New Work in the Second Industrial Revolution

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Motivation

Technological and organizational innovation can have competing effects on labor demand:

- *Displacement* of workers whose tasks are automated or replaced
- *Reinstatement* of labor in entirely **new occupations**

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This paper studies the emergence of new work in the Second Industrial Revolution

1. Introduce a novel measure of new work based on self-reported job titles

2. How did technological innovation affect employment in new and old occupations?

3. Decompose employment changes to inflows or outflows from the occupation (next step)

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1. Introduce a novel measure of new work based on self-reported job titles
   - Use Census microdata to identify thousands of new occupations from 1870 to 1940
   - Document the emergence and diffusion of new occupations over time and space
   - Lin (2011); Kim et al. (2024); Atalay et al. (2020); Katz and Margo, 2014; Gray (2013); Atack et al. (2004)
2. How did technological innovation affect employment in new and old occupations?
   - Link patents to new occupations to identify relevant technological changes
   - Innovation increased employment, on net, though emergence of new jobs
   - Acemoglu and Restrepo(2019); Autor et al. (2024); Cortes, Jaimovich, Nekarda, and Siu (2020); Hobijn and Kaplan (forthcoming)
3. Decompose employment changes to inflows or outflows from the occupation (next step)

Enumeration of Occupations in the U.S. Census

U.S. Census Bureau began collecting respondent's occupation in 1850

- Enumerators instructed to be as detailed as possible

> *The inquiry "Profession, Occupation, or Trade," is one of the most important questions of this schedule. Make a study of it. Take especial pains to avoid unmeaning terms, or such as are too general to convey a definite idea of the occupation.*
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Most researchers work with classification codes (*occ*; *occ1950*)

- IPUMS microdata also contains original occupation write-in text (*occstr*), which are digitized exactly as reported (including spelling and typographical errors)
- Use the same information available to Census Bureau staff historically, but create finer classification.
- Example:
  "Office machine operators" [occ1950] includes "Comptometer operator, Card puncher, Addressograph operator, Mimeograph operator..." [occstr]

Identifying New Occupation Titles

IPUMS Complete-Count Census Microdata 1860–1940

1. Preprocessing of "occstr" text
   - Use NLP to correct spelling, replace abbreviations, standardize word order, remove stop words ($\sim$ 30,000 titles)
2. Consolidating duplicate titles
   - Manually review titles using 1910 to 1960 Census Classified Index of Occupations (CAIO)
   - $\sim$ **10,000** "cleaned" occupation titles cover **95%** of workers in 1860 to 1940 Census
3. Identifying new occupation titles
   - A title is new in year t first year that it is reported by 100 or more individuals
   - **6634** new titles

Ex: Comptometer operator

- comptometer op
- comptometer
- compt opt
- compt oper
- comptometer
- comptometrist
- operates comptometer
- contometer
- ....

Trend

New Titles Reflect Both Technological and Organizational Changes

Top Five Occupations by Employment in 1940

1870	1880	1900	1910	1920	1930	1940
Truck driver	Electrician	Chauffeur	Registered nurse	Mechanic, auto	Beautician	Recreation leader
Stenographer	Delivery person	Typist	Practical nurse	Maintenance man	Gas-station attendant	Housekeeper aide
Telephone operator	Welder	Assembler	Serviceman	Beauty operator	Station attendant	Jackhammer operator
Trucker	Stock clerk	File clerk	Executive	Receptionist	Bus operator	Teacher, mathematics
Timekeeper	Elevator operator	Checker	Comptometer operator	Electric welder	Mechanic, airplane	Teacher, history

