ECO 442: Quantitative Trade Models

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Trade Costs and Tariffs

So far in our models, international trade has been frictionless

- Instantly teleport goods from one country to another at no cost
- Obviously not true in the real world

Focus on two primary trade costs

- **Iceberg Trade Costs**
- **Tariffs**

Iceberg Trade Costs

Iceberg Trade Costs are costs associated with transporting goods across countries

- Fuel to ship the goods
- Loss of product due to spoilage
- Additional workers needed to fill out paper work and follow international regulations

Iceberg trade costs means to deliver 1 unit of exports, necessary to ship $\tau > 1$ units

- For simplicity, we set domestic iceberg trade costs as $\tau = 1$

Tariffs

Tariffs are a tax imposed on imports

- Tariffs are redistributed to consumers in the country imposing the tariff

$$\text{Income} = \overbrace{wL}^{\substack{\text{Labor}\\ \text{Income}}} + \overbrace{T}^{\substack{\text{Tariff}\\ \text{Income}}}$$

- Unlike iceberg costs, nothing is physically lost

- Like iceberg costs, the presence of Tariffs distorts the equilibrium vs a frictionless world

- Tariffs are typically ad-valorem (applied proportionally to value). Model as

$$\text{price with tariff} = \text{tariff} \times \text{price without tariff}$$

$$p^{\text{import}} = \tau p^{\text{world}}$$

Multi-Good Ricardian Model of Trade

Comparative advantage: countries differ in technology and therefore opportunity costs.

- 2x2 Ricardian Model is simple. Tariffs too high $\Rightarrow$ stop trading.
- Tairffs more interesting with multiple goods (adds middleground between Trade and Autarky)

Dornbusch, Fischer and Samuelson (1979)

- Ricardian model with 2 countries and a continuum of goods

Model Setup

Two countries, $i, j = 1,2$

Continuum of goods indexed by $z \in [0,1]$

Labor (L_i) is only factor of production, supplied inelastically

Countries differ in labor productivities for each good $\left(a_i(z)\right)$: $y_i = l_i(z)/a_i(z)$

- Order the goods by relative comparative advantage $\frac{a_2(z)}{a_1(z)}$ (highest at 0, lowest at 1)
    - Country 1 can make goods relatively cheaper near zero, and country 2 can make goods relatively cheaper near one.

Equilibrium Definition

Equilibrium elements

- Prices for each good: $\hat{p}(z)$
- Wages: $\widehat{w}_1, \widehat{w}_2$
- Consumption, labor input, and production for each good: $\hat{c}_i(z), \hat{y}_i(z), \hat{l}_i(z)$

Such that

1) Given prices and wages, consumers maximize utility subject to budget constraint
2) Firms maximize profit for each good produced in a country
3) Markets clear (consumption = output, labor used in production sums to labor endowment)

1. Consumers problem

Given $\hat{p}(z), \widehat{w}_i$ consumer in country i to solve

$$\max \int_0^1 U\big(c_i(z)\big)\, dz$$

subject to budget constraint

$$\int_0^1 \hat{p}(z) c_i(z) = \widehat{w}_i L_i$$

$$c_i(z) \geq 0, \forall z$$

2. Firms Problem

Given $\hat{p}(z), \widehat{w}_i$ firms in country i maximize profits for each good z

$$\max \hat{p}(z) y_i(z) - \widehat{w} l_i(z)$$

subject to production technology:

$$y_i(z) = l_i(z)/a_i(z)$$

Where $a_i(z)$ is unit labor costs for good z in country i

Firm Optimization Yields: $\hat{p}(z) = \widehat{w}_i a_i(z)$ if $\hat{y}_i(z) > 0$

3. Market Clearing

Goods market clears for each good (if autarky instead of trade would have $\hat{c}_i(z) = \hat{y}_i(z)$)

$$\hat{c}_1(z) + \hat{c}_2(z) = \hat{y}_1(z) + \hat{y}_2(z), \qquad \forall z \in [0,1]$$

Labor market clears for each country

$$\int_0^1 \hat{l}_i(z)dz = L_i, \qquad i = 1,2$$

Equilibrium Solution: Cutoff

Cutoff $\bar{z}$ such that country 1 produces and exports goods in $[0, \bar{z}]$

