Skills, Tasks and Technologies

Beyond the Canonical Model

Daron Acemoglu and David Autor
(Handbook of Labor Economics, 2011)

James J. Heckman
University of Chicago

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Skills, Tasks and Technologies:

Beyond the Canonical Model

- *Canonical model* — Elegantly, powerfully operationalizes supply and demand for skills
  - A formalization of Tinbergen's "Education Race" analogy
  - Two distinct skill groups that perform two different and imperfectly substitutable tasks
  - Technology is *factor-augmenting*—Always raises productivity/wages
- Model is a theoretical and empirical success in the sense that it is widely used
  - Katz and Murphy (1992), Card and Lemieux (2001), Autor, Acemoglu and Lyle (2004), Goldin and Katz (2008), Carneiro and Lee (2009)

Beyond the Canonical Model of Skills and Wages

- But model silent on some *central empirical facts* of last three decades:
  1. Falling real wages of low-skill workers (at least in U.S.)
  2. Non-monotone shifts in inequality, despite rising 'return to skill'
  3. Widespread 'polarization' of employment across advanced economies
  4. Skill-*replacing* (not augmenting) technologies
- *Needed:* Model with richer interplay between skills, tasks, technologies
  1. Distinguish between 'skills' and 'tasks'
  2. Endogenize assignment of skills to tasks: Comparative advantage
  3. Direct competition between skills, technologies, trade in performing tasks
  4. Nest canonical model as one possible case

Beyond the Canonical Model of Skills and Wages

Outline

1. The canonical model: Implications and empirical successes
2. Where the canonical model falls short
3. What should an amended model offer?
4. A Ricardian model of skills, tasks and technologies patterned after Dornbusch, Fischer, Samuelson (1977, AER)
5. Some potential empirical directions
6. Conclusions

The Canonical Model

- Basic assumptions
  1. Two skills, high and low: H, L. Typically college v. high school
  2. No distinction between skills and 'tasks'—Skill is direct input into production
  3. H and L are imperfect productive substitutes: $\sigma > 0$.
  4. Wages are set on the demand curve
- Canonical representation for aggregate output y:

$$Y = \left[(A_L L)^{\frac{\sigma-1}{\sigma}} + (A_H H)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}},$$

where A_L and A_H are factor-augmenting technology terms.

The Canonical Model

- Elasticity of substitution plays key role
  - $\sigma > 1$: H and L are gross substitutes. Rise in A_H/A_L is SBTC
  - $\sigma < 1$: H and L are gross complements. *Fall* in A_H/A_L is SBTC

$$W_L = \frac{\partial Y}{\partial L} = A_L^{\frac{\sigma-1}{\sigma}} \left[A_L^{\frac{\sigma-1}{\sigma}} + A_H^{\frac{\sigma-1}{\sigma}} \left(\frac{H}{L} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{1}{\sigma-1}}$$

$$W_H = \frac{\partial Y}{\partial H} = A_H^{\frac{\sigma-1}{\sigma}} \left[A_L^{\frac{\sigma-1}{\sigma}} \left(\frac{H}{L} \right)^{\frac{\sigma-1}{\sigma}} + A_H^{\frac{\sigma-1}{\sigma}} \right]^{\frac{1}{\sigma-1}}$$

The Canonical Model

- Skill premium

$$\ln\left(\frac{W_H}{W_L}\right) = \frac{\sigma - 1}{\sigma}\ln\left(\frac{A_H}{A_L}\right) - \frac{1}{\sigma}\ln\left(\frac{H}{L}\right)$$

- Supply and demand factors represented
  1. $\ln(H/L)$ represents position of "supply curve"
  2. $\frac{\sigma - 1}{\sigma}\ln\left(\frac{A_H}{A_L}\right)$ represents position of demand curve
  3. Impact of supply on wage inequality

$$\frac{\partial \ln(W_H/W_L)}{\partial \ln(H/L)} = -\frac{1}{\sigma}$$

  4. Impact of factor technology change on wage inequality

$$\frac{\partial \ln(W_H/W_L)}{\partial \ln(A_H/A_L)} = \frac{\sigma - 1}{\sigma} > 0 \text{ iff } \sigma > 1$$

