A Long Run Anatomy of Task Exposures to Technology

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Introduction

Motivation

- To what extent has technological progress led to destruction and creation of work in the US in the post-war period?
- Which technologies explain reallocation across tasks/task wage premia?

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- Which technologies drive reallocation across tasks and task wage premia?

Findings

- Anatomy of task exposures: heterogeneous effects of tech. factors on task employment (positive, negative, persistent, transitory...)
- Characterize task-bias and technology domain of tech. factors
- Which technologies matter for change in task composition and wage premia of US economy?
  - 1970s-80s: manual-biased, machinery tech.
  - 1990s-: cognitive-biased, computers & software tech.
  - Trade exposure: more important than technology in early 00s

Outline

- Measuring technological exposure of tasks
- Anatomy of task exposures
- Variable importance analysis for task shares and wage premia

Measuring Technological Exposure of Tasks

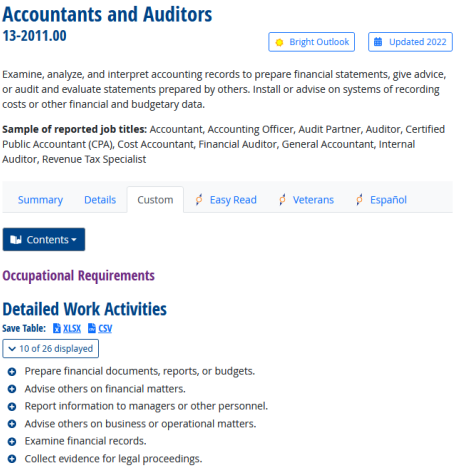
What is technological exposure?

- A model of flow of new task-relevant technologies
- $i \in [1, I]$ indexes tasks, $j \in [1, J]$ indexes technological factors
- At time t, flow of new tech $X_{i,t}$ is given by

$$X_{i,t} = \mu_{1,i} f_{1,t} + \mu_{2,i} f_{2,t} + \cdots + \mu_{J,i} f_{J,t} + \chi_{i,t}$$

- Common technological factors f affect tasks with loadings μ
- We measure $X_{i,t}$ as *average relevance* of patents granted at time t to task i

Task Data



Accountants and Auditors

13-2011.00

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Examine, analyze, and interpret accounting records to prepare financial statements, give advice, or audit and evaluate statements prepared by others. Install or advise on systems of recording costs or other financial and budgetary data.

Sample of reported job titles: Accountant, Accounting Officer, Audit Partner, Auditor, Certified Public Accountant (CPA), Cost Accountant, Financial Auditor, General Accountant, Internal Auditor, Revenue Tax Specialist

Summary | Details | Custom | Easy Read | Veterans | Español

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Occupational Requirements

Detailed Work Activities

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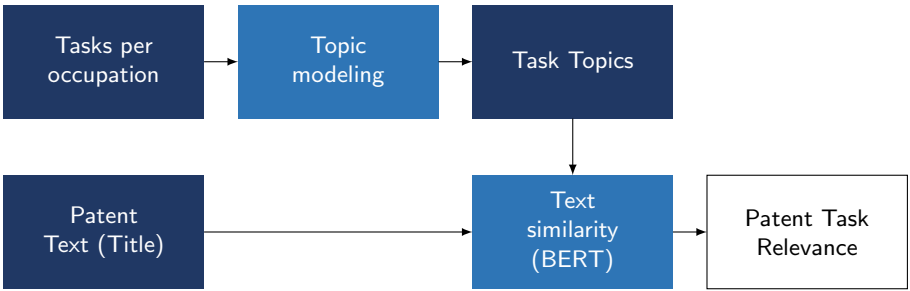
- Prepare financial documents, reports, or budgets.
- Advise others on financial matters.
- Report information to managers or other personnel.
- Advise others on business or operational matters.
- Examine financial records.
- Collect evidence for legal proceedings.

#	Detailed work activity
1	Review art or design materials
⋮	
2071	Monitor resources.

year	DWA	Hours
1976	1	...
⋮	2071	...
1977	1	...

