PhD Topics in Macroeconomics

Lecture 13: heterogeneous firms and trade, part one

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This lecture

Krugman (1980) model of scale economies, monopolistic competition and intraindustry trade

1- Closed economy model of monopolistic competition

2- Two-country open economy with variable trade costs

3- Gains from trade and implications for aggregate trade flows

Background

- Traditional motives for trade depend on differences between countries
  - differences in technology (Ricardo)
  - differences in factor endowments (Heckscher/Ohlin)
- But much actual trade is between similar countries and in similar goods, that is *intraindustry trade*
- Krugman develops model with trade due to *scale economies*
  - even identical countries will trade with each other

Model: key features

- Monopolistic competition with CES demand
- Increasing returns to scale in production
- Multiplicative variable trade costs

Closed economy: consumers

- Representative consumer, inelastic labor supply L

- CES consumption aggregate over symmetric varieties

$$C = \left(\int_{\Omega} c(\omega)^{\frac{\sigma-1}{\sigma}} \, d\omega \right)^{\frac{\sigma}{\sigma-1}}, \qquad \sigma > 1$$

for some set Ω of varieties (to be determined endogenously)

- Budget constraint

$$PC = \int_{\Omega} p(\omega) c(\omega) \, d\omega \leq wL$$

(implicitly defines ideal price index P)

Demand and price index

- Demand for each variety

$$c(\omega) = \left(\frac{p(\omega)}{P}\right)^{-\sigma} C, \qquad \omega \in \Omega$$

with demand elasticity $\sigma > 1$

- Implies CES price index

$$1 = \int_{\Omega} \frac{p(\omega)c(\omega)}{PC}\, d\omega = \int_{\Omega} \left(\frac{p(\omega)}{P}\right)^{1-\sigma} d\omega$$

so that

$$P = \left(\int_{\Omega} p(\omega)^{1-\sigma}\, d\omega\right)^{\frac{1}{1-\sigma}}$$

Firms

- Each ω produced by monopolist (costless product differentiation)

- Labor $l(y)$ required to produce y units of output

$$l(y) = f + \frac{y}{a}$$

  Fixed cost $f > 0$, marginal cost $1/a$ (productivity a)

- Average cost $l(y)/y$ declining in y, *increasing returns to scale*

- Firms maximize profits

$$\pi = py - wl(y) = \left(p - \frac{w}{a}\right)y - wf$$

  subject to residual demand $y = c = (p/P)^{-\sigma}C$

- With constant demand elasticity $\sigma > 1$, solution is *constant markup* over marginal cost

$$p(\omega) = \frac{\sigma}{\sigma - 1}\frac{w}{a}, \qquad \omega \in \Omega$$

Quantity $y(\omega)$ then pinned down by market conditions

- Gross profits proportional to size

$$\pi(\omega) + wf = \left(p - \frac{w}{a}\right)y = \left(\frac{\sigma}{\sigma - 1} - 1\right)\frac{w}{a}y(\omega)$$

- Free entry then drives profits to zero

$$\pi(\omega) = 0 \qquad \Leftrightarrow \qquad wf = \left(\frac{1}{\sigma - 1}\right)\frac{w}{a}y(\omega)$$

$$\Leftrightarrow \qquad y(\omega) = (\sigma - 1)\, a\, f, \qquad \omega \in \Omega$$

Number of varieties

- Number of varieties that can be produced under these conditions determined by labor market clearing

$$L = \int_\Omega l(y(\omega))\, d\omega = \int_\Omega \left(f + \frac{y(\omega)}{a}\right) d\omega = \int_\Omega \left(f + \frac{(\sigma-1)af}{a}\right) d\omega$$

or

$$n = \frac{L}{\sigma f}, \qquad n := \int_\Omega d\omega$$

- Adam Smith: "division of labor limited by extent of the market".

