

Global Supply Chains and Wage Inequality

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- Most production processes consist of many sequential stages
 - Production of pins in late eighteenth century England
 - Production of tee-shirts, cars, computers, and semi-conductors today
- But production processes today increasingly involve vertical supply chains spanning multiple countries, with each country specializing in particular stages of a good's production sequence
 - This is what Hummels et al. (2001) refer to as “vertical specialization”

- In Costinot, Vogel and Wang (2011) (**CVW**) we have developed a simple model of trade with sequential production
- In this paper we present a multi-factor extension of CVW to explore how global supply chains affect wage inequality within countries
- We start from basic environment of Costinot and Vogel (2010) (**CV**)
 - Two countries, North and South, each populated by a continuum of workers with different skills
 - Both countries have access to the same technology for producing a unique final good, but North is skill abundant relative to South
- Crucially, as in **CVW**, production of the final good requires a continuum of stages to be performed sequentially

- Our model of trade with sequential production features a continuum of heterogeneous workers, but remains highly tractable
- **Key features:**
 - Factor prices are always equalized in a free trade equilibrium
 - Assignment of workers to stages exhibits positive assortative matching
- **Main results:**
 - 1 Global supply chains lead all Southern workers to move into earlier stages of production
 - 2 Wage inequality in South decreases at the bottom of the skill distribution, but increases at the top, an anti-Stolper-Samuelson effect

Basic Environment

Basic Environment

Worker Heterogeneity

- Two countries, North (N) and South (S)
- Measure one of heterogeneous workers with skill $s \in [\underline{s}, \bar{s}] \subset (0, 1)$
 - $L_c(s) > 0$ denotes supply of workers with skill s in country $c = N, S$
 - $w_c(s)$ denotes wage of these workers in country c
- North is skill-abundant compared to South in the sense that

$$\frac{L_N(s')}{L_N(s)} > \frac{L_S(s')}{L_S(s)}, \text{ for all } s' > s.$$

- There is one final good:
 - To produce the final good, a continuum of stages $\sigma \in [0, 1]$ must be performed (more on that on the next slide)

Basic Environment

Sequential Production

- At each stage, producing 1 unit of intermediate good requires a fixed amount of previous intermediate good and a fixed amount of labor
- If a firm combines $q(\sigma)$ units of intermediate good σ with $q(\sigma)d\sigma$ units of workers of skill s , its output of intermediate good $\sigma + d\sigma$ is

$$q(\sigma + d\sigma) = (1 + (\ln s) d\sigma) q(\sigma).$$

- All markets are perfectly competitive and all goods are freely traded
 - “Intermediate good 0” is in infinite supply and has zero price
 - “Intermediate good 1” corresponds to final good mentioned before
 - We use the final good as our numeraire

Free Trade Equilibrium

Free Trade Equilibrium

Factor Price Equalization

- In a free trade equilibrium, markets clear and firms maximize profits
- Profit maximization requires that

$$p(\sigma + d\sigma) \leq (1 - (\ln s) d\sigma) p(\sigma) + w_c(s) d\sigma,$$

with equality if employment is positive between stages σ and $\sigma + d\sigma$

- Together with the labor market clearing conditions, this condition implies that FPE must hold in a free trade equilibrium
- Thus the free trade equilibrium replicates the integrated equilibrium of closed economy with endowments $L(s) \equiv L_N(s) + L_S(s)$
- We denote by $w(\cdot)$ the common wage schedule in both countries

Free Trade Equilibrium

Positive Assortative Matching

Lemma

In a free trade equilibrium there exists a strictly increasing matching function $M : [\underline{s}, \bar{s}] \rightarrow [0, 1]$ such that in both countries: (i) workers with skill s are employed in stage σ if and only if $M(s) = \sigma$, (ii) $M(\underline{s}) = 0$, and (iii) $M(\bar{s}) = 1$.

