The Future of Work: Under the Threat of AI and Excessive Automation

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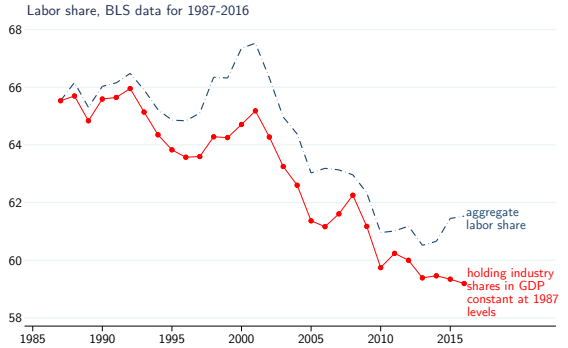
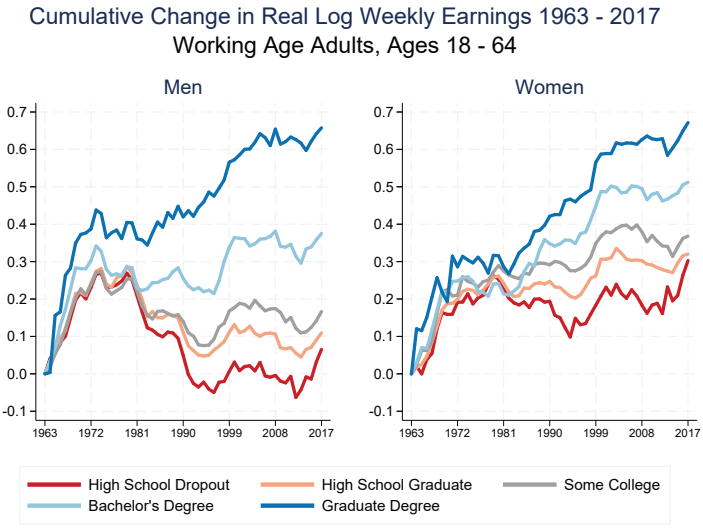
Shifts Against Labor



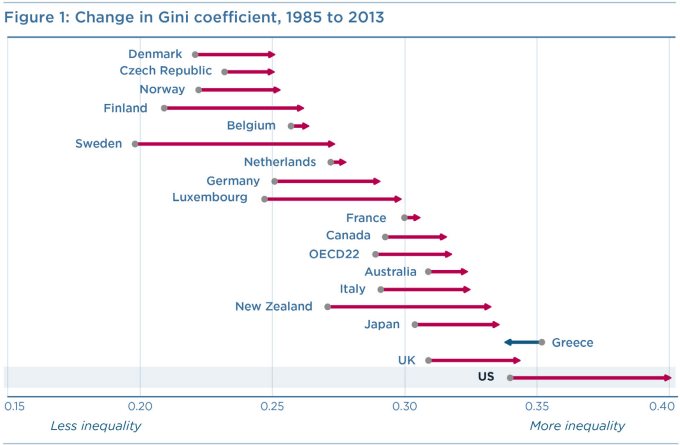
- Declining labor share in the US; similar in Europe and the emerging world.
- Capital deepening? Markups? Monopsony? The march forward of technology?
- I will argue: much more connected to the changing task content of production — in particular driven by excessive automation.
- AI the next act in the suite of automation technologies—though no technological necessity that it should be.

Some Consequences: Wages

- Labor market trends over the last several decades look nothing like a tide lifting all boats.



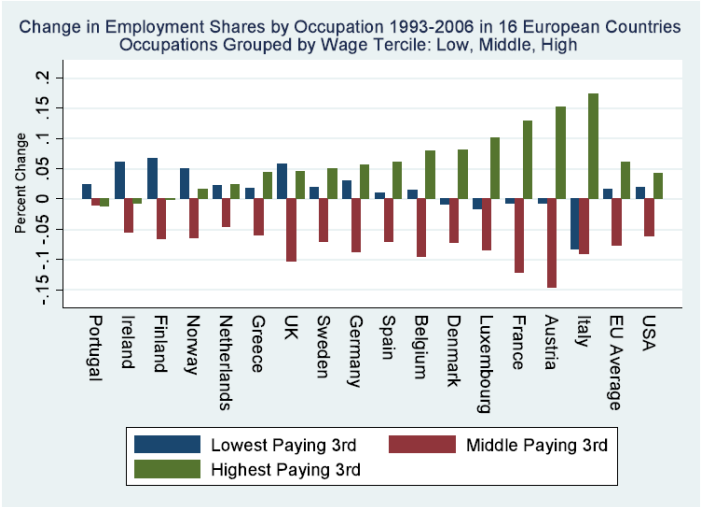
Rise in Inequality Is Not Just a US Phenomenon



Note: 1985 data refer to 1985 or closest available year. 2013 data refer to 2013 or nearest available year. The Gini coefficient measures how equally income is distributed across a population, from 0 (perfectly equal) to 1 (all income to one person).

Automation is Not Just a US Phenomenon

- Similar polarization of employment— but not of wages, indicating an important role for labor market institutions.



The Need to Think in Terms of Tasks

- Tasks and automation at the center of technological change throughout the last 200 years.
  1. horse-powered reapers, harvesters, and threshing machines replaced manual labor
  2. machine tools replaced labor-intensive artisan techniques
  3. industrial robotics automated welding, machining, assembly, and packaging
  4. software automated routine tasks performed by white-collar workers
- Hard to map to canonical production function factor-augmenting technologies:

$$Y = F(A_L L, A_K K).$$

  - In this formulation, allocation of tasks to factors remain unchanged, and
  - technological change makes capital (or labor) uniformly more productive in all tasks.

