Automation and the Future of Work.

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Based on joint work with Daron Acemoglu.

1. Conceptual framework: Tasks, automation, and displacement.
2. Empirical evidence: Industrial robots and the automation of manufacturing.
3. New tasks and reinstatement.
4. The future of work.

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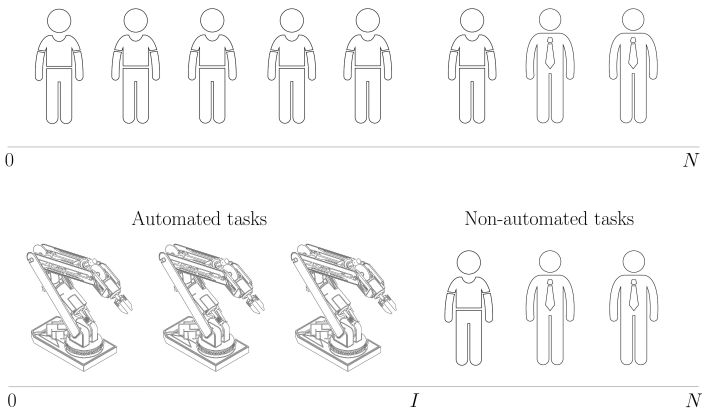
Tasks and Technology

- Production requires tasks, produced by machines (productivity γ) or labor.
- Over time, more tasks automated.



Automation and the displacement effect

- If tasks are combined via a Cobb-Douglas aggregator

$$Y = A \cdot L^{\alpha} K^{1-\alpha},$$

- Allocation of tasks linked to factor shares and productivity

$$\alpha = \text{Labor share} = \text{Share of tasks performed by labor}$$

- Automation has an ambiguous effect on labor demand:

$$\text{Wages} = \alpha \times \frac{Y}{L}.$$

- $\alpha \downarrow$ displacement effect and $Y/L \uparrow$ productivity effect.

Concerns about Single-minded Focus on Automation

- The displacement effect:
  - Automation could reduce employment and/or wages.
  - Suppose the labor share goes down from 65% to 45%, One needs output to expand by 44% (=65/45-1) to sustain employment and wages.
  - Automation reduces the labor share and decouples W from Y/L.
  - Distributional consequences: capital income becomes more relevant.
- By itself, automation brings limited productivity gains:
  - Productivity gains depend on $\gamma \cdot W/R$.
  - Alone, automation runs out of steam.
  - Worst case for productivity and labor: replacement by mediocre robots and machines!

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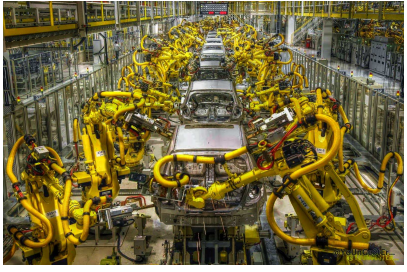
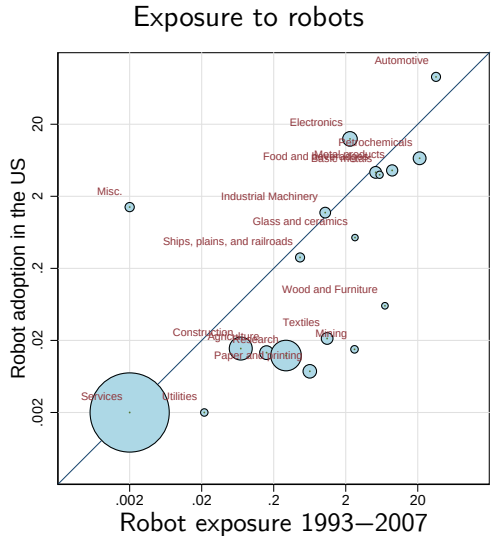
Empirical evidence: Industrial robots

- Automatic and multipurpose machines with several axis suitable for industry.
- Robots perform tasks that used to be labor intensive (machining, welding, assembling, inspecting, packaging).
- Large increase between 1993 and 2014: in the US, fivefold increase from 2 to 10 robots per thousand industry workers.



Industries exposure to robots

- Data on stock of robots from the *International Federation of Robotics* for the 1993-2007 period.
- Measure of *exposure to robots* based on adoption of robots among European industries.
- Adoption highly correlated across industries, which suggest it is driven by technology.



