Trade Policy and Global Sourcing: A Rationale for Tariff Escalation

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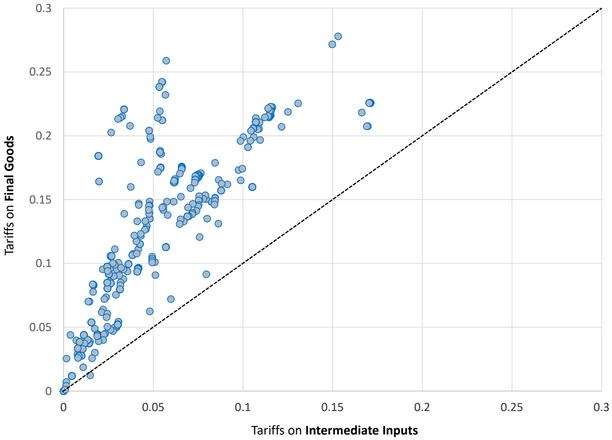
Work in Progress

Trade Policy, Really?

Tariff Escalation

- Tariffs are systematically higher for final goods than for intermediate inputs

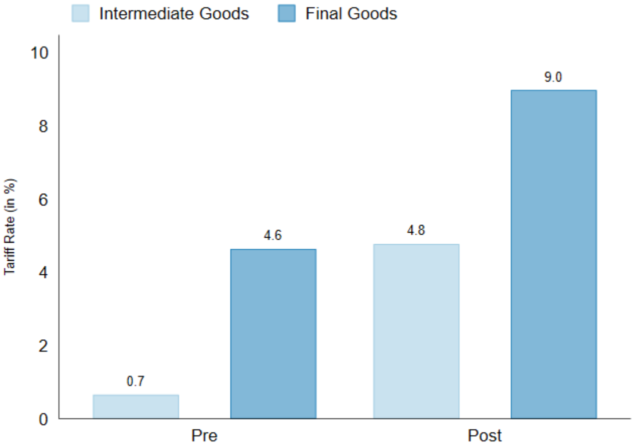
Tariffs on Final Goods versus on Intermediate Inputs (by Country Pair in 2007)



Source: Simple averages of country-pair tariffs by UN-BEC good types for the year 2007 from Shapiro (2020)

Tariff Escalation in the US Pre and Post Trade War

- Although 60 percent of Trump tariffs targeted inputs, tariff escalation still reigns



Source: Weighted averages of applied tariffs from USITC, Bown, Fajgelbaum et al. (2020)

Why Do We Observe Tariff Escalation?

- Neoclassical theory does not provide a simple rationale for tariff escalation
  - Theoretically, no sharp insights from traditional work featuring homogenous goods: Ruffin (1969), Casas (1973), Das (1983)
- Modern Ricardian models stress the (first-best) optimality of common tariffs across sectors: Costinot et al. (2015), Beshkar and Lashkaripour (2020)
- Could tariff escalation reflect lower sectoral inverse export supply elasticities for inputs than for final goods?
  - Empirically, 'upstreamness' and inverse export supply elasticities appear to be very weakly correlated (0.049)
- Political Economy Rationale: final-good producers counterlobby against protection for inputs; see Cadot et al. (2004), Gawande et al. (2012)

Our Contribution

- This Paper: We explore optimal tariffs for final goods vs inputs in an environment with IRS, monopolistic competition, and product differentiation (Krugman, Venables, Ossa)
- Some considerations ...
  - Are production relocation effects more beneficial in the upstream or downstream sector?
  - How do tariffs upstream affect production relocation downstream, and vice versa?
  - How do these tariffs affect relative wages?
  - How do these tariffs interact with domestic distortions?
- Study first- and second-best policies in economies with and without domestic distortions
- Main result: First-best trade policies *may* and second-best trade policies *do* feature tariff escalation

Related Literature

- **Optimal tariffs**
  - Johnson (1953); Gros (1985); Bagwell and Staiger (1999, 2001), Venables (1987), Ossa (2011), Costinot et al. (2015); Costinot et al. (2020); Beshkar and Lashkaripour (2020)
- **Trade policy with input trade**
  - Neoclassical theory: Ruffin (1969); Casas (1973); Das (1983); Blanchard, Bown, and Johnson (2021); Beshkar and Lashkaripour (2021)
  - Political Economy: Cadot et al. (2004), Gawande et al. (2012)
  - Scale Economies: Krugman and Venables (2005); Caliendo et al. (2021); Lashkaripour and Lugovskyy (2021)
  - Other approaches: Antràs and Staiger (2012); Ornelas and Turner (2008, 2012), Grossman and Helpman (2020); Liu (2019)
- **Effects of input tariffs and of recent trade war**
  - Amiti, Redding, and Weinstein (2019); Fajgelbaum et al. (2020); Flaaen and Pierce (2020); Handley et al. (2020); Bown et al. (2021); Cox (2021)

Outline of Talk

1. Closed-economy model
2. Open economy with final-good and input tariffs
3. Quantification of optimal final-good versus input tariff
4. Counterfactuals related to recent US-China Trade War

Closed Economy: Krugman '80 with Input and Final-Good Sectors

- Consumers have CES preferences over final-good varieties

$$U = \left(\int_0^{M^d} q^d\left(\omega\right)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

- Final goods production uses labor and a bundle of inputs to cover fixed & marginal costs

$$f^d + x^d(\omega) = A^d \ell^d(\omega)^{\alpha} Q^u(\omega)^{1-\alpha}, \qquad \omega \in [0, M^d], \tag{2}$$

$$Q^u(\omega) = Q^u = \left(\int_0^{M^u} q^u\left(\varpi\right)^{\frac{\theta-1}{\theta}} d\varpi \right)^{\frac{\theta}{\theta-1}} \tag{3}$$