Thinking in Terms of Tasks: Framework

$$Y = \left(\int_{N-1}^{N} \mathcal{Y}(z)^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}}$$

Elast of substitution

Output

Task services

- Tasks can be produced using capital or labor:

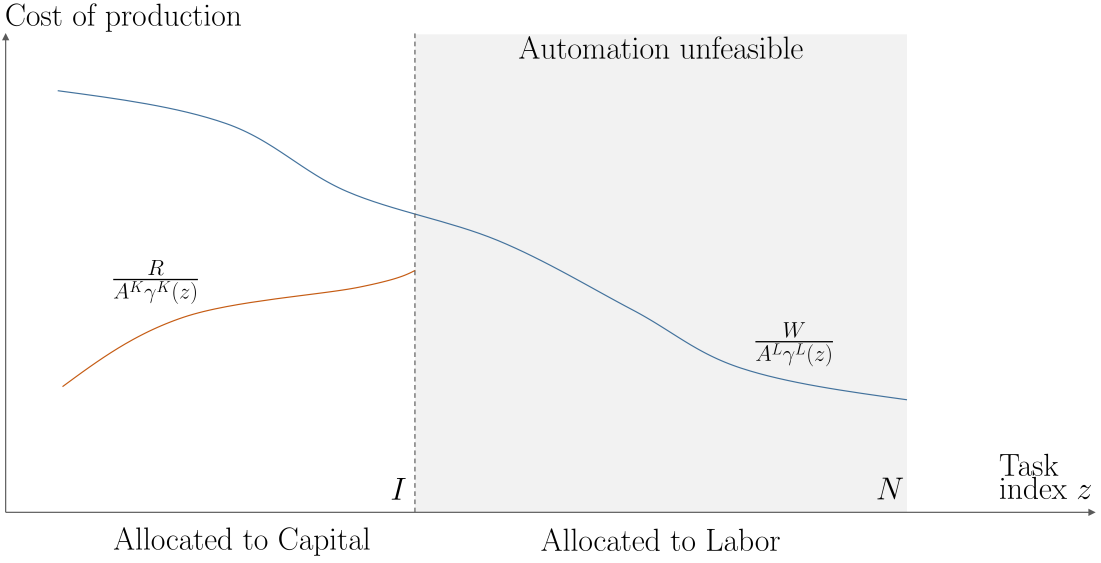
$$\mathcal{Y}(z) = \begin{cases} A^L \gamma^L(z) \ell(z) + A^K \gamma^K(z) k(z) & \text{if } z \in [N-1, I] \\ A^L \gamma^L(z) \ell(z) & \text{if } z \in (I, N]. \end{cases}$$

Feasible to automate

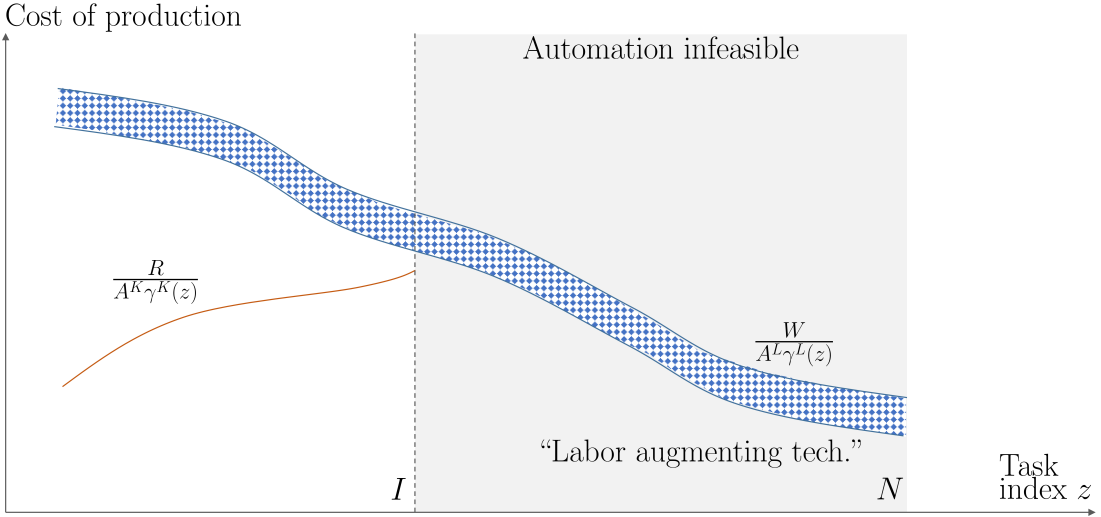
New tasks

- Comparative advantage: $\gamma^L(z)/\gamma^K(z)$ and $\gamma^L(z)$ increasing in z.

