Effects of eliminating internal tariffs by PTA members

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Introduction

- Under the current rules of the World Trade Organization (WTO), countries entering into a preferential trade agreement (PTA) are required to eliminate tariffs on substantially all trade with each other
  - In the existing literature, this rule has often been invoked as a justification for the assumption that PTA members impose zero tariffs on each other

- However, this approach
  - masks the incentives underlying the tariff setting behavior of PTA members
  - fails to shed light on the consequences of requiring them to eliminate internal tariffs

Introduction

- In addition, although much attention has been devoted to the study of international trade models that consider heterogeneous firms since the seminal work of Melitz (2003), little is known about the effects of tariff policy in such models

- I analyze

(1) the tariff setting behavior of PTA members in a monopolistically competitive model with heterogeneous firms á la Melitz and Ottaviano (2008)

(2) the effects of requiring PTA members to eliminate internal tariffs

Main results:
(1) The tariff setting behavior of PTA members

(1-1) External tariffs:

Each PTA member independently imposes its external tariff on the non-member country to maximize its own welfare

→ The optimal external tariffs are positive

(1-2) Internal tariff:

PTA members choose the symmetric internal tariff to maximize their joint welfare

→ The optimal internal tariff is positive

when the introduction of a small symmetric internal tariff sufficiently improves a within-sector misallocation

The within-sector misallocation

- In the Melitz-Ottaviano model, the presence of endogenous markups affects resource allocation efficiency
- Using the multi-country setting of Melitz and Ottaviano (2008), Nocco et al. (2019) show that endogenous markups create a within-sector misallocation and free trade allocation of resources fails to be efficient:
  - <u>more productive firms end up selling quantities below the globally efficient levels</u> because they do not pass on their entire cost advantage to consumers by raising their markup
  - <u>less productive firms end up being oversupplied</u>

→ In the present study, an increase in an import tariff improves this within-sector misallocation by increasing (decreasing) the output level of more (less) productive exporters

→ The optimal internal tariff is positive

Main results
(2) the effects of requiring PTA members to eliminate internal tariffs

Requiring PTA members to eliminate internal tariff induces them to lower their external tariffs

→ It increases the welfare level of the non-member country

Related works

- Saggi et al. (2019) study the effects of requiring PTA members to eliminate internal tariffs in a modified version of the three-country competing exporters framework of Bagwell and Staiger (1999)
- They show that
  - in the absence of such a requirement, PTA members impose positive tariffs on each other to maximize their joint welfare
  - requiring PTA members to eliminate internal tariffs induces them to lower their external tariffs (tariff complementarity)

→ I examine the tariff setting behavior of PTA members in a three- country model with heterogeneous firms and variable markups

They assume that PTA members can coordinate internal tariffs before setting their individually optimal external tariffs

This assumption makes PTA members choose the positive internal tariffs to manipulate the external tariffs due to the tariff complementarity between the internal and external tariffs

Model: households in country i ($i = 1,\ 2,\ 3$)

- Consider a three-country economy labeled 1 , 2, and 3
- Labor L_i is inelastically supplied from households in each country and immobile between countries
- The utility function and the budget constraint of households in country i :

$$U_i = q_{0,i}^c + \alpha \int_{\Omega_i} q_i^c(\omega)\, d\omega - \frac{\gamma}{2} \int_{\Omega_i} q_i^c(\omega)^2\, d\omega - \frac{\eta}{2} \left[\int_{\Omega_i} q_i^c(\omega)\, d\omega \right]^2 \quad (1)$$

$$q_{0,i}^c + \int_{\Omega_i} p_i(\omega) q_i^c(\omega)\, d\omega = I_i \quad (2)$$

$q_{0,i}^c$: the individual consumption of the homogeneous (numeraire) good
Ω_i: the set of all available differentiated goods varieties in country i
$q_i^c(\omega)$: the individual consumption of each variety $\omega \in \Omega_i$
$p_i(\omega)$: the price of variety ω in country i
I_i: income of households in country i
$\alpha, \eta, \gamma > 0$: parameters