Consensus is that $\sigma \in (1.4, 2.5)$, so technology that raises relative output of H also raises its relative wage

The Canonical Model

Some key testable predictions

1. Rise in supply of H/L reduces skilled wage differential
   - $\partial \ln (w_H/w_L) / \partial \ln (H/L) = -1/\sigma < 0$
2. Rise in supply of H/L also *raises* real wage of L : $\partial w_L / \partial (H/L) > 0$
   - This follows from imperfect substitutability between H and L and complementarity
3. Factor augmenting tech Δ always raises wages of L workers: $\partial W_L / \partial A_L > 0$ and $\partial W_L / \partial A_H > 0$
   - This also follows from imperfect substitutability
4. *Predictions of this model always apply to both skills*
   - A bit tautological since there are only two skills/wages
   - But assume a continuum of efficiencies in each skill group: still true
   - *Loosely:* Wage inequality is either rising or falling in this model, *not both*

The Canonical Model: Implementation

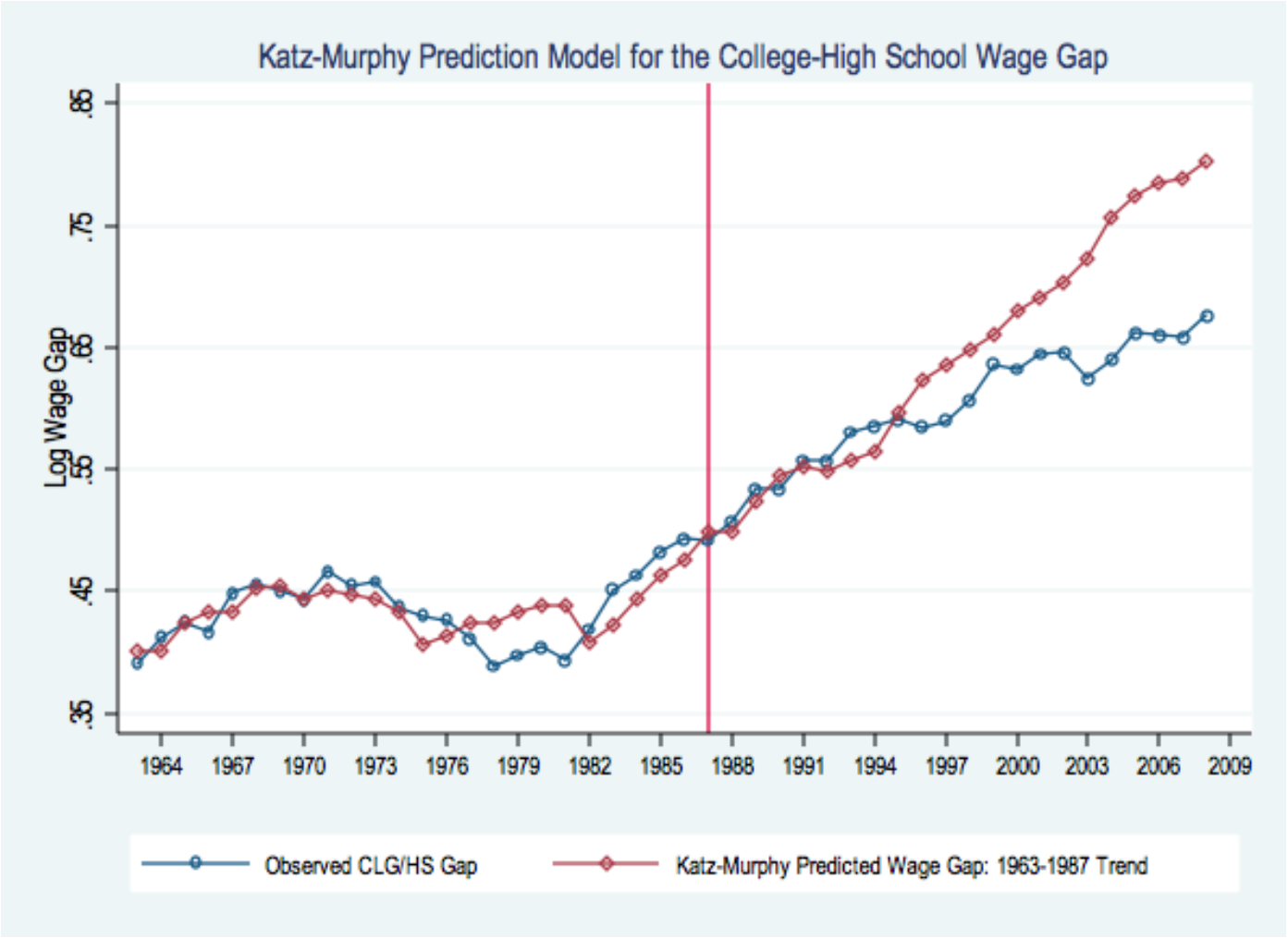
- The two-factor model estimated by Katz and Murphy (1992):
  - Used data from 1963 through 1987, fit by OLS

