ddots & \vdots \\ \varepsilon_{1i,1}^{(Ni,K)} & \cdots & \varepsilon_{i-1i,k}^{(Ni,K)} & \varepsilon_{i+1i,k}^{(Ni,K)} & \cdots & \varepsilon_{Ni,K}^{(Ni,K)} \end{bmatrix}}_{\mathbf{E}_{-ii}} \begin{bmatrix} 1 - \frac{1+\bar{\tau}_i}{1+t_{1i,1}} \\ \vdots \\ 1 - \frac{1+\bar{\tau}_i}{1+t_{Ni,K}} \end{bmatrix} = \mathbf{0}. \tag{9}$$

To invert the above system we need to establish that $\mathbf{E}_{-ii}$ is invertible, which is established below.

Lemma 1. *Matrix $\mathbf{E}_{-ii}$ is invertible for every i.*

Proof. The Marshallian demand function's homogeneity of degree zero entails that $1 + \sum_n \sum_g \varepsilon_{ji,k}^{(ni,g)} = 0$ for all ji,k (see Proposition 2.E.2 in Mas-Colell et al. (1995)). Invoking this property and observing that $\varepsilon_{ji,k}^{(ji,k)} < -1$ and $\varepsilon_{ni,g}^{(ji,k)} > 0$, we can immediately show that $\mathbf{E}_{-ii}^{\mathrm{T}}$ is strict diagonally dominant. In particular,

$$\left|\varepsilon_{ji,k}^{(ji,k)}\right| - \sum_{n \neq i} \sum_{g} \left|\varepsilon_{ji,k}^{(ni,g)}\right| = 1 + \sum_{g} \varepsilon_{ji,k}^{ii,g} > 0 \implies \left|[\mathbf{E}_{-ii}]_{jk \times jk}\right| > \sum_{ng \neq jk} \left|[\mathbf{E}_{-ii}]_{ng \times jk}\right|.$$

The Lèvy-Desplanques Theorem (Horn and Johnson (2012)), thus, ensures that $\mathbf{E}_{-ii}^{\mathrm{T}}$ (and as a result $\mathbf{E}_{-ii}$) is non-singular and invertible. □

formally stated as

$$\text{[Slutsky equation]} \qquad e_{ii,g} \varepsilon_{ii,g}^{(ji,k)} + e_{ji,k} e_{ii,g} \eta_{ii,g} = e_{ji,k} \varepsilon_{ji,k}^{(ii,g)} + e_{ii,g} e_{ji,k} \eta_{ji,k}.$$

Using the above lemma and inverting Equation 9, we can produce the following formula for optimal tariffs:

$$\left[\frac{1+\bar{\tau}_i}{1+t^*_{ji,k}}\right]_{j\times k} = \mathbf{1} + \mathbf{E}^{*-1}_{-ii}\ \mathbf{E}^{(ii)*}_{-ii}\ \left[1-\frac{\mu_k}{\bar{\mu}_i}\right]_k, \tag{10}$$

where $\mathbf{E}_{-ii} \equiv \left[\mathbf{E}^{(ji)}_{ni}\right]_{j,n\neq i}$ and $\tilde{\mathbf{E}}^{(ii)}_{-ii} \equiv \left[\mathbf{E}^{(ii)}_{ni}\right]_{n\neq i}$ are respectively $(N-1)K \times (N-1)K$ and $(N-1)K \times K$ matrixes of demand elasticities (as defined in Section 2 of the paper). The superscript "$*$" indicates that a variable is evaluated in the (counterfactual) equilibrium in which $\mathbf{t}^*_i$ is applied.

Characterizing $\bar{\tau}_i$.

What remains is the task of characterizing, $\bar{\tau}_i$, which is defined as follows:

$$\bar{\tau}_i \equiv \frac{\frac{(\partial W_i(.)/\partial \ln w_i)_{\bar{\mathbf{w}}_{-i}}}{\partial V_i(.)/\partial Y_i}}{(\partial \mathrm{T}_i(.)/\partial \ln w_i)_{\bar{\mathbf{w}}_{-i}}} \sim \frac{\frac{(\partial W_i(.)/\partial \ln w_i)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}}{\partial V_i(.)/\partial Y_i}}{(\partial \mathrm{T}_i(.)/\partial \ln w_i)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}}. \tag{11}$$

Borrowing from *Section A* of the main appendix, the numerator in Equation 11 can be characterized along the following steps (keeping in mind that $\mathbf{a}\cdot\mathbf{b} = \sum_i a_i b_i$ and $\mathbf{a}\odot\mathbf{b} = [a_i b_i]_i$):

$$\begin{aligned}
\frac{(\partial W_i(.)/\partial \ln w_i)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}}{\partial V_i(.)/\partial Y_i} &= \left(\frac{\partial Y_i}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} + \left(\frac{\partial V_i}{\partial Y_i}\right)^{-1} \frac{\partial V_i(.)}{\partial \ln \tilde{\mathbf{P}}_{ii}} \cdot \frac{\partial \ln \tilde{\mathbf{P}}_{ii}}{\partial \ln w_i} \\
&= \bar{\mu}_i w_i L_i + \left(\frac{\partial \bar{\mu}_i}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} w_i L_i + \left(\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii}\right)\cdot\left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} - \mathbf{P}_{ii}\cdot\mathbf{Q}_{ii} \\
&= \sum_{n\neq i}\left(\mathbf{P}_{in}\cdot\mathbf{Q}_{in}\right) + \left(\mathbf{1} - \frac{\bar{\mu}_i}{\boldsymbol{\mu}}\right)\odot\mathbf{P}_{ii}\cdot\left(\frac{\partial \mathbf{Q}_{ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} + \left(\tilde{\mathbf{P}}_{ii} - \mathbf{P}_{-ii}\right)\cdot\left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}.
\end{aligned} \tag{12}$$

As in *Section A* of the main appendix, the denominator in Equation 11 can be specified as follows:

$$\left(\frac{\partial \mathrm{T}_i(.)}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} = \left(\frac{\partial}{\partial \ln w_i}\sum_{j\neq i}\left[\mathbf{P}_{ji}\cdot\mathbf{Q}_{ji} - \mathbf{P}_{ij}\cdot\mathbf{Q}_{ij}\right]\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} = \mathbf{P}_{-ii}\cdot\left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} - \sum_{j\neq i}\left[\left(\frac{\partial \mathbf{P}_{ij}\cdot\mathbf{Q}_{ij}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]. \tag{13}$$

Plugging Equations 12 and 13 back into the expression for $\bar{\tau}_i$ yields the following:

$$\tau_i = \frac{\sum_{n\neq i}\left(\mathbf{P}_{in}\cdot\mathbf{Q}_{in}\right) + \left(\mathbf{1} - \frac{\bar{\mu}_i}{\boldsymbol{\mu}}\right)\odot\mathbf{P}_{ii}\cdot\left(\frac{\partial \mathbf{Q}_{ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} + \left(\tilde{\mathbf{P}}_{ii} - \mathbf{P}_{-ii}\right)\cdot\left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}}{\mathbf{P}_{-ii}\left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} - \sum_{j\neq i}\left[\left(\frac{\partial \mathbf{P}_{ij}\cdot\mathbf{Q}_{ij}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]}. \tag{14}$$

To further simplify the above equation, note that F.O.C. (Equation 7) entails that

$$\sum_{j\neq i}\sum_{k}\left[\left(\mathbf{1}-\frac{\bar{\mu}_i}{\boldsymbol{\mu}}\right)\odot\mathbf{P}_{ii}\cdot\left(\frac{\partial\mathbf{Q}_{ii}}{\partial\ln\tilde{P}_{ji,k}}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}+\left(\tilde{\mathbf{P}}_{-ii}-(1+\bar{\tau}_i)\mathbf{P}_{-ii}\right)\cdot\left(\frac{\partial\mathbf{Q}_{-ii}}{\partial\ln\tilde{P}_{ji,k}}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]=0,$$

Since demand is homogeneous of degree zero and $\frac{\partial\ln Y_i}{\partial\ln w_i}\approx\frac{\partial\ln\tilde{P}_{ii,k}}{\partial\ln w_i}=1$, the above equation indicates that

$$\left(\mathbf{1}-\frac{\bar{\mu}_i}{\boldsymbol{\mu}}\right)\odot\mathbf{P}_{ii}\cdot\left(\frac{\partial\mathbf{Q}_{ii}}{\partial\ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}+\left(\tilde{\mathbf{P}}_{ii}-(1+\bar{\tau}_i)\mathbf{P}_{-ii}\right)\cdot\left(\frac{\partial\mathbf{Q}_{-ii}}{\partial\ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}=0.$$

We can use the above equation to cancel out the mirroring expressions in the numerator and denominator of Equation 14. After performing this simplification, the expression for $\bar{\tau}_i$ reduces to

$$\bar{\tau}_i=\frac{-\sum_{n\neq i}\left(\mathbf{P}_{in}\cdot\mathbf{Q}_{in}\right)}{\sum_{j\neq i}\left[\left(\frac{\partial\mathbf{P}_{ij}\cdot\mathbf{Q}_{ij}}{\partial\ln w_i}\right)_{\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]}=\frac{-1}{\sum_{j\neq i}\left[\mathbf{X}^*_{ij}\cdot\left(\mathbf{I}_K+\mathbf{E}^*_{ij}+\frac{t_j}{1+t_j\lambda^*_{jj}}\tilde{\mathbf{E}}^{(ij)*}_{jj}\right)\mathbf{1}_K\right]}. \tag{15}$$

The second line derives from the exact same steps discussed in *Section A* of the main appendix. The superscript "$*$" is added in the second line to indicate that a variable is evaluated in the (counterfactual) equilibrium under $\mathbf{t}^*_i$.

