

# Technology-Skill Complementarity and Labor Displacement: Evidence from Linking Two Centuries of Patents with Occupations

Leonid Kogan, Dimitris Papanikolaou, Lawrence D. W. Schmidt, Bryan Seegmiller

Discussion by:

Miao Ben Zhang

University of Southern California

WFA 2022

# Big Question: How Does Technology Affect Jobs?

## Edison's incandescent light bulbs

- Extend working hours
- Improve workplace safety (e.g., mining)
- Boost nighttime leisure
- Likely to boost jobs in many industries!



# Big Question: How Does Technology Affect Jobs?

## Edison's incandescent light bulbs

- Extend working hours
- Improve workplace safety (e.g., mining)
- Boost nighttime leisure
- Likely to boost jobs in many industries!



## Automation—Robotic arms

- Replace assembly line workers
- Likely to displace jobs in some focused industries!



# Big Question: How Does Technology Affect Jobs?

## Edison's incandescent light bulbs

- Extend working hours
- Improve workplace safety (e.g., mining)
- Boost nighttime leisure
- Likely to boost jobs in many industries!



## Automation—Robotic arms

- Replace assembly line workers
- Likely to displace jobs in some focused industries!



**Important question, difficult to answer!**

# Prior studies are limited by scope

Prior studies focused on the labor market impact of *certain* technologies, e.g.,

- **Computerization in the 1980s-2000s:** Routine-task labor who are mid-skilled production and administrative workers (Autor, Levy, and Murnane (2003), Autor and Dorn (2013), Gaggle and Wright (2017), Tuzel and Zhang (2021)...) )
- **Artificial intelligence in the 2010s:** Highly-educated and older workers but with substantial uncertainty on the direction (Webb (2020))

These studies are limited by the scope for generalizing the relation between technology and labor, e.g., for modeling technologies in a production function.

# Summary of this paper

An exciting study on the relation between technology and jobs in a massive scope!

- 1 Empirically links patents with occupations over the past two centuries
  - Carefully selects breakthrough patents
  - Uses appropriate textual analysis tools to overcome many technical obstacles
  - Measures the similarity between an occupation's tasks and a patent's purpose
- 2 Creates a technology exposure for each occupation based on the similarities
- 3 Shows strong **negative labor outcomes** of technology across the board
  - Job displacement channel dominates the overall impact of technology
  - Consistent with tech-skill complementarity, skilled workers are less affected
  - Nuanced heterogeneous effects: older workers with higher earnings are more affected
- 4 Calibrates a model which embeds skill displacement into a standard technology-skill complementarity production function

**Implication:** Technology may widen or narrow income inequality

# Overview

- A study likely to guide future work on technology and labor
- The scope of this paper is unmatched by prior studies
- A striking claim that technology is associated with **worsening** labor outcomes
- My comments will be focused on strengthening of this claim
  - ★ Endogenous choice of technology innovations
  - ★ Endogenous choice by firms to adopt the technologies

## Comment 1: More discussions on heterogeneous technologies

Which technologies lead to the labor displacement?

- Conventional wisdom based on few glamorous examples of general purpose technologies (GPTs) such as light bulbs, GPS, and Wi-Fi, may argue that technology can prosper many industries and jobs

Do technologies of general and focused scopes displace jobs similarly?

## Comment 1: More discussions on heterogeneous technologies

Which technologies lead to the labor displacement?

- Conventional wisdom based on few glamorous examples of general purpose technologies (GPTs) such as light bulbs, GPS, and Wi-Fi, may argue that technology can prosper many industries and jobs

Do technologies of general and focused scopes displace jobs similarly?

- If yes, then, we should update the conventional wisdom
- If no, then, we may interpret the findings in this paper as a *composition effect*
  - ★ most technologies in the past two centuries are different from light bulbs; they may tilt more towards improving production efficiency in certain industries

## Comment 1: More discussions on heterogeneous technologies

Which technologies lead to the labor displacement?

