Automation and Appropriate Technology

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Roadmap

- **Why automation increasing?**
  - ⋆ Falling prices;
  - ⋆ Wages of low-skilled workers;
  - ⋆ Aging
- **Why automation could be bad for developing countries?**
  - ⋆ Appropriate technology:
    developing countries are poor in capital, which automation technologies require
- **Policy implications:**
  - Policies to smooth adjustment of workers: training programs or unemployment insurance
  - Investment in education

Rising Wages Drive Automation

- Firm minimises cost $rK + wL$ subject to a CES technology:

$$Y = A\left[\alpha K^{\rho} + (1-\alpha)L^{\rho}\right]^{1/\rho}$$

- K and L are substitutes if:

$$\rho > 1$$

- Choice of K/L:

$$\frac{\alpha}{1-\alpha}\left(\frac{K}{L}\right)^{\rho-1} = \frac{r}{w} \quad \Longrightarrow \quad \boxed{K^* = L\left(\frac{\alpha}{1-\alpha}\right)^{\frac{1}{1-\rho}}\left(\frac{w}{r}\right)^{\frac{1}{1-\rho}}}$$

How Prices and Wages Drive Robot Adoption

- Effect of robot prices (r):

$$\frac{\partial K^*}{\partial r} = -\frac{1}{1-\rho}\frac{K^*}{r} < 0$$

Lower prices raise capital (robot) demand.

- Effect of wages (w):

$$\frac{\partial K^*}{\partial w} = \frac{1}{1-\rho}\frac{K^*}{w} > 0$$

Higher wages raise capital (robot) demand.

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Robot Prices Have Fallen Dramatically

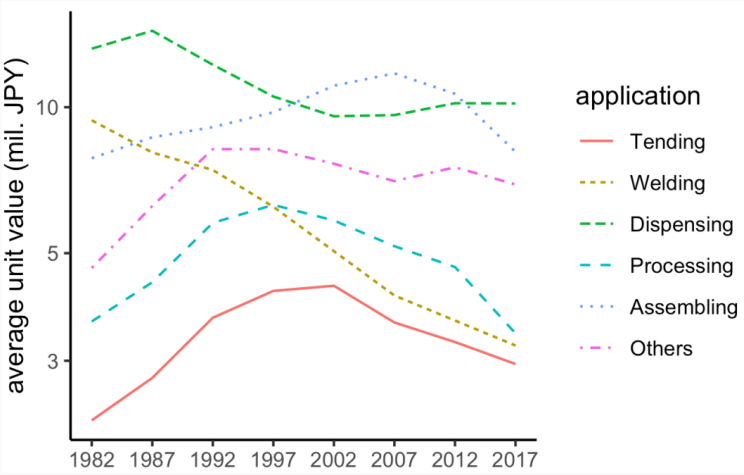

Figure: Robot price per unit in Japan. Source: Adachi, Kawaguchi, and Saito (2022).

Imported Robot Prices in Brazil

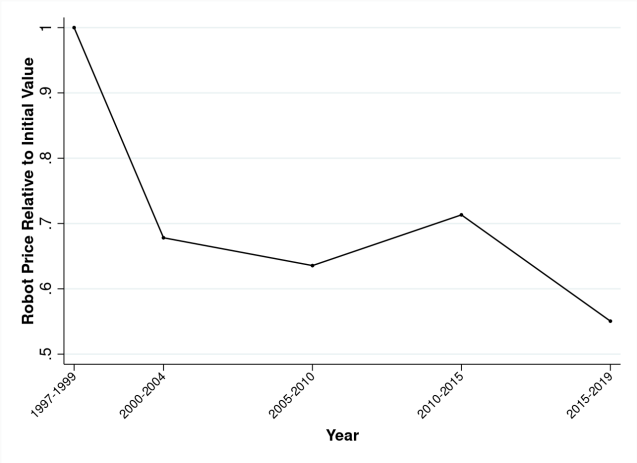

Figure: Imported robot price in Brazil. Source: de Souza and Li (2025).

