New Frontiers:
The Origins and Content of New Work, 1940 – 2018

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NBER Labor Studies
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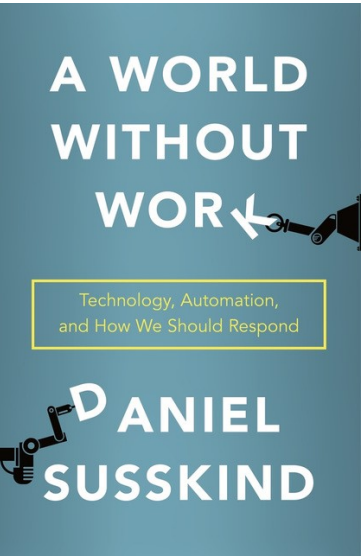
Is automation eroding human comparative advantage?



Asymptotic task encroachment

"Machines will not do everything in the future, but they will do more. And as they slowly, but relentlessly, take on more and more tasks, human beings will be forced to retreat to an ever-shrinking set of activities." –Susskind, 2020

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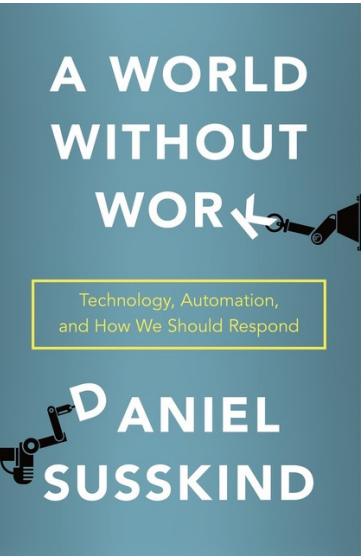

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Channeling Leontief's 'horse equilibrium'

"...[P]rogressive introduction of new computerized, automated, and robotized equipment can be expected to reduce the role of labor... similar to the process by which the introduction of tractors and other machinery first reduced and then completely eliminated horses and other draft animals." –*Leontief, 1983*

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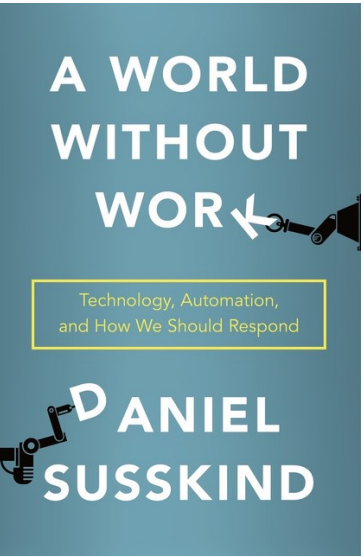

Task models of technological progress: Leontief formalized

- Automation simultaneously substitutes some tasks, complements remainder
- Machines have expanding comparative advantage

Zeira '88; Autor-Levy-Murnane '03; Acemoglu-Autor '11; Acemoglu-Restrepo '18, '21; Susskind '20

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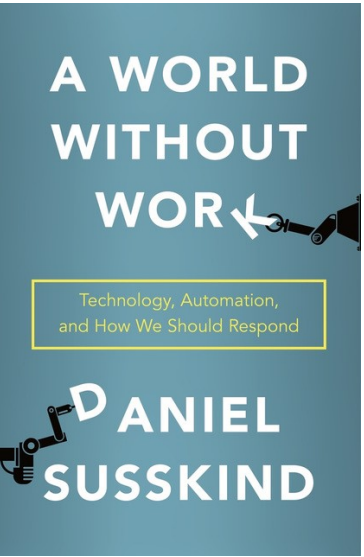

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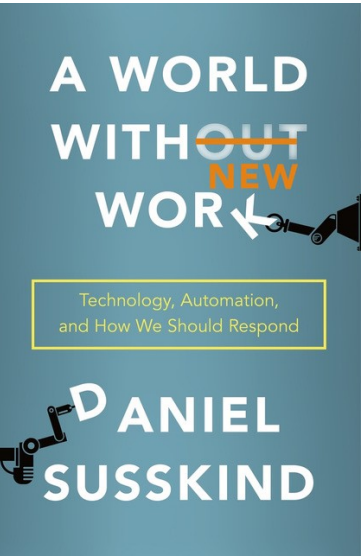
Empirical evidence of task displacement

- Striking substitution of computers and robotics for directly affected occupations / industries

Autor-Dorn '13; Michaels-Natraj-Van-Reenen '13; Cortes '16; Goos-Manning-Salomons '14; Graetz-Michaels '18; Acemoglu-Restrepo '19, '21; Bessen-Goos-Salomons-VandenBerge '19; Deschezlepretre-Hemous-Olsen-Zanella '19; Kogan-Papanikolaou-Schmidt-Seegmiller '19; Webb '20

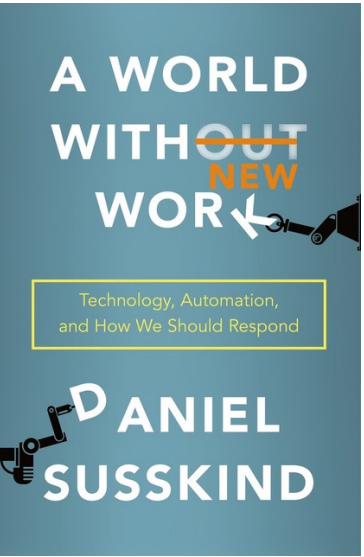
Countervailing force: The emergence of new work tasks



Asymptotic task encroachment vs. new work emergence

- Set of tasks is not fixed/static
- Jeff Lin '11: Measures new work over 1970–2000

Countervailing force: The emergence of new work tasks



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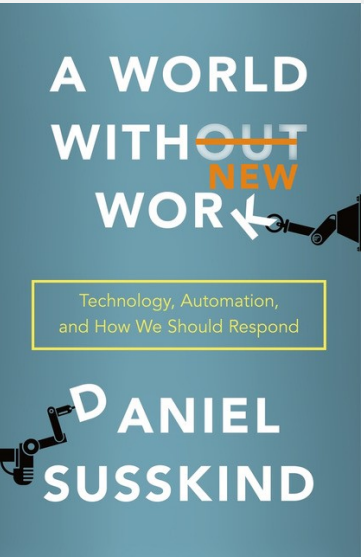
Adding new work to the 'task model'

- New tasks → Labor 'reinstatement' (counters displacement)
- Race between task displacement and new task creation
- Acemoglu-Restrepo '18,'19 ('A-R' for short)

Limited evidence on the emergence of new work tasks



Acemoglu-Restrepo '18-'19 add to new work evidence

- Develop ingenious empirical proxies for new work

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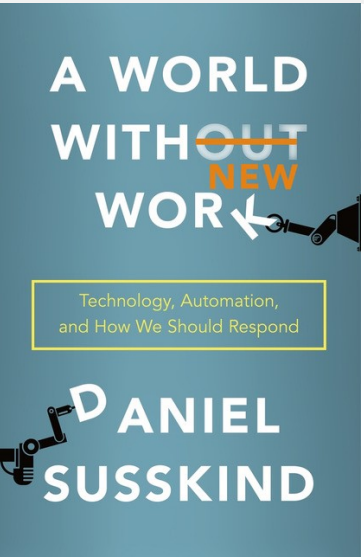

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Related evidence on task change within occupations

- Atack-Margo-Rhode '19: *Hand & Machine Labor Study 1899*
- Atalay-et-al '20: Historical job advertisements
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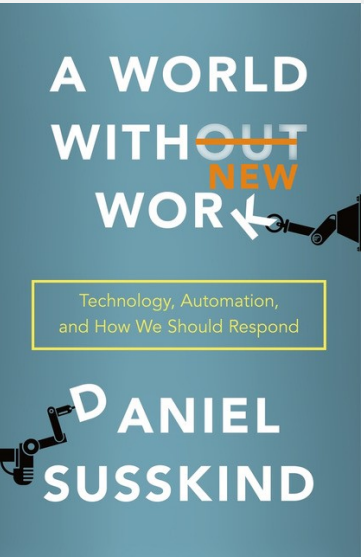