- Conventional wisdom based on few glamorous examples of general purpose technologies (GPTs) such as light bulbs, GPS, and Wi-Fi, may argue that technology can prosper many industries and jobs

Do technologies of general and focused scopes displace jobs similarly?

- If yes, then, we should update the conventional wisdom
- If no, then, we may interpret the findings in this paper as a *composition effect*
  - ★ most technologies in the past two centuries are different from light bulbs; they may tilt more towards improving production efficiency in certain industries
- The composition effect is consistent with studies on endogenous innovation
  - Habakkuk thesis: American innovations are heavily influenced by land abundance and labor scarcity
  - Acemoglu (2002): “Directed Technical Change”

## Comment 1: More discussions on heterogeneous technologies

Which technologies lead to the labor displacement?

- Conventional wisdom based on few glamorous examples of general purpose technologies (GPTs) such as light bulbs, GPS, and Wi-Fi, may argue that technology can prosper many industries and jobs

Do technologies of general and focused scopes displace jobs similarly?

- If yes, then, we should update the conventional wisdom
- If no, then, we may interpret the findings in this paper as a *composition effect*
  - ★ most technologies in the past two centuries are different from light bulbs; they may tilt more towards improving production efficiency in certain industries
- The composition effect is consistent with studies on endogenous innovation
  - Habakkuk thesis: American innovations are heavily influenced by land abundance and labor scarcity
  - Acemoglu (2002): “Directed Technical Change”

**Suggestion 1: Consider separating patents into GPT and Non-GPT and conducting subsample analyses**

- Patents evenly matched to many industries or occupations may be viewed as GPT?

## Comment 1: More discussions on heterogeneous technologies

Another important dimension of technology heterogeneity is “product-innovation” versus “process-innovation”

- Bena and Simintzi (2019): Firms exposed to low-cost labor from China adjust innovation away from improving their production methods (i.e., process innovation)

Are the labor-displacing effects driven by both types of innovation, or are the breakthrough innovations dominated by process innovation (i.e., a composition effect)?

- Using data from Bena and Simintzi (2019), I measure each patent's process-innovation intensity (PII) as  $\#Process\ Claims / \#Total\ Claims$
- Merging data to KPST (2021), I observe a positive but modest correlation between breakthrough innovations and PII: 7% based on 3.9 million patents

## Comment 1: More discussions on heterogeneous technologies

Another important dimension of technology heterogeneity is “product-innovation” versus “process-innovation”

- Bena and Simintzi (2019): Firms exposed to low-cost labor from China adjust innovation away from improving their production methods (i.e., process innovation)

Are the labor-displacing effects driven by both types of innovation, or are the breakthrough innovations dominated by process innovation (i.e., a composition effect)?

- Using data from Bena and Simintzi (2019), I measure each patent's process-innovation intensity (PII) as  $\#Process\ Claims / \#Total\ Claims$
- Merging data to KPST (2021), I observe a positive but modest correlation between breakthrough innovations and PII: 7% based on 3.9 million patents

**Suggestion 2: Consider separating patents into high and low process-innovation and conducting subsample analyses**

**In sum, it would be helpful to shed light on how pervasive different types of technologies displace labor to win the battle.**

## Comment 2: Mechanism—Vintage skills or labor market frictions?

The paper explains the heterogeneous effects on older or high-income workers based on technology displacing certain vintages of skills.

## Comment 2: Mechanism—Vintage skills or labor market frictions?

The paper explains the heterogeneous effects on older or high-income workers based on technology displacing certain vintages of skills.

An alternative mechanism is that technology displaces all workers in an occupation, but heterogeneous labor market frictions, such as firing frictions due to union, played a role.