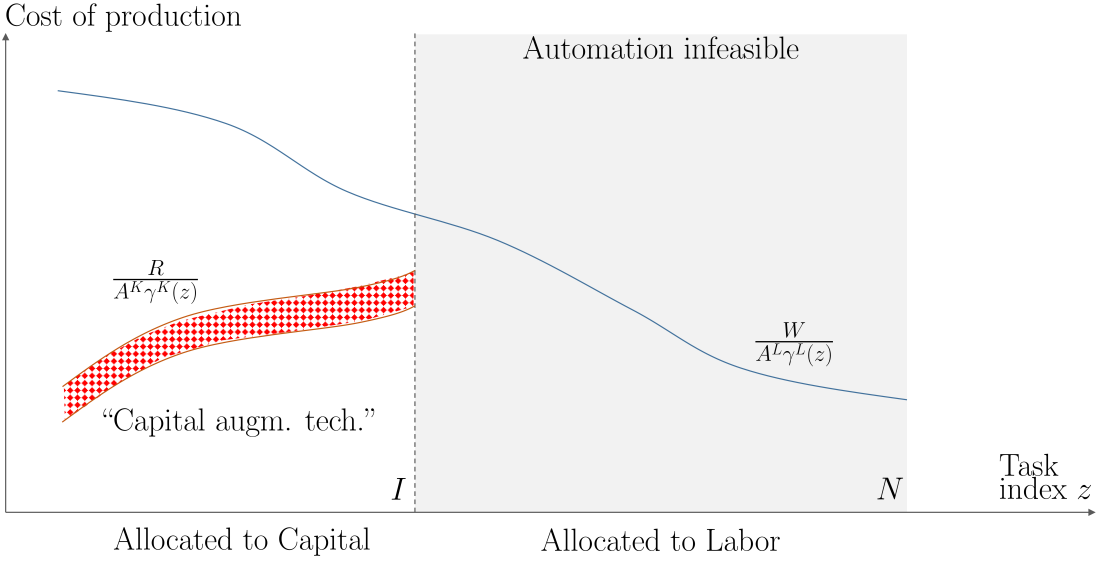
Allocation of Tasks to Factors



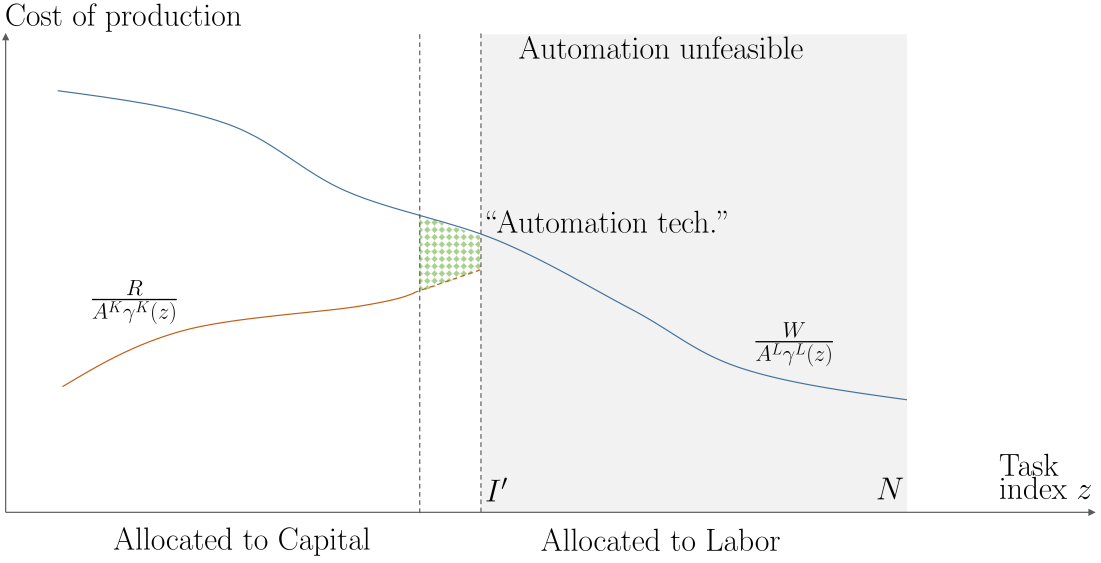
Labor-Augmenting Technological Change



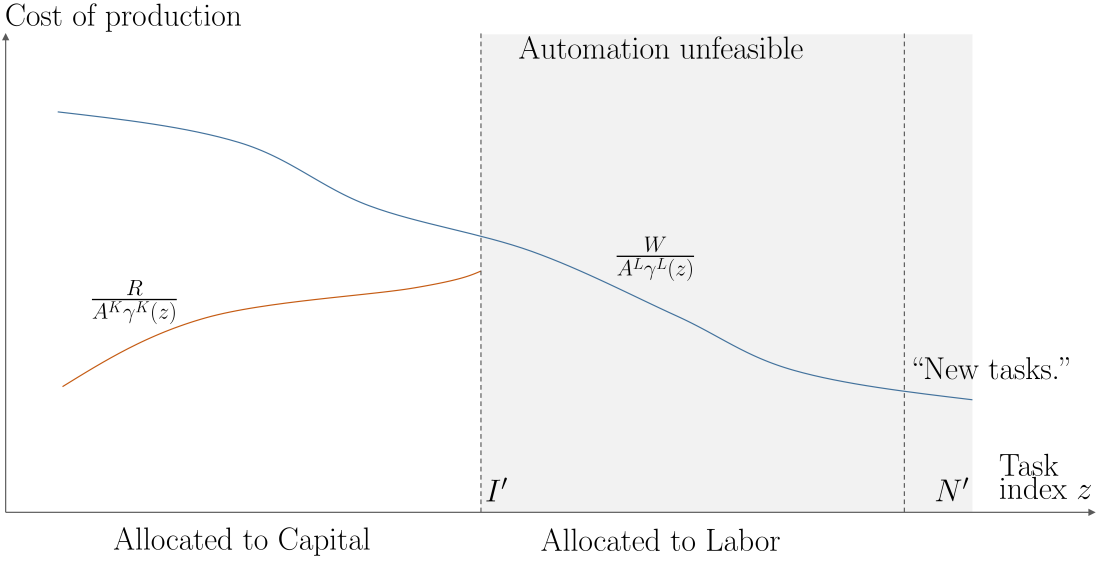
Capital-Augmenting Technological Change



Automation: An Increase from I to I'