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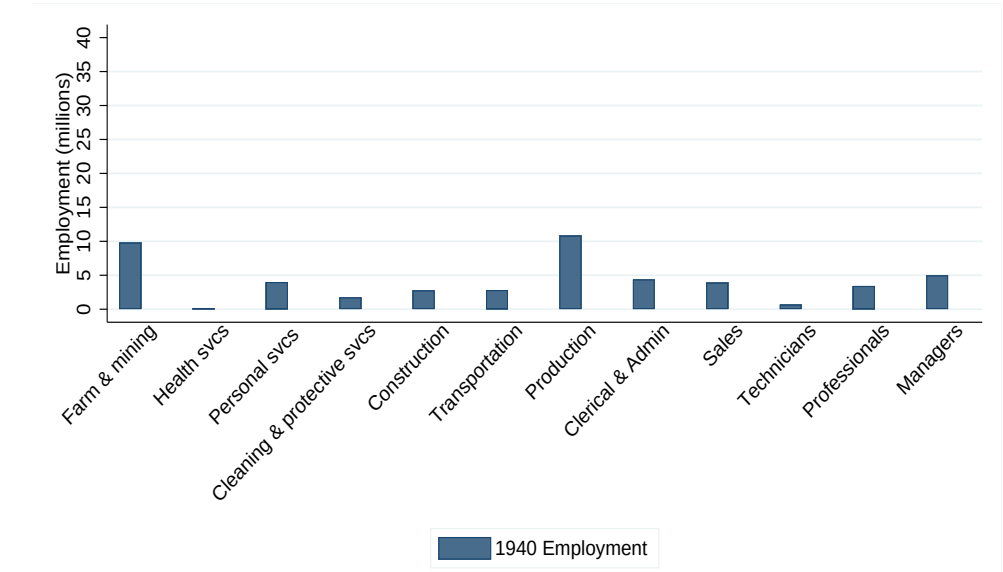
Our objectives

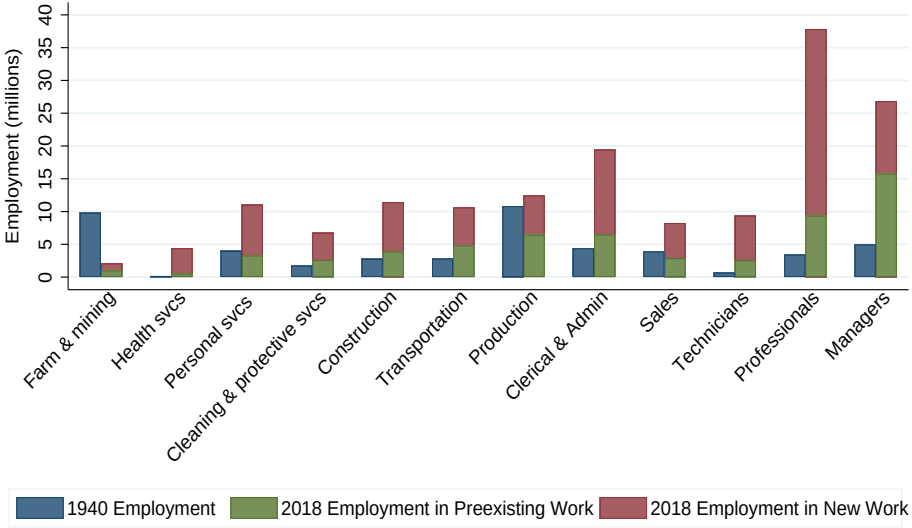
1. Consistently measure the task content of new work over eight decades, 1940 – 2018
2. Explore its technological and economic origins
3. Analyze its relationship to labor demand

Occupational distribution of U.S. work in 1940: Lots of agriculture, production



Occupational distribution of work in 2018 v. 1940

About 63% of employment in 2018 found in job types added since 1940



New Frontiers: Contributions

New work: Where does it come from, and what is it made up of?

1. **Hypothesize** new task creation and task displacement are linked to three forces:
   - Technologies that complement the outputs of occupations ('augmentation')
   - Technologies that substitute for the inputs of occupations ('automation')
   - Demand shifts that create incentives for task creation and task automation

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2. **Measure**
   - The emergence of **new work** over 1940–2018; document evolution
   - Technologies that **augment** occupational outputs vs. **automate** occupational inputs

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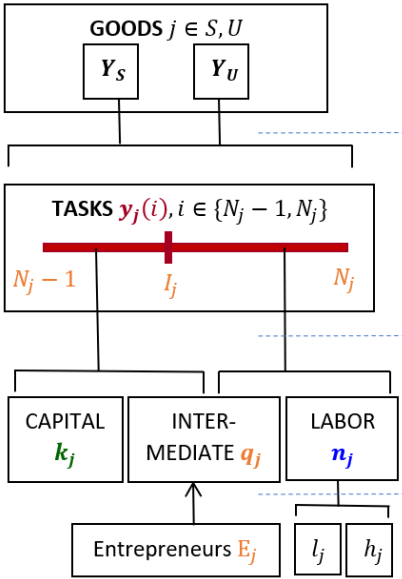
3. **Test empirically, whether:**
   - Augmentation and demand forces **explain new task creation**
   - **Augmentation** and **automation** have countervailing consequences for labor demand

Agenda

1. **Hypotheses**
2. **Data, measurement, and descriptive evidence**
   - Measuring new work over eight decades
   - Distinguishing augmentation and automation technologies
3. **Hypothesis test I: Technological advances and new task creation**
   - Augmentation: Spurring new tasks
   - Automation: *Not* spurring new tasks
4. **Hypothesis test II: Labor demand shifts and new task creation**
   - Demand contraction: China import competition
   - Demand expansion: Demographic shifts
5. **Hypothesis test III: Augmentation vs. automation: Employment & wage relationships**
6. **Conclusions**



$$u(Y_U, Y_S) = Y_U^{\beta} Y_S^{1-\beta} \quad with\ \beta \in (0,1)$$

$$Y_j = A_j \left(\int_{N_j - 1}^{N_j} y_j(i)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

$$y_j(i) = \begin{cases} B_j q_j(i)^{\eta_j} \left(k_j(i) + \gamma_j(i) n_j(i) \right)^{1-\eta_j} & \text{if } i \le I_j \\ B_j q_j(i)^{\eta_j} \left(\gamma_j(i) n_j(i) \right)^{1-\eta_j} & \text{if } i > I_j \end{cases}$$

$$with\ \eta_j \in (0,1)$$

$$n_j(i) = l_j(i)^{\alpha_j} h(i)^{1-\alpha_j} \quad with\ 1 > \alpha_U > \alpha_S > 0$$

Inelastic supply of k

l and h mobile between sectors

Elastic supply of E; mobile between sectors

E produce intermediates which raise I_j or N_j

Testable hypotheses

1. Augmentation creates new tasks; Automation does not
   - Augmentation *complements* labor's outputs, demands specialization, new expertise
   - Conversely, automation *substitutes* for labor's inputs
2. New task creation responds elastically to demand
   - Outward shifts in occupational demand *accelerate* emergence of new tasks
   - Inward shifts in occupational demand *slow* emergence of new tasks
3. Augmentation & Automation occur in same occs—with opposing demand impacts
   - New task creation $\rightarrow$ Increases employment and wagebill
   - Task automation $\rightarrow$ Decreases employment and wagebill

Three key empirical inputs into analysis

▸ examples

1. Catalog of new 'tasks' ('micro-titles') entering U.S. Census over eight decades
   - **Source:** Census Alphabetical Index of Occupations & Industries, 1930–2018 editions
   - Approx 30K occupational titles, 20K industry titles, in each decade
2. Technologies that complement occupational outputs ('augmentation')
   - **Source:** U.S. utility patents 1930–present
   - Linked to Census Alphabetical Index of Occupations and Industries, 1930–2018
3. Technologies that substitute occupational inputs ('automation')
   - **Source:** U.S. utility patents 1930–present
   - Linked to Dictionary of Occupational Titles (DOT) '91 job descriptions
   - Based on Kogan et al. '19, and similar in spirit to Webb '20 and Mann-Püttmann '20

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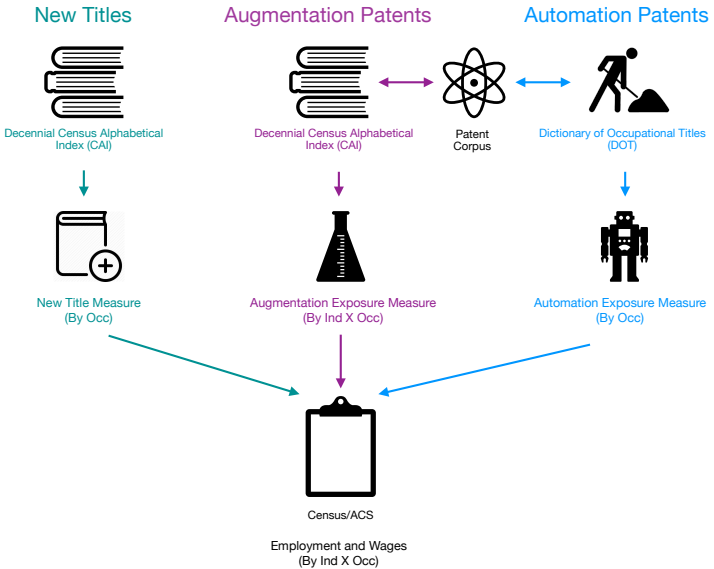
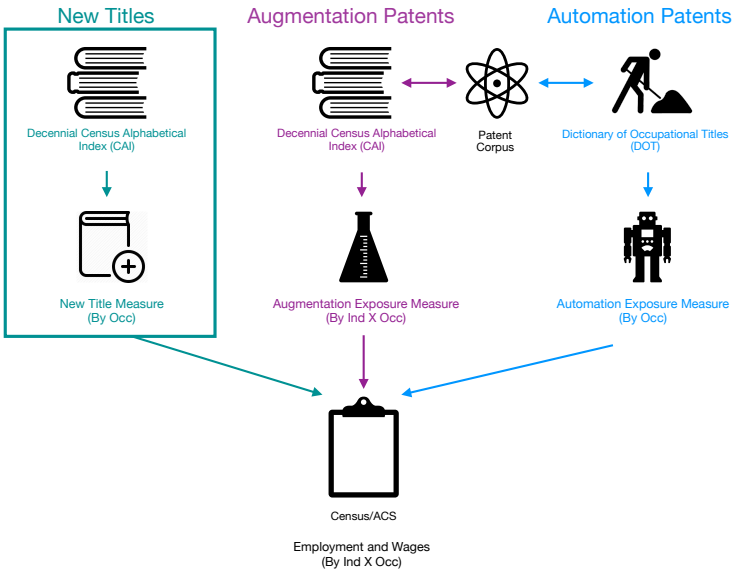
Data sources



