

# International Economics I

## Lecture Set 4: The Krugman model

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# Goals and Plan

- with increasing returns to scale at the firm level:
  - perfect competition assumption fails → problem
- solve it with two assumptions of the "New" trade theory:
  - *differentiated goods*
  - *monopolistic competition*
- allowing us to consider
  - intra-industry trade (each country imports and exports different varieties of the same good)
  - trade between similar countries (e.g., North-North)

# Increasing Returns and Differentiated Goods: Intuition

- consider differentiated goods within a sector:
  - e.g., iPhone and Galaxy S are 2 varieties perceived as imperfect substitutes
- internal economies of scale imply:
  - each variety is cheaper if production is concentrated in one large firm
  - Apple is located in one country (US) and Samsung possibly in another (Korea)
- in both countries, some prefer Apple and some Samsung
- trade allows both varieties to be sold in both countries
- gains:
  - Americans (Koreans) preferring Samsung (Apple) are happier
  - "competition" with foreign variety reduces the price of both
- this theory (from the 80s) earned Krugman the Nobel prize in 2008

## Increasing Returns: A Problem

- assume production requires:
  - fixed input of  $F$  units of labor (building a plant or designing a product)
  - variable input of  $\beta$  units of labor per unit of output
  - total cost of producing  $q$  units:

$$TC = (F + \beta q) w$$

- $w =$  wage;  $Fw =$  fixed cost;  $\beta w =$  marginal cost ( $MC$ )
- take wage as the numeraire ( $w = 1$ )
  - average production cost decreasing in  $q$

$$AC = F/q + \beta$$

- perfect competition is impossible
  - firms selling at  $MC$  make losses
  - the firm that produces more can sell cheaper and get all the market

# Differentiated Goods + Monopolistic Competition

- assume  $n$  firms in the sector (economy)
- each firm produces a different variety of the same good
  - varieties are imperfect substitutes
    - consumers are willing to pay more to have them all
  - each firm has market power over its variety (monopoly)
- each firm chooses price to maximize profit
  - taking the demand for its variety as given (as in monopoly)
  - without considering the effect of its price on market conditions (as in perfect competition)

## The Model: Preferences and Demand

- consider a country with  $L$  agents (work & consume)
- consumers draw utility from the  $n$  varieties

$$U = \sum_{i=1}^n c_i^\alpha \quad \alpha \in (0, 1)$$

- love of variety: consumers are happier the more varieties they have
  - assume consumption of each variety  $c_i = c = C/n$  (equal shares of total consumption)
  - then  $U = n(C/n)^\alpha = C^\alpha n^{1-\alpha}$ , increasing in  $n$  since  $\alpha \in (0, 1)$
- individual demand of each variety  $i$  is the solution to

$$\begin{aligned} \max_{c_i} \quad & \sum_{i=1}^n c_i^\alpha \\ \text{s.t.} \quad & w \geq \sum_{i=1}^n p_i c_i \end{aligned}$$

- $w$  = income,  $p_i$  = price of  $i$

## The Model: Demand

- to obtain demand, set the Lagrangean

$$\mathcal{L} = \sum_{i=1}^n c_i^\alpha - \lambda \left( \sum_{i=1}^n p_i c_i - w \right)$$

- the f.o.c. for  $c_i$  requires that

$$\alpha c_i^{\alpha-1} = \lambda p_i$$

- demand of variety  $i$  relative to  $j$  is

$$\frac{c_i}{c_j} = \left( \frac{p_i}{p_j} \right)^{-\frac{1}{1-\alpha}}$$

- demand for each variety  $i$  is

$$c_i = \frac{w}{P} \left( \frac{P}{p_i} \right)^{\frac{1}{1-\alpha}}$$

- $P = \left[ \sum_{i=1}^n p_i^{-\alpha/(1-\alpha)} \right]^{-(1-\alpha)/\alpha}$  is the price index (note:  $P$  decreasing in  $n$ )