Country 2 produces and exports goods in $(\bar{z}, 1]$

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Analytic Simplifications:

Cobb Douglas Preferences: $U\big(c_i(z)\big) = \log\big(\mathrm{c_i(z)}\big)$

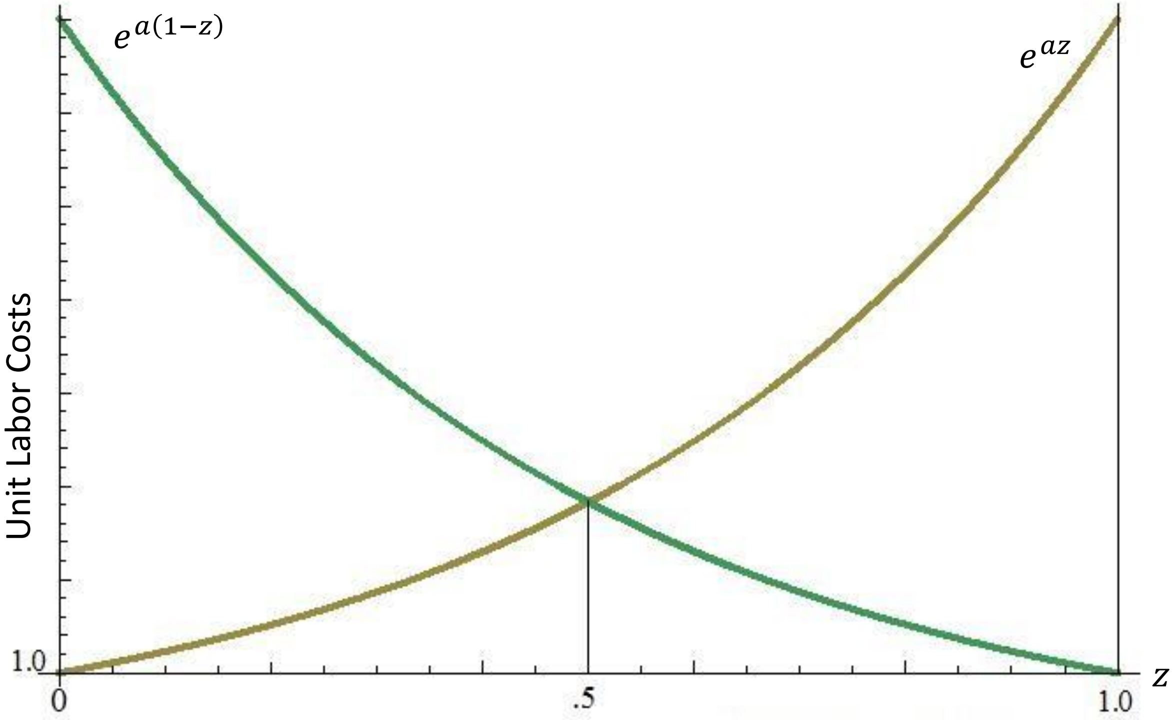
Symmetry: $L_1 = L_2 = L$

Production technologies:

$$a_1(z) = e^{az}$$

$$a_2(z) = e^{a(1-z)}$$

Production Technologies



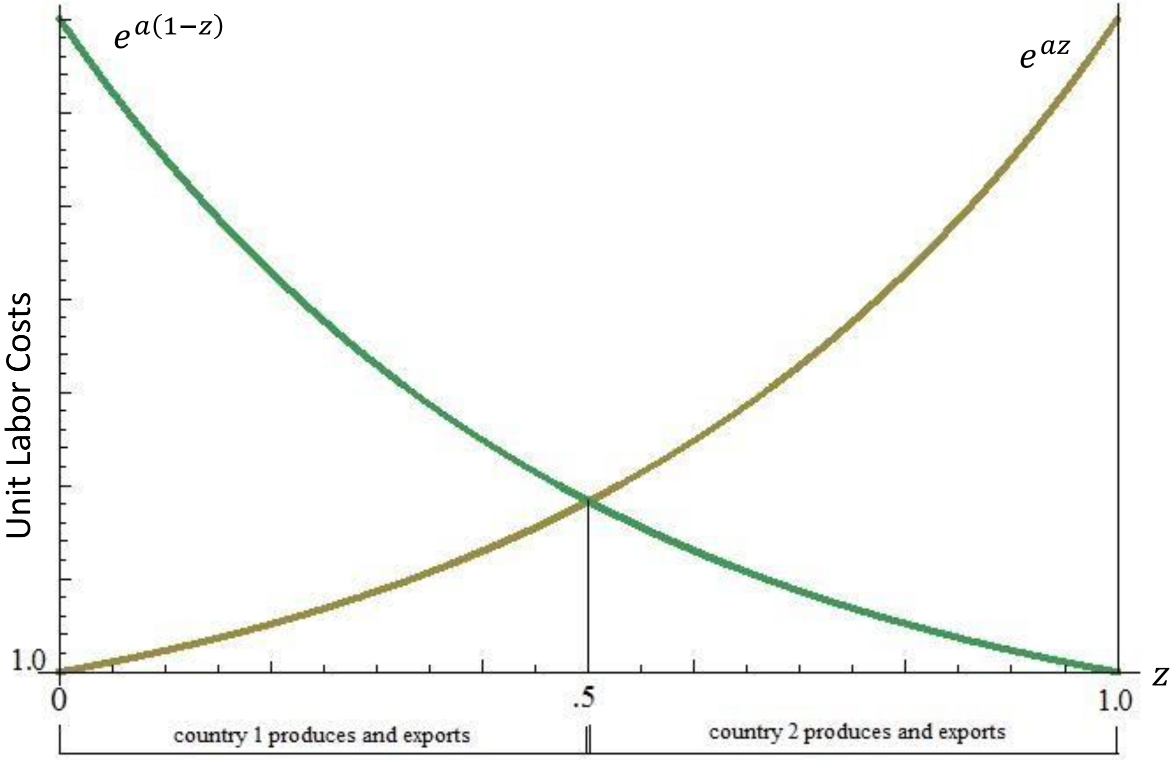
Symmetry

Will have equilibrium with $\hat{w}_1 = \hat{w}_2$ (relative wages $\frac{\hat{w}_1}{\hat{w}_2} = 1$)

Will have cutoff $\bar{z} = 1/2$

- Country 1 produces and exports goods in $Z_1 = \left[0, \frac{1}{2}\right]$
- Country 2 produces and exports goods in $Z_2 = \left(\frac{1}{2}, 1\right]$

Symmetric Equilibrium



Symmetric Equilibrium

- Prices

$$\hat{p}(z) = \begin{cases} e^{az}, & z \in [0, \bar{z}) \\ e^{a(1-z)}, & z \in (\bar{z}, 1] \end{cases}$$

- Wages: $\hat{w}_1, \hat{w}_2 = 1$ (normalize wages to 1)

- Consumption, labor input, and production:

$$\hat{c}_i(z) = \frac{L}{\hat{p}(z)} \ \forall z \in [0,1]$$

$$\hat{y}_i(z) = \frac{2L}{\hat{p}(z)} \ if \ \ z \in Z_i, \qquad (\hat{y}_i(z) = 0 \ if \ z \notin Z_i)$$

$$\hat{l}_i(z) = 2L \ if \ z \in Z_i, \qquad \left(\hat{l}_i(z) = 0 \ if \ z \notin Z_i\right)$$

Trade Costs and Trade Policy

Have a working model, can use it to think about the effects of trade costs and trade policy

Iceberg Trade Costs:

Suppose each country faces an iceberg transportation cost of $\tau > 1$ when exporting:

$$y_i^j(z) = \frac{l_i(z)}{\tau a_i(z)}, \qquad if\ i \neq j$$

Still costless to produce for domestic market: $y_i^i(z) = l_i(z)/a_i(z)$

Iceberg Trade Costs: Cutoffs

Will no longer have single cutoff

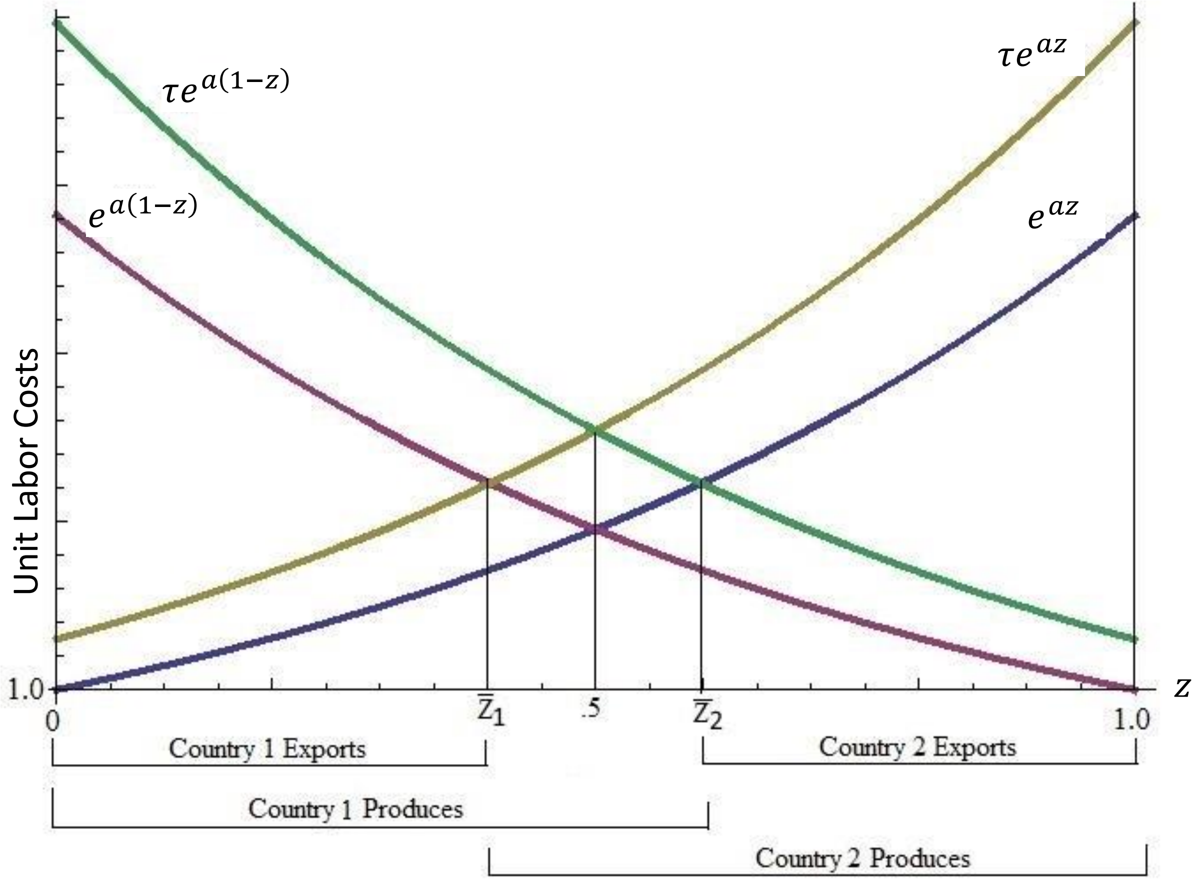
- If $\tau > \max\left\{\frac{a_1(z)}{a_2(z)}, \frac{a_2(z)}{a_1(z)}\right\}$ then good will not be exported by either country

Two cutoffs $\bar{z}_1$ and $\bar{z}_2$ ($\bar{z}_2 > \bar{z}_1$):

- Country 1 produces goods $z \in [0, \bar{z}_2]$, exports goods $z \in [0, \bar{z}_1]$
- Country 2 produces goods $z \in (\bar{z}_1, 1]$, exports goods $z \in (\bar{z}_2, 1]$

Keep the same symmetric setup, so still have an equilibrium with $\hat{w}_1 = \hat{w}_2 = 1$.

Symmetric Equilibrium: Iceberg Trade Costs



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Tariff Trade Costs

Now suppose τ is an ad valorem tariff instead of an iceberg trade cost.