Data: Use highly detailed Census occ/ind coding manuals to identify new work



Example of Index of Occupation (CAIO) entries, 1990

208 HEALTH TECHNOLOGISTS AND TECHNICIANS, N.E.C.

Ambulance driver, para-medic
Animal technician
Artificial-limb fitter—(372)

Assistant
  Anesthesiologist
  Anesthetic
  Laboratory, n. s.—Medical school 850
  Medical—(612)
  Occupational therapy

  Ophthalmic
  Optometric
  Orthopedic
  Orthotics
  Pharmacist's

  Physical therapist
  Physical therapy
  Podiatrist's—830
  Prosthetics
  Public health
  Speech correction
  Speech therapy

Audiometrist
Biochemistry technician
Biological technician, health
Brace maker—372,831,840
Brain-wave technician—(640)
C.M.T. (certified medical technician)

Cardiograph operator—(640)
Cardiographer—(640)
Cardiopulmonary technician
Cardiovascular technologist
Certified medical technician

Child-health associate—831,832,840
Closed circuit screen watcher—831
Dialysis technician
E.e.g. technician—(640)
E.e.g. technologist
E.k.g. technician—(640)
E.m.t.
Electrocardiograph operator—(640)
Electrocardiograph technician—(640)
Electroencephalograph technician— (640)

Emergency medical technician
Encephalographer—(831)
Environmental health sanitarian
Environmental-health technician
Environmental-health technologist

Extracorporeal-circulation specialist
Food-service technician—831,832,840
Health sanitarian
Hospital technician—831
Industrial hygienist

Inspector
  Sanitarian—840

Laboratory technician, veterinary
Laboratory technician, n. s.—030,812
Laboratory technician, n. s.— Medical school 850
Laboratory tester—030,812
Laboratory tester—Medical school 850
Laboratory worker, n. s.—030,812
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Mechanic
  Orthopedic

Medical-emergency technician
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Ocular-care technician
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Sanitarian—470,471,831,840
Scrub technician—831

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Surgical-brace maker
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Watch-closed-circuit screen—831
Water-pollution specialist

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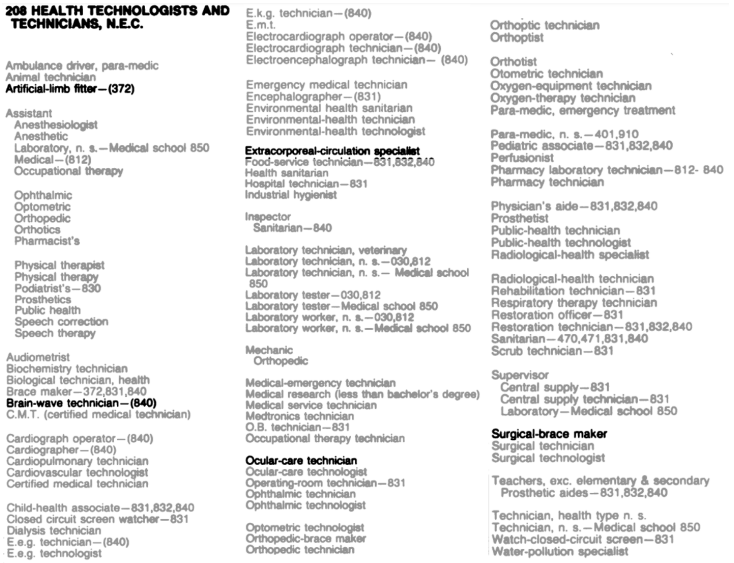

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Examples of job titles

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~30,000 titles per edition

Each title is classified to a Census occupation

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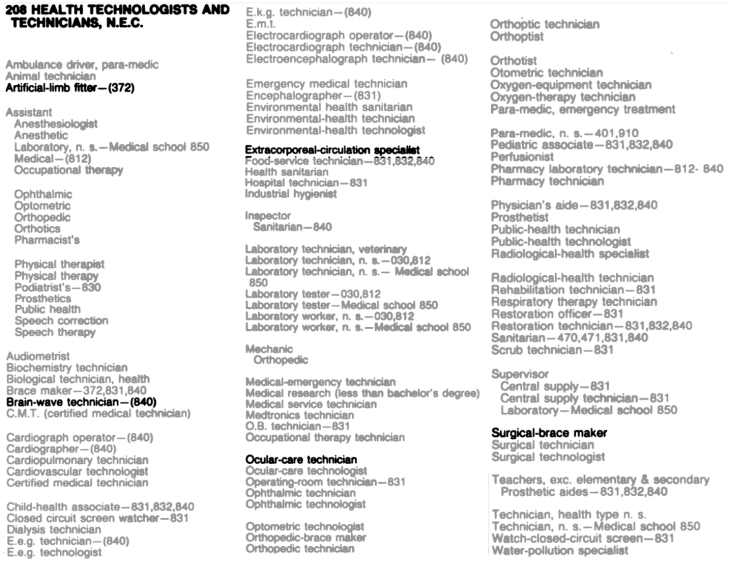

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Compare successive CAIO editions to identify new titles

Identifying new work, building on Lin '11

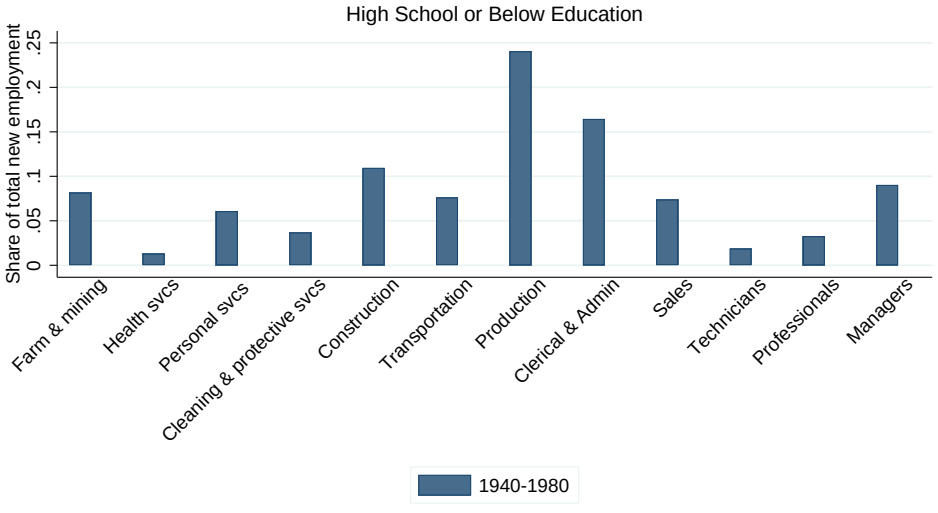
Emergence of new 'tasks' measured by:

- Flow of $newtitles_{jt}$ by Census occupation during a decade (e.g., 1930 – 1940)
- New title share $\frac{newtitles_{jt}}{alltitles_{jt}}$, equals the flow of new titles over stock of titles within Census occupation during a decade

