Micro to Macro: Optimal Trade Policy with Firm Heterogeneity

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Motivation

- Large firms tend to export, whereas small firms do not
- What are the policy implications of that empirical observation?

This Paper

- Optimal trade policy in generalized version of Melitz (2003)
- Two polar assumptions about set of available policy instruments:
  1. Unconstrained taxes across firms
  2. Uniform taxes across firms

Optimal Unconstrained Taxes

- At the micro-level:
  - No discrimination across domestic exporters
  - Discrimination against most profitable foreign exporters
- At the macro-level:
  - Standard ToT considerations pin down the optimal level of trade policy.
    - Given ToT elasticities, level of protection not affected by heterogeneity
    - Though heterogeneity affects optimal pattern of protection at the micro-level

Optimal Uniform Taxes

- A generalized optimal tariff formula
  - Gros (1987), Demidova and Rodriguez-Clare (2009), Felbermayr et al. (2013)
- Three sufficient statistics for optimal tariffs:
  - Foreign's share of expenditure on domestically produced goods
  - Foreign's EoS between domestically produced and imported goods
  - **Foreign's EoT between domestically produced and exported goods**
- Selection of heterogeneous firms tends to:
  - Create aggregate non-convexities (negative EoT)
  - Lower optimal tariff (given other two statistics)
    - Lerner paradox: Optimal tariff may become an **import subsidy**

Related Literature

- Firm Heterogeneity in International Trade:
  - Extensive literature has revisited **positive** results of Helpman and Krugman 85; see Melitz and Redding's handbook chapter
  - Few papers have revisited **normative** results of Helpman and Krugman 89; see Demidova and Rodriguez-Clare (2009), Felbermayr, Jung and Larch (2013), Haaland and Venables (2014), Bagwell and Lee (2015), and Demidova (2015)
- Methodology:
  - Primal approach and general Lagrange multiplier methods, as in Costinot, Lorenzoni, Werning (2014) and Costinot, Donaldson, Vogel, Werning (2015)
  - New "micro-to-macro" strategy that breaks down the design of optimal taxes into a series of "micro problems" and a "macro problem"

Outline of Presentation

Technology

- Two countries $i = H, F$:
  - L_i = labor endowment
  - w_i = wage
- Firms pay fixed entry cost $f_i^e > 0$ in order to draw $\varphi \in \Phi$:
  - N_i = measure of entrants
  - G_i = distribution of φ
- Technology of a firm with draw φ:

$$\begin{aligned} l_{ij}(q, \varphi) &= a_{ij}(\varphi) q + f_{ij}(\varphi), \text{ if } q > 0, \\ l_{ij}(q, \varphi) &= 0, \text{ if } q = 0. \end{aligned}$$

- Melitz (2003) = special case s.t. $a_{ij}(\varphi) = \tau_{ij}/\varphi$ and $f_{ij}(\varphi) = f_{ij}$

Preferences

- Representative agent with two-level homothetic utility function:

$$U_j = U_j(Q_{Hj}, Q_{Fj}),$$
$$Q_{ij} = [\int_{\Phi} N_i (q_{ij}(\varphi))^{1/\mu_i} dG_i(\varphi)]^{\mu_i}.$$

with $\mu_i \equiv \sigma_i/(\sigma_i - 1)$ and $\sigma_i > 1 =$ EoS between varieties from country i.

- Melitz (2003) = special case s.t. $\mu_H = \mu_F = \mu$ and

$$U_j(Q_{Hj}, Q_{Fj}) = [Q_{Hj}^{1/\mu} + Q_{Fj}^{1/\mu}]^{\mu}$$

Market Structure

- All goods markets are monopolistically competitive with free entry.
- All labor markets are perfectly competitive.

Policy Instruments

- Full set of ad-valorem consumption and production taxes
- $t_{ij}(\varphi) =$ tax charged by country j on the consumption of a variety with blueprint φ produced in country i.
  - For $i \neq j$, $t_{ij}(\varphi) > 0$ a tariff, $t_{ij}(\varphi) < 0$ an import subsidy.
- $s_{ij}(\varphi) =$ subsidy paid by country i on the production by a domestic firm of a variety with blueprint φ sold in country j.
  - For $i \neq j$, $s_{ij}(\varphi) > 0$ an export subsidy, $s_{ij}(\varphi) < 0$ an export tax.
- Tax revenues rebated through a lump-sum transfer, T_i.