- Firms suffering from more severe labor firing frictions may be more prone to adopt labor-saving technologies. In such firms, workers are older and earn higher income.
- If this is the case, technology helps combat labor market frictions instead of unpurposefully displacing vintage skills
- Labor union can be quantitatively important—union coverage rose in early 20th century to 35% in 1954 and declined since then; Union coverage also varies substantially across industries and occupations

## Comment 2: Mechanism—Vintage skills or labor market frictions?

The paper explains the heterogeneous effects on older or high-income workers based on technology displacing certain vintages of skills.

An alternative mechanism is that technology displaces all workers in an occupation, but heterogeneous labor market frictions, such as firing frictions due to union, played a role.

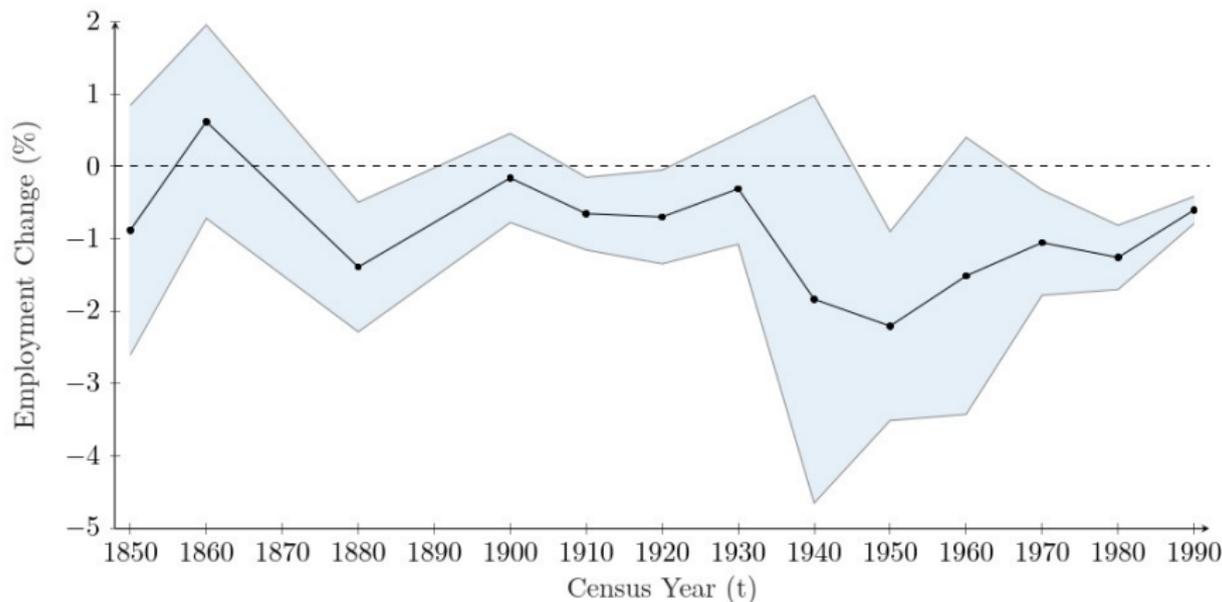
- Firms suffering from more severe labor firing frictions may be more prone to adopt labor-saving technologies. In such firms, workers are older and earn higher income.
- If this is the case, technology helps combat labor market frictions instead of unpurposefully displacing vintage skills
- Labor union can be quantitatively important—union coverage rose in early 20th century to 35% in 1954 and declined since then; Union coverage also varies substantially across industries and occupations

**Suggestion 3: Consider running the age and income subsample analyses but using union affiliation in the CPS data**

- Are there different labor outcomes for union and non-union workers in the same occupation?

# Can the suggested mechanisms explain the waves of tech-displacement effects?

**Figure 7:** Employment and Technology Exposure (long-run: 1850–present)



# Conclusion

- An important paper that are likely to guide future views on technology and labor
- A thorough analysis of how different workers are affected by technology
- Striking yet intuitive findings: technology negatively affects exposed workers
- These findings open the door to answering many timely and important questions
  - ★ How should we prepare the aging population in light of technology displacement?
  - ★ Does one size fit all, e.g., are all technologies replacing labor?