EC9AA Term 3: Lectures on Economic Inequality

Debraj Ray, University of Warwick

- **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**

The Fourth Fundamental Law of Capitalism

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The labor share in national income must progressively vanish.

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With economic growth, capital displaces labor:

The labor share in national income must progressively vanish.

- 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.
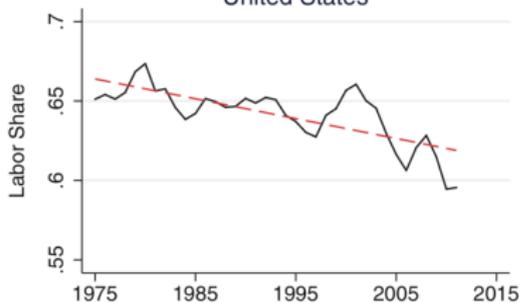
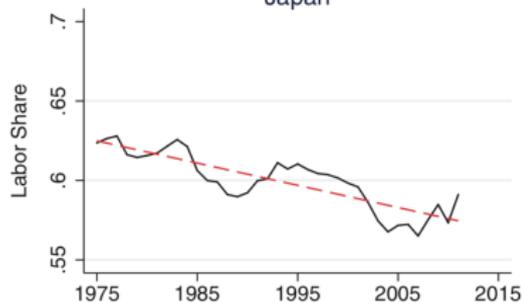# Death of a Kaldor Fact

The falling labor share:

Guerriero (2019)
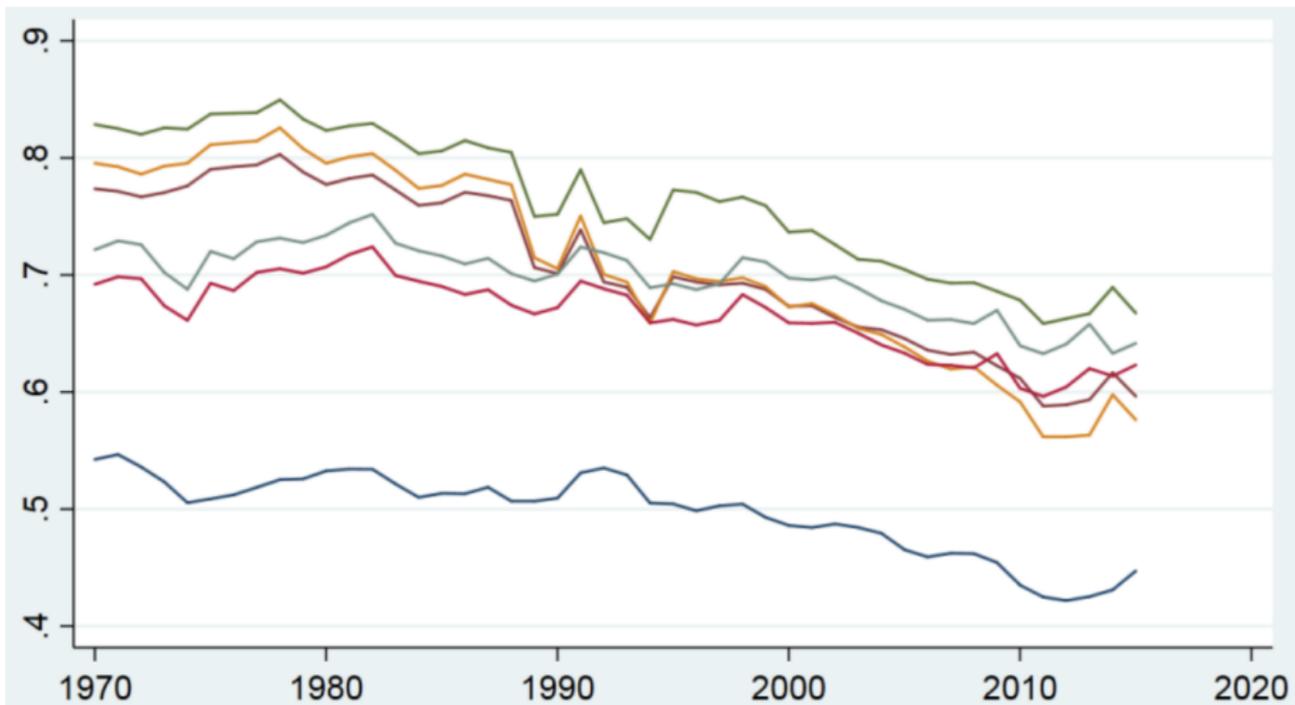
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The falling labor share:

United States, Japan, China, Germany — Labor Share plotted 1975–2015 with declining trend lines.
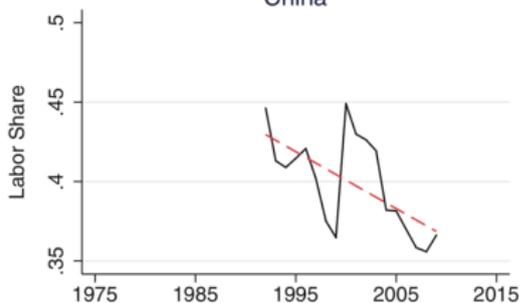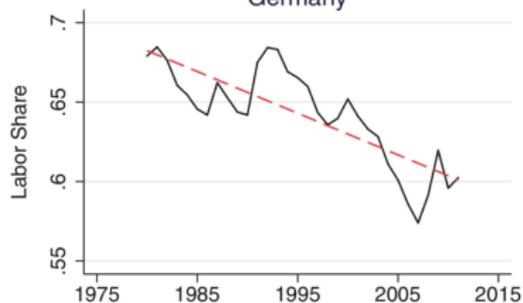
Karabarbounis and Neiman (2014). Also Harrison (2002) and Rodríguez and Jayadev (2010),

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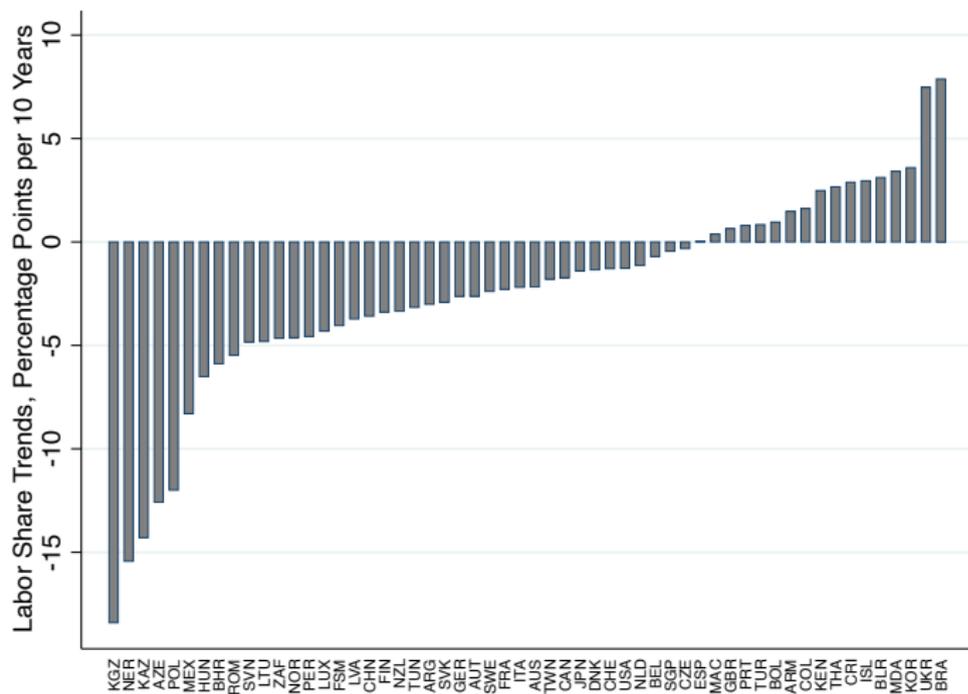
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The falling labor share:

Labor Share Trends
Percentage Points per 10 Years

Categories (left to right): Mining, Transport, Manufacturing, Utilities, Wholesale & Retail, Public Svs., Construction, Hotels, Agriculture, Fin. & Bus. Svs.