Methodology: Measuring Task Exposure



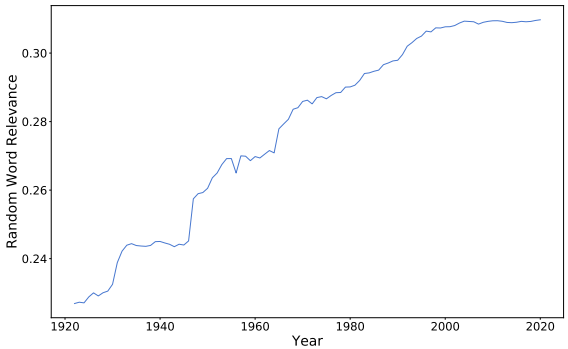
Language trends

Data source

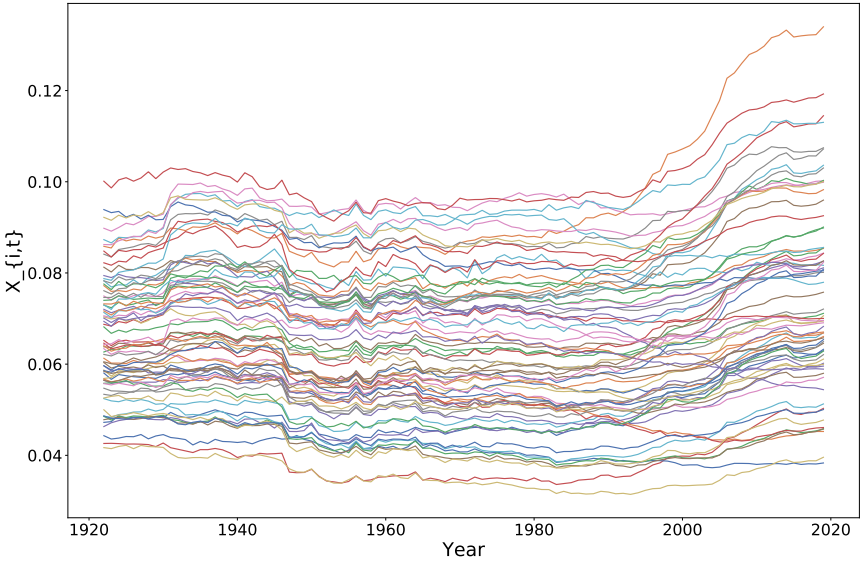
- Corpus of Contemporary American English (COCA)

Method

- Random draws from the 10,000 most frequent words in the corpus
- Calculate similarity between random samples and patent titles



Task Technological Exposure, $X_{i,t}$



What are the factors that drive technological exposure?

- Principal components analysis to estimate μ's and f's

$$X_{i,t} = \mu_{1,i} f_{1,t} + \mu_{2,i} f_{2,t} + \cdots + \mu_{J,i} f_{J,t} + \chi_{i,t}$$

- So far, "black box". What are the factors?

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- Task-bias of technological change (use NLP to assign scores to each task) Task Scores

$$\mu_{k,i} = c + \beta_1 \text{Manual-Cognitive}_i + \beta_2 \text{Routine-Non-routine}_i + \beta_3 \text{Social}_i$$

- Underlying tech: patent categories that account for variation in factors Patent Categories

Finding: main factors

- First two factors (65% of variance)

	Factor 1	Factor 2
Manual-Cognitive	Cognitive-biased	Manual-biased
Social	+	–
Technology Category	Computers & Software	Machinery

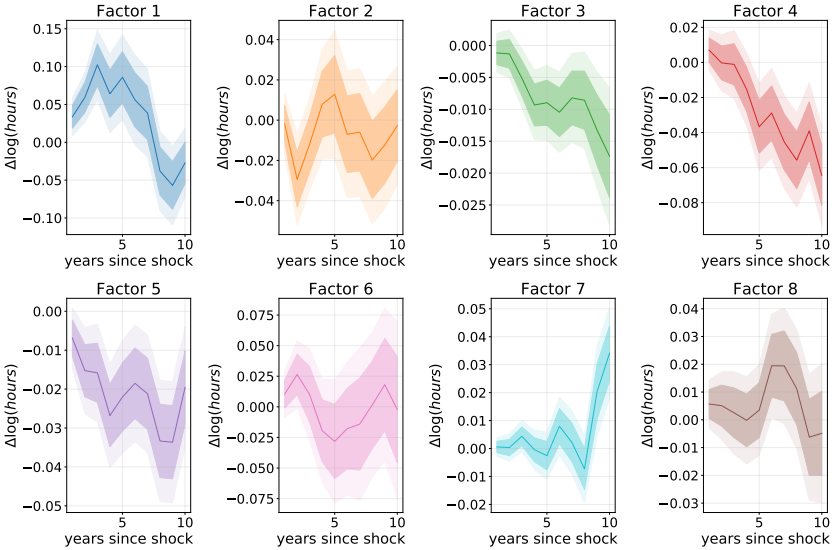
Estimating the IRFs of technology shocks

