Monopolistic Competition with Endogeneous Investments: International Trade Model

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Abstract

- (**Theoretical ?**): Impact of market size or trade liberalization on *productivity/quality* in monop. competition;
- (**Model novelties**): variable elasticity of substitution (*VES*) and each firm chooses investment in decreasing marginal cost or increasing quality;
- (**Expected results for trade**): Trade liberalization (decrease in trade costs) or country size influences equilibrium investments and prices like growing market: in DES case investments increase.

Outline

Motivation, topic

Empirics on international trade show:

- noticeable cross-countries differences in productivity and quality;
- firms operating in bigger markets have lower markups (Syverson-2007);
- firms are larger in larger markets (Campbell-Hopenhayn-2005);
- larger economies export higher volumes of each good, a wider set of goods, and higher-quality goods (Hummels-Klenow-2005);

Various explanations in literature. "Monopolistic competition" idea suggests that a *bigger market invites more R&D investment from a firm* because of *economies of scale*.

Literature, topic

- *Basic idea* of Monopolistic Competition: many firms - price-makers producing "varieties", free entry, fixed and variable costs => increasing returns. Chamberlin (1929), Dixit and Stiglitz (1977), for trade Krugman (1979).
- MC model with CES or quadratic utility was recently generalized to any (VES) utility: Zhelodobko, Kokovin & Thisse (2010, 2011)
- Oligopolistic choice of technology in quasilinear setting: Vives (2008): firm's R&D investment in economy go up$\uparrow$ with market size always, and number of varieties can increase or decrease.

Our goal is to combine choice of technology like in Vives - with monop. competition under VES
(under CES combining was non-interestiong: zero effects).

MC trade model: assumptions

- *Increasing returns to scale* in a firm, due to investment cost f and marginal costs $c(f)$. Firms are identical.
- Each firm i produces one "variety" as a *price-maker*, but its demand $x_i(p_i, p_j...)$ is influenced by other varieties.
- Each demand function results from *additive utility* function $U = \int_{i \leq N} u(x_i) di$. Degree of u concavity (i.e., elasticity of demand or *substitution among varieties)* - determines intensity of competition.
- *Number of firms is big enough* to ignore firm's influence on the whole industry/economy.
- *Free entry* drives all profits to zero.
- Labor supply/demand in each country is balanced, trade is balanced.

Trade model: Consumers

- N^H firms=varieties in Home country
  N^F firms=varieties in Foreign country
- L_H identical consumers in Home country
  L_F identical consumers in Foreign country
  world population: $L = L_H + L_F$, shares $s = L_H/L$, $(1-s) = L_F/L$
- Consumer's elementary utility function is $u(.)$, price vector is $p(.) : [0, N] \to \mathbb{R}_+$; $p(i) \equiv p_i$ - price for i-th variety, and $x(i) \equiv x_i$ is demand for i-th variety.
- Each consumer sells 1 of labor and chooses an (infinite-dimensional) consumption vector $x(\cdot) : [0, N] \to \mathbb{R}_+$ in utility-maximization as follows...

Trade model: Utility-maximization

$$\begin{cases} \int_0^{N^H} u(x_i^{HH})di + \int_0^{N^F} u(x_i^{FH})di \to \max\limits_{x^{HH},x^{FH}\geq 0} \\ s.t. \\ \int_0^{N^H} p_i^{HH} x_i^{HH} di + \int_0^{N^F} p_i^{FH} x_i^{FH} di \leq w^H. \end{cases}$$

p_i^{FH} is price of variety i produced in country F and consumed in H, w^H and w^F, are wages normalized as $w^H = w$ and $w^F = 1$.

- Using Lagrange multiplier λ_k in country k and FOC, inverse demand for i-th variety is:

$$p_i^{*jk}(x_i^{jk};\lambda_k) = \frac{u'(x_i^{jk})}{\lambda_k}.$$

Trade model: Producers

i-th firm in country k knows both inverse-demand functions $p_i^{*kk}(x_i^{kk};\lambda_k)$, $p_i^{*kj}(x_i^{kj};\lambda_j)$, chooses output $Q_i^k = L_k x_i^{kk} + \tau L_j x_i^{kj}$ where $\tau > 1$ is iceberg trade-cost coeficient.

