Interindustry Wage Differentials, Technology Adoption, and Job Polarization

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Job Polarization

- Three occupation groups: cognitive occupations, routine occupations, and manual occupations
- Job polarization: employment share of non-routine occupations increased while employment share of routine occupations declined since 1980

▸ More on Job Polarization

Job Polarization: Employment

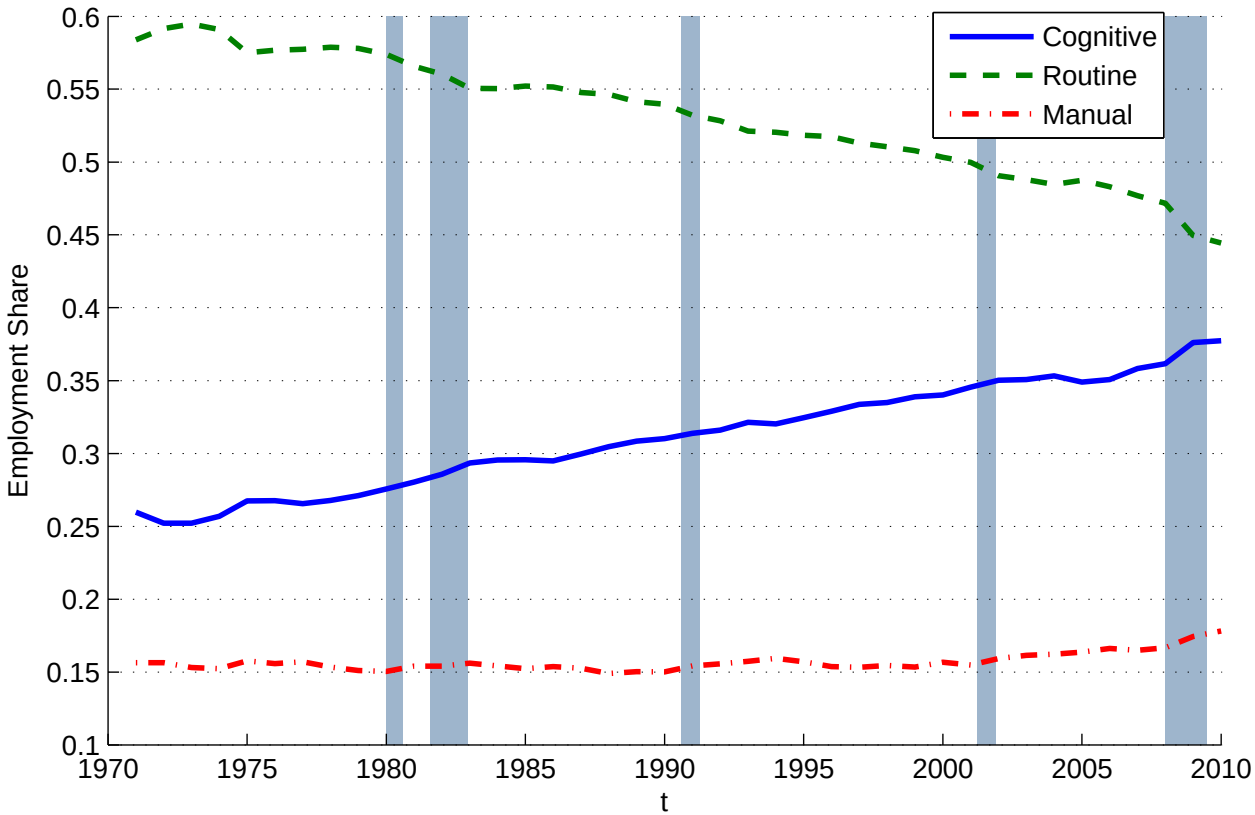


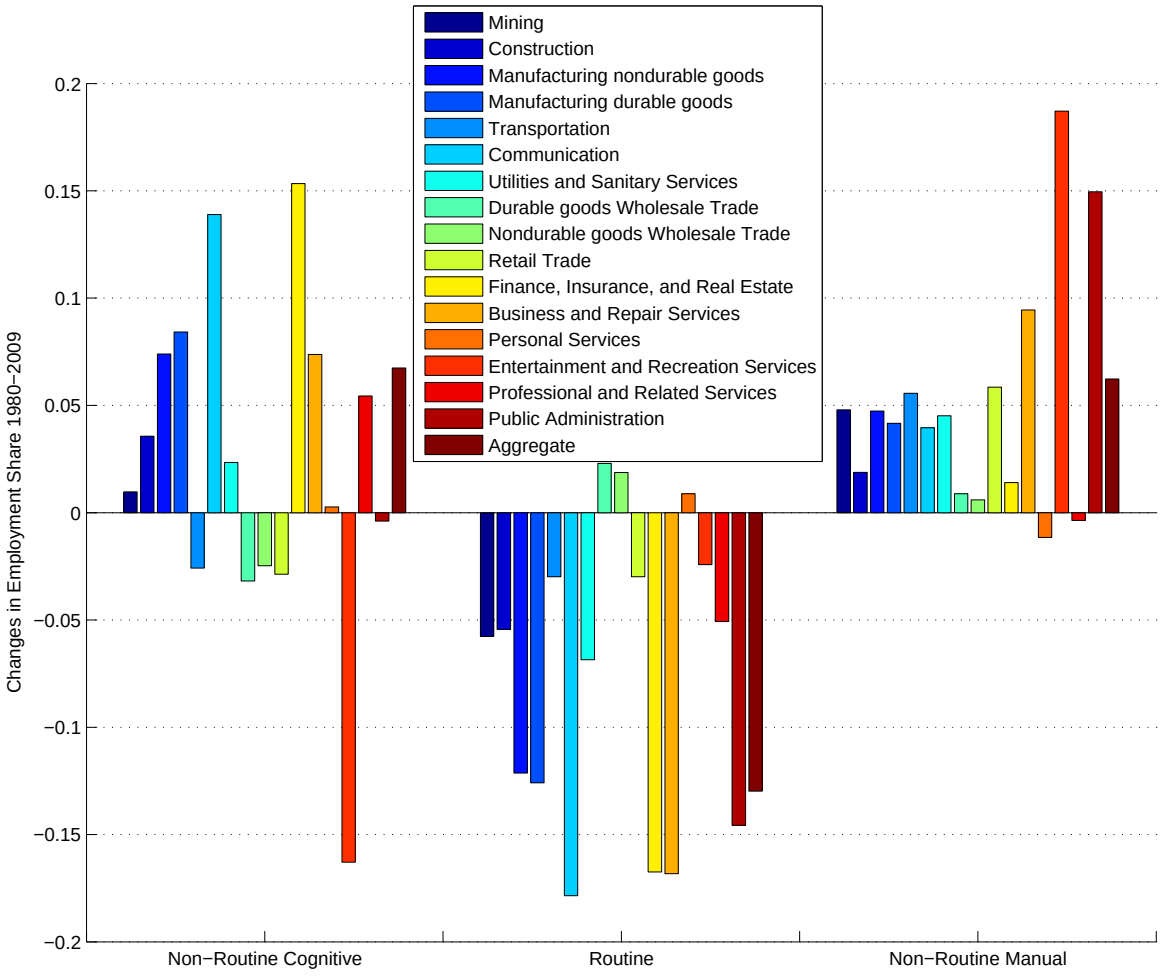
Figure: Job Polarization

Source: The March CPS.