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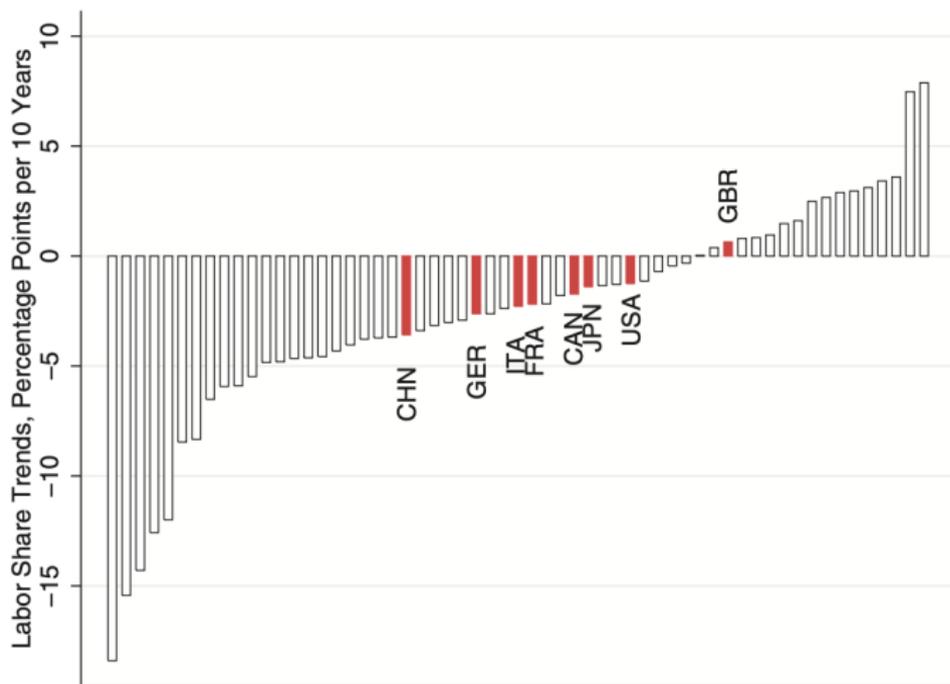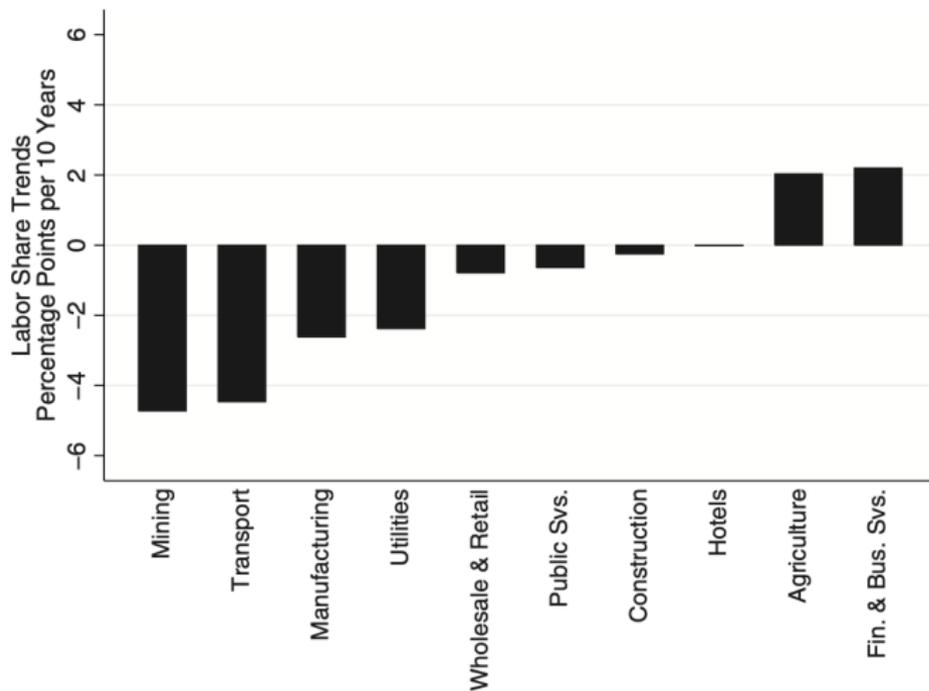
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- **China Shock** Autor, Dorn and Hansen (2016)