A.1 The Cobb-Douglas-CES Case

Suppose preferences have a Cobb-Douglas-CES parameterization:

$$U_i(\mathbf{Q}_{1i},...,\mathbf{Q}_{Ni})=\prod_{k=1}^{K}\left(\sum_{j=1}^{N}\varsigma_{ji,k}Q_{ji,k}^{\rho_k}\right)^{\frac{e_{i,k}}{\rho_k}};$$

where $\varsigma_{ji,k}\in\mathbb{R}_+$ is a constant taste shifter. Consistent with our earlier definition, $e_{i,k}$ denotes the expenditure share on industry k. Also, recall that λ denotes the *within-industry* expenditure share:

$$\lambda_{ji,k}=\frac{\tilde{P}_{ji,k}Q_{ji,k}}{\sum_{n=1}^{N}\tilde{P}_{ni,k}Q_{ni,k}}=\frac{\tilde{P}_{ji,k}Q_{ji,k}}{e_{i,k}Y_i}=\frac{e_{ji,k}}{e_{i,k}}.$$

Define $\epsilon_k\equiv\rho_k/(1-\rho_k)$. The Cobb-Douglas-CES demand structure yields the following that for demand elasticities:

$$\varepsilon_{ij,k}=-1-\epsilon_k(1-\lambda_{ij,k});\qquad\varepsilon^{(ij,k)}_{nj,k}=\epsilon_k\lambda_{ij,k};\qquad\varepsilon^{(nj,g)}_{ij,k}=0.$$

Plugging these elasticity values into Equations 10 and 15, delivers the following formulation for $t^*_{i,k}$:

$$1+t^*_{i,k}=\left[1+\frac{1}{\sum_g\sum_{j\neq i}\left(\chi^*_{ij,g}\epsilon_g\left[1-(1-\frac{t_{j,g}\lambda^*_{jj,g}e_{j,g}}{1+\sum_g t_{j,g}\lambda^*_{jj,g}e_{j,g}})\lambda^*_{ij,g}\right]\right)}\right]\frac{1+\epsilon_k\lambda^*_{ii,k}}{1+\frac{\bar{\mu}^*_i}{\mu_k}\epsilon_k\lambda^*_{ii,k}}.$$

B Proof of Proposition 5

The proof of Proposition 5 resembles that of Proposition 1 except in one detail: in the reformulated IO model, $P_{ji,k}(w_1,...,w_N)$ depends on the wage rate in every country. Specifically,

$$\begin{aligned} P_{ji,k}(w_j) &= \bar{\tau}_{ji,k}\bar{a}_{j,k}w_j && \text{[baseline model]} \\ P_{ji,k}(w_1,...,w_N) &= \bar{\bar{\tau}}_{ji,k}\bar{\bar{a}}_{j,k}\prod_{\ell} w_\ell^{\tilde{\gamma}_{j,k}(\ell)} && \text{[model w/ input trade]}. \end{aligned} \tag{16}$$

Considering the close correspondence between this case and the baseline case, we deduce from Lemma 2 that optimal tariff problem is convertible to one where each country i choses a vector of consumer prices, $\tilde{\mathbf{P}}_i$, subject to feasibility conditions:

$$\max_{\tilde{\mathbf{P}}_i}\ W_i(\tilde{\mathbf{P}}_i,\mathbf{t}_{-i};\mathbf{w})\equiv V_i(Y_i(\tilde{\mathbf{P}}_i,\mathbf{t}_{-i};\mathbf{w}),\tilde{\mathbf{P}}_i)\quad s.t.\ (\tilde{\mathbf{P}}_i,\mathbf{t}_{-i};\mathbf{w})\in\mathbb{F} \qquad \text{(P1 - IO)}$$

It is immediate that the only difference between problems (P1 - IO) and (P1) stems from the different elasticities of producer prices w.r.t. wage rates. Specifically, Equation 16 implies that

$$\begin{aligned} \left(\frac{\partial \ln P_{ij,k}(.)}{\partial \ln w_i}\right)_{\mathbf{w}_{-i}} &= 1 && \text{[baseline model]} \\ \left(\frac{\partial \ln P_{ij,k}(.)}{\partial \ln w_i}\right)_{\mathbf{w}_{-i}} &= \gamma_{ii,k} && \text{[model w/ input trade]}. \end{aligned}$$

Hence, provided that $\left(\frac{\mathrm{d}W_i}{\mathrm{d}\ln\mathbf{w}}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i}}\cdot\frac{\mathrm{d}\ln\mathbf{w}}{\mathrm{d}\ln\tilde{P}_{ji,k}}=\left(\frac{\mathrm{d}W_i}{\mathrm{d}\ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\mathbf{w}_{-i}}\frac{\mathrm{d}\ln w_i}{\mathrm{d}\ln\tilde{P}_{ji,k}}$ to a first-order approximation, all the steps that establish the uniformity of optimal tariffs in *Section A* of the main appendix continue to hold. That is, following the same exact steps that established uniformity in *Section A* of the main appendix, we can conclude that country i's optimal tariff is uniform and given by

$$1+t^*_i=1+\bar{\tau}_i,\quad \forall i\in\mathbb{C}.$$

Like before, $\bar{\tau}_i$ is defined by *Equation 34* in the main appendix:

$$\bar{\tau}_i \equiv \frac{\frac{(\partial W_i(.)/\partial \ln w_i)_{\bar{\mathbf{w}}_{-i}}}{\partial V_i(.)/\partial Y_i}}{(\partial \mathrm{T}_i(.)/\partial \ln w_i)_{\bar{\mathbf{w}}_{-i}}} \sim \frac{\frac{(\partial W_i(.)/\partial \ln w_i)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}}{\partial V_i(.)/\partial Y_i}}{(\partial \mathrm{T}_i(.)/\partial \ln w_i)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}}.$$

The numerator of the above equation can characterized along the following steps (recalling that $\mathbf{a}\cdot\mathbf{b} = \sum_i a_i b_i$ denotes the inner product of two equally-sized vectors and $\mathbf{a}\odot\mathbf{b} = [a_i b_i]_i$ denotes the element-wise product):

$$\begin{aligned}\frac{(\partial W_i(.)/\partial \ln w_i)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}}{\partial V_i(.)/\partial Y_i} &= \frac{\partial V_i(.)/\partial Y_i}{\partial V_i(.)/\partial Y_i}\left(\frac{\partial Y_i}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} = w_i L_i - \left(\frac{\partial}{\partial \ln w_i}\sum_n (\tilde{\mathbf{P}}_{ni}-\mathbf{P}_{ni})\cdot\mathbf{Q}_{ni}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} \\ &= w_i L_i - \tilde{\gamma}_{ii}\odot\mathbf{P}_{ii}\cdot\mathbf{Q}_{ii} + \sum_{j\neq i}\left[(\tilde{\mathbf{P}}_{ji}-\mathbf{P}_{ji})\cdot\left(\frac{\partial \mathbf{Q}_{ji}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right] = w_i L_i - \tilde{\gamma}_{ii}\odot\mathbf{P}_{ii}\cdot\mathbf{Q}_{ii} + \bar{\tau}_i\left(\frac{\partial \mathbf{P}_{-ii}\cdot\mathbf{Q}_{-ii}}{\partial \ln w_i}\right)\end{aligned}$$

where, $\tilde{\gamma}_{ii} \equiv [\tilde{\gamma}_{ii,k}]_k$, $\tilde{\mathbf{P}}_{ji} \equiv [\tilde{P}_{ji,k}]_k$, $\mathbf{P}_{ji} \equiv [P_{ji,k}]_k$, and $\mathbf{P}_{-ii} = [\mathbf{P}_{ji}]_{j\neq i}$. The last line in the above equation follows from that fact that the optimal tariff choice entails that $\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii} = \bar{\tau}_i\mathbf{P}_{-ii}$. Likewise, the denominator in Equation 17 can be specified as follows:

$$\left(\frac{\partial \mathrm{T}_i(.)}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} = \left(\frac{\partial}{\partial \ln w_i}\sum_{j\neq i}\left[\tilde{\mathbf{P}}_{ji}\cdot\mathbf{Q}_{ji} - \tilde{\mathbf{P}}_{ij}\cdot\mathbf{Q}_{ij}\right]\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} = \mathbf{P}_{-ii}\cdot\left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}} - \sum_{j\neq i}\left[\left(\frac{\partial \mathbf{P}_{ij}\cdot\mathbf{Q}_{ij}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]$$

