

Horizontal and Vertical Polarization: Task-Specific Technological Change in a Multi-Sector Economy

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September 2019

Empirical Observations

Known facts:

1. Middle-skill employment has shrunk since the 1980s (*polarization*); similar pattern for relative wage
2. Employment shifting from manufacturing to services (*structural change*)

We document that:

1. Rise in employment share and relative wage of managers (*vertical polarization*)
2. Both sectors have polarized, but more in manufacturing
3. Manufacturing's relative TFP took off since the 1980s

What We Do

1. Present a tractable model with
 - Managers and workers (span-of-control)
 - Workers working in different tasks
 - Manufacturing and services sectors
2. Routinization (TSTC among middle-skill tasks) can qualitatively *and* quantitatively account for:
diff. H. and V. polarization b/w sectors \Rightarrow structural change
3. Calibrated TSTC correlates strongly with routine-manual and manual-interpersonal indices in O*NET

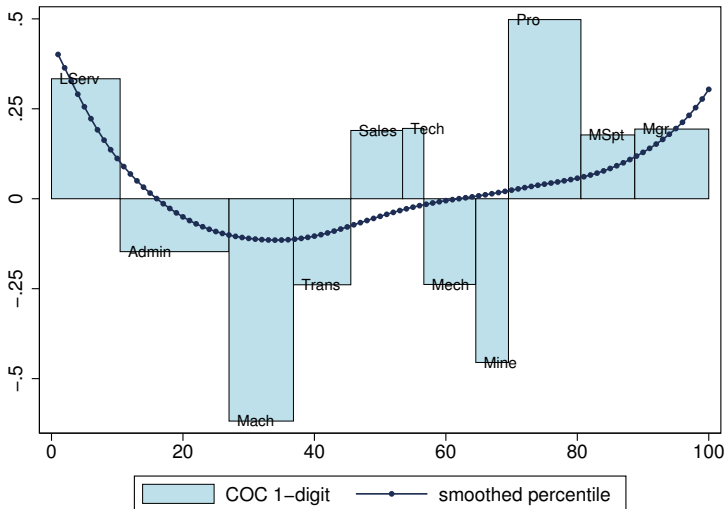
Employment Polarization

1980-2010, extends [Autor and Dorn \(2013\)](#)

▶ by dec.

▶ wages

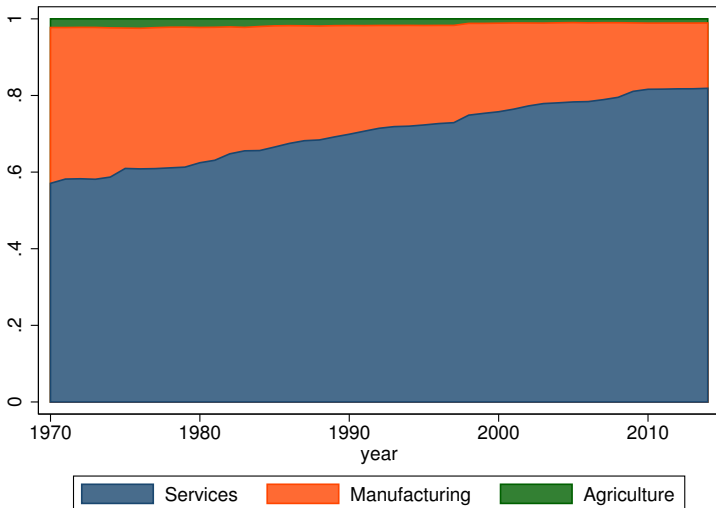
▶ RTI



Structural Change: Employment

BEA NIPA Accounts (similar in Census)

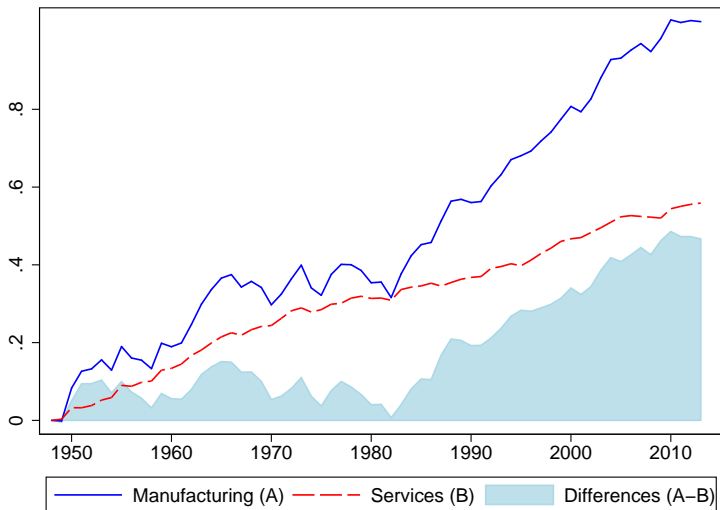
▶ GDP (Nominal)



Sectoral TFP's: Since 1947

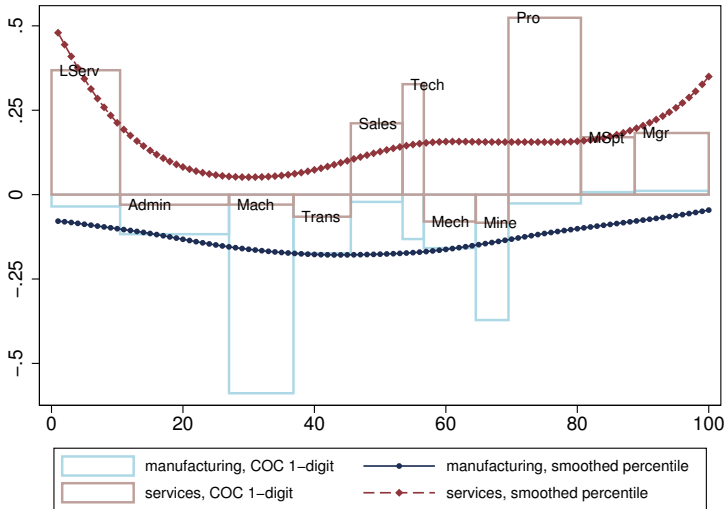
BEA NIPA Accounts

▶ Counterfactuals



Employment Polarization by Sector

► by COC



Vertical Polarization

- Employment share of management and their compensation have been rising relative to wage-workers'
- Less well-known that this has been faster in manufacturing
- We explain this by routinization replacing wage-workers, who at the margin instead become managers

