INTERNATIONAL TRADE - ECON 245

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INCREASING RETURNS

INTRODUCTION

- Models on international trade so far all about:
  - **Inter**industry trade, e.g., Ricardo's wine versus cloth
  - Trade between **dissimilar** economies, e.g., in terms of factor endowments
- Two important unexplained regularities:
  - Large amount of **intra**industry trade, e.g, within consumer goods
  - Large amount of trade among similar economies

INTRODUCTION

- Armington model did not **explain** these regularities: just re-produced them
- Also: so far CRS+perfect competition. What happens if we relax this?

- **Krugman (1980)**:
  - Combines increasing returns to scale and imperfect competition
  - Provides theoretical justification for intraindustry and similar-country trade

MONOPOLISTIC COMPETITION+INCREASING RETURNS

- Monopolistic Competition
  - MP is tractable form of imperfect competition *without* strategic interaction
  - But as with monopoly: firms face downward sloping demand curves
- Increasing Returns:
  - Fixed cost of production: in equilibrium only one firm produces each variety
  - There are profits - where do they go?
    - They are spent on fixed costs
    - Other profits competed away by free entry of *other* varieties

KRUGMAN (1980): SETUP WITH ONE COUNTRY

- Firms:
  - Endogenous mass ("number") Ω of firms
  - Firms pay fixed cost of entry f^e denominated in terms of domestic labor
  - Each firm produces a unique variety of a differentiated product
  - Each firm has same productivity and produces with labor only
- Consumers/Workers:
  - CES preferences + L workers supplying one unit of labor inelastically

KRUGMAN (1980): PREFERENCES

- Krugman re-writes the representative consumer's utility function as follow:

$$U = \left(\int_{\Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$

- As in Armington we assume $\sigma > 1$.
- **Note**:
  - Diminishing marginal utility of consumption to extra units of each good
  - Love for variety - adding varieties has no DRS. In symmetric equilibrium $U = \Omega^{(\sigma)/(\sigma-1)} q$

KRUGMAN (1980): FIRMS

- The problem of a firm is given as follows

$$\max_{\{p(\omega)\}} p(\omega)q(\omega) - \frac{w}{z}q(\omega) - wf^e$$

where demand for each variety, $q(\omega)$, sloped downward in price

- First order condition with respect to $p(\omega)$:

$$q(\omega) + [p(\omega) - \frac{w}{z}]\frac{\partial q(\omega)}{\partial p(\omega)} = 0$$

KRUGMAN (1980): FIRMS

- General definition of elasticity of demand wrt price:

$$\epsilon(\omega) = -\frac{p(\omega)}{q(\omega)}\frac{\partial q(\omega)}{\partial p(\omega)} > 0$$

- Using this, rewrite the first order expression for optimal pricing rule:

$$p(\omega) = \frac{\epsilon(\omega)}{\epsilon(\omega) - 1}\frac{w}{z}$$

- In equilibrium prices are mark-up over marginal cost
- Size of markup depends on elasticity of demand

KRUGMAN (1980): CONSUMER OPTIMIZATION

- We already solved the consumer problem last time. Recall:

$$q(\omega) = p(\omega)^{-\sigma} X P^{\sigma-1}$$

- Assuming each variety accounts for little of aggregate spending:

$$\frac{\partial q(\omega)}{\partial p(\omega)} = -\sigma p(\omega)^{-\sigma-1} X P^{\sigma-1}$$

- Use both of these:

$$\epsilon(\omega) = -\frac{p(\omega)}{q(\omega)}\frac{\partial q(\omega)}{\partial p(\omega)} = \frac{p(\omega)}{p(\omega)^{-\sigma} X P^{\sigma-1}} \sigma p(\omega)^{-\sigma-1} X P^{\sigma-1} = \sigma$$

KRUGMAN (1980): EQUILIBRIUM PRICES

- Plugging in the elasticity of demand from consumer optimization into the firm pricing rule gives the monopolistic competition price:

$$p = \frac{\sigma}{\sigma - 1} \frac{w}{z}$$

- With CES preferences: price is **constant** markup over marginal cost
- Equilibrium is **symmetric** so consumption of individual good:

$$c(\omega) = c = \frac{w}{\Omega p}$$

KRUGMAN (1980): EQUILIBRIUM QUANTITIES

- Free entry assumption implies firms enter until profits are zero:

$$\pi = p(\omega)q(\omega) - \frac{w}{z}q(\omega) - wf^e = 0$$

- Plugging in equilibrium prices and imposing symmetry ($q(\omega) = q$) yields:

$$q = (\sigma - 1)zf^e$$

- The quantity produced is just a function of parameters!
- What does this imply for the effect of trade?