Decentralized Equilibrium with Taxes

- In a decentralized equilibrium with taxes:
  1. consumers choose consumption in order to maximize their utility subject to their budget constraint;
  2. firms choose their output in order to maximize their profits taking their residual demand curves as given;
  3. firms enter up to the point at which expected profits are zero;
  4. markets clear;
  5. the government's budget is balanced in each country.
- Notation:
  - $\bar{p}_{ij}(\varphi) \equiv \mu_i w_i a_{ij}(\varphi)/(1 + s_{ij}(\varphi))$
  - $\bar{q}_{ij}(\varphi) \equiv [(1 + t_{ij}(\varphi))\bar{p}_{ij}(\varphi)/P_{ij}]^{-\sigma_i} Q_{ij}$

Equilibrium Conditions

$$q_{ij}(\varphi) = \begin{cases} \bar{q}_{ij}(\varphi) & \text{, if } (\mu_i - 1)a_{ij}(\varphi)\bar{q}_{ij}(\varphi) \geq f_{ij}(\varphi), \\ 0 & \text{, otherwise,} \end{cases} \tag{1}$$

$$p_{ij}(\varphi) = \begin{cases} \bar{p}_{ij}(\varphi) & \text{, if } (\mu_i - 1)a_{ij}(\varphi)q_{ij}(\varphi) \geq f_{ij}(\varphi), \\ \infty & \text{, otherwise,} \end{cases} \tag{2}$$

$$Q_{Hj}, Q_{Fj} \in \arg\max_{\tilde{Q}_{Hj}, \tilde{Q}_{Fj}} \{U_j(\tilde{Q}_{Hj}, \tilde{Q}_{Fj}) | \sum_{i=H,F} P_{ij}\tilde{Q}_{ij} = w_j L_j + T_j\}, \tag{3}$$

$$P_{ij}^{1-\sigma_j} = \int_{\Phi} N_j[(1 + t_{ij}(\varphi))p_{ij}(\varphi)]^{1-\sigma_i} dG_i(\varphi), \tag{4}$$

$$f_i^e = \sum_{j=H,F} \int_{\Phi} [\mu_i a_{ij}(\varphi)q_{ij}(\varphi) - l_{ij}(q_{ij}(\varphi))] dG_i(\varphi), \tag{5}$$

$$L_i = N_i[\sum_{j=H,F} \int_{\Phi} l_{ij}(q_{ij}(\varphi), \varphi) dG_i(\varphi) + f_i^e], \tag{6}$$

$$T_i = \sum_{j=H,F} [\int_{\Phi} N_j t_{ji}(\varphi)p_{ji}(\varphi)q_{ji}(\varphi)dG_j(\varphi) - \int_{\Phi} N_i s_{ij}(\varphi)p_{ij}(\varphi)q_{ij}(\varphi)dG_i(\varphi)]. \tag{7}$$

Home Government's Problem

Definition

The home government's problem is

$$\max_{T_H, \{\mathbf{t_{jH}}, \mathbf{s_{Hj}}\}_{j=H,F}, \{\mathbf{q_{ij}}, Q_{ij}, p_{ij}, P_{ij}, w_i, N_i\}_{i,j=H,F}} U_H(Q_{HH}, Q_{FH})$$

subject to equilibrium conditions (1)-(7).

- We assume that only the home government is strategic, whereas the foreign government is passive, with all foreign taxes equal to zero.
- We solve the home government's problem using the primal approach:
  1. Consider a relaxed planning problem in which domestic consumption, output, and the measure of entrants can be chosen directly
  2. Show that the solution can be implemented through linear taxes and characterize the structure of these taxes.

Outline of Presentation

Home's Relaxed Planning Problem

- Start from home government's problem and drop all constraints with Home's tax instruments, $T_H, \{\mathbf{t_{jH}}, \mathbf{s_{Hj}}\}_{j=H,F}$, and Home's prices, $w_H, \{\mathbf{p}_{Hj}\}_{j=H,F}$
- Idea: planner directly chooses quantities, $\mathbf{q_{HH}} \equiv \{q_{HH}(\varphi)\}$, $\mathbf{q_{HF}} \equiv \{q_{HF}(\varphi)\}$, $\mathbf{q_{FH}} \equiv \{q_{FH}(\varphi)\}$, and measure of domestic entrants, N_H, subject to

$$N_H \left[\sum_{j=H,F} \int_{\Phi} l_{Hj}(q_{Hj}(\varphi), \varphi) dG_H(\varphi) + f_H^e \right] = L_H,$$

  as well as foreign equilibrium conditions
- Check later that we can implement solution to this problem using linear taxes

Home's Relaxed Planning Problem

$$\max_{\{\mathbf{q_{ij}}, Q_{ij}\}_{i,j=H,F}, \mathbf{p_{FF}}, \mathbf{p_{FH}}, P_{FF}, P_{HF}, \{N_i\}_{i=H,F}} U_H(Q_{HH}, Q_{FH})$$

subject to resource constraint in H and F, and

$$q_{FF}(\varphi) = \begin{cases} \bar{q}_{FF}(\varphi) & \text{, if } (\mu_F - 1)a_{FF}(\varphi)\bar{q}_{FF}(\varphi) \geq f_{FF}(\varphi), \\ 0 & \text{, otherwise,} \end{cases}$$

$$p_{Fj}(\varphi) = \begin{cases} \bar{p}_{Fj}(\varphi) & \text{, if } (\mu_F - 1)a_{Fj}(\varphi)q_{Fj}(\varphi) \geq f_{Fj}(\varphi), \\ \infty & \text{, otherwise,} \end{cases} \quad \text{for } j = H, F$$

