Occupational Sorting and Development

Jan Eeckhout[1] Boyan Jovanovic[2]

[1]UPenn

[2]NYU

Minnesota Workshop in Macroeconomic Theory
August 2, 2007

MOTIVATION

IMPACT OF OPENNESS ON GAINS FROM TRADE AND SORTING

- Openness has increased in the last 30 years
- Labor services (both workers and management) increasingly flow across borders
- Distant agents produce together due to improved transportation/information technology (trade of inputs, outsourcing of services, multinationals, VC management exports services, etc.)
- Our theory: increased trade of labor services $\Rightarrow$ efficient reallocation: occupational sorting (manager vs. worker)
- Theoretical issue: separate standard gains from trade effect from the sorting effect

Theoretical Exercise

- Start with autarky
- Introduce global labor market
- Who gains most? The poor and the rich
- Who gains least? The middle class
- Implied sorting effect is qualitatively big relative to standard trade effect (in examples)

The Model
Economy

- Population of agents indexed by x # efficiency units $x\tilde{\ }F(x)$
- Production
$$q = xQ(h)$$
  - x: manager's skill
  - h: # of efficiency units of labor hired
  - w: wage per efficiency unit
  - Q concave
- Characteristics of the Technology:
  - Complementarity in skill of worker and manager: marginal product of worker increases in manager skill
  - Production is asymmetric: contribution of identically skilled agent depends on occupation
  - Managers: imperfect substitutes; Workers' efficiency units: perf substitutes (no mass point in wages as in Lucas (78))
  - Span of control depends on efficiency, not on # bodies

Market Equilibrium:

1. The firm's decision problem

$$\begin{aligned} \pi(x, w) &= \max_{h} \{xQ(h) - wh\} \\ \Rightarrow FOC &: \quad xQ'(h) = w \end{aligned}$$

2. Occupational Choice. The set of Managers:

$$E(w) = \{x \in \mathbb{R}_{+} \mid \pi(x, w) > wx\}$$

3. Market clearing

The Model

Autarky: All agents are identical in economy

- Let n be the fraction workers ($1 - n$ managers)
- An Equilibrium $\{w(x), n(x)\}$ solving the FOC:

$$xQ'\left(\frac{xn}{1-n}\right) = w.$$

- Occupational choice/market clearing

$$\begin{aligned} \pi(x, w) &= wx \\ xQ\left(\frac{xn}{1-n}\right) - w\frac{xn}{1-n} &= wx \end{aligned}$$

- An Example: $Q(h) = h^{\alpha}$

$$n(x) = \alpha \qquad w(x) = (1-\alpha)^{(1-\alpha)}\alpha^{\alpha}x^{\alpha}$$

- Let $h = g(x, w)$ be the demand function from FOC
- Occupational choice:

$$E(w) = \{x \in \mathbb{R}_+ \mid \pi(x, w) > wx\}$$

- Market Clearing

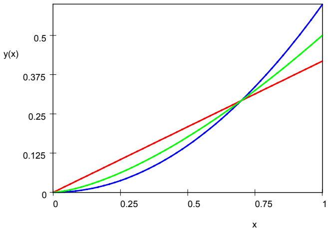
$$\int_{E(w)} g(x, w)\, dF(x) = \int_{\mathbb{R}_+ - E(w)} x dF(x)$$

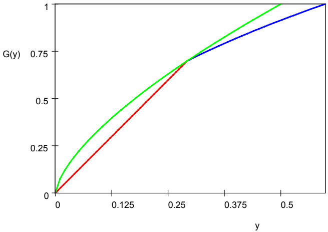
Results

Example

- Let $Q(h) = h^{\frac{1}{2}}, F(x) = x$
- Autarky income $w(x)x = \frac{1}{2}x^{\frac{3}{2}}$
- Free trade incomes:

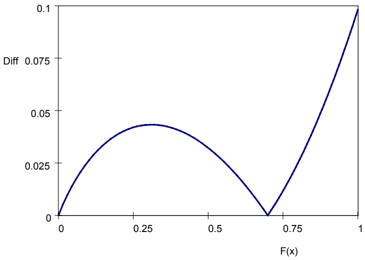
$$y(x) = \max\left(w^F x, \pi^F(x)\right) = \max\left(0.42x, 0.59x^2\right)$$