Price index and welfare

- Price index

$$P = \left(\int_\Omega p(\omega)^{1-\sigma} \, d\omega \right)^{\frac{1}{1-\sigma}} = pn^{\frac{1}{1-\sigma}}$$

so decreasing in number of varieties. Using solutions for p and n

$$P = \frac{\sigma}{\sigma - 1} \frac{w}{a} \left(\frac{L}{\sigma f} \right)^{\frac{1}{1-\sigma}}$$

- Welfare

$$C = \left(\int_\Omega c(\omega)^{\frac{\sigma-1}{\sigma}} \, d\omega \right)^{\frac{\sigma}{\sigma-1}} = yn^{\frac{\sigma}{\sigma-1}} \qquad (= Y)$$

so increasing in number of varieties. Using solutions for y and n

$$\frac{Y}{L} = \frac{w}{P} = \left[\frac{\sigma - 1}{\sigma} \left(\frac{L}{\sigma f} \right)^{\frac{1}{\sigma-1}} \right] a$$

Open economy

- Two countries, identical except for size L, L^*

- No fixed cost of trade

- Variable *trade costs* of the '*iceberg*' form: for every $\tau \geq 1$ units shipped, only 1 unit arrives

- Segmented markets:

$$\text{domestic price (f.o.b.)} = p = \frac{\sigma}{\sigma - 1} \frac{w}{a}$$

$$\text{export price (c.i.f.)} = \tau p$$

Likewise $p^*, \tau p^*$ set by foreign firms

Aggregate price indexes

- Number of varieties produced n, n^* (to be determined)
- Aggregate price index at home

$$P = \left[np^{1-\sigma} + n^*(\tau p^*)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

and abroad

$$P^* = \left[n(\tau p)^{1-\sigma} + n^*(p^*)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

- Trade will increase welfare through added varieties

Production and profits

- Firms produce y_d for domestic market and τy_x for export market

$$y = y_d + \tau y_x$$

- Profits from both markets

$$\begin{aligned}\pi &= \Big(py_d + (\tau p)y_x\Big) - \Big(\frac{w}{a}y_d + \frac{w}{a}(\tau y_x)\Big) - wf \\ &= py - \frac{w}{a}y - wf \\ &= \frac{1}{\sigma-1}\frac{w}{a}y - wf\end{aligned}$$

- Hence as in closed economy, free-entry pins down quantity

$$\pi = 0 \qquad \Leftrightarrow \qquad y = (\sigma-1)af$$

and by symmetry $y^* = (\sigma-1)af$ too

Number of varieties in each country

- Labor market clearing pins down number of varieties

$$L = n\left(f + \frac{y}{a}\right) = n\sigma f \qquad \Rightarrow \qquad n = \frac{L}{\sigma f}$$

and

$$L^* = n^*\left(f + \frac{y^*}{a}\right) = n^*\sigma f \qquad \Rightarrow \qquad n^* = \frac{L^*}{\sigma f}$$

Discussion

- Scale of production unaffected by trade: y and n unchanged

- But increased range of goods for consumption, consumers have access to both n and n^*

  - consume *less* of each domestic good
  - but also access to new foreign goods, keeping production unchanged

- Opening from autarky ($\tau = +\infty$) to some amount of trade increases varieties from n to $n + n^*$

  - *extensive margin* of trade

- But further reductions in trade costs do not change number of varieties, remains $n + n^*$

  - now consume more of each foreign good (fewer icebergs ...)

Solving the model

- Still need to solve for wages w, w^*
- Solve for relative wage w/w^* such that trade is balanced

  (or clear market for domestic goods, or for foreign goods $\ldots$)

Aggregate trade flows

- Aggregate value of exports (f.o.b.) from home to foreign

$$X = n\tau p y_x = n(\tau p)\left(\frac{\tau p}{P^*}\right)^{-\sigma} Y^* = n(\tau p)\left(\frac{\tau p}{P^*}\right)^{-\sigma} \frac{w^* L^*}{P^*}$$

and on using the solutions for n and p

$$X = \lambda L L^* \left(\frac{\tau w}{P^*}\right)^{1-\sigma} w^*, \qquad \lambda := \frac{1}{\sigma f}\left(\frac{\sigma}{(\sigma-1)a}\right)^{1-\sigma}$$