New Tasks: N shifts to N'



Thinking in Terms of Tasks: Aggregate Representation

$$Y(L,K) = \left(\left(\int_{N-1}^{I} \gamma^K(z)^{\sigma-1} dz \right)^{\frac{1}{\sigma}} (A^K K)^{\frac{\sigma-1}{\sigma}} + \left(\int_{I}^{N} \gamma^L(z)^{\sigma-1} dz \right)^{\frac{1}{\sigma}} (A^L L)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

- The labor share is given by

$$s^L = \frac{\Gamma(N,I)(W/A^L)^{1-\sigma}}{(1-\Gamma(N,I))(R/A^K)^{1-\sigma} + \Gamma(N,I)(W/A^L)^{1-\sigma}}$$

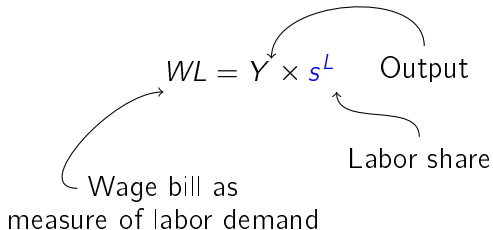
Task content $\Gamma = \frac{\int_I^N \gamma^L(z)^{\sigma-1} dz}{\int_{N-1}^I \gamma^K(z)^{\sigma-1} dz + \int_I^N \gamma^L(z)^{\sigma-1} dz}$

Task-price subs.

- When $\sigma = 1$ or $\gamma^L(z) = \gamma^K(z) = 1$, then $\Gamma = N - I$.
- Factor-augmenting technologies and automation work through different channels: task content vs task-price substitution
- Automation always reduces the labor share regardless of the value of σ.

Thinking in Terms of Tasks: Labor Demand

- The labor share also determines labor demand:



- For now, ignoring markups and other non-competitive elements.
- Let us also postpone a discussion of inequality until later, focusing for now on average wages.

Automation and Labor Demand

$$\frac{\partial \ln WL}{\partial I} = \frac{1}{\sigma - 1}\left[\left(\frac{R}{A^K \gamma^K(I)}\right)^{1-\sigma} - \left(\frac{W}{A^L \gamma^L(I)}\right)^{1-\sigma}\right] \quad \text{(Productivity effect}>0\text{)}$$

$$+ \frac{1}{\sigma}\frac{1 - s^L}{1 - \Gamma(N, I)}\frac{\partial \ln \Gamma(N, I)}{\partial I} \quad \text{(Displacement effect}<0\text{)}$$

- In the absence of the displacement effect, the wage bill changes proportionately to output, and the labor share is constant.
- Because the displacement effect is negative, wage bill increases less than output.
- Net effect on wage bill depends on technology/context:
  - "brilliant technologies," large displacement effect and large productivity gains
  - "so-so technologies," large displacement effect and small productivity gains
- Modest productivity growth does not necessarily signal slowdown of automation.

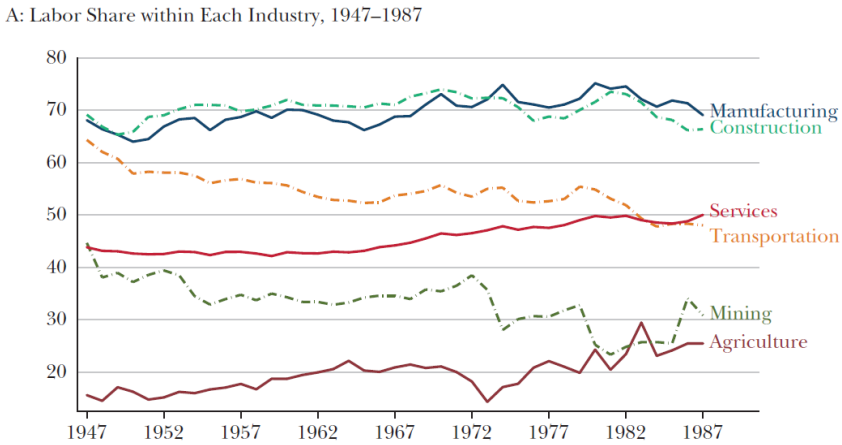
New Tasks and Labor Demand

- The effects of creation of new tasks in which labor has a competitive advantage—an expansion in N—can be determined similarly to our analysis of automation:

$$\frac{\partial \ln WL^d(L, K; \theta)}{\partial N} = \text{Productivity effect} + \text{Reinstatement effect}$$

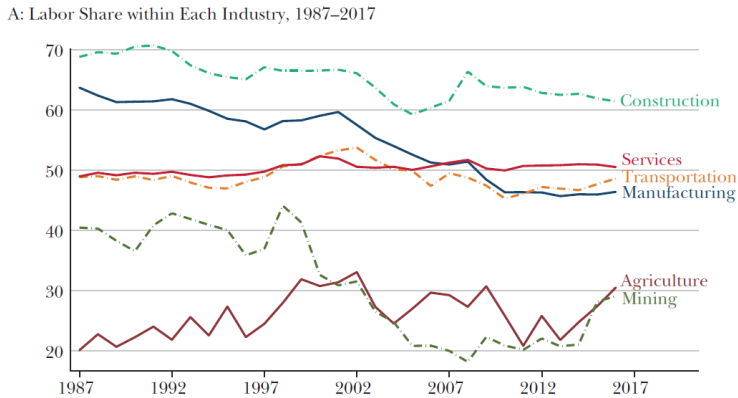
- The reinstatement effect is always positive, increasing the labor share.

