CAN TRADE TAXES BE A MAJOR SOURCE OF GOVERNMENT REVENUE?

Lecture Slides, PhD level class

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Background

The Tariff-for-Revenue Argument

- The tariff-for-revenue argument has been invoked repeatedly in recent years to justify protectionist policies.
- **What is the argument?** Foreign consumers and producers pay for the tariffs (or trade taxes) $\Longrightarrow$ public spending can be beneficially financed with tariff revenues.

President Trump (Twitter, July 2019)

"Tariffs are a great negotiating tool, a great revenue producer"

Three Rudimentary Questions

A formal assessment of the *tariff-for-revenue* argument amounts to answering three rudimentary questions:

- **Question #1** Absent the threat of retaliation, can a country possibly gain from replacing domestic tax revenues with trade tax revenues?
- **Question #2** If so, what fraction of the public spending can be financed with only trade taxes?
- **Question #3** Above all, how large are the potential losses from retaliation by trading partners?

The Traditional Answer to Questions #1 and #2

- We have virtually no evidence on the max. % of public spending that is financeable with trade taxes.

- Traditional theories assume that all countries are small and lack market power vis-à-vis the rest of the world $\Longrightarrow$ The burden of trade taxes falls entirely on domestic consumers $\Longrightarrow$ trade taxes are *unilaterally* less efficient than other revenue-raising instruments.[1]

- The limitation of this perspective: in the presence of national product/technology differentiation, even small countries posses market power vis-à-vis the rest of the world (Alvarez-Lucas, 2007).

[1] See Dixit (1985) and Anderson (1996) for a survey.

The Traditional Answer to Question #3

Traditional Theories of Retaliation and Trade Wars

- Any gains from raising trade tax revenues will generally dissipate after retaliation by trading partners...
- ... but, under certain assumptions, an excessively large country can gain unilaterally from raising trade taxes, and can remain better off even after retaliation (Syropoulos, 2002; Kennan and Riezman, 2013).

- The limitation of this perspective:
  - Overlooks export or import market power due to product/technology differentiation and general equilibrium linkages.
  - Traditional theories are difficult to map to data $\Longrightarrow$ unclear what "sufficiently large" means in practice.

The Traditional Answer to Question #3

Traditional Quantitative Analyses of Retaliation and Trade Wars

- Existing estimates for the cost of retaliation and trade wars are based on the *welfarist* approach, wherein government's care solely about social welfare as opposed to revenue-generation (Ossa, 2014; 2016).
- Ossa (2014) finds that all countries can gain from raising tariffs unilaterally, but the gains are more than wiped out after retaliation.
- Limitations of traditional analyses
  1. They focus on a small set of countries to handle computational issues.
  2. No analysis of the pure revenue-raising motives behind trade taxation.
  3. They assume an inelastic supply of labor and lump-sum tax rebates $\Longrightarrow$ overlook the fiscal cost of trade wars.

This Paper: *Conceptual Contribution*

- Adopt a multi-industry Eaton and Kortum (2002) model with elastic labor supply.

- Derive *sufficient statistics* formulas for
  1. Revenue-maximizing trade taxes: determine the max. % of public spending that can be financed with trade taxes
  2. Welfarist revenue-maximizing trade taxes: determine the max. % of public spending that can be *beneficially* financed with trade taxes.

- These formulas have several other applications:
  - they uncover a trade-off between *revenue-generation* and *terms-of-trade*.
  - they shed new light on the fiscal consequences of trade wars.
  - they simplify the quantitative analysis of retaliation and trade wars.

This Paper: *Main Findings*

- Most countries have limited market power even after we account for product differentiation $\Longrightarrow$ the average country can beneficially finance **only 16%** of its public spending with trade taxes.

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  - 50% of the collected trade tax revenues disappear $\Longrightarrow$ governments are forced to increase domestic taxes to counter their shrinking tax base
  - real GDP drops across-the-board by an average of 7%.

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- After retaliation by trading partners:
  - 50% of the collected trade tax revenues disappear $\Longrightarrow$ governments are forced to increase domestic taxes to counter their shrinking tax base
  - real GDP drops across-the-board by an average of 7%.
- The flip side of these findings: the gains from free trade agreements are 30% larger once we account for the fiscal cost of trade wars.

Theoritical Framework

Environment

Multi-Industry Eaton-Kortum Model

- Many countries: $i = 1,\ldots,N$
- Many tradable or non-tradable industries: $k = 1,\ldots, K$
- Industry k consists of a continuum of homogeneous goods: $\omega \in \Omega_k$
- CRS + Labor is the sole factor of production
- Each country i is populated with L_i units of labor, who can move freely across industries but not across countries.

Demand-Side of Economy i

Representative consumer's utility

$$U_i(\mathbf{q}, L) = \mathcal{Q}_i(\mathbf{q}) - \nu(L)$$

—1st component of U_i: Cobb-Douglas-CES utility from consuming a basket $\mathbf{q}$ of goods from various industries:

$$\mathcal{Q}_i(\mathbf{q}) = \prod_{k=1}^{K} \left(\int_{\omega \in \Omega_k} q(\omega)^{\rho_k} d\omega \right)^{\frac{e_{i,k}}{\rho_k}}$$

—2nd component of U_i: Disutility from supplying L units of labor,

$$\nu(L) = \frac{1}{1 + \frac{1}{\kappa}} L^{1+\frac{1}{\kappa}}$$

Supply-Side of Economy i

The price of good ω in destination i if sourced from origin j:

$$p_{ij,k}(\omega) = \frac{1}{z_{i,k}(\omega)}\tau_{ij,k}w_i, \qquad \omega \in \Omega_k$$