- Task-hour regressions:

$$\log\left(\text{Hours}_{i,t+h}\right) = \alpha_{i,h} + \gamma_{t,h} + \sum_{k=1}^{N} \beta_{k,h}\mu_{i,k} f_{k,t} + \ldots$$
$$\sum_{\ell=0}^{5} a_{h,\ell} \log(\text{Hours}_{i,t-\ell}) + \sum_{J} \sum_{\ell=1}^{10} c_{j,h,\ell}\mu_{i,J} f_{j,i,t-\ell} + \xi_{i,h}$$

- Recursive identification: technological shocks do not affect hours contemporaneously

IRF yearly data - Task Hours



Variable Importance

Variable importance

- Baseline specification (OLS)

$$y_{i,t+h} = \alpha_i + \gamma_t + \sum_k \beta_k \mu_{k,i} f_{k,t} + \text{Import Exposure}_{i,t} + \varepsilon_{i,t}$$

- Interact factors and import exposure with task content scores (Ridge)
- y: task shares, task wage premia

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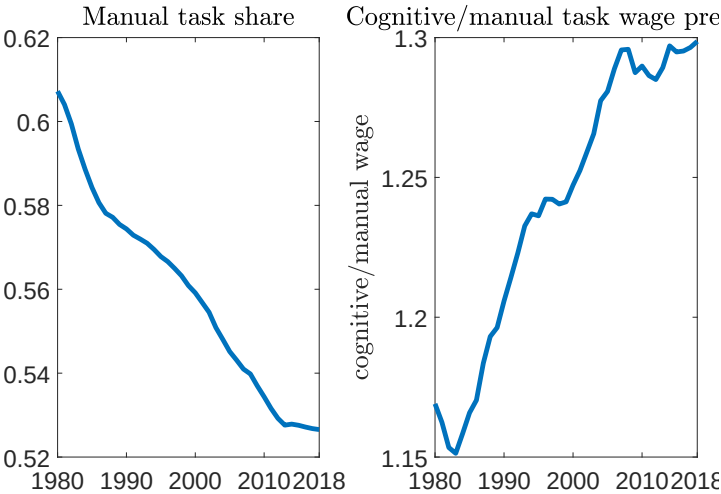
- Variable importance (Gu, Kelly and Xiu (2020)):

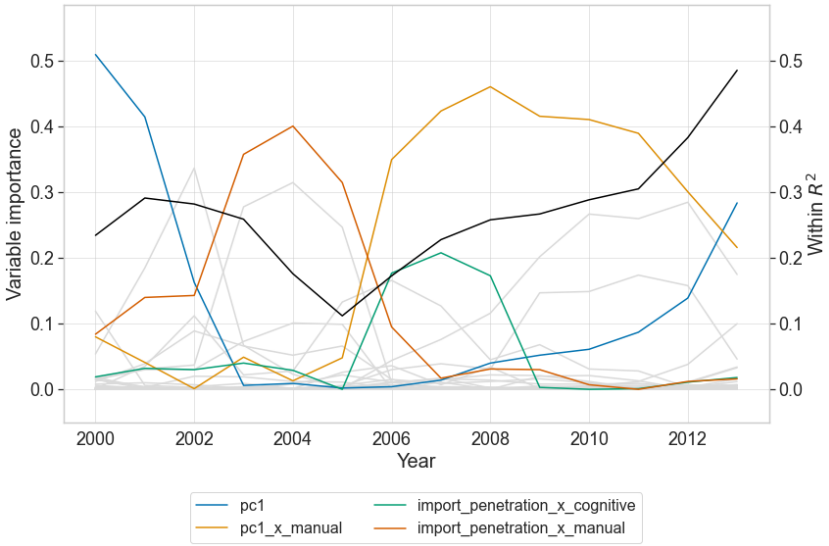
$$VI_j = \frac{R^2 - R^2_{-j}}{\sum_j R^2 - R^2_{-j}}$$

