Should Appropriate Technology Be Revived?

Fabrizio Zilibotti

Yale University

IEA, February 2022

Gradual Adoption of Inappropriate Technologies

- AZ (2001): a theory of (in)appropriate technologies can account for a significant share of international productivity differences.
  - Theory: the technology leader(s) innovate(s); the rest of the world immediately adopts at zero cost.
- Today: A framework in which *frontier* technologies are first introduced in advanced economies and then *gradually* adopted by developing economies.
  - In line with the lessons from Grilliches (1957).
  - Based on joint research with Gino Gancia and Andreas Mueller.
- Horse race between *inappropriate technology* and *barriers to adoption*.

Innovation and Adoption I

- A CES aggregate production function:

$$Y_c = K_c^{\alpha} \left(\left[(N_{Lc} L_c)^{\frac{\sigma-1}{\sigma}} + (N_{Hc} H_c)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \right)^{1-\alpha},$$

- K is capital, H high-skill labor, L low-skill labor and $\sigma > 1$.
- An advanced economy (the North) pushes ahead the world technology frontier (N_L, N_H).
- Innovators can only sell new technologies to firms in the North —e.g., because of weak international IPR protection.

Innovation and Adoption II

- Southern countries *adopt* factor-specific technologies at a cost that is decreasing in their distance from the frontier.
- Technology adoption—like innovation—is profit-driven.
- The technology *menu* can be inappropriate to local endowment of complementary factors (capital, skills, land soil, weather, etc.).

The Endogenous Skill Bias of Technology I

- The skill bias of the world technology (N_H / N_L) compatible with balanced growth is as in AZ 2001:

$$\frac{N_{HN}}{N_{LN}} \propto \left(\frac{H_N}{L_N}\right)^{\sigma-1}.$$

- For Southern firms, the cost of adoption is a decreasing function of the distance to frontier:

$$c_L = \frac{1}{\eta}\left(\frac{N_{LN}}{N_{LS}}\right)^{-\xi} \quad \text{and} \quad c_H = \frac{1}{\eta}\left(\frac{N_{HN}}{N_{HS}}\right)^{-\xi}, \quad \xi \geq 0.$$

- ξ is an inverse measure of barriers to technology adoption in the South.

The Endogenous Skill Bias of Technology II

- The steady-state equilibrium pins down the skill bias of technology in the South:

$$\frac{N_{HS}}{N_{LS}} \propto \left[\left(\frac{H_S}{L_S} \right) \left(\frac{H_N}{L_N} \right)^{\sigma\xi} \right]^{\frac{\sigma-1}{1+\sigma\xi}} .$$

- Technology adoption in the South depends on the skill endowment both in the North and in the South.
    - A high skill endowment in the North means that skill-complement innovations are abundant and therefore cheap to adopt.
    - A low skill endowment in the South weakens incentive to adopt skill-complement innovations.
- The skill-bias of the Southern technology, N_{HS} / N_{LS}, is increasing in ξ, i.e., decreasing in barriers.

The Endogenous Skill Bias of Technology III

- Extreme cases:
  - If $\xi \to 0$ (prohibitive barriers) the South develops technologies independently from the North:
$$\frac{N_{HS}}{N_{LS}} \propto \left[\frac{H_S}{L_S}\right]^{\sigma-1}.$$
  - If $\xi \to \infty$ adoption is free (no barriers) so that the South is using the same technology as the North. This is the case studied by Acemoglu and Zilibotti (QJE 2001).
$$\frac{N_{HS}}{N_{LS}} \to \frac{N_{HN}}{N_{LN}} \propto \left[\frac{H_N}{L_N}\right]^{\sigma-1}.$$

The Structural Equation I

- For any "southern country", the output relative to the frontier is

$$\frac{Y_S}{Y_N} = \left(\left(\frac{K_S}{K_N}\right)^{\alpha} \left[\frac{L_S^{\beta} + \left(Z\frac{H_N}{L_N}\right)^{\frac{\xi(\sigma-1)}{1+\xi}\beta} (ZH_S)^{\beta}}{L_N^{\beta} + \left(Z\frac{H_N}{L_N}\right)^{\frac{\xi(\sigma-1)}{1+\xi}\beta} (ZH_N)^{\beta}} \right]^{\frac{1-\alpha}{\beta}} \right)^{\frac{1+\xi}{\alpha+\xi}}$$