- Intermediate input sector uses labor to cover fixed & marginal costs

$$f^u + x^u(\varpi) = A^u \ell^u(\varpi), \qquad \varpi \in [0, M^u] \tag{4}$$

- Both sectors features monopolistic competition and free entry, as in Krugman (1980)

Closed Economy: Market Equilibrium versus First Best

- Aggregate decentralized market allocation of labor to the upstream sector is given by

$$M^u \ell^u = (1-\alpha)L,$$

- Social planner would allocate a larger share of labor to that upstream sector

$$(M^u \ell^u)^* = \frac{\theta}{\theta-\alpha}(1-\alpha)L \geqslant (1-\alpha)L.$$

- Firm-level output is at its socially efficient level
- Although too much labor is allocated downstream, there is still too little entry downstream because there are too few input varieties

$$\left(M^d\right)^* = \left(\frac{\theta-1}{\theta-\alpha}\right)^{\alpha}\left(\frac{\theta}{\theta-\alpha}\right)^{\frac{\theta(1-\alpha)}{\theta-1}} M^d \geqslant M^d$$

Closed Economy: Results

Proposition 1. In the decentralized equilibrium, firm-level output is at its socially optimal level in both sectors, but the market equilibrium features too little entry into both the downstream and upstream sectors unless $\alpha = 1$ (so the upstream sector is shut down) or $\alpha = 0$ (i.e., when the downstream sector does not use labor directly in production).

Proposition 2. The social planner can restore efficiency in the market equilibrium by subsidizing upstream production at a rate $(s^u)^* = 1/\theta$.

Closed Economy: Interpretation

- What is the source of the decentralized market inefficiency? Is it a double-marginalization inefficiency?

- Useful Isomorphism: Consider a framework with external economies of scale and perfect competition (no markups!):

$$
\begin{aligned}
x^u &= A^u \ell^u \left(L^u\right)^{\gamma^u} \\
x^d &= A^d \left(\ell^d\right)^{\alpha} \left(q^u\right)^{1-\alpha} \left(\left(L^d\right)^{\alpha} \left(Q^u\right)^{1-\alpha}\right)^{\gamma^d}
\end{aligned}
$$

- This model with external economies of scale is isomorphic to our model if $\gamma^u = 1/\left(\theta - 1\right)$ and $\gamma^d = 1/\left(\sigma - 1\right)$

- Upstream subsidy $\left(s^u\right)^* = \gamma^u / \left(1 + \gamma^u\right)$ restores efficiency

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Open Economy: Allow for Trade in Both Sectors

- Two-country model with international trade in both final goods and inputs

- Trade is costly due to the presence of iceberg trade costs and import tariffs
  - τ^d and τ^u are iceberg trade costs applied to final goods and to inputs
  - t_i^d and t_i^u the tariffs set by country i on imports of final goods and intermediate inputs
  - Also consider production subsidies (s_i^d and s_i^u) and export taxes (ν_i^d and ν_i^u)

- Countries also differ in labor forces (L) and cost parameters (A^d, A^u, f^d, f^u)

- Easy to derive equilibrium conditions, but not so easy to characterize optimal policy

- To build intuition, we proceed as follows:
  1. Solve for optimal policy for the special case of small open economy and $\alpha = 0$
  2. Solve for optimal policy for small open economy and $\alpha > 0$
  3. Further intuition from first-order approximation around zero-tariff equilibrium
  4. Quantitative evaluation of optimal tariffs under second- and first-best policies

Optimal Trade Policy for a Small Open Economy

- We can solve analytically for optimal trade policy for a Small Open Economy
- Follow the primal approach in Costinot et al. (2015) – also Stokey and Lucas (1983)

1. First, solve the planner problem to characterize optimal allocation
2. Characterize market equilibrium with taxes and study how to implement the first best
3. Solve for second-best policies in an analogous manner, but with optimal allocation problem being a (further) constrained problem

- We do all this for an isomorphic economy featuring external rather than internal economies of scale

Isomorphic External Economies of Scale Economy

- Although our model features rich firm-level decisions on entry, exporting, importing and pricing, we can define the following industry-level aggregates:

$$
\begin{aligned}
C_{ji} &= \left(M_j^d\right)^{\frac{\sigma}{\sigma-1}} q_{ji}^d; \\
X_{ij} &= M_j^d \left(M_i^u\right)^{\frac{\theta}{\theta-1}} q_i^u; \\
L_i^u &= l_i^u M_i^u; \\
L_i^d &= l_i^d M_i^d; \\
\hat{A}_i^u &\equiv (\theta-1) f_i^u \left(\frac{A_i^u}{f_i^u \theta}\right)^{\frac{\theta}{\theta-1}} \left(L_i^u\right)^{\gamma^u}; \qquad (5) \\
\hat{A}_i^d &\equiv (\sigma-1) f_i^d \left(\frac{A_i^d}{f_i^d \sigma}\right)^{\frac{\sigma}{\sigma-1}} \left(\left(L_i^d\right)^{\alpha} \left(\left(X_{ii}\right)^{\frac{\theta-1}{\theta}} + \left(X_{ji}\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta(1-\alpha)}{\theta-1}}\right)^{\gamma^d}; \qquad (6) \\
\gamma^u &= \frac{1}{\theta-1}; \qquad \gamma^d = \frac{1}{\sigma-1}
\end{aligned}
$$

Optimal Allocation in $\alpha = 0$ Case (No Labor Misallocation)