Managers vs Workers, Aggregate

▶ occupation coding

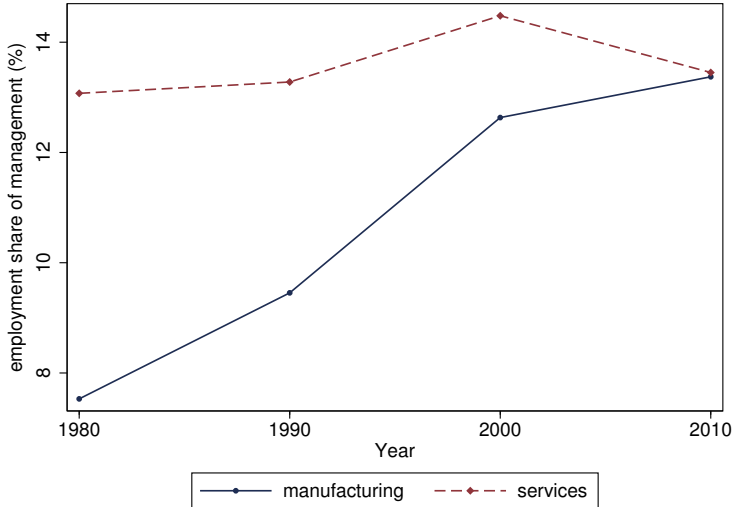
▶ firm-individual census



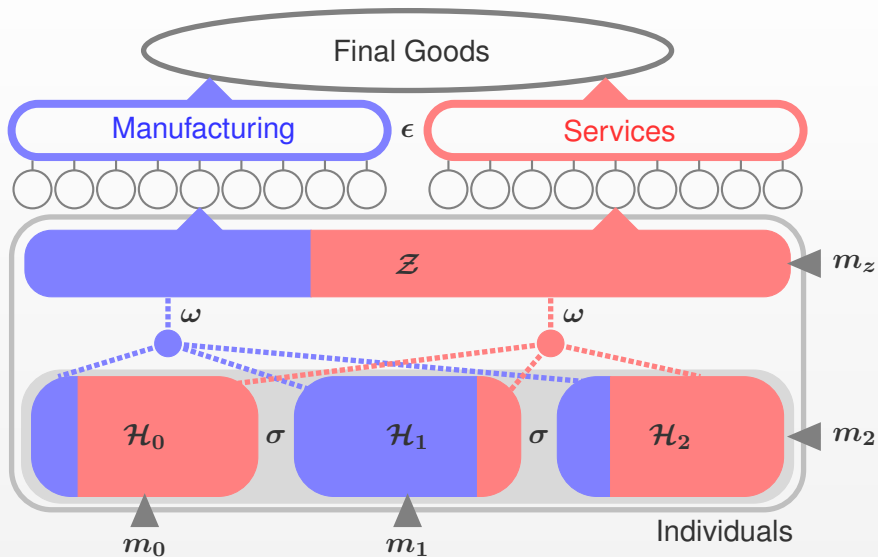
Manager Employment by Sector

▸ SC by Mgr/Wkr

▸ Wages



Task-Based Macro Model



Model Elements: Individuals

1. Unit mass of individuals differ in terms of **2 skills**
 $s = (z, h) \in \mathcal{S} \subset \mathbb{R}_+^2$ with distribution μ
 - z : managerial talent
 - h : worker skill
 - **neither sector- nor task-specific**
2. Occupation choice: Individuals can work as a span-of-control **manager**, or as a **worker in 1 of 3 tasks**:
 - Managers organize tasks, using z
 - Tasks $j \in \{0, 1, 2\}$ (e.g., manual, routine, abstract) use h

► firm-individual census

c.f. All results go through with continuum of tasks j (in paper)

Task-Specific Technologies

- Production unit: a manager in sector i combines tasks τ_{ij} :

$$y_i(z) = \left[\eta_i^{\frac{1}{\omega}} x_{iz}^{\frac{\omega-1}{\omega}} + (1 - \eta_i)^{\frac{1}{\omega}} x_{ih}^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}$$
$$x_{iz} = M_z k_{iz}^{\alpha} z_i^{1-\alpha}, \quad x_{ih} = \left(\sum_{j=0}^2 \nu_{ij}^{\frac{1}{\sigma}} \tau_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

- Simple form of log-supermodularity in skills and tasks:

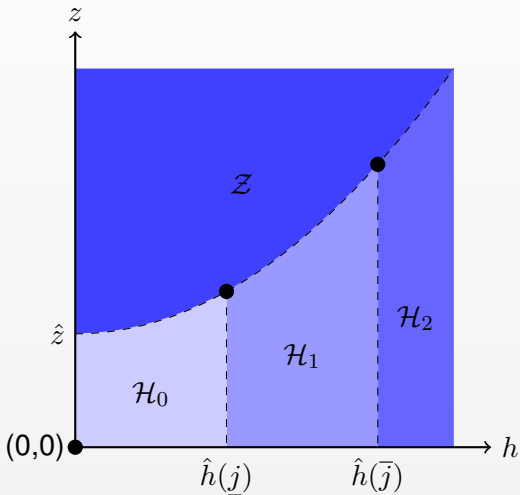
$$\tau_{i0} = M_0 k_{i0}^{\alpha} [\bar{h} \mu_i(h_0)]^{1-\alpha}$$
$$\tau_{i1} = M_1 k_{i1}^{\alpha} \left[\int_{h_1} h d\mu_i \right]^{1-\alpha}$$
$$\tau_{i2} = M_2 k_{i2}^{\alpha} \left[\int_{h_2} (h - \chi) d\mu_i \right]^{1-\alpha}$$

where M_j : task-specific TFP, h_j : set of workers hired

c.f. Discrete analog of general log-supermodular function $b(h, j)$ (in paper)

One Sector Equilibrium

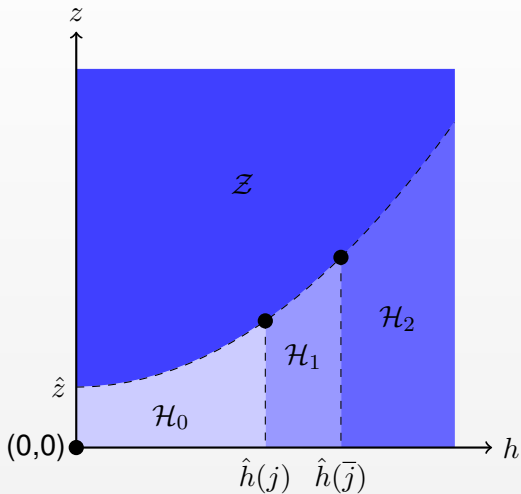
Comparative Advantage and Positive Sorting:
Equal to optimal assignment



Routinization and Job Polarization

Within-Sector: Relative Increase in M_1

Assume $\omega < \sigma < 1$:



Task-Specific Technologies: Sectors

- Production unit: a manager in sector i combines tasks τ_{ij} :

$$y_i(z) = \left[\eta_i^{\frac{1}{\omega}} x_{iz}^{\frac{\omega-1}{\omega}} + (1 - \eta_i)^{\frac{1}{\omega}} x_{ih}^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}$$
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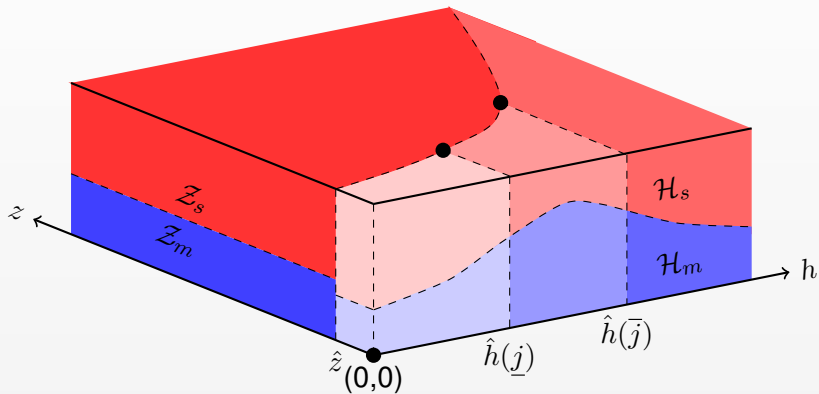
► Manu Shares

- Two types of sectoral output $i \in \{m, s\}$ (i.e., manufacturing and services) form final good:

$$Y = \left[\gamma_m^{\frac{1}{\epsilon}} Y_m^{\frac{\epsilon-1}{\epsilon}} + \gamma_s^{\frac{1}{\epsilon}} Y_s^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}.$$

where $\gamma_m + \gamma_s = 1$ and $\epsilon < 1$.