# The Model: Demand

- – the price-elasticity of demand is

$$\epsilon_p = \frac{\% \Delta c_i}{\% \Delta p_i} = - \frac{\partial \ln c_i}{\partial \ln p_i} = \frac{1}{1 - \alpha}$$

$\epsilon_p$  is increasing in  $\alpha$

- the elasticity of substitution between any two varieties is

$$\epsilon_{ij} = \frac{\% \Delta (c_i/c_j)}{\% \Delta (p_i/p_j)} = - \frac{\partial \ln (c_i/c_j)}{\partial \ln (p_i/p_j)} = \frac{1}{1 - \alpha}$$

$\epsilon_{ij}$  is increasing in  $\alpha$

- we interpret  $\alpha$  as the substitutability between varieties



# The Model: Firms and Prices

- firm producing variety  $i$  chooses its quantity (or alternatively its price) so as to
  - maximize profit  $\pi_i$ , given aggregate demand  $q_i = Lc_i$  and  $w = 1$

$$\begin{aligned} & \max_{q_i} [\pi_i = p_i q_i - (F + \beta q_i)] \\ \text{s.t. } & q_i = (P/p_i)^{1/(1-\alpha)} L/P \Leftrightarrow p_i = (L/q_i)^{(1-\alpha)} P^\alpha \end{aligned}$$

- the f.o.c. requires that

$$p_i + \frac{\partial p_i}{\partial q_i} q_i = \beta$$

- differentiate  $p_i$  with respect to  $q_i$  and using the aggregate demand to obtain

$$p_i - (1 - \alpha) \left( \frac{L}{q_i} \right)^{(1-\alpha)} P^\alpha = \beta$$

hence

$$p_i = \frac{\beta}{\alpha} \quad \text{and} \quad q_i = \left( \frac{P\alpha}{\beta} \right)^{1/(1-\alpha)} \frac{L}{P}$$

# Monopolistic Competition Pricing and Scale

- $p_i$  equals perfect-competition price \* mark-up

$$p_i = \underset{\text{marginal cost}}{\beta} * \underset{\text{mark-up}}{\frac{1}{\alpha}} > \beta$$

- higher elasticity of substitution ( $\alpha \uparrow$ ):
  - firms have less market power
  - firms can charge lower mark-up  $\rightarrow$  lower price ( $\alpha \uparrow \rightarrow p \downarrow$ )
- same technology + isoelastic demand imply
  - same price ( $p_i = p$ )
  - same scale ( $q_i = q = (P/p)^{1/(1-\alpha)} L/P$ )

# Monopolistic Competition: Free Entry

- all firms have the same scale and prices, hence profits

$$\pi = A\beta^{-\frac{\alpha}{1-\alpha}} - F$$

with  $A \equiv (1 - \alpha)L (\alpha P)^{\alpha/(1-\alpha)}$

- profit decreasing in marginal and fixed cost  $\beta$  and  $F$
- profit increasing in mkt size  $L$  and price index  $P$

- re-write profit as

$$\pi = \left( \frac{\beta}{\alpha} - \beta \right) q - F = 0$$

- new firms (i.e., varieties) enter the sector as long as  $\pi > 0$
- in equilibrium, entry drives profit to zero  $\rightarrow$  obtain scale  $q$

$$q = \frac{\alpha}{1 - \alpha} \frac{F}{\beta}$$

## Equilibrium Varieties

- to obtain the equilibrium number of varieties,  $n$ , impose labor market clearing:
  - supply =  $L$  workers
  - demand = workers needed in overall production (fixed+variable)

$$L = (F + \beta q) n = F \left( 1 + \frac{\alpha}{1 - \alpha} \right) n$$

- hence

$$n = \frac{L}{F} (1 - \alpha)$$

- larger economies produce more varieties ( $L \uparrow \rightarrow n \uparrow$ )
- the higher the fixed cost the fewer varieties ( $F \uparrow \rightarrow n \downarrow$ )
- the higher the elasticity of substitution the fewer varieties ( $\alpha \uparrow \rightarrow n \downarrow$ )