- Planner chooses $\{C_{HH}, C_{FH}, C_{HF}, X_{HH}, X_{FH}, X_{HF}\}$ to

$$
\begin{aligned}
\max \quad & U_H\left(C_{HH}, C_{FH}\right) = \left(\left(C_{HH}\right)^{\frac{\sigma-1}{\sigma}} + \left(C_{FH}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \\
s.t. \quad & \hat{A}^u_H\left(L_H\right) L_H = X_{HH} + X_{HF} \\
& \hat{A}^d_H\left(F^d\left(X_{HH}, X_{FH}\right)\right) F^d\left(X_{HH}, X_{FH}\right) = C_{HH} + C_{HF} \\
& P^d_{FH} C_{FH} + P^u_{FH} X_{FH} = C_{HF}\left(C_{HF}\right)^{-\frac{1}{\sigma}} \overline{P}^d_{FF}\left(\overline{C}^d_{FF}\right)^{\frac{1}{\sigma}} + X_{HF}\left(X_{HF}\right)^{-\frac{1}{\theta}} \overline{P}^u_{FF}\left(\overline{X}_{FF}\right)^{\frac{1}{\theta}}
\end{aligned}
$$

- $\hat{A}^u_H\left(L_H\right)$ and $\hat{A}^d_H\left(F^d\left(X_{HH}, X_{FH}\right)\right)$ are given in (5) and (6) with $\alpha = 0$, respectively, and

$$
F^d\left(X_{HH}, X_{FH}\right) = \left(\left(X_{HH}\right)^{\frac{\theta-1}{\theta}} + \left(X_{FH}\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}
$$

Optimality Conditions and First-Best Implementation with Trade Policy

$$\frac{U_{C_{HH}}(C_{HH}, C_{FH})}{U_{C_{FH}}(C_{HH}, C_{FH})} = \frac{\frac{\sigma-1}{\sigma} P^d_{HF}}{P^d_{FH}}$$

$$\frac{F^d_{X_{HH}}(X_{HH}, X_{FH})}{F^d_{X_{FH}}(X_{HH}, X_{FH})} = \frac{\frac{\theta-1}{\theta} P^u_{HF}}{P^u_{FH}}$$

$$\left(1+\gamma^d\right) \hat{A}^d_H F^d_{X_{HH}}(X_{HH}, X_{FH}) = \frac{\frac{\theta-1}{\theta}}{\frac{\sigma-1}{\sigma}} \frac{P^u_{HF}}{P^d_{HF}}$$

$$\frac{U_{C_{HH}}(C_{HH}, C_{FH})}{U_{C_{FH}}(C_{HH}, C_{FH})} = \frac{\left(1-\nu^d_H\right) P^d_{HF}}{\left(1+t^d_H\right) P^d_{FH}}$$

$$\frac{F^d_{X_{HH}}(X_{HH}, X_{FH})}{F^d_{X_{FH}}(X_{HH}, X_{FH})} = \frac{\left(1-\nu^u_H\right) P^u_{HF}}{\left(1+t^u_H\right) P^u_{FH}}$$

$$\hat{A}^d_H F^d_{X_{HH}}(X_{HH}, X_{FH}) = \frac{\left(1-\nu^u_H\right)}{\left(1-\nu^d_H\right)} \frac{P^u_{HF}}{P^d_{HF}}$$

- Can implement first best with the following trade taxes/subsidies

$$1 + t^d_H = \frac{\sigma}{\sigma-1}\left(1+\bar{T}\right)$$

$$1 + t^u_H = \frac{\sigma}{\sigma-1}\frac{1}{(1+\gamma^d)}\left(1+\bar{T}\right)$$

$$1 - \nu^d_H = 1 + \bar{T}$$

$$1 - \nu^u_H = \frac{\theta-1}{\theta}\frac{\sigma}{\sigma-1}\frac{1}{(1+\gamma^d)}\left(1+\bar{T}\right)$$

Optimality Conditions and First-Best Implementation with Trade Policy

$$\frac{U_{C_{HH}}\left(C_{HH},C_{FH}\right)}{U_{C_{FH}}\left(C_{HH},C_{FH}\right)} = \frac{\frac{\sigma-1}{\sigma}P^{d}_{HF}}{P^{d}_{FH}} \qquad \frac{U_{C_{HH}}\left(C_{HH},C_{FH}\right)}{U_{C_{FH}}\left(C_{HH},C_{FH}\right)} = \frac{\left(1-\nu^{d}_{H}\right)P^{d}_{HF}}{\left(1+t^{d}_{H}\right)P^{d}_{FH}}$$

$$\frac{F^{d}_{X_{HH}}\left(X_{HH},X_{FH}\right)}{F^{d}_{X_{FH}}\left(X_{HH},X_{FH}\right)} = \frac{\frac{\theta-1}{\theta}P^{u}_{HF}}{P^{u}_{FH}} \qquad \frac{F^{d}_{X_{HH}}\left(X_{HH},X_{FH}\right)}{F^{d}_{X_{FH}}\left(X_{HH},X_{FH}\right)} = \frac{\left(1-\nu^{u}_{H}\right)P^{u}_{HF}}{\left(1+t^{u}_{H}\right)P^{u}_{FH}}$$

$$\left(1+\gamma^{d}\right)\hat{A}^{d}_{H}F^{d}_{X_{HH}}\left(X_{HH},X_{FH}\right) = \frac{\frac{\theta-1}{\theta}}{\frac{\sigma-1}{\sigma}}\frac{P^{u}_{HF}}{P^{d}_{HF}} \qquad \hat{A}^{d}_{H}F^{d}_{X_{HH}}\left(X_{HH},X_{FH}\right) = \frac{\left(1-\nu^{u}_{H}\right)}{\left(1-\nu^{d}_{H}\right)}\frac{P^{u}_{HF}}{P^{d}_{HF}}$$