- The intuition is the same as in **CVW**:
 - Efficiency requires more skilled workers to leverage higher productivities on larger amounts of inputs by operating higher up the chain
- Since North is skill abundant, same matching function implies
 - North produces relatively more in later stages of production
 - There must be global supply chains with Southern workers at the bottom and Northern workers at the top under free trade

Free Trade Equilibrium

Characterization

Lemma

In a free trade equilibrium the matching function and wage schedule are given by the solution of two ordinary differential equations

$$\frac{d \ln M'(s)}{ds} = -\ln s e^{\ln M'(s)} + \frac{d \ln L(s)}{ds},$$
$$\frac{d^2 \ln w(s)}{ds^2} = -\frac{1 + sM'(s) \ln s}{s} \frac{d \ln w(s)}{ds} - \left(\frac{d \ln w(s)}{ds} \right)^2 + \frac{M'(s)}{s},$$

with boundary conditions such that:

$$\int_{\underline{s}}^{\bar{s}} \left[\frac{d \ln L(s)}{ds} - \frac{d \ln M'(s)}{ds} \right] \frac{ds}{\ln s} = 1,$$
$$w'(\underline{s}), w'(\bar{s}) = 0.$$

Consequences of Global Supply Chains

- **Thought experiment:**

Suppose that North and South were to go from autarky to free trade, i.e. to an equilibrium with both local and global supply chains

- **Question:**

What would be the implications for the assignment of workers to stages of production and for wage inequality?

- **Approach:**

Because of FPE, the effects are the same as changing the skill distribution from $L_i(\cdot)$ to $L(\cdot) \equiv L_N(\cdot) + L_S(\cdot)$

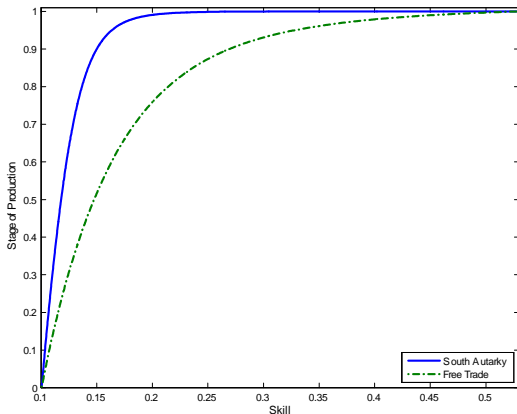
Proposition

Starting from autarky, the emergence of global supply chains leads to stage downgrading for all Southern workers, $M(s) \leq M_S(s)$. The converse is true in North.

- The basic intuition is the same as in **CV**:
 - Since North is skill abundant, the world skill distribution features relatively more high-skill workers than the Southern skill distribution.
 - Accordingly, more stages should employ high-skill workers
 - This explains why $M^{-1}(\sigma) \geq M_S^{-1}(\sigma)$, and so, $M(s) \leq M_S(s)$

Matching

Example: Truncated Pareto with Different Shape Parameters in North and South



Wage Inequality

Main Result

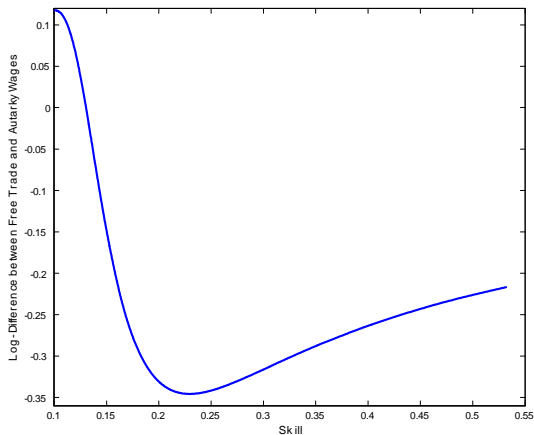
Proposition

Starting from autarky, the emergence of global supply chains decreases wage inequality among low-skill Southern workers, $d \ln w(s) / ds \leq d \ln w_S(s) / ds$ for $s \leq \hat{s}$, but increases wage inequality among high-skill Southern workers, $d \ln w(s) / ds \geq d \ln w_S(s) / ds$ for $s \geq \hat{s}$, with $\hat{s} \in [\underline{s}, \bar{s}]$. The converse is true in North.

- The logic of such non-monotonic effects is discussed in **CVW**
- **Basic Idea:**
 - In model without sequential production, changes in wages reflect changes in the prices of the goods produced by different workers
 - In model with sequential production, changes in wages also reflect changes in the prices of the intermediate goods used by these workers

Wage Inequality

Example: Truncated Pareto with Different Shape Parameters in North and South



Concluding Remarks

- We have developed a multi-factor extension of **CVW** to investigate the consequences of global supply chains on wage inequality
- Our model of trade with sequential production features a continuum of heterogeneous workers, but remains highly tractable
- Global supply chains tend to increase inequality at the top in less skill-abundant countries, an anti-Stolper-Samuelson effect
- Model is stylized, but message is more general: because of global supply chains, consequences of globalization for wage inequality may be very different in primary sectors than in manufacturing sectors