$$Q_{HF}, Q_{FF} \in \arg\max_{\tilde{Q}_{HF}, \tilde{Q}_{FF}} \{U_F(\tilde{Q}_{HF}, \tilde{Q}_{FF}) | P_{HF}\tilde{Q}_{HF} + P_{FF}\tilde{Q}_{FF} = w_F L_F\},$$

$$P_{FF}^{1-\sigma_j} = \int_\Phi N_F[p_{FF}(\varphi)]^{1-\sigma_F} dG_F(\varphi),$$

$$f_F^e = \sum\nolimits_{j=H,F} \int_\Phi [\mu_F a_{Fj}(\varphi)q_{Fj}(\varphi) - l_{Fj}(q_{Fj}(\varphi))]dG_F(\varphi),$$

$$Q_{ij} = [\int_\Phi N_i(q_{ij}(\varphi))^{1/\mu_i} \mathrm{d}G_i(\varphi)]^{\mu_i} \text{ for } i = H \text{ or } j = H.$$

Micro to Macro: an Overview

- **Micro problem (I)**: Home's Production Possibility Frontier ($\mathbf{q_{HH}}$, $\mathbf{q_{HF}}$, N_H)
- **Micro problem (II)**: Foreign's Offer Curve ($\mathbf{q_{FH}}$, N_F, Q_{FF})
- **Macro problem**: Manipulating terms-of-trade (Q_{HH}, Q_{FH}, Q_{HF})

$$\max_{Q_{HH},Q_{FH},Q_{HF}} U_H(Q_{HH}, Q_{FH})$$
$$Q_{FH} \le Q_{FH}(Q_{HF})$$
$$L_H(Q_{HH}, Q_{HF}) \le L_H$$

with $L_H(Q_{HH}, Q_{HF})$ determined by the solution to micro problem (I) and $Q_{FH}(Q_{HF})$ determined the solution to micro problem (II)

Micro Problem (I): Home's Production Possibility Frontier

$$L_H(Q_{HH}, Q_{HF}) \equiv \min_{\mathbf{q}_{HH}, \mathbf{q}_{HF}, N_H} N_H \left(\sum_{j=H,F} \int_{\Phi} l_{Hj}(q_{Hj}(\varphi), \varphi) dG_H(\varphi) + f_H^e \right)$$

$$N_H \int_{\Phi} (q_{Hj}(\varphi))^{1/\mu_H} dG_H(\varphi) \geq Q_{Hj}^{1/\mu_H}, \text{ for } j = H, F.$$

- For $\mathbf{q^*_{HH}}$ and $\mathbf{q^*_{HF}}$, solve good-by-good using a Lagrangian approach,

$$\min_q l_{Hj}(q, \varphi) - \lambda_{Hj} q^{1/\mu_H}$$

- Discontinuity of $l_{ij}(q, \varphi)$ at $q = 0$ due to fixed cost $\Rightarrow$ cut-off rule,

$$q^*_{Hj}(\varphi) = \begin{cases} (\mu_H a_{Hj}(\varphi)/\lambda_{Hj})^{-\sigma_H}, & \text{if } \varphi \in \Phi_{Hj}, \\ 0, & \text{otherwise,} \end{cases}$$

with the set of varieties with non-zero output such that

$$\Phi_{Hj} \equiv \{\varphi : \mu_H a_{Hj}(\varphi)(\mu_H a_{Hj}(\varphi)/\lambda_{Hj})^{-\sigma_H} \geq l_{Hj}((\mu_H a_{Hj}(\varphi)/\lambda_{Hj})^{-\sigma_H}, \varphi)\}.$$

Micro Problem (I): Home's PPF

$$L_H(Q_{HH}, Q_{HF}) \equiv \min_{q_{HH}, q_{HF}, N_H} N_H \left(\sum_{j=H,F} \int_{\Phi} l_{Hj}(q_{Hj}(\varphi), \varphi) dG_H(\varphi) + f_H^e \right)$$

$$N_H \int_{\Phi} (q_{Hj}(\varphi))^{1/\mu_H} dG_H(\varphi) \geq Q_{Hj}^{1/\mu_H}, \text{ for } j = H, F.$$

- For N_H^*, linearity of the Lagrangian implies

$$\sum_{j=H,F} \int_{\Phi_{Hj}} [\mu_H a_{Hj}(\varphi) q_{Hj}^*(\varphi) - l_{Hj}(q_{Hj}^*(\varphi), \varphi)] dG_H(\varphi) = f_H^e.$$

- Conditional on (Q_{HH}, Q_{HF}), output and number of entrants in decentralized equilibrium w/o taxes and at the solution to the planner's problem coincide.
  - Government will not want to use micro-level taxes for domestic varieties.