Model: households in country i ($i = 1,\ 2,\ 3$)

- FOCs:

$$p_i(\omega) = \alpha - \gamma q_i^c(\omega) - \eta Q_i \qquad \forall \omega \in \Omega_i^* \tag{3}$$

$\Omega_i^* \subset \Omega_i$: the subset of varieties in which $q_i^c(\omega) > 0$

$Q_i \equiv \int_{\Omega_i^*} q_i^c(\omega) d\omega$: the aggregate consumption of all differentiated goods

- Integrating both sides of (3) over Ω_i^*

$$Q_i = \frac{N_i}{\gamma + \eta N_i}(\alpha - \bar{p}_i) \tag{4}$$

N_i: the number of consumed (domestic and imported) varieties

$\bar{p}_i \equiv \frac{1}{N_i} \int_{\Omega_i^*} p_i(\omega) d\omega$: the average price of consumed varieties in country i

Model: households in country i ($i = 1,\ 2,\ 3$)

- Let p_i^{max} be the threshold price in country i at which demand for a variety is driven to zero
  - Using (3) and (4), the threshold price in country i is

$$q_i^c(\omega) \geq 0 \Leftrightarrow p_i(\omega) \leq \frac{\gamma\alpha + \eta N_i \overline{p_i}}{\gamma + \eta N_i} \equiv p_i^{max} \qquad (5)$$

Note that (3) implies $p_i^{max} < \alpha$

- The market demand for variety ω in country i: (6)

$$q_i(\omega) = L_i q_i^c(\omega) = \frac{L_i}{\gamma}\left(p_i^{max} - p_i(\omega)\right)$$

Model: Firms in country i ($i = 1,\ 2,\ 3$)

- The homogeneous good sector
  - Perfect competition
  - One unit of production requires one unit of labor input
  - Freely traded between the countries

  ⇒ The wage becomes one in all countries

Model: Firms in country i ($i = 1,\ 2,\ 3$)

- The differentiated good sector
  - A continuum of K_i (constant) potential firms
  - Monopolistic competition
  - Requires c units of labor to produce one unit of output
  - c follows the Pareto distribution: $c \sim G_i(c) = \left(\frac{c}{c_i^M}\right)^{\theta}, c \in [0, c_i^M], \theta \geq 1$

    c_i^M: the upper bound of cost

    θ : the index of the dispersion of the cost
  - An ad valorem import tariff t_{ij} is imposed on exports from country i to h:

    $t_{ii} = 1$ and $t_{ij} \geq 1$ for $i, j \in \{1, 2, 3\}$
  - Firms produce for the country where they can earn positive profits

⇒ The profit maximizing price , quantity and profit for firms in country i that sell their goods in country j are

$$p_{ij}(c) = \frac{t_{ij}}{2}\left(\frac{p_j^{max}}{t_{ij}} + c\right), q_{ij}(c) = \frac{L_j t_{ij}}{2\gamma}\left(\frac{p_j^{max}}{t_{ij}} - c\right), \pi_{ij}(c) = \frac{L_j t_{ij}}{4\gamma}\left(\frac{p_j^{max}}{t_{ij}} - c\right)^2 \quad (7)$$

Model: Firms in country i ($i = 1,\ 2,\ 3$)