- $\tau_{ij,k}$ ~ iceberg trade cost
- w_i ~ wage rate in origin i
- $z_{i,k}(\omega)$ is drawn *i.i.d.* from a Fréchet distribution: $F_{i,k}(z) = e^{-T_{i,k}z^{-\theta_k}}$
- Reminder: subscript k indicates that good ω belongs to industry k

Trade and Income Taxes

Trade Taxes: Each good ω is subjected to *origin* $j \times$ *destination* $i \times$ *industry* k-specific trade taxes, which imply the following consumer price:

$$\underbrace{\tilde{p}_{ji,k}(\omega)}_{\text{consumer price}} = \underbrace{(1 + t_{ji,k})}_{\text{import tariff}} \times \underbrace{(1 + x_{ji,k})}_{\text{export tax}} \times \underbrace{p_{ji,k}(\omega)}_{\text{producer price}}$$

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Income Taxes:: Each country i can also apply a *linear* income tax, δ_i, which raises a revenue equal to

$$\text{Income tax revenue} = \delta_i w_i L_i$$

Equilibrium Expenditure Shares: *The Gravity Equation*

- As in Eaton-Kortum, destination i buys good $\omega \in \Omega_k$ from the cheapest supplier:

$$\tilde{p}_{i,k}(\omega) = \min_{j \in \mathbb{C}} \{\tilde{p}_{ji,k}(\omega)\}$$

- The share of destination i's expenditure on industry k goods from origin j is $\lambda_{ji,k} \times e_{i,k}$, where:

$$\lambda_{ji,k}(\mathbf{t}, \boldsymbol{x}; \boldsymbol{w}) = \frac{T_{j,k}\left[(1+t_{ji,k})(1+x_{ji,k})\tau_{ji,k} w_j\right]^{-\theta_k}}{\sum_{\ell \in \mathbb{C}} T_{\ell,k}\left[(1+t_{\ell i,k})(1+x_{\ell i,k})\tau_{\ell i,k} w_\ell\right]^{-\theta_k}}$$

  - $\boldsymbol{w} \equiv \{w_i\}$, $\mathbf{t} \equiv \{t_{ji,k}\}$, and $\boldsymbol{x} \equiv \{x_{ji,k}\}$.

General Equilibrium: For a given vector of trade and income taxes, $\mathbf{t}$, $\boldsymbol{x}$, $\boldsymbol{\delta}$, equilibrium consists of a vector of wage rates, $\boldsymbol{w}$, and national expenditure levels, $\mathbf{Y}$, that satisfy the *labor market clearing* (LMC) and *balanced budget* (BB) conditions:

$$\text{[LMC]} \qquad w_i L_i = \sum_{j=1}^{N} \sum_{k=1}^{K} \left[\frac{1}{(1+t_{ij,k})(1+x_{ij,k})} \lambda_{ij,k}(\mathbf{t}, \boldsymbol{x}; \boldsymbol{w}) e_{j,k} Y_j \right].$$

$$\text{[BB]} \qquad Y_i = [1-\delta_i] w_i L_i(\mathbf{t}, \boldsymbol{x}, \boldsymbol{\delta}; \boldsymbol{w}) + \underbrace{\delta_i w_i L_i(\mathbf{t}, \boldsymbol{x}, \boldsymbol{\delta}; \boldsymbol{w}) + \mathcal{R}_i(\mathbf{t}, \boldsymbol{x}, \boldsymbol{\delta}; \boldsymbol{w}, \mathbf{Y})}_{\text{government spending}}$$

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where trade tax revenues, $\mathcal{R}_i$, and the total supply of labor, L_i, are given by

$$\begin{cases} \mathcal{R}_i \equiv \sum_{j=1}^{N} \sum_{k=1}^{K} \left[\frac{t_{ji,k}}{1+t_{ji,k}} \lambda_{ji,k} e_{i,k} Y_i + \frac{x_{ij,k}}{(1+x_{ij,k})(1+t_{ij,k})} \lambda_{ij,k} e_{j,k} Y_j \right] \\ L_i = \left([1-\delta_i] \frac{w_i}{\tilde{P}_i} \right)^{\kappa}; \qquad \tilde{P}_i = \bar{\gamma} \prod_k \left(\sum_n T_{n,k} \left[(1+t_{ni,k})(1+x_{ni,k}) \tau_{ni,k} w_n \right]^{-\theta_k} \right)^{\frac{e_{i,k}}{\theta_k}} \end{cases}$$

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elasticity of labor supply

Effectiveness of Trade Taxes at Raising Revenue

What do we Mean by Effectiveness at Raising Revenue?

- Effectiveness is defined as the *max. % of government spending, G_i, that is financeable with trade taxes*, where

$$G_i = \underbrace{\delta_i w_i L_i}_{\text{income tax rev.}} + \underbrace{\mathcal{R}_i}_{\text{trade tax rev.}}$$

We should differentiate between two cases:

- **Case #1.** plain effectiveness ~ relevant when governments have a strict political preference for trade tax revenues over other revenue sources.

- **Case #2.** effectiveness *s.t.* not worsening welfare

Case #1: *Plain Effectiveness of Revenue-Raising Trade Taxes*

- Let $\mathbb{F}$ denote the set of feasible *tax*×*wage*×*income* combinations:

$$\mathbb{F} \equiv \{(\mathbf{t}, \boldsymbol{x}, \boldsymbol{\delta}; \boldsymbol{w}, \mathbf{Y}) \mid (\boldsymbol{w}, \mathbf{Y}) \text{ satisfy eq. conditions given } (\mathbf{t}, \boldsymbol{x}, \boldsymbol{\delta})\}$$

- The trade tax schedule that maximizes the contribution of trade tax revenues to government spending, $\overline{G}_i$, solves the following problem

$$\max_{(\mathbf{t},\boldsymbol{x},\boldsymbol{\delta};\boldsymbol{w},\mathbf{Y})\in\mathbb{F}} \mathcal{R}_i\left(\mathbf{t}_i, \boldsymbol{x}_i; \mathbf{t}_{-i}, \boldsymbol{x}_{-i}, \boldsymbol{\delta}; \boldsymbol{w}, \mathbf{Y}\right) \qquad \text{(P1)}$$

$$\text{s.t.} \quad \delta_i w_i L_i + \mathcal{R}_i(.) = \overline{G}_i,$$

  - $\mathbf{t}_{-i}$ and $\boldsymbol{x}_{-i}$ denote taxes in the RoW, which are treated as given.