- Total cost, measured in money is $C(Q_i^k) = w_k[c(f_i^k)Q_i^k + f_i^k]$, where marginal cost $c(\cdot)$ depends on **investment** f_i^k, being decreasing: $c' < 0$. Firms choose (x_i, f_i^k) to maximize profits:

$$\pi_i^H = [p_i^{HH}(x_i^{HH}) - wc(f_i^H)] \cdot L_H x_i^{HH} + [p_i^{HF}(x_i^{HF}) - \tau wc(f_i^H)] \cdot L_F x_i^{HF} - wf_i^H$$

$$\pi_i^F = [p_i^{FH}(x_i^{FH}) - \tau c(f_i^F)] \cdot L_H x_i^{FH} + [p_i^{FF}(x_i^{FF}) - c(f_i^F)] \cdot L_F x_i^{FF} - f_i^F$$

- and FOC w.r.t. f_i^k yield (dropping index i because of symmetry):

$$c'(f^H) \cdot (L_H x^{HH} + \tau L_F x^{HF}) = -1 \qquad c'(f^F) \cdot (\tau L_H x^{FH} + L_F x^{FF}) = -1.$$

- *Symmetric equilibrium* is (x, f, p, N, λ, w) satisfying all FOC and budgets, free entry and labor balances:

Equilibrium $(x^{HH}, x^{FH}, x^{HF}, x^{FF}, w, N^H, N^F, f^H, f^F)$:

$$\frac{u'(x^{HH})}{u'(x^{FH})} = \frac{wc^H}{\tau c^F} \cdot \frac{1 - r_u(x^{FH})}{1 - r_u(x^{HH})} \qquad \frac{u'(x^{FF})}{u'(x^{HF})} = \frac{c^F}{\tau w c^H} \cdot \frac{1 - r_u(x^{HF})}{1 - r_u(x^{FF})},$$

$$\frac{N^H w c^H x^{HH}}{1 - r_u(x^{HH})} + \frac{\tau N^F c^F x^{FH}}{1 - r_u(x^{FH})} = w \qquad \frac{\tau N^H w c^H x^{HF}}{1 - r_u(x^{HF})} + \frac{N^F c^F x^{FF}}{1 - r_u(x^{FF})} = 1$$

$$\frac{s r_u(x^{HH}) x^{HH}}{1 - r_u(x^{HH})} + \frac{\tau (1-s) r_u(x^{HF}) x^{HF}}{1 - r_u(x^{HF})} = \frac{f^H}{c^H L}$$

$$\frac{\tau s r_u(x^{FH}) x^{FH}}{1 - r_u(x^{FH})} + \frac{(1-s) r_u(x^{FF}) x^{FF}}{1 - r_u(x^{FF})} = \frac{f^F}{c^F L}$$

$$c'(f^H)(sLx^{HH} + \tau(1-s)Lx^{HF}) = -1 \qquad c'(f^F)(\tau s L x^{FH} + (1-s)Lx^{FF}) = -1$$

$$f^H + c^H sLx^{HH} + \tau c^H (1-s)Lx^{HF} = \frac{sL}{N^H} \qquad f^F + \tau c^F sLx^{FH} + c^F(1-s)Lx^{FF} = \frac{(1-s)L}{N^F}$$

SOC

For country H, SOC is

$$2 - r_{u'}\left(x^{HH}\right) > 0, \quad 2 - r_{u'}\left(x^{HF}\right) > 0,$$

$$\frac{sL\left(1 - r_u\left(x^{HH}\right)\right)x^{HH}}{\left(2 - r_{u'}\left(x^{HH}\right)\right)r_u\left(x^{HH}\right)} + \frac{(1-s)L\left(1 - r_u\left(x^{HF}\right)\right)\tau x^{HF}}{\left(2 - r_{u'}\left(x^{HF}\right)\right)r_u\left(x^{HF}\right)} - \frac{r_c(f^H)}{\mathcal{E}_c(f^H)c'(f^H)} < 0.$$