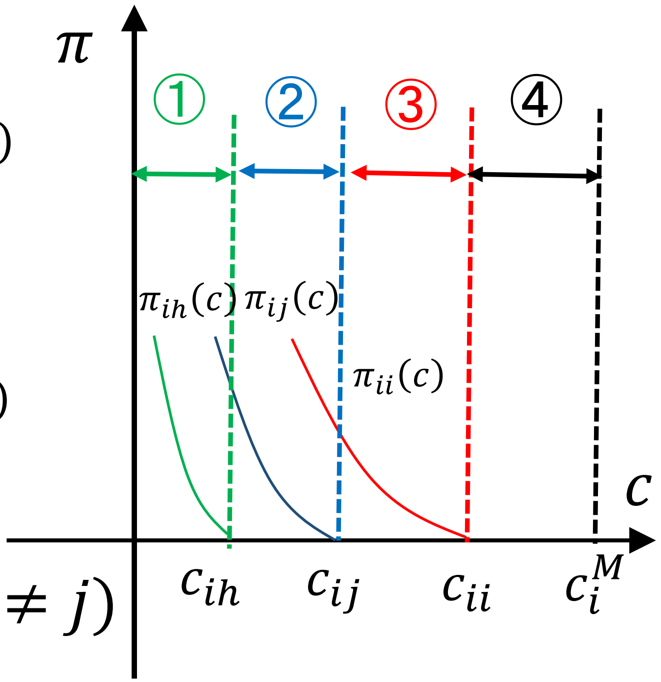
- The cost cutoffs
  - Let c_{ij} be the upper bound of the cost for firms in country i that sell in the market of country j

The domestic cost cutoff:

$$c_{ii} = \sup\{c: \pi_{ii}(c) > 0\} = p_i^{max} (< \alpha) \qquad (8)$$

The export cost cutoff:

$$c_{ij} = \sup\{c: \pi_{ij}(c) > 0\} = \frac{p_j^{max}}{t_{ij}} = \frac{c_{jj}}{t_{ij}} \quad \text{for } i \neq j \qquad (9)$$



- $c_{ii} > c_{ij}$ and $c_{ii} > c_{ih}$ holds in equilibrium ($h = \{1,2,3\}, h \neq i, h \neq j$)

$\Rightarrow$ There are no firms that export but do not produce domestically

① Firms with cost $c \in [0, c_{ih}]$ produce for all countries

② Firms with cost $c \in [c_{ih}, c_{ij}]$ produce for country i and j

③ Firms with cost $c \in (c_{ij}, c_{ii}]$ produce for country i

④ Firms with cost $c \in (c_{ii}, c_M]$ do not produce

Model: Firms in country i ($i = 1,\ 2,\ 3$)

- Using (8) and (9) into (7),

$$
\begin{aligned}
p_{ij}(c) &= \frac{t_{ij}}{2}\left(c_{ij} + c\right) \\
q_{ij}(c) &= \frac{L_j t_{ij}}{2\gamma}\left(c_{ij} - c\right) \\
\pi_{ij}(c) &= \frac{L_j t_{ij}}{4\gamma}\left(c_{ij} - c\right)^2 \\
\mu_{ij}(c) &\equiv \frac{p_{ij}(c)}{c} = \frac{t_{ij}}{2}\left(\frac{c_{ij}}{c} + 1\right)
\end{aligned}
\qquad (10)
$$

Lower cost (more productive) firms set lower price but they also set higher markups $\mu_{ij}(c)$. This generates the within-sector misallocation.

Model: Government in country i

- The government in country i imposes the tariffs t_{ji} and t_{hi} on exporters in country j and h ,respectively and transfers the tariff revenue to households
- The number of exporters in country j and h is $K_j G_j(c_{ji})$ and $K_h G_h(c_{hi})$

The budget constraint of the government:

$$T_i = K_j G_j(c_{ji})(t_{ji} - 1)\overline{r_{ji}} + K_h G_h(c_{hi})(t_{hi} - 1)\overline{r_{hi}}$$

$$= \frac{L_i}{2\gamma(\theta + 2)}\left[k_j(t_{ji} - 1)t_{ji}^{-(\theta+1)} + k_i(t_{hi} - 1)t_{hi}^{-(\theta+1)}\right] c_{ii}^{\theta+2} \quad (11)$$

$\overline{r_{ji}}$: the average revenue of firms in country j from sales in country i

$k_i \equiv \frac{K_i}{{c_i^M}^\theta}$: the productivity index which measures the number of productive firms in country i