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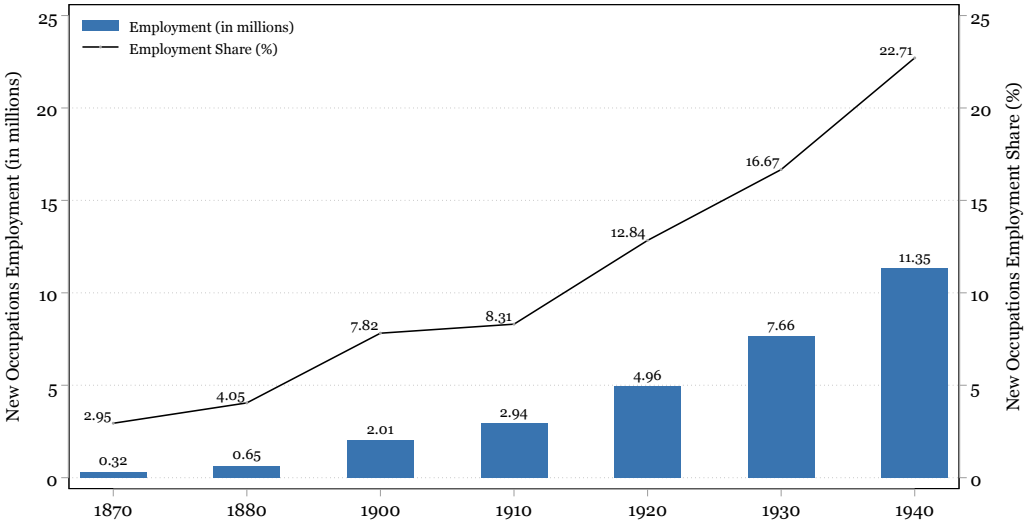
Caveat 1: We cannot distinguish occupations with the same title but changed tasks.

- e.g. truck driver operating a horse-drawn vehicle vs a motor vehicle.

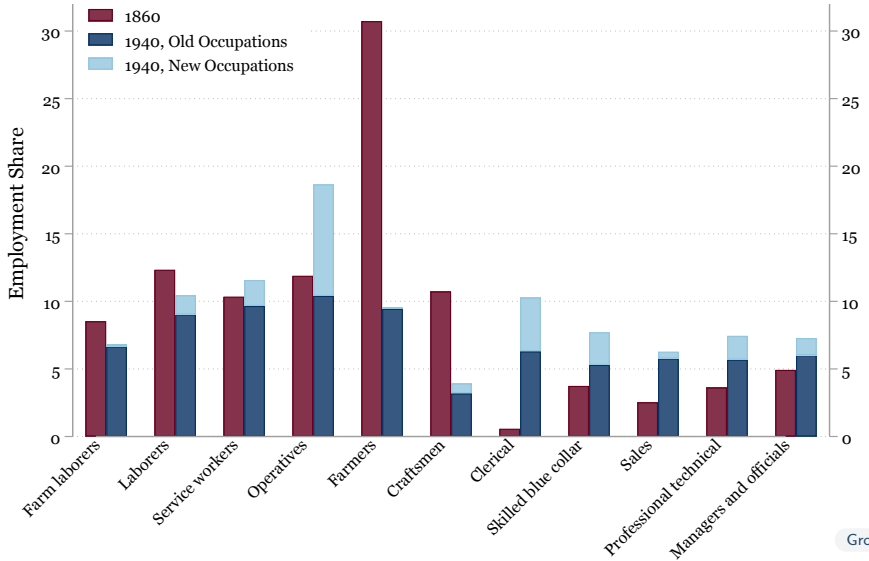
Caveat 2: More likely to report generic titles $\Rightarrow$ under-count new titles

- e.g. "works at cotton factory" vs "loom fixer"