Plugging the above expressions back into Equation 17 yields the following:

$$\bar{\tau}_i = \frac{w_i L_i - \tilde{\gamma}_{ii}\odot\mathbf{P}_{ii}\cdot\mathbf{Q}_{ii} + \bar{\tau}_i\mathbf{P}_{-ii}\cdot\left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i}}}{\mathbf{P}_{-ii}\cdot\left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i}} - \sum_{j\neq i}\left[\mathbf{P}_{ij}\odot\mathbf{Q}_{ij}\cdot\left(\frac{\partial \ln \mathbf{P}_{ij}\odot\mathbf{Q}_{ij}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]} = \frac{-1}{\sum_{j\neq i}\left[\mathbf{X}_{ij}\cdot\left(\frac{\partial \ln \mathbf{P}_{ij}\odot\mathbf{Q}_{ij}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]} \tag{17}$$

where $\mathbf{X}_{ij} = \{\chi_{ij,k}\}_{j,k}$ denotes the vector of export shares, as defined in *Section A* of the main appendix. To specify $\mathbf{X}_{ij}\cdot\left(\frac{\partial \ln \mathbf{P}_{ij}\odot\mathbf{Q}_{ij}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i}.\mathbf{w}_{-i}}$, we can appeal to the Marshallian demand elasticities defined under *Definition A* in the main appendix. This step yields the following formulation:

$$\begin{aligned}\mathbf{X}_{ij}\cdot\left(\frac{\partial \ln \mathbf{P}_{ij}\odot\mathbf{Q}_{ij}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i}.\mathbf{w}_{-i}} &= \sum_{k=1}^{K}\left[\tilde{\gamma}_{ii,k}\chi_{ij,k}\left(\frac{\partial \ln P_{ij,k}Q_{ij,k}}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right] \\ &= \sum_{k=1}^{K}\left(\tilde{\gamma}_{ii,k}\chi_{ij,k}\left[1+\sum_{g=1}^{K}\sum_{n=1}^{N}\left(\frac{\tilde{\gamma}_{in,g}}{\tilde{\gamma}_{ii,g}}\varepsilon_{ij,k}^{(nj,g)}\right)+\eta_{ij,k}\left(\frac{\partial \ln Y_j}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]\right),\end{aligned} \tag{18}$$

where the second line follows from the fact that $\frac{\partial \ln P_{ij,k}}{\partial \ln w_i} = \left(\frac{\partial \ln \tilde{P}_{ij,k}}{\partial \ln w_i}\right)_{\mathbf{t}_{-i}} = \tilde{\gamma}_{ii,k}$. Let $\phi_{ij,k}$ denote the share of good ij,k in country i's *value-added* exports. In particular,

$$\phi_{ij,k} \equiv \frac{\tilde{\gamma}_{ii,k} P_{ij,k} Q_{ij,k}}{w_i L_i - \tilde{\gamma}_{ii} \odot \mathbf{P}_{ii} \cdot \mathbf{Q}_{ii}} = \frac{\tilde{\gamma}_{ii,k} P_{ij,k} Q_{ij,k}}{\sum_{j \neq i} \tilde{\gamma}_{ii} \odot \mathbf{P}_{ij} \cdot \mathbf{Q}_{ij}} = \frac{\tilde{\gamma}_{ii,k} P_{ij,k} Q_{ij,k}}{\sum_{j \neq i} \sum_{g=1}^{K} \tilde{\gamma}_{ii,g} P_{ij,g} Q_{ij,g}}.$$

The term $\left(\frac{\partial \ln Y_j}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i, \mathbf{t}_{-i}, \bar{\mathbf{w}}_{-i}}$ in Equation 18 can be characterized analogous to *Equation 36* in the main appendix as $\left(\frac{\partial \ln Y_j}{\partial \ln w_i}\right)_{\tilde{\mathbf{P}}_i, \mathbf{t}_{-i}, \bar{\mathbf{w}}_{-i}} = \frac{\bar{t}_j}{1+\bar{t}_j e_{jj}} \sum_g \sum_{n,k} \left(\gamma_{in,k} e_{jj,g} \varepsilon^{(nj,k)}_{jj,g}\right)$. Te final step is to invoke two properties of the Marshallian demand function: (i) the Cournot Aggregation, (ii) homogeneity of degree zero. Doing so (as elaborated in *Section A* of the main appendix) and assuming homothetic preferences (i.e., $\eta_{ij,k} = 1$ for all ij,k), produces the following expression for $\bar{\tau}_i$:

$$t_i^* = \bar{\tau}_i = \frac{-1}{\sum_{j \neq i} \left[\mathbf{\Phi}^*_{ij} \cdot \left(\mathbf{I}_K + \mathbf{E}^*_{ij} \tilde{\mathbf{\Gamma}}_i + \frac{\bar{t}_j}{1+\bar{t}_j e_{jj}} \tilde{\mathbf{E}}^*_{jj} \tilde{\mathbf{\Gamma}}_i\right) \mathbf{1}_K\right]}, \tag{19}$$

where $\mathbf{\Phi}_{ij} \equiv [\phi_{ij,k}]_k$ denotes the vector of value-added export shares to destination j; $\mathbf{E}_{ij} \equiv \begin{bmatrix} \mathbf{E}^{(1j)}_{ij} & \cdots & \mathbf{E}^{(Nj)}_{ij} \end{bmatrix}$ and $\tilde{\mathbf{E}}_{jj} \equiv \begin{bmatrix} \tilde{\mathbf{E}}^{(1j)}_{ij} & \cdots & \tilde{\mathbf{E}}^{(Nj)}_{ij} \end{bmatrix}$ are $N \times NK$ matrixes of actual and expenditure-adjusted demand elasticities—as defined in Section 2 of the paper. The $NK \times K$ matrix $\tilde{\mathbf{\Gamma}}_i$ is defined as follows

$$\tilde{\mathbf{\Gamma}}_i \equiv \mathbf{1}_{1\times K} \otimes \left[\frac{\tilde{\gamma}_{in,g}}{\tilde{\gamma}_{ii,g}}\right]_{n \times g} = \mathbf{1}_{1\times K} \otimes \begin{bmatrix} \frac{\tilde{\gamma}_{i1,1}}{\tilde{\gamma}_{ii,1}} \\ \vdots \\ \frac{\tilde{\gamma}_{iN,K}}{\tilde{\gamma}_{ii,K}} \end{bmatrix},$$

where $\mathbf{1}_{1\times K}$ is $1 \times K$ row vector of ones and $\otimes$ denotes the Kronecker product. The superscript "$*$" in Equation 19 indicates that a variable is evaluated in the (counterfactual) equilibrium under $\mathbf{t}^*_i$.

C Equivalence between Duty Drawbacks and Export Tax Aversion

This appendix demonstrates that the optimal tariff formula derived under duty drawbacks can be alternatively derived from a revised version of problem (P1 - IO) where governments are afforded the liberty to tax exports but they assign an infinitely-negative weight to export tax revenues. Capitalizing on the discussion in Online Appendix B, We can represent such a problem as follows

$$\max_{\tilde{\mathbf{P}}_i,\, \tilde{\mathbf{P}}_i^{\mathcal{X}}} \; W_i(\tilde{\mathbf{P}}_i, \tilde{\mathbf{P}}_i^{\mathcal{X}}, \mathbf{t}_{-i}; \mathbf{w}) \equiv V_i(Y_i(.), \tilde{\mathbf{P}}_i) - \psi_i \underbrace{\left| \sum_{n \neq i} \left[\left(\tilde{\mathbf{P}}_{in} - \mathbf{P}_{in} \right) \cdot \mathbf{Q}_{in} \right] \right|}_{\text{export tax revenue}} \quad s.t. \; (\tilde{\mathbf{P}}_i, \tilde{\mathbf{P}}_i^{\mathcal{X}}, \mathbf{t}_{-i}; \mathbf{w}) \in \mathbb{F}^{\mathcal{X}} \qquad (\text{P1}^{X}\text{- I}$$

where $\tilde{\mathbf{P}}_i^{\mathcal{X}}$ denotes country i's entire vector of export prices:

$$\tilde{\mathbf{P}}_i^{\mathcal{X}} = \left\{ \tilde{\mathbf{P}}_{i1}, ..., \tilde{\mathbf{P}}_{ii-1}, \tilde{\mathbf{P}}_{ii+1}, ..., \tilde{\mathbf{P}}_{iN} \right\},$$

The weight ψ_i accounts for the governments attitude towards export taxation. A infinitely-high ψ_i inidcates complete aversion to export taxation, whereas $\psi_i = 0$ indicates no aversion. Total income $Y_i(.) \sim Y_i(\tilde{\mathbf{P}}_i, \tilde{\mathbf{P}}_i^{\mathcal{X}}, \mathbf{t}_{-i}; \mathbf{w})$, in this setup, is the sum of wage income plus import and export tax revenues:

$$Y_i = w_i L_i + \left(\tilde{\mathbf{P}}_{ii} - \mathbf{P}_{ii} \right) \cdot \mathbf{Q}_{in} + \underbrace{\sum_{n \neq i} \left[\left(\tilde{\mathbf{P}}_{ni} - \mathbf{P}_{ni} \right) \cdot \mathbf{Q}_{in} \right]}_{\text{import tariff revneue}} + \underbrace{\sum_{n \neq i} \left[\left(\tilde{\mathbf{P}}_{in} - \mathbf{P}_{in} \right) \cdot \mathbf{Q}_{in} \right]}_{\text{export tax revneue}}.$$

Recall from Online Appendix B that $\tilde{\mathbf{P}}_{ii}$ is added to the government's problem for the sake of simplicity. The fact that markets are efficient indicates that the optimal choice w.r.t. $\tilde{\mathbf{P}}_{ii}$ amounts to zero taxations of domestically produced and consumed goods: $\tilde{\mathbf{P}}_{ii}^* = \mathbf{P}_{ii}$. Also note that in the above setup, we are allowing for taxes to propagate through the input-output network. specifically, the producer price of good ij, g which is exported by country i depends on the tariff-inclusive price paid for inputs from different origins (denoted by ℓ) and industries:

$$P_{ij,k} = \bar{\tau}_{ij,k} \bar{a}_{i,k} w_i^{\gamma_{j,k}} \prod_{\ell, g} P_{\ell i, g}^{\alpha_{i,k}^{\ell, g}}$$

With the above background in mind, we can build on the observation in Beshkar and Lashkaripour (2020) that holding $\tilde{\mathbf{P}}_i^{\mathcal{X}}$ fixed, the choice w.r.t. $\tilde{\mathbf{P}}_i$ has no effect on foreign markets whatsoever. The intuition is simple: The only price variables associated with country i that matter to economic outcomes in the rest of the world are encompassed in $\tilde{\mathbf{P}}_i^{\mathcal{X}}$. Fixing country i's choice w.r.t. $\tilde{\mathbf{P}}_i^{\mathcal{X}}$ and holding $\mathbf{w}_{-i}$ fixed, the choice w.r.t. import tariffs (or $\tilde{\mathbf{P}}_i$) has no consequence for foreign economies. The consequences of Home's policy choice for the rest of the world are entirely pinned down by vector $\tilde{\mathbf{P}}_i^{\mathcal{X}}$. To be clear, this assertion is true because there are no economies or diseconomies of scale in production. Enter (dis)economies of scale, the choice w.r.t. $\tilde{\mathbf{P}}_i$ can have an independent effect on the scale of foreign production and its producer prices, even after we fix $\tilde{\mathbf{P}}_i^{\mathcal{X}}$.