- Likewise value of exports (f.o.b.) from foreign to home

$$X^* = \lambda L L^* \left(\frac{\tau w^*}{P}\right)^{1-\sigma} w$$

Aggregate trade flows

- Price indexes at home and foreign reduce to

$$P = \left[\lambda\left(Lw^{1-\sigma} + L^*(\tau w^*)^{1-\sigma}\right)\right]^{\frac{1}{1-\sigma}}$$

and

$$P^* = \left[\lambda\left(L(\tau w)^{1-\sigma} + L^*(w^*)^{1-\sigma}\right)\right]^{\frac{1}{1-\sigma}}$$

- Therefore aggregate trade flows are

$$X = LL^* \frac{(\tau w)^{1-\sigma}}{L(\tau w)^{1-\sigma} + L^*(w^*)^{1-\sigma}} w^*$$

$$X^* = LL^* \frac{(\tau w^*)^{1-\sigma}}{Lw^{1-\sigma} + L^*(\tau w^*)^{1-\sigma}} w$$

Balanced trade $X = X^*$

- Hence balanced trade requires

$$\frac{(\tau w)^{1-\sigma}}{L(\tau w)^{1-\sigma} + L^*(w^*)^{1-\sigma}} w^* = \frac{(\tau w^*)^{1-\sigma}}{L w^{1-\sigma} + L^*(\tau w^*)^{1-\sigma}} w$$

- Implicitly determines relative wage w/w^*. If $\tau > 1$ then

$$L = L^* \quad \Rightarrow \quad w = w^*$$

$$L > L^* \quad \Rightarrow \quad w > w^*$$

- Special case $\tau = 1$ (costless trade) implies $w = w^*$ independent of L, L^* and trade flows

$$X = \frac{LL^*}{L + L^*}$$

Wages and market size

- If $\tau > 1$, then higher nominal wages w in large market. Why?

- In a large market,

  – more domestic varieties n, lower price index

  – consumers relatively less inclined to import foreign goods (‘resistance’)

  – relative wage w/w^* appreciates to balance trade

- Since lower price index in large market, real wage w/P higher too

Welfare

- Real wage (= output/worker) in home country

$$w/P = w\Big(\lambda\Big(Lw^{1-\sigma} + L^*(\tau w^*)^{1-\sigma}\Big)\Big)^{\frac{1}{\sigma-1}}$$

- Holding w/w^* fixed ('partial equilibrium')
  - decrease in trade costs τ increases welfare, access to foreign goods at lower price
  - increase in size L or L^* increases welfare, more varieties produced

Krugman 1979

- Departs from CES demand, has

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

but $u(c)$ not isoelastic, assumes elasticity

$$\varepsilon(c) := -\frac{u'(c)}{u''(c)c}$$

is decreasing in c (more elastic as move up demand curve)

- Firms set prices

$$p = \frac{\varepsilon(c)}{\varepsilon(c) - 1} \frac{w}{a}$$

but now markup is increasing in c

Krugman 1979

- Closed economy solution

- Zero profits (price = average cost)

$$\pi = 0 \qquad \Leftrightarrow \qquad \frac{p}{w} = \frac{1}{a} + \frac{f}{Lc}, \qquad (y = Lc) \qquad (*)$$

- Marginal revenue = marginal cost

$$\frac{p}{w} = \frac{\varepsilon(c)}{\varepsilon(c) - 1} \frac{1}{a} \qquad (**)$$

- Solve $(*)$ and $(**)$ for p/w and c, then $y = Lc$ and $n = L/(f + y/a)$

- Opening to trade now changes both quantities produced y and number of producers n. Exit of some domestic producers, but foreign products now also available. Scale and selection effects

Next

- Heterogeneous firms and international trade, part two
  - MELITZ (2003): The impact of trade of intra-industry reallocations and aggregate industry productivity, *Econometrica*.
- Further reading
  - MELITZ AND REDDING (2014): Heterogeneous firms and trade, *Handbook of International Economics*.