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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).

Country	Yearly, 1991–2000		Yearly, 2001–2015	
	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
Vietnam	7.40	2.20	6.54	2.33

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  - 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:

$$y_j = f_j(k_j, \tau_j), \text{ [sector-specific, CRS]}$$

- where $k =$ machines and $\tau =$ tasks.

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- **So capital comes in two flavors**:

  - k: machines, complementary to labor.

  - r: robots, substitutes for labor.

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■ Which does not mean that automation is optimal

- Or that it will ever fully happen; e,g.:

- $\tau_j(h, r) = \nu_j r + \mu_j h + r^{\alpha_j} h^{1-\alpha_j}$ 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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- **Asymptotic Homotheticity of Preferences:**

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

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

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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- **Unit cost function for tasks** determines task price q_j by CRS:

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

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

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

Price System

Some Properties and Implications of Prices

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- profit-maximization:

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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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  - Physical capital can scale within and across sectors

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  - machines and robots **Pillar II**

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- **Asymmetry in accumulation**
- Physical capital can scale within and across sectors
- Human capital expands across tasks/sectors **Pillar I**
- **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:

$$y = f_r(k, \tau), \text{ where } \tau = \tau_r(h, r).$$

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- **Combining:**

$$p_r \leq c_r(1, \nu_r^{-1} p_r).$$

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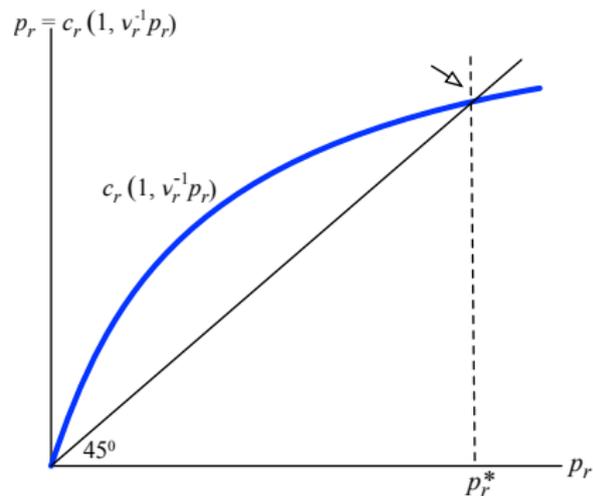
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- Depends on whether $c_r(1, \nu_r^{-1} p_r)$ goes below $45°$ line as $p^r \uparrow$.

- I.e., whether $c_r(1, \nu_r^{-1} p_r) < p_r$ for all large p_r.

