An Eaton-Kortum model of trade and growth

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Revival of Ricardian trade model

Dornbusch, Fischer, and Samuelson (1977, AER):

- two-country, continuum-good Ricardian model
- extensive margins of trade (numbers or fractions of traded varieties)

Eaton and Kortum (2002, EMA):

- extend DFS to $N(\geq 2)$ countries
- examine effects of various forms of trade liberalization on EM under cross-country asymmetries (unlike Melitz (2003, EMA))

static formulation overlooks:

$$(\text{trade cost} \downarrow \rightarrow)\ \text{growth} \uparrow \rightarrow \text{EM of exports} \uparrow$$

e.g., Hummels and Klenow (2005), Broda and Weinstein (2006), Kehoe and Ruhl (2009)

Why not extend Eaton-Kortum dynamically?

Extending Eaton-Kortum dynamically

Acemoglu and Ventura (2002, QJE):

- multi-country AK model: capital $\rightarrow$ tradable intermediate $\rightarrow$ final
- growth $\uparrow$ $\rightarrow$ relative rental ($\propto$ ToT) $\downarrow$ $\rightarrow$ growth $\downarrow$ $\rightarrow$ convergence
- intermediates are differentiated $\rightarrow$ trade pattern is fixed, not evolving

Naito (2012, JIE):

- DFS x Acemoglu-Ventura
- unilateral trade liberalization $\rightarrow$ growth, welfare, & extensive margins

this paper:

- Eaton-Kortum x Acemoglu-Ventura
- various forms of liberalization $\rightarrow$ growth, welfare, & extensive margins (incl. preferential trade agreement)

Main results in three-country case

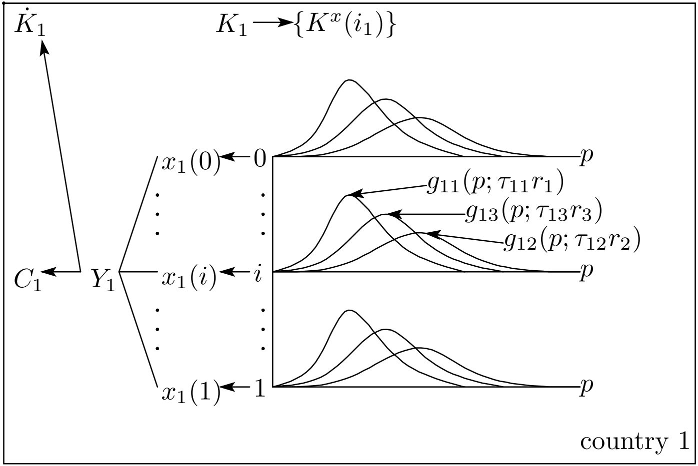
analytical results:

1. a permanent fall in any trade cost raises the balanced growth rate
   $\because \tau_{12}$ (trade cost for country 1 to buy each variety from country 2) $\downarrow$
   $\rightarrow$ 1's growth potential $\uparrow$
   $\rightarrow$ 1's rental rates relative to 2 & 3 $\downarrow$
   $\rightarrow$ 2 & 3's ToT against 1 $\uparrow$
2. trade liberalization increases the liberalizing countries' long-run fractions of exported varieties to all destinations
   $\because \tau_{12} \downarrow$
   $\rightarrow$ 1's rental rates relative to 2 & 3 $\downarrow$
   $\rightarrow$ it's cheaper for 3 (or 2) to import from 1 than from 2 (or 3)

numerical results:

$\underbrace{\text{long-run effects}}_{\text{balanced growth}} \neq \underbrace{\text{short-run effects (static Eaton-Kortum)}}_{\text{market clearing}}$

Overview (N = 3)



$\dot{K}_1$
$K_1 \longrightarrow \{K^x(i_1)\}$
$x_1(0)$
0
p
$g_{11}(p;\tau_{11}r_1)$
$g_{13}(p;\tau_{13}r_3)$
$g_{12}(p;\tau_{12}r_2)$
C_1
Y_1
$x_1(i)$
i
p
$x_1(1)$
1
p
country 1