$$\ln\left(\frac{W_H}{W_L}\right) = \frac{\sigma-1}{\sigma}\gamma_0 + \frac{\sigma-1}{\sigma}\gamma_1 t - \gamma_2 \ln\left(\frac{H_t}{L_t}\right)$$

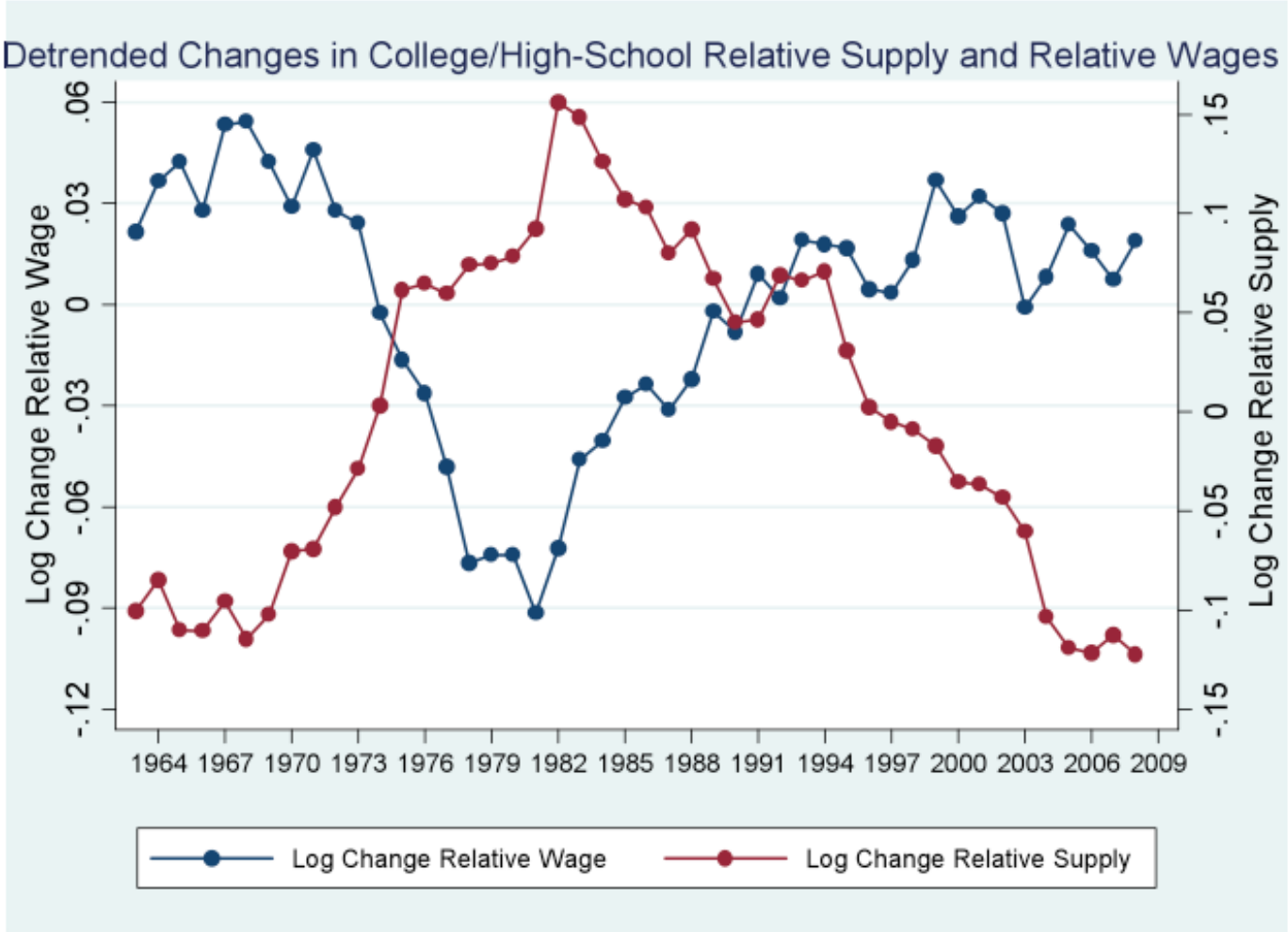
  - Replicating their approach, we get

$$\ln\left(\frac{W_H}{W_L}\right) = \underset{(0.005)}{0.027 \times t} \quad \underset{(0.128)}{-0.612 \cdot \ln\left(\frac{H_t}{L_t}\right)}$$

- This estimate implies
  1. Log relative demand for College/Non-College rising at 2.7 log points annually
  2. Elasticity of substitution $\hat{\sigma} = 1/\hat{\gamma}_2 \approx 1.6$
- You can see how well this works in the next figures
- Over predicts wage growth in 2000s


Katz-Murphy Prediction Model for the College-High School Wage Gap
Log Wage Gap
.35
.45
.55
.65
.75
.85
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Observed CLG/HS Gap
Katz-Murphy Predicted Wage Gap: 1963-1987 Trend

The Canonical Model: Easy to See Why K-M Model Fits!