Two Sector Equilibrium



Two Sector Solution

- Sectoral productions can be written as

$$Y_i = \Phi_i K_i^\alpha L_i^{1-\alpha}$$

where Φ_i is endogenous TFP determined by (\hat{h}_j, \hat{z})

- So $L_s/L_m = (\gamma_s/\gamma_m) \cdot (\Phi_s/\Phi_m)^{\epsilon-1}$ also function of (\hat{h}_j, \hat{z})
- Aggregate employment share of task j :

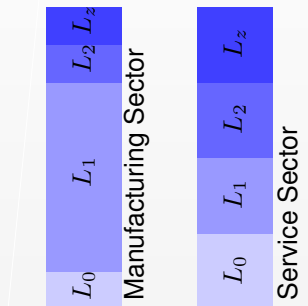
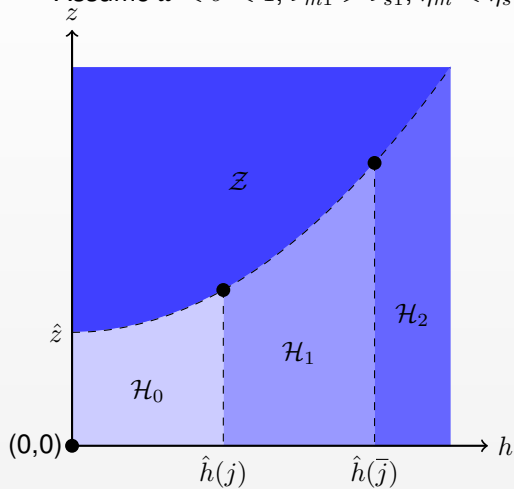
$$L_j = \sum_{i \in \{m, s\}} (L_{ij}/L_i) \cdot L_i$$

- L_j : aggregate labor supply
- L_{ij}/L_i : within-sector labor demand
- L_i : between-sector labor demand
- Equilibrium unique under well-behaved μ and small χ

Routinization and Polarization, Two Sectors

Two Sectors: Relative Increase in M_1

Assume $\omega < \sigma < 1$, $\nu_{m1} > \nu_{s1}$, $\eta_m < \eta_s$:

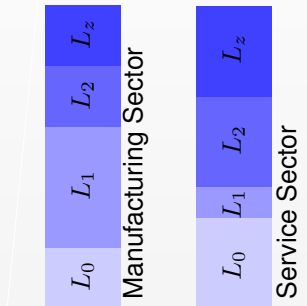
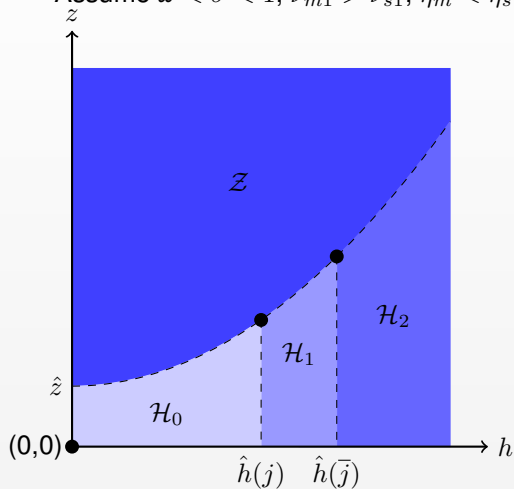


Manufacturing more (less) reliant on routine task (managers)

Routinization and Polarization, Two Sectors

Two Sectors: Relative Increase in M_1

Assume $\omega < \sigma < 1$, $\nu_{m1} > \nu_{s1}$, $\eta_m < \eta_s$:

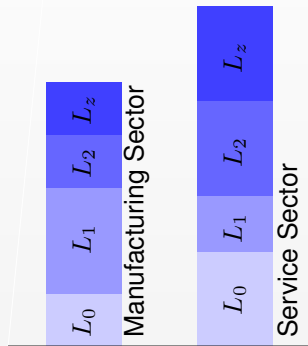
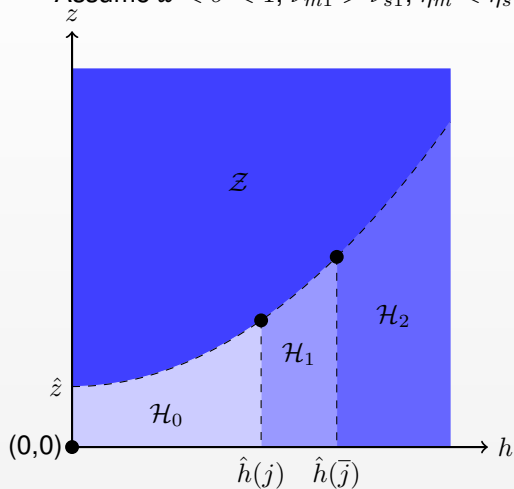


H. and V. Polarization faster in manufacturing,
ignoring sectoral reallocation (structural change)

Routinization and Structural Change

Two Sectors: Relative Increase in M_1

Assume $\omega < \sigma < 1$, $\nu_{m1} > \nu_{s1}$, $\eta_m < \eta_s$:



TFP growth higher in manufacturing
 SC toward services if $\epsilon < 1$

Quantitative Analysis

- Divide 1980 COC's into 1+1+7+2 occupations: broadly, management (11%), manual (10%), routine (59%), abstract (20%)
- Bivariate Pareto type IV distribution (γ_h, γ_z, a) fit to 1980 data on observed wage shares:

▶ graph

$$1 - \mu(z, h) = \left[1 + z^{1/\gamma_z} + h^{1/\gamma_h} \right]^{-a}$$

- Constant growth rates m_j for all 11 task productivities
- Feed k_t into model for each decade 1980-2010, target trends to calibrate parameters
- * **Robustness:** allow exogenous productivity growth (a_m, a_s) in manufacturing