Examples of new occupation titles, 1940 – 2018

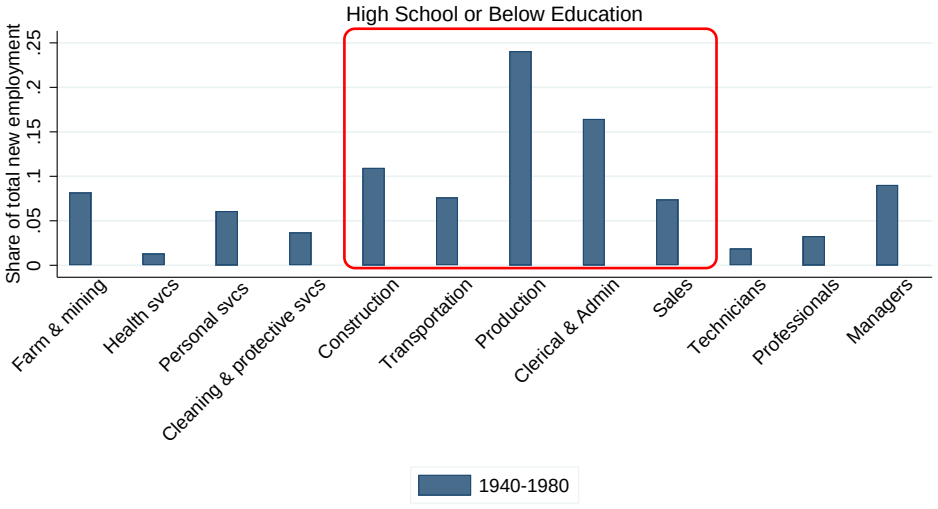
Year	Example titles added	
1940	Automatic welding machine operator	Acrobatic dancer
1950	Airplane designer	Tattooer
1960	Textile chemist	Pageants director
1970	Engineer computer application	Mental-health counselor
1980	Controller, remotely-piloted vehicle	Hypnotherapist
1990	Circuit layout designer	Conference planner
2000	Artificial intelligence specialist	Amusement park worker
2010	Technician, wind turbine	Sommelier
2018	Pediatric vascular surgeon	Drama therapist

The emergence of new work, non-college workers, 1940–1980

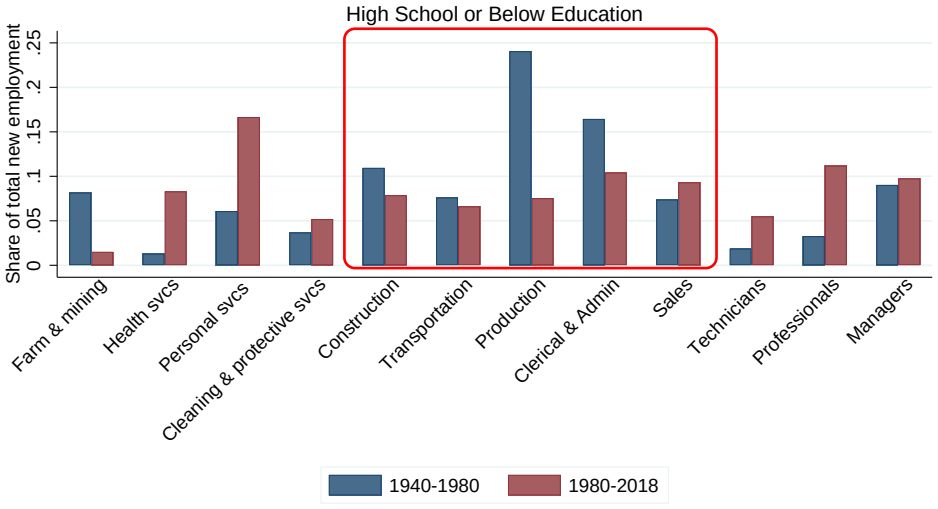


The emergence of new work, non-college workers, 1940–1980

Concentrated in middle-paid occs

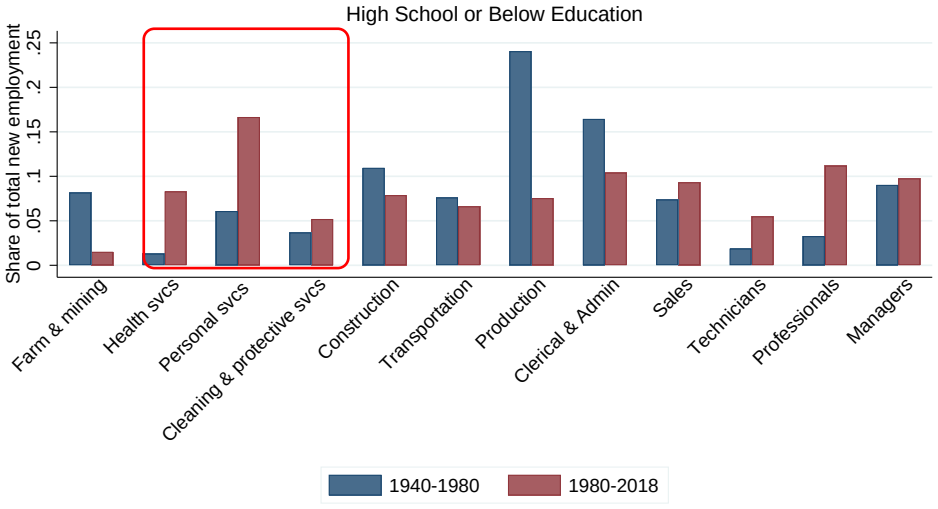


The emergence of new work, non-college workers, 1940–1980 v. 1980–2018



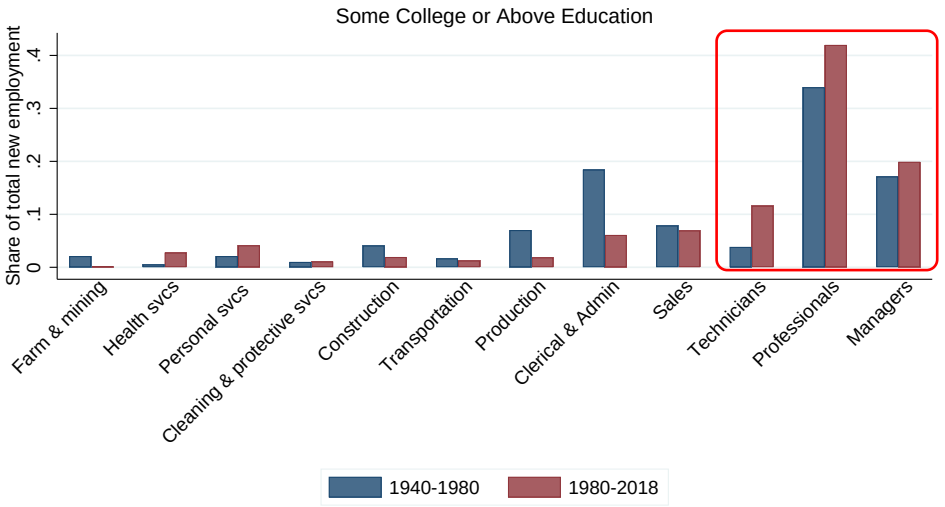
The emergence of new work, non-college workers, 1940–1980 v. 1980–2018

Moving from middle-paid to low-paid occs



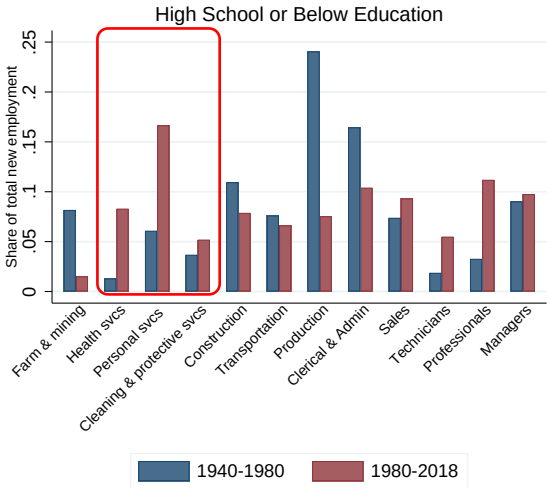
The emergence of new work, college workers, 1940–1980 v. 1980–2018

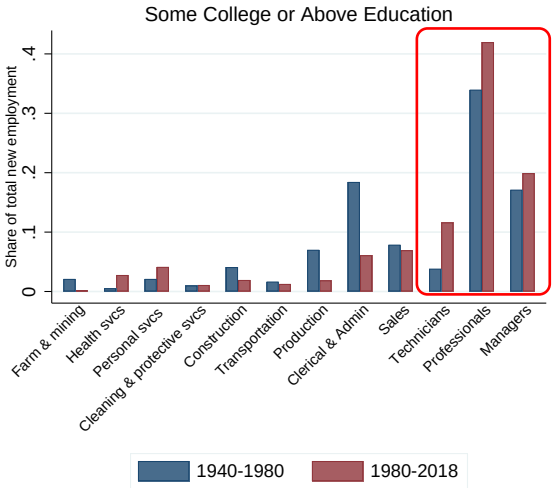
Increasingly concentrated in high-paying occs



The emergence of new work by education group, 1940–1980 v. 1980–2018

Polarizing into low-paid occs for non-college workers and high-paid occs for college workers