For country F, SOC is

$$2 - r_{u'}\left(x^{FH}\right) > 0, \quad 2 - r_{u'}\left(x^{FF}\right) > 0,$$

$$\frac{sL\left(1 - r_u\left(x^{FH}\right)\right)\tau x^{FH}}{\left(2 - r_{u'}\left(x^{FH}\right)\right)r_u\left(x^{FH}\right)} + \frac{(1-s)L\left(1 - r_u\left(x^{FF}\right)\right)x^{FF}}{\left(2 - r_{u'}\left(x^{FF}\right)\right)r_u\left(x^{FF}\right)} - \frac{r_c(f^F)}{\mathcal{E}_c(f^F)c'(f^F)} < 0.$$

Opposite impacts on investments and diversity

Proposition. (i) Increasing ***trade cost*** has ***opposite*** impacts on ***number*** of firms and productivity, i.e., the elasticities has opposite signs:

$$\mathcal{E}_{N^H/\tau} \cdot \mathcal{E}_{f^H/\tau} < 0, \ \mathcal{E}_{N^F/\tau} \cdot \mathcal{E}_{f^F/\tau} < 0$$

(ii) Under "Home-Market Effect", ***country size*** also yields ***opposite*** impacts (that appeals for empirical testing):

$$\left(\mathcal{E}_{N^H/L_H} - 1\right) \cdot \mathcal{E}_{f^H/L_H} < 0, \quad \left(\mathcal{E}_{N^F/L_F} - 1\right) \cdot \mathcal{E}_{f^F/L_F} < 0$$

(iii) Under "HME", ***country share*** *(in L)* also yields ***opposite*** impacts:

$$\left(\mathcal{E}_{N^H/s} - 1\right) \mathcal{E}_{f^H/s} < 0, \quad \left(\mathcal{E}_{N^F/s} + \frac{s}{1-s}\right) \mathcal{E}_{f^F/s} < 0$$

(iv) Moreover

$$\left(\mathcal{E}_{N^H f^H/s} - 1\right) \mathcal{E}_{f^H/s} \lesseqgtr 0 \iff r_{\ln c}(f^H) - 1 \gtreqless 0$$

$$\left(\mathcal{E}_{N^F f^F/s} + \frac{s}{1-s}\right) \mathcal{E}_{f^F/s} \lesseqgtr 0 \iff r_{\ln c}(f^F) - 1 \gtreqless 0$$

Special cases: small costs or symmetry

Now we start comparative statics of equilibria w.r.t. trade cost τ. In general, it is a difficult question, so we study special cases:

- If $s = \frac{1}{2}$ then

$$x^{HH} = x^{FF},\ x^{HF} = x^{FH},\ N^H = N^F,\ f^H = f^F,\ w = 1$$

and

$$\mathcal{E}_{x^{HH}/s} = -\mathcal{E}_{x^{FF}/s},\ \mathcal{E}_{x^{FH}/s} = -\mathcal{E}_{x^{HF}/s},\ \mathcal{E}_{N^H/s} = -\mathcal{E}_{N^F/s},\ \mathcal{E}_{f^H/s} = -\mathcal{E}_{f^F/s}$$

- If $\tau = 1$ then

$$x^{HH} = x^{HF} = x^{FH} = x^{FF},\ f^H = f^F,\ w = 1$$

and in this case elasticities w.r.t. τ can be calculated as follows

Outline

Impact of small τ on investments and diversity

We study the system when $\tau \approx 1$, $s > \frac{1}{2}$. Then at equilibrium $w = 1$ and moreover $x^{HH} = x^{HF} = x^{FH} = x^{FF} = x$, $f^H = f^F = f$.
Let us denote

$$D := \frac{x}{\left(\left(2 - r_{u'}(x)\right) r_c(f) - 1\right) r_u(x)} > 0$$

Proposition. *(i) Elasticities of investments w.r.t. trade cost has the sign as* r_u':

$$\mathcal{E}_{f^H/\tau} = (1-s) \cdot D r_u'(x), \qquad \mathcal{E}_{f^F/\tau} = s \cdot D r_u'(x)$$