Calibration Targets

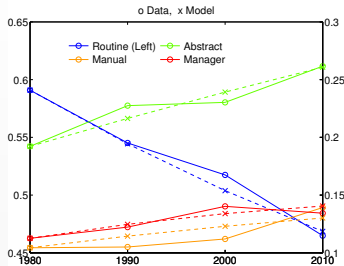
Ranked by mean wage (except management)	SOC Code	Employment Shares			
		1980	2010	Manufacturing	
Low Skill Services	400	10.44	13.92	0.59	0.23
Middle Skill		59.09	46.48	25.86	12.93
Administrative Support	300	16.57	14.13	3.47	1.53
Machine Operators	700	9.81	3.75	8.79	3.02
Transportation	800	8.73	6.64	3.80	2.28
Sales	240	7.87	9.37	0.79	0.62
Technicians	200	3.23	3.86	1.00	0.57
Mechanics & Construction	500	7.91	6.02	4.44	3.19
Miners & Precision Workers	600	4.97	2.71	3.58	1.73
High Skill		19.22	26.16	3.87	3.64
Professionals	40	11.02	16.51	1.73	1.45
Management Support	20	8.20	9.65	2.14	2.20
Management	1	11.26	13.44	2.47	2.59

Calibrated Parameters

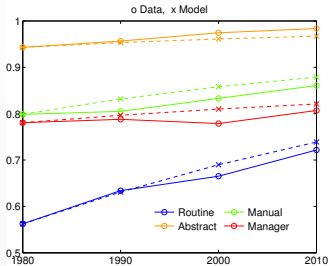
Estimated		
γ	0.371	Herrendorf, Rogerson and Valentinyi (2013)
ϵ	0.003	
α	0.361	
Fit to 1980		<i>(solved in closed form)</i>
$M_j \equiv M$	0.985	Output per worker, normalization
A_m	1.112	Manufacturing employment share
η_i (2), ν_{ij} (18)		Employment shares by task/sector
a, γ_h, χ_j (8)		Wage shares by task/sector ▶ Pareto
Fit to 2010		<i>(method of moments)</i>
σ	0.704	Output per worker growth, employment shares by task only within-sector
ω	0.341	
m_j (11)		
Fixed		
\bar{h}	1	Not separately identified from M_0
γ_z	1	Monotonic firm-size distribution

Model Fit: Employment Shares

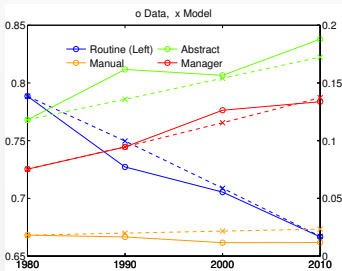
► Wage shares



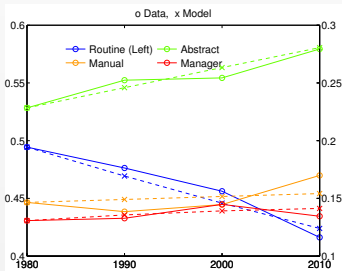
Aggregate



Service Share by Task

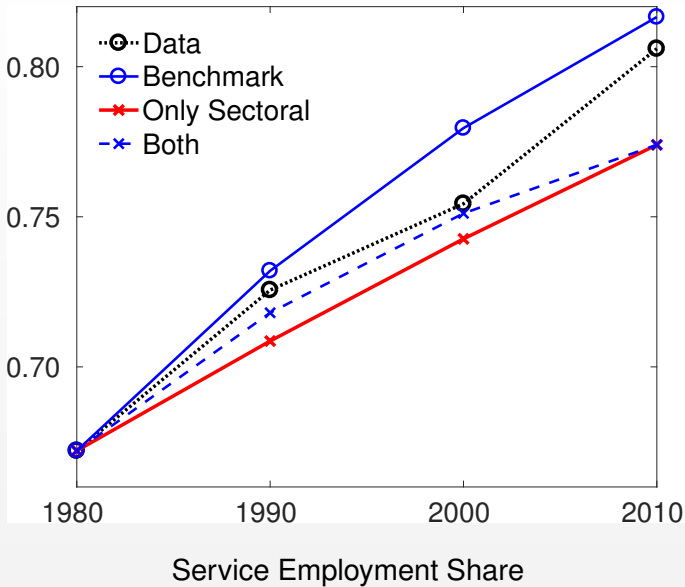


Manufacturing



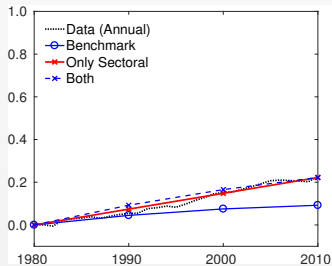
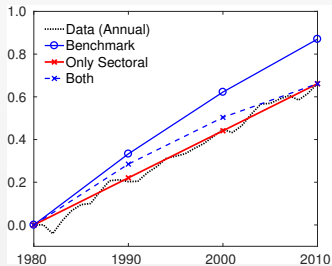
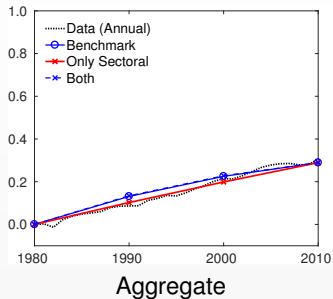
Services

Structural Change

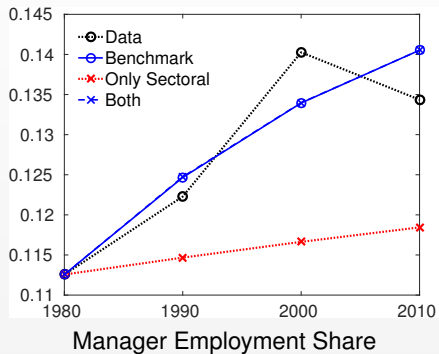
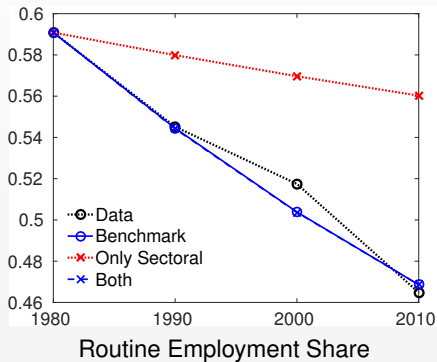


Log Measured TFP

▶ Historical



Polarization



Summary

1. Task-specific TC growth can explain
 - almost all of employment shifts at the task-level
 - observed changes in sectoral TFP's
 - almost all of structural change
2. Results robust to including sector-specific TC, which does not cause any within-sector polarization

More Implications

- More managers in manufacturing, employment decline but output increase by establishment ▶ Emp/estab ▶ VA/estab
- But total managers have increased, while average establishment sizes have not shrunk
 - ⇒ Rise of mid-level managers, which in our model comes from individuals with lower z 's ▶ within mgr shares
 - ⇒ Larger rise in inequality among managers, also in the data ▶ wage inequality