- Can implement first best with the following trade taxes/subsidies

$$1+t^{d}_{H} = \frac{\sigma}{\sigma-1}\left(1+\bar{T}\right) \qquad 1-\nu^{d}_{H} = 1+\bar{T}$$

$$1+t^{u}_{H} = \cancel{\frac{\sigma}{\sigma-1}}\,\cancel{\frac{1}{\left(1+\gamma^{d}\right)}}\left(1+\bar{T}\right) \qquad 1-\nu^{u}_{H} = \frac{\theta-1}{\theta}\,\cancel{\frac{\sigma}{\sigma-1}}\,\cancel{\frac{1}{\left(1+\gamma^{d}\right)}}\left(1+\bar{T}\right)$$

First-Best Trade Policy

Proposition 3. When $\alpha = 0$, the first-best allocation can be achieved with a combination of import and export trade taxes. Although, the levels of trade taxes are not uniquely pinned down, the tariff escalation wedge is necessarily given by $\left(1 + t_H^d\right) / \left(1 + t_H^u\right) = 1 + \gamma^d = \sigma / \left(\sigma - 1\right) > 1$. Furthermore, the first best can be achieved with a downstream import tariff at a level t_H^d equal to $1 / \left(\sigma - 1\right)$ and an upstream export tax ν_H^u equal to $1/\theta$.

- First-best policies attempt to shift final-good production toward Home, but also to exert market power in export markets in the least distortionary manner
  - For inputs, export taxes are preferred due to impact of upstream import tariffs on downstream productivity
- What about domestic policies?
  - First-best can also be achieved with only production subsidies and export taxes
  - But achieving the first best requires the use of at least two trade instruments

First-Best Trade Policy with No Scale Economies

$$\frac{U_{C_{HH}}(C_{HH}, C_{FH})}{U_{C_{FH}}(C_{HH}, C_{FH})} = \frac{\frac{\sigma-1}{\sigma} P^d_{HF}}{P^d_{FH}} \qquad \frac{U_{C_{HH}}(C_{HH}, C_{FH})}{U_{C_{FH}}(C_{HH}, C_{FH})} = \frac{\left(1-\nu^d_H\right) P^d_{HF}}{\left(1+t^d_H\right) P^d_{FH}}$$

$$\frac{F^d_{X_{HH}}(X_{HH}, X_{FH})}{F^d_{X_{FH}}(X_{HH}, X_{FH})} = \frac{\frac{\theta-1}{\theta} P^u_{HF}}{P^u_{FH}} \qquad \frac{F^d_{X_{HH}}(X_{HH}, X_{FH})}{F^d_{X_{FH}}(X_{HH}, X_{FH})} = \frac{\left(1-\nu^u_H\right) P^u_{HF}}{\left(1+t^u_H\right) P^u_{FH}}$$

$$\cancel{\left(1+\gamma^d\right)} \hat{A}^d_H F^d_{X_{HH}}(X_{HH}, X_{FH}) = \frac{\frac{\theta-1}{\theta}}{\frac{\sigma-1}{\sigma}} \frac{P^u_{HF}}{P^d_{HF}} \qquad \hat{A}^d_H F^d_{X_{HH}}(X_{HH}, X_{FH}) = \frac{\left(1-\nu^u_H\right)}{\left(1-\nu^d_H\right)} \frac{P^u_{HF}}{P^d_{HF}}$$

- Simply set $1+t^d_H = 1+t^u_H = 1+\bar{T}$; $1-\nu^d_H = \frac{\sigma-1}{\sigma}\left(1+\bar{T}\right)$; $1-\nu^u_H = \frac{\theta-1}{\theta}\left(1+\bar{T}\right)$

Proposition 4. When $\alpha = 0$, in the absence of scale economies, the first best can be attained with a combination of import and export taxes. Although, the levels of trade taxes are not uniquely pinned down, the tariff escalation wedge $\left(1+t^d_H\right)/\left(1+t^u_H\right)$ necessarily equals 1.

Second-Best Import Tariffs with Scale Economies

- Consider now a second-best world with no access to production subsidies or export taxes.
- Planner problem as before except for extra constraint:

$$\hat{A}_H^d \left(F^d \left(X_{HH}, X_{FH} \right) \right) F_{X_{HH}}^d \left(X_{HH}, X_{FH} \right) = \frac{P_{HF}^d}{P_{HF}^u} \tag{7}$$

Proposition 5. When $\alpha = 0$, the second-best optimal combination of import tariffs involves an import tariff on final goods higher than $1/(\sigma - 1)$ and a tariff escalation wedge larger than the first-best one (i.e., $\left(1 + t_H^d\right) / \left(1 + t_H^u\right) > 1 + \gamma^d = \sigma / (\sigma - 1) > 1$).

- Hence, planner now seeks to exploit terms of trade via upstream import tariffs (since no access to upstream export taxes), but it does so in an "attenuated" manner

Second-Best Import Tariffs with No Scale Effects

- Consider now combination of second-best import tariffs in the absence of scale effects.

  Proposition 6. In the absence of scale economies, the second-best optimal combination of import tariffs involves tariff escalation (i.e., $\left(1+t_H^d\right)/\left(1+t_H^u\right)>1$) if and only if $\sigma>\theta$.