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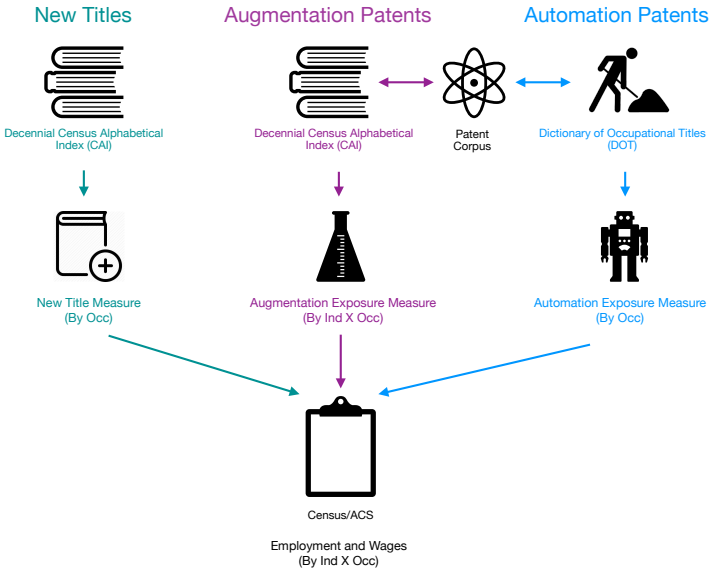
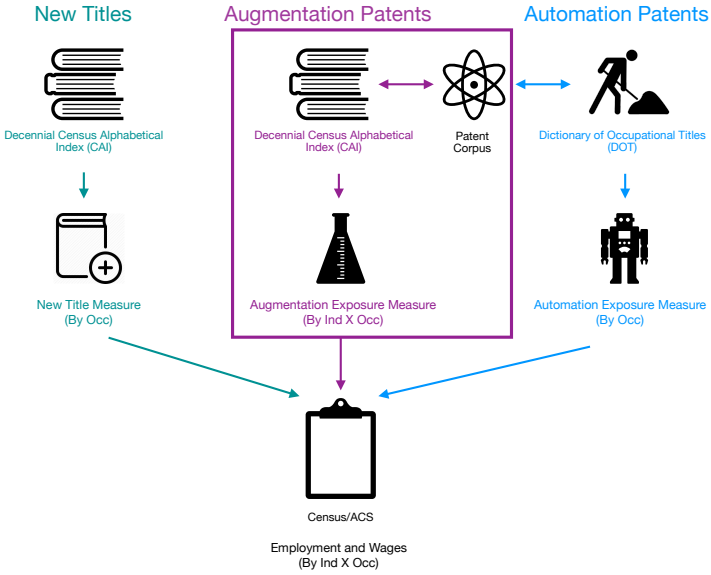
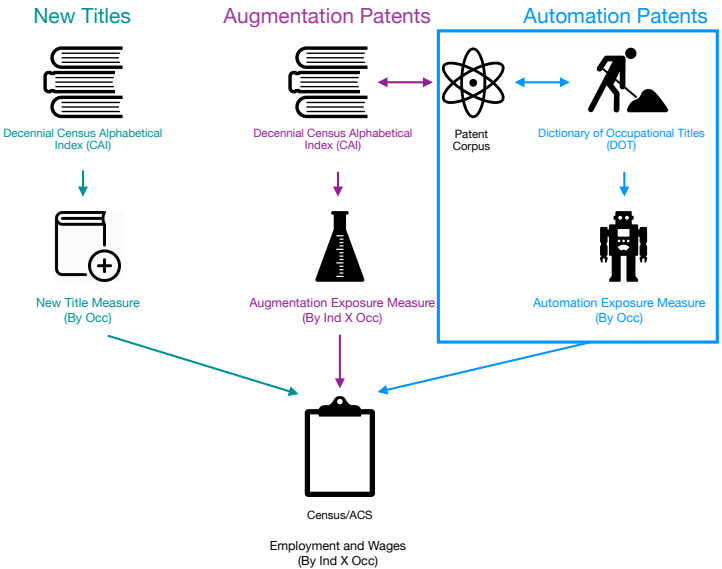
Data sources



Data: Occ'l exposure to techs complementing labor's outputs → Augmentation



Data: Occ'l exposure to techs substituting labor inputs → Automation



Health Technologists & Technicians: Outputs

Census Index of Occupations, 1990

208 HEALTH TECHNOLOGISTS AND TECHNICIANS, N.E.C.

Ambulance driver, para-medic
Animal technician
Artificial-limb fitter—(372)

Assistant
  Anesthesiologist
  Anesthetic
  Laboratory, n. s.—Medical school 850
  Medical—(812)
  Occupational therapy

  Ophthalmic
  Optometric
  Orthopedic
  Orthotics
  Pharmacist's

  Physical therapist
  Physical therapy
  Podiatrist's—890
  Prosthetics
  Public health
  Speech correction
  Speech therapy

Audiometrist
Biochemistry technician
Biological technician, health
Brace maker—372,831,840
Brain-wave technician—(640)
C.M.T. (certified medical technician)

Cardiograph operator—(640)
Cardiographer—(640)
Cardiopulmonary technician
Cardiovascular technologist
Certified medical technician

Child-health associate—831,832,840
Closed circuit screen watcher—831
Dialysis technician
E.e.g. technician—(640)
E.e.g. technologist
E.k.g. technician—(640)
E.m.t.
Electrocardiograph operator—(640)
Electrocardiograph technician—(640)
Electroencephalograph technician— (640)

Emergency medical technician
Encephalographer—(831)
Environmental health sanitarian
Environmental-health technician
Environmental-health technologist

Extracorporeal-circulation specialist
Food-service technician—831,832,840
Health sanitarian
Hospital technician—831
Industrial hygienist

Inspector
  Sanitarian—840

Laboratory technician, veterinary
Laboratory technician, n. s.—030,812
Laboratory technician, n. s.— Medical school 850
Laboratory tester—030,812
Laboratory tester—Medical school 850
Laboratory worker, n. s.—030,812
Laboratory worker, n. s.—Medical school 850

Mechanic
  Orthopedic

Medical-emergency technician
Medical research (less than bachelor's degree)
Medical service technician
Medtronics technician
O.B. technician—831
Occupational therapy technician

Ocular-care technician
Ocular-care technologist
Operating-room technician—831
Ophthalmic technician
Ophthalmic technologist

Optometric technologist
Orthopedic-brace maker
Orthopedic technician
Orthoptic technician
Orthoptist

Orthotist
Otometric technician
Oxygen-equipment technician
Oxygen-therapy technician
Para-medic, emergency treatment

Para-medic, n. s.—401,910
Pediatric associate—831,832,840
Perfusionist
Pharmacy laboratory technician—812- 840
Pharmacy technician

Physician's aide—831,832,840
Prosthetist
Public-health technician
Public-health technologist
Radiological-health specialist

Radiological-health technician
Rehabilitation technician—831
Respiratory therapy technician
Restoration officer—831
Restoration technician—831,832,840
Sanitarian—470,471,831,840
Scrub technician—831

Supervisor
  Central supply—831
  Central supply technician—831
  Laboratory—Medical school 850

Surgical-brace maker
Surgical technician
Surgical technologist

Teachers, exc. elementary & secondary
  Prosthetic aides—831,832,840

Technician, health type n. s.
Technician, n. s.—Medical school 850
Watch-closed-circuit screen—831
Water-pollution specialist

Health Technologists & Technicians: Outputs vs. Inputs

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Water-pollution specialist

Dictionary of Occupational Titles, 1991

078.261-038 MEDICAL TECHNOLOGIST (medical ser.)

Performs medical laboratory tests, procedures, experiments, and analyses to provide data for diagnosis, treatment, and prevention of disease: Conducts chemical analyses of body fluids, such as blood, urine, and spinal fluid, to determine presence of normal and abnormal components. Studies blood cells, their numbers, and morphology, using microscopic technique. Performs blood group, type, and compatibility tests for transfusion purposes. Analyzes test results and enters findings in computer.

