Input Tariff in Oligopoly: Entry, Heterogeneity, and Demand Curvature

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August 21, 2023

@ Prof. Jota Ishikawa's Sixtieth Birthday Celebration Workshop

Introduction

- Tariffs distort production and consumption but improve the terms of trade:
  - Balancing these two considerations, a government of an importing country sets the tariff rate equal to the inverse of foreign export elasticity

$$t^* = \frac{1}{e_s^*}$$

  - Key assumptions: (i) trade involves final goods; (ii) final-good markets are perfectly competitive
  - Nearly two-thirds of trade involves intermediate goods (Johnson and Noguera, 2012)
  - Market structure is characterized by oligopoly (Head and Spencer, 2017)

Introduction

- Question:
  - How does the optimal tariff on *intermediate input* differ from the competitive benchmark when a final-good sector is *oligopolistic?*

$$t^* \lesseqgtr \frac{1}{e_s^*}?$$

- Vertical specialization:
  - Oligopolistic downstream Home firms (in an importing country)
  - Perfectly competitive upstream Foreign firms (in an exporting country)
  - Monopolistic firms do not have a supply function (Mrázová and Neary, 2017)

Introduction

- In monopolistic comp with CES demand, recent work has provided a rationale for lower input tariffs compared to output tariffs
- In oligopoly with general demand, we identify the conditions for $t^* < \frac{1}{e_s^*}$:
  1. Short run
  2. Long run (with free entry)
  3. Heterogeneity (in production efficiency)

	Symmetric firms	Heterogeneous firms
Short run	①	③
Long run	②	N.A.

Introduction

- Effects of tariffs on welfare in oligopoly:
  1. Improves terms of trade
  2. Exacerbates underproduction
  3. Mitigates excess entry (Mankiw and Whinston, 1986)
  4. Improves/worsens production efficiency (Melitz and Ottaviano, 2008)

- Conditions for $t^* < \frac{1}{e_s^*}$:
  - Short run $\Rightarrow$ always
  - Long run $\Rightarrow$ demand curvature
  - Heterogeneity $\Rightarrow$ demand curvature and cost heterogeneity

Related literature: Trade policy

- Oligopoly with intermediate input:
  - Ishikawa and Lee (1997), Ishikawa and Spencer (1999), Spencer and Qiu (2001), Qiu and Spencer (2002)
- Monopolistic comp with search, matching, and incomplete contracts:
  - Ornelas and Turner (2008, 2012), Antràs and Staiger (2012), Grossman et al. (2023)
- Perfect/monopolistic comp with input-output linkages:
  - Blancard et al. (2017), Caliendo et al. (2021), Antràs et al. (2023), Lashkaripour and Lugovskyy (2023)

Model

- Vertical specialization: firms from one country (Home) produce a final good by using an imported input from another country (Foreign)
- Quasilinear preferences: $U = U(Q) + y$
- Inverse demand: $P = P(Q)$
  - $P'(Q) < 0$
  - $2P'(Q) + QP''(Q) < 0 \Leftrightarrow \eta \equiv \frac{QP''(Q)}{P'(Q)} > -2$ (Mrázová and Neary, 2017)
  - E.g. $Q = AP^{-e_d}$ $(e_d > 1) \Rightarrow \eta = -(1 + \frac{1}{e_d}) < -1$

Model

- Final good (Q):
  - M Home firms enter a final-good sector after paying the entry cost K
  - Production function

$$q_i = \min\left\{\frac{l_i}{a_i}, x_i\right\}$$

    where $a_i = a = 0$ for now

- Intermediate input (X):
  - A large number of price-taking Foreign firms producing intermediate input
  - Supply function

$$r = h(X)$$

    where $h'(X) > 0$

Model

- Tariffs:
  - Home government imposes ad-valorem tariffs on intermediate imports
  - Tariff revenues rtX are rebated back to Home consumers

- Home welfare:

$$W \equiv \underbrace{\left[\int_0^{\hat{Q}} P(y)dy - P(\hat{Q})\hat{Q}\right]}_{\text{Consumer surplus}} + \underbrace{\left[P(\hat{Q})\hat{Q} - (\hat{r}(1+t))\,\hat{X} - \hat{M}K\right]}_{\text{Firm profits}}$$

$$+ \underbrace{\hat{r}t\hat{X}}_{\text{Tariff revenues}} + \underbrace{\bar{L}}_{\text{Labor income}}$$

Model

- Welfare maximization:

$$\frac{dW}{dt} = \underbrace{\left(\left(\hat{P} - \hat{r}(1+t) \right) \hat{x} - K \right) \frac{d\hat{M}}{dt}}_{=0 \text{ (fixed } M \text{ or free entry)}} + \hat{M} \underbrace{\left(\hat{P} - \hat{r}(1+t) \right)}_{>0 \text{ (oligopoly)}} \frac{d\hat{x}}{dt} + \hat{r} \left(t - \frac{1}{e_s} \right) \underbrace{\frac{d\hat{X}}{dt}}_{<0}$$

where $e_s \equiv \frac{r}{Xh'(X)}$

- From $\frac{dW}{dt} = 0$, it follows that:

$$\text{sgn} \left(t - \frac{1}{e_s} \right) = \text{sgn} \left(\frac{d\hat{x}}{dt} \right)$$