Model: Equilibrium

- The number of sellers in country i, N_i, is composed of domestic producers and exporters in country j and h:

$$N_i = K_i G_i(c_{ii}) + K_j G_j(c_{ji}) + K_h G_h(c_{hi}) \\ = \left(k_i + k_j t_{ji}^{-\theta} + k_h t_{hi}^{-\theta}\right) c_{ii}^{\theta} \qquad (12)$$

- Putting (8) into the threshold price condition (5):

$$c_{ii} = \frac{\gamma\alpha + \eta N_i \bar{p}_i}{\gamma + \eta N_i} \Leftrightarrow N_i = \frac{2(\theta+1)}{A} \frac{\alpha - c_{ii}}{c_{ii}} \qquad (13)$$

where $\bar{p}_i = \frac{2\theta+1}{2(\theta+1)} c_{ii}$ and $A \equiv \frac{\eta}{\gamma}$

- From (12) and (13), c_{ii} is determined by the following equation:

$$A\left(k_i + k_j t_{ji}^{-\theta} + k_h t_{hi}^{-\theta}\right) c_{ii}^{\theta+1} + 2(\theta+1) c_{ii} = 2(\theta+1)\alpha \qquad (14)$$

Note that the import tariffs set by governments in country j and h do not affect the domestic cost cutoff in country i

Model: Equilibrium

- The effects of t_{ji} on cutoffs and the number of varieties are

$$\frac{dc_{ii}}{dt_{ji}} > 0, \qquad \frac{dc_{hi}}{dt_{ji}} > 0, \qquad \frac{dc_{ji}}{dt_{ji}} < 0, \qquad \frac{dN_i}{dt_{ji}} < 0 \tag{15}$$

- An increase in t_{ji}

(1) increases the export competition in country *j* : c_{ji} ↓

→ Some of the less productive firms in country *j* stop exporting to country i: $K_j G_j(c_{ji})$ ↓

(2) reduces the competition in the domestic market in country i : c_{ii} ↑

→ Less productive firms in country i can start producing domestically : $K_i G_i(c_{ii})$ ↑

(3) reduces the export competition from country h to country i: c_{hi} ↑

→ Less productive firms in country h can start exporting to country i: $K_h G_h(c_{hi})$ ↑

(4) (1) dominates (2) and (3): N_i ↓

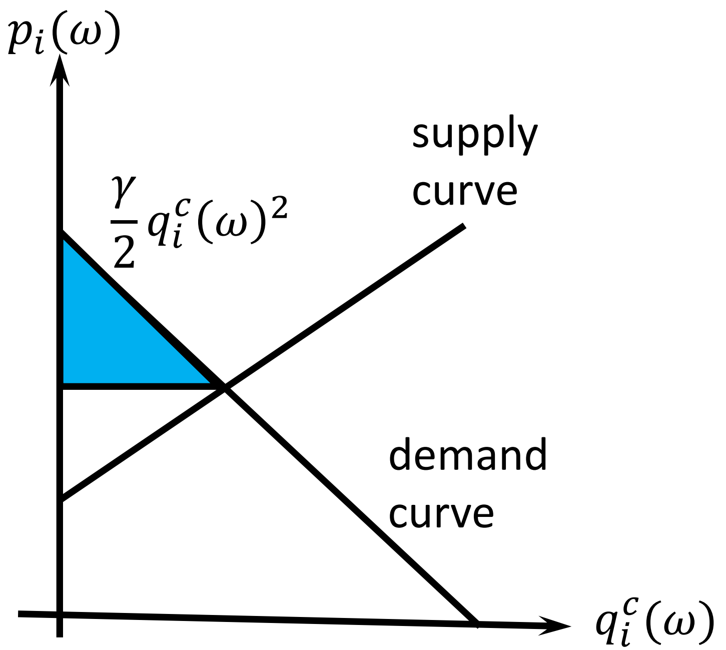
Welfare

- Substituting (3) into (2),

$$q_{0,i}^{c} = I_i - \alpha Q_i + \gamma \int_{\Omega_i^*} q_i^c(\omega)^2 d\omega + \eta Q_i^2$$