Employment Share of New Occupation Titles



Employment Growth Driven by New Occupations

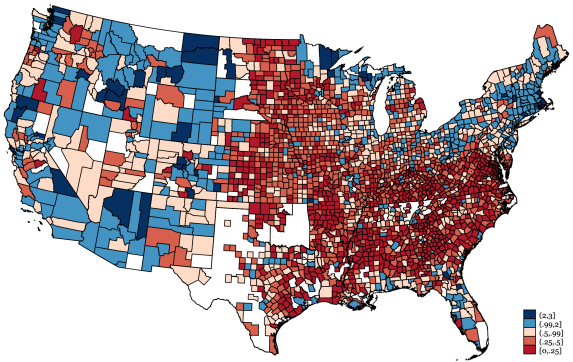


Growth vs New Share

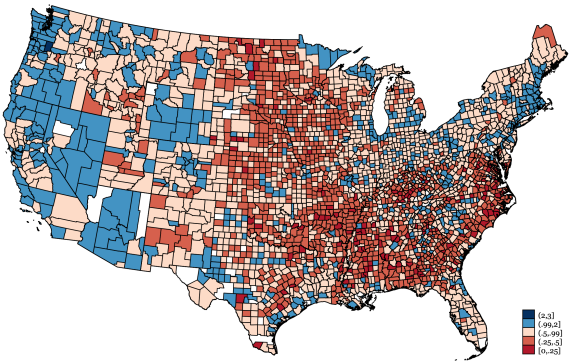
Where Did New Occupations First Emerge?

$$\text{Norm. Employment Share} = \frac{\%\text{Employment in New Occupation}}{\%\text{Population}}$$

1900



1940



Top Counties | Demographics | Binscatter

Linking Patents to Occupations

1. Two sources of texts
   - **Patent**: Full patent text from 2.2 mil patents issued 1836-1940
   - **Occupations**: *Dictionary of Occupational Titles*
     "Electrician: Lays out, assembles, installs, and tests electrical fixtures, apparatus, control equipment, and wiring ..."
     Combine task descriptions of all titles within each occupation group (OCC1950)
2. Represent the texts as 300-dimension vectors (Kogen et al., 2021; Autor et al. 2024)
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- **Draftsmen**: "Combined T Square, Protractor, and Rule" "Stencil for drawing structural details in technical plans"
- **Shipping and receiving clerks**: "Account and shipping pad" "Manifolding invoice-sheets"

Did Innovation Create New Jobs?

$$y_{j,t} = \beta_1 \log(\text{Patent}_{j,t}) + \beta_2 \text{Emp Share}_{j,t-10} + \delta_{O,t}$$

- $y_{j,t}$: Employment of occupation j in year t
- $\log(\text{Patent}_{j,t})$: Cumulative number of relevant patent for occupation j up to time t
- $\text{Emp Share}_{j,t-10}$: Employment share of occupation j in last census
- $\delta_{O,t}$: 11 broad occupation group by year fixed effects (Katz Margo 2014)

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- Instrument: number of *breakthrough* patents for occupation j up to year t (Kelly et al. 2021)

Stage Zero

Innovation Increases Employment in New Titles

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	(1)	(2)	(3)
Outcome: Log employment	Total	New Titles	Old Titles
Log Related Patents$_{jt}$	0.047**	0.248***	0.020
	(0.023)	(0.041)	(0.026)
Obs.	1,183	1,183	1,183
Kleibergen–Paap F-statistic	23500.851	23500.851	23500.851
R-squared	0.638	0.416	0.577
Occupation Group× Year FE	✓	✓	✓