Micro Problem (II): Foreign's Offer Curve

$$Q_{FH}^{1/\mu_F}(Q_{HF}) \equiv \max_{\mathbf{q_{FH}}, Q_{FF}, N_F} \int_{\Phi} N_F q_{FH}^{1/\mu_F}(\varphi) dG_F(\varphi))$$

$$L_F = P_{FF}(Q_{FF}, N_F)(Q_{FF} + MRS_F(Q_{HF}, Q_{FF})Q_{HF})$$

$$N_F f_F^e = \Pi_{FF}(Q_{FF}, N_F)$$

$$+ N_F \int [\mu_F a_{FH}(\varphi) q_{FH}(\varphi) - l_{FH}(q_{FH}(\varphi), \varphi)] dG_F(\varphi),$$

$$L_F = N_F f_F^e + L_{FF}(Q_{FF}, N_F) + N_F \int_{\Phi} l_{FH}(q_{FH}(\varphi), \varphi) dG_F(\varphi),$$

$$\mu_F a_{FH}(\varphi) q_{FH}(\varphi) \geq l_{FH}(q_{FH}(\varphi), \varphi),$$

- For $\mathbf{q^*_{FH}}$, maximize the Lagrangian good-by-good

$$\max_q q^{1/\mu_F} - \lambda_E \mu_F a_{FH}(\varphi) q + (\lambda_E - \lambda_L) l_{FH}(q, \varphi)$$

$$\mu_F a_{FH}(\varphi) q \geq l_{FH}(q, \varphi),$$

Micro Problem (II): Foreign's Offer Curve

- Let $q^u_{FH}(\varphi) =$ solution ignoring constraint, and let $q^c_{FH}(\varphi) = q$ that satisfies the constraint with equality
  - If $q^u_{FH}(\varphi) > q^c_{FH}(\varphi)$ then $q^*_{FH}(\varphi) = q^u_{FH}(\varphi)$. But otherwise two possibilities: constraint with equality or zero imports.
- "Profitability" index of foreign varieties in the home market,

$$\theta_{FH}(\varphi) \equiv (\lambda_{FH}/\chi_{FH}\mu_F)[(\mu_F - 1)Q_{FH}(a_{FH}(\varphi))^{1-\sigma_F}/f_{FH}(\varphi)]^{1/\sigma_F}$$

- Optimal imports are

$$q^*_{FH}(\varphi) = \begin{cases} (\mu_F \chi_{FH} a_{FH}(\varphi))^{-\sigma_F}, & \text{if } \varphi \in \Phi^u_{FH}, \\ f_{FH}(\varphi)/((\mu_F - 1)a_{FH}(\varphi)), & \text{if } \varphi \in \Phi^c_{FH}, \\ 0, & \text{otherwise,} \end{cases}$$

- For $\varphi \in \Phi^c_{FH} \equiv \{\varphi : \theta_{FH}(\varphi) \in [\lambda_L/(\lambda_L + (\mu_F - 1)\lambda_E), 1)\}$, Home finds it optimal to alter its importing decision so that foreign firms are willing to produce and export strictly positive amounts.
  - Government will want to impose import taxes that vary across firms.

Macro Problem: Manipulating TOT

- Goal of Home's planner is max $U_H(Q_{HH}, Q_{FH})$ s.t. resource constraint and Foreign's offer curve.
  - Resource constraint can be expressed as

$$L_H(Q_{HH}, Q_{HF}) = L_H$$

  - Foreign's offer curve can be expressed as

$$Q_{FH} \leq Q_{FH}(Q_{HF}).$$

- Hence, optimal aggregate quantities must solve

$$\begin{aligned} \max_{Q_{HH}, Q_{FH}, Q_{HF}} \; & U_H(Q_{HH}, Q_{FH}) \\ & Q_{FH} \leq Q_{FH}(Q_{HF}), \\ & L_H(Q_{HH}, Q_{HF}) = L_H, \end{aligned}$$

First-Order Conditions

- Let us define Home's terms-of-trade as

$$P(Q_{FH}, Q_{HF}) \equiv P_{HF}(Q_{HF})/\tilde{P}_{FH}(Q_{HF}, Q_{FH}),$$

with

$$P_{HF}(Q_{HF}) = P_{FF}(Q_{FF}(Q_{HF}), N_F(Q_{HF}))MRS_F(Q_{HF}, Q_{FF}(Q_{HF})),$$
$$\tilde{P}_{FH}(Q_{HF}, Q_{FH}) = N_F(Q_{HF}) \int_{\Phi} \mu_F a_{FH}(\varphi) q_{FH}(\varphi|Q_{HF}) dG_F(\varphi)/Q_{FH}.$$

- FOCs imply

$$MRT_H^* P^*/MRS_H^* = 1/\eta^*,$$

with $MRS_H^* \equiv U_{HH}/U_{FH}$, $MRT_H^* \equiv L_{HH}/L_{HF}$, and $\eta^* \equiv d \ln Q_{FH}/d \ln Q_{HF}$ is the elasticity of Foreign's offer curve