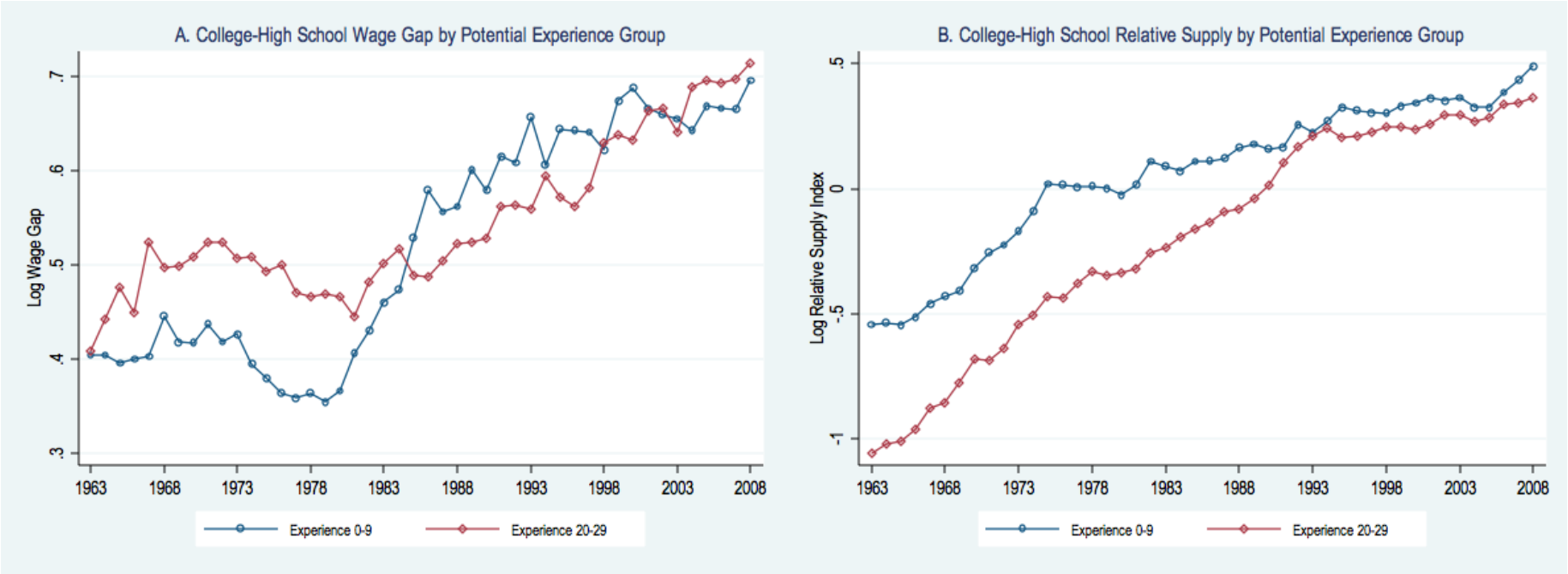


The Canonical Model: Many more Successes

1. Katz and Goldin (2008): Fit to data for 1915 – 2006
2. Carneiro and Lee (2009): Fit to data for U.S. regions
3. Card and Lemieux (2001):
   - Fit to data for three countries: U.S., U.K., Canada
   - Allow for imperfect substitutability among age cohorts
   - Explain cross-country variation in timing of rise of college premium *and* within-country variation in magnitude of rise in premium by age groups within countries
   - See also Fitzenberger and Kohn (2006) for German application

The Canonical Model

Explaining the College Premium by Experience Group



The Canonical Model

Explaining the College Premium by Experience Group

- The model can be extended to account for differing trends by experience group
- Estimate a regression model for the college wage premium by experience group:

$$\begin{aligned}\ln \omega_{jt} =& \beta_0 + \beta_1 \left[\ln \left(\frac{H_{jt}}{L_{jt}} \right) - \ln \left(\frac{H_t}{L_t} \right) \right] + \beta_2 \ln \left(\frac{H_t}{L_t} \right) \\ & + \beta_3 \times t + \beta_4 \times t^2 + \delta_j + n_{jt},\end{aligned}$$