- This remains true for $\alpha > 0$

- Somewhat surprisingly, tariff escalation is associated with high values of σ

- Rough Intuition: upstream import tariff mimicks downstream export tax, and is thus more beneficial, the lower is σ (cf., Beshkar-Lashkaripour, 2020)

Optimal Policy for a SOE when $\alpha > 0$ (Labor Misallocation)

- Planner now chooses $\left\{L_H^u, L_H^d, C_{HH}, C_{FH}, C_{HF}, X_{HH}, X_{FH}, X_{HF}\right\}$ to

$$\max \quad U_H\left(C_{HH}, C_{FH}\right) = \left(\left(C_{HH}\right)^{\frac{\sigma-1}{\sigma}} + \left(C_{FH}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

$$\begin{aligned} s.t. \quad & L_H^u + L_H^d = L_H \\ & \hat{A}_H^u\left(L_H^u\right) L_H^u = X_{HH} + X_{HF} \\ & \hat{A}_H^d\left(F^d\left(L_H^d, X_{HH}, X_{FH}\right)\right) F^d\left(L_H^d, X_{HH}, X_{FH}\right) = C_{HH} + C_{HF} \\ & P_{FH}^d C_{FH} + P_{FH}^u X_{FH} = C_{HF}\left(C_{HF}\right)^{-\frac{1}{\sigma}} \overline{P}_{FF}^d \left(\overline{C}_{FF}^d\right)^{\frac{1}{\sigma}} + X_{HF}\left(X_{HF}\right)^{-\frac{1}{\theta}} \overline{P}_{FF}^u \left(\overline{X}_{FF}\right)^{\frac{1}{\theta}} \end{aligned}$$

- $\hat{A}_H^u\left(L_H\right)$ and $\hat{A}_H^d\left(F^d\left(X_{HH}, X_{FH}\right)\right)$ are given in (5) and (6), respectively, and

$$F^d\left(L_H^d, X_{HH}, X_{FH}\right) = \left(L_H^d\right)^{\alpha}\left(\left(X_{ii}\right)^{\frac{\theta-1}{\theta}} + \left(X_{ji}\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta(1-\alpha)}{\theta-1}}$$

Optimality Conditions and First-Best Implementation when $\alpha > 0$

- Same three optimality conditions as before, plus

$$F^d_{L^d_H}\left(L^d_H, X_{HH}, X_{FH}\right) = (1+\gamma^u)\hat{A}^u\left(L^u_H\right)F^d_{X_{HH}}\left(L^d_H, X_{HH}, X_{FH}\right), \qquad (8)$$

- This is an 'internal' optimality condition, so trade taxes **cannot** help ensure it holds
- But, as in closed economy, a production subsidy for inputs, s^u_H, can ensure it holds while not affecting the other optimality/equilibrium conditions

  Proposition 7. The first-best allocation can be achieved with a production subsidy for inputs, and (at least two) trade taxes associated with a tariff escalation wedge $\left(1+t^d_H\right)/\left(1+t^u_H\right) = 1+\gamma^d = \sigma/\left(\sigma-1\right) > 1$.

- Caveat: this is one of many implementations; First best can be achieved with only production subsidies and export taxes
  - But achieving the first best this way requires the use of at least four instruments

Second-Best Policies with Labor Misallocation

- Consider now a second-best world with no access to production subsidies or export taxes
- Planner problem as before except for extra constraint (7)

  Conjecture 8. Even when $\alpha > 0$, the second-best optimal combination of import tariffs is associated with a tariff escalation wedge larger than one, i.e., $\left(1 + t_H^d\right) / \left(1 + t_H^u\right) > 1$.

- Proof is still in progress - numerically, we have not been able to produce an example with $TE < 1$, but have struggled with numerical simulations with α close to one
- Main challenge: When $\alpha > 0$, upstream import tariff is useful in mimicking the effects of an upstream subsidy, so this reduces the tariff escalation wedge
  - Numerically, this appears to be a dominated effect (obvious concerns about functional forms)

Large Open Economy: Decomposing the Effects of Small Tariffs

$$
\begin{aligned}
\frac{dU_H}{U_H} = \quad & -\left(b_H^H \Omega_{F,H} + b_F^H \left(\Omega_{F,F} + \alpha\right)\right) \frac{dw_F}{w_F} && \leftarrow \text{Relative wage effects} \\
& + \left(\frac{b_H^H \Omega_{H,H} + b_F^H \Omega_{H,F}}{\theta - 1}\right) \frac{dM_H^u}{M_H^u} && \leftarrow \text{Relocation of upstream firms to home} \\
& + \left(\frac{b_H^H \Omega_{F,H} + b_F^H \Omega_{F,F}}{\theta - 1}\right) \frac{dM_F^u}{M_F^u} && \leftarrow \text{Relocation of upstream firms to foreign} \\
\text{Relocation of downstream firms to home} \rightarrow \quad & + \left(\frac{b_H^H}{\sigma - 1}\right) \frac{dM_H^d}{M_H^d} \\
\text{Relocation of downstream firms to foreign} \rightarrow \quad & + \left(\frac{b_F^H}{\sigma - 1}\right) \frac{dM_F^d}{M_F^d} \\
\text{Input tariff re-exported to foreign} \rightarrow \quad & + \left(\lambda_H^d - b_H^H\right) \Omega_{F,H} (dt) \mathbb{I}_{\{t = t^u\}}
\end{aligned}
$$

b_i^j: share of j income spent on i varieties

$\Omega_{i,j}$: share of j final-good revenue spent on i input varieties

λ_i^d: ratio of domestic final-good revenue to income in i

▸ Derivations

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Quantification: Parameterization

- Four alternative ways of estimating θ and σ
  1. Symmetric case: $\theta = \sigma = 4$
  2. Response in trade flows to US-China trade war ($\theta = 3.35$, $\sigma = 4.08$)
  3. Mark-ups ($\theta = 4.43$, $\sigma = 6.44$)
  4. Scale economies from Bartelme et al. (2019) ($\theta = 8.52$, $\sigma = 8.41$)
- $1 - \alpha = 0.45$ (from WIOD)
- Relative population size from CEPII
- Calibrate trade costs and productivities to best fit moments that appear in the exact hat algebra equations