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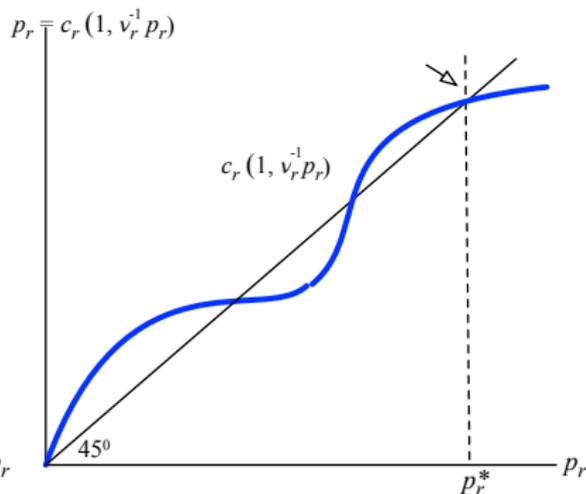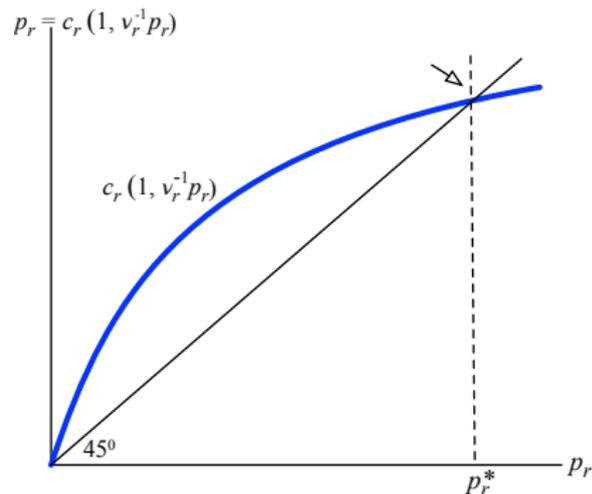
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$p_r = c_r(1, \nu_r^{-1} p_r)$

$c_r(1, \nu_r^{-1} p_r)$

45^0

p_r^*

p_r

The Critical Role Played by Robot Production

- $c_r(1, \nu_r^{-1} p_r) < p_r$ for all large p_r.

- Equivalent to $\nu_r > \lim_{\rho \to 0} c_r(\rho, 1)$.

- **If this condition holds, then p_r must be bounded**.

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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

Escape Hatches

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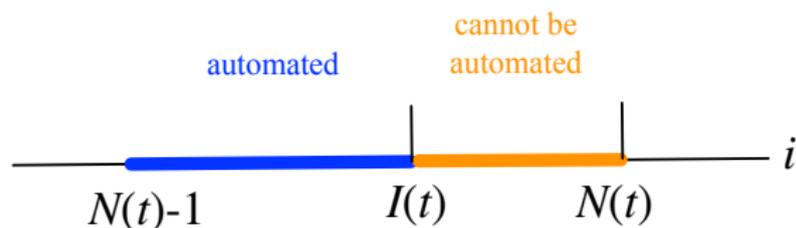
- Technical progress.

Directed Technical Progress

Directed technical progress to the rescue?

- That depends on what you choose to assume.

