Global Supply Chains and Wage Inequality

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Motivation

- 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.
Main Results

- 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
- 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 $\sigma$ 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
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 \( \sigma \) 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 \( M : [s, \bar{s}] \rightarrow [0, 1] \) such that in both countries: (i) workers with skill \( s \) are employed in stage \( \sigma \) if and only if \( M(s) = \sigma \), (ii) \( M(\bar{s}) = 0 \), 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 Norther workers at the top under free trade
Lemma

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

\[
\frac{d \ln M'(s)}{ds} = - \ln se^{\ln M'(s)} + \frac{d \ln L(s)}{ds},
\]

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

with boundary conditions such that:

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

\[
w'(\bar{s}), \ w'(\bar{s}) = 0.
\]
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 $L(\cdot) \equiv L_N(\cdot) + L_S(\cdot)$.
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
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 $\hat{s} \in [s, \bar{s}]$. 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

![Graph showing the Log-Difference between Free Trade and Autarky Wages vs Skill](image-url)
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.