KRUGMAN (1980): EQUILIBRIUM NUMBER OF FIRMS

- Equilibrium number of varieties produced is determined by labor market clearing:

$$L = \int_{\omega} l(\omega) d\omega = \Omega(q/z + f^e) \Rightarrow \Omega = \frac{L}{\sigma f^e}$$

- Without loss of generality we can normalize the price to 1, so that all endogenous variables are pinned down.

KRUGMAN (1980): EFFECTS OF INTERNATIONAL TRADE

- Suppose we add a symmetric second economy with which trade is free
- Since economies are identical wages, prices, number of firms will be the same in both
- Equilibrium consumption of each variety however is different:

$$c = c^\star = \frac{w}{p(\Omega + \Omega^\star)}$$

KRUGMAN (1980): EFFECTS OF INTERNATIONAL TRADE

- Gains from trade: consumers have access to a greater variety of goods and representative consumer's utility is increasing in the # of varieties consumed
- Trade is intra-industry
- Direction of trade is indeterminate
- Volume of trade: value of imports in home country (simple gravity eq!)

$$M = \frac{\Omega^{\star}}{(\Omega + \Omega^{\star})} = (1 - \lambda)Lw$$

where λ is the "home share" of production.

QUESTIONS

- What would have happened with constant elasticity and perfect competition?
  - IRS+MP together *explain* what we see in the world
  - CRS long criticizes as highly unrealistic, IRS crucial force in the world!
- Of course, regions within the US are like “similar” countries doing intraindustry trade
- IRS likely plays a crucial role in ICT-enabled services
  - Much more work needed

SCALE AND TRADE

INTRODUCTION

- So far increasing returns were a crucial as a motive for trade with symmetric countries
    - However, there were no “scale effects“ from trade: idea that increase in market allows some firms to “exploit scale better”
- The reason is our constant elasticity assumption. Suppose instead:

$$U = \int_{\Omega} v(c(\omega))d\omega$$

where $v(\cdot)$ is increasing in its argument and concave

ELASTICITY OF SUBSTITUTION

- Firm side is as before, so firm pricing rule is unchanged:

$$p(\omega) = \frac{\epsilon(\omega)}{\epsilon(\omega) - 1}\frac{w}{z}$$

- Derive general elasticity of substitution:

$$v'(c(\omega)) = \lambda p(\omega)$$

- Effect of a price change, assuming no effect on λ:

$$v''dc(\omega) = dp(\omega)\lambda \Rightarrow \frac{dc(\omega)}{dp(\omega)} = \frac{\lambda}{v''} < 0$$

ELASTICITY OF SUBSTITUTION

- So the elasticity of demand is now:

$$\epsilon(\omega) = -\frac{p(\omega)}{q(\omega)}\frac{\partial q(\omega)}{\partial p(\omega)} = -\frac{v'c(\omega)}{v''} > 0$$

- We now this is positive from assumptions on $v(\cdot)$.
  - But don't know whether this is increasing or decreasing in $c(\omega)$
  - This is crucial and we assume

$$\frac{d\epsilon(\omega)}{dc(\omega)} < 0$$

  - So as we move up the demand curve the elasticity rises

ELASTICITY OF SUBSTITUTION

- Free entry is as before (Zero Profits)

$$\pi = p(\omega)q(\omega) - \frac{w}{z}q(\omega) - wf^e = 0 \Rightarrow p/w = 1/z + f/(Lc(\omega))$$

- Also the firm pricing equation (profit maximization)

$$p/w = \epsilon(\omega)/(\epsilon(\omega) - 1)1/z$$

- Note that $\epsilon(\omega)$ is only a function of $c(\omega)$ so that equilibrium pinned down by p/w and c
- Once we have solved for p/w and c, we can then solve for the mass of firms from labor market clearing:

$$L = \int_\omega l(\omega)d\omega = \Omega(Lc(\omega)/z + f^e) \Rightarrow \Omega = \frac{L}{(Lc(\omega)/z + f^e)}$$