j indexes experience groups, δ_j is a set of experience group main effects. A quadratic time trend is included.

The Canonical Model

Explaining the College Premium by Experience Group

Regression models for the college/high school log wage gap by potential experience group, 1963-2008.

	Potential experience groups (years)				
	All	*0-9*	*10-19*	*20-29*	*30-39*
Own minus aggregate supply	−0.272	−0.441	−0.349	0.109	−0.085
	(0.025)	(0.136)	(0.095)	(0.079)	(0.099)
Aggregate supply	−0.553	−0.668	−0.428	−0.343	−0.407
	(0.082)	(0.209)	(0.142)	(0.138)	(0.141)
Time	0.027	0.035	0.016	0.015	0.020
	(0.004)	(0.011)	(0.008)	(0.007)	(0.008)
$\text{Time}^2/100$	−0.010	−0.023	0.007	0.001	−0.008
	(0.004)	(0.011)	(0.008)	(0.007)	(0.009)
Constant	−0.056	−0.118	0.120	0.138	0.018
	(0.085)	(0.212)	(0.169)	(0.145)	(0.144)
Observations	184	46	46	46	46
R-squared	0.885	0.885	0.959	0.929	0.771

Source: March CPS data for earnings years 1963-2008. See notes to Figs 2 and 19.

