PhD Topics in Macroeconomics

Lecture 18: aggregate gains from trade, part two

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This lecture

Arkolakis, Costinot, Donaldson and Rodríguez-Clare (2012wp)

1- Absence of '*pro-competitive*' effects of trade in monopolistic competition models with variable markups

- main result, sufficient conditions
- examples

2- Importance of *joint distribution* of markups and employment

- unconditional markup distribution invariant to trade costs
- but joint distribution not invariant

ACR vs. ACDR

- **ACR**: class of 'quantitative trade models' for which the gains from trade can be written

$$\widehat{C} = -\frac{1}{\varepsilon}\widehat{\lambda}$$

where $\widehat{C}$ is the change in real consumption/income and $\widehat{\lambda}$ is the change in spending on domestic goods

- **ACDR**: generalized formula for when markups are not constant

$$\widehat{C} = -(1-\eta)\frac{1}{\varepsilon}\widehat{\lambda}$$

where $\eta \in [0,1]$ is a constant that depends on model details

$$\widehat{C} = -(1-\eta)\frac{1}{\varepsilon}\widehat{\lambda}$$

- Since $\eta \in [0, 1]$ gains are generally *smaller* than ACR benchmark
- That is, *in aggregate* there are no 'pro-competitive effects' from variable markups
- Mechanisms
  - markups change for both domestic and foreign producers
  - incomplete pass-through from marginal costs to prices
  - labor reallocation towards low-productivity/high-price goods (*)

Model

- Countries $i = 1, ..., N$ of sizes L_i
- Labor is only factor of production and is in inelastic supply
- Monopolistic competition with differentiated goods $\omega \in \Omega$
- Variable markups through *non-CES* preferences

  (i) separable but non-CES (Krugman 1979)
  (ii) quadratic, non-separable (Melitz/Ottaviano 2008) [* in extension]
  (iii) 'symmetric' translog (Feenstra 2003)

  encompassed by general demand system

Demand system

- In log levels, demand for good ω is

$$\log c(\omega) = -\beta \log p(\omega) + \gamma \log w + D(\log(p(\omega)/p^*))$$

given income w and critical price p^*

- *Own-price elasticity*

$$-\frac{d \log c(\omega)}{d \log p(\omega)} = \beta - D'(\log(p(\omega)/p^*))$$

hence markups will be variable under monopolistic competition

- Prices of goods $\omega' \neq \omega$ enter only via aggregate statistic p^*

- *Cross-price elasticity*

$$-\frac{d \log c(\omega)}{d \log p^*} = D'(\log(p(\omega)/p^*))$$

Difference between own and cross price elasticities is constant $(= \beta)$ and independent of ω, ω' [hence 'symmetric' translog]

Example

- Krugman (1979), maximize

$$U = \int u(c(\omega))\, d\omega, \qquad \text{subject to} \qquad \int p(\omega)c(\omega)\, d\omega \leq wL$$

with first order condition

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

- Hence

$$\log c(\omega) = D(\log(p(\omega)/p^*))$$

where

$$p^* := 1/\lambda, \qquad \text{and} \qquad D(x) := \log\left[u'^{\,-1}(\exp(x))\right]$$

- Special case obtained by setting $\beta = \gamma = 0$ and then $D(x)$ as above

Key assumptions

Demand system

A1 Parameter values: $\beta = \gamma \leq 1$

e.g., separable non-CES $\beta = \gamma = 0$
symmetric translog $\beta = \gamma = 1$

A2 Choke price: $D(x) = -\infty$ for all $x \geq 0$

i.e., no producer can profitably operate with $p(\omega) > p^*$

A3 Log-concavity: $D''(x) < 0$ for all $x \leq 0$

Key assumptions

Firms

A4 Firm-level productivity is Pareto with

$$G_i(a) := \text{Prob}[a' \leq a] = 1 - T_i a^{-\xi}, \qquad \xi > \beta - 1$$

- Monopolistic competition with free entry subject to fixed cost
- Iceberg trade costs τ_{ij}, unit cost to deliver from i to j is $\tau_{ij} w_i / a$
- With Pareto all ACR 'macro-level' assumptions satisfied: constant profit share and gravity equation with constant trade elasticity

Firm problem

- Firm marginal cost $\tau_{ij} w_i / a$, demand $c(p, p^*, w)$ taken as given

- Standard first-order condition, price solves

$$p = \frac{\varepsilon(p, p^*, w)}{\varepsilon(p, p^*, w) - 1} \frac{\tau_{ij} w_i}{a}$$

where the demand elasticity is, as above,

$$\varepsilon(p, p^*, w) = -\frac{\partial \log c}{\partial \log p} = \beta - D'(\log(p/p^*))$$