Policy Implication

A Hypothetical Intervention

“Dislocation” blamed on trade

- Polarization within services
- Subsidizing manufacturing when ϵ is nearly 0

Policy Implication

A Hypothetical Intervention

“Dislocation” blamed on trade

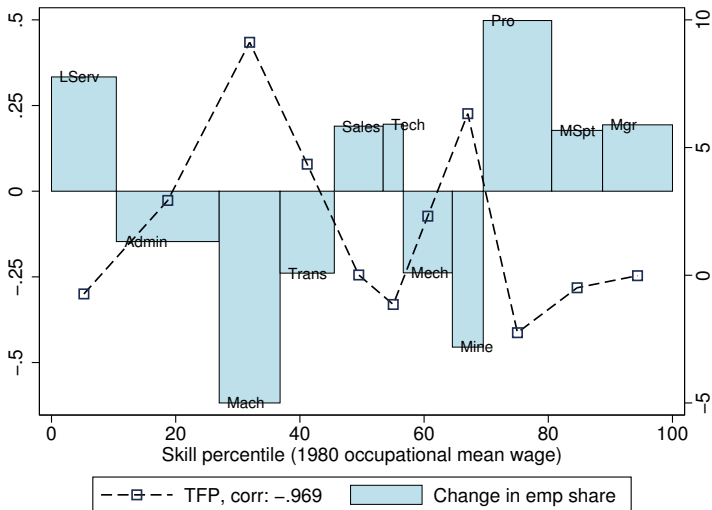
- Polarization within services
- Subsidizing manufacturing when ϵ is nearly 0
- Manufacturing polarized faster:
1 p.p. increase in manufacturing employment share \Rightarrow
0.25 p.p. increase in middle-skill/routine job share

What is driving TSTC?

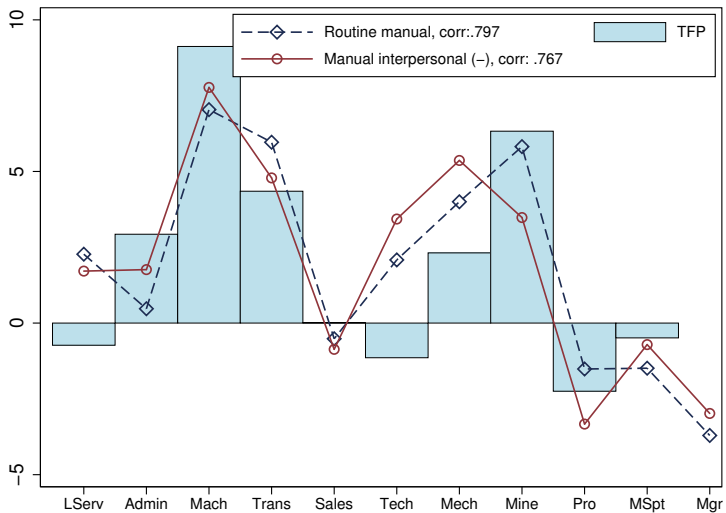
Correlate/regress college shares and empirical measures of COC task content with our calibrated task productivities

1. Disaggregated O*NET measures: [routine-manual](#) and [manual-interpersonal](#) explain more than 3/4
 2. Managers are distinct: highest in all cognitive/interpersonal measures and lowest in routine/physical measures
 3. Aggregate RTI indices lose explanatory power
 4. College measures explain little ([Acemoglu and Autor, 2011](#); [Autor and Dorn, 2013](#))
- * Offshoring indices explain little ([Goos, Manning and Salomons, 2014](#))

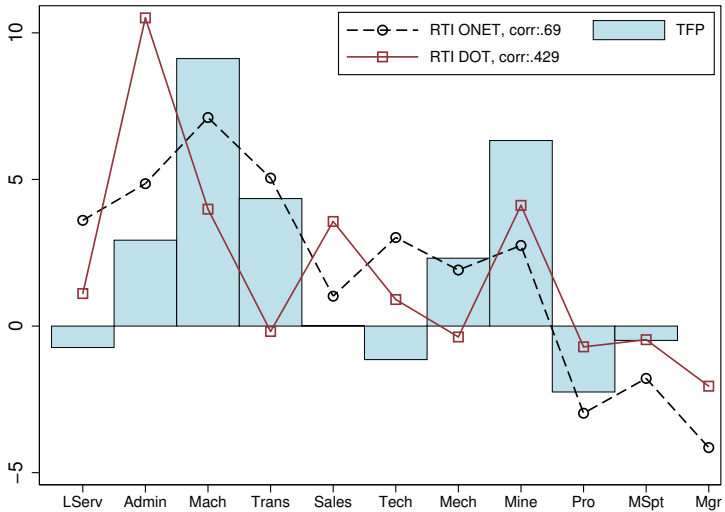
Polarization and TSTC



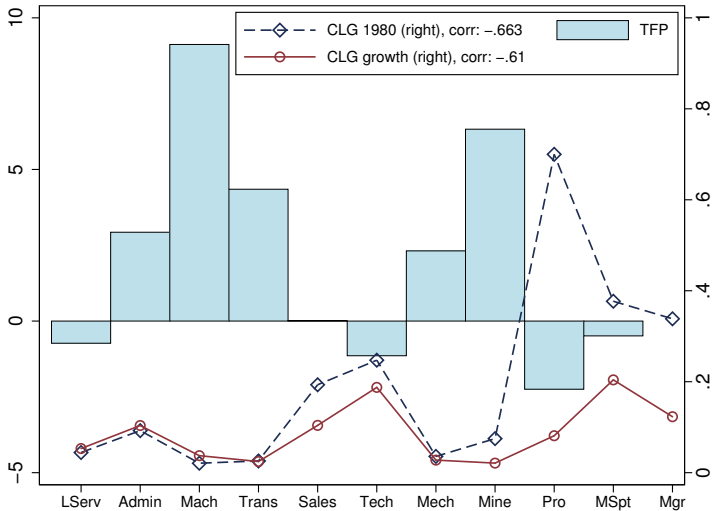
O*NET and TSTC



RTI and TSTC



College and TSTC



Conclusion

- A tractable task-based macro model of horizontal/vertical polarization, structural change and growth
- Polarization leads to structural change, which further reinforces polarization
- TSTC accounts for almost all of polarization and structural change
- TSTC strongly correlates with routine-manual and (negatively with) interpersonal jobs

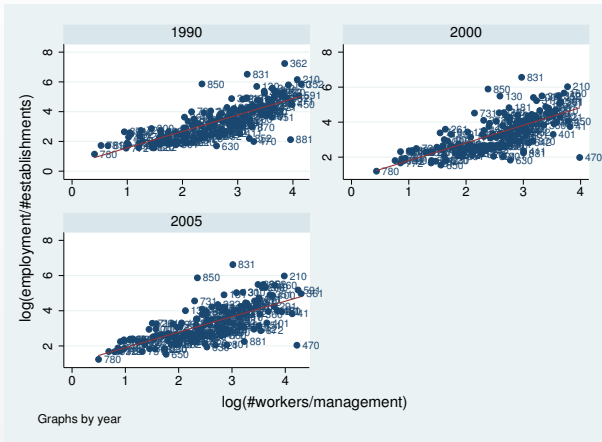
Long-Run Agenda

- Trade and off-shoring among heterogeneous countries
- Endogenous skill distribution dynamics over time
- Differentiated managerial occupations; firm-side inequality (between-firm and within-firm inequality)
- Heterogeneous capital-skill complementarity across jobs

