A Long Run Anatomy of Task Exposures to Technology

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Introduction

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- To what extent has technological progress led to destruction and creation of work in the US in the post-war period?

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- Estimate the causal effect of technology factors on employment
- Which technologies drive reallocation across tasks and task wage premia?

Findings

- A small number of factors drive technological progress, these have heterogeneous effects on employment
  - Manual-biased: $-$ employment
  - Cognitive-biased $+$ employment
- Which technologies matter for change in task composition and wage premia in the US?
  - 1970s-80s: manual-biased, machinery tech.
  - 1990s-: cognitive-biased, computers & software tech.
  - Trade exposure: more important than technology in early 00s

Methodology

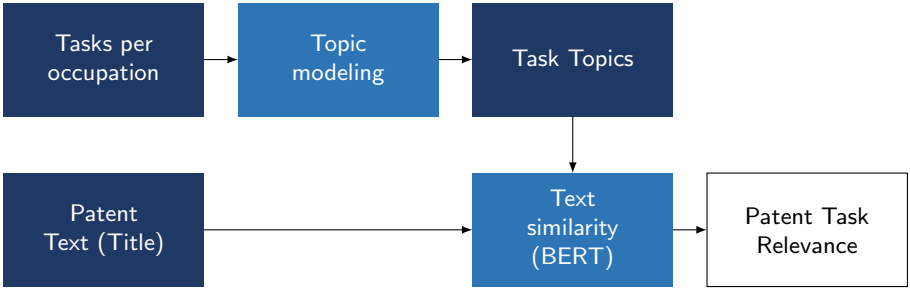
What is technological exposure?

- 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

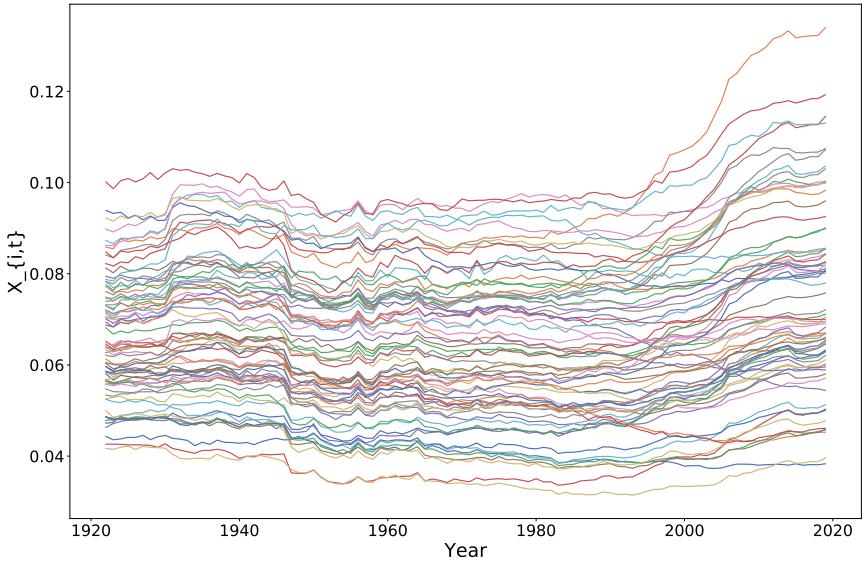
$$X_{i,t} = \mu_{1,i} f_{1,t} + \mu_{2,i} f_{2,t} + \cdots + \mu_{J,i} f_{J,t} + \chi_{i,t}$$

- 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

Methodology: Measuring Task Exposure



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



What are the factors that drive technological exposure?

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

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

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- So far, "black box". What are the factors?
  - Task-bias of technological change Task Scores
  - Underlying technology Patent Categories

- First two factors (65% of variance)

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

Empirical Analysis

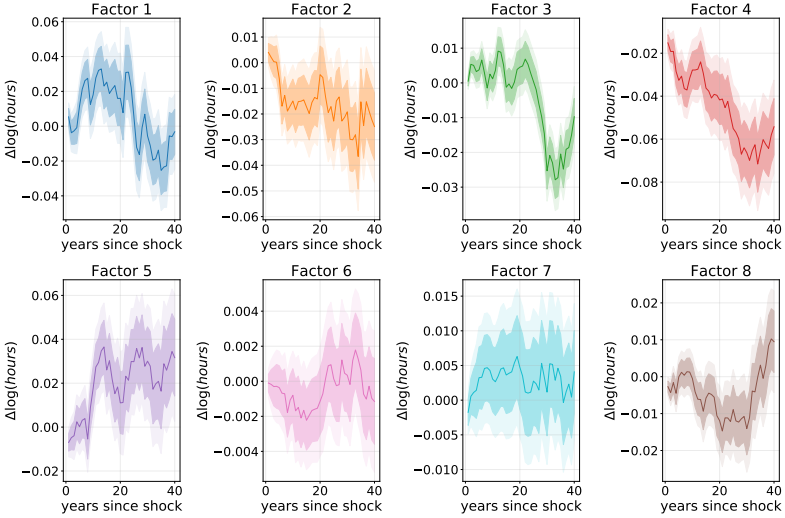
Estimating the IRFs of technology shocks