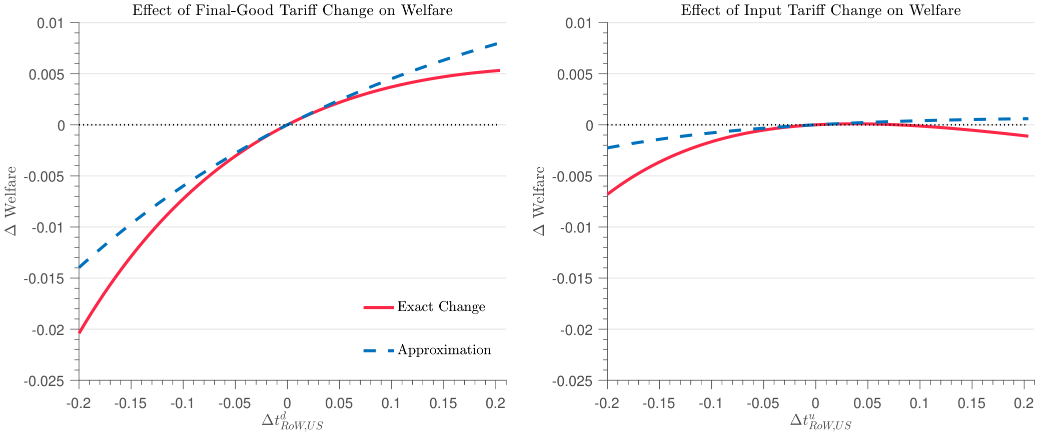
Calibrated Parameters

A. Calibrated Parameters	
Productivity in final-good sector, RoW relative to US, A^d_{row}	0.3127
Productivity in input sector, RoW relative to US, A^u_{row}	0.1364
Iceberg cost for final goods from US to RoW, τ^d	3.2312
Iceberg cost for inputs from US to RoW, τ^u	2.5912

B. Moments	Data	Model
Sales share to US from US in final goods	0.9431	0.9641
Sales share to RoW from RoW in final goods	0.9884	0.9854
Sales share to US from US in intermediate good	0.8974	0.8890
Sales share to RoW from Row in intermediate good	0.9825	0.9778
Expenditure share in US final goods for the US	0.9603	0.9464
Expenditure share in RoW final good for the RoW	0.9811	0.9892
Expenditure share in US int. good for the US	0.9055	0.9207
Expenditure share in RoW int. good for the RoW	0.9801	0.9670
Total US sales (int. goods) to total US expenditure (final goods)	0.7711	0.4665
Total RoW sales (int. goods) to total RoW expenditure (final goods)	1.2418	0.4463
Total US sales (final goods) to total US expenditure (final goods)	1.0182	0.9973
Total RoW sales (final goods) to total RoW expenditure (final goods)	0.9926	0.9993
Total expenditure in final goods by the US relative to RoW	0.3032	0.2850

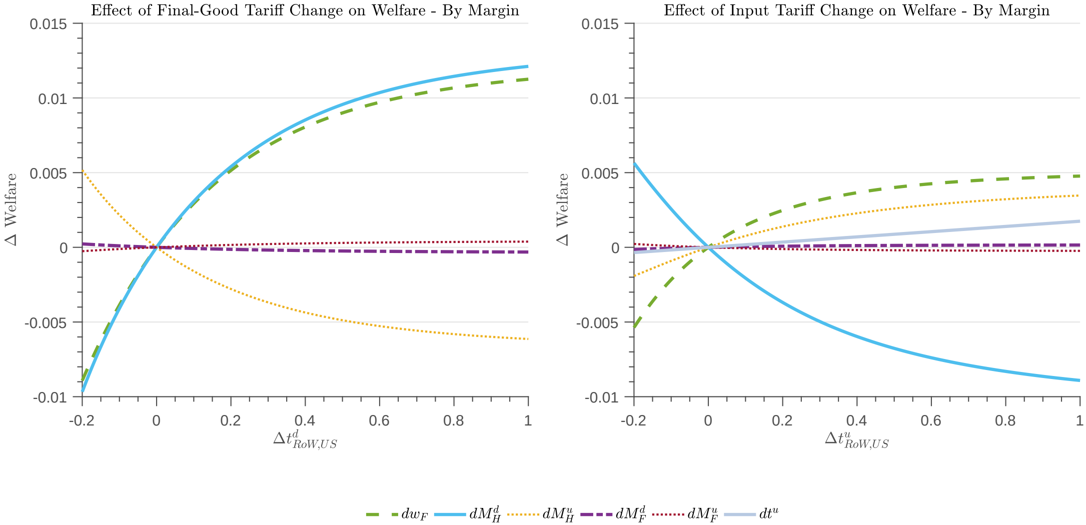
Notes: Panel B presents the targeted moments in the estimation. Column 1 presents moments from the data and column 2 presents their estimated counterparts. Note that in the model, total sales upstream to total expenditure downstream cannot be larger than 1 since the upstream sector is pure value added.

Approximation Works Well for Small Changes



- Negative welfare effects for large range of input tariffs

Channels of Tariffs' Welfare Effects Differ by Good Type



Optimal Tariffs

- Next, calculate optimal tariffs when ...
  1. Only import tariffs are available
  2. Import tariffs and an upstream (input) production subsidy is available
  3. Additionally, an export tax for upstream goods is available (sufficient to achieve First Best)
- Remember that Lerner symmetry implies that (gross) tariff levels are only pinned down up to a scalar
- But 'tariff escalation wedge' $(1 + t_H^d)/(1 + t_H^u)$ is independent of normalization
- We (naturally) rule out the use of downstream production subsidies, but as mentioned before, this is not immaterial!