# Equilibrium in Open Economy

- consider 2 countries:
  - same technology  $(F, \beta)$  and preferences  $(\alpha)$ 
    - all firms charge the same price  $(p = p^*)$
    - and produce the same quantities  $(q = q^*)$
  - possibly different country size  $(L \neq L^*)$ 
    - different number of varieties

$$n = \frac{L}{F} (1 - \alpha) \neq \frac{L^*}{F} (1 - \alpha) = n^*$$

# Gains From Trade

- consumers in both countries can consume more varieties ( $n + n^*$ )
- utility is increasing in  $n$ 
  - utility in autarky and free trade

$$U_A = n \left( \frac{q}{L} \right)^\alpha \quad \text{and} \quad U_{FT} = (n + n^*) \left( \frac{q}{L + L^*} \right)^\alpha$$

- GFT: utility is higher under free trade

$$\frac{U_{FT}}{U_A} = \frac{n + n^*}{n} \left( \frac{L}{L + L^*} \right)^\alpha = \left( \frac{L + L^*}{L} \right)^{1-\alpha} > 1$$

- new type of GFT: gains from variety
  - gains are lower if varieties are better substitutes ( $\alpha \uparrow \rightarrow U_{FT}/U_A \downarrow$ )
  - gains are higher for smaller countries
    - if  $L^* > L \rightarrow (L + L^*)/L > (L + L^*)/L^*$

## Pattern of Trade

- each country exports its varieties and imports the foreign ones

$$X = \frac{L^*}{L^* + L} nq \quad \text{and} \quad M = \frac{L}{L^* + L} n^* q$$

- all firms in both countries are exporters
- trade is intra-industry trade
  - export and import same good (different varieties)

## Extension: Pro-Competitive GFT

- assume that  $\alpha$  is increasing in  $n$ 
  - smartphones become better substitutes as more varieties enter the market (e.g., HTC, Motorola, Nokia, Sony etc.)
  - monopoly power erodes as  $n$  increases
  - mark-ups and prices fall:  $n \uparrow \rightarrow \alpha \uparrow \rightarrow p \downarrow$
  - profits fall  $\rightarrow$  less entry
- effects of trade
  - varieties increase by less:  $n_{FT} < n_A$ ,  $n_{FT}^* < n_A^*$
  - less gains from variety
  - prices fall  $\rightarrow$  pro-competitive GFT



## Evidence on Intra-Industry Trade (IIT)

- how to measure IIT?
- Grubel y Lloyd index ( $IIT$ ):

$$IIT_j = 1 - \frac{|e_j - i_j|}{e_j + i_j}$$

- $j$  = sector (more or less disaggregated definition)
- $e$  = export of the sector
- $i$  = import of the sector
- $IIT_j = 0$  if  $j$  only imports or exports (no IIT)
- $IIT_j = 1$  if  $j$  imports as much as it exports (max IIT)
- $IIT$  higher for differentiated and high-tech goods