Exposure to robots and the labor share

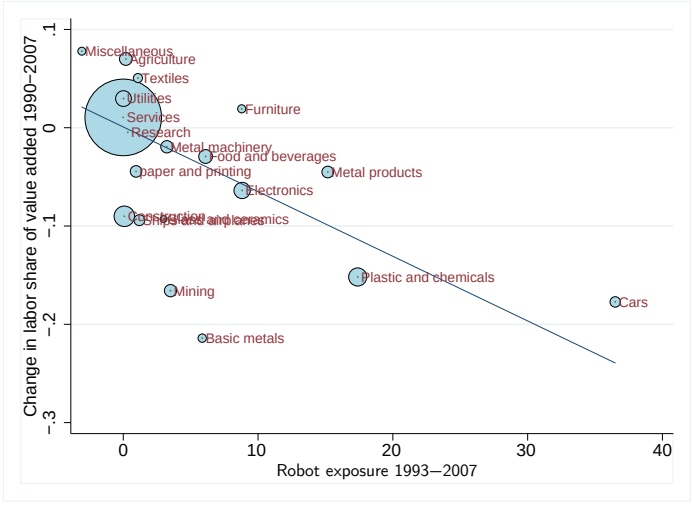


Figure: Change in the labor share and exposure to robots. Data from the BEA.

Exposure to robots and output

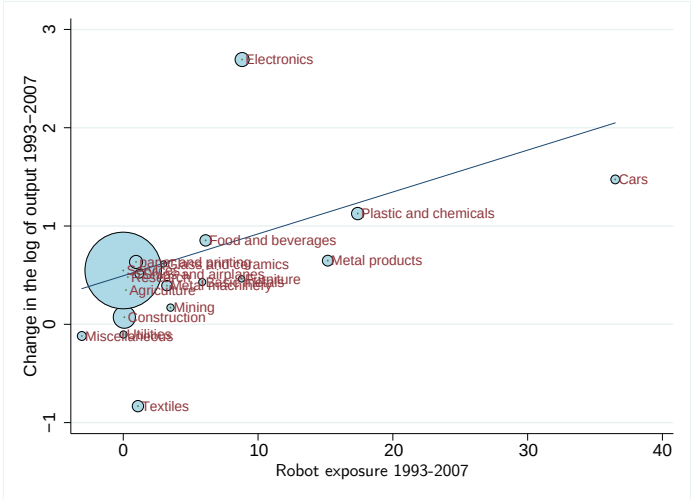
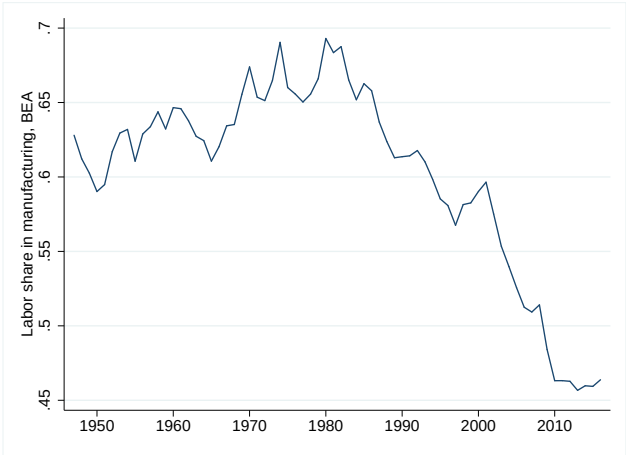


Figure: Change in the log of quantities produced and exposure to robots. Data from the BEA.

A broader transformation of manufacturing

- Broader transformation of manufacturing starting in the late 80s.
- Labor share of the sector declined from 65% to 45% in 20 years.
- Consistent with an increased emphasis in industrial automation.



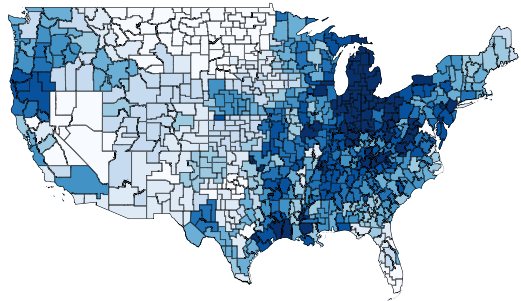
Estimating the impact of exposure to robots on US

- Adjustment of local-labor markets.
- Exposure to robots between 1993-2007 for commuting zones, c:

$$\sum_i \underbrace{\text{Baseline Employment share}_{ci}}_{\text{Baseline}} \times \underbrace{\text{Robot Exposure}_i}_{\text{Robot}}$$

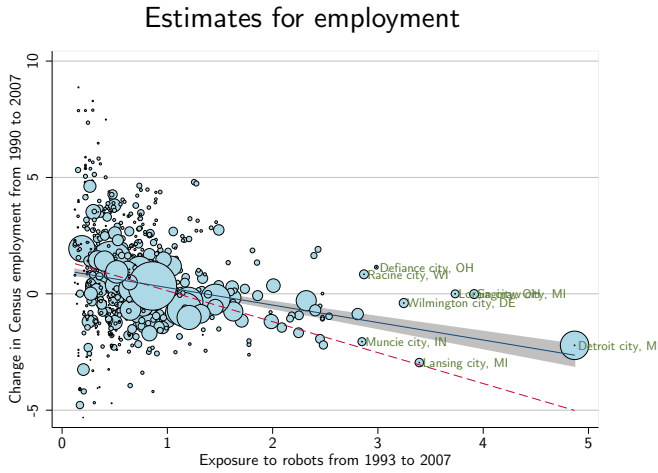
- What happened to exposed labor markets during the 1990-2007 period?