Two-Tier Approach to Solving Problem (P1)

Lemma. For any positive number $a \in \mathbb{R}_+$:

1. $A \equiv (\mathbf{1} + \mathbf{t}_i, \mathbf{1} + \mathbf{x}_i; w_i, \ldots) \in \mathbb{F} \Longrightarrow A' \equiv (a(\mathbf{1} + \mathbf{t}_i), \frac{1}{a}(\mathbf{1} + \mathbf{x}_i); a w_i, \ldots) \in \mathbb{F}$
2. The share of trade tax-to-income tax revenues is preserved under allocations A and A′ : $\frac{\mathcal{R}_i(A)}{\delta_i w_i L_i} = \frac{\mathcal{R}_i(A')}{\delta_i w_i' L_i'}$.[2]

[2]**Notation:** $A \equiv (\mathbf{1} + \mathbf{t}_i, \mathbf{1} + \mathbf{x}_i; w_i, \ldots) \sim (\mathbf{1} + \mathbf{t}_i, \mathbf{t}_{-i}, \mathbf{1} + \mathbf{x}_i, \mathbf{x}_{-i}, \delta; w_i, \boldsymbol{w}_{-i}, Y)$.

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The above lemma lets us split Problem (P1) into two smaller problems:

- Lower Tier Problem: Solve an unconstrained version of (P1) without imposing the revenue-neutrality constraint.
- Upper Tier Problem: Identify and apply a uniform tax shifter, a, to the solution of the lower-tier problem to satisfy revenue-neutrality.

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Proposition 1. The trade tax rates that maximize country i's revenue from trade taxes (for a fixed level of government spending G) are given by the following formulas

$$1 + t^*_{ji,k} = \left[1 + \frac{1}{\theta_k \lambda^*_{ii,k}}\right](1 + \bar{t}_i), \qquad \forall j \neq i;\ \forall k \in \mathbb{K}$$

$$1 + x^*_{ij,k} = \left[1 + \frac{1}{\theta_k (1 - \lambda^*_{ij,k})}\right](1 + \bar{t}_i)^{-1}, \qquad \forall j \neq i;\ \forall k \in \mathbb{K},$$

where $\bar{t}_i \in \mathbb{R}_+$ is a tax shifter that regulates the nominal tax revenue and is chosen to satisfy the revenue-preserving constraint.[3]

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Revenue-Maximizing Trade Taxes: *Intuition*

- Proposition 1 indicates that the standard *Laffer curve* result extends to a multilateral general equilibrium economy:

$$\text{revenue-maximzing tax rate} = \frac{-1}{1+\varepsilon}$$

demand elasticity

- Revenue maximizing export tax $=$ optimal export tax
- Revenue maximizing import tax $\neq$ optimal import tax
  - **Why?** because the revenue-maximizing rate does not internalize the welfare cost of distorting consumer prices in the local economy.

Case #2: *Effectiveness s.t. Not Worsening Welfare*

- *Revenue-maximizing rate* $\neq$ *optimal rate* $\Longrightarrow$ plain revenue-maximizing trade taxes may worsen domestic welfare

- Governments may attach a prominent weight to social welfare (Goldberg and Maggi, 1999) $\Longrightarrow$ They are interested in determining the ***max. % of government spending that is "beneficially" financeable with trade taxes***:

$$\max_{(\mathbf{t},\mathbf{x},\delta;\boldsymbol{w},\mathbf{Y})\in\mathbb{F}} \mathcal{R}_i\left(\mathbf{t}_i,\mathbf{x}_i;\mathbf{t}_{-i},\mathbf{x}_{-i},\delta;\boldsymbol{w},\mathbf{Y}\right) \qquad \text{(P2)}$$

$$\text{s.t.} \quad \delta_i w_i L_i + \mathcal{R}_i(.) = \overline{G}_i,$$

$$\Delta W_i(\mathbf{t}_i,\mathbf{x}_i;\mathbf{t}_{-i},\mathbf{x}_{-i},\delta;\boldsymbol{w},\mathbf{Y}) \geqslant 0.$$

extra constraint: raise trade tax revenue w/o worsening welfare

Solving Problem (P2) using an Intermediate Lemma

Lemma. $\Delta W_i(\mathbf{t}_i, \mathbf{x}_i; \mathbf{t}_{-i}, \mathbf{x}_{-i}, \delta; \boldsymbol{w}, \mathbf{Y}) > 0$ if trade taxes are changed from their applied rate to

revenue-maximizing rate

$$\mathbf{t}_i^{'} = \mathbf{0}, \qquad \mathbf{x}_i^{'} = \left\{ \frac{1}{\theta_k(1-\lambda_{ij,k})} \right\}_{j,k}$$

optimal rate

The above lemma in combination with the *Intermediate Value Theorem* indicate that the solution to Problem (P2) consists of:

- $x^* =$ plain revenue-maximizing export tax
- $t^* =$ weighted avg $\{t = 0$, plain revenue-maximizing $t\}$

Proposition 2. The trade tax rates that maximize country i's trade tax revenues without deteriorating domestic welfare are given by

$$1 + t^{*}_{ji,k} \approx \left[\bar{\alpha}_i + \left(1 + \frac{1}{\theta_k \lambda^{*}_{ii,k}} \right) (1 - \bar{\alpha}_i) \right] (1 + \bar{t}_i), \quad \forall j \neq i;\ \forall k \in \mathbb{K}$$

$$1 + x^{*}_{ij,k} = \left(1 + \frac{1}{\theta_k \left(1 - \lambda^{*}_{ij,k}\right)} \right) (1 + \bar{t}_i)^{-1}, \quad \forall j \neq i;\ \forall k \in \mathbb{K},$$

where $\bar{t}_i \in \mathbb{R}_+$ is a tax shifter that regulates the nominal tax revenue and is chosen to satisfy the revenue-neutrality constraint and $\bar{\alpha}_i \in (0, 1)$ is a uniform tax shifter that is chosen to satisfy the welfare-neutral constraint, $\Delta W_i(.) = 0$.