▸ Wage Polarization

Job Polarization at Industry Level

- Progress of job polarization is heterogenous across industries

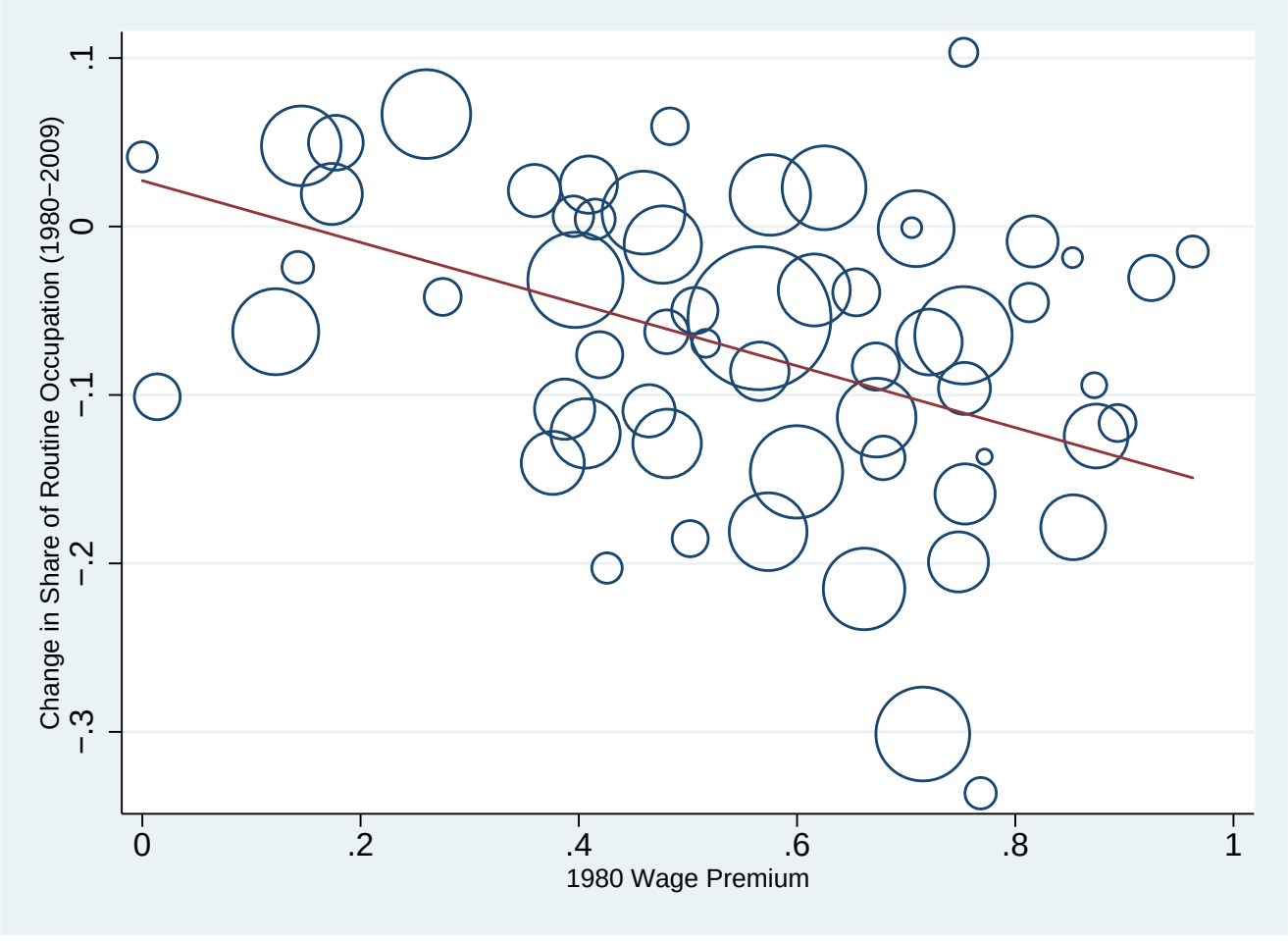


Any Systematic Patterns?

- Previous explanations
  - Heterogenous production functions across industries (Autor, Levy, and Murnane (2003), Goos, Manning, and Salomons (2014))
  - Unspecified (Michaels, Natraj, and van Reenen (2014))
- New finding in this paper: interindustry wage differentials are closely related to job polarization
  - Interindustry wage differentials
    - Observationally equivalent workers but employed in different industries earn differently

▸ Persistency ▸ More about Causes

Job Polarization and Interindustry Wage Differentials: They Are Related!



Behind the Scenes

- We first examine several hypotheses, none of which are supported by data

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- We first examine several hypotheses, none of which are supported by data
- Two sources of interindustry wage differentials
  1. Worker heterogeneity
  2. Exogenous factors
     eg. labor union, compensating differentials
- Worker heterogeneity alone cannot explain patterns in data but exogenous factor(s) can

Main Idea

- Firms paying relatively higher wages than others by exogenous reasons
  $\Rightarrow$ Greater incentives to replace workers with other production factors over time (Borjas and Ramey (2000))

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- Firms paying relatively higher wages than others by exogenous reasons
  $\Rightarrow$ Greater incentives to replace workers with other production factors over time (Borjas and Ramey (2000))
- Employment adjustments of firms may affect workers disproportionately
  - Routine workers are easiest to be replaced by Information, Communication, and Technology (ICT) capital (Autor, Levy, and Murnane (2003))

Main Idea

- Price of ICT capital has declined over time $\Rightarrow$ Provides opportunity to replace routine workers

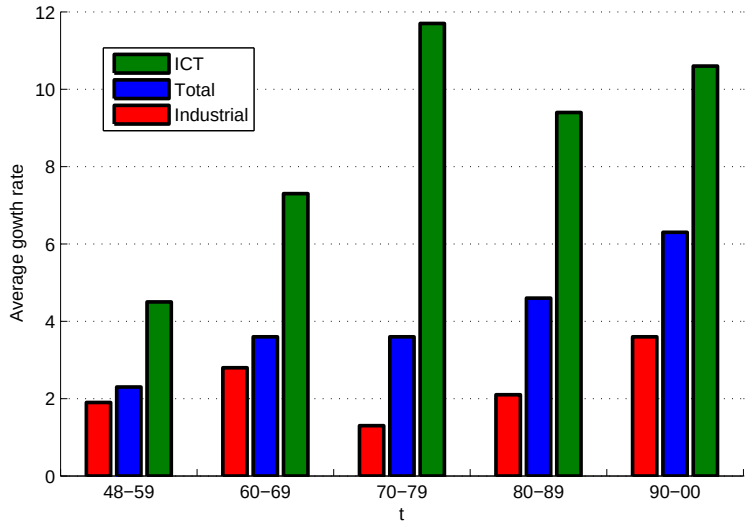


Figure: Growth Rate of Investment-Specific Technological Changes

Source: Data from Cummins and Violante (2002).

Main Idea

- Price of ICT capital has declined over time $\Rightarrow$ Provides opportunity to replace routine workers

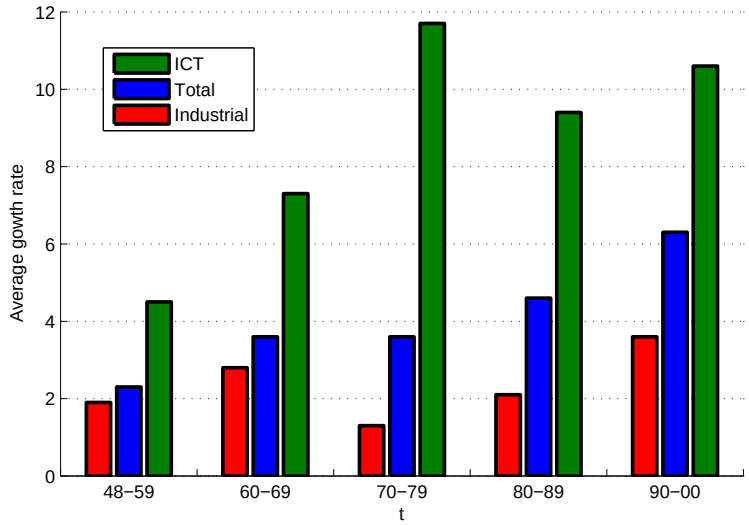


Figure: Growth Rate of Investment-Specific Technological Changes

Source: Data from Cummins and Violante (2002).

- High-wage industry had more incentives to replace routine workers
  $\Rightarrow$ Job polarization was more evident in high-wage industry.