Capitalizing on the observation presented above, we can follow the same steps from *Section A* of the main appendix to produce the following optimality condition w.r.t. $\tilde{P}_{ji,k} \in$

$\tilde{\mathbf{P}}_i$ given $\tilde{\mathbf{P}}_i^{\mathcal{X}}$ (see *Equation 32* in the main appendix) :

$$\sum_{n\neq i}\left[\left(\tilde{\mathbf{P}}_{ni,g}-(1+\bar{\tau}_i)\mathbf{P}_{ni,g}\right)\cdot\mathbf{Q}_{ni}\odot\boldsymbol{\varepsilon}_{ni}^{(ji,k)}\right]=0\qquad\forall ji,k\neq ii,k.$$

Importantly, the above equation is independent of the value assigned ψ_i. That is, it holds even in the limit where ψ_i approaches infinity. Hence, we can immediately conclude that the optimal tariff implied by problem (P1$^{\mathrm{X}}$- IO) is uniform and given by:

$$1+t_{ni,g}^{*}=\frac{\tilde{P}_{ni,g}^{*}}{P_{ni,g}}=1+\bar{\tau}_i.$$

Now, if we set $\psi_i\rightarrow\infty$, it immediately follows that the export tax on any good in,g is zero. Otherwise, if $\tilde{P}_{in,g}-\tilde{P}_{in,g}\neq 0$, the government's objective function will approach negative infinity, i.e., $\lim_{\psi_i\rightarrow\infty}\tilde{P}_{in,g}^{*}-\tilde{P}_{in,g}\neq 0\implies\lim_{\psi_i\rightarrow\infty}W_i\rightarrow-\infty$. Stated, formally the optimal export tax under complete export tax aversion is given by:

$$\lim_{\psi_i\rightarrow\infty}1+x_{in,g}^{*}=\frac{\tilde{P}_{in,g}}{P_{in,g}}=0.$$

The final step is to determines $\bar{\tau}_i$. To this end we invoke the definition of $\bar{\tau}_i$ and follow the same exact steps as in Online Appendix B. Doing so while noting that $\tilde{P}_{in,g}^{*}-\tilde{P}_{in,g}=0$, yields the following

$$\lim_{\psi_i\rightarrow\infty}\bar{\tau}_i=\frac{-1}{\sum_{j\neq i}\left[\mathbf{X}_{ij}\cdot\left(\frac{\partial\ln\mathbf{P}_{ij}\odot\mathbf{Q}_{ij}}{\partial\ln w_i}\right)_{\tilde{\mathbf{P}}_i,\mathbf{t}_{-i},\bar{\mathbf{w}}_{-i}}\right]}.$$

Observing that $\partial\ln P_{nj,k}/\partial\ln w_i=\tilde{\gamma}_{in,k}$, we can immediately produce the exact same optimal tariff formula specified under Proposition 5. Note that the same argument can be applied to the baseline optimal tariff problem (P1). That is, assuming governments cannot use export taxes in (P1) is equivalent to affording them the liberty of using export taxes, but assigning an infinitely-high negative weight to export tax revenues.

D Optimal Tariff Formulas under the Integrated Model

This appendix characterizes the optimal tariffs under the integrated model, while assuming that preferences have a Cobb-Douglas-CES parameterization. Combining the insights from the proof of Propositions 3 and 4, we can express all equilibrium variables in terms of the triplet, $(\tilde{\mathbf{P}}_{-ii},\mathbf{t}_{-i};\mathbf{w})$. Nest, following the same argument presented in Online Appendix A, the optimal tariff problem in the integrated model can be recast as a problem where the government chooses the import price vector, $\tilde{\mathbf{P}}_{-ii}$. This problem can be formally represented as

$$\max_{\tilde{\mathbf{P}}_{-ii}} \; W_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) \equiv V_i(Y_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}), \tilde{\mathbf{P}}_{-ii}, \tilde{P}_{ii}(w_i)) \qquad s.t. \;\; (\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) \in \mathbb{F} \qquad \text{(P1 - Unified)}$$

In the above problem, country i's total income, Y_i, is the sum of revenue from sales as well as tax revenues. So, using the *inner product* ($\mathbf{a} \cdot \mathbf{b} = \sum_i a_i b_i$) to economize on the notation, Y_i can be formulated as

$$Y_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) = \bar{\mu}_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) w_i L_i + \left[\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{ii}(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w})\right] \cdot \mathbf{Q}_{-ii}(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}).$$

The the average markup, $\bar{\mu}_i$, in economy i given by

$$\bar{\mu}_i(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) = \frac{\sum_j \sum_n \left[\tilde{\gamma}_{ij} \odot \mathbf{P}^{\mathcal{C}}_{jn}(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) \cdot \mathbf{Q}^{\mathcal{C}}_{jn,k}(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w})\right]}{\sum_j \sum_n \left[\left(\tilde{\gamma}_{ij} \oslash \tilde{\boldsymbol{\mu}}^{\mathcal{C}}_j\right) \odot \mathbf{P}^{\mathcal{C}}_{jn}(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w}) \cdot \mathbf{Q}^{\mathcal{C}}_{jn,k}(\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}; \mathbf{w})\right]},$$

with $\odot$ and $\oslash$ denoting element-wise division and multiplication operators for equally-sized vectors, while $\tilde{\gamma}_{ij} \equiv \left[\tilde{\gamma}_{ij,k}\right]_k$ and $\tilde{\boldsymbol{\mu}}^{\mathcal{C}}_j \equiv \left[\mu^{\mathcal{C}}_{j,k}\right]_k$ are $K \times 1$ vectors, the elements of which are given by *Equations 18* and *22* in the paper. Also, recall that $\tilde{\mu}^{\mathcal{C}}_{n,k}$ denotes the compounded markup charged on the final traded goods from origin n–industry k. These constant compounded markups are, by definition, given by

$$\left[\tilde{\mu}^{\mathcal{C}}_{n,k}\right]_{n \times k} = (\mathbf{I}_{NK} - \mathbf{A})^{-1} (\mathbf{1}_N \otimes \boldsymbol{\mu}), \tag{20}$$

where $\boldsymbol{\mu} \equiv [\mu_k]_k$ is a $K \times 1$ column vector of industry-level markups.

There is extensive overlap between the above problem and those analyzed in Online Appendixes A and B. Hence, in the interest of space, I will leave out some repetitive derivation details. Following the same steps as those presented in A, the necessary condition for optimality the of price instrument $\tilde{P}_{ji,k}$ can be expressed as

$$\sum_{n=1}^{N} \left[\tilde{\gamma}_{in} \odot \left(\mathbf{1} - \frac{\bar{\mu}_i}{\tilde{\boldsymbol{\mu}}_n}\right) \odot \mathbf{P}^{\mathcal{C}}_{ni} \odot \mathbf{Q}^{\mathcal{C}}_{ni} \cdot \boldsymbol{\varepsilon}^{(ji,k)}_{ni}\right] + \left(\tilde{\mathbf{P}}^{\mathcal{C}}_{-ii} - (1 + \bar{\tau}_i)\mathbf{P}^{\mathcal{C}}_{-ii}\right) \odot \mathbf{Q}^{\mathcal{C}}_{-ii} \cdot \boldsymbol{\varepsilon}^{(ji,k)}_{-ii} = 0. \tag{21}$$

Recall that $\boldsymbol{\varepsilon}^{(ji,k)}_{-ii} \equiv \left[\varepsilon^{ji,k}_{ni,g}\right]_{n \neq i,g}$ is a $(N-1)K$ vector of Marshallain demand elasticities. Likewise, $\mathbf{Q}^{\mathcal{C}}_{-ii} \equiv \left[Q^{\mathcal{C}}_{ni,g}\right]_{n \neq i,g}$ and $\mathbf{P}^{\mathcal{C}}_{-ii} \equiv \left[P^{\mathcal{C}}_{ni,g}\right]_{n \neq i,g}$ are $(N-1)K$ vectors of import quantitates and prices for the final goods (demoted by $\mathcal{C}$). Meanwhile, $\bar{\tau}_i$, is a uniform scalar that encapsulates general equilibrium wage effects and is defined as follows:

$$\bar{\tau}_i \equiv \frac{\frac{(\partial W_i(.)/\partial \ln w_i)_{\bar{\mathbf{w}}_{-i}}}{\partial V_i(.)/\partial Y_i}}{(\partial \mathrm{T}_i(.)/\partial \ln w_i)_{\bar{\mathbf{w}}_{-i}}} \sim \frac{\frac{(\partial W_i(.)/\partial \ln w_i)_{\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}, \bar{\mathbf{w}}_{-i}}}{\partial V_i(.)/\partial Y_i}}{(\partial \mathrm{T}_i(.)/\partial \ln w_i)_{\tilde{\mathbf{P}}_{-ii}, \mathbf{t}_{-i}, \bar{\mathbf{w}}_{-i}}}.$$