Firm markups

- Let $m := \log(pa/\tau w) \geq 0$ denote log markup, let $v := \log(p^* a/\tau w)$ denote firm-specific efficiency relative to choke price

$$m - v = \log(p/p^*)$$

- Firm level markup $m = \mu(v)$ implicitly defined by

$$m = \log\left(\frac{\beta - D'(m-v)}{\beta - D'(m-v) - 1}\right)$$

- Can show

$$\mu'(v) \in [0, 1]$$

  That more efficient firms set higher markups follows from log-concavity (**A3**). That this elasticity is bounded above by 1 follows from (**A1**). Both aspects critical for signing effects below

Firm sales and profits

- Given this markup function, firm price is $p = e^{\mu(v)} \frac{\tau w}{a}$
- Firm sales $x = pc$ are then given by

$$x(a, v, w, L) = (e^{\mu(v)} \frac{\tau w}{a})^{1-\beta} (e^{D(\mu(v)-v)})\, w^{\gamma} L$$

- Firm profits are likewise

$$\pi(a, v, w, L) = \left(\frac{e^{\mu(v)} - 1}{e^{\mu(v)}} \right) x(a, v, w, L)$$

Aggregate sales and profits

- Let X_{ij} denote total sales from i to j and Π_{ij} denote total profits

- *Cutoff productivity*

  – only firms with marginal cost $\tau_{ij} w_i / a \leq p_j^*$ sell in country j
  – hence for each country i there is a cutoff productivity a_{ij}^* such that firm a from i sells in j if and only if

$$a \geq a_{ij}^* = \tau_{ij} w_i / p_j^* \quad \Leftrightarrow \quad v = \log(a/a_{ij}^*) \geq 0$$

- With n_i producers, total sales and total profits are

$$X_{ij} = n_i \int_{a_{ij}^*}^{\infty} x_{ij}\left(a \, , \, \log\left(\frac{a}{a_{ij}^*}\right) , \, w_j \, , \, L_j\right) dG_i(a)$$

$$\Pi_{ij} = n_i \int_{a_{ij}^*}^{\infty} \pi_{ij}\left(a \, , \, \log\left(\frac{a}{a_{ij}^*}\right) , \, w_j \, , \, L_j\right) dG_i(a)$$

Aggregate sales and profits

- Using the Pareto distribution $G_i(a)$, do the integration to get

$$X_{ij} = \bar{x} n_i T_i (\tau_{ij} w_i)^{-\xi} (p_j^*)^{1-\beta+\xi} w_j^{\gamma} L_j$$

$$\Pi_{ij} = \bar{\pi} n_i T_i (\tau_{ij} w_i)^{-\xi} (p_j^*)^{1-\beta+\xi} w_j^{\gamma} L_j$$

where $\bar{x}, \bar{\pi}$ are constants independent of i, j

- Hence profits are a constant share of total sales

$$\Pi_{ij} = \frac{\bar{\pi}}{\bar{x}} X_{ij}$$

- The constants $\bar{x}, \bar{\pi}$ depend on the cross-sectional distribution of markups, but are the same for every country. For example

$$\bar{x} = \xi \int_0^{\infty} e^{-(1-\beta)(v-\mu(v))+D(\mu(v)-v)-\xi v}\, dv$$

Thus this is really a consequence of the function $m = \mu(v)$ being independent of country details

Markup distribution

- Let $M_{ij}(m, \boldsymbol{\tau})$ denote distribution of markups from country i to j given trade costs $\boldsymbol{\tau} := \{\tau_{ij}\}$, that is

$$M_{ij}(m, \boldsymbol{\tau}) := \text{Prob}[\mu(v) \leq m \,|\, v \geq 0]$$

where

$$v = \log(a/a_{ij}^*)$$

- Write this in terms of joint probabilities

$$M_{ij}(m, \boldsymbol{\tau}) = \frac{\text{Prob}[\,\mu(\log(a_{ij}^*/a)) \leq m\,,\, \log(a_{ij}^*/a) \leq 0\,]}{\text{Prob}[\log(a_{ij}^*/a) \leq 0]}$$

- Using the fact that $m = \mu(v)$ is monotone increasing

$$M_{ij}(m, \boldsymbol{\tau}) = \frac{\int_{\log a_{ij}^*}^{\log a_{ij}^* - \mu^{-1}(m)} \tilde{g}_i(u)\, du}{T_i(a_{ij}^*)^{\xi}}$$

where $\tilde{g}_i(u) := \xi T_i e^{-\xi u}$ is the density of $u = \log a$ when a is Pareto

- Calculating the definite integral and simplifying

$$M_{ij}(m, \boldsymbol{\tau}) = 1 - e^{-\xi \mu^{-1}(m)} =: M(m)$$

- Since $\mu(v)$ is identical across countries and independent of $\boldsymbol{\tau}$, so too is the markup distribution $M(m)$ identical across countries and independent of $\boldsymbol{\tau}$