- $R^2 - R^2_{-j} \equiv$ change in within R^2 setting variable j to zero
- Calculate variable in importance in rolling windows to look at time variation

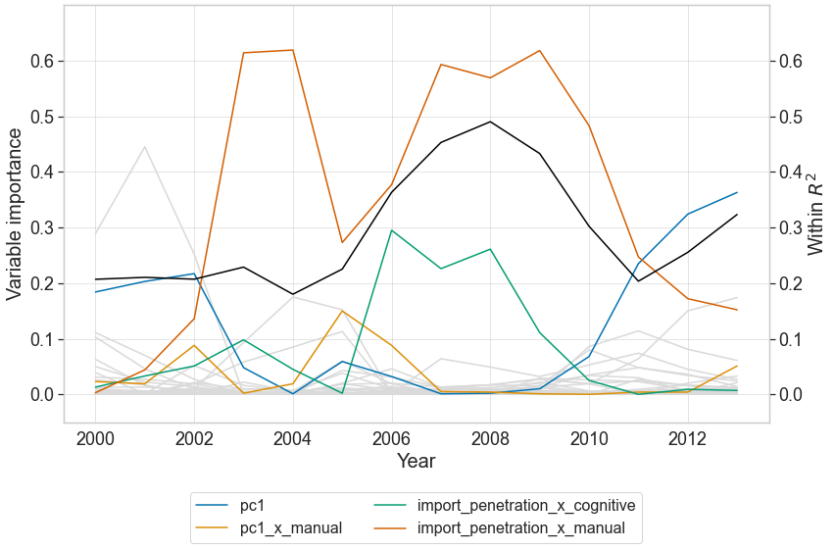
Task shares and wage premia



Variable importance: task shares



Variable importance: task wage premia



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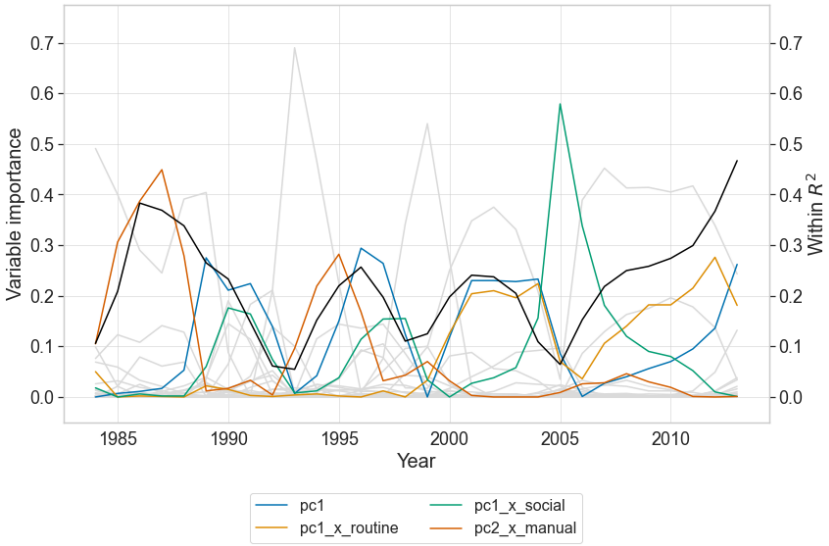

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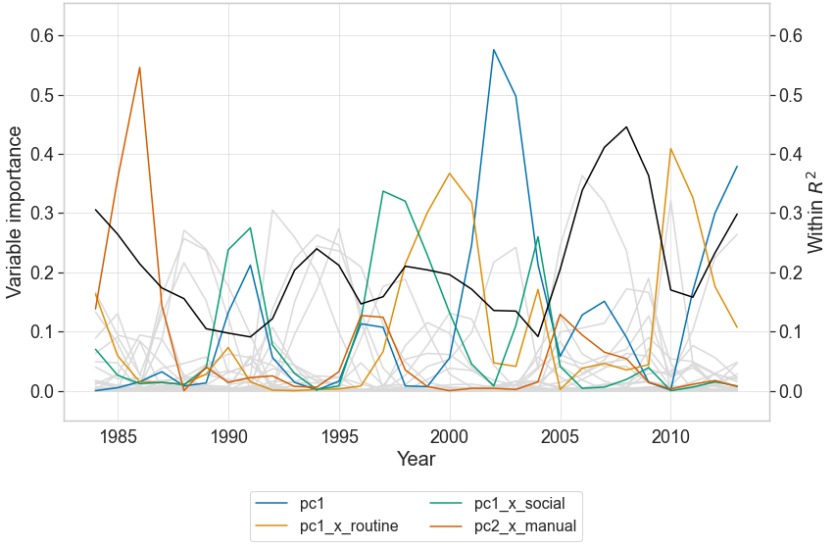