Outline of Presentation

Micro-Level Taxes on Domestic Varieties

Lemma

To implement solution to relaxed problem, need to set **domestic taxes** *s.t.*

$$(1 + s^*_{HH}(\varphi))/(1 + t^*_{HH}(\varphi)) = (1 + s^*_{HH})/(1 + t^*_{HH}) \text{ if } \varphi \in \Phi_{HH}.$$

Lemma

To implement solution to relaxed problem, need to set **export taxes** *s.t.*

$$s^*_{HF}(\varphi) = s^*_{HF} \text{ if } \varphi \in \Phi_{HF}.$$

Micro-Level Taxes on Imported Varieties

Lemma

To implement solution to relaxed problem, need to set **import taxes** *s.t.*

$$t^*_{FH}(\varphi) = (1 + t^*_{FH}) \min\{1, \theta_{FH}(\varphi)\} - 1 \textit{ if } \varphi \in \Phi_{FH} \equiv \Phi^u_{FH} + \Phi^c_{FH}.$$

- Higher taxes on more profitable exporters
- Like anti-dumping duties, but here to import from less profitable exporters

Overall Level of Taxes

Lemma

To implement solution to relaxed problem, need to set

$$\frac{(1+t^*_{FH})/(1+t^*_{HH})}{(1+s^*_{HF})/(1+s^*_{HH})} = \frac{\int_{\Phi_{FH}} \left((\min\{1,\theta_{FH}(\varphi)\})^{\mu_F} a_{FH}(\varphi)\right)^{1-\sigma_F} dG_F(\varphi)}{\eta^* \int_{\Phi_{FH}} \left((\min\{1,\theta_{FH}(\varphi)\}) a_{FH}(\varphi)\right)^{1-\sigma_F} dG_F(\varphi)}.$$

- If Φ^c_{FH} is measure zero then $\min\{1,\theta_{FH}(\varphi)\} = 1$ for all $\varphi \in \Phi_{FH}$ so optimal import taxes are uniform and

$$\frac{(1+t^*_{FH})/(1+t^*_{HH})}{(1+s^*_{HF})/(1+s^*_{HH})} = 1/\eta^*.$$

  - This is what would happen w/o fixed exporting costs, as in Krugman (1980).

Overall Level of Taxes

Lemma

To implement solution to relaxed problem, need to set

$$\frac{(1+t^*_{FH})/(1+t^*_{HH})}{(1+s^*_{HF})/(1+s^*_{HH})} = \frac{\int_{\Phi_{FH}} \left((\min\{1,\theta_{FH}(\varphi)\})^{\mu_F} a_{FH}(\varphi)\right)^{1-\sigma_F} dG_F(\varphi)}{\eta^* \int_{\Phi_{FH}} \left((\min\{1,\theta_{FH}(\varphi)\}) a_{FH}(\varphi)\right)^{1-\sigma_F} dG_F(\varphi)}.$$

- If Φ^c_{FH} is not measure zero, then $\mu_F > 1$ implies

$$\frac{(1+t^*_{FH})/(1+t^*_{HH})}{(1+s^*_{HF})/(1+s^*_{HH})} > 1/\eta^*.$$

  - To implement same wedge, need higher import taxes on varieties $\varphi \in \Phi^u_{FH}$

Implementation

- Augmented with high enough taxes on the goods that are not consumed, previous taxes are sufficient to implement solution to relaxed problem.

Lemma

There exists a decentralized equilibrium with taxes that implements the solution to relaxed problem.

- Since Home's planning problem is a relaxed version of Home's government problem, its solution must also satisfy previous necessary properties.

Proposition

At the micro-level, unilaterally optimal taxes should be s.t.: (i) domestic taxes are uniform across all domestic producers; (ii) export taxes are uniform across all exporters; (iii) import taxes are uniform across Foreign's most profitable exporters and strictly increasing with profitability across a set of marginally unprofitable ones. At the macro-level, unilaterally optimal taxes should reflect standard terms-of-trade considerations.

Firm heterogeneity and Trade Policy

- Macro-elasticity, η^*, determines the wedge between Home and Foreign's marginal rates of substitution at the first-best allocation.
  - Like in ACR, this relationship is not affected by firm heterogeneity.
  - At the macro-level, Home's planning problem can still be reduced to a standard ToT manipulation problem.
- But even conditioning on macro-elasticity, firm heterogeneity affects policy:
  - Optimal trade taxes are heterogeneous across foreign exporters.
  - To lower the price of its imports, P_{FH}, Home's government imposes tariffs that are increasing with the profitability of foreign exporters.
- Very different micro-level policies under perfect and monopolistic competition:
  - Ricardian model: uniform import taxes, discriminatory export taxes (CDVW).
  - Melitz model: discriminatory import taxes, uniform export taxes.

