Wage inequality, technology, and trade

Joseph Zeira

JET (forthcoming)

November 6, 2007

Motivations

- The recent widening of wage inequality has been attributed to
  - skill-biased-technical-change
  - trade liberalization
- This paper
  - examines the two explanations within a unified model and do a horse racing.
  - presents a new modeling of skill-biased-technical-change, where skilled workers replace unskilled ones.

A static model

- The final good Y is produced by a continuum of intermediate goods $i \in [0, 1]$.

$$logY = \int_0^1 \log X(i)di$$

where $X(i)$ is the amount of intermediate good i.

- Intermediate goods are produced in two alternative technologies
  - production of one unit of intermediate good i with the unskilled labor technology in country j requires $\frac{n(i)}{a_j}$ units of unskilled labor.
  - production of one unit of intermediate good i with the skilled labor technology in country j requires $\frac{s(i)}{a_j}$ units of skilled labor.
- Assumption: $s(i) < n(i)$. Denote the relative gain in labor from replacing unskilled workers by skilled workers, by $g(i)$:

$$g(i) = \frac{n(i)}{s(i)} > 1$$

It is assumed to be a decreasing function.

A static model (cont.)

- The skilled labor technologies are invented over time. At period t the these technologies are known for only some intermediate goods, i.e. for a set $F_t = [0, f_t] \subset [0, 1]$. Technical progress means $F_{t-1} \subset F_t$.
- The size of the labor force in the country is L. A share h of it is skilled and a share $1 - h$ is unskilled.
- Markets are perfectly competitive. The final good is not traded. The set of traded intermediate goods is M_t, uniformly distributed over $[0, 1]$. The amount of traded goods, is a measure for trade openness:

$$m_t = \int_{M_t} di$$

- The global model has only two countries, A and B. The two countries differ in productivity, $a_A > a_B$. And $h_A > h_B$.

Equilibrium in a country without trade

- $M = \phi$.
- The choice of technology in the production of intermediate good.
  - For $i > f_t$, the unskilled technology is used.
  - For $i \leq f_t$, the skilled technology is adopted if

$$\frac{s(i)w_s}{a} \leq \frac{n(i)w_n}{a}$$

or if

$$g(i) = \frac{n(i)}{s(i)} \geq \frac{w_s}{w_n}$$

- Wage ratio $W = \frac{w_s}{w_n} > 1$ determines the level of technology adoption. The set of adopted technologies $Z = [0, z]$. where

$$z = \min\{g^{-1}(W), f\}$$

Equilibrium wages

- Demand side for intermediate goods

$$p(i) = \frac{\partial Y}{\partial X(i)} = \frac{Y}{X(i)}$$

- Supply side of intermediate goods

$$p(i) = \begin{cases} \frac{s(i)w_s}{a} & \text{if } i \in Z \\ \frac{n(i)w_n}{a} & \text{otherwise} \end{cases}$$

- Equilibrium in the market for skilled labor

$$Lh = \int_0^z \frac{s(i)}{a} X(i)di = z\frac{Y}{w_s}$$

- Equilibrium in the market for skilled labor

$$L(1-h) = \int_z^1 \frac{n(i)}{a} X(i)di = (1-z)\frac{Y}{w_n}$$

Equilibrium wages (cont.)

- W curve

$$W = \frac{w_s}{w_n} = \frac{1-h}{h}\frac{z}{1-z}$$

- G curve

$$z = \min\{g^{-1}(W), f\}$$

- Determine the technology adoption and wage ratio. (graph 1)

- Two kinds of countries
  - 'Developed' country, $z = f$.
  - 'Less-developed' country, $z < f$.

Effects of technical progress

- For 'developed' country
  - The skilled wage $\uparrow$

$$\frac{\partial \log w_s}{\partial f} = \frac{1}{f} + \log g(f) - \log W \geq 0$$

  - The unskilled wage (ambiguous effect)

$$\frac{\partial \log w_n}{\partial f} = -\frac{1}{1-f} + \log g(f) - \log W$$

    The unskilled wages might even fall if W is close to $g(f)$.
- For 'Less-developed' country, the equilibrium is not affected.
- A developed economy reacts by more than a less developed country.

Productivity or TFP

- TFP in a model without capital is labor productivity.

$$TFP = \frac{Y}{L} = w_s h + w_n(1-h) = w_n[1 + h(W-1)]$$

  - For a developed economy, the effect of technical progress on productivity is positive:

$$\frac{\partial \log TFP_D}{\partial f} = \log g(f) - \log W \geqslant 0.$$

  - Technical progress has no effect on a less developed country.

- Technical progress increases the productivity difference between developed and less developed countries.

World trade equilibrium

- Tradable intermediate goods set $M \neq \phi$, and $m = \int_M di > 0$.
- $a_B = 1$, and $a_A = a > 1$. and

$$W_A = \frac{w_{s,A}}{w_{n,A}} < W_B = \frac{w_{s,B}}{w_{n,B}}$$

- Lemma 2. Wages in the two countries satisfy: $w_{s,A} \leq a w_{s,B}$ and $w_{n,A} \geq a w_{n,B}$. One of the inequalities is strict.
- Two patterns of trade
  - full specialization,
  - equality of costs of skilled production in the two countries (partial specialization).

World trade equilibrium (cont.)