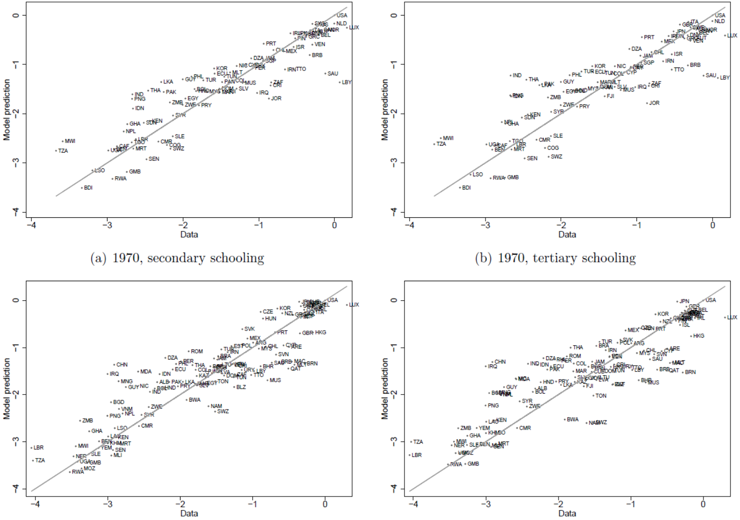
where

$$\beta \equiv \frac{(\sigma-1)(1+\xi)}{1+\sigma\xi}$$

- The quantitative analysis is based on a mixture of calibration and estimation of this equation.

The Structural Equation II

Figure 2: Baseline estimation: GDP pw (log-difference from the US)



(a) 1970, secondary schooling

(b) 1970, tertiary schooling

(c) 2000, secondary schooling

(d) 2000, tertiary schooling

What Do We Learn? I

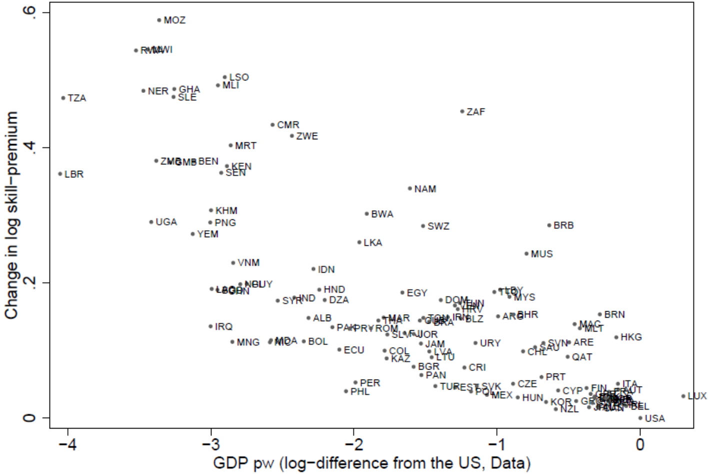
1. The model accurately fits the international data;
2. Estimated barriers to technology adoption are important, especially for the poorest countries;
3. However, inappropriate technology are *even more important*—reducing skill mismatch (education gap) has a larger effect than in standard development accounting exercise (a double dividend)
4. Counterfactual analysis:
    1. Cutting barriers to technology adoption;
    2. Reducing trade frictions.

Changes in Inequality I

- If we remove barriers to technology adoption ($\uparrow \xi$), all countries use the same technology.
  - For the followers, technology becomes more skill biased.
  - Therefore, inequality goes up in developing economies.

Changes in Inequality II

Figure 6: Change in skill premium: benchmark to no barrier counterfactual

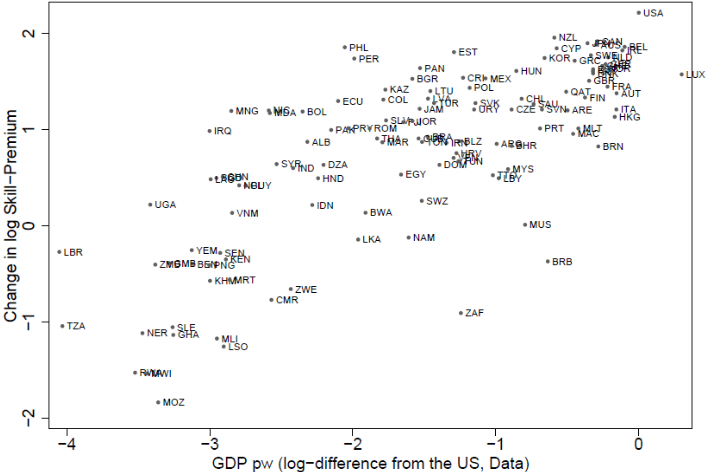


Changes in Inequality III

- For trade liberalization, two opposite effects (in the Sotuh):
  - the skill premium falls because of a Stolper-Samuelson effect;
  - the skill premium increases due to the increase in the skill bias of technical change in the North.
- Calibrated economies: wage inequality increases in most countries after trade liberalization.
  - Exceptions: a few (sub-Saharan) countries.
  - Inequality rises sharply in India and China.

Changes in Inequality IV

Figure 7: Change in skill premium: benchmark to free trade counterfactual



Themes for Debate & Future Research I

- Recent technologies may be *very* inappropriate (e.g., labor-saving robots)
  - distributional effects dominate over efficiency gains?
- Recently, many developing economies are growing without industrializing (*service-led growth*).
  - Are technology in service sector more portable?
- *China* is becoming a new innovation powerhouse.
  - Does it make a difference either way?
- Is there a case for *local development of new technologies*?
  - Problem: market size, efficiency of local innovation.