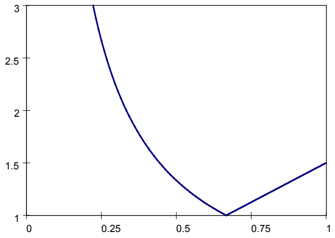


Results
Example

Gains in earnings relative to autarky



Level



Ratio

Proposition 1. *If (i) $F(\cdot)$ is atomless and continuous, and if (ii) $Q'(h)$ decreases continuously from $+\infty$ when $h = 0$ to 0 when $h = \infty$, an equilibrium with Factor Mobility exists at z, satisfying*

$$x_{\min} < z < x_{\max},$$

and, moreover,

$$\pi\left(z, w^{A}[z]\right) = w^{A}(z)\, z = w^{F} z = \pi^{F}(z)\,.$$

Proof: Lemma 1 and 2.

Lemma 1. *If (z^F, w^F) is a free-market equilibrium, then w^F is the autarky wage in a country for which $x = z^F$.*

- (z^F, w^F) is equilibrium $\Rightarrow \pi(z^F, w^F) = w^F z^F$
- In autarky in country $x = z^F$, occupational choice is met
- market-clearing condition and the FOC: there is n such that

$$z^F Q'\left(\frac{nz^F}{1-n}\right) = w^F \iff Q'\left(\frac{nz^F}{1-n}\right) = \frac{w^F}{z^F},$$

  by (ii), there is a unique $n \in (0,1)$
- supply nz^F, equals demand:

$$nz^F = (1-n)\left(\frac{nz^F}{1-n}\right).$$

- Conditions autarky equilibrium are met at (z^F, w^F) QED.

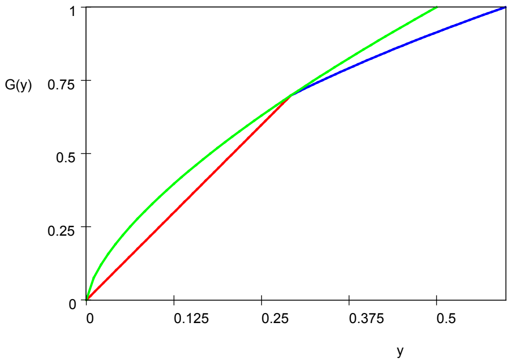
Lemma 2. *z^F satisfies $x_{\min} < z < x_{\max}$.*

- Premise: no mass points in F
- Suppose $z^F = x_{\max}$: then demand for h would be zero and there would be excess supply of workers
- Conversely, if $z^F = x_{\min}$ there would be an excess supply of workers. QED.

RESULTS

GENERAL: DISTRIBUTION

Proposition 2. *(First order stochastic dominance) The distribution of earnings under Factor Mobility (weakly) stochastically dominates the distribution under Autarky.*



- Experiment: global labor market, no occupational switching
- Global labor market $\Rightarrow$ single market-clearing wage w
- No occupational switching: $n(x)$ type-x agents are "forced" to be workers, where $n(x)$ is determined under autarky
- Market clearing wage solves:

$$\int_0^\infty g(x, w)\,[1 - n(x)]\,dF(x) = \int_0^\infty xn(x)\,dF(x)$$

instead of

$$\int_{E(w)} g(x, w)\,dF(x) = \int_{\mathbb{R}_+ - E(w)} x dF(x)$$

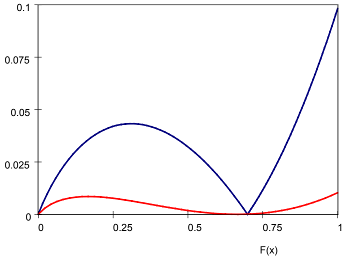
- Occupation dependent earnings: income for identical types is not equalized (low x : $wx > \pi(x)$; high x : $wx < \pi(x)$)