Establishment Size and Span of Control

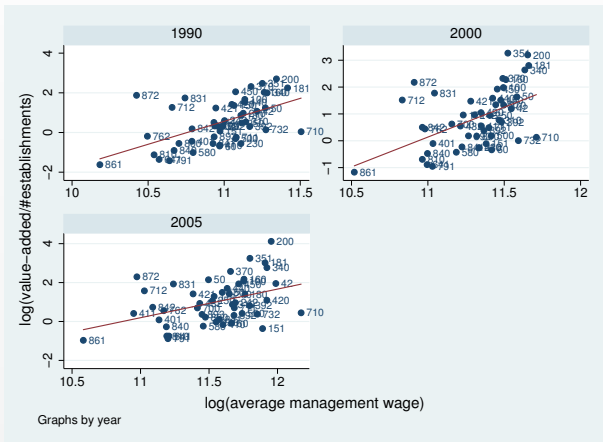
[▶ back to data](#)

[▶ back to model](#)



x-axis: Census, *y*-axis: SUSB, 170 industries.

Establishment Output and Manager Compensation

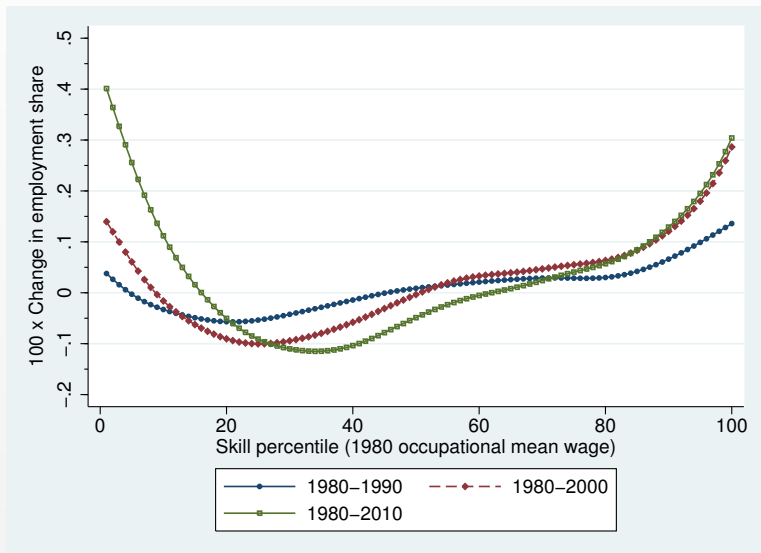


x-axis: Census, *y*-axis: BEA, 48 industries.

Employment Polarization

1980-2010, replicated following [Autor and Dorn \(2013\)](#)

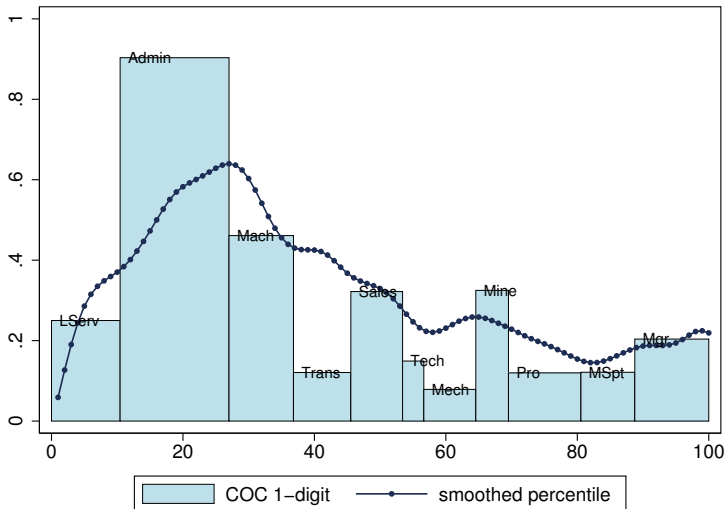
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Routinization Hypothesis

Extends [Autor and Dorn \(2013\)](#)

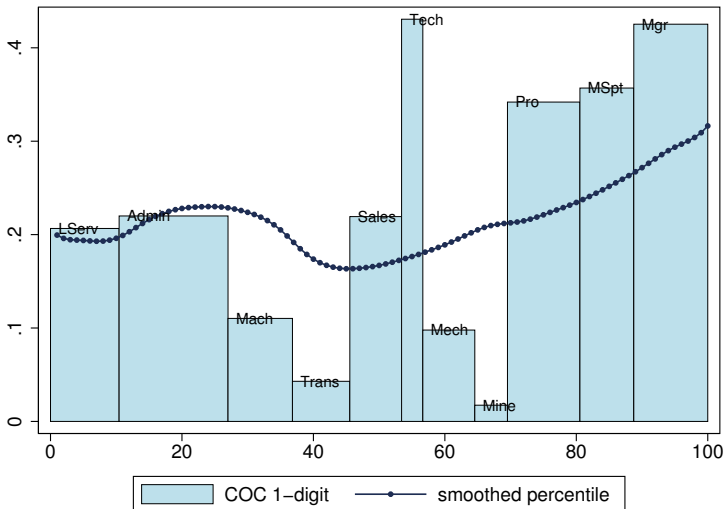
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Wage Polarization

1980-2010, replicated following [Autor and Dorn \(2013\)](#)

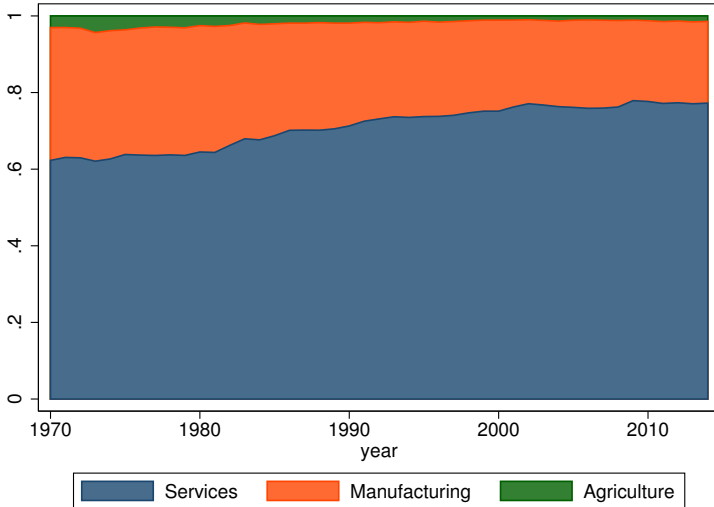
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Structural Change: GDP (Nominal)