- Tariffs go on prices rather than in production function
- Let $p_i(z)$ be the price firms in i charge domestically if they produce the good
- Let $p_i^j(z)$ be the price of good z, produced in country $i,$ and consumed in country $j,$ then

$$p_i^j(z) = \begin{cases} \tau p_i(z), & if \;\; i \neq j \\ p_i(z), & if \; i = j \end{cases}$$

Tariff Trade Costs

For both iceberg trade costs and tariffs, will have

$$\hat{p}_i^j(z) y_i^j(z) = \begin{cases} \dfrac{\hat{w}_i l_i(z)}{\tau}, & if\ i \neq j \\ \hat{w}_i l_i(z), & if\ i = j \end{cases}$$

This means it doesn't matter if we put τ on prices or output. Solution to problem is same.

Difference is that tariffs are rebated back to consumers. Consumer budget constraint:

$$\int_0^1 \hat{p}_i(z) c_i(z) dz = \hat{w}_i L_i + \overbrace{T_i}^{\text{Tariff Revenue}}$$

$$T_i = \int_z (\tau - 1) \hat{p}_j(z) y_j^i(z) dz$$

Cutoffs and Symmetric Equilibrium: Tariff Trade Costs

Same as with iceberg trade costs.

Two cutoffs $\bar{z}_1$ and $\bar{z}_2$ ($\bar{z}_2 > \bar{z}_1$):

- Country 1 produces goods $z \in [0, \bar{z}_2]$, exports goods $z \in [0, \bar{z}_1]$
- Country 2 produces goods $z \in (\bar{z}_1, 1]$, exports goods $z \in (\bar{z}_2, 1]$

Consumption Differences: Iceberg Costs vs Tariffs

Under iceberg transportation costs:

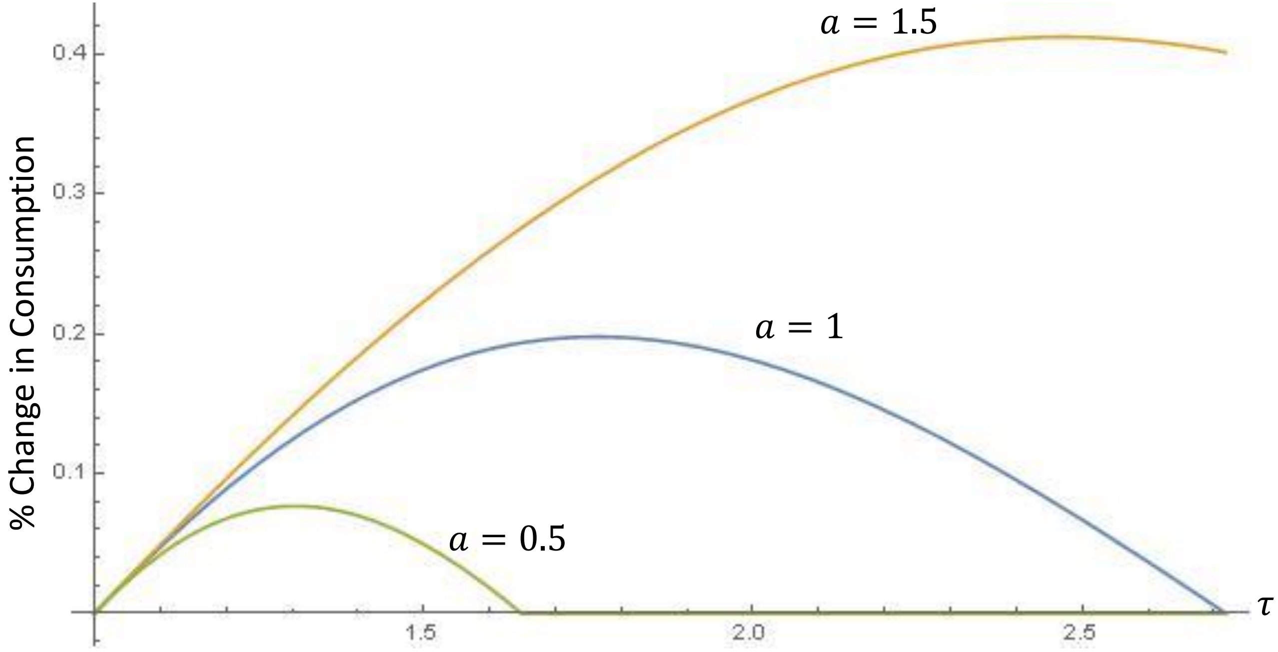
$$c_1(z) = \begin{cases} \frac{L}{e^{az}}, z \in [0, \bar{z}_2] \\ \frac{L}{\tau e^{a(1-z)}}, z \in (\bar{z}_2, 1] \end{cases} ; \; c_2(z) = \begin{cases} \frac{L}{\tau e^{az}}, z \in [0, \bar{z}_1] \\ \frac{L}{e^{a(1-z)}}, z \in (\bar{z}_1, 0] \end{cases}$$