Discussion

- Consider a reduction in trade costs, reduces cutoff a_{ij}^*
- Two effects at work:

  (i) incumbents more efficient, increase markups [by **A3**]
  (ii) entry by relatively low-efficiency firms, reduces markups

- Overall effect of $\boldsymbol{\tau}$ depends on which of (i) or (ii) dominates.
  In turn, depends on whether $G_i(a)$ is log-concave or log-convex
- Pareto is *log-linear* specification for which (i) and (ii) exactly offset

Free entry and number of producers

- Free entry condition given fixed cost f_i in units of local labor

$$\sum_j \Pi_{ij} = n_i w_i f_i$$

- Market clearing

$$\sum_j X_{ij} = w_i L_i = X_i$$

- Given constant profit share

$$\sum_j \Pi_{ij} = \frac{\bar{\pi}}{\bar{x}} \sum_j X_{ij} \qquad \Rightarrow \qquad n_i = \frac{\bar{\pi}}{\bar{x}} \frac{L_i}{f_i}$$

- Entry level and aggregate profit share invariant to trade costs also

Gravity

- Can write bilateral spending X_{ij} in terms of a gravity equation

$$X_{ij} = \frac{n_i T_i (\tau_{ij} w_i)^{-\xi}}{\sum_k n_k T_k (\tau_{kj} w_k)^{-\xi}} X_j$$

  where $X_j = \sum_k X_{kj}$ denotes total expenditure

- Model satisfies all three of ACR's macro-level restrictions (including strong form of 'CES import demand system')

- However, the micro-level differences (variable markups) will now give rise to different aggregate welfare implications

Sketch of derivation

- Let E_j denote expenditure to obtain initial utility

- Envelope theorem, for each variety ω

$$\frac{dE_j}{dp_j(\omega)} = c_j(\omega)$$

- Adding up across varieties $\omega \in \Omega_{ij}$

$$dE_j = \sum_i \int_{\Omega_{ij}} c_j(\omega) dp_j(\omega)\, d\omega$$

or in log deviation form (relative to initial equilibrium)

$$\widehat{E}_j = \sum_i \int_{\Omega_{ij}} \frac{p_j(\omega) c_j(\omega)}{E_j} \widehat{p}_j(\omega)\, d\omega$$

$$= \sum_i \int_{\Omega_{ij}} \lambda_j(\omega) \widehat{p}_j(\omega)\, d\omega$$

- Replacing price changes with marginal cost changes plus markup changes and then using the LLN gives

$$\widehat{E}_j = \sum_i \int_{a_{ij}^*}^{\infty} \lambda_{ij}(a) \Big[\widehat{\tau}_{ij} + \widehat{w}_i + \widehat{m}_{ij}(a) \Big] \, dG_i(a)$$

- This simplifies to

$$\widehat{E}_j = \sum_i \lambda_{ij} \Big[\widehat{\tau}_{ij} + \widehat{w}_i - \rho \widehat{a}_{ij}^* \Big]$$

where $\lambda_{ij} = X_{ij}/X_j$ and where the coefficient ρ is a weighted average of firm-level markup elasticities

$$\rho := \int_0^{\infty} \mu'(v) \frac{e^{-(1-\beta)(v-\mu(v)+D(\mu(v)-v)-\xi v)}}{\int e^{-(1-\beta)(v'-\mu(v')+D(\mu(v')-v')-\xi v')} \, dv'} \, dv \in [0,1]$$

where the weights are simply the expenditure shares on goods of relative efficiency v and $\rho \in [0,1]$ since $\mu'(v) \in [0,1]$ for all v

Direct and indirect effects

- Now since $a_{ij}^* = \tau_{ij} w_i / p_j^*$ can also write this as

$$\widehat{E}_j = \sum_i \lambda_{ij}(\widehat{\tau}_{ij} + \widehat{w}_i) - \rho \sum_i \lambda_{ij}(\widehat{\tau}_{ij} + \widehat{w}_i) + \rho\, \widehat{p}_j^*$$

- Influence of variable markups broken into (i) a 'direct effect' and (ii) an indirect 'GE effect'

  (i) firms more productive because of lower trade costs, but incomplete pass-through means full reduction in marginal cost not passed on to consumers

  (ii) lower trade costs reduces choke price, $\widehat{p}_j^* < 0$ so there also a pro-competitive gain

- But is there a *net* pro-competitive gain? Need to determine the relative strengths of the direct and indirect effects

Relative strengths

- Market clearing can be written

$$w_j L_j = \sum_i X_{ij} = \sum_i \bar{x} n_i T_i (\tau_{ij} w_i)^{-\xi} (p_j^*)^{1-\beta+\xi} w_j^{\gamma} L_j$$