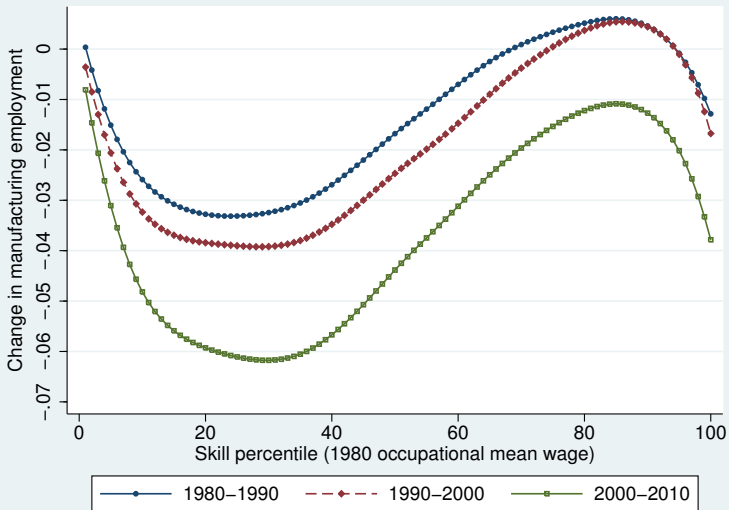
BEA NIPA Accounts

▶ Employment



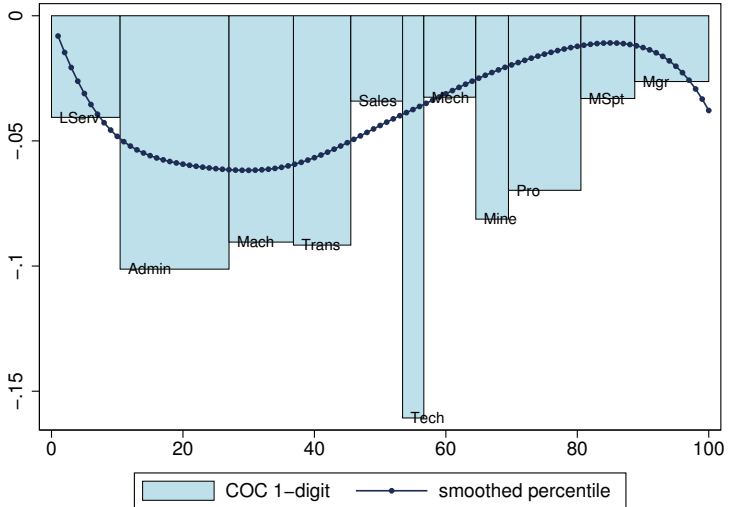
Change in Manufacturing Employment

▶ back



Change in Manufacturing Employment

▶ back

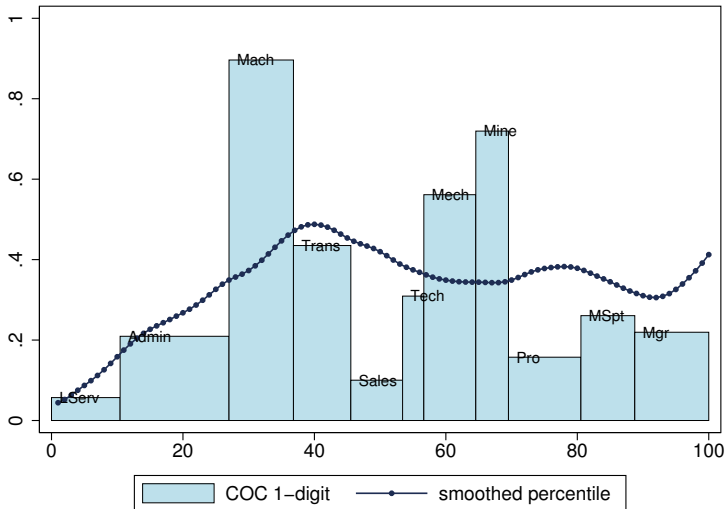


Manufacturing Employment Shares

$$\eta_m < \eta_s, \quad \nu_{m1} > \nu_{s1}$$

▶ data

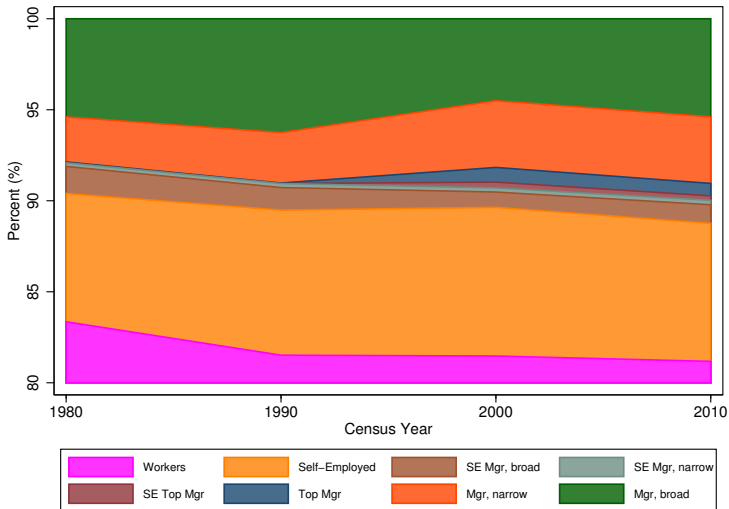
▶ model



Manager COC and Self-employment

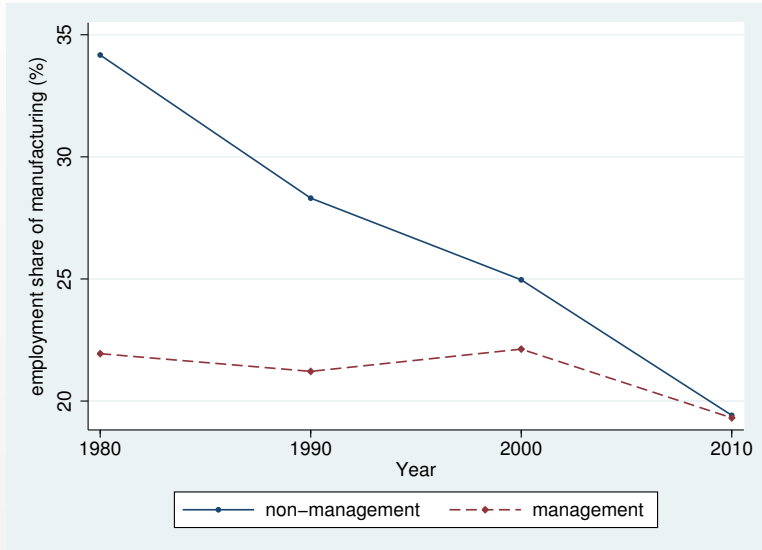
▶ back1

▶ back2



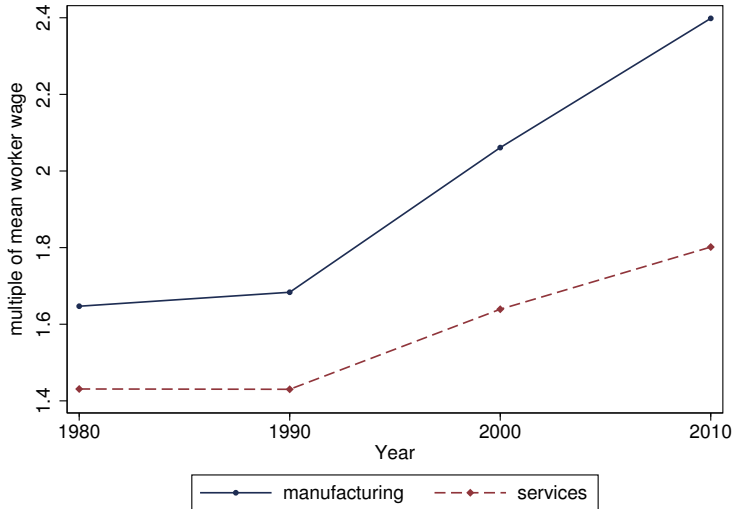
Sectoral Employment Shares by Occupation