Households

budget constraint:

$$p_{jt}^{Y}\left(C_{jt} + \dot{K}_{jt}\right) = r_{jt} K_{jt}; \dot{K}_{jt} \equiv dK_{jt}/dt. \tag{1}$$

w/ log utility, Euler equation:

$$\dot{K}_{jt}/K_{jt} = \dot{C}_{jt}/C_{jt} = r_{jt}/p_{jt}^{Y} - \rho_{j} \forall t \in [0, \infty). \tag{2}$$

Final good firms

unit cost function (= intermediate good price index):

$$q_j(\{p_j(i)\}_{i=0}^1) = B_j^{-1}\left(\int_0^1 p_j(i)^{1-\sigma_j} di\right)^{1/(1-\sigma_j)}; \sigma_j > 1. \tag{3}$$

profit maximization $\Rightarrow$ zero profit:

$$p_j^Y = q_j. \tag{4}$$

Intermediate good firms: price distributions

A_j: random variable for country j's unit capital requirement, i.i.d. across i

capital productivity $1/A_j$ follows a Fréchet distribution:

$$F_j(z) \equiv \Pr(1/A_j \leq z) \equiv \exp(-b_j z^{-\theta}); b_j > 0, \theta > 1.$$

distrib. of unit cost $P_{nj} = \tau_{nj} r_j A_j$ & demand price $P_n = \min\{\{P_{nj}\}_{j=1}^N\}$:

$$G_{nj}(p) \equiv \Pr(P_{nj} \leq p) = 1 - \exp(-p^\theta b_j (\tau_{nj} r_j)^{-\theta}),$$
$$G_n(p) \equiv \Pr(P_n \leq p) = 1 - \exp(-p^\theta \Phi_n); \Phi_n \equiv \sum_{j=1}^N b_j (\tau_{nj} r_j)^{-\theta}.$$

properties of $G_{nj}(p)$ and $G_n(p)$:

- $b_j \uparrow$, $\tau_{nj} r_j \downarrow \rightarrow G_{nj}(p) \uparrow$: P_{nj} tends to be lower
- $\theta \uparrow \rightarrow 1/A_j$ is less variable $\rightarrow \tau_{nj} r_j$ matters relatively more
- $G_n(p) \geq G_{nn}(p)$: trade makes lower P_n more likely

Three important properties (Eaton-Kortum)

1. probability that n buys a variety from j is:

$$\pi_{nj}(\{\tau_{nk} r_k\}_{k=1}^N) \equiv b_j(\tau_{nj} r_j)^{-\theta} / [\underbrace{\textstyle\sum_{k=1}^N b_k(\tau_{nk} r_k)^{-\theta}}_{=\Phi_n}]. \tag{6}$$

2. conditional distribution of P_{nj}, given that n buys a variety from j, is the same as $G_n(p) \forall j$

$$\because \Pr(P_{nj} \leq \min\{\{P_{nk}\}_{k \neq j}\}, P_{nj} \leq p) = \pi_{nj} G_n(p).$$

3. intermediate good price index function (3) for n is rewritten as:

$$\begin{aligned} Q_n(\{\tau_{nj} r_j\}_{j=1}^N) &\equiv c_n [\underbrace{\textstyle\sum_{j=1}^N b_j(\tau_{nj} r_j)^{-\theta}}_{=\Phi_n}]^{-1/\theta}; \\ c_n &\equiv B_n^{-1} \Gamma(1 + (1-\sigma_n)/\theta)^{1/(1-\sigma_n)}. \end{aligned} \tag{7}$$

Implications of three properties

- π_{nj}: fraction of varieties n buys from j

  $\because$ probability π_{nj} applies to a large number of varieties in [0,1]
- π_{nj} is homogeneous of degree zero;
  Q_n is homogeneous of degree one, in $\{\tau_{nj} r_j\}_{j=1}^N$
- π_{nj}: cost share of varieties n buys from j

$$\because \int_{I_{nj}} \underbrace{p_n(i_j) x_n(i_j)}_{E[\cdot|\cdot]=Q_n Y_n} di_j / (Q_n Y_n) = \pi_{nj}(\{\tau_{nk} r_k\}_{k=1}^N). \qquad (13)$$