- Task-hour regressions:

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

- Recursive identification: technological shocks do not affect hours contemporaneously

IRFs - Task Hours



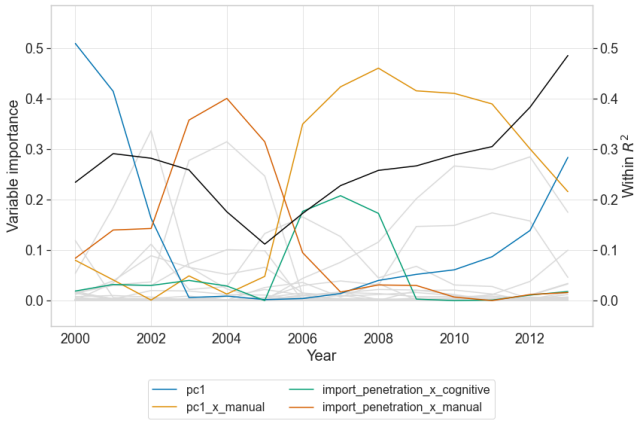
Which factors matter for the US economy?

Explanatory model

$$\Delta y_{i,t+h} = \alpha_i + \gamma_t + \sum_k \beta_k \mu_{k,i} f_{k,t} + IP_{i,t} + \varepsilon_{i,t}$$

Variable importance

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



Summary

- 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.
  - Trade exposure: more important than technology in early 00s

Questions or comments?
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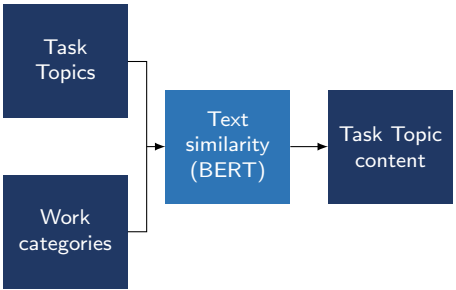
Thank you!

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'

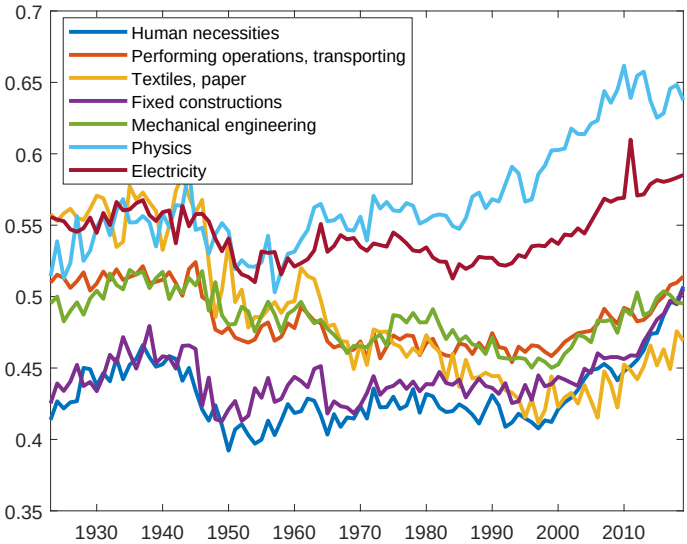


- Assign each task topic a manual-cognitive score

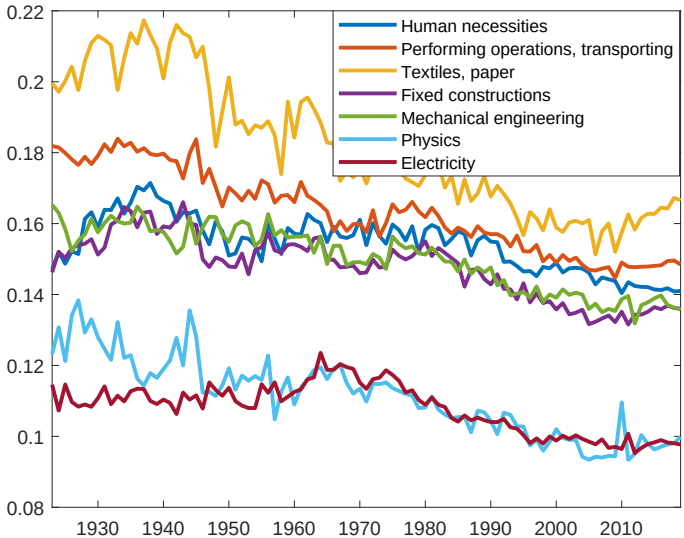
$$\text{Manual-Cognitive Score} = \frac{\text{Manual Relevance}}{\text{Manual Relevance} + \text{Cognitive Relevance}}$$

Back

PC1 (Cognitive Factor): IPC decomposition



PC2 (Manual Factor): IPC decomposition



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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

Variable importance: task wage premia