# Intra-Industry Trade: Data

United States		Germany	
Top 10 products			
Product (SITC-2)	Grubel Lloyd Index	Product (SITC-2)	Grubel Lloyd Index
Metalworking machinery	0.9980	Crude fertilizer/mineral	0.985
Dairy products & eggs	0.9941	Leather manufactures	0.975
Leather manufactures	0.9915	Railway/tramway equipment	0.970
Power generating equipment	0.9876	Sugar/sugar prep/honey	0.966
Electrical equipment	0.9740	Non-ferrous metals	0.953
Perfume/cosmetic/...	0.9479	Meat & preparations	0.947
Crude fertilizer/mineral	0.9405	Furniture/furnishings	0.946
Animal/veg oils processed	0.9393	Coffee/tea/cocoa/spices	0.946
Industry special machine	0.9186	Animal feed	0.937
Plastics non-primary form	0.9009	Organic chemicals	0.935
Bottom 10 products			
Cork/wood manufactures	0.2876	Dyeing/tanning/...	0.55
Furniture/furnishings	0.2830	Metalworking machinery	0.54
Gas natural/manufactured	0.2727	Fixed veg oils/fats	0.47
Petroleum and products	0.1798	Industry special machine	0.45
Travel goods/handbag/etc	0.1612	Vegetables and fruit	0.45
Hide/skin/fur, raw	0.1590	Pulp and waste paper	0.44
Oil seeds/oil fruits	0.1384	Petroleum and products	0.40
Apparel/clothing/access	0.1135	Gas natural/manufactured	0.24
Footwear	0.1110	Oil seeds/oil fruits	0.18
Manufactured fertilizers	0.0789	Coal/coke/briquettes	0.13

# Horizontal vs Vertical IIT

- the *IIT* index has 2 potential limitations
  - the less disaggregated the sectors, the higher *IIT*
  - *IIT* does not distinguish between intermediates (engines) and final goods (cars) within a sector
- solution: 2 indexes computed on super-disaggregated data
  - "vertical" *IIT*: intermediate goods imported and exported in the same industry
  - "horizontal" *IIT*: similar final goods imported and exported in the same industry
- both *IIT* predominant between similar (advanced) countries
- unidirectional trade predominant between different countries (North-South)

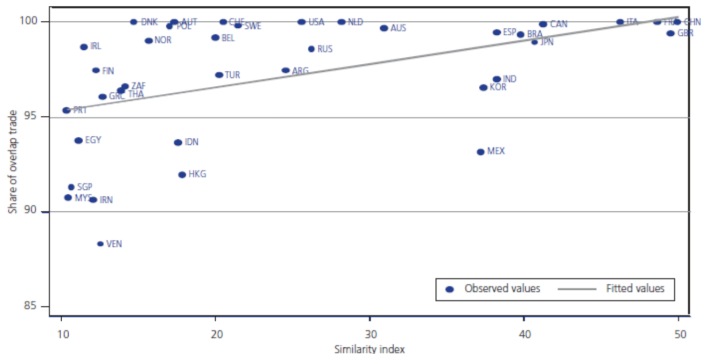
# Intra-Industry Trade: Data

- share of German trade with its partners
- share of German trade with its partners

Partner	Horizontal	Partner	Vertical	Partner	One way
United Kingdom	0.56	Malaysia	0.49	Bangladesh	1.00
Switzerland	0.53	Italy	0.41	Zimbabwe	0.99
France	0.52	Spain	0.39	Madagascar	0.98
Austria	0.51	Belgium	0.38	Algeria	0.98
Netherlands	0.49	Portugal	0.37	Nigeria	0.97
Denmark	0.49	Netherlands	0.37	Macao, China	0.97
Czech Republic	0.47	France	0.36	Panama	0.97
US	0.47	Slovenia	0.35	FYROM	0.97
Belgium	0.45	Sri Lanka	0.34	Iran	0.96
Singapore	0.44	Hong Kong, China	0.34	Ghana	0.96

# Intra-Industry Trade and Similarity

Intra-industry trade and similarity in economic size, selected trading partners, Germany, 2004  
(Percent)



# Summary

- IRS + differentiated goods → monopolistic competition
  - monopolist's price is decreasing in substitutability
- larger markets → more varieties
- more varieties → happier consumers
- effect of trade = increase market size
  - more varieties → more varieties can be consumed in both countries
  - gains from trade = gains from variety
- pattern of specialization and trade
  - each country specializes in a number of different varieties depending on its size
  - each country exports all domestic and imports all foreign varieties: intra-industry trade
- smaller countries benefit more from trade