$\Rightarrow$ all adjustments in the cost shares occur at the extensive margins

Dynamic system

dynamic system ($r_N \equiv 1, \kappa_j \equiv K_j/K_N$):

$$\dot{\kappa}_j = \kappa_j(\gamma_j(\{\tau_{jn}r_n/r_j\}_{n=1}^N) - \gamma_N(\{\tau_{Nn}r_n\}_{n=1}^N)), j = 1, ..., N-1; \quad (14)$$

$$\gamma_j(\cdot) \equiv \dot{C}_j/C_j = 1/Q_j(\{\tau_{jn}r_n/r_j\}_{n=1}^N) - \rho_j,$$

$$\kappa_j = \textstyle\sum_{n=1}^N \pi_{nj}(\{\tau_{nk}r_k/r_n\}_{k=1}^N)\kappa_n/(r_j/r_n), j = 1, ..., N-1. \quad (15)$$

(14): growth rate of κ_j = growth rate in j − growth rate in N
(15): capital market-clearing condition in j relative to N
(= labor market-clearing condition in Eaton and Kortum (2002))

ceteris paribus effects:

- $\tau_{jn} \downarrow, r_j/r_n \uparrow \to \gamma_j \uparrow$
- $\tau_{nj} \downarrow, r_n/r_j \uparrow \to \pi_{nj} \uparrow$
- $\tau_{nk} \downarrow, r_n/r_k \uparrow \forall k \neq j \to \pi_{nj} \downarrow$

Three-country model

$$\dot{\kappa}_1 = \kappa_1(\gamma_1(1, \tau_{12} r_2 / r_1, \tau_{13} / r_1) - \gamma_3(\tau_{31} r_1, \tau_{32} r_2, 1)), \tag{19}$$

$$\dot{\kappa}_2 = \kappa_2(\gamma_2(\tau_{21} r_1 / r_2, 1, \tau_{23} / r_2) - \gamma_3(\tau_{31} r_1, \tau_{32} r_2, 1)), \tag{20}$$

$$\kappa_1 = \pi_{11}(1, \tau_{12} r_2 / r_1, \tau_{13} / r_1)\kappa_1 + \pi_{21}(\tau_{21} r_1 / r_2, 1, \tau_{23} / r_2)\kappa_2 / (r_1 / r_2) + \pi_{31}(\tau_{31} r_1, \tau_{32} r_2, 1) / r_1, \tag{21}$$

$$\kappa_2 = \pi_{12}(1, \tau_{12} r_2 / r_1, \tau_{13} / r_1)\kappa_1 / (r_2 / r_1) + \pi_{22}(\tau_{21} r_1 / r_2, 1, \tau_{23} / r_2)\kappa_2 + \pi_{32}(\tau_{31} r_1, \tau_{32} r_2, 1) / r_2. \tag{22}$$

w/ κ_{1t}, κ_{2t} predetermined, (21), (22): $r_{1t}, r_{2t} \to$ (19), (20): $\dot{\kappa}_{1t}, \dot{\kappa}_{2t}$

BGP:

$$0 = \gamma_1(1, \tau_{12} r_2^* / r_1^*, \tau_{13} / r_1^*) - \gamma_3(\tau_{31} r_1^*, \tau_{32} r_2^*, 1) \Leftrightarrow r_1^* = R_1(r_2^*), \tag{23}$$

$$0 = \gamma_2(\tau_{21} r_1^* / r_2^*, 1, \tau_{23} / r_2^*) - \gamma_3(\tau_{31} r_1^*, \tau_{32} r_2^*, 1) \Leftrightarrow r_2^* = R_2(r_1^*). \tag{24}$$