Contributions

- First paper to connect job polarization and interindustry wage differentials both theoretically and empirically
  - Between 1980 and 2009,
    - Progress of job polarization was more evident in high-wage industry
    - ICT capital per worker grew more in high-wage industry
- Results highlights importance of considering exogenous factors to explain interindustry wage differentials
- Additional evidence to literature on firms' optimal responses to the labor market structure

Related Literature: Job Polarization

- Aggregate Level Analysis
  Acemoglu and Autor (2011), Autor, Katz, and Kerney (2006), Beaudry, Green, and Sand (2013), Cortes (2012), Goos, Manning, and Salomons (2009), Jaimovich and Siu (2014), Foote and Ryan (2014),
- Industry Level Analysis
  Autor, Levy, and Murnane (2003), Goos, Manning, and Salomons (2014), Michaels, Natraj, and Reenen (2014), Oldenski (2012)
- Local Market Level Analysis
  Autor and Dorn (2013), Autor, Dorn, and Hanson (2013a, 2013b)

Related Literature: Causes of Interindustry Wage Differentials

- Competitive models of labor market
  - Unobserved heterogeneity: Murphy and Topel (1987), Blackburn and Neumark (1992)
  - Option value theory: Neumuller (2014)
- Non-competitive models of labor market
  - Rent-sharing model: Nickell and Wadhwani (1990), Borjas and Ramey (2000) and Montgomery (1991)
  - Efficiency wage model: Walsh (1999) and Alexopoulos (2006)

▸ Intro ▸ Model

Related Literature: Responses to Labor Market

- Consequences of interindustry wage differentials: Borjas and Ramey (2000)
- Firm responses to market structure: Alder, Lagakos and Ohanian (2013), Acemoglu and Shimer (2000), Caballero and Hammour (1998)

▸ Model

Agenda

- Empirical Analysis
  – Discuss possible hypotheses
- Theoretical Considerations
- Conclusion

Empirical Analysis

Data

- Two data sets are used:
  - Census
  - EU KLEMS

Census

- We use decennial Census data (1960, 1970, 1980, 1990, 2000) & 2007, 2009 American Community Survey (ACS) from IPUMS
  - drop farmers (and related industries) and armed forces
  - age: 16-64
  - Restricted to persons employed in wage-and-salary sector
- Consider 60 industries including
  - Metal Mining, Construction
  - Manufacturing (non-durable and durable goods): Furniture, Metal, Food, Tobacco, etc.
  - Retail trade, Finance, Personal services

EU KLEMS

- Contains data on value added, labor, various types of capital for various industries in many developed countries
- Period: 1980-2007
- Consider 29 industries
- Only use data for the U.S
  - Match Census industry codes to North American Industry Classification System (NAICS) which is used by EU KLEMS eg. Real estate activities and Renting of machine & equipments in NAICS, but they are grouped as Real estate, including real estate-insurance offices in Census

Industry Wage Premium

- First stage: estimating wage equation

$$\log w_{hit} = X_{hit}\theta_t + \omega_{it} + \varepsilon_{hit} \tag{1}$$

where h: worker, i: industry, t: time

  - Control for socioeconomic characteristics (X_{hit})
    - age, educational attainment, race, gender, region of residence, occupations
  - We estimate wage equation separately in each Census year

    ▸ Estimates from wage equation ▸ Persistency
  - ω_{it}: Industry wage premium

Estimating Firm's Response to Industry Wage Premium

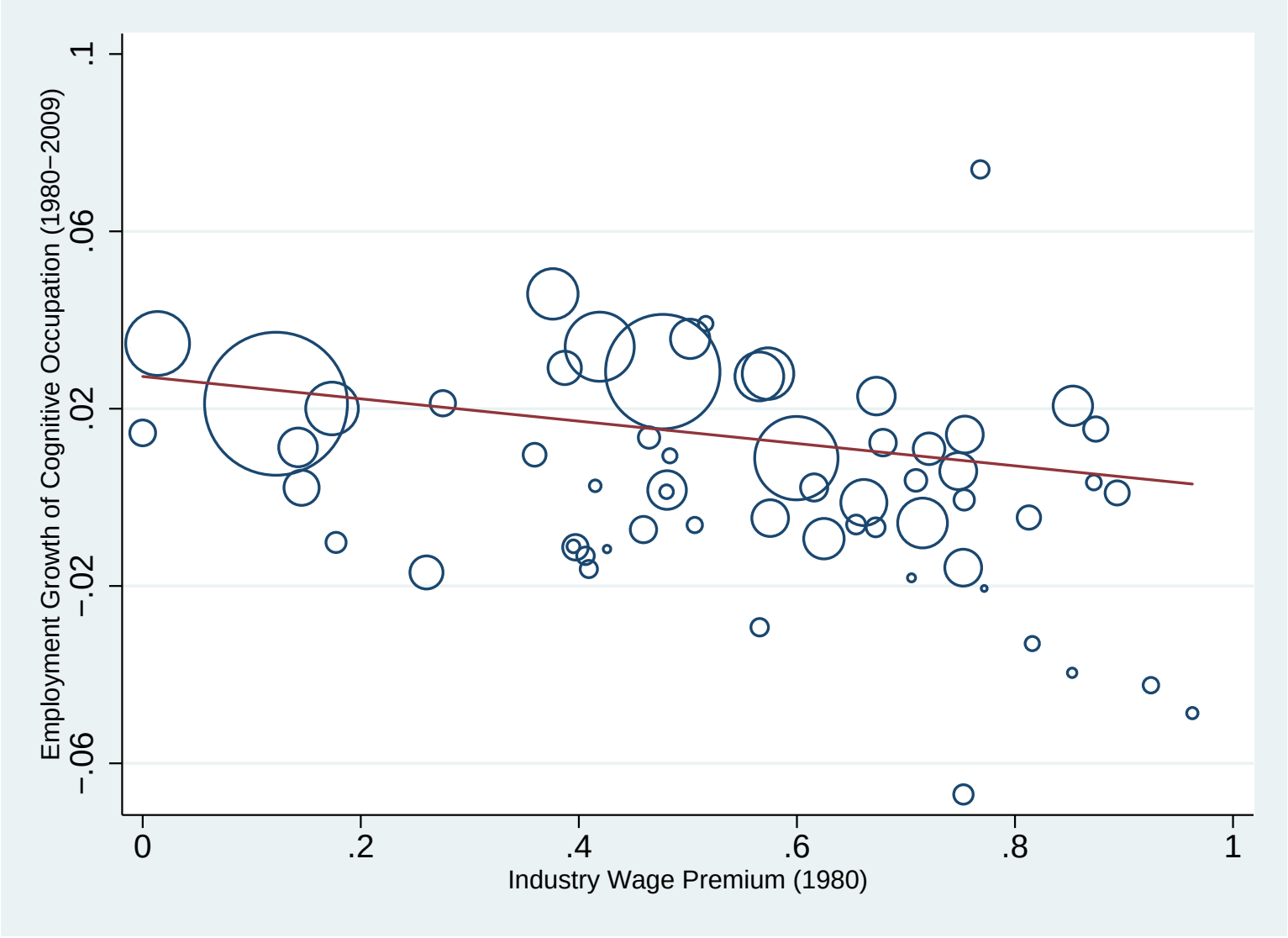
- Second Stage: estimating main regression

$$\Delta y_{ijt,t+k} = \theta_j \hat{\omega}_{it} + \eta_{ijt} \tag{2}$$

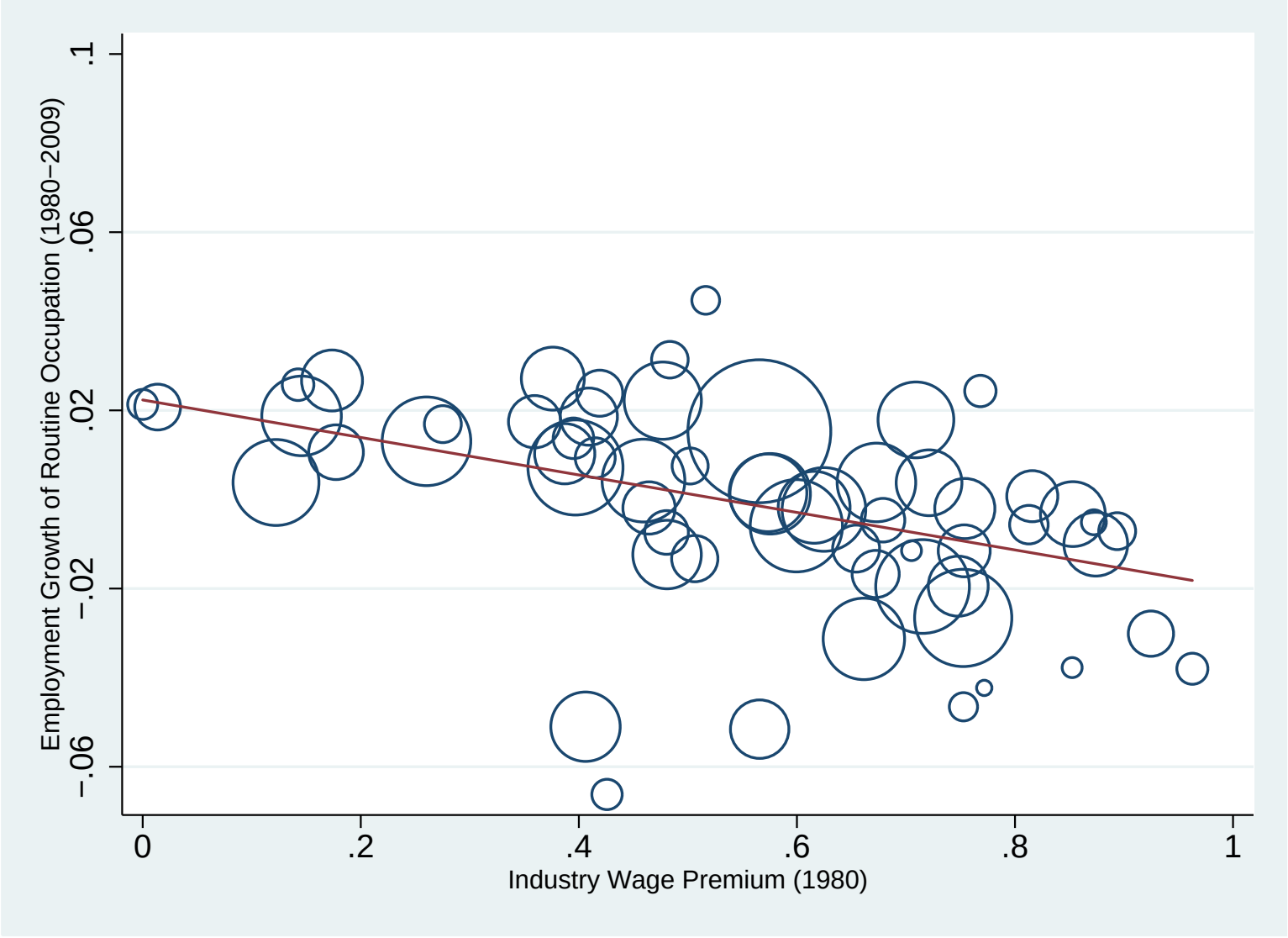
where $j \in \{Cognitive, Routine, Manual\}$: occupation, and $\Delta y_{ijt,t+k}$: average growth rate of variable y between t and $t+k$