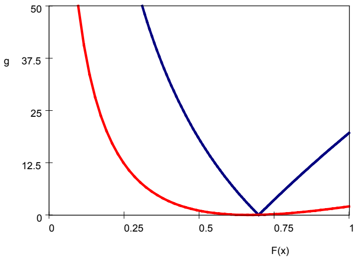
- Autarky: $n(x) = \alpha$
- Income

$$y(x) = n(x)\tilde{w}x + (1 - n(x))\tilde{\pi}(x)$$

instead of

$$y(x) = \max\{wx, \pi(x)\}$$





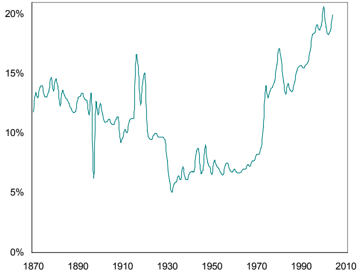
Results

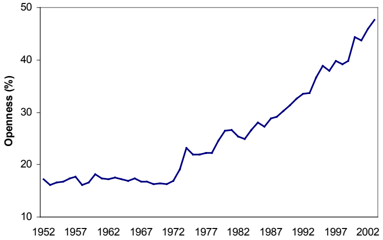
Predictions of the Model

- Gains from openness: in the tails
- Middle: small or no gains
- U-shaped pattern of growth
- Mechanism:
  - one world labor market $\Rightarrow$ one wage
  - wages increase for low skill types
  - wages decrease for high skill types $\Rightarrow$ most productive managers gain most, given complementarity
  - factor prices for middle types: similar under autarky
- Occupational sorting is important

Predictions of the model and Openness

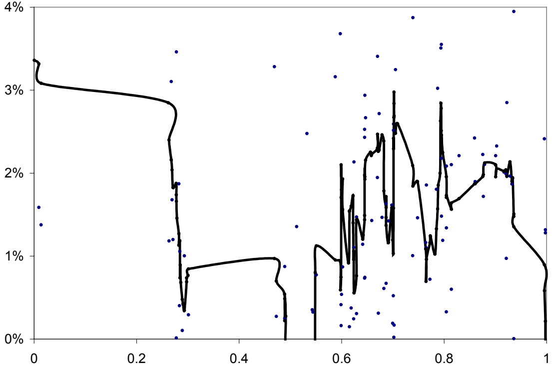
Openness





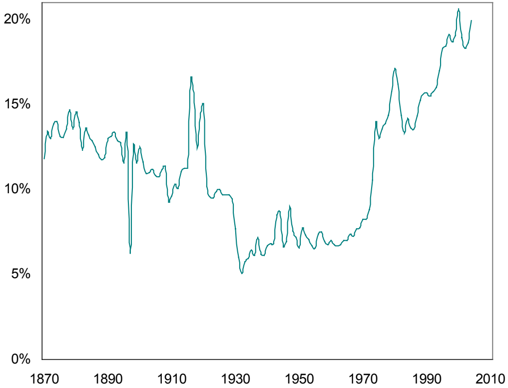
Predictions of the model and Openness

Growth 1970-2000



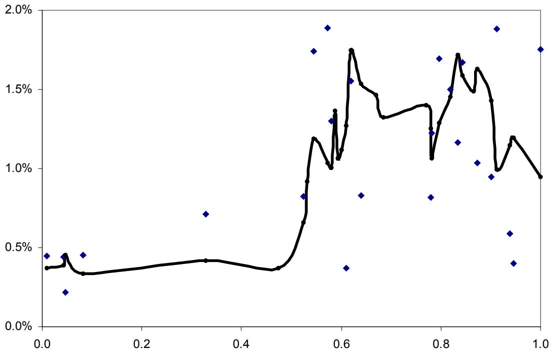
Predictions of the model and Openness

Growth 1910-1929



Predictions of the model and Openness

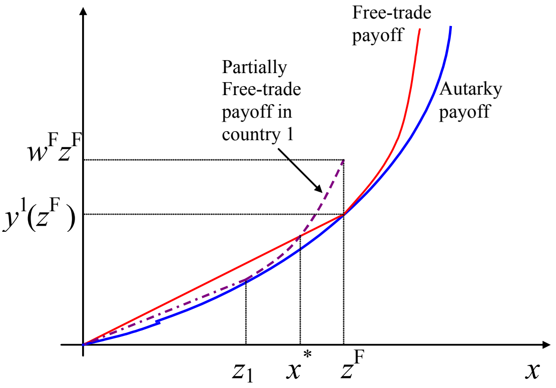
Growth 1910-1929



Results

Partially-Free Trade: No Pareto dominance

Proposition 3. *(Free vs. Partially-free trade). Suppose F is* atomless on the interval $[x_{\min}, x_{\max}]$. *Then there is a partially-free trade allocation that is not weakly Pareto dominated by free trade.*