THE EFFECTS OF FREE TRADE

- Now suppose adding a second identical country with which trade is free
  - This is exactly like keeping a single economy but doubling L. So we analyze that instead.
  - Graph zero profit eq ($p/w = 1/z + f/(Lc(\omega))$) and price setting ($p/w = \epsilon(\omega)/(\epsilon(\omega) - 1)1/z$) with p/w on the y-axis and $c(\omega)$ on the x-axis.
  - A doubloon in L shifts zero profit curve down: so c falls and p/w falls.
- Does not change firm pricing equation, only free entry adjusts
  - [AS BEFORE] Total product variety increases, so utility increases
  - [NEW!] Equilibrium consumption of each variety falls: consume less of each variety, raising elasticity of demand [since it is no longer constant], lowering markups and hence price, increasing welfare.
  - [NEW!] Firms increase scale, which lowers average costs, hence price [Can see this since number of firms in each country now falls! (see next slide)]

FIRM SELECTION

- Contrary to before, the number of varieties produced within each country now **falls** when open to trade
- We saw that p/w falls so revenue falls or costs increase: so it is less profitable to run a firm which must mean that fewer firms enter and so Ω decreases.
- Can also see this since p/w falls firms must move down their average cost curves, so q increases. But then Ω in each country (holding L fixed) must decrease from:

$$\Omega = \frac{L}{(q/z + f^e)}$$

  - There is "selection", prices fall as firms move down average cost curves: surviving firms increase output, sell less per person but to more consumers

TRANSPORT COSTS

REINTRODUCE ICEBERG TRADE COST - WHAT CHANGES?

- Iceberg trade costs: for one unit to arrive in destination, need to ship τ units.
- Price of foreign variety in home country:

$$p^\star = \frac{\sigma}{\sigma - 1}\frac{w}{z}\tau$$

- Define as ζ demand of home residence for foreign relative to domestic variety

$$\zeta = \frac{(\frac{\sigma}{\sigma-1}\frac{\tau w^\star}{z^\star})^{-\sigma} X P^{\sigma-1}}{(\frac{\sigma}{\sigma-1}\frac{w}{z})^{-\sigma} X P^{\sigma-1}} = \frac{(\frac{w^\star \tau}{z^\star})^{-\sigma}}{(\frac{w}{z})^{-\sigma}}$$

REINTRODUCE ICEBERG TRADE COST - WHAT CHANGES?

- Home consumers' budget constraint implies that their expenditure equals their income:

$$(\Omega p + \zeta \Omega^{\star} p) d = w$$

where d is the consumption of a representative domestic variety.

- Since elasticity of demand remains the same, pricing rules of firms remain the same.
- Since pricing is the same, free entry is the same so Ω and $\Omega^{\star}$ are unchanged

REINTRODUCE ICEBERG TRADE COST – WHAT CHANGES?

- Introducing transport costs *does* have implications for relative wage
- If $L > L^{\star}$ then home will have higher wage:
  - Large market advantage when production is subject to economies of scale **and** world markets are segregated by transport costs
- Gives rise to notion of **market access** [indexing shipment origin i, destination j]

$$p_i q_i = \sum_j \tau_{ij}^{1-\sigma} p_i^{1-\sigma} P_j^{\sigma-1} E_j \Leftrightarrow p_i^{\sigma} = \frac{1}{q_i} \sum_j \tau_{ij}^{1-\sigma} P_j^{\sigma-1} E_j \equiv \frac{1}{q_i} MA_i$$

So wage in i increasing in “Market Access” (MA) since $p_i = \sigma/(\sigma - 1)w_i/z_i \propto w_i$

HOME MARKET EFFECT

INTRODUCTION

- With increasing returns to scale (IRS) **and** transport costs: locations export the good they have large local demand for
  - This is called the home market effect
  - Can think of it as sectoral specialization
- *Intuition*: IRS imply firms wish to concentrate production, transport cost imply this is optimally done close to large markets.
- Krugman developed this as an argument for agglomeration more general

INTRODUCING TWO SECTORS AND TYPES OF CONSUMERS

- Need a two sector version of above model.
- There are two industries, A and B, and within each industry there are many different varieties.
- Demand for each industries comes from separate local populations L_A and L_B:

$$U_A = \left(\int_{\Omega_A} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\frac{\sigma}{\sigma-1}} \qquad U_B = \left(\int_{\Omega_B} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\frac{\sigma}{\sigma-1}}$$

- Each type of worker can *work* in any industry and supplies 1 unit inelastically.
- Production technologies in both industries identical and as before.