and then, (21), (22): κ_1^*, κ_2^*

Rental rates at the BGP

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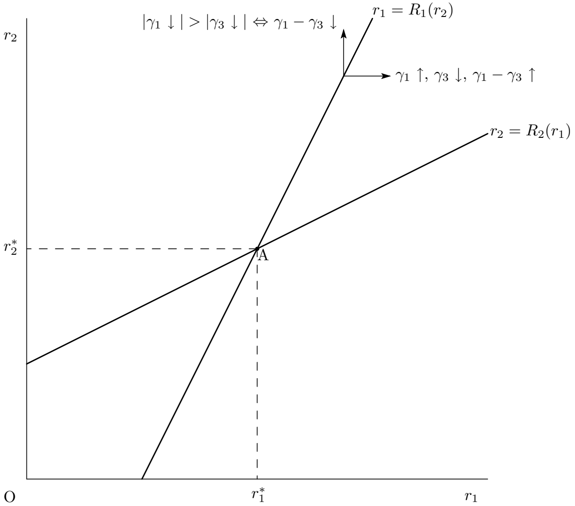

Determination of r_1^* and r_2^*.

Transitional dynamics

(19), (20), (21), (22):

$$\dot{\kappa}_1/\kappa_1 = d\gamma_1 - d\gamma_3 = \underbrace{a_{11}}_{>0} dr_1/r_1 + a_{12} dr_2/r_2, \quad (27')$$

$$\dot{\kappa}_2/\kappa_2 = d\gamma_2 - d\gamma_3 = a_{21} dr_1/r_1 + \underbrace{a_{22}}_{>0} dr_2/r_2, \quad (28')$$

$$dr_1/r_1 = (r_1\kappa_1/\underbrace{c}_{>0})\underbrace{e_{11}}_{<0} d\kappa_1/\kappa_1 + (r_2\kappa_2/c)e_{12} d\kappa_2/\kappa_2, \quad (29)$$

$$dr_2/r_2 = (r_1\kappa_1/c)e_{21} d\kappa_1/\kappa_1 + (r_2\kappa_2/c)\underbrace{e_{22}}_{<0} d\kappa_2/\kappa_2. \quad (30)$$

e.g., $\kappa_{10} < \kappa_1^*, \kappa_{20} < \kappa_2^*$
$\rightarrow r_{10} > r_1^*, r_{20} > r_2^* (\because e_{11} < 0, e_{22} < 0)$
$\rightarrow \gamma_{10} - \gamma_{30} > 0, \gamma_{20} - \gamma_{30} > 0 (\because a_{11} > 0, a_{22} > 0)$
$\rightarrow \kappa_{1t} \uparrow, \kappa_{2t} \uparrow, r_{1t} \downarrow, r_{2t} \downarrow$
$\therefore$ BGP is locally stable iff these "own effects" outweigh "cross effects"

Changes in rental rates at the BGP

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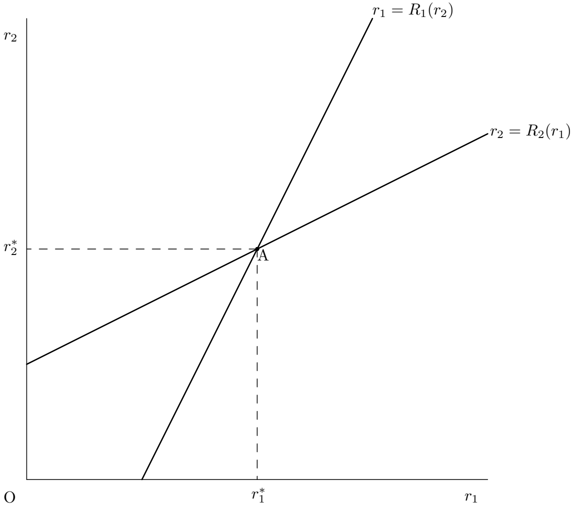

Fig. 1. Rental rates at the balanced growth path: $a_{12} < 0, a_{21} < 0$.