- Substituting this into (1),

$$U_i = I_i + \underbrace{AC_i + CS_i}_{\text{Consumer surplus}} \qquad (16)$$



where

$AC_i \equiv \frac{\eta}{2} Q_i^2$: consumer surplus at individual aggregate consumption of all differentiated goods Q_i

$CS_i \equiv \frac{\gamma}{2} \int_{\Omega_i^*} q_i^c(\omega)^2 d\omega$: the sum of consumer surplus at each variety

($\frac{\gamma}{2} q_i^c(\omega)^2$ corresponds to the triangular region under the demand curve for variety ω)

Welfare

- From (9), (10) and (11), income is given by

$$\begin{aligned} I_i &= 1 + \frac{1}{L}\Big[\overbrace{K_i G_i(c_{ii})\bar{\pi}_{ii} + K_i G_i(c_{ij})\bar{\pi}_{ij} + K_i G_i(c_{ih})\bar{\pi}_{ih}}^{\text{Profits}}\Big] + \frac{T_i}{L} \\ &= 1 + \frac{k_i + (\theta+1)(t_{ji}-1)t_{ji}^{-(\theta+1)}k_j + (\theta+1)(t_{hi}-1)t_{hi}^{-(\theta+1)}k_h}{2\gamma(\theta+1)(\theta+2)} c_{ii}^{\theta+2} \\ &+ \frac{L_j}{L_i}\frac{k_i t_{ij}^{-(\theta+1)}}{2\gamma(\theta+1)(\theta+2)} c_{jj} + \frac{L_h}{L_i}\frac{k_i t_{ih}^{-(\theta+1)}}{2\gamma(\theta+1)(\theta+2)} c_{hh} \end{aligned} \tag{17}$$

$\bar{\pi}_{ij}$: the average revenue of firms in country j from sales in country i

- From (9) and (10),

$$AC_i = \frac{\eta}{2}Q_i^2 = \frac{(\alpha - c_{ii})^2}{2\eta}, \qquad CS_i = \frac{(\alpha - c_{ii})c_{ii}}{2\eta(\theta+2)} \tag{18}$$

Where

$$Q_i = \frac{\alpha - c_{ii}}{\eta}$$

Welfare: I_i

t_{ji} ↑

① The domestic profits ↑

② Tariff revenue from j ↗↘

③ Tariff revenue from h ↑ (when $t_{hi} > 1$)

} I_i ↗↘

Welfare: AC_i

$$\frac{dAC_i}{dt_{ji}} = -2B_{ji}t_{ji}(\theta + 2)(\alpha - c_{ii}) < 0$$

$t_{ji} \uparrow \Rightarrow c_{ii} \uparrow$

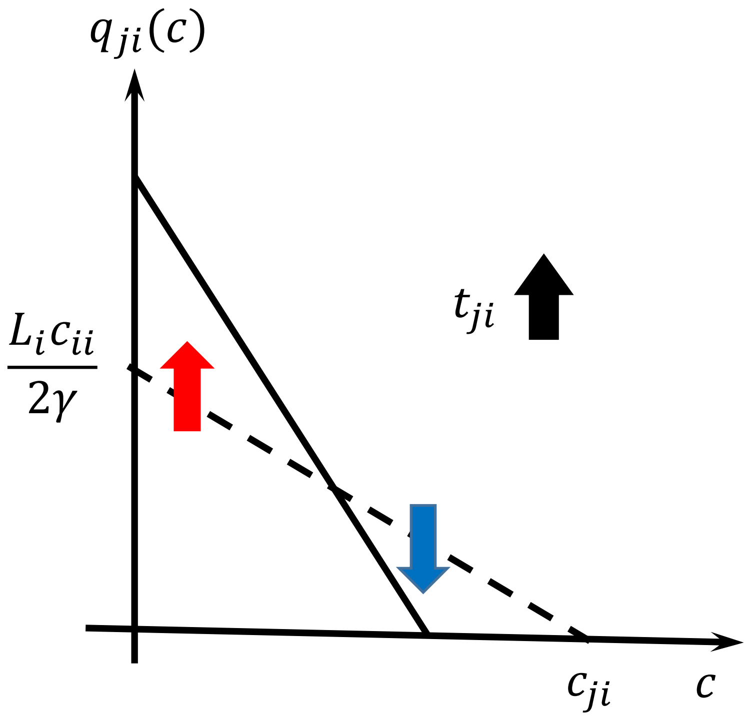
① The average price $\bar{p}_i = \frac{2\theta+1}{2(\theta+1)} c_{ii} \uparrow$