To economize on the notation, I hereafter omit the "$\mathcal{C}$" superscript that identifies the final good variables (except for $\tilde{\mu}_i^{\mathcal{C}}$). Also, since we are focusing on Cobb-Douglas-CES preferences, the reduced-form demand elasticities are given by the following formulation:

$$\varepsilon_{ij,k}^{(ij,k)} = -1 - \epsilon_k \left(1 - \lambda_{ij,k}\right); \qquad \varepsilon_{nj,k}^{(ij,k)} = \epsilon_k \lambda_{ij,k}; \qquad \varepsilon_{ij,k}^{(ij,g)} = 0.$$

Plugging these values into the F.O.C. (Equation 21) and noting that $1 + t_{ni,k} = \tilde{P}_{ni,k}/P_{ni,k}$, yields the following optimality condition:

$$(1 - \frac{\bar{\mu}_i}{\tilde{\mu}_{i,k}^{\mathcal{C}}})\tilde{\gamma}_{ii,k}\epsilon_k \lambda_{ii,k} - \left(1 - \frac{1 + \bar{\tau}_i - (1 - \frac{\bar{\mu}_i}{\tilde{\mu}_{j,k}^{\mathcal{C}}})\tilde{\gamma}_{ij,k}}{1 + t_{ji,k}}\right)(1 + \epsilon_k) + \sum_{n \neq i}\left[\left(1 - \frac{1 + \bar{\tau}_i - (1 - \frac{\bar{\mu}_i}{\tilde{\mu}_{n,k}^{\mathcal{C}}})\tilde{\gamma}_{in,k}}{1 + t_{ni,k}}\right)\lambda_{ni,k}\epsilon_k\right] = 0$$

Define $1 - \Delta_{ni,k} \equiv \frac{1 + \bar{\tau}_i - (1 - \frac{\bar{\mu}_i}{\tilde{\mu}_{n,k}})\tilde{\gamma}_{in,k}}{1 + t_{ni,k}}$; we can immediately infer from the above F.O.C. optimal tariffs require a uniform $\Delta_{ji,k}^* = \Delta_{i,k}^*$. Invoking this observation, we can simplify the F.O.C. w.r.t. $\tilde{P}_{ji,k}$ as

$$(1 - \frac{\bar{\mu}_i}{\tilde{\mu}_{i,k}^{\mathcal{C}}})\tilde{\gamma}_{ii,k}\epsilon_k \lambda_{ii,k} - (1 + \epsilon_k)\Delta_{i,k}^* + \Delta_{i,k}^*(1 - \lambda_{ii,k})\epsilon_k = 0.$$

Rearranging the above equation and invoking the definition of $\delta_{ji,k}$ delivers the following formula for the optimal tariff on good ji, k:

$$1 + t_{ji,k}^* = \left[\frac{1 + \epsilon_k \lambda_{ii,k}^*}{1 + \left[1 - \tilde{\gamma}_{ii,k}\left(1 - \frac{\bar{\mu}_i^*}{\tilde{\mu}_{i,k}^{\mathcal{C}}}\right)\right]\epsilon_k \lambda_{ii,k}^*}\right]\left(1 + \bar{\tau}_i^* - [1 - \frac{\bar{\mu}_i}{\tilde{\mu}_{j,k}^{\mathcal{C}}}]\tilde{\gamma}_{ij,k}\right) \tag{22}$$

The final step is to characterize $\bar{\tau}_i$. Using the definition for $\bar{\tau}_i$ and combining the steps outlined in Online Appendixes A and B indicates that

$$\bar{\tau}_i^* = \frac{1}{\sum_{j \neq i,k}\left[\phi_{ij,k}^* \epsilon_k \left(1 - \left(1 - \delta_{j,k}^*\right)\sum_n \frac{\tilde{\gamma}_{in,k}}{\tilde{\gamma}_{ii,k}}\lambda_{nj,k}^*\right)\right]}, \tag{23}$$

where $\delta_{j,g}^* \equiv \frac{t_{j,g}\lambda_{jj,g}^* e_{j,g}}{1 + \sum_g t_{j,g}\lambda_{jj,g}^* e_{j,g}}$ accounts for the effect of w_i on tax revenue income in country j.

Mapping the Optimal Tariff Formula to Data. Equations 22 and 23 provide a sufficient statistics characterization of unilaterally optimal tariffs as a function of trade elasticities elasticities, markup wedges, and observable shares. So, as in the previous cases, we can use the exact hat-algebra notation to jointly solve (a) the optimal tariffs specified by Equations 22 and 23, plus (b) equilibrium conditions. Doing so involves solving the following system featuring $N(N-1)K + 2N$ independent equation and unknowns, namely,

$\mathbf{t}^* \equiv \{t^*_{ji,k}\}$, $\hat{\mathbf{w}} \equiv \{\hat{w}_i\}$, and $\hat{\mathbf{Y}} \equiv \{\hat{Y}_i\}$:

Proposition 1. *Suppose preferences are described by the CES-Cobb-Douglas functional from (Equation 10 in the paper). The Nash tariffs under the integrated model, $\{t^*_{i,k}\}$, and their effect on wages, $\{\hat{w}_i\}$, and total income, $\{\hat{Y}_i\}$, can be solved as a solution to the following system:*

$$\begin{cases} 1+t^*_{i,k} = \left[1+\frac{1}{\sum_{j\neq i}\sum_k\left[\phi^*_{ij,k}\epsilon_k\left(1-\left(1-\delta^*_{j,k}\right)\sum_n\frac{\tilde{\gamma}_{in,k}}{\tilde{\gamma}_{ii,k}}\hat{\lambda}^{\mathcal{C}}_{nj,k}\lambda^{\mathcal{C}}_{nj,k}\right)\right]}\right]\frac{1+\epsilon_k\hat{\lambda}^{\mathcal{C}}_{ii,k}\lambda^{\mathcal{C}}_{ii,k}}{1+\frac{\bar{\mu}_i}{\mu_k}\epsilon_k\hat{\lambda}^{\mathcal{C}}_{ii,k}\lambda^{\mathcal{C}}_{ii,k}} & [\text{optimal tariff}] \\ \phi^*_{ij,k} = \frac{\frac{\tilde{\gamma}_{ii,k}}{1+t^*_{j,k}}\hat{\lambda}^{\mathcal{C}}_{ij,k}\lambda^{\mathcal{C}}_{ij,k}e_{j,k}\hat{Y}_jY_j}{\sum_{n\neq i}\sum_k\frac{\tilde{\gamma}_{ii,k}}{1+t^*_{n,k}}\hat{\lambda}^{\mathcal{C}}_{in,k}\lambda^{\mathcal{C}}_{in,k}e_{n,k}\hat{Y}_nY_n}; \qquad \delta^*_{j,k}\equiv\frac{t^*_{j,k}\hat{\lambda}^{\mathcal{C}}_{jj,k}\lambda^{\mathcal{C}}_{jj,k}e_{j,k}}{1+\sum_k t^*_{j,k}\hat{\lambda}^{\mathcal{C}}_{jj,k}\lambda^{\mathcal{C}}_{jj,k}e_{j,k}} & [\text{export shares and } \delta] \\ \hat{\lambda}^{\mathcal{C}}_{ji,k} = \frac{\left[(\widehat{1+t}_{ji,k})\prod_\ell\hat{w}_\ell^{\gamma_{\ell j,k}}\right]^{-\epsilon_k}}{\sum_{n=1}^N\left(\lambda^{\mathcal{C}}_{ni,k}\left[(\widehat{1+t}_{ni,k})\prod_\ell\hat{w}_\ell^{\gamma_{\ell n,k}}\right]^{-\epsilon_k}\right)}; \qquad \widehat{1+t}_{ji,k}=\frac{1+t^*_{i,k}}{1+\bar{t}_{ji,k}} & [\text{expenditure shares}] \\ \hat{w}_iw_iL_i = \sum_k\sum_j\left[\frac{1}{\mu_k(1+t^*_{j,k})}\hat{\lambda}^{\mathcal{C}}_{ij,k}\lambda^{\mathcal{C}}_{ij,k}e_{j,k}\hat{Y}_jY_j\right] & [\text{wage income}] \\ \bar{\mu}_i = \sum_k\sum_j\left[\frac{1}{(1+t^*_{j,k})}\hat{\lambda}^{\mathcal{C}}_{ij,k}\lambda^{\mathcal{C}}_{ij,k}e_{j,k}\hat{Y}_jY_j\right]/\hat{w}_iw_iL_i & [\text{average markup}] \\ \hat{Y}_iY_i = \bar{\mu}_i\hat{w}_iw_iL_i+\sum_k\sum_{j\neq i}\left(\frac{t^*_{i,k}}{1+t^*_{i,k}}\hat{\lambda}^{\mathcal{C}}_{ji,k}\lambda^{\mathcal{C}}_{ji,k}e_{i,k}\hat{Y}_iY_i\right) & [\text{income = sales + tax revenue}] \end{cases},$$

Moreover, solving the above system requires information on only (i) industry-level trade elasticities, $\{\epsilon_k\}$;(i) applied tariffs, $\bar{t}_{ji,k}$, (ii)observable shares $\lambda^{\mathcal{C}}_{ji,k}$, $e_{i,k}$, and $\alpha^{\ell,g}_{j,k}$; and (iii) national expenditure and income levels, Y_i and w_iL_i.