Overall inequality in the canonical model

- Within group inequality is invariant to skill prices

$$\frac{W_i}{W_{i'}} = \frac{w_L l_i}{w_L l_{i'}} = \frac{l_i}{l_{i'}} \text{ for } i,\ i' \in \mathcal{L}.$$

- There can be within group wage inequality, but it will be independent of the skill premium

Overall inequality in the canonical model

- It is possible to make within group inequality responsive to the wage premium
- Assume that the two observable groups are college and non-college
- Fraction ϕ_c college graduates are high skill
- Fraction $\phi_n < \phi_c$ non-college graduates are high skill
- Skill premium is $\omega = w_H / w_L$
- College wages, w_C, non-college, w_N

$$\omega^c = \frac{w_C}{w_N} = \frac{\phi_c w_H + (1-\phi_c) w_L}{\phi_n w_H + (1-\phi_n) w_L} = \frac{\phi_c \omega + (1-\phi_c)}{\phi_n \omega + (1-\phi_n)}.$$

- Like Gorman-Lancaster Model

Overall inequality in the canonical model

- Because $\phi_n < \phi_c$, when the true price of skill increases, the observed college premium will also arise
- Trivially explains wage inequality within groups as a function of skill premium

Beyond the 'Canonical Model' of Skills and Wages

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3. What should an amended model offer?
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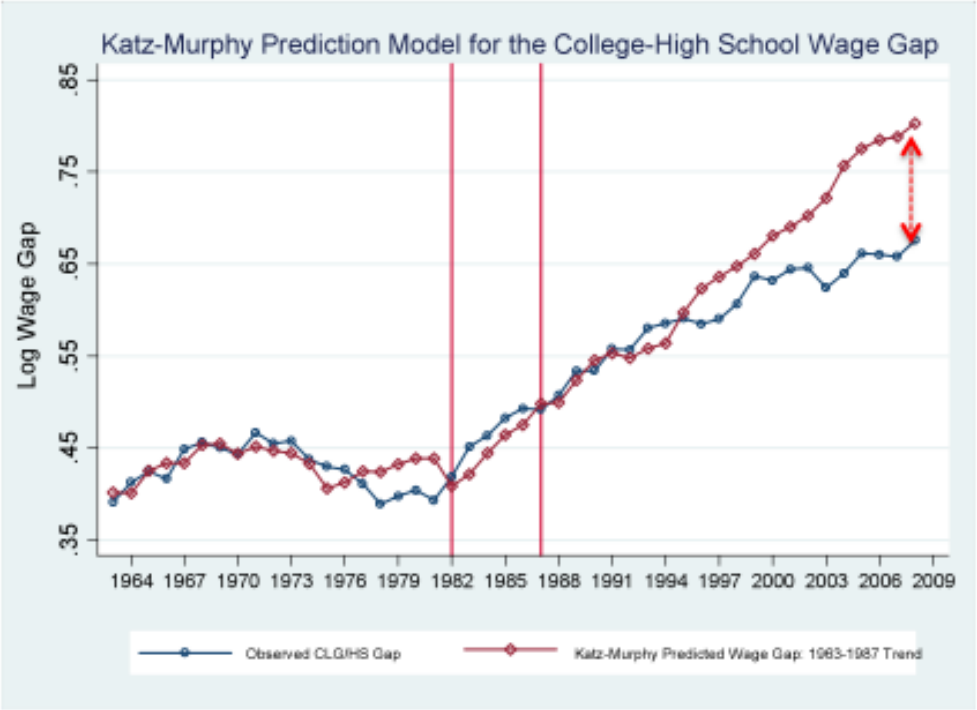
5. Some potential empirical directions
6. Conclusions

Where the Canonical Model is Silent (or Mis-speaks)