Implication: *The Importance of the Trade Elasticities*

- The effectiveness of trade taxes at *beneficially* raising revenue is regulated by the industry-level trade elasticities, θ_k.
- High $\text{Avg}_k(\theta_k) \implies$ "export" taxes are ineffective.
- High $\text{Var}_k(\theta_k) \implies$ "import" taxes are ineffective, because maximizing import tax revenues coincides with maximizing the burden of taxes on domestic consumers.
- **Bottomline:** Trade taxes are most effective at *beneficially* raising revenue if trade elasticities are (on average) low and homogeneous.

Effectiveness at Raising Revenue After Retaliation

Retaliation and Nash Trade Taxes

- We have thus far focused on the effectiveness of trade taxes before retaliation by trading partners.

- The post retaliation Nash equilibrium: non-cooperative countries simultaneously apply taxes that maximize the contribution of trade tax revenues to domestic government spending.

- Nash trade taxes solve the following system of $2N(N-1)K$ equations

$$\begin{cases} \mathbf{t}_1 = \mathbf{t}_1^*(\mathbf{t}_{-1}, \boldsymbol{x}); & \boldsymbol{x}_1 = \boldsymbol{x}_1^*(\mathbf{t}, \boldsymbol{x}_{-1}) \\ \vdots & \vdots \\ \mathbf{t}_N = \mathbf{t}_N^*(\mathbf{t}_{-N}, \boldsymbol{x}); & \boldsymbol{x}_N = \boldsymbol{x}_N^*(\mathbf{t}, \boldsymbol{x}_{-N}) \end{cases}$$

revenue-maximizing rate

Determining Nash Taxes using Analytic Formulas

- The ToT gains from unilateral taxation dissipate after retaliation.

- We can invoke *Propositions 1* and *2* to determine the Nash trade taxes and their welfare consequence.

Proposition 3. The Nash revenue-maximizing trade taxes solve the following system of equations:

$$\begin{cases} 1+t^*_{i1,k} = \left(1+\frac{1}{\theta_k \lambda_{11,k}(\mathbf{t}^*,\boldsymbol{x}^*)}\right)(1+\bar{t}_1) & 1+x^*_{1i,k} = \left(1+\frac{1}{\theta_k [1-\lambda_{1i,k}(\mathbf{t}^*,\boldsymbol{x}^*)]}\right)(1+\bar{t}_1)^{-1} \\ \vdots & \vdots \\ 1+t^*_{iN,k} = \left(1+\frac{1}{\theta_k \lambda_{NN,k}(\mathbf{t}^*,\boldsymbol{x}^*)}\right)(1+\bar{t}_N), & 1+x^*_{Ni,k} = \left(1+\frac{1}{\theta_k [1-\lambda_{Ni,k}(\mathbf{t}^*,\boldsymbol{x}^*)]}\right)(1+\bar{t}_N)^{-1} \end{cases},$$

where $\bar{t}_i$ is a country-specific tax shifter that is pinned down by the revenue-neutrality constraint.

A Key Implication of Proposition 3

When industry-level trade elasticities, θ_k, are low:

- trade taxes are more effective at revenue-raising instrument...
- ...but the potential losses from retaliation are also larger.

Bottomline: in situations where trade taxes are more effective at raising revenue, the potential welfare cost of using them is also higher!

Mapping Sufficient Statistics Tax Formulas to Data

Some Background and Notation

- Propositions 1-3 presented *sufficient statistics* formulas for revenue-maximizing and Nash trade taxes.

- Combining these formulas w/ hat-algebra $\implies$ we can compute the effectiveness and deadweight burden of trade taxation without performing numerical optimization or knowing the structural parameters of the model (other than θ_k and κ).

Hat-Algebra notation (generic variable z)

- z: observed (factual) level
- z^*: counterfactual level under revenue-maximizing taxes
- $\hat{z} \equiv z^*/z$

Computing the Counterfactual Nash Eq. in Changes

– We can calculate counterfactual trade shares w/o knowing $T_{i,k}$ or $\tau_{ij,k}$:

$$\lambda_{ij,k} = \frac{T_{i,k}\left[(1+x_{ij,k})(1+t_{ij,k})\tau_{ij,k}w_i\right]^{-\theta_k}}{\sum_{n=1}^{N} T_{n,k}\left[(1+x_{nj,k})(1+t_{nj,k})\tau_{nj,k}w_n\right]^{-\theta_k}} \longrightarrow \hat{\lambda}_{ij,k} = \frac{\left[(\widehat{1+x_{ij,k}})(\widehat{1+t_{ij,k}})\hat{w}_i\right]^{-\theta_k}}{\sum_{n=1}^{N} \lambda_{nj,k}\left[(\widehat{1+x_{nj,k}})(\widehat{1+t_{nj,k}})\hat{w}_n\right]^{-\theta_k}}$$

