EC9AA Term 3: Lectures on Economic Inequality

Debraj Ray, University of Warwick, Summer 2024

- **Slides 3**: Functional Inequality: The Falling Labor Share

The Fourth Fundamental Law of Capitalism

- We now downplay personal endowments and accumulation
  - Though still very much in the background
- Our focus: **the functional distribution across capital and labor**

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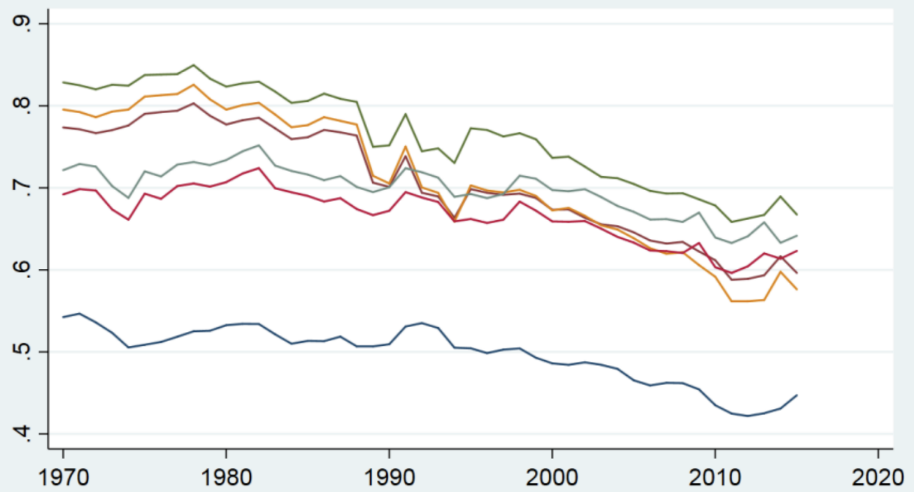
- A **fundamental law**? You can't be serious.
  - It isn't even testable (though stronger versions of it are)
  - But it *is* a fundamental device for organizing our thoughts.

Death of a Kaldor Fact

The falling labor share:



Guerriero (2019)

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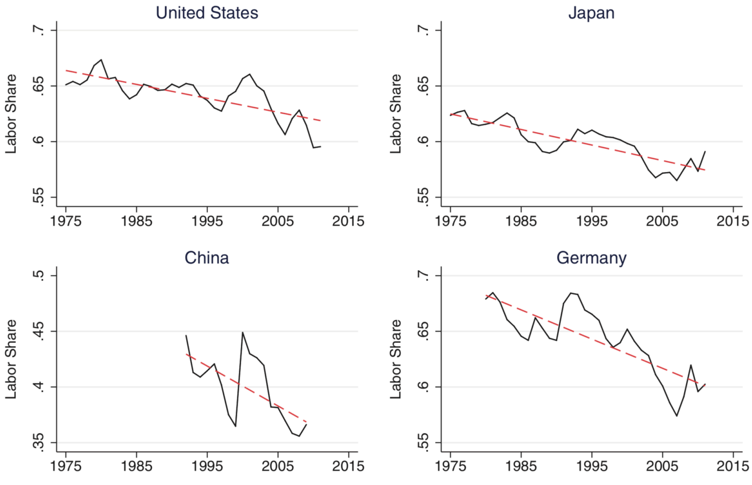

Karabarbounis and Neiman (2014). Also Harrison (2002) and Rodríguez and Jayadev (2010),

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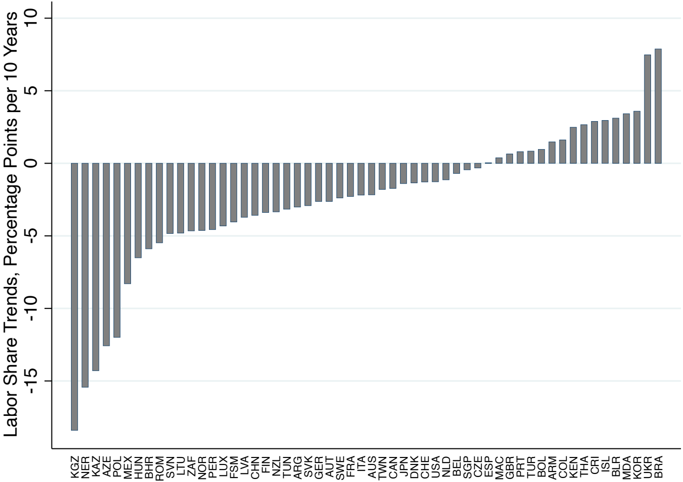