An important detail regarding the above system: at first glance, it appears that this system features $N(N-1)K$ unknown Nash tariff rates. The system however, can be solve with substantially fewer degrees of freedom. Specifically, to pin down country i's entire tariff schedule we need to solve for one value for $\bar{t}^*_i$ and K values for $\Delta^*_{i,k}$. As such, country i's $(N-1)K$ Nash tariff rates can be pinned down with knowledge of $K+1$ variables. Accordingly, the above system effectively features $N(K+1)$ unknown tariff rates, which leads to notable gains in computation speed.

E The Characterization of Cooperative Tariffs

Recall from *Section 4* that cooperative tariffs solve the following problem:

$$\mathbf{t}^\star = \arg\max_{\mathbf{t}} \sum_{i=1}^N W_i(\mathbf{t};\mathbf{w}) \qquad \text{(P2)}$$

In the same vein as Lemma 1 (in *Section A* of the main appendix) we can formulate all equilibrium variables as function trade prices in each economy $n\in\mathbb{C}$, $\{\tilde{\mathbf{P}}_{-nn}\}_n$, and the vector of wages, $\mathbf{w}$ (see Online Appendix A). Welfare in country i, in that case, can be expressed as follows:

$$W_i(\mathbf{t};\mathbf{w}) \sim W_i(\{\tilde{\mathbf{P}}_{-nn}\}_n;\mathbf{w}) \equiv V_i(Y_i(\{\tilde{\mathbf{P}}_{-nn}\}_n;\mathbf{w}),\tilde{\mathbf{P}}_{-ii},\tilde{P}_{ii}(w_i)).$$

Invoking the above formulation, we can recast Problem (P2) as one where global welfare is maximized by directly choosing the "consumer" price of traded goods all over the world.

Lemma 2. *we can reformulate Problem (P2) as one where a central planer chooses the "consumer" price of import varieties in every country. Namely,*

$$\max_{\{\tilde{\mathbf{P}}_{-ii}\}_i} \sum_{i=1}^{N} W_i\left(\{\tilde{\mathbf{P}}_{-ii}\}_i;\mathbf{w}\right) \qquad s.t.\ \ (\{\tilde{\mathbf{P}}_{-ii}\}_i;\mathbf{w}) \in \mathbb{F} \qquad (\text{P2}'),$$

where $\mathbb{F}$ is the set of price-wage combinations such that given $\{\tilde{\boldsymbol{P}}_{-ii}\}_i$, the wage vector $\boldsymbol{w}$ solves the labor market clearing in every country, i.e., $w_i L_i = \sum_{j=1}^{N} \boldsymbol{P}_{ij}(\{\tilde{\boldsymbol{P}}_{-nn}\}_n;\boldsymbol{w}) \cdot \boldsymbol{Q}_{ij}(\{\tilde{\boldsymbol{P}}_{-nn}\}_n;\boldsymbol{w})$.

The proof of the above lemma is akin to that provided for Lemma 2 in *Section A* of the main appendix, and "$\cdot$" as before denotes the inner product operator: $\mathbf{a}\cdot\mathbf{b} = \sum_i a_i b_i$. The solution to Problem (P2') automatically pins down the cooperative tariffs as the optimal wedge between consumer and producer prices:

$$1 + t^{\star}_{ji,k} = \tilde{P}^{\star}_{ji,k}/P_{ji,k} \qquad \forall j \neq i.$$

Next, we need to derive the necessary F.O.C.s for optimality w.r.t. each price instrument. Using the notation introduced for partial derivatives in *Section A* of the main appendix (under *Notation A*), we can express the F.O.C. w.r.t. to $\tilde{P}_{ji,k}$ as

$$\sum_{n=1}^{N}\left(\frac{\mathrm{d}W_n}{\mathrm{d}\ln \tilde{P}_{ji,k}}\right) = \frac{\partial V_i(.)}{\partial \ln \tilde{P}_{ji,k}} + \sum_{n=1}^{N}\left[\frac{\partial V_n(.)}{\partial Y_n}\left(\frac{\partial Y_n}{\partial \ln \tilde{P}_{ji,k}}\right)_{\mathbf{w}}\right] + \left(\sum_{n=1}^{N}\frac{\partial W_n(.)}{\partial \ln \mathbf{w}}\right)_{\{\tilde{\mathbf{P}}_{-nn}\}} \cdot \frac{\mathrm{d}\ln \mathbf{w}}{\mathrm{d}\ln \tilde{P}_{ji,k}} = 0. \tag{24}$$

The above equation derives from the observation that, holding $\mathbf{w}$ fixed, $\tilde{P}_{ji,k}$ has no effect on consumer prices in countries other than i. That is, $\frac{\partial V_n(Y_n,\tilde{\mathbf{P}}_n)}{\partial \ln \tilde{P}_{ji,k}} = 0$ if $n \neq i$. To simplify the above equation, we can invoke two intermediate results. First, since (1) preferences across industries have a Cobb-Douglas parmaterization and (2) markups are constant, global profits are a constant share of global sales, i.e., $\sum_{n=1}^{N} \bar{\mu}_n w_n L_n = \overline{\mu} \sum_{n=1}^{N} w_n L_n$ where $\overline{\mu}$ in invariant to the choice of tariffs (see Chaney (2008) for a proof of this result). Second, we can appeal to an envelope result on the welfare-neutrality of wage effects, as is presented below.

Lemma 3. *Wage effects are globally welfare neutral:* $\left(\sum_{n=1}^{N} \frac{\partial W_n(.)}{\partial \ln \boldsymbol{w}}\right)_{\{\tilde{\boldsymbol{P}}_{-nn}\}} = 0.$

Proof. Noting that $Y_i = \bar{\mu}_i w_i L_i + \left(\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii}\right)\cdot \mathbf{Q}_{-ii}$, we can write global income as follows:

$$\sum_{n=1}^{N} Y_n = \sum_{n=1}^{N} (\bar{\mu}_n w_n L_n) + \sum_{n=1}^{N} \left[\left(\tilde{\mathbf{P}}_{-nn} - \mathbf{P}_{-nn} \right) \cdot \mathbf{Q}_{-nn} \right]$$

The fact that profits are a constant share of output entails that $\sum_{n=1}^{N} \left(\frac{\partial \bar{\mu}_n}{\partial w_i} \right)_{\mathbf{w}} w_n L_n$. So, given that $\frac{\partial V_n(.)}{\partial Y_n} = 1$ for all n (per the Cobb-Douglas-CES assumption), the derivative of global welfare w.r.t. country i's wage can be expressed as

$$\left(\sum_{n=1}^{N} \frac{\partial W_n(.)}{\partial \ln w_i} \right)_{\{\tilde{\mathbf{P}}_{-nn}\}, \mathbf{w}_{-i}} = \frac{\partial V_i(.)}{\partial \tilde{\mathbf{P}}_{ii}} \cdot \frac{\partial \tilde{\mathbf{P}}_{ii}}{\partial \ln w_i} + \left(\sum_{n=1}^{N} \frac{\partial V_n(.)}{\partial Y_n} \frac{\partial Y_n(.)}{\partial \ln w_i} \right)_{\{\tilde{\mathbf{P}}_{-nn}\}, \mathbf{w}_{-i}} = \frac{\partial V_i(.)}{\partial \tilde{\mathbf{P}}_{ii}} \cdot \frac{\partial \tilde{\mathbf{P}}_{ii}}{\partial \ln w_i} + \left(\frac{\partial \sum_{n=1}^{N} Y_n(.)}{\partial \ln w_i} \right)_{\{\tilde{\mathbf{P}}_{-nn}\}, \mathbf{w}_{-i}}$$

$$= -\mathbf{P}_{ii} \cdot \mathbf{Q}_{ii} + \mu_i w_i L_i - \sum_i \left(\frac{\partial \left[\left(\tilde{\mathbf{P}}_{-nn} - \mathbf{P}_{-nn} \right) \cdot \mathbf{Q}_{-nn} \right]}{\partial \ln w_i} \right)_{\{\tilde{\mathbf{P}}_{-nn}\}, \mathbf{w}_{-i}} = \sum_{j \neq i} \left(\mathbf{P}_{ij} \cdot \mathbf{Q}_{ij} - \mathbf{P}_{ij} \cdot \mathbf{Q}_{ij} \right) = 0,$$

where last line follows from Roy's identity, $\frac{\partial V_i(.)}{\partial \tilde{\mathbf{P}}_{ii}} = -\mathbf{Q}_{ii}$, the labor-market clearing condition, $\sum_n \mathbf{P}_{in} \cdot \mathbf{Q}_{in} = \bar{\mu}_i w_i L_i$, and the fact that $\partial \ln P_{in,k} / \partial \ln w_i = 1$ for all in, k. To elaborate more on the derivation, the above calculations materialize on the two observations: First: fixing $\tilde{\mathbf{P}}_{-ii}$ to its optimal level (as implied by by the system specified by Equation 24, below), w_i has no effect on Q_{-ii} due to the Marshallian demand being homogeneous of degree zero. Second, holding the entire vector of consumer prices for traded goods $\{\tilde{\mathbf{P}}_{-nn}\}$ fixed, w_i only affects the consumer price of goods produced and consumed domestically in country i—i.e., fixing $\{\tilde{\mathbf{P}}_{-nn}\}$, w_i has no effect on $\tilde{\mathbf{P}}_n$ nor $\mathbf{Q}_{-nn}$ for any $n \neq i$. □