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- We can apply the same idea to the formulas specified by Proposition 3 to calculate the counterfactual Nash taxes:

$$1+t^*_{ji,k} = \left[1+\frac{1}{\theta_k\lambda^*_{ii,k}}\right](1+\bar{t}_i) \longrightarrow 1+t^*_{ji,k} = \left[1+\frac{1}{\theta_k\lambda_{ii,k}\hat{\lambda}_{ii,k}}\right](1+\bar{t}_i)$$

$$1+x^*_{ij,k} = \left[1+\frac{1}{\theta_k(1-\lambda^*_{ij,k})}\right](1+\bar{t}_i)^{-1} \longrightarrow 1+x^*_{ij,k} = \left[1+\frac{1}{\theta_k(1-\lambda_{ij,k}\hat{\lambda}_{ij,k})}\right](1+\bar{t}_i)^{-1}$$

Computing the Counterfactual Nash Eq. in Changes

– We can calculate counterfactual trade shares w/o knowing $T_{i,k}$ or $\tau_{ij,k}$:

$$\lambda_{ij,k} = \frac{T_{i,k}\left[(1+x_{ij,k})(1+t_{ij,k})\tau_{ij,k}w_i\right]^{-\theta_k}}{\sum_{n=1}^{N} T_{n,k}\left[(1+x_{nj,k})(1+t_{nj,k})\tau_{nj,k}w_n\right]^{-\theta_k}} \longrightarrow \hat{\lambda}_{ij,k} = \frac{\left[(\widehat{1+x_{ij,k}})(\widehat{1+t_{ij,k}})\hat{w}_i\right]^{-\theta_k}}{\sum_{n=1}^{N} \lambda_{nj,k}\left[(\widehat{1+x_{nj,k}})(\widehat{1+t_{nj,k}})\hat{w}_n\right]^{-\theta_k}}$$

– We can apply the same idea to the formulas specified by Proposition 3 to calculate the counterfactual Nash taxes:

applied rate

$$1+t^*_{ji,k} = \left[1+\frac{1}{\theta_k\lambda^*_{ii,k}}\right](1+\bar{t}_i) \longrightarrow \widehat{1+t_{ji,k}} = \left[1+\frac{1}{\theta_k\lambda_{ii,k}\hat{\lambda}_{ii,k}}\right]\frac{(1+\bar{t}_i)}{1+\bar{t}_{ji,k}}$$

$$1+x^*_{ij,k} = \left[1+\frac{1}{\theta_k(1-\lambda^*_{ij,k})}\right](1+\bar{t}_i)^{-1} \longrightarrow 1+x^*_{ij,k} = \left[1+\frac{1}{\theta_k(1-\lambda_{ij,k}\hat{\lambda}_{ij,k})}\right]\frac{(1+\bar{t}_i)^{-1}}{1+\bar{x}_{ij,k}}$$

– **Final piece:** Simultaneously solve the optimal tax formulas and the equilibrium conditions in changes to determine $\hat{w}_i$ and $\hat{Y}_i$.

Proposition 4. *The Nash import and export taxes and their effect on wages, $\hat{w}_i$, and total income, $\hat{Y}_i$, can be solved as the solution to the following system of equations:*

$$
\begin{cases}
1 + t^*_{ji,k} = \left[1 + \frac{1}{\theta_k \hat{\lambda}_{ii,k} \lambda_{ii,k}}\right](1 + \bar{t}_i); \qquad 1 + x^*_{ij,k} = \left[1 + \frac{1}{\theta_k \left(1 - \hat{\lambda}_{ij,k} \lambda_{ij,k}\right)}\right](1 + \bar{t}_i)^{-1} \\
\hat{\lambda}_{ji,k} = \left[\frac{(1+x^*_{ji,k})(1+t^*_{ji,k})}{(1+\bar{x}_{ji,k})(1+\bar{t}_{ji,k})} \hat{w}_j\right]^{-\theta_k} \hat{\tilde{P}}^{\theta_k}_{i,k}; \qquad \hat{\tilde{P}}_{i,k} = \sum_\ell \left(\left[\frac{(1+x^*_{\ell i,k})(1+t^*_{\ell i,k})}{(1+x_{\ell i,k})(1+t_{\ell i,k})} \hat{w}_\ell\right]^{-\theta_k} \lambda_{\ell i,k}\right)^{-\frac{1}{\theta_k}} \\
\text{[BB]} \quad \hat{Y}_i Y_i = \hat{w}_i \hat{L}_i w_i L_i + \hat{\mathcal{R}}_i \mathcal{R}_i; \qquad \hat{L}_i = \left[\hat{w}_i / \prod \hat{\tilde{P}}^{e_{i,k}}_{i,k}\right]^\kappa \\
\text{[LMC]} \quad \hat{w}_i \hat{L}_i w_i L_i = \sum_k \sum_j \left[\frac{1}{(1+t^*_{ij,k})(1+x^*_{ij,k})} \hat{\lambda}_{ij,k} \lambda_{ij,k} e_{j,k} \hat{Y}_j Y_j\right] \\
\hat{\mathcal{R}}_i \mathcal{R}_i = \sum_k \sum_{j \neq i} \left(\frac{t^*_{ji,k}}{1+t^*_{ji,k}} \hat{\lambda}_{ji,k} \lambda_{ji,k} e_{i,k} \hat{Y}_i Y_i + \frac{x^*_{ij,k}}{(1+t^*_{ij,k})(1+x^*_{ij,k})} \hat{\lambda}_{ij,k} \lambda_{ij,k} e_{j,k} \hat{Y}_j Y_j\right) \\
\text{[Revenue-Neutrality]} \quad \hat{\mathcal{R}}_i \mathcal{R}_i + \delta_i \hat{w}_i \hat{L}_i w_i L_i = \mathcal{R}_i + \delta_i w_i L_i
\end{cases}
$$