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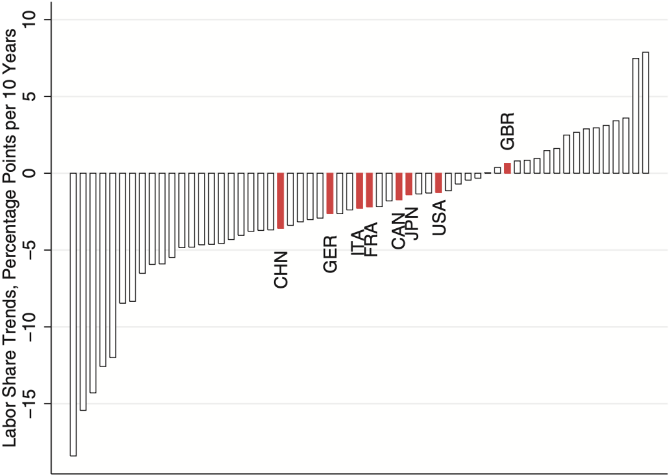

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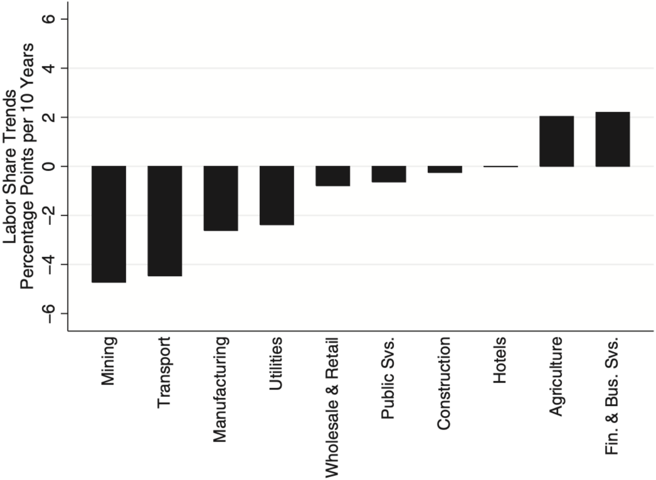

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- **Covid-19**

Explanations

- **Capital-Labor Substitution**

Explanations

Capital-Labor Substitution

- Employment elasticities by sector, various regions. Kapsos (2005).

Region	Agriculture	Industry	Services
World	0.24	0.21	0.61
W. Europe	-1.08	-0.50	0.74
N. America	-0.02	0.26	0.60
Central/Eastern Europe	-0.51	0.11	0.51
East Asia (excl. Japan)	0.10	0.07	0.47
Japan	-2.04	-0.83	0.76
Australia/NZ	0.18	0.26	0.61
South-East Asia	0.01	0.82	1.08
South Asia	0.38	0.41	0.46
Latin America	-0.16	0.63	1.09
Sub-Saharan Africa	0.69	0.88	0.89

Explanations

Capital-Labor Substitution

- GDP and employment growth, some developing countries. An et al. (2017).

	Yearly, 1991–2000		Yearly, 2001–2015	
Country	GDP	EMP	GDP	EMP
Egypt	4.27	1.47	4.33	2.31
India	5.73	0.60	7.09	0.61
Indonesia	4.84	1.96	5.41	1.73
Kenya	2.09	2.20	4.38	2.00
Morocco	4.78	5.11	4.46	1.04
Nicaragua	3.17	5.61	3.66	3.19
Pakistan	4.48	1.99	4.29	2.84
Philippines	2.75	2.51	5.11	2.46
Tanzania	4.15	2.55	6.41	3.34
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  - Intuitively compelling:
  - As growth occurs per-capita, capital becomes plentiful relative to labor
  - So it makes sense that the relative prices of capital goods fall.
- **But** …
  - Net effect on labor share depends on the **elasticity of substitution**.
  - E.g., dividing line: Cobb-Douglas production function.
- This is what I want to try and explore further.