Where Does the Labor Share Decline Comes from? 1947-1987



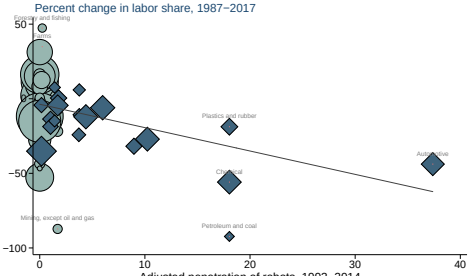
- Important to look at labor share in value added (not sales, since the share of intermediates in sales is increasing over time).

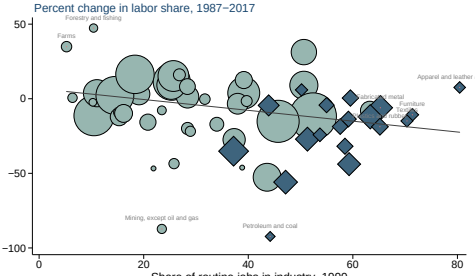
Where Does the Labor Share Decline Comes from? 1987-2017

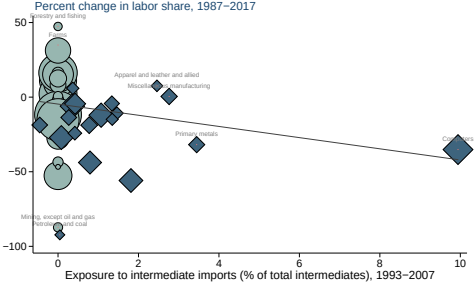


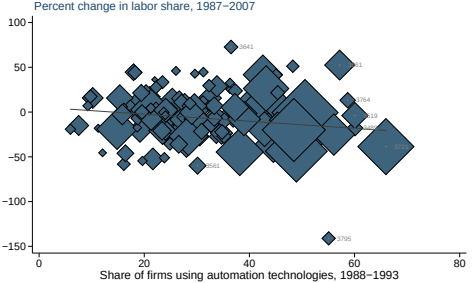
- Some declines in labor share in wholesale and retail during this time period.
- But the decline in the labor share is mostly a manufacturing phenomenon.

Automation and the Labor Share: Industry Evidence

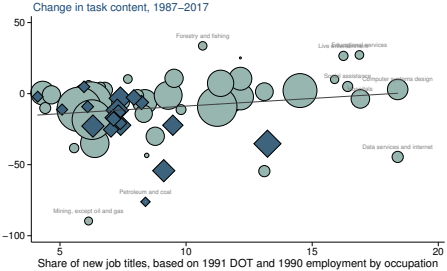


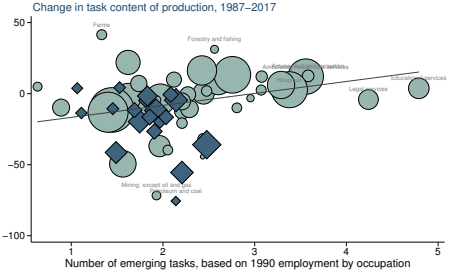


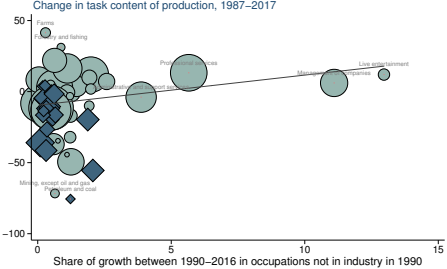


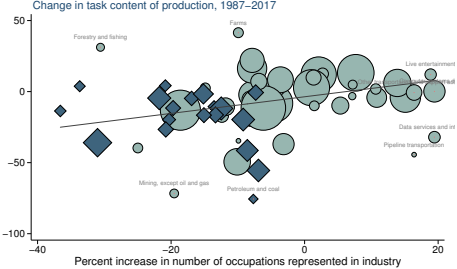


New Tasks and Changes in Task Content









Robots and Jobs: Local Labor Market Effects

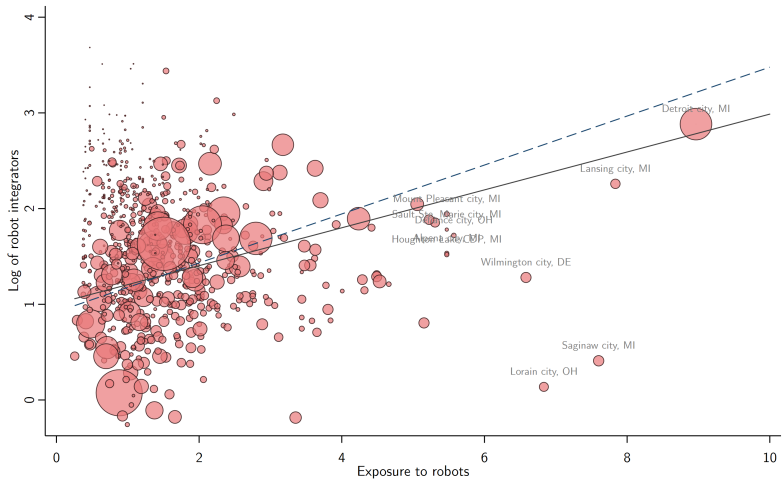
- Let's look at the equilibrium effects of automation in a little more detail, focusing on local labor markets affected by robots.
- Data from decennial censuses, ACS and various other sources, plus, crucially, from the International Federation of Robotics (IFR) on industry-level robots data across countries.
- Zero in on labor markets where the distribution of industry employment makes adoption of robots more likely — according to "exposure to robots" measure in Acemoglu and Restrepo (JPE, 2020).
- Loosely speaking, exposure to robots is given by a Bartik measure of baseline industrial structure interacted with the penetration of robots into that industry in countries that are more advanced than the US in robot adoption:

$$\begin{aligned} \text{exposure to robots}_c &= \sum_i \text{robot penetration industry}_i \times \text{baseline industry share}_{ic} \\ &= \sum_{i \in \mathcal{I}} \overline{APR}_i \times \ell_{zi}^{1970}, \end{aligned}$$

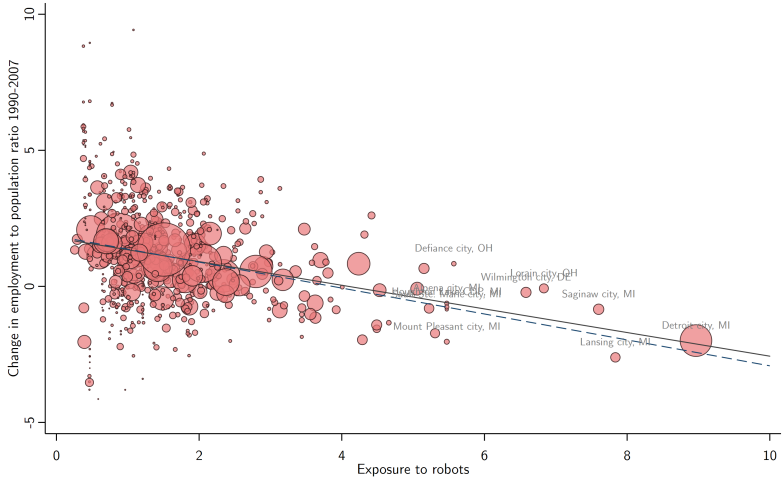
- Then see how this affects employment and wages.

Reality Check: Exposure to Robots and Robotics Activity

- No data on robot adoption at the commuting zone level, but we can use robot integrator activity (from Leigh and Kraft, 2017), which is an excellent proxy for local robotics activity.

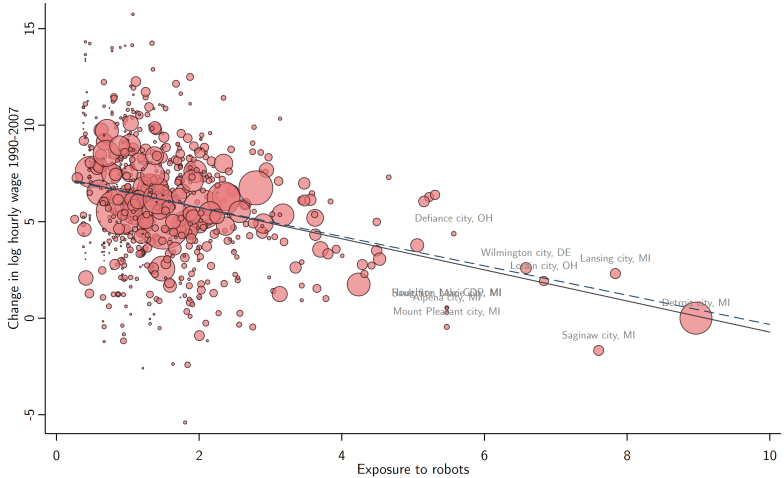


Exposure to Robots and Local Employment



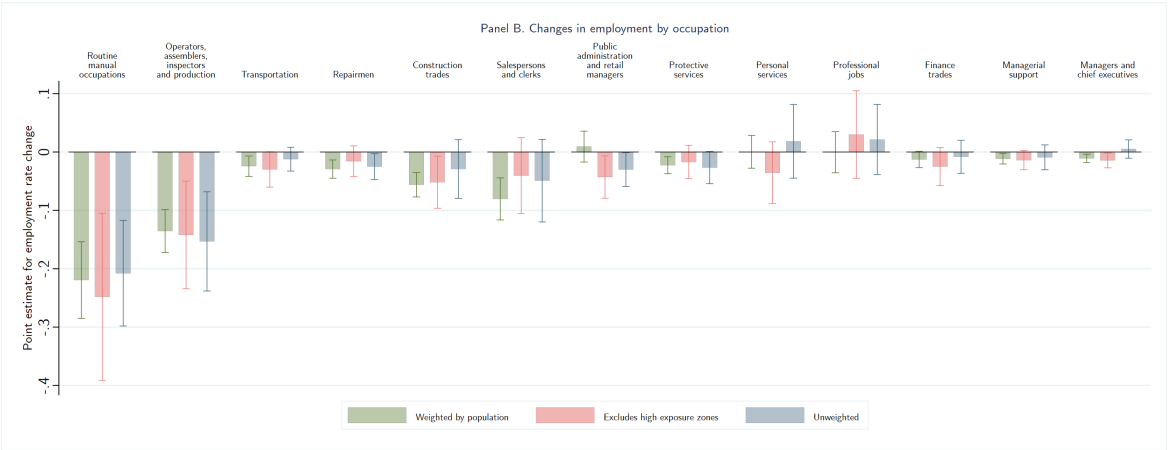
- Dashed line excludes the most exposed areas; thus the relationship is unchanged without the key parts of the industrial heartland.