Using the above lemma, and the fact that $Y_i = \bar{\mu}_i w_i L_i + \left(\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii} \right) \cdot \mathbf{Q}_{-ii}$ and $\sum_{n=1}^{N} \bar{\mu}_n w_n L_n = \overline{\mu} \sum_{n=1}^{N} w_n L_n$, the F.O.C. under Equation 24 reduces to

$$\frac{\partial V_i(.)}{\partial \ln \tilde{P}_{ji,k}} + \sum_{n=1}^{N} \left[\left(\frac{\partial Y_n}{\partial \ln \tilde{P}_{ji,k}} \right)_{\mathbf{w}} \right] = \frac{\partial V_i(.)}{\partial \ln \tilde{P}_{ji,k}} + \tilde{P}_{ji,k} Q_{ji,k} + \left(\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii} \right) \cdot \frac{\partial \mathbf{Q}_{-ii}}{\partial \ln \tilde{P}_{ji,k}} + \sum_{n=1}^{N} \left[\left(\frac{\partial \overline{\mu}_n}{\partial \tilde{P}_{ji,k}} \right)_{\mathbf{w}} w_n \bar{L}_n \right]$$

$$= \left(\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii} \right) \cdot \left(\frac{\partial \mathbf{Q}_{-ii}}{\partial \ln \tilde{P}_{ji,k}} \right)_{\mathbf{w}} + \sum_{n=1}^{N} \left[\left(\mathbf{1} - \overline{\mu} \oslash \boldsymbol{\mu} \right) \odot \mathbf{P}_{ni} \odot \mathbf{Q}_{ni} \cdot \left(\frac{\partial \ln \mathbf{Q}_{ni}}{\partial \ln \tilde{P}_{ji,k}} \right)_{\mathbf{w}} \right] = 0 \tag{25}$$

where the second line derives from Roy's identity, whereby $\frac{\partial V_i(.)}{\partial \ln \tilde{P}_{ji,k}} = -\tilde{P}_{ji,k} Q_{ji,k}$. As before, $\odot$ and $\oslash$ denote element-wise vector multiplication and division. Mimicking the steps presented earlier in *Section A* of the main appendix and Online Appendix A, Equation 25 is satisfied if

$$\left(\tilde{\mathbf{P}}_{-ii} - \mathbf{P}_{-ii} \right) \odot \mathbf{Q}_{-ii} \cdot \boldsymbol{\varepsilon}_{-ii}^{(ji,k)} + \sum_{n=1}^{N} \left[\left(\mathbf{1} - \overline{\mu} \oslash \boldsymbol{\mu} \right) \odot \mathbf{P}_{ni} \odot \mathbf{Q}_{ni} \cdot \boldsymbol{\varepsilon}_{ni}^{(ji,k)} \right] = 0. \tag{26}$$

Now, let us switch to the demand elasticity formulations implied by CES-Cobb-Douglas preferences:

$$\varepsilon_{ij,k}^{(ij,k)} = -1 - \epsilon_k \left(1 - \lambda_{ij,k} \right); \qquad \varepsilon_{nj,k}^{(ij,k)} = \epsilon_k \lambda_{ij,k}; \qquad \varepsilon_{ij,k}^{(ij,g)} = 0.$$

Plugging these eslaticity values into Equation 26 yields the following optimality condition w.r.t. $\tilde{P}_{ji,k}$:

$$-\left[1-\frac{\overline{\mu}}{\mu_k}\frac{P_{ji,k}}{\tilde{P}_{ji,k}}\right]\lambda_{ji,k}(1+\epsilon_k)+\sum_{n\neq i}\left[\left(1-\frac{\overline{\mu}}{\mu_k}\frac{P_{ni,k}}{\tilde{P}_{ni,k}}\right)\lambda_{ni,k}\epsilon_k\lambda_{ji,k}\right]+\left(1-\frac{\overline{\mu}}{\mu_k}\right)\lambda_{ii,k}\epsilon_k\lambda_{ji,k}=0$$

Dividing the above equation by $\lambda_{ji,k}$ indicates that the optimal ratio $\frac{P^\star_{ni,k}}{\tilde{P}^\star_{ni,k}}=1/(1+t^\star_{ni,k})=/1/(1+t^\star_{i,k})$ is uniform across exporters. From this observations we can immediately deduce that

$$-\left(1-\frac{\overline{\mu}}{\mu_k}\frac{1}{1+t^\star_{i,k}}\right)(1+\epsilon_k\lambda_{ii,k})+\left(1-\frac{\overline{\mu}}{\mu_k}\right)\lambda_{ii,k}\epsilon_k=0.$$

Rearranging the above equation yields the following formula for cooperative tariffs:

$$1+t^\star_{i,k}=\frac{\epsilon_k\lambda^\star_{ii,k}+1}{\epsilon_k\lambda^\star_{ii,k}+\frac{\mu_k}{\overline{\mu}}},\tag{27}$$

where the $\star$ superscript indicates that $\lambda^\star_{ii,k}$ is evaluated in the cooperative equilibrium.

Mapping the Cooperative Tariff Formula to Data. Equation 27 provides a sufficient statistics characterization of cooperative tariffs as a function of trade elasticity values; observable domestic expenditure shares; and constant markup wedges. So, like the previous settings, we can use the exact hat-algebra notation to characterize the cooperative equilibrium by jointly solving (a) the cooperative tariffs specified by Equation 27 and (b) the equilibrium conditions. This procedure amounts to solving the following system of $NK+2N$ independent equation and unknowns, where the unknowns are $\mathbf{t}^*\equiv\{t^*_{i,k}\}$, $\hat{\mathbf{w}}\equiv\{\hat{w}_i\}$, and $\hat{\mathbf{Y}}\equiv\{\hat{Y}_i\}$.

Proposition 2. *Suppose preferences are described by the CES-Cobb-Douglas functional from (Equation 10 in the paper). The cooperative tariffs, $\{t^\star_{i,k}\}$, and their effect on wages, $\{\hat{w}_i\}$, and total income, $\{\hat{Y}_i\}$, can be solved as a solution to the following system:*

$$\begin{cases}1+t^\star_{i,k}=\frac{\epsilon_k\hat{\lambda}_{ii,k}\lambda_{ii,k}+1}{\epsilon_k\hat{\lambda}_{ii,k}\lambda_{ii,k}+\frac{\mu_k}{\bar{\mu}^\star}} & [\textit{optimal tariff}]\\ \hat{\lambda}_{ji,k}=\frac{\left[(\widehat{1+t_{ji,k}})\hat{w}_j\right]^{-\epsilon_k}}{\sum_{n=1}^N\left(\lambda_{ni,k}\left[(\widehat{1+t_{ni,k}})\hat{w}_n\right]^{-\epsilon_k}\right)};\qquad \widehat{1+t_{ji,k}}=\frac{1+t^\star_{i,k}}{1+\bar{t}_{ji,k}} & [\textit{expenditure shares}]\\ \hat{w}_iw_iL_i=\sum_k\sum_j\left[\frac{1}{\mu_k(1+t^\star_{j,k})}\hat{\lambda}_{ij,k}\lambda_{ij,k}e_{j,k}\hat{Y}_jY_j\right] & [\textit{wage income}]\\ \bar{\mu}_i=\sum_k\sum_j\left[\frac{1}{(1+t^\star_{j,k})}\hat{\lambda}_{ij,k}\lambda_{ij,k}e_{j,k}\hat{Y}_jY_j\right]/\hat{w}_iw_iL_i & [\textit{national average markup}]\\ \bar{\mu}^\star=\sum_k\sum_i\sum_j\left[\frac{1}{(1+t^\star_{j,k})}\hat{\lambda}_{ij,k}\lambda_{ij,k}e_{j,k}\hat{Y}_jY_j\right]/\sum_i\left(\hat{w}_iw_iL_i\right) & [\textit{global average markup}]\\ \hat{Y}_iY_i=\bar{\mu}_i\hat{w}_iw_iL_i+\sum_k\sum_{j\neq i}\left(\frac{t^\star_{i,k}}{1+t^\star_{i,k}}\hat{\lambda}_{ji,k}\lambda_{ji,k}e_{i,k}\hat{Y}_iY_i\right) & [\textit{income = sales + tax revenue}]\end{cases},$$

Moreover, solving the above system requires information on only (i) *observable shares,* $\lambda_{ji,k}$ *and* $e_{i,k}$, (ii) *national output,* $Y_i = w_i L_i$; (iii) *industry-level trade elasticities,* ϵ_k, *and* (iv) *industry-level markup wedges* μ_k.

Empirical Appendix

F Prevalence of Duty Drawbacks

This appendix provides some background information on the prevalence of duty drawbacks in practice. Recall from *Section 3.2* of the paper that duty drawbacks rebate or exempt the tariff paid on inputs if the good produced with tariffed inputs is exported. As such, duty drawbacks allow governments to avoid taxing exports and prevent the propagation of tariff distortions through the input-output network. Table 1 reports the prevalence of the duty drawback program across the major countries included in the quantitative analysis performed in *Section 5* of the paper. With the exception of Russia, all countries have either a comprehensive duty drawback program in place or they offer a partial drawback program that covers a subset of imports/exports. In addition to duty drawbacks, many developing countries offer additional tax relief programs that rebate the VAT or other domestic taxes incurred by exporters (see Michalopoulos (1999) for more details).