Our Theory: Accumulation and Automation

- **Two pillars:**

I. Human-physical asymmetry

II. Machine capital and robot capital

I. The Human-Physical Asymmetry

Mankiw-Romer-Weil 1992:

$$\dot{k}(t) = s_k y(t) - (n + \delta)k(t)$$

$$\dot{h}(t) = s_h y(t) - (n + \delta)h(t)$$

What does the second equation mean?

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- Physical capital can be indefinitely replicated:
  - And so can individual claims to them.
- But human capital *cannot* be replicated in the same way.
  - always in *one* physical self **[inalienable]**.
  - To some extent, scalable within occupation or sector
  - But more fundamentally, scales across sectors.

II. Machines and Robots

- **Many sectors** indexed by j:

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- **So capital comes in two flavors**:
  - k: machines, complementary to labor.
  - r: robots, substitutes for labor.

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- $\tau_j(h, r) = \nu_j r + \mu_j h + r^{\alpha_j} h^{1-\alpha_j}$ for for $\nu_j > 0$, $\mu_j > 0$, and $\alpha_j \in (0, 1)$.

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- But certainly a threat if the price is right:

"nothing humans do as a job is uniquely safe anymore. From hamburgers to healthcare, machines can be created to successfully perform such tasks with no need or less need for humans, and at lower costs than humans..." Scott Santens, *The Boston Globe*, 2016

Three Special Sectors

- **Machine capital:** $y_k = f_k(k_k, \tau_k)$, with $\tau_k = \tau_k(h_k, r_k)$.

- **Robot capital:** $y_r = f_r(k_r, \tau_r)$, with $\tau_r = \tau_r(h_r, r_r)$.

- **Education:** $y_e = f_e(k_e, \tau_e)$, with $\tau_e = \tau_e(h_e, r_e)$.

- All assumptions made earlier **apply to these sectors** as well.

A Bit More on Education

- Raw labor is given (or normalized), but **human capital grows endogenously**.
  - Initial allocation of humans across occupations.
  - Individuals can move from sector to sector (or task to task).
  - Educational cost $= e(i, j)p_e$, the endogenous price of education.

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  - **Ends** with new wealth, maybe new sector. **Repeat**.

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- **Asymptotic Homotheticity of Preferences:**
  - If $\mathbf{x}_m(\mathbf{p}, z)$ is demand for goods by type m as function of current z, then

$$\lim_{z \to \infty} \frac{\mathbf{x}_m(\mathbf{p}, z)}{z} = \mathbf{d}_m(\mathbf{p}) \text{ for some function } \mathbf{d}_m(\mathbf{p}).$$

Price System

Competitive Pricing

- numeraire: rental rate on machine capital
- $\mathbf{p}$: prices, includes (p_r, p_k, p_e)
- $\mathbf{w}$: wages, includes (w_r, w_k, w_e)

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$$q_j = q_j(w_j, p_r) = \min \left\{ w_j h_j + p_r r_j | \tau_j(h_j, r_j) = 1 \right\}.$$

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- **Unit cost function for output** determines output price p_j by CRS:

$$p_j = c_j(1, q_j) = \min\left\{k_j + q_j \tau_j | f_j(k_j, \tau_j) = 1\right\}$$

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- automation index for each sector j and relative price $\zeta_j \equiv w_j/p_r$:

$$a_j(\zeta_j) \equiv \min_{(r_j,h_j)} \left\{ \frac{r_j}{h_j\zeta + r_j} \middle| (r_j,h_j) \text{ minimizes unit cost under } \zeta_j \right\} \in [0,1].$$

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- consumption-savings choices pinned down by:

$$\text{Interest rate } (t) = \frac{1 + (1-\delta) p_k(t+1)}{p_k(t)} - 1.$$

where $\delta \in (0, 1)$ is the rate of depreciation.

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- The two faces of capital
  - machines and robots **Pillar II**
- Otherwise pretty standard:
  - (Asymptotically) homothetic preferences
  - Competitive price system;
  - Condition for growth (patience relative to technology).

The Critical Role Played by Robot Production

- **Robot production function** like any other:

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- **Combining:**

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- **Big question:** given this inequality, how high can robot prices go?