Exposure to Robots and Local Wages



- Dashed line excludes the most exposed areas.

Exposure to Robots and Task Content of Production



- The decline in areas exposed to robots comes from occupations where workers perform tasks that are being replaced by robots.

Robots and Jobs: Recap

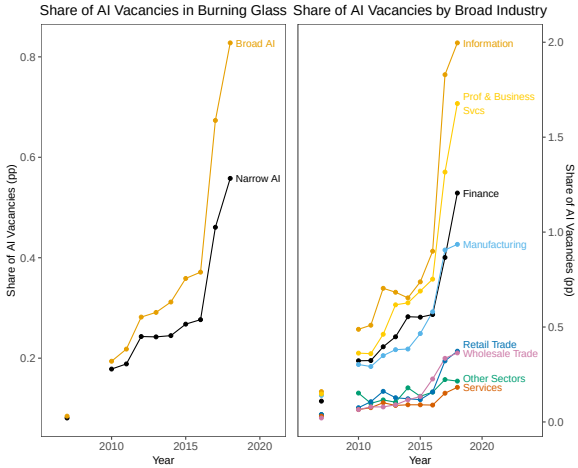
- The results shown in the previous four figures are highly robust (to various demographic and economic controls, in various subsamples, and most importantly to the inclusion of other technology measures, proxying for non-automation technologies).
- Moreover, no pre-trends — more exposed commuting zones were not on differential economic trends before the 1990s.
- Overall, this evidence suggests significant displacement effects associated with changes in the task structure.
- But the local labor market context is not ideal for seeing changes in labor share and substitution between different types of workers (partly because, as emphasized in Acemoglu and Restrepo, 2020a, there are market-level adjustments in services as well).
- For that reason, we now turn to firm-level evidence.

Inequality

- Changes in task content affect different types of workers differently, and thus also have first-order effects on inequality.
- How much have these changes impacted changes in wage structure (starting with the US)?
- Answer: quite a lot.
- Acemoglu and Restrepo (2021): about 60-70 percent of changes in US wage structure due to automation.

What about AI?

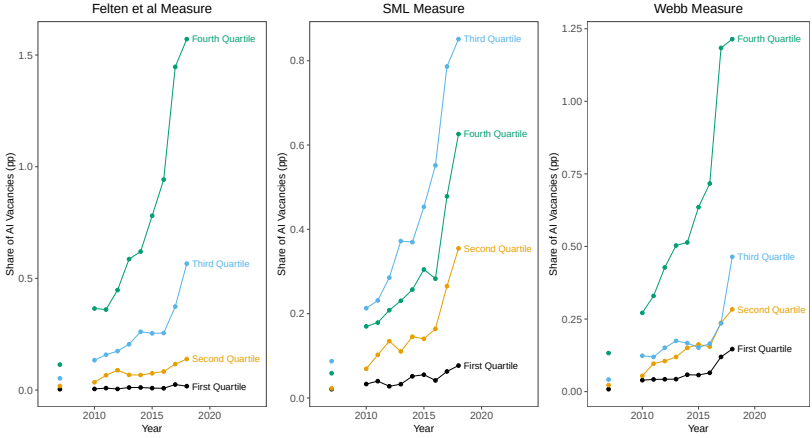
- Measure AI from its footprints in vacancies from Burning Glass.
- Huge increase in AI since 2015.



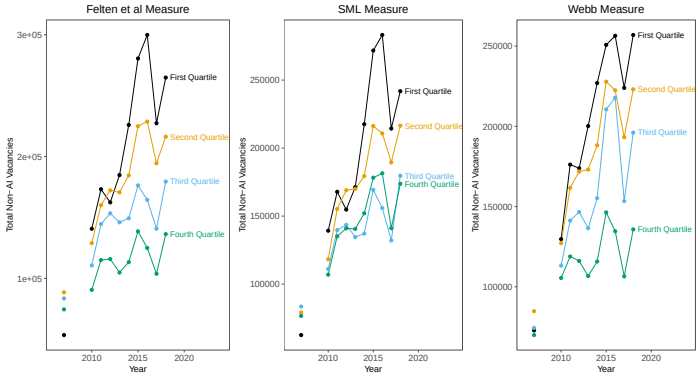
Narrow AI vacancies up from 0.1% to 0.6%

Establishment Share of AI Vacancies by Quartile of AI Exposure

- Define AI exposure using various measures, all related to task structure and AI-replaceable tasks at the establishment level.
- AI surge driven by establishments with more AI-replaceable tasks.



AI Negatively Associated with Establishment Hiring



- Acemoglu, Autor, Hazel and Restrepo (2021) show that this is a robust pattern of establishments hiring, especially with the Felten et al. and Webb measures of AI exposure.
- AI so far mostly focused on algorithmic automation of simple tasks.

Understanding the Changing Nature of Labor Demand: Displacement and Reinstatement, 1947-1987

- Change in task content=displacement + reinstatement.
- Empirical counterparts of automation and new tasks.