Linking patents to occ/ind inputs and outputs

Details | Examples | Robustness

1

Strip punctuation, remove stop words, retain nouns and verbs lemmatization

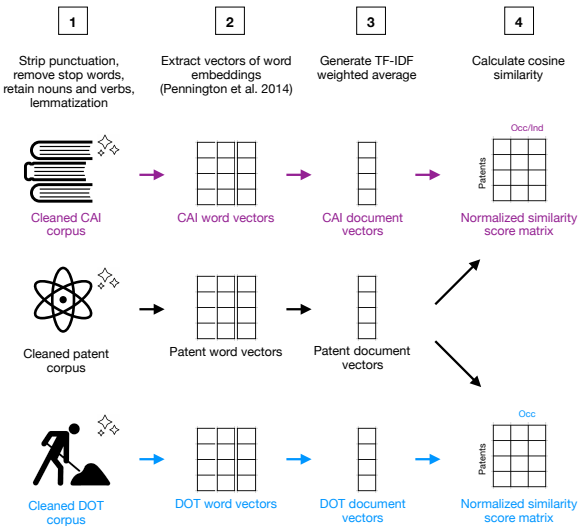
Cleaned CAI corpus

Cleaned patent corpus

Cleaned DOT corpus

Linking patents to occ/ind inputs and outputs

Details | Examples | Robustness



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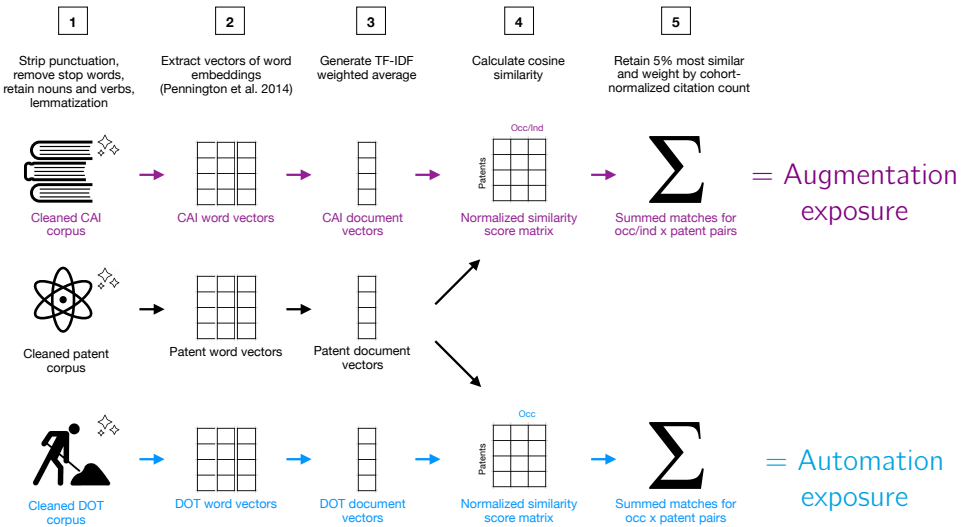
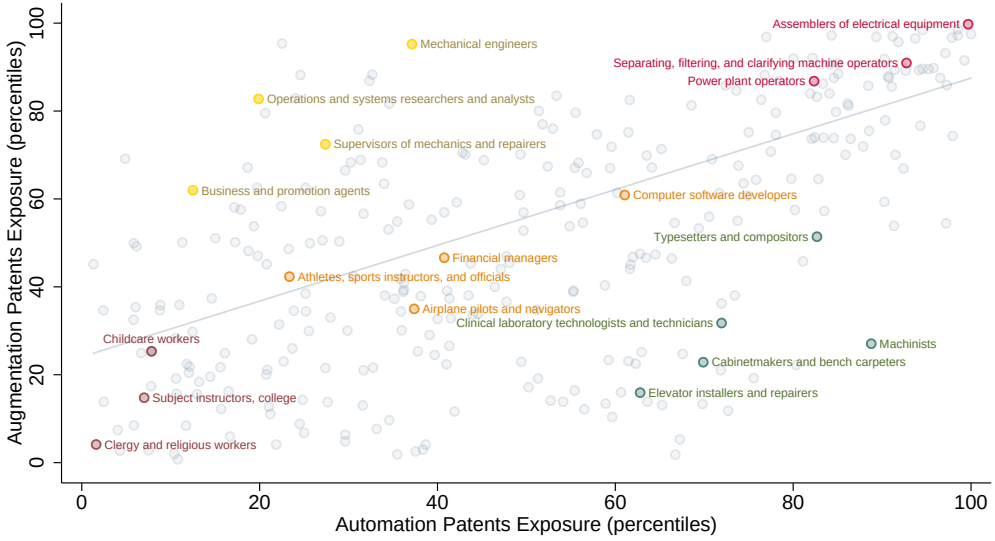


Automation vs. augmentation exposure at the occupation level, $r = 0.62$



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Do new titles emerge in occupations exposed to augmentation?

Relating augmentation to new occupation titles, 1940–2018

$$\text{IHS}(\text{newtitles}_{jt}) = \beta_1 \text{AugX}_{jt} + \beta_2 \frac{E_{jt}}{\sum_j E_{jt}} + D_t \left(+D_J + D_{Jt}\right) + \varepsilon_{jt}$$

- IHS(newtitles_{jt}): Inverse hyperbolic sine (IHS) occupational new title count
- AugX_{jt}: Occupational exposure to augmentation (patents linked to industry, or to occupation)
- Controls: Occupational employment shares and fixed effects, where J indexes 12 broad occupation groups.

New occupational titles emerge in augmentation-exposed occupations

▸ robustness

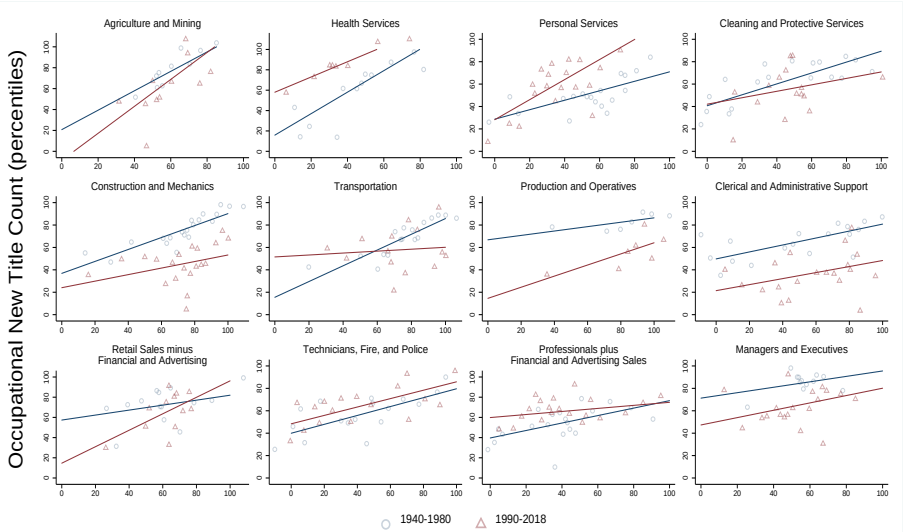
Dependent variable: 100 × IHS **Occupational New Title Count**, 1940–2018

	(1)	(2)	(3)	(4)	(5)	(6)
Augmentation (Pat Count IHS, Ind-Link)	15.91*** (3.39)	11.47*** (2.25)	9.63*** (1.81)			
Augmentation (Pat Count IHS, Occ-Link)				13.00*** (1.59)	12.74*** (1.21)	12.48*** (0.97)
N	3,668	3,668	3,668	3,668	3,668	3,668
R^2	0.634	0.674	0.754	0.679	0.718	0.795
Year FE	X	X		X	X	
Broad Occ FE		X			X	
Broad Occ × Year FE			X			X
Occ Emp Shares	X	X	X	X	X	X

Notes: Census occupations over 1940–2018. Models weighted by annual occupational employment shares. Broad occupations are 12 groups consistently defined over time. Robust standard errors in parentheses. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Augmentation exposure robustly predicts new tasks: 1940–1980, 1980–2018

$$\textbf{Newtitles}_{jt} = \beta_1 \textbf{AugX}_{jt} + \beta_2 \left(E_{jt}/\Sigma_j E_{jt}\right) + D_t + \varepsilon_{jt}$$



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Do augmentation & automation have distinct relationships with new work tasks?

Hypotheses:

1. New titles emerge in augmentation-exposed occupations
2. New titles do not (differentially) emerge in automation-exposed occupations

Focus on 1980 – 2018 for this and subsequent analyses

- Panel of 303 consistent 3-digit Census occupations (Autor-Dorn '13; Deming '17)
- Automation exposure measure built from 1991 DOT, mapped to consistent occupations for 1980–2018

Unlike augmentation, automation does not predict new title emergence

Dependent variable: 100 × IHS **Occupational New Title Count**, 1980–2018

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Augmentation	14.60***	15.82***	14.44***		15.43***	15.91***	15.08***
(Pat Count IHS, Occ-Link)	(2.23)	(1.50)	(1.49)		(2.44)	(1.45)	(1.43)
Automation				10.51**	-1.61	-0.29	-3.02
(Pat Count IHS, Task-Link)				(3.26)	(3.04)	(2.74)	(2.90)
N	1,212	1,212	1,212	1,212	1,212	1,212	1,212
R^2	0.59	0.66	0.73	0.52	0.59	0.66	0.73
Year FE	X	X		X	X	X	
Broad Occ FE		X				X	
Broad Occ X Year FE			X				X
Occ Emp Shares	X	X	X	X	X	X	X

Notes: Consistently defined Census occupations over 1980–2018. Models weighted by annual occupational employment shares. Broad occupations are 12 groups consistently defined over time. Standard errors clustered by occupation in parentheses. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

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N	1,212	1,212	1,212	1,212	1,212	1,212	1,212
R^2	0.59	0.66	0.73	0.52	0.59	0.66	0.73
Year FE	X	X		X	X	X	
Broad Occ FE		X				X	
Broad Occ X Year FE			X				X
Occ Emp Shares	X	X	X	X	X	X	X

Notes: Consistently defined Census occupations over 1980–2018. Models weighted by annual occupational employment shares. Broad occupations are 12 groups consistently defined over time. Standard errors clustered by occupation in parentheses. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