(relative to the normalized cost of machine rentals, set to 1)

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- **Big question:** given this inequality, how high can robot prices go?

  (relative to the normalized cost of machine rentals, set to 1)

  - Depends on whether $c_r(1, \nu_r^{-1} p_r)$ goes below 45° line as $p^r \uparrow$.
  - I.e., whether $c_r(1, \nu_r^{-1} p_r) < p_r$ for all large p_r.

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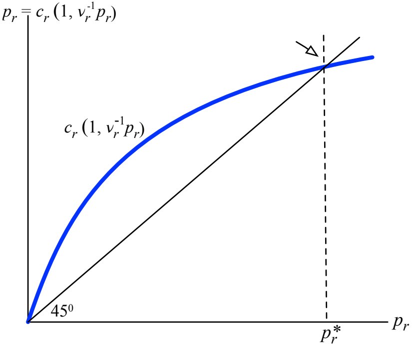

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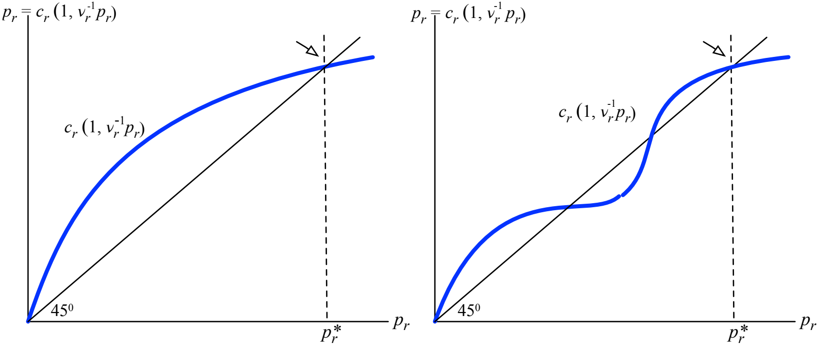

- Equivalent to $\nu_r > \lim_{\rho \to 0} c_r(\rho, 1)$.
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- Could fail if elasticity of substitution is below 1.
- **Example**: $y_r = \left[\frac{1}{2}k_r^{-1} + \frac{1}{2}\tau_r^{-1}\right]^{-1}$
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- Connection to self-replication in the robot sector (von Neumann).

The Critical Role Played by Robot Production

- **This boundedness of robot prices is key.**
  - It bounds machine capital prices $p_k(t)$, and therefore the average interest rate

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- So under sufficient patience, the economy must grow.
  - Human wages rise, robot prices bounded
  - $\Rightarrow$ **automation index $\to 1$ in every growing sector.**

Automation and the Declining Labor Share

Theorem 1

- *Assume* (a) *high patience among some subset of population,* (b) *asymptotically homothetic preferences, and* (c) *self replication. Then:*

(i) *Per-capita national income grows without bound:* $Y(t) \to \infty$*;*

(ii) *Each sector that grows without bound is asymptotically fully automated in the long run;*

(iii) *The share of human labor in national income must converge to zero.*

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Link to Piketty

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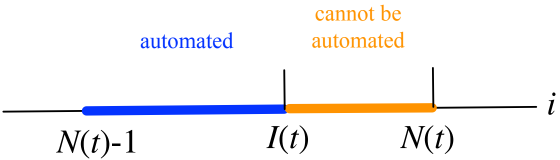

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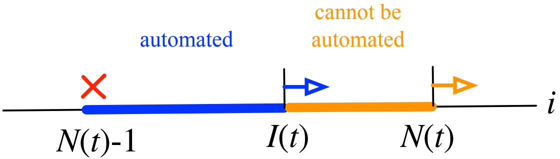

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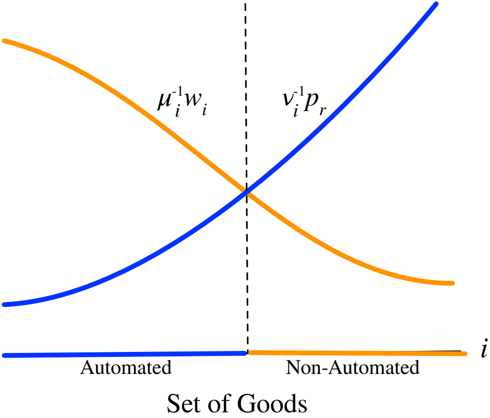

Directed technical progress to the rescue?