Changes in rental rates at the BGP

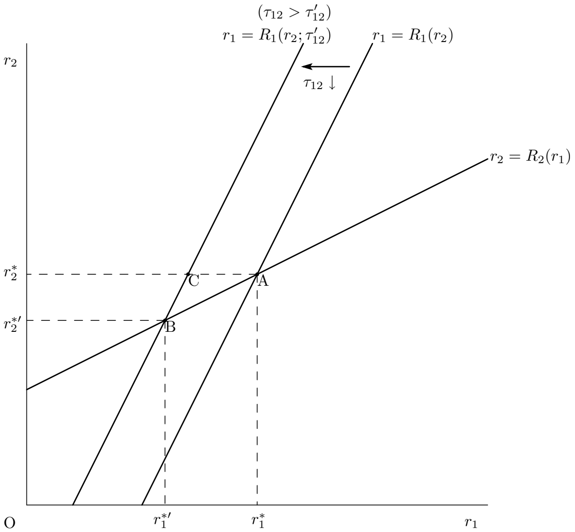

Fig. 1. Rental rates at the balanced growth path: $a_{12} < 0, a_{21} < 0$.

Balanced growth rate

Proposition 2
For all $j, n = 1, 2, 3, n \neq j$, *a permanent fall in* τ_{jn} *raises the balanced growth rate.*

intuition:
$\tau_{12} \downarrow$
$\rightarrow \gamma_1 \uparrow$
$\rightarrow r_1 \downarrow$, $r_1/r_2 \downarrow$: 3 & 2's ToT against 1 $\uparrow$
$\rightarrow \gamma_3 \uparrow$, $\gamma_2 \uparrow$

Unilateral trade liberalization

Proposition 3

A permanent fall in τ_{12} *increases* $\pi_{12}^{*}, \pi_{21}^{*}$, *and* π_{31}^{*}, *whereas it decreases* π_{13}^{*}.

intuitions:

- $\tau_{12} \downarrow \rightarrow \pi_{12} \uparrow, \pi_{13} \downarrow$
- $\tau_{12} \downarrow \rightarrow r_1 \downarrow, r_1/r_2 \downarrow \rightarrow \pi_{21} \uparrow, \pi_{31} \uparrow$

Bilateral trade liberalization

Proposition 4

Permanent falls in τ_{12} and τ_{21}, with r_1^* / r_2^* unchanged, increase $\pi_{12}^*, \pi_{21}^*, \pi_{31}^*$, and π_{32}^*, whereas they decrease $\pi_{11}^*, \pi_{13}^*, \pi_{22}^*, \pi_{23}^*$, and π_{33}^*.

intuitions:

- $\tau_{12} \downarrow \to |\pi_{12} \uparrow| > |\pi_{13} \downarrow| \to \pi_{11} \downarrow$
- $\tau_{21} \downarrow \to |\pi_{21} \uparrow| > |\pi_{23} \downarrow| \to \pi_{22} \downarrow$
- $\tau_{12} \downarrow, \tau_{21} \downarrow \to r_1 \downarrow, r_2 \downarrow \to \pi_{31} \uparrow, \pi_{32} \uparrow \to \pi_{33} \downarrow$