Under tariffs

$$c_1(z) = \begin{cases} \frac{L + T_1}{e^{az}}, z \in [0, \bar{z}_2] \\ \frac{L + T_1}{\tau e^{a(1-z)}}, z \in (\bar{z}_2, 1] \end{cases} ; \; c_2(z) = \begin{cases} \frac{L + T_2}{\tau e^{az}}, z \in [0, \bar{z}_1] \\ \frac{L + T_2}{e^{a(1-z)}}, z \in (\bar{z}_1, 1] \end{cases}$$

Where $T_i = \frac{L\left(\frac{\tau-1}{\tau}\right)\bar{z}_1}{1-\left(\frac{\tau-1}{\tau}\right)\bar{z}_1}$

Increased Consumption from Tariff Revenue (vs Iceberg Costs)



GDP and Tariffs

Country 1's Gross Domestic Product/Real Consumption (same in symmetric model)

$$GDP_1 = \int_0^{\bar{z}_2} p_1(z) c_1(z) dz + \int_0^{\bar{z}_1} p_1^2(z) c_2(z) dz = \frac{L}{1 - \left(\frac{\tau - 1}{\tau}\right) \bar{z}_1}$$

- Can see how GDP and real GDP change as tariffs change
- Increasing in productivity level (a) and country size (L), decreasing in tariffs (τ)

Real GDP and Tariffs: Base Prices

Real GDP is value of production evaluated at base period prices

- Let the base period be at $\tau = 0$, then base prices are

$$\tilde{p}(z) = \begin{cases} e^{az}, & z \in \left[0, \frac{1}{2}\right] \\ e^{a(1-z)}, & z \in \left(\frac{1}{2}, 1\right] \end{cases}$$