Optimal Import Tariffs Exhibit Tariff Escalation

	A. Tariff & Tax Instruments					**B.** Welfare	
	t_H^d	t_H^u	v_H^u	s_H^u	$\frac{1+t_H^d}{1+t_H^u}$	U_{US}	U_{RoW}
Zero Tariff Equilibrium						0.031565	0.14148
Optimal Import Tariff	0.4025	0.2142			1.155	0.031810	0.140823
Optimal Import Tariffs & Production Subsidy	0.6225	0.2222		0.2334	1.3275	0.032251	0.140827
Optimal Trade & Tax Policies	0.3367	0.0033	0.2507	0.2500	1.3322	0.032317	0.140784

Robustness to Different Parameter Values

- Tariff escalation is robust to wide range of parameter values

	$\theta = 3.35$ $\sigma = 4.08$	$\theta = 4.43$ $\sigma = 6.44$	$\theta = 8.52$ $\sigma = 8.41$	$\theta = 2.5$ $\sigma = 4$	$\theta = 5.5$ $\sigma = 4$	$\alpha = 0.75$	$\alpha = 0.25$	$\alpha = 0$
A. Second Best Optimal Import Tariffs								
t^d	0.3791	0.2245	0.1617	0.3648	0.3877	0.3377	0.4511	0.4770
t^u	0.2380	0.1755	0.0911	0.3010	0.1514	0.2314	0.1457	0.0788
$\frac{1+t^d}{1+t^u}$	1.1139	1.0417	1.0647	1.0490	1.2052	1.0864	1.2666	1.3691

Robustness to Trade and Tax Policies

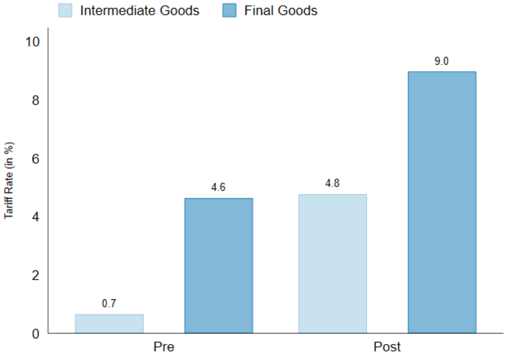
- Tariff escalation is robust to various tax policies

	$\theta = 3.35$ $\sigma = 4.08$	$\theta = 4.43$ $\sigma = 6.44$	$\theta = 8.52$ $\sigma = 8.41$	$\theta = 2.5$ $\sigma = 4$	$\theta = 5.5$ $\sigma = 4$	$\alpha = 0.75$	$\alpha = 0.25$	$\alpha = 0$
B. Optimal Import Tariffs & Production Subsidy								
t^d	0.6290	0.3486	0.2026	8034	0.5062	0.5238	0.5411	0.4769
t^u	0.2330	0.1488	0.0714	0.3524	0.1340	0.1299	0.1726	0.0788
s^u	0.2798	0.1994	0.0899	0.3835	0.1640	0.2306	0.2336	0
$\frac{1+t^d}{1+t^u}$	1.3211	1.1739	1.1225	1.3335	1.3283	1.3486	1.3142	1.3691
C. Optimal Trade & Tax Policies								
t^d	0.3295	0.1868	0.1375	0.3381	0.3388	0.3440	0.3377	0.3518
t^u	0.0034	0.0028	0.0015	0.0029	0.0032	0.0030	0.0036	0.0027
v^u	0.3001	-0.2270	0.1183	-0.426	0.1822	0.2560	0.2506	0.2624
s^u	0.2985	0.2261	0.1185	0.4000	0.1818	0.2500	0.2500	0
$\frac{1+t^d}{1+t^u}$	1.3250	1.1835	1.1358	1.3342	1.3345	1.3400	1.3329	1.3482

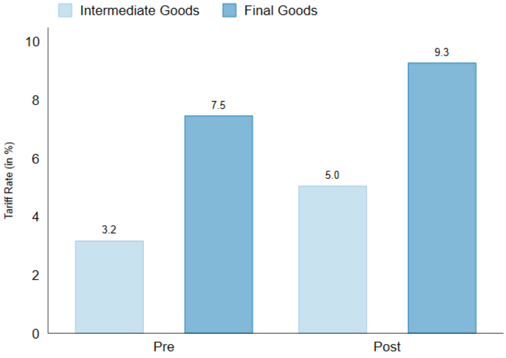
Outline of Talk

1. Closed-economy model
2. Open economy with final-good and input tariffs
3. Quantification of optimal final-good versus input tariff
4. Counterfactuals related to recent US-China Trade War

Counterfactuals: Tariff Escalation and the US-China Trade War



(a) US average tariffs on ROW



(b) ROW average tariffs on US

Counterfactuals: Effects of Trump Tariffs and Retaliation

Here: Use estimates for θ and σ from response in trade flows to tariffs ($\theta = 3.35$, $\sigma = 4.08$)

	A. RoW tariff at 2017 level			**B.** RoW tariff at 2019 level		
	U_{US}	U_{RoW}	$\frac{U_{US}}{U_{US,2017}}$	U_{US}	U_{RoW}	$\frac{U_{US}}{U_{US,2017}}$
US tariffs - 2017 level	0.028422	0.131439				
US tariffs - 2019 level	0.028479	0.131301	1.0020	0.028436	0.131329	1.0005
2019 US tariff only Downstream	0.028459	0.131367	1.0013	0.028416	0.131396	0.9998
2019 US tariff only Upstream	0.028437	0.131377	1.0005	0.028395	0.131406	0.9991
Counterfactual Tariff only Downstream	0.028488	0.131293	1.0023	0.028444	0.131322	1.0008
Counterfactual Tariff only Upstream	0.028443	0.131333	1.0007	0.028401	0.131360	0.9993
Optimal US Import Tariffs	0.028612	0.130663	1.0067	0.028566	0.130683	1.0051
Optimal US Tax Policy	0.029312	0.130611	1.0313	0.029264	0.130631	1.0296