Wages Drive Automation Innovation

- **Dechezleprêtre, Hémous, Olsen, and Zanella (2025)**: firm-level patent data across 41 countries
- **Main finding**: a 1% increase in low-skill wages raises automation innovation
  - ⋆ High-skill wage increases *reduce* automation innovation
- **Natural experiment**: German Hartz reforms (2003–2005)
  - ⋆ Reforms reduced unemployment insurance and expanded low-wage labour supply
  - ⋆ Firms more exposed to Germany *innovated less* in automation after the reforms

Hartz Reforms Reduced Automation Innovation

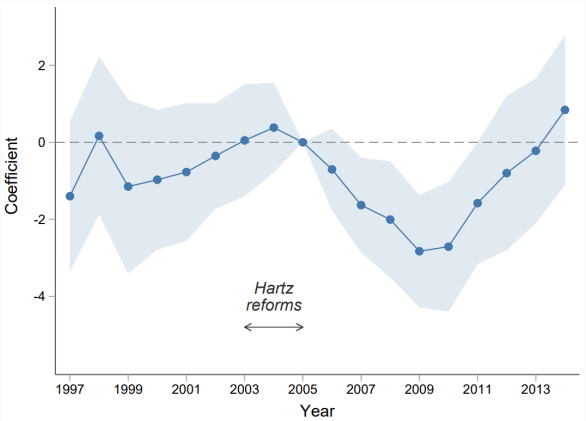

Figure: Effect of the Hartz reforms on robot patent applications. The reforms reduced unemployment insurance and increased low-wage labour supply, lowering firms' incentive to automate. Source: Dechezleprêtre et al. (2025).

Population Aging Drives Robot Adoption

- **Acemoglu and Restrepo (2021)**: cross-country panel linking demographic aging to robot adoption
- **Mechanism**: aging makes middle-aged workers (36–55) relatively scarce $\Rightarrow$ their wages rise $\Rightarrow$ firms substitute with robots
- **Key finding**: demographic aging alone accounts for 35% of cross-country variation in robot adoption

$\Longrightarrow$ **As developing countries age, robot adoption will accelerate.**

Aging and Robot Adoption Across Countries

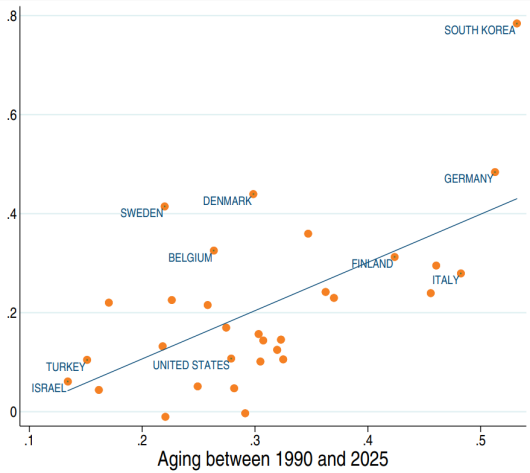

Figure: Correlation between aging and robot adoption across countries. Source: Acemoglu and Restrepo (2021).

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Appropriate Technology

- Fix K and L; firm chooses capital-intensity of technology α:

$$\max_{\alpha} \; Y = A\left[\alpha K^{\rho} + (1-\alpha)L^{\rho}\right]^{1/\rho} \quad \text{s.t.} \quad f(\alpha) = 0$$

- Y is increasing in α iff $K^{\rho} > L^{\rho}$. If $\rho > 1$:

$$\frac{\partial Y}{\partial \alpha} > 0 \iff K > L$$

$\Longrightarrow$ **Capital-abundant (advanced) economies gain more from high-α robot technologies; labour-abundant (developing) economies do not.**