- Planner: choose allocation to maximize output Y s.t. market clearing

$$\max_{z,h} \int_z^{\infty} xQ(h(x))dF(x) + \lambda \left[\int_{\infty}^{z} xdF(x) - \int_z^{\infty} h(x)dF(x) \right]$$

- FOC:

$$\begin{aligned} h &: \quad xQ'(h) = \lambda \\ z &: \quad zQ(h) - \lambda h = \lambda z \end{aligned}$$

- **Proposition 4.** *The decentralized equilibrium outcome implements the planner's solution.*

RESULTS

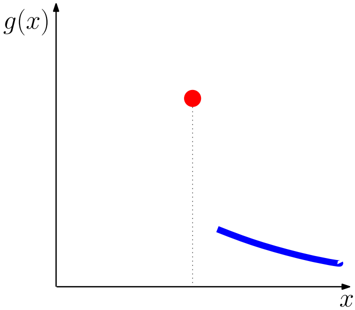
GENERAL: INTEGRATION MAXIMIZES OUTPUT

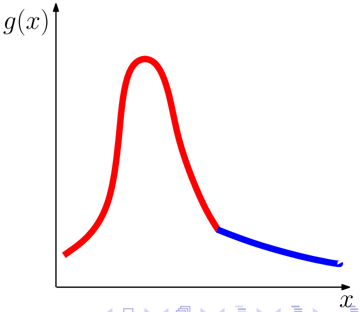
- Consider two economies $F_1(x), F_2(x)$ with world pop. shares α_1, α_2; integrated economy $F(x) = \alpha_1 F_1 + \alpha_2 F_2$
- **Proposition 5.** $w_1 \neq w_2 \Leftrightarrow Y(F) > \alpha_1 Y(F_1) + \alpha_2 Y(F_2)$
- From FOC: $g(w_1, x) \neq g(w_2, x)$
- By concavity of Q: convex combination of g_1, g_2 increases world output
- Counterpart: $Y(F) = \alpha_1 Y(F_1) + \alpha_2 Y(F_2)$ even if $F_1 \neq F_2$, provided $w_1 = w_2$
- ...
- F maximizes output, but does not Pareto dominate F_1, F_2

Related Literature

Model builds on Lucas (1978): "On the Size Distribution of Business Firms"

Lucas	Ours
Technology: # workers	Technology: # efficiency units
Mass point income distribution	Non-degenerate income distr.
Variance wages = 0	Variance $w^2\sigma^2(x \mid x < z)$





Related Literature

McGrattan-Prescott (2007)

- Our theory: hire labor across borders
- MP: worldwide application of ideas (technology capital)
- Production function (let N be number of locations):

$$\underbrace{Y = xQ\left(\sum_{i=1}^{N} h_i\right)}_{\text{(1) ours}} \qquad \underbrace{Y = x\sum_{i=1}^{N} Q\left(h_i\right)}_{\text{(2) MP}}$$

- MP: Limits to firm size are at plant level, not at firm level
  - Our production function: Autarky, all N plants in the country of manager; Free Trade: plants can be anywhere
  - MP: firm can operate unlimited # plants $\Rightarrow$ large estimates of the gains to openness (no span of control limits globally)
  - Data fits better (1): constant returns at plant level, diminishing returns at firm level (AC curve: flat, wide bottom): Olley and Pakes (1996), Syverson (2004)...
  - Firm's location (MP): x' should be in all locations $x < x'$ is in

Related Literature

Gabaix-Landier (2008)

- Managerial earnings as competitive matching market of firms/capital and managers
- Rise in managerial earnings due to increase in efficiency and value of (largest) firms
- Our theory: explanation (globalization) for why the distribution of value has changed
- Ours: manager collects all profits, but similar implications if manager collects given fraction leaving the rest to shareholders