Outline of Presentation

Optimal Uniform Taxes

- Now suppose that government can only impose taxes that are uniform across firms: $t_{HF}(\varphi) = \bar{t}_{HF}$; $t_{HH}(\varphi) = \bar{t}_{HH}$; $s_{HF}(\varphi) = \bar{s}_{HF}$; and $s_{HH}(\varphi) = \bar{s}_{HH}$
- With this restricted set of instruments, one can check that

$$\frac{(1+\bar{t}^*_{FH})/(1+\bar{t}^*_{HH})}{(1+\bar{s}^*_{HF})/(1+\bar{s}^*_{HH})} = 1/\eta^*$$

- Next: What determines elasticity of Foreign's offer curve, η^*?

Foreign Equilibrium Conditions with Uniform Taxes

- With uniform taxes, Foreign will be on its PPF,

$$L_F(Q_{FH}, Q_{FF}) = L_F$$

with

$$L_F(Q_{FH}, Q_{FF}) \equiv \min_{q_{FH}, q_{FF}, N_F} N_F \left[\sum_{j=H,F} \int_{\Phi} l_{Fj}(q_{Fj}(\varphi), \varphi) dG_F(\varphi) + f_F^e \right]$$

$$N_F \int_{\Phi} (q_{Fj}(\varphi))^{1/\mu_F} dG_F(\varphi) \geq Q_{Fj}^{1/\mu_F}, \text{ for } j = H, F.$$

- In line with our previous notation, let

$$MRT_F(Q_{FH}, Q_{FF}) \equiv L_{FH}/L_{FF}$$

Foreign Equilibrium Conditions with Uniform Taxes

Lemma

Conditional on Q_{HF} and Q_{FH}, the decentralized equilibrium abroad satisfies

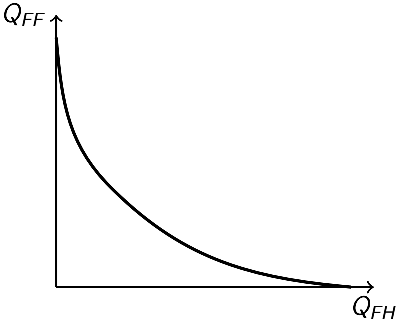
$$\begin{aligned} MRS_F(Q_{HF}, Q_{FF}(Q_{FH})) &= P_{HF}/P_{FF}, \\ MRT_F(Q_{FH}, Q_{FF}(Q_{FH})) &= \tilde{P}_{FH}/P_{FF}, \\ P_{HF}Q_{HF} &= \tilde{P}_{FH}Q_{FH}, \end{aligned}$$

with local production, $Q_{FF}(Q_{FH})$, given by the implicit solution of

$$L_F(Q_{FH}, Q_{FF}) = L_F.$$

- In terms of aggregate quantities and prices, this is isomorphic to a neoclassical equilibrium with three goods: *FF*, *FH*, *HF*
- Only difference is that under monopolistic competition, Foreign's production set may not be convex.

Aggregate Nonconvexities with Firm Heterogeneity



Terms-of-Trade Elasticities

- Let

$$\epsilon \equiv -\frac{d\ln(Q_{HF}/Q_{FF})}{d\ln(P_{HF}/P_{FF})}$$

denote the EoS between imports and domestic goods and let

$$\kappa \equiv \frac{d\ln(Q_{FH}/Q_{FF})}{d\ln(P_{FH}/P_{FF})}$$

denote the EoT between exports and domestic goods

- Previous lemma plus homotheticity of MRS_F and MRT_F implies that

$$\begin{aligned} \epsilon &= -\left(\frac{d\ln MRS_F(Q_{HF}/Q_{FF},1)}{d\ln(Q_{HF}/Q_{FF})}\right)^{-1}, \\ \kappa &= \left(\frac{d\ln MRT_F(Q_{FH}/Q_{FF},1)}{d\ln(Q_{FH}/Q_{FF})}\right)^{-1}. \end{aligned}$$

Elasticities with Uniform Taxes

- Previous lemma also implies that

$$P(Q_{FH}, Q_{HF}) = MRS_F(Q_{HF}, Q_{FF}(Q_{FH}))/MRT_F(Q_{FH}, Q_{FF}(Q_{FH})).$$

- Foreign offer curve can then be represented as

$$P(Q_{FH}, Q_{HF})Q_{HF} = Q_{FH},$$

- Differentiating w.r.t. Q_{HF} and Q_{FH}, we get

$$\eta = (1 + \rho_{HF})/(1 - \rho_{FH}),$$

with $\rho_{ij} \equiv \partial \ln P(Q_{FH}, Q_{HF})/\partial \ln Q_{ij}$ s.t.

$$\rho_{HF} = -1/\epsilon,$$
$$\rho_{FH} = -(1/x_{FF} - 1)/\epsilon - 1/(x_{FF}\kappa),$$

where $x_{FF} \equiv P_{FF}Q_{FF}/L_F$ is the share of expenditure on domestically produced goods in Foreign.