Conclusion

- We propose a methodology to measure task-specific technological exposure
- Document heterogeneous impacts on task composition of economy
- Which technologies matter most?
  - 1970s-80s: manual-biased, machinery tech.
  - 1990s-: cognitive-biased, computers & software tech.
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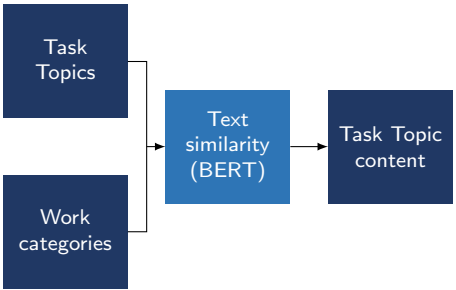
Appendix

Categorizing work

Cognitive 'cognitive, conscious, intellectual activity, thinking, reasoning, remembering, decision making, understanding and producing language, communicating; empathy, creativity'

Manual 'manual work involving the hands, strength, physical presence, manual dexterity; moving, carrying, lowering, lifting objects'



- Assign each task topic a manual-cognitive score

$$\text{Manual-Cognitive Score} = \frac{\text{Manual Relevance}}{\text{Manual Relevance} + \text{Cognitive Relevance}}$$

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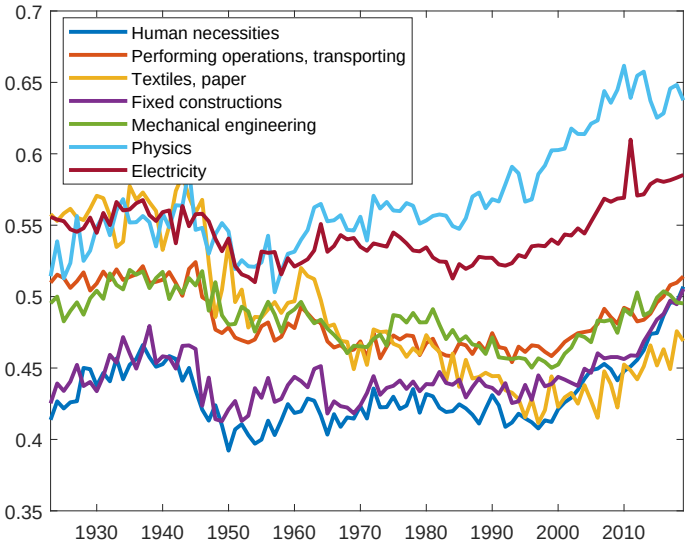
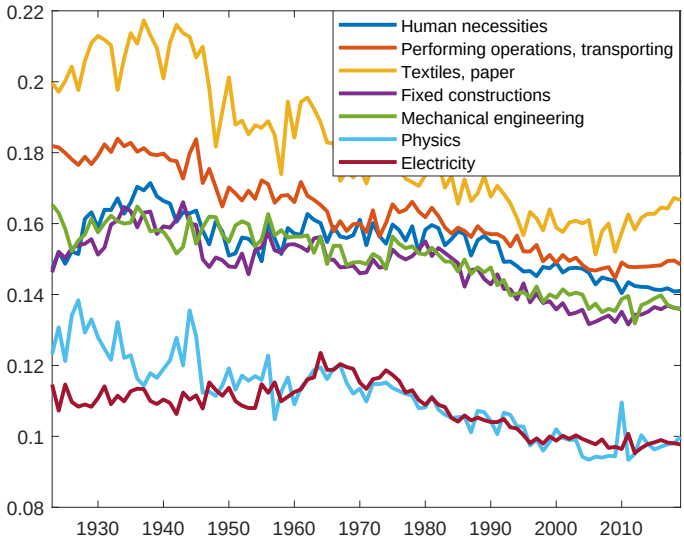
PC1 (Cognitive Factor): IPC decomposition



PC2 (Manual Factor): IPC decomposition



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