② The individual aggregate consumption $Q_i = \frac{\alpha - c_{ii}}{\eta} \downarrow$

} $AC_i \downarrow$

Welfare: CS_i

$$\frac{dCS_i}{dt_{ji}} = B_{ji}t_{ji}(\alpha - 2c_{ii})$$



$t_{ji} \uparrow$

① The number of varieties $N_i \downarrow$

② The within-sector allocation $\uparrow$

In this model,

- more productive firms (which set lower prices) end up being undersupplied
- less productive firms (which set higher prices) end up being oversupplied

⇒ An increase in t_{ji} increases (decreases) the output levels of more (less) productive exporters in country j

⇒ This improves the within-sector misallocation distortion

Preferential trade agreement (PTA)

- Assume that member countries i and j are symmetric:

$$L_i = L_j, K_i = K_j, c_i^M = c_j^M$$

- Suppose that country i and j form a PTA and adopt symmetric internal tariff:

$$\tau \equiv t_{ji} = t_{ij}$$

PTA members

- PTA members independently choose their external tariffs t_{ji} and t_{jh} to maximize their own welfare
- They choose the symmetric internal tariff τ to maximize their joint welfare $L_i U_i + L_j U_j$

The non-member country

- The non-member country j sets the optimal MFN tariff t_h^{MFN}:

$$\max_{t_h} U_h \ \ such\ that\ t_{ih} = t_{jh} \equiv t_h$$

The optimal external tariffs

- Differentiating (16) with respect to t_{hi},

$$\frac{dU_i}{dt_{hi}} = B_{hi}\left[2(\theta+1)c_{ii}(1-t_{hi}) + \alpha\left(2\frac{\theta}{\theta+1} - t_{hi}\right) + (\theta+2)Ak_i c_{ii}^{\theta+1}\left(1+\tau^{-\theta} - \left(\frac{\theta}{\theta+1} + \tau^{-(\theta+1)}\right)t_{hi}\right)\right] \tag{19}$$

where $B_{hi} > 0$.

$$\Rightarrow \quad \left.\frac{d\,U_i}{\mathrm{d}t_{hi}}\right|_{t_{hi}=1} > 0$$

$$\frac{dU_i}{dt_{hi}} < 0 \text{ for } t_{hi} > \frac{2(\theta+1)}{\theta}$$

The optimal external tariffs

Proposition 1.

If country i and j form PTA and adopt symmetric internal tariff, there exists the optimal external tariff t_{hi}^* that maximizes the welfare level of that country. It satisfies

$$t_{hi}^* = 1 + \frac{1}{\theta} \frac{\left(\frac{\theta}{\theta+1} + \theta\tau^{-(\theta+1)}(\tau - 1)\right)(\theta+2)Ak_i c_{ii}^{\theta+1} + (\theta+2)\alpha}{\left(\frac{\theta}{\theta+1} + \tau^{-(\theta+1)}\right)(\theta+2)Ak_i c_{ii}^{\theta+1} + 2(\theta+1)c_{ii} + \alpha} (> 1), \quad (20)$$

where c_{ii} is endogenously determined and $1 < t_{hi}^* < \frac{2(\theta+1)}{\theta}$.