  - $\hat{\omega}_{it}$: estimated coefficient for industry dummies
  - Generated regressor problem
    - regressions are weighted by each industry's initial employment
  - IV: Previous decade's estimated industry wage premium $\Rightarrow$ Results are almost identical to OLS

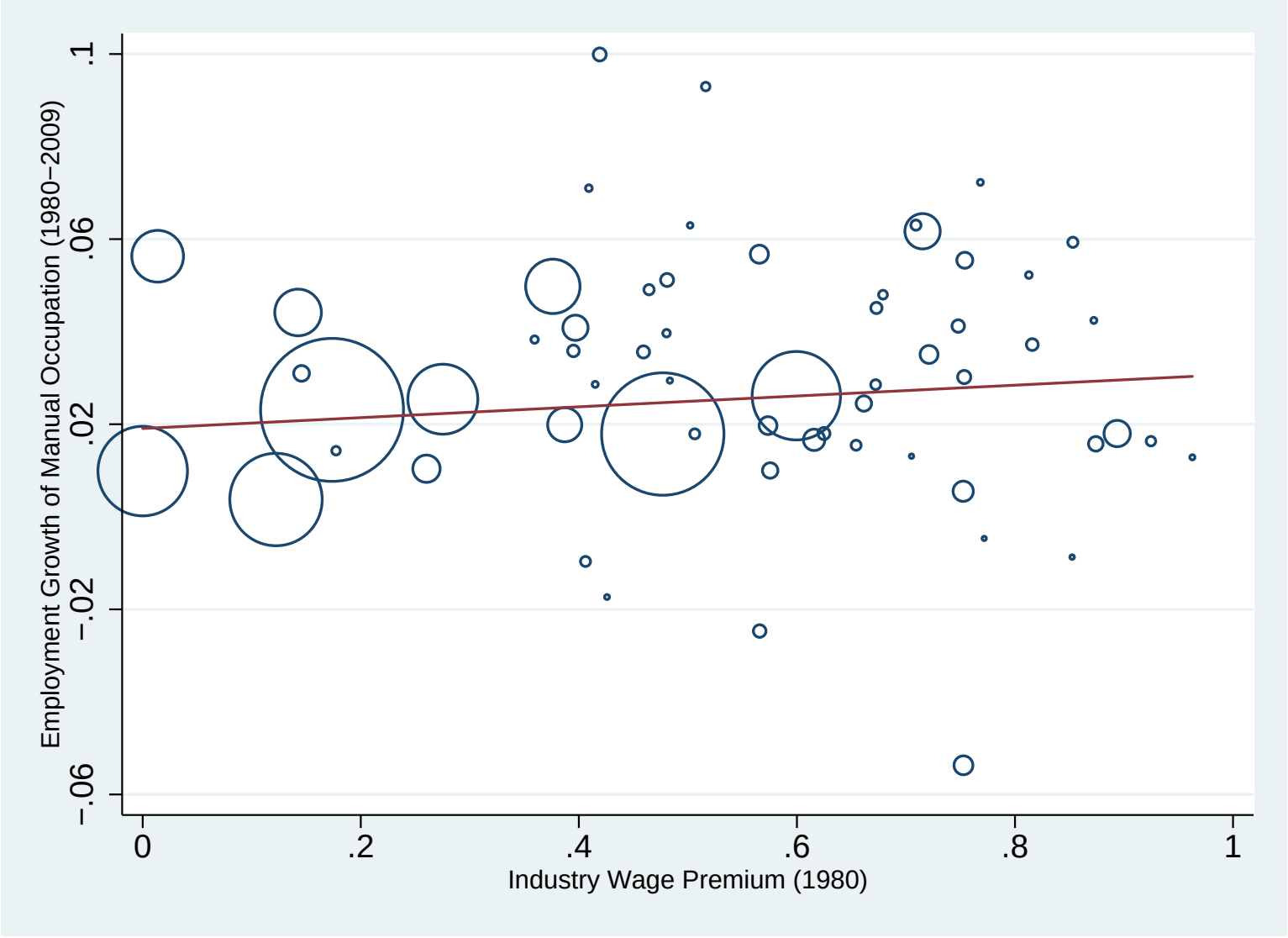
Cognitive Occupation



Routine Occupations



Manual Occupations



Regression Results

Table: OLS Estimates of Employment Growth by Occupation Groups (1980-2009)

Occupation Groups	Coefficient	R-squared
Total	$-0.0381^{***}(0.0073)$	0.24
Cognitive Occupations	$-0.0252^{***}(0.0071)$	0.14
Routine Occupations	$-0.0421^{***}(0.0090)$	0.21
Manual Occupations	$0.0117(0.0137)$	0.03

▸ IV Estimates ▸ 1960 Estimates ▸ 1980-2007 Estimates ▸ Full-time only ▸ Changes in Share

Interindustry Wage Differentials and Job Polarization

- **Finding**: Job polarization is more evident in high-wage industries
  : $\theta_r < \theta_c, \theta_m$

Robustness: Controls with Industry-Specific Variables

- Robust to controlling for various industry-specific variables

Table: OLS Estimates of Employment Growth by Occupation Groups (1980-2009)

	Cognitive	Routine	Manual
Industry wage premium	-0.0010	-0.0339^{**}	0.0068
Routine share	-0.0393^{***}	-0.0085	0.0269^{*}
Union membership (1983)	-0.0418^{***}	-0.0192	-0.0564^{***}
Capital per worker	0.0000^{**}	0.0000^{**}	0.0000
ICT capital per worker	0.0005^{***}	0.0003^{**}	0.0011^{**}
R^2	0.52	0.26	0.29

Interindustry Wage Differentials and ICT Capital-Labor Ratio

- EU KLEMS data (1980-2007) are used to estimate following equation

$$\Delta y_{it,t+k} = \theta \hat{\omega}_{it} + \eta_{it} \tag{3}$$

ICT Capital per Worker

Regression Results

Table: OLS Regressions on Initial Wage Premium

Dependent	Coefficient	R-squared
Capital/Worker	$0.0145 (0.0134)$	0.05
ICT Capital/Worker	$0.0350^{*} (0.0190)$	0.09
non-ICT Capital/Worker	$0.0037 (0.0136)$	0.00
Capital	$-0.0201^{*} (0.0110)$	0.10
ICT Capital	$0.0004 (0.0217)$	0.00
non-ICT Capital	$-0.0308^{***} (0.0107)$	0.25
Output	$-0.0055 (0.0089)$	0.01
Labor Productivity	$0.0290^{***} (0.0089)$	0.22
Employment	$-0.0345^{***} (0.0076)$	0.27