Appropriate Technology

- In developing countries, labor is **abundant** and capital is **scarce**
- Industrial robots rely on the *scarce* factor and replace the *abundant* one $\Rightarrow$ **mismatch**
- Technologies designed in advanced economies reflect their factor endowments and may be ill-suited for developing economie (*Acemoglu & Zilibotti (2001); Basu & Weil (1998)*)
- Yet firms in developing countries may still adopt robots if productivity gains are large enough (*de Souza (2022)*)

$\Longrightarrow$ **Firms become more productive, but less so than in advanced economies where the technology is truly appropriate.**

Effect on Innovation

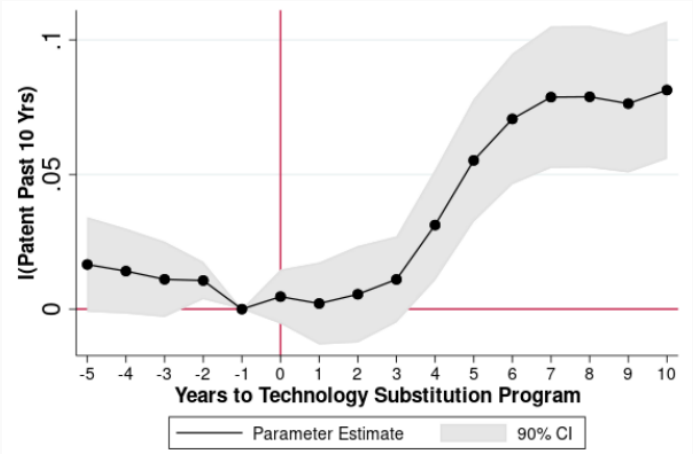

Figure: Effect of the technology substitution program on innovation. Source: de Souza (2022).

Effect on Expenditure Share

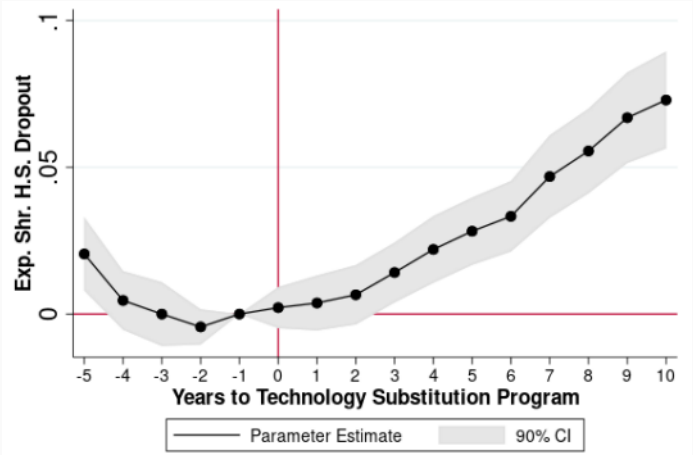

Figure: Effect of the technology substitution program on expenditure share. Source: de Souza (2022).

Effect on Firm Size

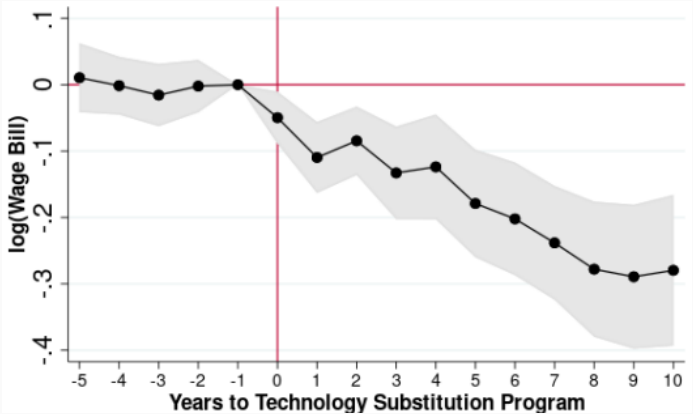

Figure: Effect of the technology substitution program on firm size. Source: de Souza (2022).

What you learned from me:

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