Within Country Heterogeneity

1. Multidimensional Skills

- Agent type: $\{x, y\}$, x manager skill, y worker skill
- Independently distributed $F(x, y)$, conditionals $F(x), G(y)$ (before $x = y$)
- FOC is as before $xQ'(h) = w$
- Set of managers $E(w) = \{x, y \in \mathbb{R}^2_+ \mid \pi(x, w) > wy\}$
- Market-clearing condition

$$\int_{E(w)} g(y, w)\, dF(x, y) = \int_{\mathbb{R}^2_+ - E(w)} x dF(x, y)$$

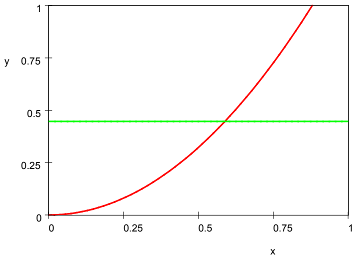
- Type $\overline{y}$ is indifferent: $\pi(x, w) = w\overline{y}$
- Autarky: $\overline{y}$ solves (independent of x, separability $xQ(h)$)

$$\int_0^{\overline{y}} g(\overline{y}, w) dG(y) = \int_{\overline{y}}^{\infty} y dG(y)$$

- Free trade, market clearing solves

$$\int_0^\infty \int_0^{\overline{y}(x)} g(\overline{y}, w) dG(y) dF(x) = \int_0^\infty \int_{\overline{y}(x)}^\infty y dG(y) dF(x)$$

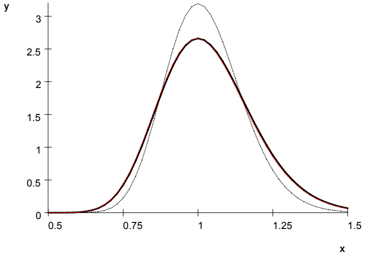
- **Proposition.** *Under free trade, $\overline{y}(x)$ strictly increasing in x.*
- Cobb-Douglas example ($\alpha = \frac{1}{2}$)

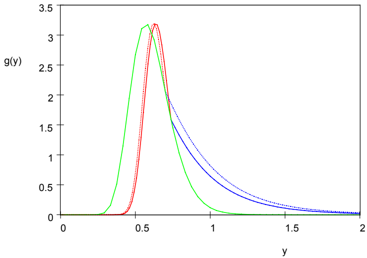


Within Country Heterogeneity

2. Increasing "reach" of labor: an lognormal example

- Let a country have skill distribution $F(x)$: allows for closed form solution using moment-generating function
- (Marginal) effect of increased openness: access to skill distribution $F'(x)$, mean-preserving spread of $F(x)$
- Examples: w increases, $\pi(x)$ decreases $\Rightarrow$ no First-order stochastic dominance





- **Proposition.** Zero-profit firms replicate market equilibrium
- Hire N agents: fraction n workers, $1-n$ managers; Let p be the wage per worker. The firm problem

$$\max_{n,N}\left\{\left[(1-n)\,xQ\left(\frac{nx}{1-n}\right)-p\right]N\right\}$$

- Zero profits $\Rightarrow Q=\frac{p}{(1-n)x}$ (N drops out)
- Remains: show occupational choice $xQ-w\frac{nx}{1-n}=wx$
- From the firm's problem:

$$\max_{n}\left\{\left[(1-n)\,Q\left(\frac{nx}{1-n}\right)-w\right]\right\}.$$

- The FOC: $0=Q-\frac{x}{1-n}Q'\left(\frac{1-n}{n}x\right)$
- Subst. Q, mult. by n: $xQ'(h)=w$ occupational choice

- Skill-dependent price $p\,(x)$; hire $n(x)$ agents: $n_m(x)$ managers, $n(x) - n_m(x)$ workers
- The firm problem

$$V = \max_{n(.),n_m(.),h(.)} \left\{ \int xQ\,(h\,[x])\, n_m\,(x)\, dx - \int p\,(x)\, n\,(x)\, dx \right\}$$

subject to:

$$\underbrace{\int h\,(x)\, n_m\,(x)\, dx}_{\text{\# efficiency units}} \leq \underbrace{\int x\,[n\,(x) - n_m\,(x)]\, dx}_{\text{\# non-managerial workers}}$$

and $0 \leq n_m\,(x) \leq n\,(x)$, and zero profits $V = 0$

- Solving this constrained program gives

$$p\,(x) = \begin{cases} w^F x & \text{for } x < z^F \\ \pi\left(x, w^F\right) & \text{for } x \geq z^F \end{cases}$$

Conclusion

- Theory of labor mobility as a result of openness
- Gains from openness are U-shaped
- Occupational sorting: in response to new equilibrium wages, occupational choice changes. More managers in high skill economy
- Can disentangle sorting from standard trade effect
- Openness and integration increase aggregate output
- But: openness is not Pareto improving in general