Tax Levels

Conclusions

- We provide a rationale for tariff escalation – a prevalent feature of real-world tariffs
- Relatively low input tariffs are *not* explained by a second-best correction to a domestic distortion
  - Tariff escalation applies even without domestic distortions
  - If anything, misallocation of labor makes upstream import tariffs more appealing
- Instead, input tariffs are less beneficial because they lead final-good produce to relocate abroad
  - Consumers cannot run away from expensive final goods; but final-good producers can run away from expensive inputs

Derivations for the welfare approximation

$$\frac{dU_H}{U_H} = \left[-\frac{dP_H}{P_H} + \frac{dR_H}{w_H L_H} \right], \tag{9}$$

$$\frac{dR_H}{w_H L_H} = b_F^H \times dt_H^d + \lambda_H^d \times \Omega_{F,H} \times dt_H^u, \tag{10}$$

$$\frac{dP_H}{P_H} = b_H^H \times \left(\frac{1}{1-\sigma} \frac{dM_H^d}{M_H^d} + \frac{dp_{H,H}^d}{p_{H,H}^d} \right) + b_F^H \times \left(\frac{dM_F^d}{M_F^d} \frac{1}{1-\sigma} + \frac{dp_{F,H}^d}{p_{F,H}^d} + dt_H^d \right) \tag{11}$$

$$\frac{dp_{i,i}^d}{p_{i,i}^d} = \alpha \frac{dw_i}{w_i} + (1-\alpha) \frac{dP_i^u}{P_i^u}, \tag{12}$$

$$(1-\alpha)\frac{dP_i^u}{P_i^u} = \left(\frac{dM_i^u}{M_i^u} \frac{1}{1-\theta} + \frac{dp_{i,i}^u}{p_{i,i}^u} \right) \Omega_{i,i} + \left(\frac{dM_j^u}{M_j^u} \frac{1}{1-\theta} + \frac{dp_{j,i}^u}{p_{j,i}^u} + dt_i^u \right) \Omega_{j,i} \tag{13}$$

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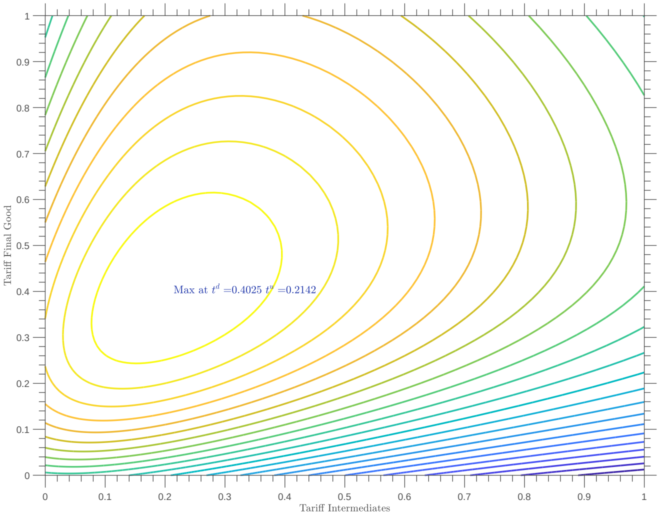
Key Moments in First-Order Approximation

Table: Statistics around the Zero Tariff Equilibrium

$\Omega_{H,H}$	$\Omega_{F,H}$	$\Omega_{F,F}$	$\Omega_{H,F}$	b_H^H	b_F^H	λ_H^d
0.41	0.04	0.44	0.02	0.94	0.06	0.98

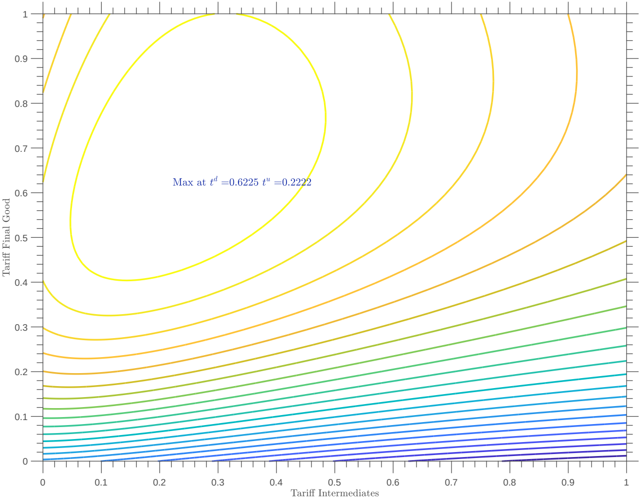
Notes: This table contains summary statistics of the endogenous aggregate variables relevant for the first order approximation around the zero tariff equilibrium.

Optimal second-best input tariff is lower than the final-good tariff



Tariff escalation persists with a domestic production subsidy

- We now introduce the closed-economy optimal subsidy $(s^u)^* = 1/\theta$



Counterfactuals: Level of Taxes

	A. RoW tariff at 2017 level				B. RoW tariff at 2019 level			
	t^d	t^u	ν^u	s^u	t^d	t^u	ν^u	s^u
Optimal US Import Tariffs	0.4175	0.2715			0.4176	0.2717		
Optimal US Tax Policy	0.3270	0.0041	0.3023	0.2985	0.3269	0.0040	0.3023	0.2985

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