A Generalized Optimal Tariff Formula

- W.l.o.g set $\bar{t}^*_{HH} = \bar{s}^*_{HH} = \bar{s}^*_{HF} = 0$ to focus on optimal tariff, $\bar{t}^*_{FH}$
- Previous results for η combined with

$$\frac{(1+\bar{t}^*_{FH})/(1+\bar{t}^*_{HH})}{(1+\bar{s}^*_{HF})/(1+\bar{s}^*_{HH})} = 1/\eta^*$$

imply

Proposition

Optimal uniform tariffs are such that

$$\bar{t}^*_{FH} = \frac{1+(\epsilon^*/\kappa^*)}{(\epsilon^*-1)x^*_{FF}},$$

where ϵ^*, κ^*, and x^*_{FF} are the values of ϵ, κ, and x_{FF} evaluated at those taxes.

A Generalized Optimal Tariff Formula

- Our new formula:

$$\bar{t}^*_{FH} = \frac{1 + (\epsilon^*/\kappa^*)}{(\epsilon^* - 1)x^*_{FF}}$$

- This is a strict generalization of Gros' (1987) formula obtained in an economy without firm heterogeneity, as in Krugman (1980)
  - Utility is CES, $\epsilon^* = \sigma_H = \sigma_F \equiv \sigma$.
  - All firms export to all markets and MRT_F is constant,

$$MRT_F = \frac{\left(\int_\Phi (a_{FH}(\varphi))^{1-\sigma_F} dG_F(\varphi)\right)^{1/(1-\sigma_F)}}{\left(\int_\Phi (a_{FF}(\varphi))^{1-\sigma_F} dG_F(\varphi)\right)^{1/(1-\sigma_F)}}.$$

  - Hence, the elasticity of transformation κ^* goes to infinity so

$$\bar{t}^*_{FH} = \frac{1}{(\sigma - 1)x^*_{FF}} > 0.$$

  - New formula clarifies the importance of TOT considerations, which depend on ϵ^*, relative to markup distortions, which depend on σ (HK 89)

A Generalized Optimal Tariff Formula

- Our new formula:

$$\bar{t}^*_{FH} = \frac{1 + (\epsilon^*/\kappa^*)}{(\epsilon^* - 1)x^*_{FF}}$$

- This is a strict generalization of the formulas in Demidova and Rodriguez-Clare (2009) and Felbermayr, Jung and Larch (2013) where
  - Utility is CES, $\epsilon^* = \sigma_H = \sigma_F \equiv \sigma$
  - Firms only differ in productivity, productivity distribution is Pareto, so that

    $$\kappa^* = -\frac{\sigma\theta - (\sigma - 1)}{\theta - (\sigma - 1)} < 0$$

    where $\theta > \sigma - 1$ is the shape parameter of the Pareto distribution.
  - Hence the optimal tariff is

    $$\bar{t}^*_{FH} = \frac{1}{(\theta\mu - 1)x^*_{FF}} > 0.$$

Nonconvexities and Optimal Trade Policy

- Our new formula,

$$\bar{t}^*_{FH} = \frac{1 + (\epsilon^*/\kappa^*)}{(\epsilon^* - 1)x^*_{FF}},$$

and the fact that $\epsilon^* - 1 > 0$ (needed for FOC), then $\kappa^* \to \infty$ (firms are homogeneous) leads to

Corollary

Conditional on (ϵ^*, x^*_{FF}), optimal uniform tariffs are strictly lower with than without firm heterogeneity iff heterogeneity $\to$ aggregate nonconvexities, $\kappa^* < 0$.

- Home's trade restrictions derive from the negative effects of exports and imports on its terms of trade.
  - By reducing elasticity of Home's ToT w.r.t. its imports, aggregate nonconvexities dampen this effect and reduce optimal level of protection.

Firm Heterogeneity and Nonconvexities

- When do we have $\kappa^* < 0$?

Lemma

If $\partial N_F^*(Q_{FH}, Q_{FF})/\partial Q_{Fj} \geqslant 0$ for $j = H, F$, then firm heterogeneity creates aggregate nonconvexities, $\kappa^* \leq 0$, with $\kappa^* < 0$ if selection is active in at least one market.

- Combining this result with our optimal tariff formula leads to:

Proposition

If the measure of foreign entrants increases with aggregate output to any market, then conditional on (ϵ^*, x_{FF}^*), optimal uniform tariffs are lower with than without firm heterogeneity, with strict inequality whenever selection is active in at least one market.