▶ back



Manager Wages by Sector

▶ back



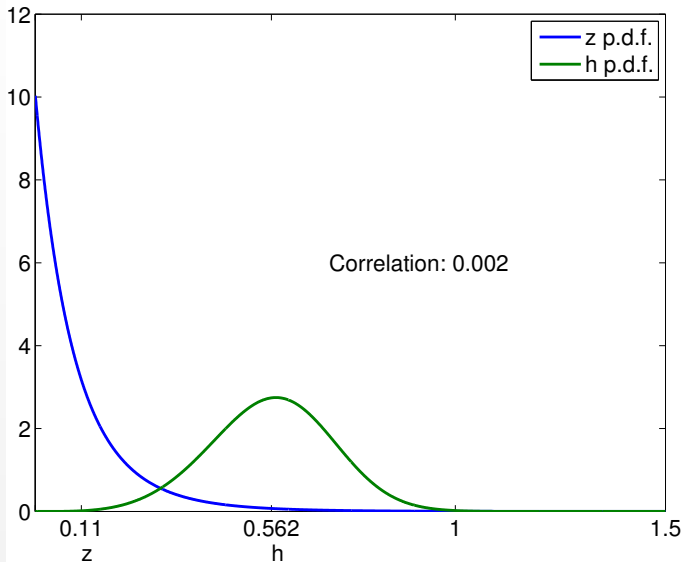
Sectoral Wage Ratios by Occupation

▶ back



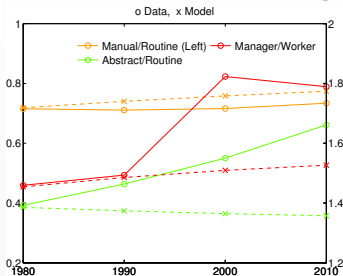
Bivariate Pareto Skill Distribution

▶ back

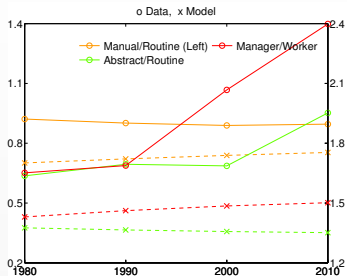


Model Fit: Total Wage Shares

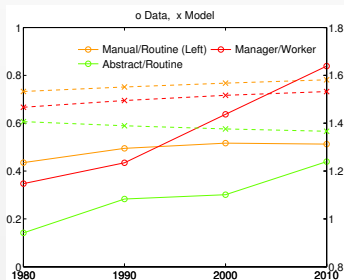
Emp. shares



Aggregate Shares



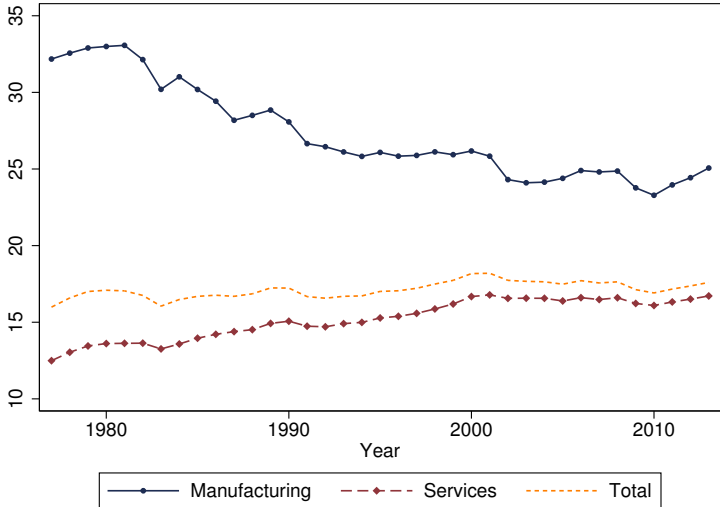
Manufacturing



Services

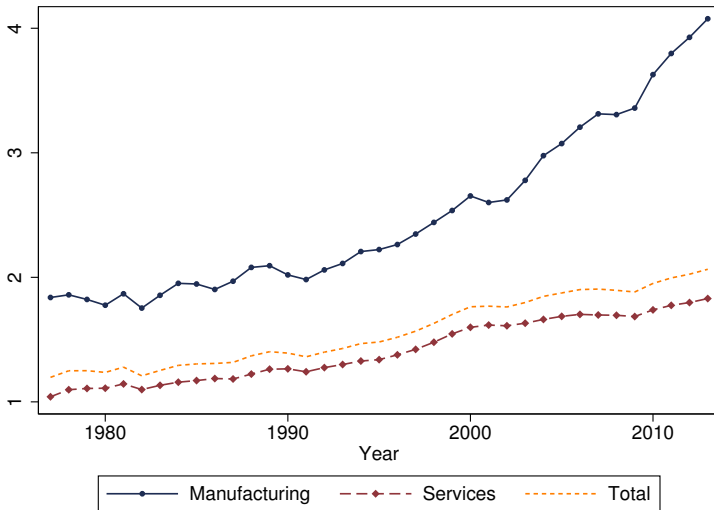
Employment by Establishment

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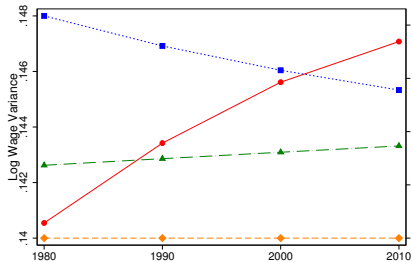
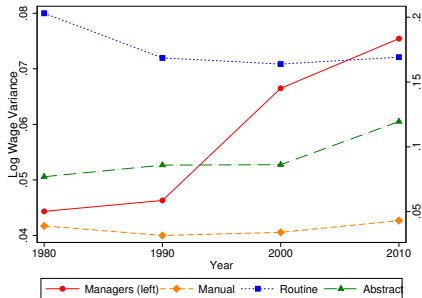
VA Output by Establishment

▶ back



Wage Inequality

▶ back



Acemoglu, Daron and David Autor, “Skills, Tasks and Technologies: Implications for Employment and Earnings,” in David Card and Orley Ashenfelter, eds., *Handbook of Labor Economics*, Vol. 4, Part B, Elsevier, 2011, pp. 1043 – 1171.

Autor, David H. and David Dorn, “The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market,” *American Economic Review*, 2013, 103 (5), 1553–97.

Gabaix, Xavier and Augustin Landier, “Why Has CEO Pay Increased So Much?,” *Quarterly Journal of Economics*, 2008, pp. 49–100.

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