- Taking log-deviations and simplifying

$$\widehat{p}_j^* = \frac{1-\gamma}{1-\beta+\xi} \widehat{w}_j + \frac{\xi}{1-\beta+\xi} \sum_i \lambda_{ij} (\widehat{\tau}_{ij} + \widehat{w}_i)$$

- Using this to eliminate the choke price and recalling $\gamma = \beta$ by **A1**

$$\widehat{E}_j = \rho \frac{1-\beta}{1-\beta+\xi} \widehat{w}_j + \left[1 - \rho \left(\frac{1-\beta}{1-\beta+\xi} \right) \right] \sum_i \lambda_{ij} (\widehat{\tau}_{ij} + \widehat{w}_i)$$

ACR to ACDR

- From the gravity equation

$$\sum_i \lambda_{ij}(\widehat{\tau}_{ij} + \widehat{w}_i) = \frac{1}{\xi}\widehat{\lambda}_{jj} + \widehat{w}_j$$

- And compensating variation is

$$\widehat{C}_j = \widehat{w}_j - \widehat{E}_j$$

- So, at long last,

$$\widehat{C}_j = -(1-\eta)\frac{1}{\xi}\widehat{\lambda}_{jj}, \qquad \eta := \rho\frac{1-\beta}{1-\beta+\xi}$$

with $\eta \in [0,1]$ under assumptions **A1**-**A3**. In particular, $\rho \in [0,1]$ because log-concavity implies $\mu'(v) \in [0,1]$ for all v

Implications

- Implied welfare gains weakly lower than ACR benchmark $\widehat{\lambda}_{jj}/\xi$
  - separable non-CES ($\beta = \gamma = 0$), then $\eta > 0$ and lower gains
  - symmetric translog ($\beta = \gamma = 1$), then $\eta = 0$ and identical gains
- Moreover value of $\widehat{\lambda}_{jj}$ itself same as in ACR, since strong version of CES import demand system satisfied

Alternate decomposition

- Can rewrite the welfare gains as

$$\widehat{C}_j = \text{ACR} + \text{TOT} + \text{COV}$$

$$= -\frac{1}{\xi}\widehat{\lambda}_{jj} - \sum_{i \neq j}\left[\lambda_{ij}\widehat{m}_{ij} - \frac{X_i}{X_j}\lambda_{ji}\widehat{m}_{ji}\right] + \sum_i \int_{\Omega_{ij}} e^{\mu_i(\omega)}\widehat{L}_i(\omega)\frac{L_i(\omega)}{L_j}\, d\omega$$

- ACR: standard effects in a model with constant markups
- TOT: differential terms of trade effects from variable markups
- COV: *covariance* that reflects whether labor reallocated towards goods with high markups (that are undersupplied), if so COV > 0

Intuition / explanation

- Consider *symmetric* change $\widehat{\tau}_{ij} = \widehat{\tau} < 0$ (no TOT)

$$\widehat{C}_j = \text{ACR} + \text{COV}$$

  Choke price falls, $\widehat{p}_j^* < 0$, reflecting more competition

- Under assumption **A1** ($\beta \leq 1$) can show that

$$\widehat{\tau}\Big(\sum_{i \neq j} \lambda_{ij}\Big) < \widehat{p}_j^* < 0$$

  from market clearing, fall in $\widehat{p}_j^*$ is 'small' relative to shock

- Under assumption **A3** (log-concavity) this implies relatively larger increase in demand for low-productivity/high-price goods

$$\frac{\partial^2 \widehat{c}(\omega)}{\partial \widehat{p}(\omega) \partial \widehat{p}^*} = -D''(\widehat{p}(\omega) - \widehat{p}^*) > 0$$

Intuition / explanation

- Labor reallocated to relatively low-productivity/high-price firms

- Since $\mu'(v) > 0$ these are also relatively low-markup firms

- So change in trade costs is redistributing employment away from high-productivity, high-markup firms and COV < 0

- Hence welfare gains are less than ACR benchmark

- Ultimately, welfare gains are lower because the change in trade costs *amplifies* rather than reduces pre-existing misallocation

Discussion

- Note unconditional markup distribution is invariant to trade costs

- What matters is the *joint distribution* of markups and employment and this joint distribution does vary with trade costs

- New formula is quite model specific. Details (**A1**, **A3** etc) matter for sign and size of reduced form coefficient η

- If model details are such that misallocation is reduced by trade liberalization, can still have net pro-competitive effects

Next class

- Aggregate gains from trade, part three

- Trade with oligopolistic competition and variable markups

  - Edmond, Midrigan and Xu, "Competition, markups, and the gains from international trade," working paper, 2014