EQUILIBRIUM WITHOUT TRADE

- Since consumers are identical within each group:

$$q_A = L_A c_A \qquad q_B = L_B c_B$$

- Labor market clearing overall:

$$L = \int_{\omega \in \Omega_A} l(\omega) d\omega + \int_{\omega \in \Omega_B} l(\omega) d\omega = \Omega_A (q_A / z + f^e) + \Omega_B (q_B / z + f^e)$$

- Pricing rule of firms is the same as before
- Pricing rule+Free entry implies equilibrium output of each of the two types of varieties is the same as before

EQUILIBRIUM WITHOUT TRADE

- So we can determine $\Omega_A + \Omega_B$ from labor market clearing (previous slide)
- The size of each industry is determined by goods market clearing for each sector:

$$\Omega_A pq = wL_A \qquad \Omega_B pq = wL_B$$

- But then:

$$\frac{\Omega_A}{\Omega_B} = \frac{L_A}{L_B}$$

- So we have solved for all endogenous objects of an individual country!

EQUILIBRIUM WITH TRADE

- Assume the foreign country and home are mirror images:

$$L_A = L_B^\star \qquad L_B = L_A^\star$$

- As a result equilibrium outcomes are the same except for the mass of type A and type B products produced.
- Home's share of expenditure on the home good is:

$$\lambda = \frac{\Omega_A p d}{(\Omega_A p + \zeta \Omega_A^\star p^\star) d} = \frac{\Omega_A}{\Omega_A + \zeta \Omega_A^\star}$$

EQUILIBRIUM WITH TRADE: LABOR MARKET CLEARING

- For *each industry* value of production in each country has to equal value of expenditure on the varieties produced in that country.
- In sector A, we hence need:

$$\Omega_A p_A q_A = \frac{\Omega_A}{\Omega_A + \zeta \Omega_A^\star} w L_A + \frac{\zeta \Omega_A}{\zeta \Omega_A + \Omega_A^\star} w^\star L_A^\star$$

$$\Omega_A^\star p_A^\star q_A^\star = \frac{\Omega_A \zeta}{\Omega_A + \zeta \Omega_A^\star} w L_A + \frac{\Omega_A}{\zeta \Omega_A + \Omega_A^\star} w^\star L_A^\star$$

- Suppose that both countries are imperfectly specialized $\Omega_A, \Omega_B, \Omega_A^\star, \Omega_B^\star > 0$

EQUILIBRIUM WITH TRADE: LABOR MARKET CLEARING

- Divide through by Ω_A and $\Omega_A^\star$ respectively and notice that $w = w^\star, p_A = p_A^\star$, and $q_A = q_A^\star$:

$$\frac{L_A}{L_A^\star} = \frac{\Omega_A + \zeta\Omega_A^\star}{\zeta\Omega_A + \Omega_A^\star} \Rightarrow \frac{\Omega_A}{\Omega_A^\star} = \frac{\frac{L_A}{L_A^\star} - \zeta}{1 - \zeta\frac{L_A}{L_A^\star}}$$

- If $L_A = L_A^\star$ then mass of size of industry A the same.
- For $\zeta < L_A/L_A^\star < 1/\zeta$ (range of incomplete specialization), a rise in the relative size of $L_A/L_A^\star$ leads to a rise of home's share in the industry.
- So labor market clearing across countries pins down sector size now!

VOLUME AND PATTERN OF TRADE

- Home's *sectoral* trade balance for industry A:

$$T_A = \frac{\zeta \Omega_A}{\zeta \Omega_A + \Omega_A^\star} w L_A^\star - \frac{\zeta \Omega_A^\star}{\Omega_A + \zeta \Omega_A^\star} w L_A = \frac{\zeta w L_A^\star}{\Omega_A \zeta + \Omega_A^\star} [\Omega_A - \Omega_A^\star]$$

- But we just showed that industry A is larger at home if it has a larger share of type A workers!
  - So home is a net exporter of industry A if it has a larger relative home market for industry A
- With transport cost and IRS: differences in demand matter for patterns of trade!
  - Increases in relative demand lead to more than proportionate increase in supply!

