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Robots and Work

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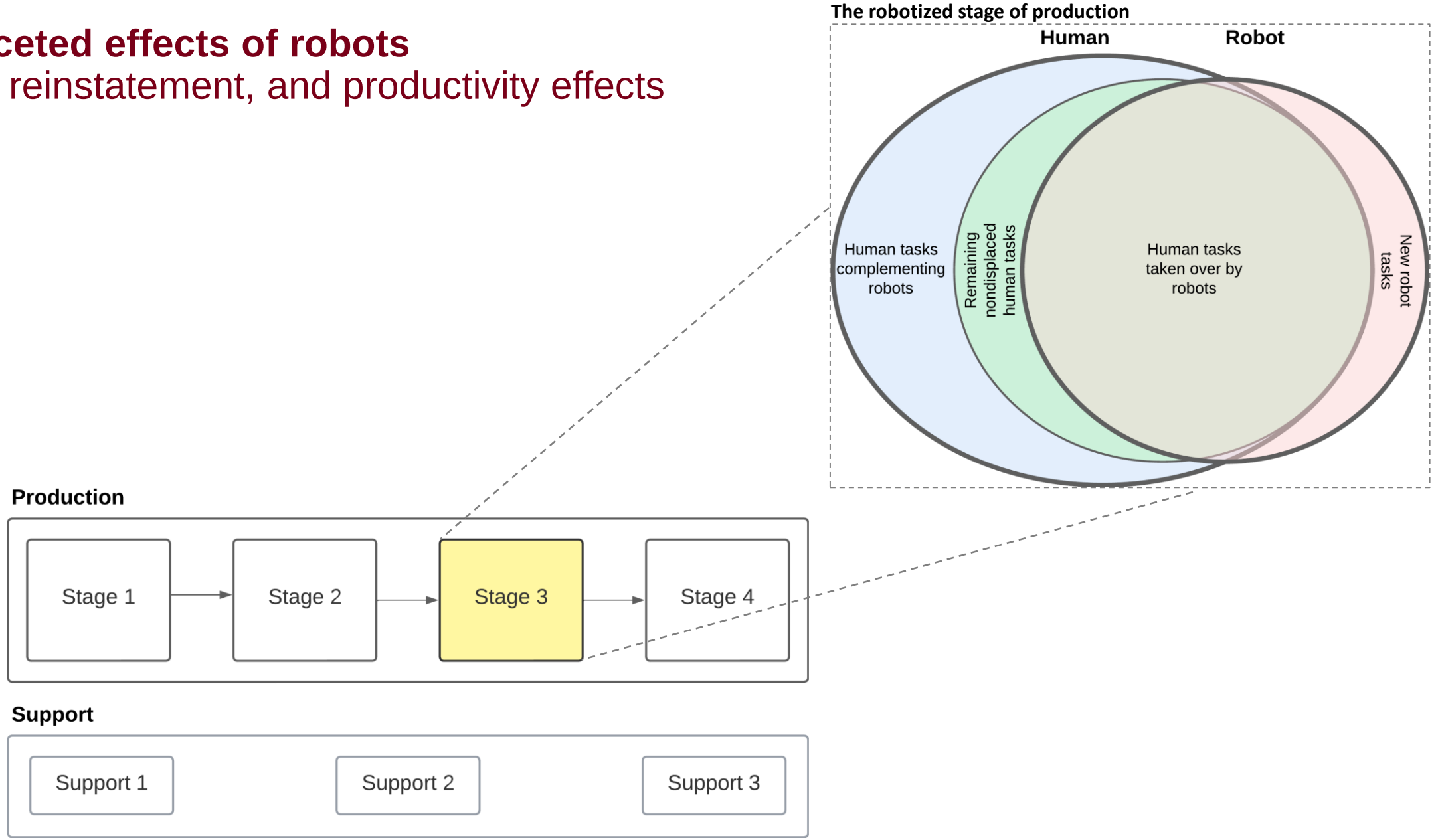
The multifaceted effects of robots

Substitution, reinstatement, and productivity effects



What we do in this study

- Data: online job postings and plant employment in US manufacturing, 2010-2022
- Jobs are separated into:
  - **Production occupations**
    - High-skill (production managers, engineers, programmers)
    - Medium-skill (technicians)
    - Low-skill (operators)
  - **Support occupations**
    - Finance, HR, logistics, etc.
- Empirical strategy:
  - Callaway-Sant'Anna's (staggered) diff-in-diff matched by plant size, industry, and local labor cost
  - Instrumental variables design (for spillover analysis on nonadopting competitors)
- Outcomes:
  - Number of job postings (hiring) and employment
  - Change in frequency of technical and general skills in robotic and nonrobotic jobs

534 adopting firms

- **1,085** robotic plants
- **8,898** nonrobotic plants

7,615 nonadopting firms

- **18,411** nonrobotic plants

Robotic terms: 'motoman robot programming', 'advanced robotics', 'robotic liquid handling', 'next generation robotics', 'pick and place robots', 'robot framework', 'robot operating system (ROS)', 'robot programming', 'robotic systems', or 'robotics'

Robotic plants: plants with a minimum number of robotic job postings.