Since PTA members set the same optimal external tariff, I drop the country index from the optimal external tariffs: $t^* \equiv t_{hi}^* = t_{hj}^*$

The optimal internal tariff

- Differentiating the joint welfare with respect to τ,

$$\frac{d(L_iU_i + L_jU_j)}{d\tau} = 2L_iB_{ji}\left[(1-\tau)\left(\frac{\theta(\theta+2)}{\theta+1}Ak_ic_{ii}^{\theta+1} + 2\theta c_{ii}\right) - 2\tau c_{ii} + (2-\tau)\alpha + (\theta+2)Ak_ht^{-(\theta+1)}c_{ii}^{\theta+1}\left(\frac{\theta}{\theta+1}t - \tau\right)\right] \qquad (21)$$

where $B_{ji} > 0$

Since $t^* < \frac{2(\theta+1)}{\theta}$ from Proposition 1,

$$\frac{d(L_iU_i + L_jU_j)}{d\tau} < 0 \quad \text{for } \tau > 2 \qquad (22)$$

The optimal internal tariff

- Then, the optimal internal tariff is positive if

$$\left.\frac{d(L_iU_i + L_jU_j)}{\mathrm{d}\tau}\right|_{\tau=1,t=t^*} > 0.$$

$$\Leftrightarrow \underbrace{\theta\left(\frac{\theta+2}{\theta+1}\right)^2\left(Ak_i{c_{ii}^{\dagger}}^{\theta+1} + (\theta+1)c_{ii}^{\dagger} - (\theta+1)\alpha\right)Ak_i{c_{ii}^{\dagger}}^{\theta+1}}_{<0} + \underbrace{(\theta+1)\left((\theta+1)\alpha - \theta c_{ii}^{\dagger}\right)}_{>0}\left(\alpha - 2c_{ii}^{\dagger}\right) > 0 \qquad (23)$$

$c_{ii}^{\dagger}$: the domestic cost cutoff when $\tau = 1$ and $t = t^*$

- (23) holds only if

$$\alpha - 2c_{ii}^{\dagger} > 0 \Leftrightarrow \left.\frac{dCS_i}{\mathrm{d}\tau}\right|_{\tau=1,t=t^*} > 0$$

→ The optimal internal tariff is positive when the introduction of a small symmetric internal tariff sufficiently improves the within-sector misallocation

The optimal internal tariff

From (21) - (23), I obtain the following proposition

Proposition 3.

If (23) holds, the optimal internal tariff τ that maximizes the sum of the welfare of member countries satisfies

$$\tau^* = 1 + \frac{\frac{\theta(\theta+2)}{\theta+1} A k_h c_{ii}^{\theta+1} t^{*-(\theta+1)} \left(t^* - \frac{\theta+1}{\theta}\right) + \alpha - 2c_{ii}}{\frac{\theta(\theta+2)}{\theta+1} A k_i c_{ii}^{\theta+1} + (\theta+2) A k_h c_{ii}^{\theta+1} t^{*-(\theta+1)} + 2(\theta+1)c_{ii} + \alpha} (> 1), \tag{24}$$

where c_{ii} is endogenously determined and $1 < \tau^* < 2$.

(14), (20), and (24) determine c_{ii}, t^*, τ^*

The effect of the external and internal tariffs on the non-member country

Proposition 2.

An increase in the external tariff generates welfare loss in the non-member country:

$$\frac{dU_h}{dt_{hi}} = \frac{dI_h}{dt_{hi}} < 0, \qquad \frac{dU_h}{dt_{hj}} = \frac{dI_h}{dt_{hj}} < 0$$

Proposition 4.

An increase in the internal tariff generates welfare gain in the non-member country:

$$\frac{dU_h}{d\tau} = \frac{dI_h}{d\tau} > 0$$

The effect of eliminating the internal tariff

- t^*_{const} : the constrained optimal external tariff

- Benchmark: $A = 10, \alpha = 2, \theta = 1.5, K_i = 10, K_h = 10, L_i = 10, L_h = 10.$

$(\tau,^* t^*)$	$(1, t^*_{const})$	$U_i(\tau,^* t^*)$	$U_i(1, t^*_{const})$	$U_h(\tau^*, t^*)$	$U_h(1, t^*_{const})$
(1.0629,1.4821)	(1, 1.4236)	1.1721	1.1720	1.1717	1.1718