TAKE-AWAYS

- In Constant Returns to Scale world, increases in home demand lead either to proportional or less than proportional increase in local production
- The gravity equation is not a good test of IRS+transport cost since other models make this prediction.
  - Implications like scale effects on firm level or home market effect can be used to test increasing IRS+transport cost (see Davis Weinstein 1999, 2003)

GENERAL VERSION

KRUGMAN (1980): PREFERENCES

- Krugman re-writes the representative consumer's utility function as follow:

$$U_j = \left(\sum_{\omega \in \Omega} a_{ij}(\omega)^{1/\sigma} q_{ij}(\omega)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} = \left(\sum_{i \in S} \int_{\Omega_i} q_{ij}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$

- We can user our previous results for demand

$$q_{ij}(\omega) = p_{ij}(\omega)^{-\sigma} X_j P_j^{\sigma-1} \quad \text{where} \quad P_j \equiv \left(\sum_{i \in S} p_{ij}(\omega)^{1-\sigma)} d\omega \right)^{\frac{1}{1-\sigma}}$$

- …and trade flows:

$$x_{ij}(\omega) = p_{ij}(\omega)^{1-\sigma} X_j P_j^{\sigma-1} \quad X_{ij} = \int_{\Omega_i} x_{ij}(\omega) d\omega = X_j P_j^{\sigma-1} \int_{\Omega_i} p_{ij}(\omega)^{1-\sigma} d\omega$$

KRUGMAN (1980): FIRMS

- Firms in country i have the same productivity z_i and produce using labor only.
- The optimization problem faced by firm ω in country i is:

$$\max_{\{p_j(\omega)\}_j} \left(\sum_{j \in S} (p_j(\omega) q_j(\omega) - w_i \frac{\tau_{ij}}{z_i} q_j(\omega) \right) - w_i f_i^e \text{ s.t. } q_j(\omega) = p_j(\omega)^{-\sigma} X_j P_j^{\sigma-1}$$

- Subbing in the constraint:

$$\max_{\{p_j(\omega)\}_j} \left(\sum_{j \in S} p_j(\omega)^{1-\sigma} X_j P_j^{\sigma-1} - w_i \frac{\tau_{ij}}{z_i} p_j(\omega)^{-\sigma} X_j P_j^{\sigma-1}(\omega) \right) - w_i f_i^e$$

- Constant marginal cost imply that can consider each destination a separate problem

KRUGMAN (1980): FIRMS

- Profit maximization implies the following optimal pricing:

$$p_{ij}(z_i) = \frac{\sigma}{\sigma - 1}\frac{\tau_{ij}w_i}{z_i}$$

- We can drop the ω since all firms in i make the same optimal decisions.
    - We carry the z_i for contrast with the heterogeneous firm case
    - In Melitz (2003) firms in country i will differ in their productivity

KRUGMAN (1980): GRAVITY

- We substitute the optimal pricing equation into the bilateral trade expression:

$$X_{ij} = X_j P_j^{\sigma-1} \int_{\Omega_i} (\frac{\sigma}{\sigma-1}\frac{\tau_{ij} w_i}{z_i})^{1-\sigma} d\omega = (\frac{\sigma}{\sigma-1})^{1-\sigma} \tau_{ij}^{1-\sigma} (\frac{w_i}{z_i})^{1-\sigma} N_i X_j P_j^{\sigma-1}$$

- Where N_i is the measure of firms producing in country i
- Compare this to gravity equation in Armington model:
  - Additional term relating to markups: all else equal reduces trade
  - Additional term relating to number of firm: need additional eq. condition

KRUGMAN (1980): WELFARE

- With firm profits the real wage no longer equals welfare of consumers
  - Need an additional restriction: will assume free entry driving profits to zero
- Can derive an expression for real wages similar to Armington model:

$$\frac{w_j}{P_j} = (\frac{\sigma - 1}{\sigma})N_j^{\frac{1}{\sigma - 1}} z_j \lambda_{jj}^{\frac{1}{1-\sigma}}$$

- Recall from Armington:

$$U_j = \frac{w_j}{P_j} = a_{jj}^{\frac{1}{\sigma - 1}} A_j \lambda_{jj}^{\frac{1}{1-\sigma}} = A_j \lambda_{jj}^{\frac{1}{1-\sigma}}$$

  - Last equality because Krugman assumed $a_{ji} = 1 \, \forall j, i$

NEW GAINS FROM TRADE

NEW SOURCES OF GAINS

- Get access to foreign varieties+love for varieties [Krugman with CES]
- Lower price from larger scale at home firms [Krugman without CES]
- Lower price from decrease in markup [Krugman without CES]
- Selection of better firms? [Not yet, all firms the same]
    - Melitz (2003) [his JMP!!!] which is up next