Proposition 4. *The Nash import and export taxes and their effect on wages, $\hat{w}_i$, and total income, $\hat{Y}_i$, can be solved as the solution to the following system of equations:*

$$\begin{cases} 1+t^*_{ji,k} = \left[1+\frac{1}{\theta_k \hat{\lambda}_{ii,k}\lambda_{ii,k}}\right](1+\bar{t}_i); \qquad 1+x^*_{ij,k} = \left[1+\frac{1}{\theta_k\left(1-\hat{\lambda}_{ij,k}\lambda_{ij,k}\right)}\right](1+\bar{t}_i)^{-1} \\ \hat{\lambda}_{ji,k} = \left[\frac{(1+x^*_{ji,k})(1+t^*_{ji,k})}{(1+\bar{x}_{ji,k})(1+\bar{t}_{ji,k})}\hat{w}_j\right]^{-\theta_k} \hat{\tilde{P}}^{\theta_k}_{i,k}; \qquad \hat{\tilde{P}}_{i,k} = \sum_\ell \left(\left[\frac{(1+x^*_{\ell i,k})(1+t^*_{\ell i,k})}{(1+x_{\ell i,k})(1+t_{\ell i,k})}\hat{w}_\ell\right]^{-\theta_k} \lambda_{\ell i,k}\right)^{-\frac{1}{\theta_k}} \\ \text{[BB]} \quad \hat{Y}_i Y_i = \hat{w}_i \hat{L}_i w_i L_i + \hat{\mathcal{R}}_i \mathcal{R}_i; \qquad \hat{L}_i = \left[\hat{w}_i / \prod \hat{\tilde{P}}^{e_{i,k}}_{i,k}\right]^{\kappa} \\ \text{[LMC]} \quad \hat{w}_i \hat{L}_i w_i L_i = \sum_k \sum_j \left[\frac{1}{(1+t^*_{ij,k})(1+x^*_{ij,k})}\hat{\lambda}_{ij,k}\lambda_{ij,k}e_{j,k}\hat{Y}_j Y_j\right] \\ \hat{\mathcal{R}}_i \mathcal{R}_i = \sum_k \sum_{j\neq i}\left(\frac{t^*_{ji,k}}{1+t^*_{ji,k}}\hat{\lambda}_{ji,k}\lambda_{ji,k}e_{i,k}\hat{Y}_i Y_i + \frac{x^*_{ij,k}}{(1+t^*_{ij,k})(1+x^*_{ij,k})}\hat{\lambda}_{ij,k}\lambda_{ij,k}e_{j,k}\hat{Y}_j Y_j\right) \\ \text{[Revenue-Neutrality]} \quad \hat{\mathcal{R}}_i \mathcal{R}_i + \delta_i \hat{w}_i \hat{L}_i w_i L_i = \mathcal{R}_i + \delta_i w_i L_i \end{cases}$$

- **Note 1:** Highlighted variables are either observable or estimable.
- **Note 2:** A similar logic can be invoked to compute revenue-maximizing taxes before retaliation.

Let's Put Proposition 4 in Perspective

- **Standard Optimization-Based Approach**[4]
  - Solves Nash export and import taxes by performing an iterative numerical optimization procedure.
  - Each iteration performs N optimizations with $2(N-1)K+2N$ free-moving variables (N is # of countries; K is # of industries).

- **New Optimization-Free Approach (Proposition 4)**
  - Solve a system of $2(N-1)K+2N$ independent equations and $2(N-1)K+2N$ independent unknowns, only once.

[4] See (Ossa, 2014; 2016) for an application of the optimization-based approach to computing Nash tariffs.

The Welfare and Fiscal Consequences of Nash Taxes

- The max. fraction of government spending that is financeable with trade taxes after retaliation is given by

$$\frac{\mathcal{R}_i^*}{G_i} = \frac{\hat{\mathcal{R}}_i \mathcal{R}_i}{\mathcal{R}_i + \delta_i w_i L_i}$$

  where $\mathcal{R}_i$ and $\delta_i w_i L_i$ are observable and $\hat{\mathcal{R}}_i$ is implied by *Proposition 4*.

- The welfare consequences Nash trade taxes can be computed as

$$\hat{W}_i = \phi_i \frac{\hat{Y}_i}{\hat{\tilde{P}}_i} + (1 - \phi_i) \frac{\hat{w}_i \hat{L}_i}{\hat{\tilde{P}}_i}$$

  where $\hat{\tilde{P}}_i$, $\hat{w}_i \hat{L}_i$, and $\hat{Y}_i$ are implied by *Proposition 4*, and $\phi_i \equiv \frac{Y_i}{Y_i - \frac{\kappa(1-\delta_i)}{1+\kappa} w_i L_i}$ is an observable that weighs consumption effects.

Quantitative Implementation

Data Sources

World Input-Output Database

- Latest release: year 2014
- Reports expenditure levels by *origin*×*destination*×*industry*.
- Covers 44 Countries + an aggregate of the rest of the world
- Spans 56 Industries (traded + non-traded services)

Unctad-Trains database : Applied Tariffs ($\bar{t}_{ji,k}$)

World Bank Indicators database: income + VAT tax rates (δ_i)

Estimating the Industry-Level Trade Elasticities (θ_k)

– We can estimate θ_k by applying *Caliendo and Parro's (2015)* triple-difference methodology to the gravity equation for trade shares:

$$\lambda_{ij,k} = \frac{\overbrace{T_{i,k} w_i^{-\theta_k}}^{\text{exporter FE}}}{\underbrace{\sum_{n=1}^{\mathcal{N}} T_{n,k} \left[(1 + t_{nj,k})\tau_{nj,k} w_n\right]^{-\theta_k}}_{\text{importer FE}}} \times \tau_{ij,k}^{-\theta_k} (1 + t_{ij,k})^{-\theta_k}$$