Benchmark case

	old BGP	unilateral short-run	long-run	bilateral short-run	long-run
τ_{12}	2	1.9	1.9	1.9	1.9
τ_{21}	2	2	2	1.9	1.9
r_1	1.	0.993982	0.982479	<u>1.00271</u>	<u>0.98186</u>
r_2	1.	1.00862	1.	<u>1.00271</u>	<u>0.98186</u>
κ_1	1.	1.	1.07327	1.	1.13672
κ_2	1.	1.	1.05446	1.	1.13672
γ_1	0.0681566	0.0684447	0.0683163	0.0686664	0.0684871
γ_2	0.0681566	0.0683645	0.0683163	0.0686664	0.0684871
γ_3	0.0681566	<u>0.0681356</u>	<u>0.0683163</u>	<u>0.0681091</u>	<u>0.0684871</u>
π_{11}	0.8	0.792208	0.795667	0.78628	0.791068
π_{12}	0.1	0.110543	0.110012	0.114635	0.115333
π_{13}	0.1	0.097249	0.0943214	0.099085	0.0935993
π_{21}	0.1	0.103747	0.104875	0.114635	0.115333
π_{22}	0.8	0.794367	0.795667	0.78628	0.791068
π_{23}	0.1	<u>0.101886</u>	<u>0.0994583</u>	0.099085	0.0935993
π_{31}	0.1	0.1019	0.104875	<u>0.0993531</u>	<u>0.104466</u>
π_{32}	0.1	0.0975277	0.0994583	<u>0.0993531</u>	<u>0.104466</u>
π_{33}	0.8	<u>0.800572</u>	<u>0.795667</u>	<u>0.801294</u>	<u>0.791068</u>
U_1	-25.2097		-24.5479		-24.0169
U_2	-25.2097		-24.7112		-24.0169
U_3	-25.2097		-25.1823		-25.1627

Table: $\tau_{12} = \tau_{13} = \tau_{21} = \tau_{23} = \tau_{31} = \tau_{32} = 2, b_1 = b_2 = b_3 = 1$

Calibratad case: CJK (j=1), NAFTA (j=2), EU (j=3)

	old BGP	unilateral short-run	unilateral long-run	bilateral short-run	bilateral long-run
τ_{12}	2.95638	2.85638	2.85638	2.85638	2.85638
τ_{21}	2.91636	2.91636	2.91636	2.84512	2.84512
r_1	2.06116	2.05221	2.04319	2.05931	2.04572
r_2	2.17016	2.18396	2.17361	2.1753	2.1539
κ_1	1.12636	1.12636	1.15914	1.12636	1.17587
κ_2	0.733492	0.733492	0.756822	0.733492	0.782727
γ_1	0.0211024	0.0211283	0.0211236	0.0211424	0.0211393
γ_2	0.0211024	0.0211307	0.0211236	0.0211586	0.0211393
γ_3	0.0211024	0.0211015	0.0211236	0.0211	0.0211393
π_{11}	0.940682	0.938911	0.939228	0.937942	0.938159
π_{12}	0.0306209	0.0328175	0.0328628	0.0335221	0.0338598
π_{13}	0.0286966	0.0282713	0.0279095	0.0285361	0.0279814
π_{21}	0.044265	0.0456135	0.0455893	0.0479459	0.0475459
π_{22}	0.923504	0.921604	0.922076	0.919726	0.921026
π_{23}	0.032231	0.0327823	0.0323348	0.0323278	0.0314277
π_{31}	0.0672513	0.0681395	0.0689342	0.0674447	0.0686008
π_{32}	0.0506761	0.0497249	0.0503573	0.0503266	0.051693
π_{33}	0.882073	0.882136	0.880708	0.882229	0.879706
U_1	-136.896		-136.831		-136.796
U_2	-158.342		-158.272		-158.203
U_3	-142.84507		-142.84506		-142.847

Table: $\tau_{12} = 2.95638, \tau_{13} = 6.45658, \tau_{21} = 2.91636, \tau_{23} = 6.53986, \tau_{31} = 1.16897, \tau_{32} = 1.21261, b_1 = 0.119177, b_2 = 0.117, b_3 = 0.111751$

Concluding remarks

policy implications:

- trade liberalization, be it unilateral, bilateral, or multilateral, raises global growth

  Romalis (2007), Estevadeordal and Taylor (2008), and Wacziarg and Welch (2008)
- import promotion acts as export promotion at the extensive margins

  Hummels and Klenow (2005), Broda and Weinstein (2006), Kehoe and Ruhl(2009)

possible extensions:

- b_j is increasing in κ_j (as externalities): qualitatively unchanged
- import tariffs: unchanged if long-run welfare gains are dominant
- $N > 3$: qualitatively unchanged, quantitatively weaker