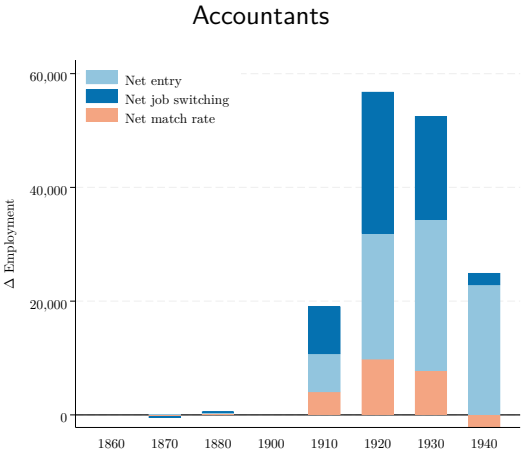
Heterogeneity Across Skill Levels

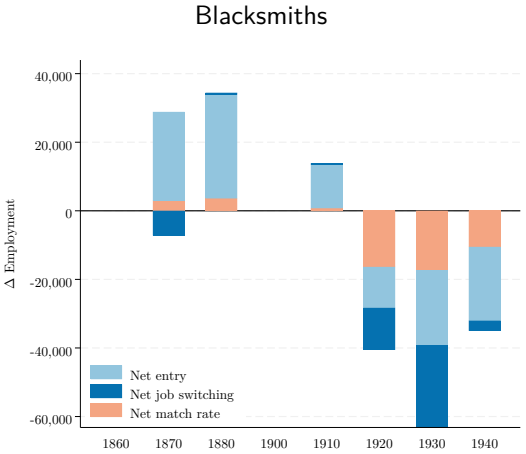
$$y_{j,t} = \beta_1 \log(\text{Patent}_{j,t}) + \beta_2 \text{Emp Share}_{j,t-10} + \delta_{O,t}$$

	(1)	(2)	(3)
Outcome: Log employment	Total	New Titles	Old Titles
		Low Skill	
Log Related Patents$_{jt}$	0.077**	0.273***	0.071*
	(0.030)	(0.055)	(0.040)
		Middle Skill	
Log Related Patents$_{jt}$	0.031*	0.311***	-0.027*
	(0.017)	(0.083)	(0.015)
		High Skill	
Log Related Patents$_{jt}$	-0.128***	0.029	-0.163***
	(0.030)	(0.035)	(0.029)

Next Steps

- Decompose employment changes to inflows or outflows from the occupation





Next Steps

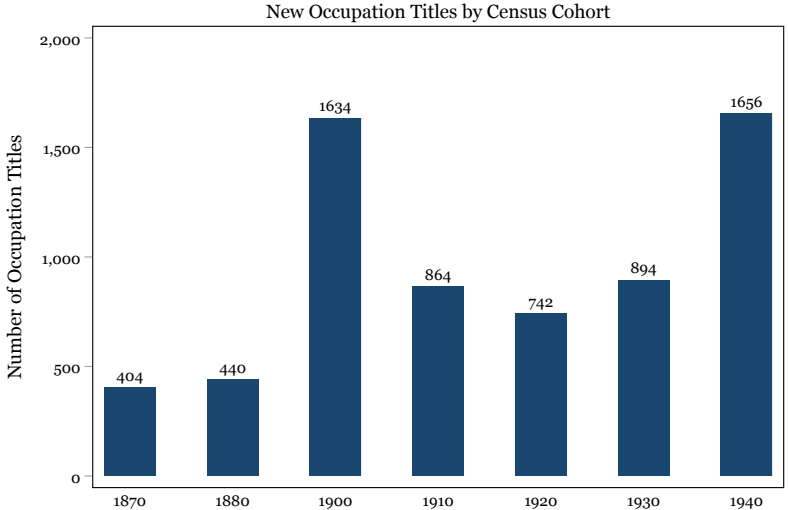
- Differentiate between technologies that substitute or complement labor.
- Parse occupation descriptions into (i) **tasks, or verb-noun pairs** (ii) tools and technologies, and (iii) output or products.

*"**Joins metal sections** (usually panels) together by means of an electric welding machine that automatically **welds** the **parts** in a continuous weld; **places parts** to be Joined in bed of machine; **alines parts** properly; **pulls lever**, causing power clamps to **hold sections** firmly; **pulls switch**, causing movable electrode to travel along line of weld to form a continuous weld; **pushes switch** to **stop** flow of **current** and to **return electrode** to starting position; **unclamps** and **removes pieces** from machine."*