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– Assuming (i) $\tau_{ji,k} = d_{ji,k} + \varepsilon_{ji,k}$, where (ii) the systematic component is symmetric ($d_{ji,k} = d_{ij,k}$), yields the following estimating equation:

$$\ln \frac{\lambda_{ji,k}\lambda_{in,k}\lambda_{nj,k}}{\lambda_{ij,k}\lambda_{ni,k}\lambda_{jn,k}} = -\theta_k \ln \frac{(1+t_{ji,k})(1+t_{in,k})(1+t_{nj,k})}{(1+t_{ij,k})(1+t_{ni,k})(1+t_{jn,k})} + \tilde{\varepsilon}_{jin,k}$$

data from WIOD

data from TRAINS

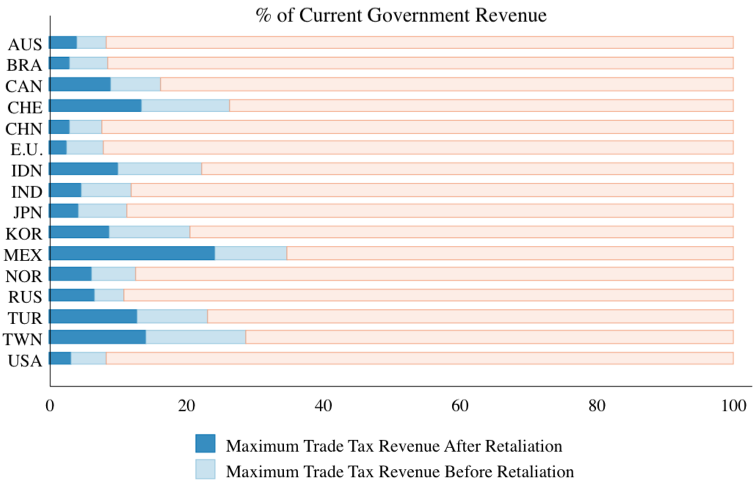
Estimated Trade Elasticities: *WIOD Industry Categories 1-8*

Number	Description	θ_k	std. err.	Obsv.
1	Crop and animal production, hunting Forestry and logging Fishing and aquaculture	0.93	0.19	12,341
2	Mining and Quarrying			
3	Food, Beverages and Tobacco	0.53	0.13	12,300
4	Textiles, Wearing Apparel and Leather	2.71	0.51	12,341
5	Wood and Products of Wood and Cork	5.64	0.87	12,183
6	Paper and Paper Products Printing and Reproduction of Recorded Media	4.65	1.49	12,300
7	Coke, Refined Petroleum and Nuclear Fuel	13.38	1.94	9,538
8	Chemicals and Chemical Products Basic Pharmaceutical Products	2.36	0.91	12,300

Estimated Trade Elasticities: *WIOD Industry Categories 9-16*

Number	**Description**	θ_k	std. err.	Obsv.
9 10 11	Rubber and Plastics Other Non-Metallic Mineral Basic Metals Fabricated Metal Products	1.51	0.89	12,341
12	Computer, Electronic and Optical Products Electrical Equipment	4.07	1.02	12,341
13	Machinery and Equipment n.e.c	5.65	1.34	12,341
14	Motor Vehicles, Trailers and Semi-Trailers Other Transport Equipment	2.70	0.45	12,341
15	Furniture; other Manufacturing	2.04	0.59	12,341
16	All Service-Related Industries (WIOD Industry No. 23-56)	3.80	0.84	12,341

Result 1. *Even before retaliation, the average country can beneficially replace only 16% of its income tax revenue with trade tax revenue.*



Result 2. *After retaliation, the trade tax revenues collected by non-cooperative countries decline by 50%. Also, every \$1 million of income tax revenue that was replaced with trade tax revenue imposes an excess burden of \$2.7 million on the economy.*

– Kay (1980): The excess burden of taxation can be calculated as

$$EB_i = e(\{P_i', w_i'\}, W_i') - e(\{P_i, w_i\}, W_i') - \Delta\mathcal{R}_i - (\delta_i' w_i' L_i' - \delta_i w_i L),$$

expenditure function

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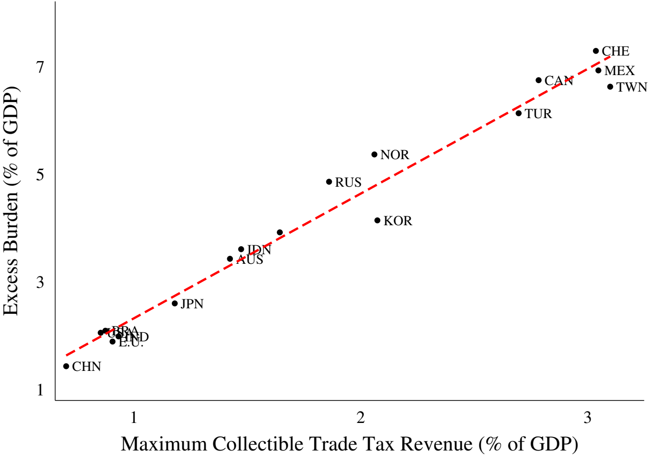
expenditure function

- Cobb-Douglas-CES demand $\Longrightarrow$ we can formulate EB_i as

$$EB_i = Y_i \hat{Y}_i \left(1 - 1/\hat{P}_i\right) - w_i L_i \left(\widehat{w_i L_i} - \hat{L}_i\right) - \Delta\mathcal{R}_i - \delta_i w_i L_i \left(\hat{L}_i - 1\right)$$