Directed Technical Progress
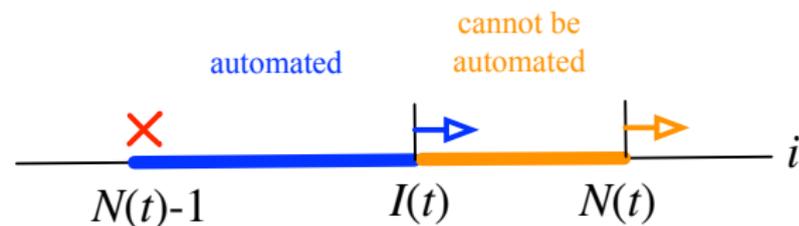
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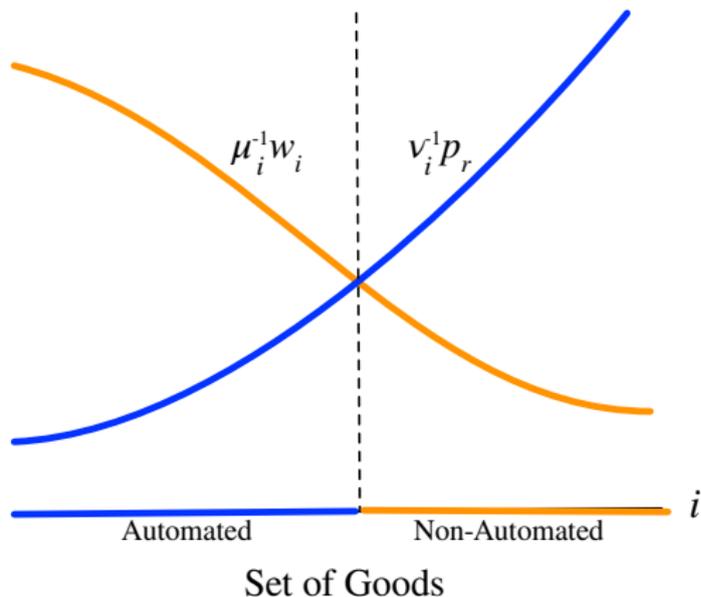- Acemoglu and Restrepo (2018): new goods are un-automatable

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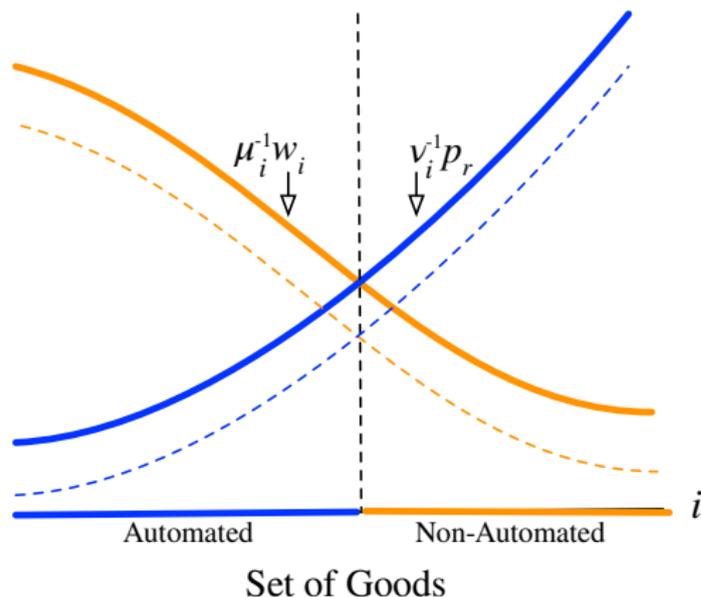
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Automated   Non-Automated

Set of Goods

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- 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.
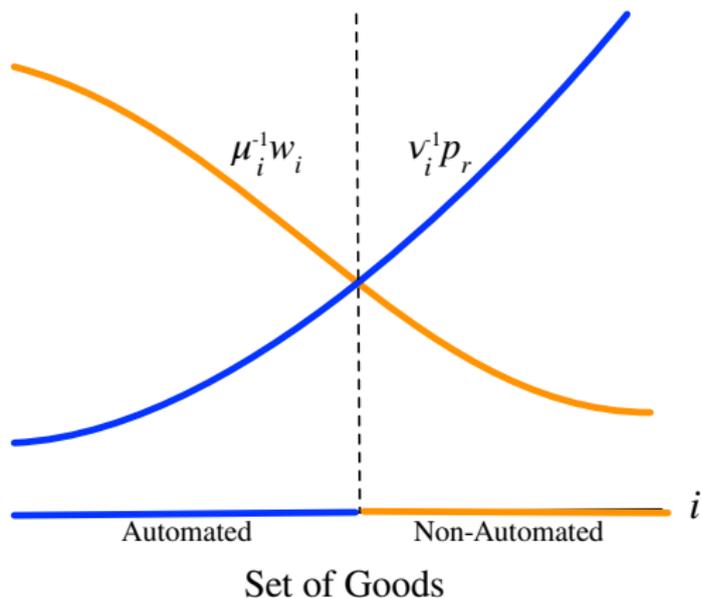
Directed Technical Progress