$\Rightarrow \quad t^* > t^*_{const}\ ,\ U_h(\tau^*, t^*) < U_h(1, t^*_{const})$

The effect of eliminating the internal tariff

- $t^* > t^*_{const}$: Tariff complementarity

$\frac{dCS_i}{dt} > 0 \Leftrightarrow \alpha - 2c_{ii} > 0$

$\tau^* \downarrow$ $\Rightarrow$ $c_{ii} \downarrow$ $\Rightarrow$ $\alpha - 2c_{ii} \uparrow$ $\Rightarrow$ $t^* \uparrow$

$\Rightarrow$ Tariff revenue from $j \downarrow$ $\Rightarrow$ $t^* \downarrow$ $\}$ $t^* \downarrow$

- $U_h(\tau^*, t^*) < U_h(1, t^*_{const})$

$\tau^* \downarrow$ $\Rightarrow$ $\pi_{hi} \downarrow$ (proposition 2) $\Rightarrow$ $U_h \downarrow$

$\Rightarrow$ $t^* \downarrow$ $\Rightarrow$ $\pi_{hi} \uparrow$ (proposition 4) $\Rightarrow$ $U_h \uparrow$ $\}$ $U_h \uparrow$

These relationship hold for all numerical examples I provide

Table 1: Characteristics of optimal tariffs

	$(\tau,^* t^*)$	$(1, t^*_{const})$	$U_i(\tau,^* t^*)$	$U_i(1, t^*_{const})$	$U_h(\tau^*, t^*)$	$U_h(1, t^*_{const})$
$A = 10$	(1.0629,1.4821)	(1, 1.4236)	1.1721	1.1720	1.1717	1.1718
$A = 20$	(1.0711,1.4911)	(1,1.4243)	1.0893	1.0892	1.0891	1.0892
$A = 100$	(1.0836,1.5053)	(1,1.4252)	1.01885	1.01884	1.01883	1.01884

Table 2: Characteristics of optimal tariffs

	$(\tau,^* t^*)$	$(1, t^*_{const})$	$U_i(\tau,^* t^*)$	$U_i(1, t^*_{const})$	$U_h(\tau^*, t^*)$	$U_h(1, t^*_{const})$
$K_i = 10$	(1.0629,1.4821)	(1, 1.4236)	1.1721	1.1720	1.1717	1.1718
$K_i = 20$	(1.0894,1.4904)	(1,1.4071)	1.1784	1.1783	1.1740	1.1741
$K_i = 100$	(1.1246,1.5092)	(1,1.3927)	1.1887	1.1886	1.18332	1.18334

Table 3: Characteristics of optimal tariffs

	(τ^*, t^*)	$(1, t^*_{const})$	$U_i(\tau^*, t^*)$	$U_i(1, t^*_{const})$	$U_h(\tau^*, t^*)$	$U_h(1, t^*_{const})$
$K_h = 10$	(1.0629,1.4821)	(1, 1.4236)	1.1721	1.1720	1.1717	1.1718
$K_h = 20$	(1.0454,1.4969)	(1,1.4546)	1.1731	1.1730	1.1782	1.1783
$K_h = 100$	(1.1085,1.7214)	(1,1.6297)	1.1799	1.1798	1.1910	1.1912

Table 4: Characteristics of optimal tariffs

	$(\tau,^* \ t^*)$	$(1, t^*_{const})$	$U_i(\tau,^* \ t^*)$	$U_i(1, t^*_{const})$	$U_h(\tau^*, t^*)$	$U_h(1, t^*_{const})$
$\theta = 1.5$	(1.0629,1.4821)	(1, 1.4236)	1.1721	1.1720	1.1717	1.1718
$\theta = 2$	(1.0261,1.3302)	(1,1.3073)	1.1604	1.1603	1.1599	1.1600
$\theta = 2.5$	(1.0064,1.2453)	(1,1.2398)	1.14972	1.14971	1.14931	1.14934