- Patterns of technology adoption. (graph 2)
- Patterns of international trade. (graph 2)
  A good $i \in M$ is exported by A if:

$$\frac{w_{s,A}s(i)}{a} \leq w_{n,B}n(i)$$

  or if

$$g(i) \geq \frac{1}{a}\frac{w_{s,A}}{w_{n,B}}$$

- Country A is exporting the set of intermediate goods $M \cap [0, f] \cap [0, v]$, where v is determined by

$$v = g^{-1}(\frac{1}{a}\frac{w_{s,A}}{w_{n,B}})$$

- Country B is exporting intermediate goods produced by non-skilled labor, which include all traded goods except those exported by A, i.e. $M \backslash M \cap [0, f] \cap [0, v]$.
- Lemma 2 guaranttes $v \in [z_B, z_A]$.

World trade equilibrium (cont.)

- Equilibrium with full specialization.
  $\int_{M\cap[0,v]} p(i)X_B(i)di = \int_{M\cap[v,1]} p(i)X_A(i)di$.
- Three curves (graph 3)

$$W_{\mathrm{A}} = \frac{1-h_{\mathrm{A}}}{h_{\mathrm{A}}}\frac{1-(1-m)(1-f)}{(1-m)(1-f)}.$$

$$W_{\mathrm{B}} = g(z_{\mathrm{B}}) = \frac{1-h_{\mathrm{B}}}{h_{\mathrm{B}}}\frac{z_{\mathrm{B}}(1-m)}{1-z_{\mathrm{B}}(1-m)}.$$

$$g(v) = \frac{1}{a}\frac{L_{\mathrm{B}}}{L_{\mathrm{A}}}\frac{1-h_{\mathrm{B}}}{h_{\mathrm{A}}}\frac{1-(1-f)(1-m)}{1-z_{\mathrm{B}}(1-m)}\frac{v}{1-v}.$$

- The shares of trade in income in the two countries are $m(1-v)$ in A and mv in B.

World trade equilibrium (cont.)

- Equilibrium with partial specialization in skilled goods

$$\int_{M\cap[0,v]} p(i)EX_{\mathrm{A}}(i)\,di = \int_{M\cap[v,1]} p(i)X_{\mathrm{A}}(i)\,di = P_{\mathrm{A}}Y_{\mathrm{A}}m(1-v),$$

  where $EX_A(i)$ is export of i from A.
- The effects of technical progress and trade liberalization
  - Skill-biased technical change
  - Trade liberalization

Skill-biased technical change-full specialization

- $f \uparrow$ shifts the G curve to the right.
  - $W_A \uparrow$ and $z_A = f \uparrow$. Technical progress increases the wage ratio by increasing the demand for skilled workers and by reducing the demand for unskilled.
  - No effect on W_B and z_B.
- Change of the trade patterns.
  - $f \uparrow$ shifts the W_T curve up and $v \downarrow$. Country A exports less intermediate goods to B and imports more intermediate goods from B.
  - The share of trade in GDP in A, $m(1-v) \uparrow$, and in B, $mv \downarrow$.

Trade liberalization-full specialization

- The effect on wage inequality.
  - $m \uparrow$ shifts the W_A curve up and thus $W_A \uparrow$.
  - $m \uparrow$ shifts the W_B curve downward and $W_B \downarrow$, $z_B \uparrow$.
- The effect on trade patterns.
  - The effect of trade liberalization on v is ambiguous.
  - Numerical example shows that it is likely that the shares of trade in GDP in both countries should rise.

Horse racing-evidence 1

- The model predicts that
  - for skill-biased-technical change, $W_B \uparrow$ or unchanged,
  - for trade liberalization, $W_B \downarrow$.
- In recent decades wage inequality increased in less developed countries as well, though by a smaller amount than in the developed countries.
- The rise in wage inequality cannot be attributed mainly to trade liberalization.

Horse racing-evidence 2

- The model predicts that
  - for trade liberalization, the share of this trade to GDP should rise in both A and B.
  - for skill-biased technical change, this share rises in A only and declines in B.
- In the recent two decades the share of inter-block trade in GDP rose slightly in the developed countries and remained stable in the less developed countries.
- The rise in wage inequality cannot be attributed mainly to trade liberalization.

Trade on productivity differences

- The PPP adjusted income ratio between the two countries:

$$I_{PPP} = \frac{Y_A}{Y_B}\frac{L_B}{L_A}$$

$$\log I_{\text{ppp}} = m \log \frac{v}{1-v} + m \log \frac{L_{\text{B}}}{L_{\text{A}}} + (1-m)\left[\begin{array}{l} \log a + \log \dfrac{1-h_{\text{A}}}{1-h_{\text{B}}} + \log \dfrac{1-z_{\text{B}}(1-m)}{1-(1-f)(1-m)} \\ + \int_{z_{\text{B}}}^{f} \log g(i)\, di - f \log W_{\text{A}} + z_{\text{B}} \log W_{\text{B}} \end{array}\right].$$

- A numerical analysis shows that trade increases the PPP TFP differential. Trade leads the developed country to specialize in skilled production, which is more productive. Under realistic conditions trade can increase productivity differences.

Conclusions & extension

- Examines how technical progress and trade liberalization affect
  - wage inequality in both developedand less developed countries,
  - the patterns of trade between the two blocks of countries,
  - and the productivity differentials between them.
- Skill-biased technical progress increases not only the gaps between wages of skilled and unskilled, but also the productivity gaps between countries, with and without trade. Trade can further increase these productivity gaps, through specialization.
- Contributes to the debates on what caused the recent rise in wage inequality in the US and in other western economies.
- To add physical capital to the analysis.