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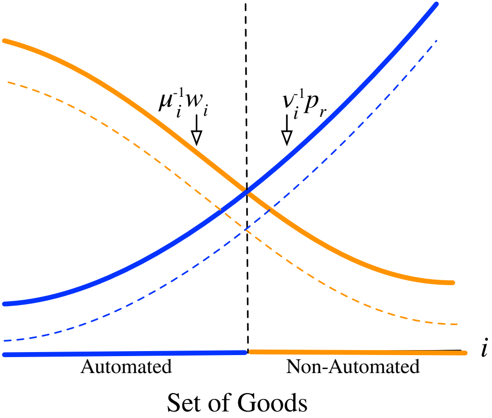

Directed Technical Progress

Production Function:

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- Inventor can advance productivity at rate ρ for any chosen factor-sector pair:
- Cost $\kappa(\rho)$ increasing, convex, prohibitive at $\bar{\rho}$, same for every factor and sector.
- Gets temporary patent protection, which she licenses to an active firm.
- After one period the advance goes public.
- Spillover fraction $\gamma > 0$ (public) for this factor in other sectors.

Directed Technical Progress

Theorem 2 (The Extended Dismal Scenario)

- *Make the same assumptions as in Theorem 1.*

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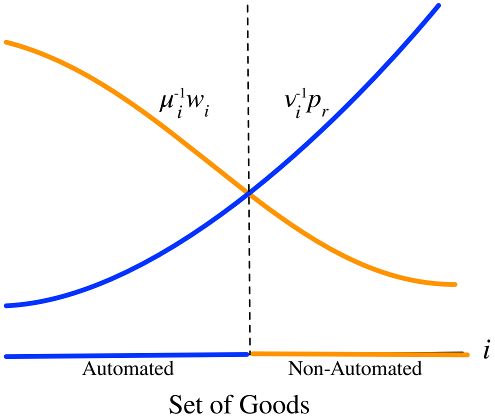

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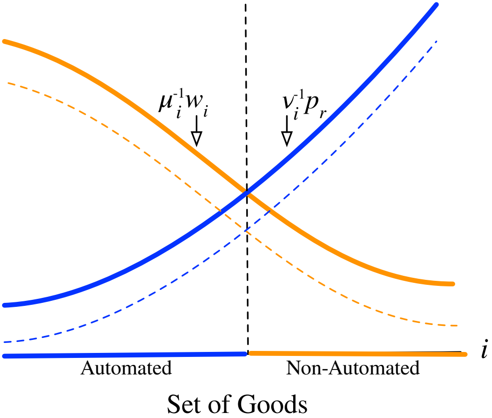

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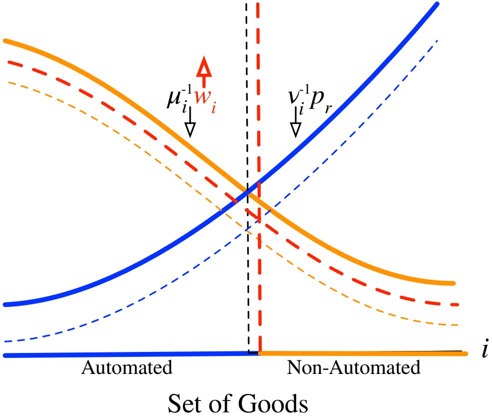

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  - A recognition that physical capital can be machine-like or robot-like.

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- **Other important features:**
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  - Enough patience for ongoing growth and capital accumulation.
  - Self-replication: production of automata by means of automata.
- **Under these conditions, labor income share $\rightarrow 0$:**
  - full automation in the long run …
  - …despite wages rising over time (slow automation).

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An age-old anxiety: that “capital” will inherit the earth.

- But the underlying worry is about the personal distribution of income.
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Social Alternatives:

- universal basic income (e.g. *Ideas for India* special issue, *Economic Survey*)
- social stock portfolios (e.g., Ghosh and Ray 2020 on the India Fund)
- See **Supplement to Slides 3**.