Exposure to robots



Exposed labor markets

- One robot per thousand workers:
  - Epop falls by 0.4pp
  - Wages fall by 0.7%
  - No evidence of migration or expansion of services.
  - People drop out of labor force
- Aggregate estimates: 300-600K jobs and 0.25-0.5% decline in wages.



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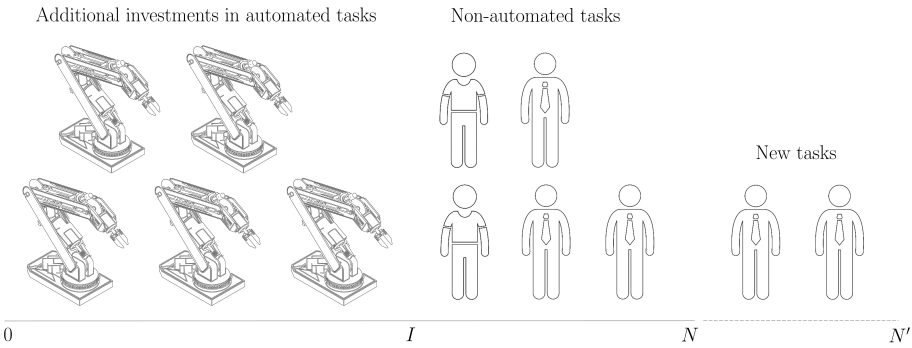
New tasks and the reinstatement effect

- Technology is not just about automation and displacement.
- Over time, we have also created new tasks and improve existing machinery.
- These technologies *reinstate* labor and interact with automation.



New job titles and employment

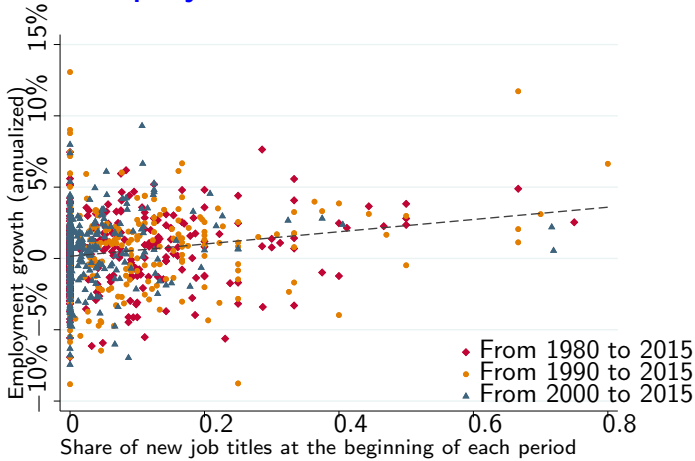
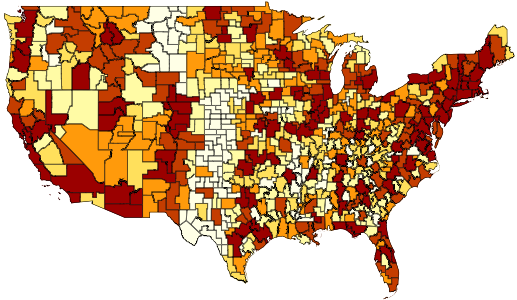


Figure: Employment growth (annualized) against the share of new job titles in each occupation. Data from Jeffrey Lin (2011).

New job titles and employment

- Even if the economy keeps creating new tasks, the adjustment may be difficult:
  - New jobs take time to appear.
  - New jobs require different skills.
  - New jobs are in other regions.

Share of workers doing new jobs.



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Looking ahead

Future of labor depends on technologies invented and adopted:

- Automation is an ongoing process, but we have found ways to counteract it in the past through technologies that reinstate labor.
- Concerns:
  - Single-minded focus on automation.
  - Possibility that new tasks and ideas about products and services that can generate a demand for labor are in turn getting harder to find.
- If concerns materialize, we are left with automation, but not the successful combination of new tasks and automation that spurred growth in productivity and labor demand in the past.