▸ IV Estimates

Interindustry Wage Differentials and ICT Capital-Labor Ratio

- **Finding**: ICT capital per worker grows more in high-wage industries
  $\theta_{ICT} > \theta_{Aggregate} > \theta_{non-ICT}$
- ICT capital vs. non-ICT capital
  – non-ICT capital: General purpose capital
  – ICT capital: can substitute certain types of workers

Possible Hypotheses

- Three possible hypotheses to explain our finding
  1. Price effect: routine workers were paid highest
  2. Level effect: heterogeneity in relative importance of routine workers
  3. Wage premium as outcome of high capital/labor ratio

Possible Hypotheses

- Three possible hypotheses to explain our finding
  1. Price effect: routine workers were paid highest
  2. Level effect: heterogeneity in relative importance of routine workers
  3. Wage premium as outcome of high capital/labor ratio
- Data do not support none of above

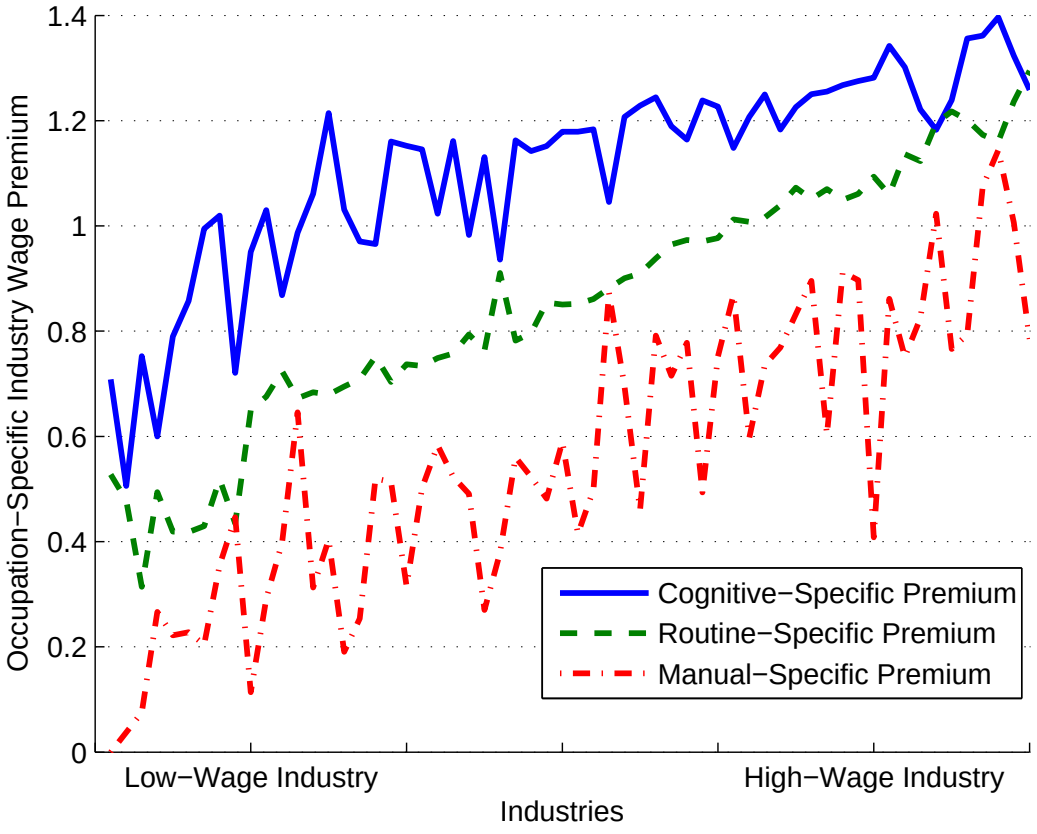
1. Price Effect: Were Routine Workers Paid Highest?

- If routine workers were paid the highest wages, it would be optimal for firms to decrease demand for routine workers relative to other workers
- We estimate following alternative wage equation:

$$\log w_{hit} = X_{hit}\beta_t + \underbrace{\omega_{it} \times \psi_{jt}}_{=\omega_{ijt}} + \varepsilon_{hit} \tag{4}$$

ω_{ijt} denotes 'occupation-specific industry wage premium'

Occupation-Specific Industry Wage Premium



- Cognitive workers earn more than routine workers in every industry

2. Level Effect: Relative Importance of Routine Workers

- In 1980, *corr*(employment share of routine workers, industry wage premium)> 0
  eg. Manufacturing industries
- Job polarization might be more evident in high-wage industry because these industries used routine workers more intensively in 1980 (level effect)
- Indirect test of hypothesis based on heterogenous production functions across industries

2. Relative Importance of Routine Workers

- Regress with employment share of routine workers in 1980

Table: OLS Estimates of Employment Growth by Occupation Groups (1980-2009)

Occupation Groups	Coefficient	R-squared
Total	$-0.0353^{***}(0.0075)$	0.30
Cognitive Occupations	$-0.0362^{***}(0.0071)$	0.33
Routine Occupations	$-0.0238^{**}(0.0116)$	0.07
Manual Occupations	$0.0236^{**}(0.0103)$	0.09

- Job polarization is not evident in routine-intensive industries in 1980

3. Wage Premium as Outcome of High Capital/Labor Ratio

- Higher $k/n \uparrow \Rightarrow w \uparrow$
  - Capital-intensive industries might pay higher wages in 1980 because labor productivity was high
  $\Rightarrow$ As price of capital declines capital-intensive industry can adopt more capital
  $\Rightarrow$ More workers are replaced by capital in capital-intensive industries in 1980

3. Wage Premium as Outcome of High Capital/Labor Ratio

- 1. This story is at odds with data:
  - Capital-labor ratio increased more in high-wage industries
  $\Rightarrow$ Industry wage dispersion should have increased by this hypothesis but slightly decreased in data (Borjas and Ramey (2000))

3. Wage Premium as Outcome of High Capital/Labor Ratio

- 2. Regress with ICT capital per worker in 1980

Table: OLS Estimates of Employment Growth by Occupation Groups (1980-2009)

Occupation Groups	Coefficient	R-squared
Total	$-0.0000537(0.0000793)$	0.00
Cognitive Occupations	$0.0000821(0.0000693)$	0.00
Routine Occupations	$-0.0000846(0.0000976)$	0.00
Manual Occupations	$0.0015398^{*}(0.0008162)$	0.03

Theoretical Consideration

Preliminaries

- Reveals mechanism why optimal responses to declining relative price of capital are different across industries
- Two sources of interindustry wage differentials
  – Worker heterogeneity $\Rightarrow$ Prediction is opposite to data
  – Exogenous factors $\Rightarrow$ Prediction is consistent with data
  $\Rightarrow$ Importance of exogenous factors

▸ Literature on Differentials

Model 1: Worker Heterogeneity Only

- We consider firm's problem (partial equilibrium) without capital at first
- Heterogenous workers are supplied in competitive labor market
  - x_i: productivity of worker i. Assume x_i is decreasing in i:

$$x_i > x_{i'} \quad \text{for} \quad i < i' \tag{5}$$

- Firms produce identical goods
  - A firm hires only one worker
  $\Rightarrow$ (Original) Production function: $y = x_i$ where x_i is productivity of worker
  - Under assumption of perfectly competitive market, $w = x_i$
- In initial equilibrium, each firm hires one worker at different wage rate (industry wage premium)

Simple Model of Productivity Difference

- Now capital is introduced
  - x_k: productivity of capital
  - Capital is supplied in international capital market at unit price p
  - Firm can buy $k \geq 0$ units of capital
  - Capital and worker are perfect substitutes

$$y = x_h + x_k k \tag{6}$$

Simple Model of Productivity Difference

- Firm solves cost minimization problem

$$\min TC = w + pk \text{ subject to } y = x_h + x_k k \tag{7}$$

- Firm chooses to use labor (resp. capital) in production if $x_k / p < 1$ (resp. $x_k / p > 1$)

Prediction: Model with Worker Heterogeneity Only

Proposition (Job Polarization when Workers are Heterogeneous)

Suppose that $x_k / p < 1$*; hence, no firm used capital. As* p *decreases, the adoption of new technology to use capital occurs at the same time in every firm. In other words, the occurrence of job polarization, that is, the replacement of workers with capital (other production factors), is not apparent in the high-wage firms.*

Model 2: Exogenous Factors Only

- Firm's problem: general equilibrium model provides same predictions
- Three key features
  - Declining relative price of capital: exogenously given (Investment specific technology changes in general model)
  - Job polarization: CES production function
  - Interindustry wage differentials: exogenous to firms