Model

Proposition

Whether the optimal tariff lies above or below the competitive benchmark depends on whether the intensive margin increases or decreases with tariffs

$$\text{sgn}\left(t^* - \frac{1}{e_s^*}\right) = \text{sgn}\left(\frac{dx^*}{dt}\right)$$

Notes:

- The sign of $\frac{dx^*}{dt}$ depends on details of the model setting
- We consider three different scenarios (short run, long run, heterogeneity) to figure out the conditions

Short run

- Home firm i chooses q_i to maximize its profits:

$$\pi_i \equiv \left(P\left(q_i + \sum_{j \neq i}^{M} q_j \right) - r(1+t) \right) q_i$$

- Symmetric equilibrium $q_1 = q_2 = ... = q_M \equiv q$:

$$q = -\frac{P(Q) - r(1+t)}{P'(Q)}$$

- Aggregate FOC:

$$MP(Q) + QP'(Q) - M(r(1+t)) = 0$$

Short run

- FOC can be solved for input demand:

$$r = g(X, M, t), \quad g_X < 0, \quad g_t < 0$$

- Input supply:

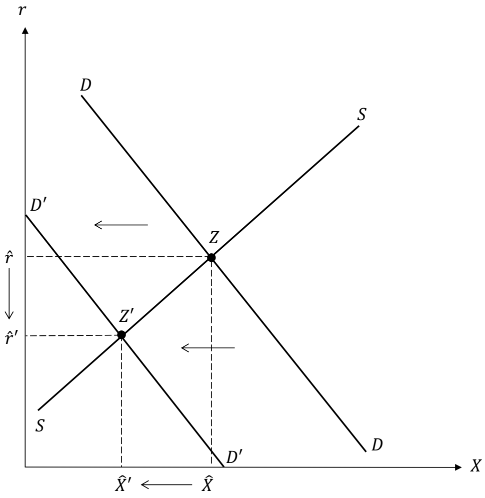
$$r = h(X), \quad h'(X) > 0$$

- Demand = Supply:

$$\hat{X}(= \hat{Q}), \quad \hat{r}$$

where $\hat{x} = \frac{\hat{X}}{M}$ always declines with tariffs

Short run



Short run

Proposition

(i) In the short run, $t^* < \frac{1}{e_s^*}$ *always holds*

(ii) The short-run optimal tariff is implicitly given by

$$t^* = \frac{1}{e_s^*} - \frac{1}{Me_d^*}\left(1 + \frac{1}{e_s^*}\right)$$

Notes:

- $\lim_{M\to\infty} t^* = \frac{1}{e_s^*} > 0$ (as $\lim_{M\to\infty} P = r(1+t)$)
- $\lim_{e_s^*\to\infty} t^* = -\frac{1}{Me_d^*} < 0$

Long run

- Aggregate FOC:

$$MP(Q) + QP'(Q) - M(r(1+t)) = 0$$

- M satisfies the zero profits condition (ZPC):

$$(P(Q) - r(1+t))q = K$$

- FOC + ZPC:

$$M = M(Q), \quad M'(Q) > 0$$

Long run

- FOC can be solved for (entry-augmented) input demand:

$$r = g(X, M(X), t) \equiv G(X, t), \quad G_X < 0, \quad G_t < 0$$

- Input supply:

$$r = h(X), \quad h'(X) > 0$$

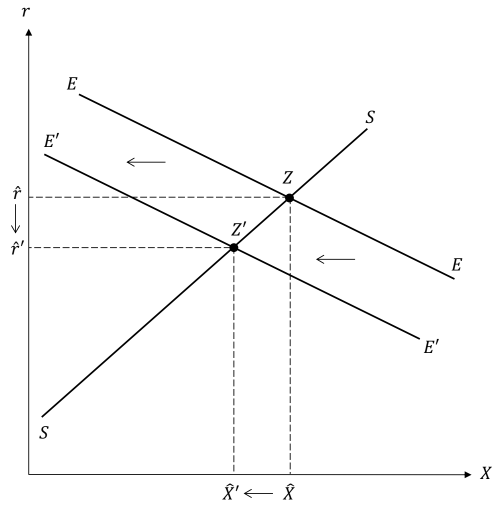
- Demand = Supply:

$$\hat{X}(= \hat{Q}), \quad \hat{r}$$

where $\hat{x} = \frac{\hat{X}}{\hat{M}}$ does not always decline with tariffs

$$t \uparrow \Rightarrow \begin{cases} \hat{r}(1+t) \uparrow \Rightarrow \ \hat{x} \downarrow \\ \hat{M} \downarrow \Rightarrow \ \hat{x} \uparrow \end{cases}$$

Long run



Long run

Proposition

(i) In the long run, $t^* < \frac{1}{e_s^*}$ *holds if and only if demand is convex*