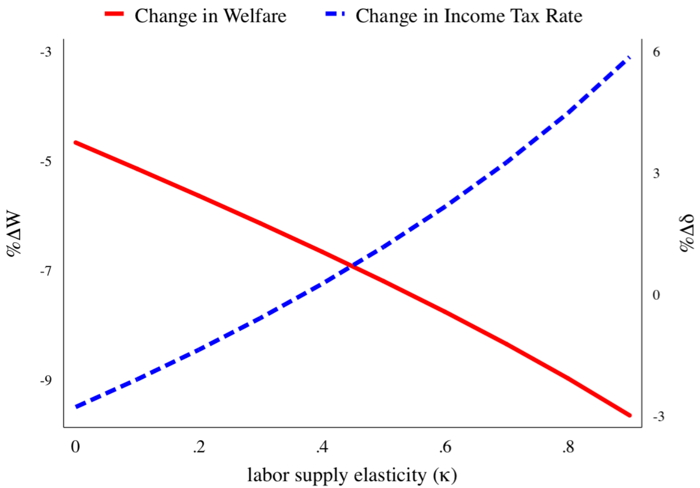
	% of income tax revenue replaceable with trade taxes			Welfare Consequences of Reltaliation	
Country	(P1)	(P2)	Post-Retaliation	%Δ Real GDP	EB/$ Rev.
AUS	9.3%	8.3%	3.9%	-5.9%	$2.8
EU	7.8%	7.8%	2.6%	-3.3%	$2.4
BRA	8.6%	8.6%	3.0%	-3.5%	$2.7
CAN	18.0%	16.3%	9.0%	-11.4%	$2.9
CHE	27.0%	26.5%	13.5%	-12.2%	$2.8
CHN	7.7%	7.7%	2.9%	-2.4%	$2.1
IDN	22.3%	22.2 %	10.0%	-5.9%	$2.5
IND	11.9%	11.9%	4.6%	-3.2%	$1.9
JPN	11.8%	11.3 %	4.3%	-4.6%	$2.5
KOR	20.6 %	20.6%	8.8%	-7.1%	$2.1
MEX	37.0%	34.6%	24.1%	-11.5%	$2.5
NOR	13.8%	12.5%	6.3%	-8.9%	$3.1
RUS	14.2%	10.9%	6.6%	-8.2%	$2.7
TUR	24.2%	23.1%	12.9%	-10.4%	$2.5
TWN	29.1%	28.7%	14.1%	-11.6%	$2.3
USA	8.8%	8.3%	3.2%	-3.5%	$2.7
Average	17.0%	16.2%	8.1%	-7.1%	$2.5

Result 3. [The effectiveness-efficiency trade-off] *In a cross-section of countries, trade taxes are the least efficient when they are most effective at raising revenue.*



Result 4. *The gains from trade agreements are 30% larger once we account for the fiscal cost of trade wars and distortions to labor supply decisions.*

The welfare and fiscal consequences of leaving FTAs (avg. country)



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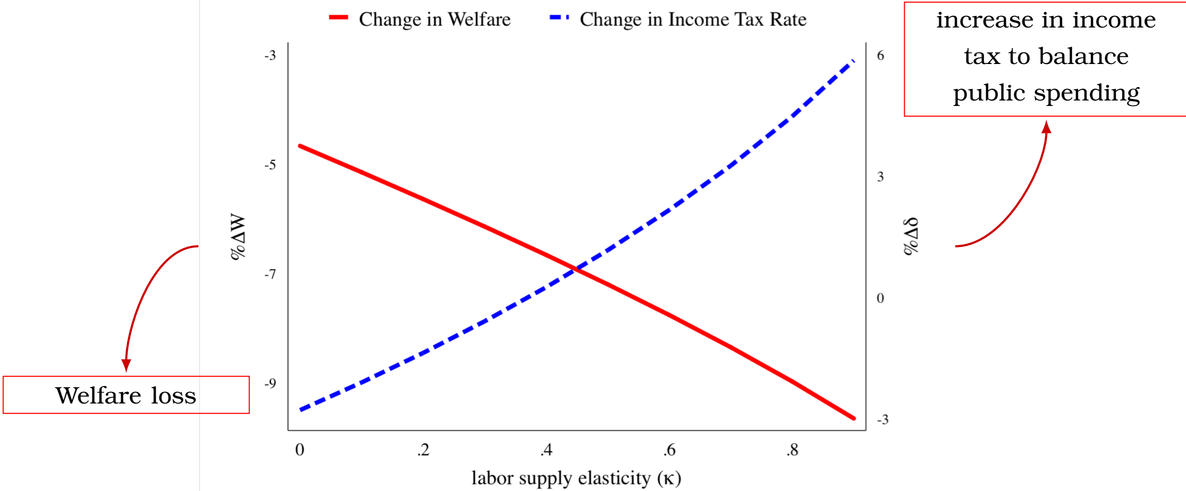

Putting Result 4 in Perspective

– Prior analyses of trade wars assume that labor is inelastically supplied (i.e., $\kappa = 0$) and governments have access to lump-sums transfers.

– Result 4 indicates that these assumptions overlook the cost of trade war by overlooking two cost channels:
  1. A trade war inflates the CPI $\Longrightarrow$ distorts labor supply decisions
  2. A trade war shrinks the trade/domestic tax base $\Longrightarrow$ to maintain real public spending, the government has to raise the income tax rate.

Conclusions

- Most countries have limited market power even after we account for product differentiation $\Longrightarrow$ the average country can beneficially finance **only 16%** of its public spending with trade taxes.

Conclusions

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- After retaliation by trading partners:
  - 50% of the collected trade tax revenues disappear $\Longrightarrow$ governments are forced to increase domestic taxes to counter their shrinking tax base
  - real GDP drops across-the-board by an average of 7%.

Conclusions

- Most countries have limited market power even after we account for product differentiation $\Longrightarrow$ the average country can beneficially finance **only 16%** of its public spending with trade taxes.
- After retaliation by trading partners:
  - 50% of the collected trade tax revenues disappear $\Longrightarrow$ governments are forced to increase domestic taxes to counter their shrinking tax base
  - real GDP drops across-the-board by an average of 7%.
- The flip side of these findings: the gains from free trade agreements are 30% larger once we account for the fiscal cost of trade wars.

Thank You.

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