Theorem 2 (The Extended Dismal Scenario)

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

- *Then in any equilibrium with ongoing wage growth, the income share of human labor must converge to zero as $t \to \infty$.*

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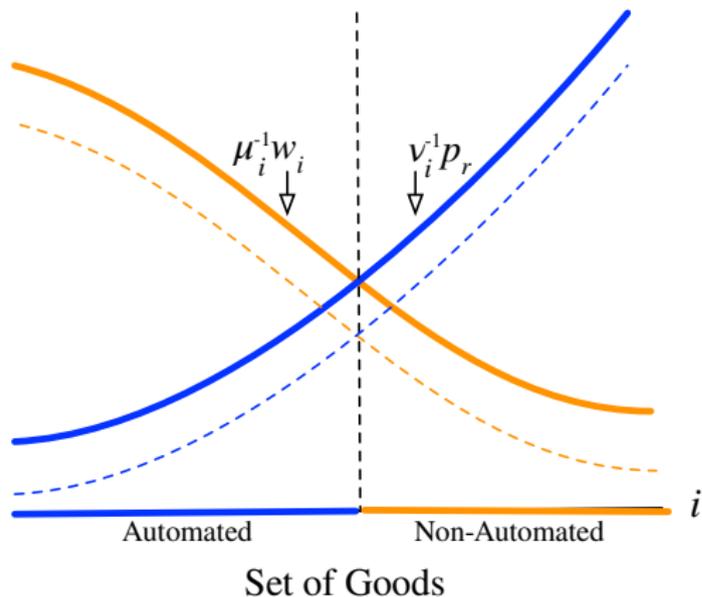
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Automated · Non-Automated · i

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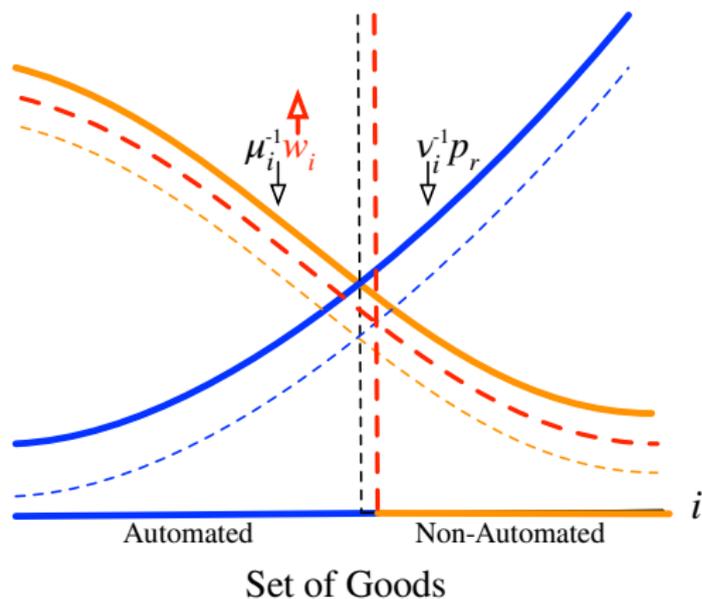
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- A natural consequence of any theory that rests on **two pillars**:

- An asymmetry in physical and human capital accumulation

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

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- Enough patience for ongoing growth and capital accumulation.

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■ **Other important features:**

▪ Preference neutrality with respect to human-friendly or robot-friendly goods.

▪ Enough patience for ongoing growth and capital accumulation.

▪ Self-replication: production of automata by means of automata.

■ **Under these conditions, labor income share $\to 0$:**

▪ full automation in the long run …

▪ …despite wages rising over time (slow automation).

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

  - *that* will depend on how much people save, and in what *form* they save.

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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**.