▸ General model

CES Production Function

- Two types of tasks: Non-routine vs. Routine

$$y_{it} = h_{it}^{\alpha} \left(\tilde{h}_{it}^{\mu} + k_{it}^{\mu} \right)^{\frac{1-\alpha}{\mu}}$$

where $\alpha \in (0,1)$ and $\mu \in (0,1)$
- Elasticity of substitution between routine worker and capital is $1/(1-\mu) > 1$
- Capital: relative substitute for routine worker but relative complement to non-routine worker

- Results hold even when production functions are heterogenous across industries under some conditions

Interindustry Wage Differentials

- Wage differentials: assumed to be exogenous

$$w_{1t} = (1+\lambda)w_{2t} \quad \tilde{w}_{1t} = (1+\lambda)\tilde{w}_{2t} \tag{8}$$

- $\lambda > 0$ captures exogenous factors out-of-control from firm's perspective
  - Results are identical when different exogenous factors: labor union, efficiency wage, and compensating wage differentials
  - Persistent wage structure: exogenous factors are more important than endogenous determination of wage premium

▸ Model with Union ▸ Persistency

Predictions: Terminology

- Job polarization: $s_i \equiv \frac{h_i}{\tilde{h}_i}$
- Capital deepening: $\kappa_i \equiv \frac{k_i}{\tilde{h}_i}$
- Simplifying assumption: Goods are perfect substitutes ($p_1 = p_2$)

Predictions: Model with Exogenous Factors Only

Proposition (Capital deepening and Interindustry Wage Differentials)

Suppose that the relative price of capital over routine workers decreases. Then the following results hold in the steady state:

- *The capital-routine worker ratio increases in both industries, while it rises more in the high-wage industry. In addition, the difference between industries increases in the wage premium (λ) and substitutability between capital and routine workers (μ). Formally,*

$$\frac{d\kappa_1}{d\frac{\tilde{w}_2}{r}} = (1+\lambda)^{\frac{1}{1-\mu}} \frac{d\kappa_2}{d\frac{\tilde{w}_2}{r}} > 0 \tag{9}$$

Predictions (Continued)

Proposition (Job Polarization)

- *Job polarization happens in both industries. Formally,*

$$\frac{ds_i}{d\frac{\tilde{w}_2}{r}} = \frac{\alpha}{\chi(1-\alpha)} \frac{d\kappa_i^{\mu}}{d\frac{\tilde{w}_2}{r}} > 0 \tag{10}$$

Predictions (Continued)

Proposition (Job Polarization: Connection to Interindustry Wage Differentials)

- *The change in the employment share of non-routine over routine workers in industry* 1 *is greater than that in industry* 2*; i.e., job polarization is more evident in the high-wage industry. In addition, the difference in the degree of job polarization across industries increases in the wage premium* (λ) *and substitutability between capital and routine workers* (μ)*. Formally,*

$$\frac{ds_1}{d\frac{\tilde{w}_2}{r}} = (1+\lambda)^{\frac{\mu}{1-\mu}} \frac{ds_2}{d\frac{\tilde{w}_2}{r}} \tag{11}$$

Conclusion

Conclusion

- Degree of job polarization differs across industries
  - Interindustry wage differentials provide different incentives for firms
- Findings
  1. Job polarization is more pronounced in industries with high industry wage premium
  2. ICT capital per worker increased more in industries with high industry wage premium
- Important to consider exogenous factors to generate interindustry wage differentials

THANK YOU

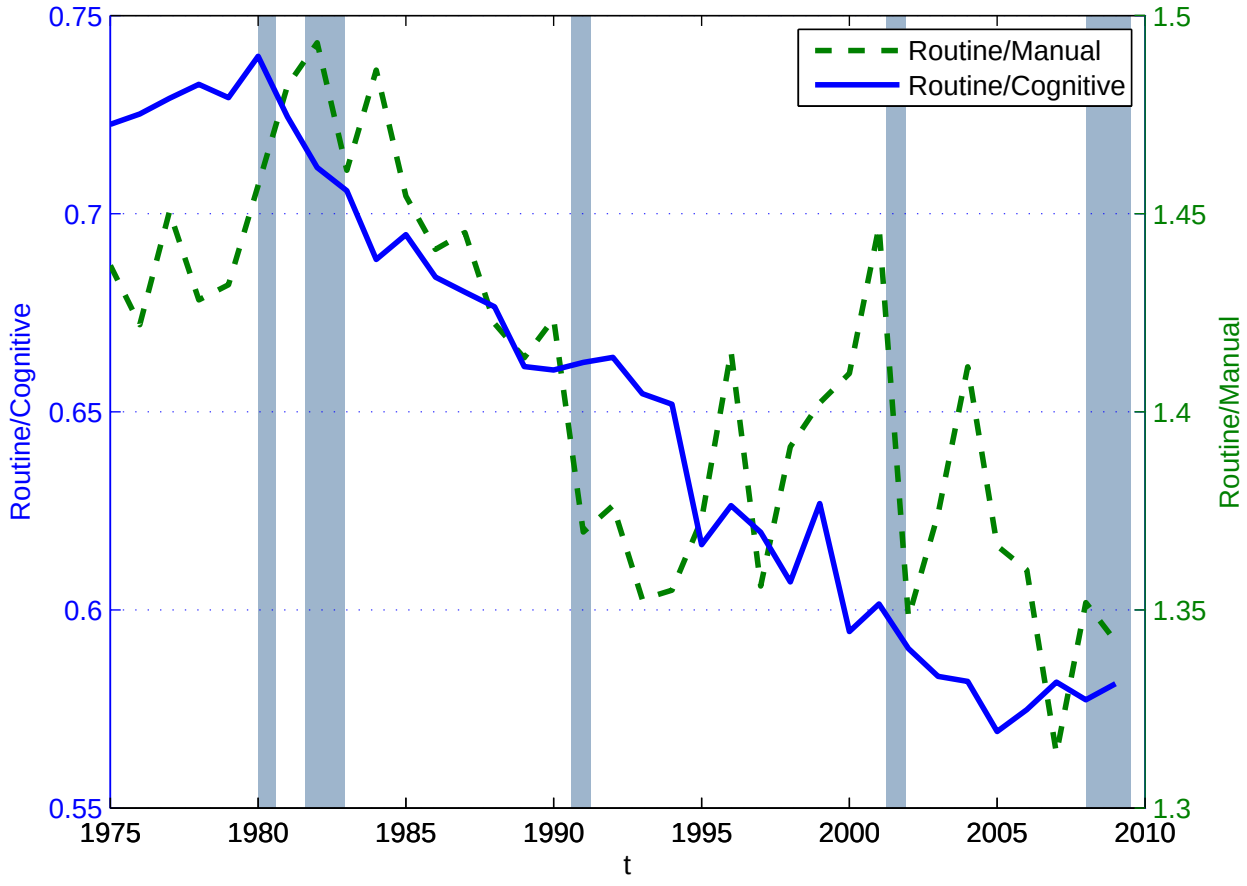
Appendix

Job Polarization

- Three occupation groups (Following Autor (2011)):
  - Non-routine cognitive occupations: Managers, Professionals, and Technicians
  - Routine occupations: Sales, 'Office and administration', 'Production, crafts, and repair' and 'Operators, fabricators, and laborers'
  - Non-routine manual occupations: Protective services, 'Food prep and building/grounds cleaning' and 'Personal care and personal services'