Real GDP and Tariffs

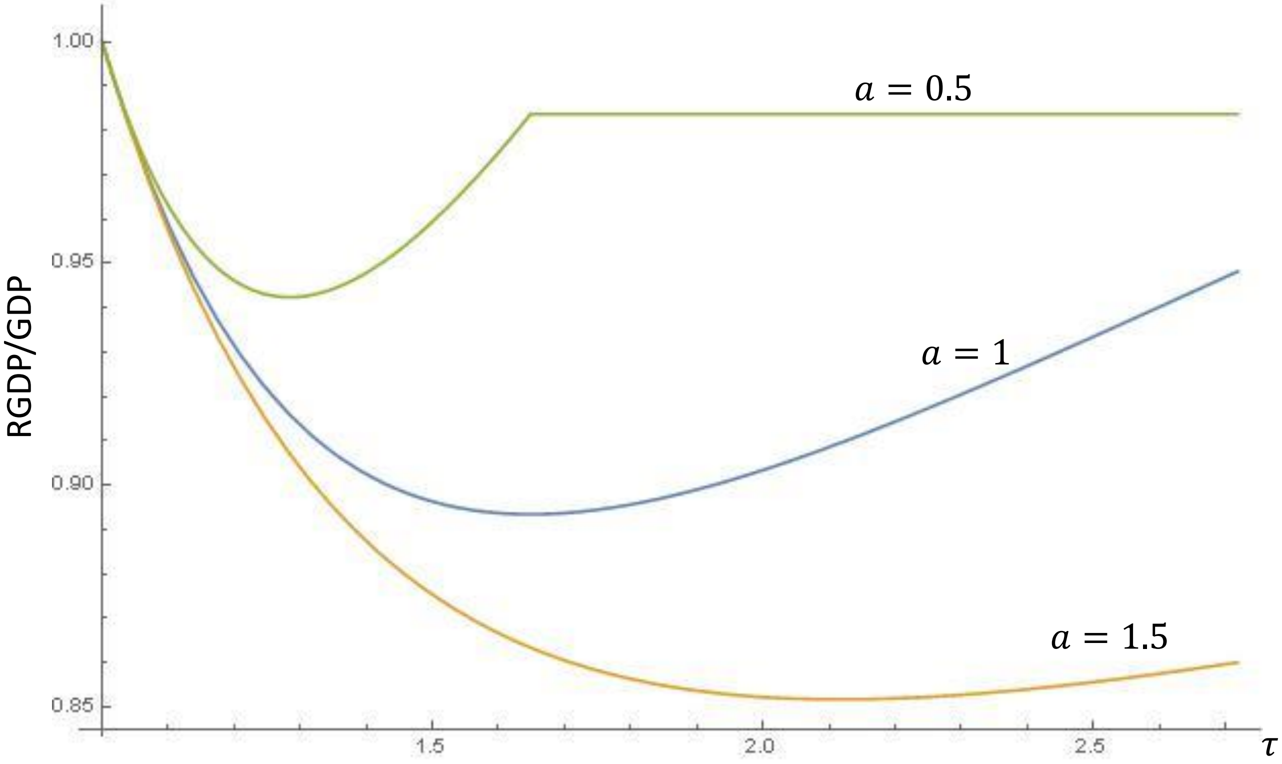
Country 1's Real Gross Domestic Product (constant price GDP)

$$RGDP_1 = \int_0^{\bar{z}_2} \tilde{p}(z) c_1(z) dz + \int_0^{\bar{z}_1} \tilde{p}(z) c_2(z) dz$$

$$= GDP_1 \left(\frac{a + \tau - 1 + a\tau - \log \tau}{2a\tau} \right)$$

Note that $RGDP_1 = GDP_1$ if $\tau = 1$, otherwise $RGDP_1 \leq GDP_1$

Tariffs: Current vs Constant Price GDP



Overview of DFS

Dornbusch, Fischer, and Samuelson (1979):

- Ricardian model: 2 countries, 1 factor of production, continuum of goods

Strengths:

- Simple and intuitive. Can be used to think about effects of trade policy and trade costs.

Weaknesses:

- No explanation for why countries differ in productivity for producing goods

- Not straightforward to extend model to multiple countries

Application of DFS: Tariff Wars

Opp (2010):

- Similar model setup: 2 countries, continuum of goods, labor only factor of production
- Constant Elasticity of Substitution (CES) preferences

$$U = \left(\int_0^1 \theta(z)^{\frac{1}{\sigma}} \left(c(z)\right)^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}}$$

Note: $\sigma = 1 \Rightarrow$ Cobb-Douglas

Question: What is the optimal tariff rate schedule?

Tariff Wars and the Prisoner’s Dilemma

Holding fixed partner‘s tariff: optimal tariff is non-zero

- Partner may retaliate and charge non-zero tariffs in return
- Global welfare always maximized by free trade

Two subquestions:

1. Without committment to free trade, what is the Nash equilibrium for tariff rates?
2. When, if ever, will one of the countries prefer the above to free trade?

Optimal Tariffs: Propositions

1. Optimal tariffs schedule is uniform across goods

2. Lerner (1936) Symmetry: Import tariff is equivalent to export tax

3. Unique interior NE in tariff rates that dominates any no-trade NE

4. NE tariff rates are increasing in degree of comparative advantage and decreasing in transportation costs

Optimal Tariffs: Main Result and Intuition

If a country is sufficiently large (productivity adjusted labor), it will prefer NE tariffs to free trade

Tradeoffs of having tariffs:

+Intensive Margin: Gain from terms-of-trade effects (relative price of exports to imports)

-Extensive margin: Lose from having to produce goods that could have been imported

If country is large enough, terms-of-trade effects dominate

- Implications for self-regulating free trade agreements