Appendix

Emergence of New Occupations

3077 New Occupation Titles



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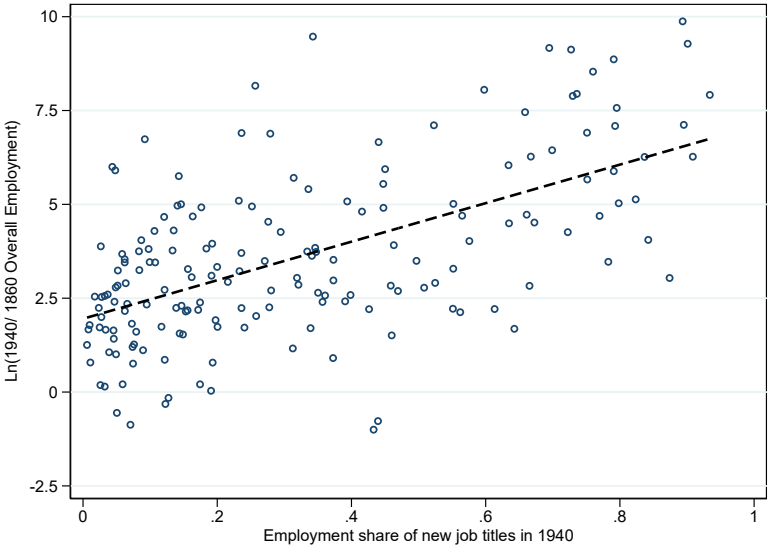
Employment Growth vs Share of Employment in New Jobs



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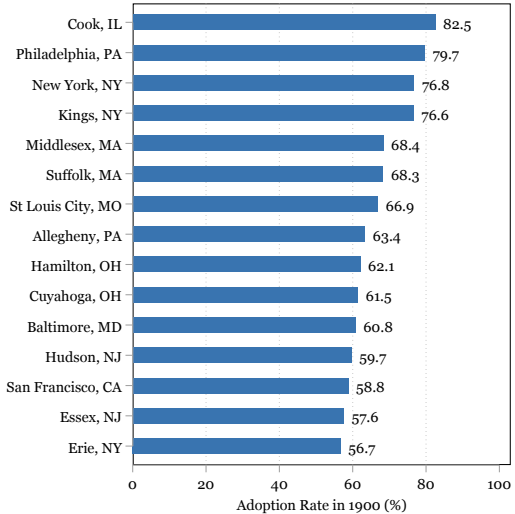
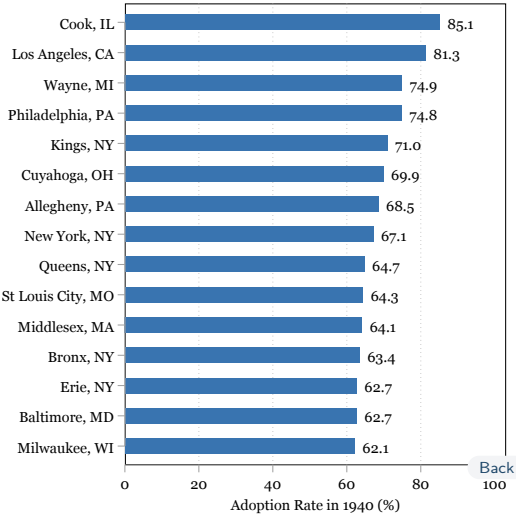
Where Did New Occupations First Emerge?

$$\text{Adoption Rate} = \frac{\text{No. New Occupation Titles}_{ct}}{\text{Total No. New Occupation Titles}_{t}}$$





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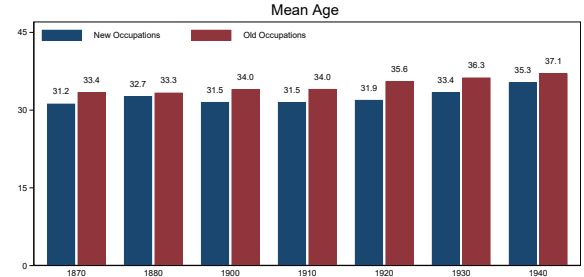
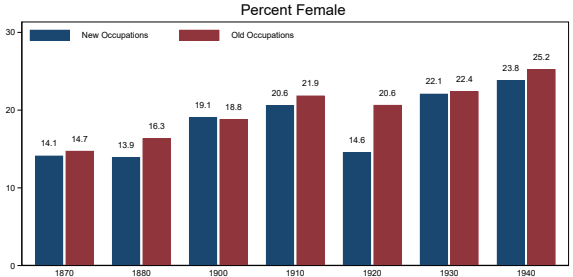
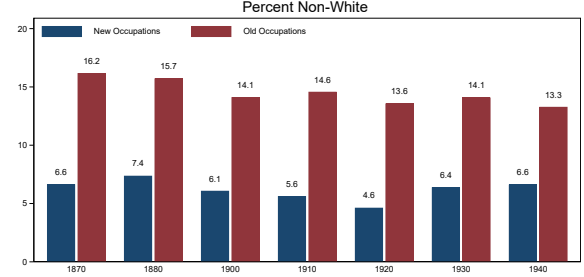
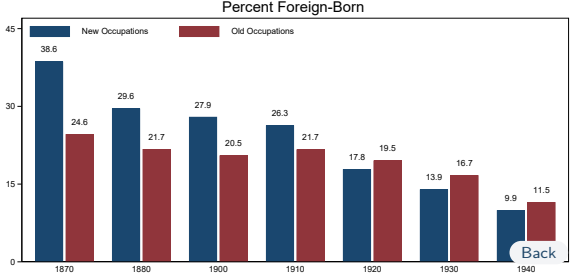
Who Worked in the New Occupations?