(ii) The long-run optimal tariff is implicitly given as

$$t^* = \frac{1}{e_s^*} + \left(\frac{\frac{\eta^*}{2M^* e_d^*}}{1 - \frac{1}{M^* e_d^*} - \frac{\eta^*}{2M^* e_d^*}} \right) \left(1 + \frac{1}{e_s^*} \right)$$

Notes:

- $\lim_{K \to 0} t^* = \frac{1}{e_s^*} > 0$
- $t^* > \frac{1}{e_s^*} \;\Leftrightarrow\; \eta^* > 0 \;\Leftrightarrow\; \frac{dx^*}{dt} > 0$

Heterogeneity

- Production function:

$$q_i = \min\left\{\frac{l_i}{a_i}, x_i\right\}$$

  where a_i varies with i

- Home welfare:

$$W = \int_0^{\hat{X}} P(y)dy - \hat{r}\hat{X} - \sum_{i=1}^{M} a_i\hat{x}_i - MK + \bar{L}$$

Heterogeneity

- Welfare maximization:

$$\frac{dW}{dt} = \frac{\hat{P}}{e_d}\left(\sum_{i=1}^{M} \hat{s}_i \frac{d\hat{x}_i}{dt}\right) + \hat{r}\left(t - \frac{1}{e_s}\right)\frac{d\hat{X}}{dt}$$

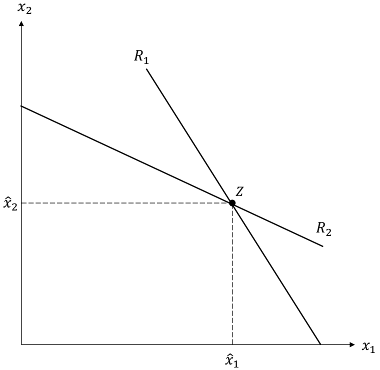
  where $s_i \equiv \frac{x_i}{X}$ is the import share

- As $\frac{d\hat{X}}{dt} < 0$ (even with heterogeneity):

$$\text{sgn}\left(t - \frac{1}{e_s}\right) = \text{sgn}\left(\sum_{i=1}^{M} \hat{s}_i \frac{d\hat{x}_i}{dt}\right)$$

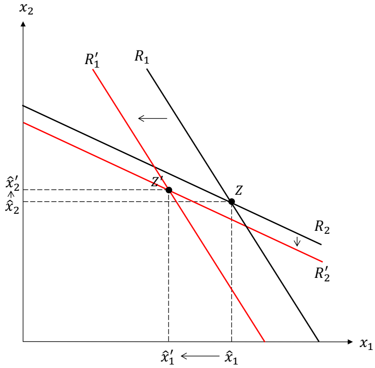
- When $a_i = a$ for all i, $x_i = x$ and $s_i = s = \frac{1}{M}$

Heterogeneity



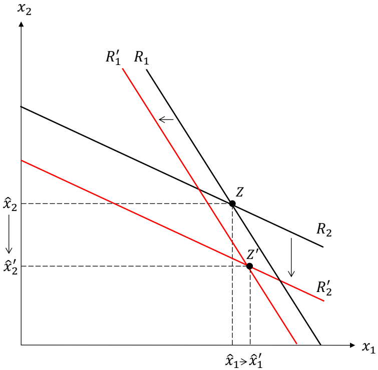
- To see the effect of tariffs on $\hat{x}_i$, consider duopoly where firm 1 is more efficient than firm 2 ($a_1 < a_2$)
- Before tariffs, firm 1 produce relatively more than firm 2 ($\hat{x}_1 > \hat{x}_2$), but what would happen after tariffs?

Heterogeneity



$$t \uparrow \Rightarrow \begin{cases} \hat{x}_1 \downarrow \\ \hat{x}_2 \uparrow \end{cases}$$

(a) $\eta < -1$ (e.g., constant elas)



$$t \uparrow \Rightarrow \begin{cases} \hat{x}_1 \uparrow \\ \hat{x}_2 \downarrow \end{cases}$$

(b) $\eta > 1$ (e.g., strictly concave)

Heterogeneity

Proposition

With heterogeneity, the optimal tariff satisfies

$$\text{sgn}\left(t^* - \frac{1}{e_s^*}\right) = \text{sgn}\Big(\eta(MH - 1) - 1\Big)$$

where $H \equiv \sum_i s_i^2$ is the Herfindahl index

Notes:

- $t^* < \frac{1}{e_s^*}$ depends on η (demand curvature) and H (cost heterogeneity)
- $t^* > \frac{1}{e_s^*}$ when $\eta > 0$ and H is sufficiently large

Conclusion

- Key features of modern trade:
  - Input trade dominates world trade
  - Market structure tends to be oligopolistic
  - Any new role of trade policy in this setting?
- Whether $t^* < \frac{1}{e_s^*}$ depends on details of the model settings:
  - Short run $\Rightarrow$ always
  - Long run $\Rightarrow$ demand curvature
  - Heterogeneity $\Rightarrow$ demand curvature and cost heterogeneity