(ii) Elasticities of masses of firms w.r.t. trade cost has the opposite sign to r_u':

$$\mathcal{E}_{N^H/\tau} = (1-s) \cdot \frac{D r_c(f) r_u'(x)}{\mathcal{E}_c(f) - 1}, \qquad \mathcal{E}_{N^F/\tau} = s \cdot \frac{D r_c(f) r_u'(x)}{\mathcal{E}_c(f) - 1}$$

Thereby, investments are higher in the bigger country: $f^H > f^F$ if and only if $r_u'(x) > 0$, while the mass of firms is smaller.

Impact of small τ on wage and firm size

Proposition. *(i) Elasticity of relative wage w.r.t. trade cost is positive:*

$$\mathcal{E}_{w/\tau} = (2s-1)(1-r_u(x)) > 0;$$

$w > 1$ for $\tau > 1$, i.e., *the bigger country has higher wages.*

(ii) Elasticites of outputs

$$Q^H \equiv sLx^{HH} + (1-s)\tau Lx^{HF}, \quad Q^F \equiv s\tau Lx^{FH} + (1-s)Lx^{FF}$$

w.r.t. τ have the same sign as r'_u:

$$\mathcal{E}_{Q^H/\tau} = (1-s)\cdot Dr_c(f)r'_u(x), \qquad \mathcal{E}_{Q^F/\tau} = s\cdot Dr_c(f)r'_u(x)$$

Thereby, the bigger country (H) has bigger firms if and only if
$r'_u(x) > 0 \Leftrightarrow Q^H > Q^F$

The case of small τ: Home market effect?

When $\tau = 1$, obviously, HME index: $\frac{N^H}{N^F} \cdot \frac{1-s}{s} = 1$, but what happens when $\tau \approx 1$ grows?

Proposition. *Elasticity of HME index has the same sign as r_u':*

$$\mathcal{E}_{\frac{N^H(1-s)}{N^F s}/\tau} = (2s-1) \cdot D \cdot (1 - r_u(x))\, r_c(f) r_u'(x)$$

Thereby, HME $\iff$ DES utility: $r_u'(x) \gtrless 0 \Leftrightarrow \frac{N^H}{N^F} \gtrless \frac{s}{1-s}$

We can study also wage-including HME index $\frac{N^H}{N^F} \cdot \frac{1-s}{s} \cdot \frac{1}{w}$. Then Generalized Home Market Effect (connecting masses of firms with GDP) is governed by the sign of $(1 - r_{\ln c}(f))$:

$$\mathcal{E}_{\frac{N^H(1-s)}{N^F sw}/\tau} = \frac{(2s-1)(1-r_u(x))^2 (1 - r_{\ln c}(f))}{(2 - r_{u'}(x))\, r_c(f) - 1} \equiv \frac{(2s-1)(1-r_u(x))^2 \mathcal{E}_c'(f) \cdot f}{((2 - r_{u'}(x))\, r_c(f) - 1)\, \mathcal{E}_c(f)}$$

Thereby, Generalized HME <=> DES utility: $\mathcal{E}_c'(f) \gtrless 0 \Leftrightarrow \frac{N^H}{N^F} \lessgtr \frac{sw}{1-s}$

Outline

1. Model

2. Impact of market integration ($\downarrow \tau$)
   - The small-cost case $\tau \approx 1$
   - Almost-symmetric case $s \approx 1/2$