Return

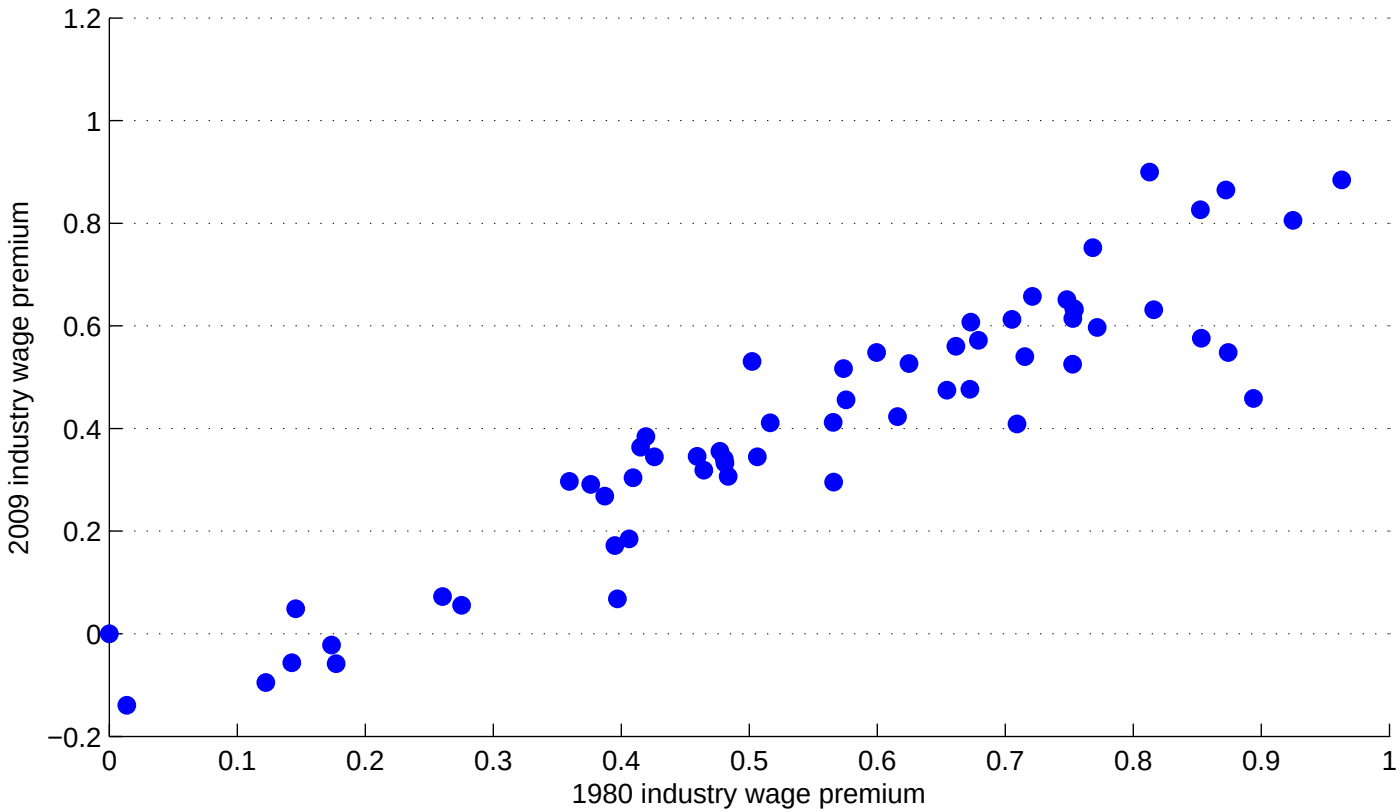
Job Polarization: Wage Rate (March CPS)



Return

Interindustry Wage Differentials: Persistent?

- Compare industry wage premium at 1980 and at 2009 (Data from Census)



▸ Return to Wage equation ▸ Return to Intro ▸ Return to Model

Industry: Important in Wage Determination?

- Following Dickens and Katz (1986):
  - Compute portion of wage variation explained by industry
  - Estimate wage equation each year and compute R^2

Table: Source of Wage Variation (R^2)

	1980	1990	2000	2009
Total	0.40	0.42	0.42	0.43
Industry only	0.14	0.14	0.13	0.16
Covariates only	0.36	0.37	0.38	0.38
Observations	4,307,598	4,940,215	5,530,409	1,202,671

Note: Data from Census and ACS

Preliminaries: Agents

- Household: Supply (identical) workers to labor market
- Labor market: Allocate workers to each intermediate firm
- Intermediate goods-producing firms: Produce intermediate goods using workers and capital
- Final goods-producing firms: Produce final goods using intermediate goods

▸ Return to Simple Model ▸ Intermediate Firms ▸ Final Goods-Producing Firms

Household Problem

$$\max_{\{c_t, k_{t+1}, x_t, h_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \left[\log c_t + \theta(\bar{n} - n_t)\right] \tag{12}$$

subject to

$$(1)\ c_t + x_t = w_t n_t + r_t k_t + \pi_t$$
$$(2)\ k_{t+1} = (1-\delta)k_t + q_t x_t$$

▸ Return

Feature 1. Investment-Specific Technology Changes

- Following Greenwood et al (1997), we introduce investment-specific technology changes

$$k_{t+1} = (1 - \delta) k_t + q x_t$$

  where $\delta \in (0, 1)$
- $1/q$: Relative price of capital
- We study effects of changes in q at steady state

Intermediate Goods-Producing Firms

$$\max_{\left\{k_{it},h_{it},\tilde{h}_{it}\right\}} p_{it}y_{it} - w_{it}h_{it} - \tilde{w}_{it}\tilde{h}_{it} - r_t k_{it}$$

subject to

$$y_{it} = h_{it}^{\alpha}\left(\tilde{h}_{it}^{\mu} + k_{it}^{\mu}\right)^{\frac{1-\alpha}{\mu}}$$

Return

Final Goods-Producing Firms

$$\max_{\{y_{1t}, y_{2t}\}} y_t - p_{1t} y_{1t} - p_{2t} y_{2t} \tag{13}$$

subject to the CES aggregator

$$y_t = \left[y_{1t}^{1-\nu} + y_{2t}^{1-\nu} \right]^{\frac{1}{1-\nu}}$$

where $\nu \in [0, 1)$. Return

Labor Union

- Union: Convenient way to model industry wage premium
- Low unionization rate?
  - Threat of forming labor union can have real effects (Taschereau-Dumouchel (2012))

Return

Labor Market with Union

- Following Smets and Wouters (2007) and Erceg, Henderson, and Levin (2000)
  - Labor unions: Buy labor from household and unpack it into different varieties
    - Heterogenous market power of union $\Longrightarrow$ Interindustry wage differentials
    - Profit: Distributed as lump-sum transfer to household
  - Labor packers: Buy differentiated labor from labor union and aggregate it
  - Firms: Buy labor (performing different tasks) from labor packers

Return

Labor Market

- Household supplies labor to labor union of each industry at wage w_{ijt}^h.
- Labor union unpacks labor into different varieties, $H_{it}^j(l)$, $l \in [0, 1]$
- Labor union acts as monopolist for each single variety where λ_w^i (wage markup) in industry i measures monopolistic power of labor union. Assume λ_w^i is different across industries:

$$\lambda_w^1 > \lambda_w^2 = 0 \tag{14}$$

Return

Labor Market

- Aggregate labor for each task j:

$$H_{it}^{j} = \left[\int_0^1 \left(H_{it}^{j}(l) \right)^{\frac{1}{1+\lambda_w^i}} \right]^{1+\lambda_w^i} \tag{15}$$

- Labor demand equation from cost-minimizing labor packers:

$$H_{it}^{j}(l) = \left(\frac{w_{it}^{j}(l)}{w_{it}^{j}} \right)^{-\frac{1+\lambda_w^i}{\lambda_w^i}} H_{it}^{j} \tag{16}$$

▸ Return

Labor Market

- Labor union solves

$$\max_{w_{it}^j(l)} d_{it}^j(l) = \left(w_{it}^j(l) - w_{ijt}^h \right) H_{it}^j(l) \tag{17}$$

  subject to $H_{it}^j(l) = \left(\frac{w_{it}^j(l)}{w_{it}^j} \right)^{-\frac{1+\lambda_w^i}{\lambda_w^i}} H_{it}^j$

- First order condition with $w_{it}^j(l) = w_{it}^j$:

$$w_{it}^j = (1 + \lambda_w^i) w_{ijt}^h$$

▸ Return

Labor Market

- with $\lambda_w^2 = 0$, $w_{ijt}^h = w_{2t}^j$. Hence

$$w_{1t}^j = (1 + \lambda_w^1) w_{2t}^j \tag{18}$$

- As a result, with $\lambda_w^1 > \lambda_w^2 = 0$, interindustry wage differentials exist and persistent in our model:

$$w_{1t}^j > w_{2t}^j \tag{19}$$

▸ Return

Estimates from wage equation in 1980

Table: OLS Estimates of the Wage Regression in 1980

Variable	Coefficient	Variable	Coefficient
Female	$-0.5413(0.0009)$	Cognitive Occupation	$0.4892(0.0030)$
Age1	$1.0227(0.0035)$	Routine Occupation	$0.2267(0.0029)$
Age2	$1.5225(0.0035)$	Manual Occupation	$0.0081(0.0031)$
Age3	$1.7141(0.0035)$	Region1	$-0.0355(0.0024)$
Age4	$1.7916(0.0035)$	Region2	$0.0329(0.0020)$
Age5	$1.7775(0.0036)$	Region3	$0.0684(0.0020)$
Edu1	$-0.5575(0.0020)$	Region4	$-0.0188(0.0023)$
Edu2	$-0.4799(0.0017)$	Region5	$-0.0045(0.0020)$
Edu3	$-0.2689(0.0013)$	Region6	$-0.0612(0.0024)$
Edu4	$-0.2418(0.0014)$	Region7	$-0.0011(0.0022)$
Edu5	0 (Omitted)	Region8	0 (Omitted)
African American	$-0.0842(0.0014)$	Region9	$0.0665(0.0021)$
R Squared	.4045	Observations	$4,307,598$