Robot adoption: The year of first robotic job posting

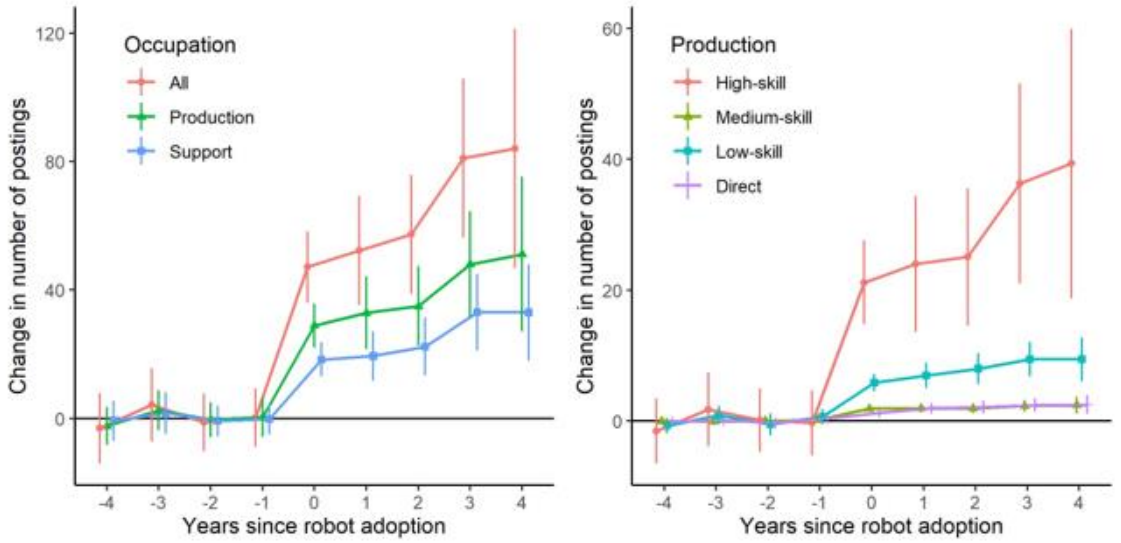
Technical skills:

- Production stages: Design, production, repair and maintenance, quality control
- Complementary technology: Machine learning and automation

General skills: Reasoning, character, social

Industrial robots add jobs at the plant level
with positive spillover to non-robotic plants in the same firm

Event study of change in job postings, plant-level



- Plant-level hiring increases by **98** job postings/year.
- Plant-level employment increases by **15%** post-adoption.

Occupation	A. Robotic plant		B. Non-robotic plant	
	Pre-adoption postings	Change in postings Pre-to-post	Pre-adoption postings	Change in postings Pre-to-post
All	72.18	**112.02*** (19.22)**	39.21	**8.23*** (0.94)**
Production	38.97	**70.95*** (12.84)**	23.32	**5.64*** (0.54)**
Support	33.22	**41.07*** (6.75)**	15.89	**2.59*** (0.39)**

Notes: Sample plants in panels A and B are owned by the same set of firms, which own at least one robotic plant and one nonrobotic plant. Significance levels: * 10%, ** 5%, *** 1%.

Robotic jobs require more technical skills

- Robotic jobs (**15%** of production workers) change the use of technical skills
- No change on non-robotic jobs and general skills → adopters add, instead of replace, incumbent workers

	Production stages				Complementary tech	
	Design (1)	Production (2)	Repair and Maintenance (3)	Quality Control (4)	Machine Learning (5)	Automation (6)
High-skill robotic job (n=22,929 plants)	0.56*** (0.05)	0.51*** (0.06)	0.33*** (0.04)	-0.05*** (0.01)	0.21*** (0.03)	0.51*** (0.03)
Medium-skill robotic job (n=12,189 plants)	0.01 (0.06)	0.32*** (0.10)	0.60*** (0.17)	0.00 (0.01)	0.03** (0.01)	0.26*** (0.05)
Low-skill robotic job (n=21,605 plants)	0.13*** (0.04)	0.71*** (0.08)	1.33*** (0.12)	-0.05*** (0.01)	0.06*** (0.02)	0.25*** (0.03)

Notes: Skills are measured as plant-level average frequency the skill used in production occupations. Significance levels: * 10%, ** 5%, *** 1%.

Statistics

Robot penetration reduces employment in non-adopting competitors

- An increase of 1 unit of robots/1,000 workers decreases employment in nonadopters by **0.4%** one year later, and further to **0.5%** in two years.
- No significant effect at the industry level

	Period relative to adoption rate in t_0		
	0	1	2
Plant-level log of employment in nonadopting firm	-0.000	-0.004**	-0.005**
	(0.002)	(0.001)	(0.002)
Industry-level log of employment	0.0009	0.0026	0.0031
	(0.0018)	(0.0025)	(0.0028)

Notes: Each cell shows the second stage coefficient and standard error (in parentheses, clustered by industry) of instrumental variable regression. In stage 1 (not shown), the number of US industrial robot stock/1,000 workers is predicted by the number of EURO5 industrial robot stock/1,000 workers and EURO5 R&D capital stock/1,000 workers. EURO5 countries include Denmark, Finland, France, Italy, and Sweden. Included as controls: US industry-level real GDP, year fixed effects, and plant fixed effects. Significance levels: * 10%, ** 5%, *** 1%.

Conclusions

1. Robots (1) **substitute** production tasks and (2) **require** new complementary tasks for lower and higher-skill workers.

2. At plant level, **productivity + complementarity > substitution**
   - ❑ Consequently, adopting plants increase employment in non-robotized stages.
   - ❑ This is likely true also for the robotized stage (but we do not have data to prove).

3. **Positive spillover** on non-robotic plants in adopting firms

   In firms where some plants adopt robots and others do not, even non-adopters grow but much less than adopters.

4. Competitive **displacement**

   In firms that do not adopt robots, plants lose employment.

Thank you!

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