Impact of τ under symmetry: $s \approx \frac{1}{2}$

Let $s \approx \frac{1}{2}$. Then

$$x^{HH} = x^{FF} = x,\; x^{HF} = x^{FH} = y,\; f^H = f^F = f,\; N^H = N^F = N,\; w = 1.$$

and equilibrium equations are symplified as:

$$\tau u'(x)\left(1 - r_u(x)\right) = u'(y)\left(1 - r_u(y)\right), \quad \frac{r_u(x)x}{1 - r_u(x)} + \frac{\tau r_u(y)y}{1 - r_u(y)} = \frac{2f}{c(f)L}$$

$$Lc'(f)(x + \tau y) = -2, \quad N\left(2f + Lc(f)(x + \tau y)\right) = L$$

under SOC: $2 - r_{u'}(x) > 0$, $2 - r_{u'}(y) > 0$ and

$$T \equiv \frac{\left(1 - r_u(x)\right)x}{\left(2 - r_{u'}(x)\right)r_u(x)} + \frac{\left(1 - r_u(y)\right)\tau y}{\left(2 - r_{u'}(y)\right)r_u(y)} - \frac{2r_c(f)}{Lc'(f)\mathcal{E}_c(f)} < 0$$

We denote

$$M \equiv \frac{r_c(f)}{\mathcal{E}_c(f)} + \frac{1 - r_u(y)}{\left(2 - r_{u'}(y)\right)r_u(y)} - \left(\frac{r_c(f)}{\mathcal{E}_c(f)} \cdot \frac{2Nf}{L} + 1\right) \lesseqgtr 0?$$

The case $s \approx \frac{1}{2}$: comparative statics w.r.t. τ

Proposition. *Under symmetric countries, elasticities of investment f, mass of firms N, domestic consumption x and imported consumption y are governed by magnitude M:*

$$\mathcal{E}_{f/\tau} = \frac{\tau y}{\mathcal{E}_c(f)} \cdot \left(Nc(f) - \frac{M}{T} \right), \qquad \mathcal{E}_{N/\tau} = \frac{Nc(f) r_c(f)}{0.5 c'(f) L} \cdot \mathcal{E}_{f/\tau}$$

$$\mathcal{E}_{x/\tau} = \frac{(1 - r_u(x))}{(2 - r_{u'}(x))\, r_u(x)} \cdot \frac{M \tau y}{T}$$

$$\mathcal{E}_{y/\tau} = \left(\frac{M \tau y}{T} - 1 \right) \cdot \frac{1 - r_u(y)}{(2 - r_{u'}(y))\, r_u(y)}$$

In particular, positive M implies:

$$M > 0 \Rightarrow \mathcal{E}_{f/\tau} < 0,\ \mathcal{E}_{N/\tau} > 0,\ \mathcal{E}_{x/\tau} < 0,\ \mathcal{E}_{y/\tau} < 0$$

Moreover,

$$M < 0 \Rightarrow \mathcal{E}_{x/\tau} > 0$$

The case $s \approx \frac{1}{2}$: comparative statics w.r.t. τ

	$M > 0$	$M = 0$	$M < 0$		
			$\tau y M > T$	$\tau y M = T$	$\tau y M < T$
$\mathcal{E}_{x/\tau}$	$-$	0	$+$	$+$	$+$
$\mathcal{E}_{y/\tau}$	$-$	$-$	$-$	0	$+$

	$M \geq 0$	$M < 0$		
		$M > Nc(f)T$	$M = Nc(f)T$	$M < Nc(f)T$
$\mathcal{E}_{f/\tau}$	$-$	$-$	0	$+$
$\mathcal{E}_{N/\tau}$	$+$	$+$	0	$-$
$\mathcal{E}_{q/\tau}$	$-$	$-$	0	$+$

	$(M - Nc(f)T) \cdot \mathcal{E}'_c(f) > 0$	$(M - Nc(f)T) \cdot \mathcal{E}'_c(f) = 0$	$(M - Nc(f)T) \cdot \mathcal{E}'_c(f) < 0$
$\mathcal{E}_{Nf/\tau}$	$+$	0	$-$

Conclusions, extensions

- In a larger economy firm size and productivity (quality) is higher $\Leftrightarrow$ DES-utility;
- Techn. progress increases R&D investment always, but [decreasing markup $\Leftrightarrow$ DES-utility];
- *Hypothesis* 1: Decreasing trade barriers have positive impact on productivity (like market size) (?);
- *Hypothesis* 2: The bigger country has technological and welfare advantage (?)
- ***Thank you.***