Firm Heterogeneity and Lerner Paradox

- Firm heterogeneity may actually lower the overall level of trade protection so much that the optimal uniform tariff may become an **import subsidy**.
- As ϵ^* goes to infinity, the optimal uniform tariff converges towards

$$\bar{t}^*_{FH} = 1/(\kappa^* x^*_{FF}),$$

  which is strictly negative if aggregate nonconvexities abroad, $\kappa^* < 0$.
- Government may lower the price of its imports by *raising* their volume and inducing more foreign firms to become exporters
  - Derives from nonconvexities unique to MC models with selection

Outline of Presentation

Intra- and Inter-Industry Trade

- Multiple sectors, homothetic uper tier preferences:

$$U_i = U_i(U_i^1, .., U_i^K),$$
$$U_i^k = U_i^k(Q_{Hi}^k, Q_{Fi}^k),$$
$$Q_{ji}^k = [\int_\Phi N_j^k (q_{ji}^k(\varphi))^{1/\mu_j^k} dG_j^k(\varphi)]^{\mu_j^k}$$

- Same results at the micro level:
  - domestic taxes should be uniform across firms within the same sector
  - import taxes should be lower on the least profitable exporters from Foreign
- At the macro level, little that can be said in general, as in a perfectly competitive environment, so we turn to simple example

Intra- and Inter-Industry Trade

- One homogeneous "outside" sector and one differentiated sector
- Optimal uniform taxes are such that

$$
\begin{aligned}
\frac{(1+\bar{t}^{D}_{FH})/(1+\bar{t}^{D}_{HH})}{(1+\bar{s}^{D}_{HF})/(1+\bar{s}^{D}_{HH})} &= (1-\Delta)/\eta^{D}, \\
(1+\bar{t}^{D}_{FH})/(1+\bar{t}^{O}_{H}) &= \Delta/\eta^{O}.
\end{aligned}
$$

with $\eta^{D} \equiv d \ln Q^{D}_{FH}(Q^{D}_{HF}, X^{O}_{H})/d \ln Q^{D}_{HF}$, $\eta^{O} \equiv d \ln Q^{D}_{FH}(Q^{D}_{HF}, X^{O}_{H})/d \ln X^{O}_{H}$, and$\Delta \equiv \left(\tilde{P}^{D}_{FH} Q^{D}_{FH} - P^{D}_{HF} Q^{D}_{HF}\right)/\tilde{P}^{D}_{FH} Q^{D}_{FH}$

- Offer curve elasticities can be computed as we did before

$$
\begin{aligned}
\eta^{D} &= \frac{\left(1+\rho^{D}_{HF}\right)\left(\Delta-1\right)}{\rho^{D}_{HF} + \left(1-\Delta\right)\rho^{D}_{FH} - \Delta\zeta_{FH}}, \\
\eta^{O} &= \frac{\Delta + \left(1-\Delta\right)\rho^{D}_{X} - \Delta\zeta_{X}}{1 + \left(\Delta-1\right)\rho^{D}_{FH} + \Delta\zeta_{FH}},
\end{aligned}
$$

with $\rho^{D}_{HF} \equiv \partial \ln P^{D}/\partial \ln Q^{D}_{HF}$, $\rho^{D}_{FH} \equiv \partial \ln P^{D}/\partial \ln Q^{D}_{FH}$, $\rho^{D}_{X} \equiv \partial \ln P^{D}/\partial \ln X^{O}_{H}$, $\zeta_{FH} \equiv \partial \ln \tilde{P}^{D}_{FH}/\partial \ln Q^{D}_{FH}$, and $\zeta_{X} \equiv \partial \ln \tilde{P}^{D}_{FH}/\partial \ln X^{O}_{H}$.

Intra- and Inter-Industry Trade

- If Home is "small" (i.e., cannot affect N_F^D nor Q_{FF}^D) then $\zeta_X = \rho_X^D = 0$ and $\zeta_{FH} = 1/\kappa^D$, and so

$$\frac{(1+\bar{t}_{FH}^D)/(1+\bar{t}_{HH}^D)}{(1+\bar{s}_{HF}^D)/(1+\bar{s}_{HH}^D)} = 1 + \frac{1+\epsilon^D/\kappa^D}{\epsilon^D - 1},$$

$$(1+\bar{t}_{FH}^D)/(1+\bar{t}_H^O) = 1 + 1/\kappa^D.$$

- Trade protection within differentiated sector same as in one-sector case
- If $\kappa^D < 0$, less trade protection in the differentiated sector relative to the homogeneous sector:
  - Import subsidy in the differentiated sector or export subsidy in the homogeneous sector

Outline of Presentation

Conclusion

- Few economic mechanisms have received as much empirical support as the selection of heterogeneous firms into exporting
- Policy makers have paid attention:
  - Prior to 1990, there were only two regional trade agreements (RTA) with provisions related to small- and medium-sized enterprises (SME) prior to 1990
  - As of March 2016, 133 RTAs, representing 49% of all the notified RTAs, include at least one provision mentioning explicitly SMEs
- Ironically, little academic work about the policy implications of the endogenous selection of firms into exporting

Conclusion

- In this paper, we have shown that when taxes are unrestricted, optimal trade policy requires micro-level policies:
  - Import taxes that discriminate against the most profitable foreign exporters.
  - Export taxes that discriminate against or in favor of the most profitable domestic exporters can be dispensed with.
- When taxes are uniform, firm heterogeneity tends to create aggregate nonconvexities that lowers the overall level of trade protection.
- A lot more to do on the normative side of the literature:
  - Variable markups, global value chains, industrial policy