Return

IV Estimates

Table: IV Estimates of Employment Growth by Occupation Groups (1980-2009)

Occupation Groups	Coefficient	R-squared
Total	$-0.0331^{***}(0.0069)$	0.24
Cognitive Occupations	$-0.0197^{***}(0.0066)$	0.13
Routine Occupations	$-0.0412^{***}(0.0086)$	0.21
Manual Occupations	$0.0206^{*}(0.0114)$	0.13

Return

IV Estimates

Table: IV Regressions on Initial Wage Premium (1980-2007)

	IV	
Dependent	Coefficient	R-squared
Capital/Worker	**0.0138**(0.0139)	0.05
ICT Capital/Worker	**0.0400*****(0.0171)	0.09
non-ICT Capital/Worker	**0.0030**(0.0144)	0.004
Capital	$-$0.0181(0.0114)	0.10
ICT Capital	0.0081(0.0204)	0.000
non-ICT Capital	$-$0.0289***(0.0115)	0.25
Output	$-$0.0044(0.0087)	0.01
Labor Productivity	**0.0275*****(0.0091)	0.22
Employment	-**0.0319*****(0.0072)	0.27

▸ Return

1980-2007 Estimates

Table: OLS Estimates of Employment Growth by Occupation Groups (1980-2007)

Occupation Groups	Coefficient	R-squared
Total	$-0.0431^{***}(0.01)$	0.23
Cognitive Occupations	$-0.0259^{***}(0.0083)$	0.12
Routine Occupations	$-0.0412^{***}(0.0097)$	0.18
Manual Occupations	$-0.0005(0.0154)$	0.00

Return

Estimates for Full-time workers only

Table: OLS Estimates of Employment Growth by Occupation Groups, Full-time workers only (1980-2009)

Occupation Groups	Coefficient	R-squared
Total	$-0.0427^{***}(0.0078)$	0.26
Cognitive Occupations	$-0.0272^{***}(0.0067)$	0.15
Routine Occupations	$-0.0461^{***}(0.0098)$	0.20
Manual Occupations	$0.0091(0.0124)$	0.02

Return

Estimates for Changes in Employment Share

Table: OLS Estimates of Employment Share by Occupation Groups (1980-2009)

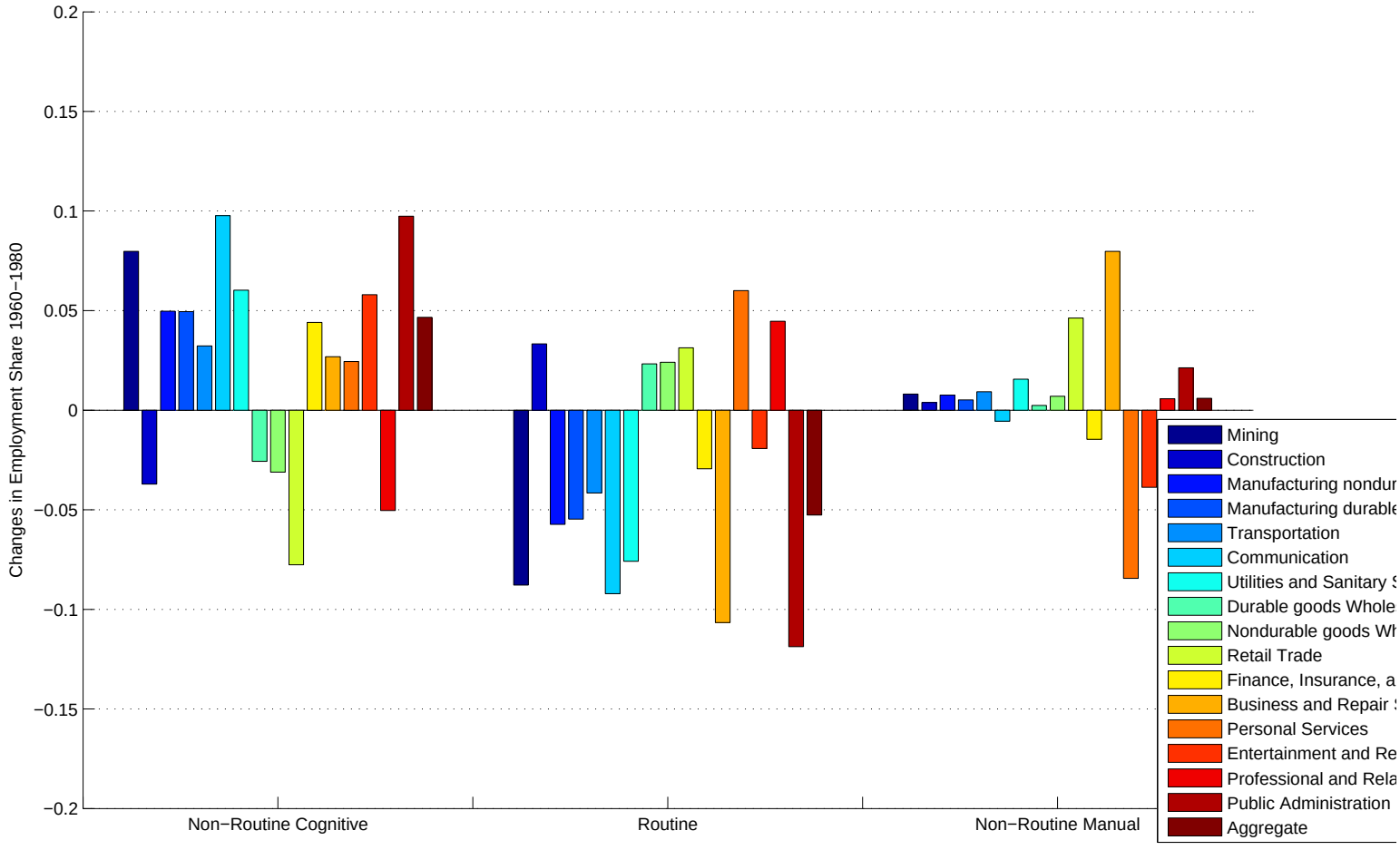
Occupation Groups	Coefficient	R-Squared
Cognitive Occupations	$0.0076(0.0802)$	0.00
Routine Occupations	$-0.1833^{***}(0.0572)$	0.19
Manual Occupations	$0.1306(0.0960)$	0.13

Return

How About Period Before 1980?

- Interindustry wage differentials: existed even before 1980
- Can we observe similar pattern for period between 1960-80?

How About Period Before 1980? (Census)



▸ 1980

How About Period Before 1980?

- Estimate wage equation to obtain industry wage premium in 1960 and re-estimate main equation

Table: OLS Estimates of Employment Growth by Occupation Groups (1960-1980)

Occupation Groups	Coefficient	R-squared
Total	$-0.0178(0.0284)$	0.03
Cognitive	$0.0053(0.0151)$	0.00
Routine	$-0.0303^{**}(0.0122)$	0.10
Manual	$0.0595^{***}(0.0077)$	0.03

▸ 1980 Estimates

How About Period Before 1980?

- Job polarization was there while estimates are smaller
- Why estimates larger after 1980?
    - Routine-replacing technological changes
    - Increased offshoring opportunity

▸ Relative price of ICT capital

Prediction: Non-Competitive Model

- Now assume $x_i = x$ for all x and let $w = \lambda_i x$ where $\lambda_i \in (0, 1)$
  - w: wage of a worker, can deviate from productivity of the worker
  - Net profit, $(1 - \lambda_i)x$, goes to owner of firm

Proposition

Suppose that $\min\left\{\frac{x}{\lambda_i}\right\} > x_k / p$ *held initially so that no firms used capital. Suppose further that the productivity of capital,* x_k / p*, increases. In this economy, it is the 'highest-wage' firm that introduces capital at first. The 'lowest-wage' firm introduces capital at last.*
i.e. Job polarization is more apparent in high-wage firms.

▸ Main model