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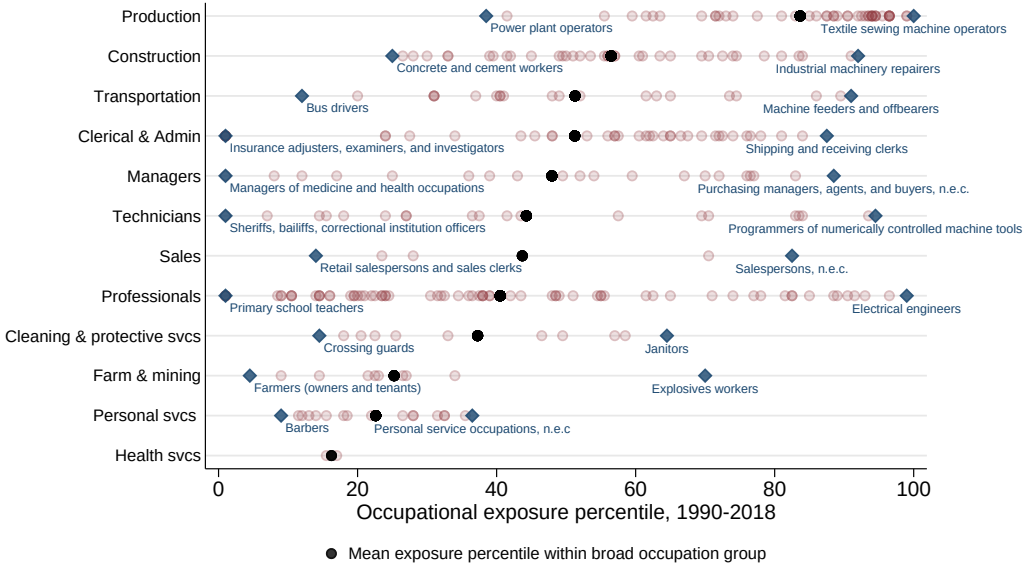
Do new titles shrink in occupations exposed to negative demand shocks?

Relating new title emergence in consistent occupation cells, 1990–2018, to changes in Chinese import competition, 1991–2014 (Autor-Dorn-Hanson '13)

$$\text{IHS}(\text{newtitles}_{jt}) = \beta_1 \text{ImportX}_{jt} + D_t + \gamma Z_{jt} + \varepsilon_{jt}$$

- $\text{IHS}(\text{newtitles}_{jt})$: IHS occupational new title count
- $\text{ImportX}_{jt} = \sum_i \frac{E_{ij,t-1}}{E_{j,t-1}} \times \frac{\Delta M^{OC}_{i,t}}{Y_{i,88} + M_{i,88} - X_{i,88}}$
  - $M^{OC}_{i,t}$: industry i's imports from China *to developed countries other than the US*
  - ImportX_{jt} captures occupation j's exposure to Chinese import competition
- Z_{jt}: Controls, including occupational employment shares (overall and across broad industries), and exposure to augmentation.

Occupational exposure to China trade shock (pctiles): Not just production occs



Less new title creation in occupations exposed to import competition

Dependent variable: 100 × IHS **Occupational New Title Count** robustness

	Years 2000 & 2018			
	(1)	(2)	(3)	(4)
ImportX 2000 & 2018	-8.93+	-11.84*	-12.51*	-11.83*
(100 × Δ Imports)	(5.18)	(5.11)	(5.10)	(5.17)
Augmentation 2000 & 2018		26.95***	32.77***	32.47***
(Pat Count IHS, Ind-Link)		(5.63)	(6.06)	(6.02)
R^2	0.368	0.435	0.566	0.568
Broad Occ FE			X	X
Δ Log Occ Emp				X
Year FE	X	X	X	X
Occ Emp Shares	X	X	X	X
Broad Ind Emp Shares	X	X	X	X

Notes: 606 observations, consistent Census occupations over 1990–2000 and 2000–2018, stacked first-differences. Models weighted by the average of start- and end-period occupational employment shares. Standard errors clustered by occupation in parentheses. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Less new title creation in occupations exposed to import competition

Dependent variable: 100 × IHS **Occupational New Title Count** ▸ robustness

	Years 2000 & 2018				Years 1980 & 1990 (Placebo Test)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ImportX 2000 & 2018	-8.93+	-11.84*	-12.51*	-11.83*	7.08	9.15	10.47	10.26
(100 × Δ Imports)	(5.18)	(5.11)	(5.10)	(5.17)	(13.93)	(8.64)	(7.62)	(7.68)
Augmentation 2000 & 2018		26.95***	32.77***	32.47***				
(Pat Count IHS, Ind-Link)		(5.63)	(6.06)	(6.02)				
Augmentation 1980 & 1990						24.75**	29.83***	29.59***
(Pat Count IHS, Ind-Link)						(7.98)	(5.03)	(5.13)
R^2	0.368	0.435	0.566	0.568	0.581	0.614	0.658	0.659
Broad Occ FE			X	X			X	X
Δ Log Occ Emp				X				X
Year FE	X	X	X	X	X	X	X	X
Occ Emp Shares	X	X	X	X	X	X	X	X
Broad Ind Emp Shares	X	X	X	X	X	X	X	X

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Do new titles emerge in occupations exposed to positive demand shocks?

Relating new title emergence in consistent occupation cells to demographically induced changes in industry demands, 1980–2018 (DellaVigna-Pollet '07)

$$\text{IHS}(\text{newtitles}_{jt}) = \beta_1 \text{DemandX}_{jt} + D_t + \gamma Z_{jt} + \varepsilon_{jt}$$

- $\text{IHS}(\text{newtitles}_{jt})$: IHS occupational new title count
- $\text{DemandX}_{jt} = \sum_i \frac{E_{ij,t-1}}{E_{j,t-1}} \times \tilde{\Delta} \ln \text{demand}_{it}$
  - $\frac{E_{ij,t-1}}{E_{j,t-1}}$: share of occupation j's employment in industry i at start of decade $(t-1)$
  - $\tilde{\Delta} \ln \text{demand}_{it}$: industry i's predicted change in demand due to Δ pop age structure $\times$ matrix of commodity demands (estimated from Consumer Expenditure Survey data)
- Z_{jt}: Controls, including occupational employment shares (overall and across broad industries), and exposure to augmentation.

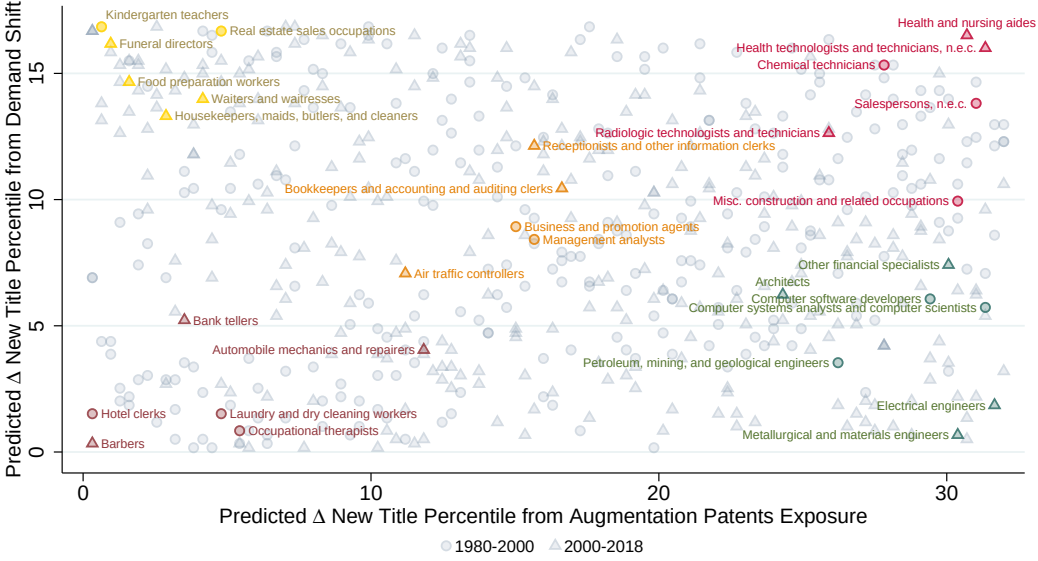
More new title creation in occupations exposed to positive demand shifts

Dependent variable: 100 × IHS Occupational New Title Count, 1980–2018 robustness

	(1)	(2)	(3)	(4)	(5)	(6)
DemandX	14.11*	18.59***	14.57***	11.18*	17.10***	14.83***
(100 × Δ Demand)	(5.72)	(4.31)	(4.26)	(5.55)	(4.09)	(4.20)
Augmentation		14.02**	27.13***		24.23***	34.22***
(Pat Count IHS, Ind-Link)		(4.94)	(4.92)		(5.34)	(5.33)
N	602	602	602	602	602	602
R^2	0.329	0.364	0.464	0.438	0.511	0.572
Broad Ind Emp Shares			X			X
Broad Occ FE				X	X	X
Year FE	X	X	X	X	X	X
Occ Emp Shares	X	X	X	X	X	X