Table 1: *The prevalence of duty drawbacks*

Country	Duty Drawback	VAT Rebate	Source
AUS	Yes	...	Australian Border Force [Link]
EU	Partial	...	World Bank [Link]
BRA	Yes	Yes	Michalopoulos (1999)
CAN	Yes	...	Canada Border Services Agency [Link]
CHE	Yes	...	Swiss Federal Customs Administration [Link]
CHN	Yes	Yes	Michalopoulos (1999)
IDN	Yes	Yes	Michalopoulos (1999)
IND	Yes	Yes	Michalopoulos (1999)
JPN	Partial	...	World Trade Organization [Link]
KOR	Yes	Yes	Michalopoulos (1999)
MEX	Yes	Yes	Michalopoulos (1999)
NOR	Yes	Yes	Norwegian Customs Service [Link]
RUS	...	...	...
TUR	Yes	Yes	Michalopoulos (1999)
TWN	Yes	...	World Bank [Link]
USA	Yes	...	U.S. Customs and Border Protection [Link]

An apparent challenge when determining the prevalence of duty drawbacks is *under-utilization*. Oh and Karimi (2006) note that only 25% of the duty drawback value available to US exporters is claimed. They also note another measurement challenge, which is that duty drawbacks are implemented using two different schemes:

i. Fixed drawback system, wherein all exporters are paid a flat rebate irrespective of whether their export good uses tariffed inputs.

ii. Individual drawback system, wherein only exporters that use tariffed inputs receive a rebate upon submitting a claim.

While the fixed drawback system does not suffer from underutilization, it may not prevent the propagation of tariff distortions the same way an individual drawback system does. Under the former scheme, some firms pay a net tax on inputs and will pass some of it onto export prices, while others receive a net subsidy on imported inputs and will pass some the subsidy onto export prices. So altogether, while duty drawbacks are offered by most governments, their prevalence is hampered by underutilization. In instances where governments address under-utilization with a fixed drawback system, they may reactivate the ripple effects that are preventable with individual drawback systems.

G Estimation of Trade Elasticities

In this appendix, I describe the estimation procedure used to attain the industry-level trade elasticities. Following the notation introduced in the main text, let $X_{ji,k} = \tilde{P}_{ji,k}Q_{ji,k}$ trade values, and let $\bar{t}_{ji,k}$ denote effectively applied tariffs. Following Caliendo and Parro (2015), the industry-level trade elasticity in the Ricardian model can be estimated using the following estimating equation that combines tariff and trade data for any triple set of countries j, i, and k:

$$\ln \frac{X_{ji,k}X_{in,k}X_{nj,k}}{X_{ij,k}X_{ni,k}X_{jn,k}} = -\hat{\epsilon}_k \ln \frac{\left(1+\bar{t}_{ji,k}\right)\left(1+\bar{t}_{in,k}\right)\left(1+\bar{t}_{nj,k}\right)}{\left(1+\bar{t}_{ij,k}\right)\left(1+\bar{t}_{ni,k}\right)\left(1+\bar{t}_{jn,k}\right)} + \varepsilon_{jin,k}.$$

The error term, $\varepsilon_{jin,k}$, is composed of (idiosyncratic) bilateral non-tariff trade barriers. Under the identifying assumption that bilateral non-tariff barriers are uncorrelated with bilateral tariffs, we can employ an OLS estimator to identify $\hat{\epsilon}_k$ for each industry k.

To perform the above estimation, I use the full sample of countries in the aggregated 2014 WIOD database, consisting of 44 economies and 16 industries. In line with Caliendo and Parro (2015), I drop zeros from the sample. I also apply Caliendo and Parro's (2015) trim, whereby exporters with the lowest/highest 2.5% share in each industry are dropped from the sample.[3] Data on applied tariffs are from UNCTAD-TRAINS, as explained in

[3]Caliendo and Parro (2015) analyze a sample of 16 countries from 1993. In comparison, I my sample includes 44 countries, some of which of very small. To handle extreme observations in my larger sample, I drop observations with the highest/lowest 2.5% values for $\frac{X_{ji,k}X_{in,k}X_{nj,k}}{X_{ij,k}X_{ni,k}X_{jn,k}}$ and $\frac{(1+\bar{t}_{ji,k})(1+\bar{t}_{in,k})(1+\bar{t}_{nj,k})}{(1+\bar{t}_{ij,k})(1+\bar{t}_{ni,k})(1+\bar{t}_{jn,k})}$.

Section . To repeat myself, the applied tariff is measured as the *simple tariff line average* of the *effectively applied tariff.*

The estimation results are reported in Table 2, the cross-industry variation in the trade elasticities broadly aligns with those in Caliendo and Parro (2015). Unfortunately for the "Mining" and "Metal" industries, my estimation did not render meaningful estimates for $\hat{\epsilon}_k$. Presumably, this is due to the main exporters in these two industries being WTO members in 2014, which leads to a lack of sufficient variation in discriminatory tariffs.[4] Considering this, I simply adopt Caliendo and Parro's (2015) estimates for these two industries.

To measure the cost of a tariff war in the generalized Krugman model, I need mutually-consistent estimates for both ϵ_k and μ_k. Attaining estimates for these parameters is only possible with micro-level data. That is, I cannot use the macro-level WIOD data to discipline both of these parameters. As an alternative solution, I borrow the estimates from Lashkaripour and Lugovskyy (2020), who use transaction-level data from 251 exporting countries during 2007-2013 to estimate the ϵ_k and μ_k for each of the WIOD industries used in my analysis. These adopted estimates are reported in Table 3. For the service-related industries, the parameters are normalized to $\epsilon = 5$ and $\mu = 1$.

An issue that requires some attention here is the discrepancy between the *average* trade elasticity levels in the two models. This discrepancy is primarily driven by the fact that the elasticities reported in Tables 3 and 2 are estimated using different datasets and different identification strategies. For instance, the correlation between non-tariff trade barriers and tariffs can challenge the identification strategy underlying Caliendo et al. (2015), but not the identification strategy in Lashkaripour and Lugovskyy (2020). Or if we believe that tariffs trigger selection effects, the trade elasticity estimated in Lashkaripour and Lugovskyy (2020) has to be adjusted for such effects. The exact adjustment, though, depends on whether tariffs are applied after or before markups are charged—see Footnote 30 in Costinot and Rodríguez-Clare (2014) for more details. These details aside, the cross-model differences in ϵ_k's can systematically inflate (or deflate) the tariff war cost predicted by the generalized Krugman model relative to the baseline model. To avoid this issue as much a possible, I apply a Hicks neutral (i.e., ratio-preserving) adjustment to the industry-level trade elasticity values in Table 3, so that the trade-weighted average ϵ_k becomes identical under the baseline and generalized Krugman models. This adjustment allows me to better isolate how markup distortions influence the cost of a global tariff war.

[4] Ossa (2016) reports a similar issue when applying the Caliendo and Parro (2015) estimation methodology to more contemporary data. He attributed this to most countries in his sample being WTO members, which leads to a lack of variation in discriminatory tariffs. I am inclined to believe that the same caveat applies here.

Table 2: List of industries and estimated trade elasticities.

Number	Description	trade elasticity ϵ_k	std. err.	N
1	Crop and animal production, hunting Forestry and logging Fishing and aquaculture	0.69	0.12	11,440
2	Mining and Quarrying	13.53	3.67	...
3	Food, Beverages and Tobacco	0.47	0.13	11,440
4	Textiles, Wearing Apparel and Leather	3.33	0.53	11,480
5	Wood and Products of Wood and Cork	5.73	0.93	11,326
6	Paper and Paper Products Printing and Reproduction of Recorded Media	8.50	1.52	11,440
7	Coke, Refined Petroleum and Nuclear Fuel	14.94	2.05	8,798
8	Chemicals and Chemical Products Basic Pharmaceutical Products	0.92	0.96	11,440
9	Rubber and Plastics	1.69	0.78	11,480
10	Other Non-Metallic Mineral	1.47	0.89	11,440
11	Basic Metals Fabricated Metal Products	3.28	1.23	...
12	Computer, Electronic and Optical Products Electrical Equipment	3.44	1.07	11,480
13	Machinery and Equipment n.e.c	3.64	1.45	11,480
14	Motor Vehicles, Trailers and Semi-Trailers Other Transport Equipment	1.38	0.46	11,480
15	Furniture; other Manufacturing	1.64	0.60	11,480
16	All Service-Related Industries (WIOD Industry No. 23-56)	4	...	...

Table 3: Parameters used in the generalized Krugman model.

Number	Description	Trade Ealsticity ϵ_k	Markup Wedge μ_k
1	Crop and animal production, hunting Forestry and logging Fishing and aquaculture	6.212	1.14
2	Mining and Quarrying	6.212	1.141
3	Food, Beverages and Tobacco	3.333	1.265
4	Textiles, Wearing Apparel and Leather	3.413	1.207
5	Wood and Products of Wood and Cork	3.329	1.270
6	Paper and Paper Products Printing and Reproduction of Recorded Media	2.046	1.397
7	Coke, Refined Petroleum and Nuclear Fuel	0.397	2.758
8	Chemicals and Chemical Products Basic Pharmaceutical Products	4.320	1.212
9	Rubber and Plastics	3.599	1.162
10	Other Non-Metallic Mineral	4.561	1.186
11	Basic Metals and Fabricated Metal	2.959	1.189
12	Computer, Electronic and Optical Products Electrical Equipment	1.392	1.453
12	Machinery, Nec	8.682	1.100
14	Motor Vehicles, Trailers and Semi-Trailers Other Transport Equipment	2.173	1.133
15	Furniture; other Manufacturing	6.704	1.142
16	All Service-Related Industries (WIOD Industry No. 23-56)	4	1

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