Worker Characteristics at Year of Emergence

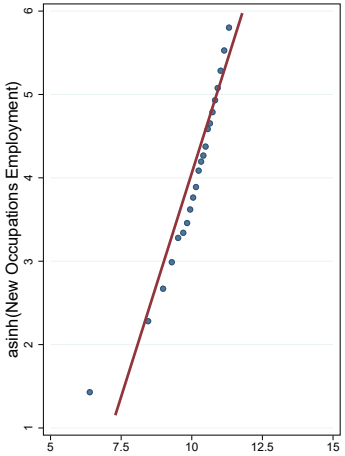




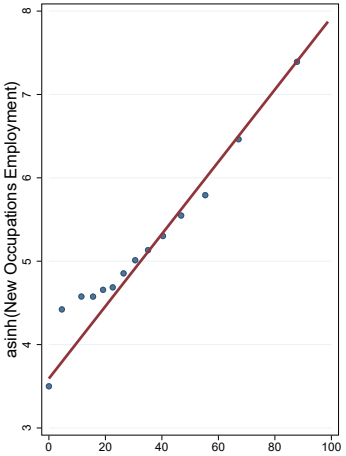




Large, Urban Counties Adopted More New Jobs



asinh(County Population)



Log County Urban Share

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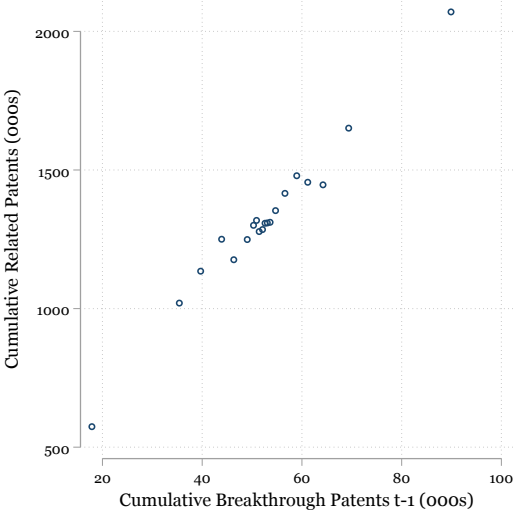
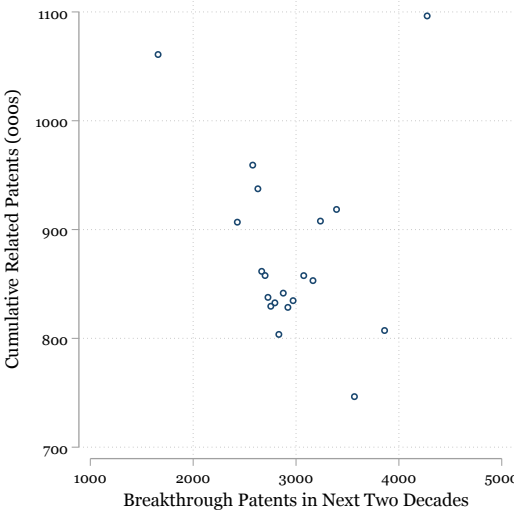
Stage Zero: Past Breakthrough Predicts Future Patents





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