Notes: Consistently defined Census occupations, 1980–2000 and 2000–2018. Models weighted by the average of start- and end-period occupational employment shares. Standard errors clustered by occupation in parentheses. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Demographic Δ's vs. augmentation patents predict new work in different occs



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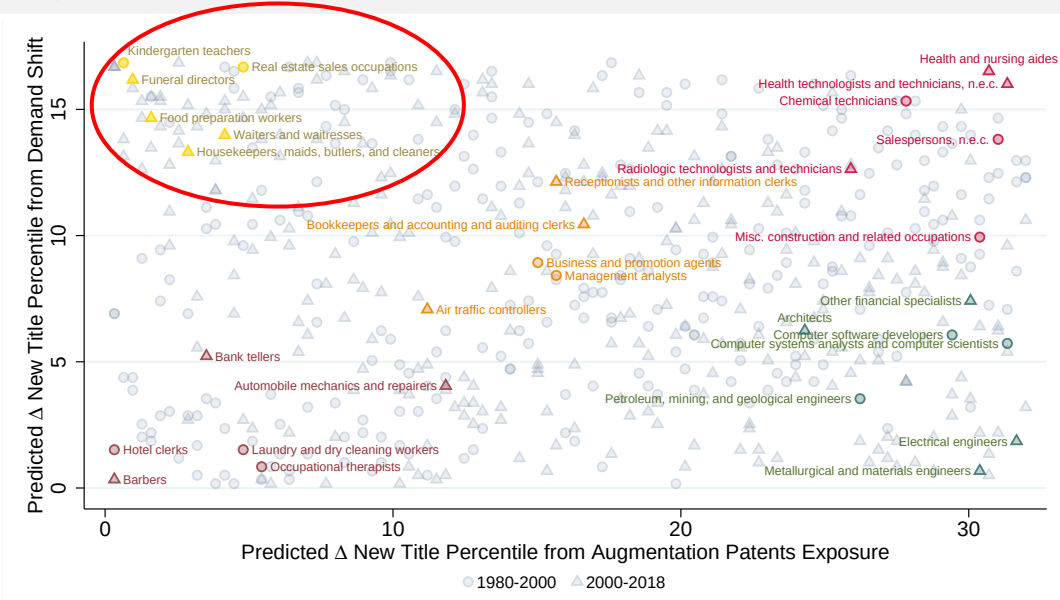

Agenda

1. **Hypotheses**
2. **Data, measurement, and descriptive evidence**
   - Measuring new work over eight decades
   - Distinguishing augmentation and automation technologies
3. **Hypothesis test I: Technological advances and new task creation**
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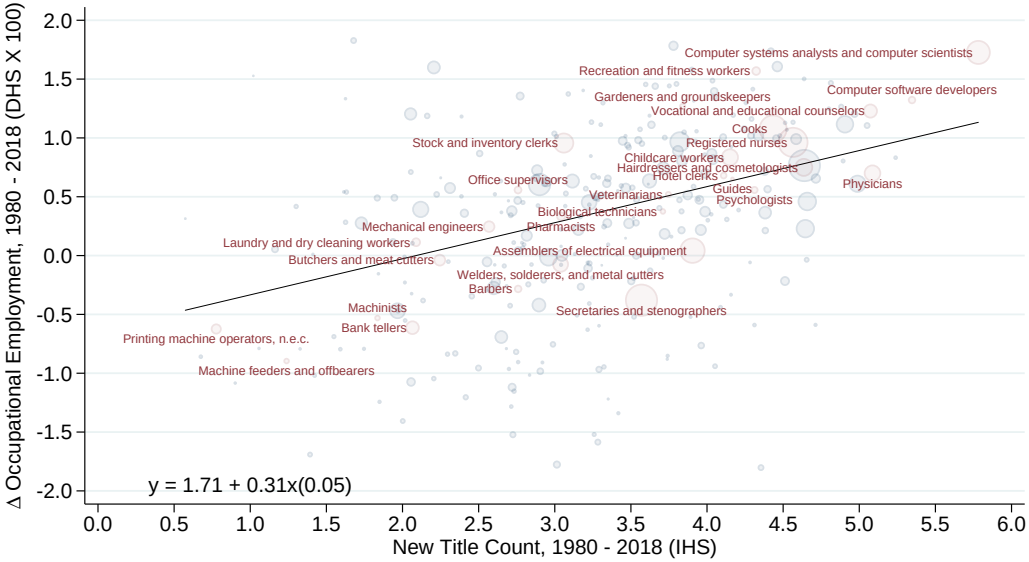
Occupational employment growth positively associated with new tasks



Task creation vs. displacement: Opposite impacts on employment growth?

Predict employment growth within 3-digit ind-occ cells, 1980–2018

$$\Delta E_{ij} = \beta_1 \text{AugX}_{ij} + \beta_2 \text{AutomX}_j + D_i \,(+D_J) + \varepsilon_{ij}$$

- ΔE_{ij}: Davis-Haltiwanger-Schuh (DHS) employment change by consistent Census occupation j and industry i, long differences over 1980–2018
- AugX_{ij}: Augmentation exposure
- AutomX_j: Automation exposure
- Controls: Fixed effects, where J indexes 12 broad occupation groups.

Builds on Kogan et al '19, Webb '20, **but with key addition – Augmentation**

Employment grows with augmentation exposure, shrinks with task displacement

Dep. var.: 100 × DHS **Employment Change** in Occupation-Industry Cells
1980–2018 Long Differences ▸ Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
Augmentation	2.38***	3.24***			3.68***	3.51***
(Pat Count IHS, Ind×Occ-Link)	(0.58)	(0.57)			(0.57)	(0.57)
Automation			-7.00***	-2.29*	-7.89***	-2.94**
(Pat Count IHS)			(0.85)	(1.10)	(0.84)	(1.09)
N	42,055	42,055	42,055	42,055	42,055	42,055
R^2	0.43	0.49	0.44	0.48	0.45	0.49
Broad Occ FE		X		X		X
Ind FE	X	X	X	X	X	X

Notes: Consistently defined Census occupations and industries over 1980–2018. Models weighted by average annual occupation-industry cell employment shares at the start and end of the time period. Broad occupations are 12 groups consistently defined over time. Standard errors clustered by occupation×industry in parentheses. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

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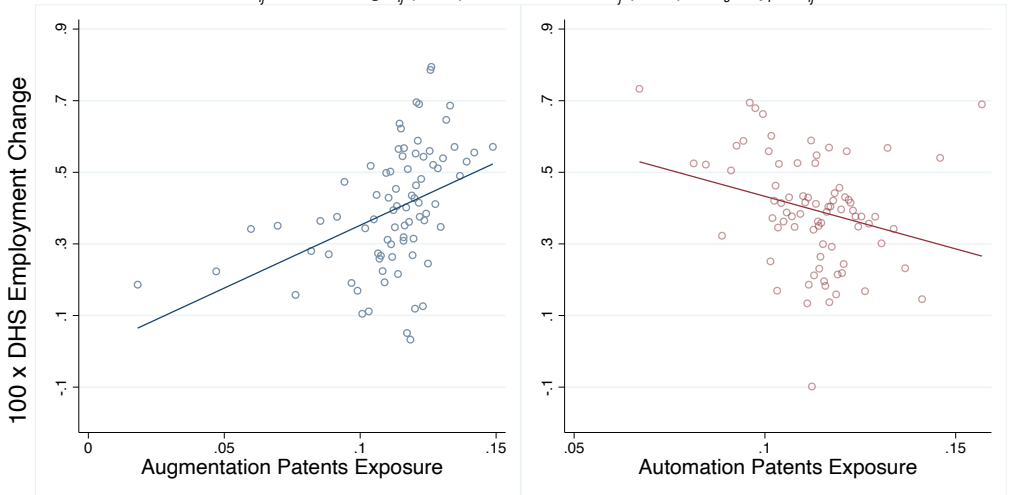
Employment growth in industry-occupation cells, 1980–2018

Employment ↑ with augmentation exposure, ↓ with automation exposure



Evidence from wagebill changes confirms labor demand effects

IHS(augmentation patents) – IHS(automation patents)

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Conclusions about the origins and content of new work

1. New work is quantitatively important: 63% of 2018 employment is in job titles that did not yet exist in 1940
2. Locus of new work has changed differentially for high- and low-educated workers
   - Concentrated in blue-collar and office work in first post-War decades
   - Concentrated in technical and professional and low-paid svcs after 1980s
3. Augmentation & demand predict where new work emerges
   - *Augmentation exposure*: new work emergence +
   - *Demand*: new work emergence + from outward shift, − from inward shift
   - *Automation exposure*: new work emergence 0
4. Task displacement and new task creation occur simultaneously, with opposing consequences for labor demand

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Thank you