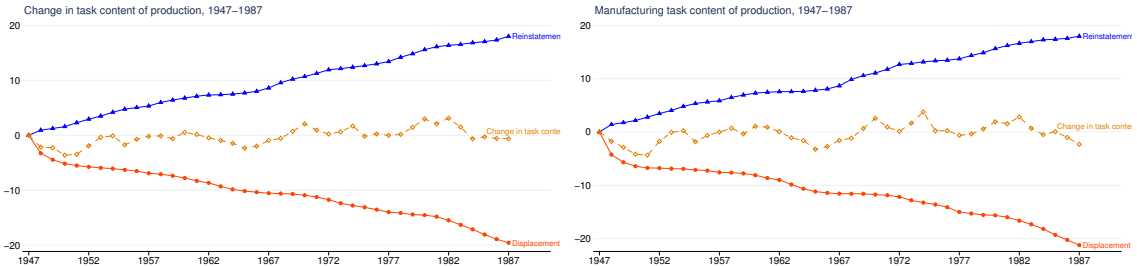
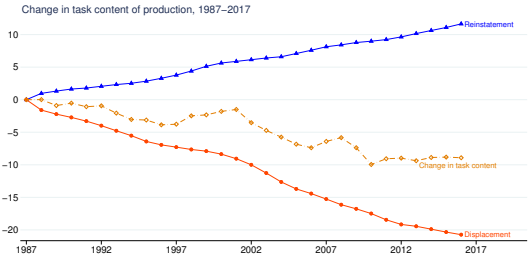


Figure: Estimates of the displacement and reinstatement effects, 1947-1987.

Understanding the Changing Nature of Labor Demand: Displacement and Reinstatement, 1987-2017



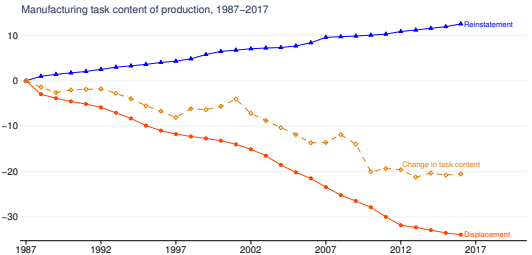
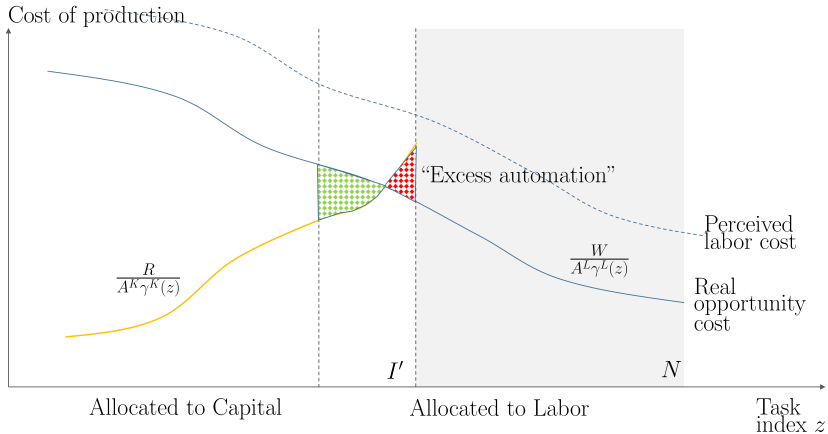


Figure: Estimates of the displacement and reinstatement effects, 1987-2017.

- Very different than during 1947-1987.
- Much faster displacement and much slower reinstatement.
- Changes in tasks content correlated with measures of automation and new tasks — consistent with theory.

Double Whammy: So-so Automation

- Recall that — via productivity effect — automation may generate benefits for labor.
- However, when policies or distorted visions encourage excessive automation, we end up with so-so automation technologies — hence plenty of labor displacement, but not much productivity gains (impact on TFP may even be negative).



Correcting Excessive Automation: Redirecting Technological Change

- Particularly important to redirect AI, since it is a broad technological platform that can be used for many things, several of them human complementary—rather than excessively automating.
- How to do that?
- First, distortions encouraging excessive automation can be removed.
- Acemoglu, Manera and Restrepo (2020): a huge gap has opened up between taxes on capital and labor, partly because of very generous depreciation allowances. This encourages firms to replace workers with machines.
- Government support for "blue sky" research, which is arguably critical for new tasks, has declined. This is easy to correct, but what type of research to support?
- Even more importantly, government leadership of the direction of research has been abandoned in favor of the vision of big tech companies. But the big tech business model focuses on (algorithmic) automation at the expense of pretty much anything else. This again underscores the importance of redirecting technological change.
- In the area of technological change, we may also need a fundamental institutional overhaul.

Lessons from Renewable Energy

- Lessons from renewable energy: huge redirection of technological change. What did it take? Subsidies to clean energy am a but first based on a measurement framework (which we currently don't fully have in the area of excessive automation).
- Equally important was a change in social norms—awareness among consumers about climate change, pressure from consumers and employees.
- In the area of technological change, we may also need a fundamental institutional overhaul.

Conclusion: Implications for the Future of Work

- But there are really two faces of automation—especially relevant for AI.
- Good automation — high-productivity automation technology going hand-in-hand with new tasks — can contribute to productivity and labor demand.
- But bad or so-so automation reduces employment growth and worsens the distribution of income — esp. when there is excessive automation due to policy or vision distortions.
- The problem is even worse when automation is not counterbalanced by new tasks.
- Preliminary evidence that a highs going very much in this direction of excessive (algorithmic) automation.
- If the future is one of ceaseless algorithmic automation and nothing else, then the future of work will not be bright. There would be lower and lower labor share across industries and in national income. And there would be no guarantee of sufficient job growth.
- Improving labor market institutions, by itself, cannot be the solution — if we push wages up, this will cause more automation, unless technology becomes more "human-friendly".
- But good automation, particularly when combined with rapid creation of new tasks for workers, can be powerful engine of growth and prosperity.