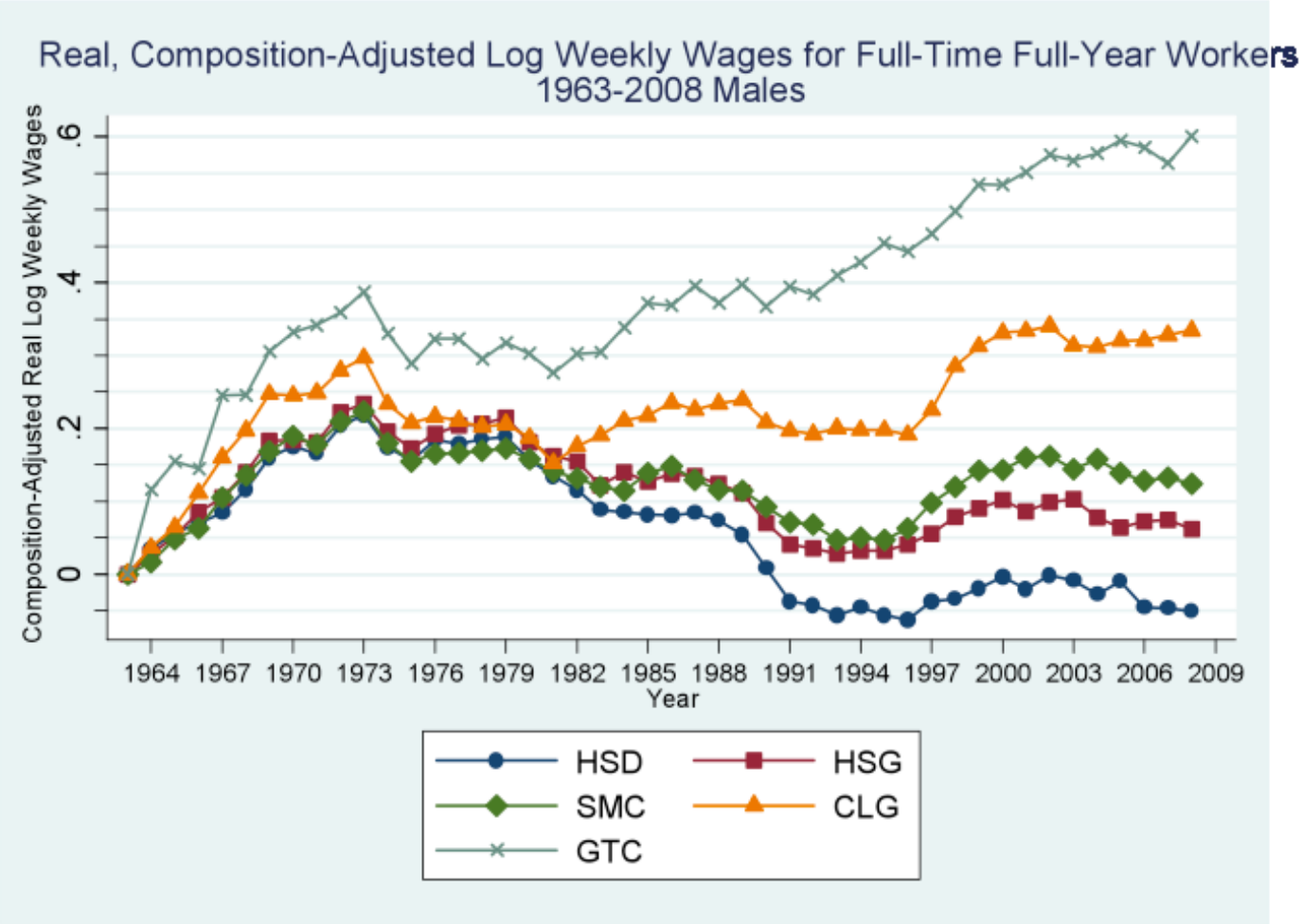
1. Wage inequality (as measured by $\ln \frac{W_H}{W_L}$) rises less than predicted
2. *Real wage levels fall* for some groups
3. Wage changes non-uniform in skill
4. Polarization of employment growth across high/low-skill occupations (also non-uniform)
5. Rising importance of *occupation* as a predictor of earnings
6. Casual empiricism only
   - Directly skill-replacing technologies commonplace
   - Offshoring may function like a skill-replacing technology

Wage Inequality Rises by Much Less than Predicted



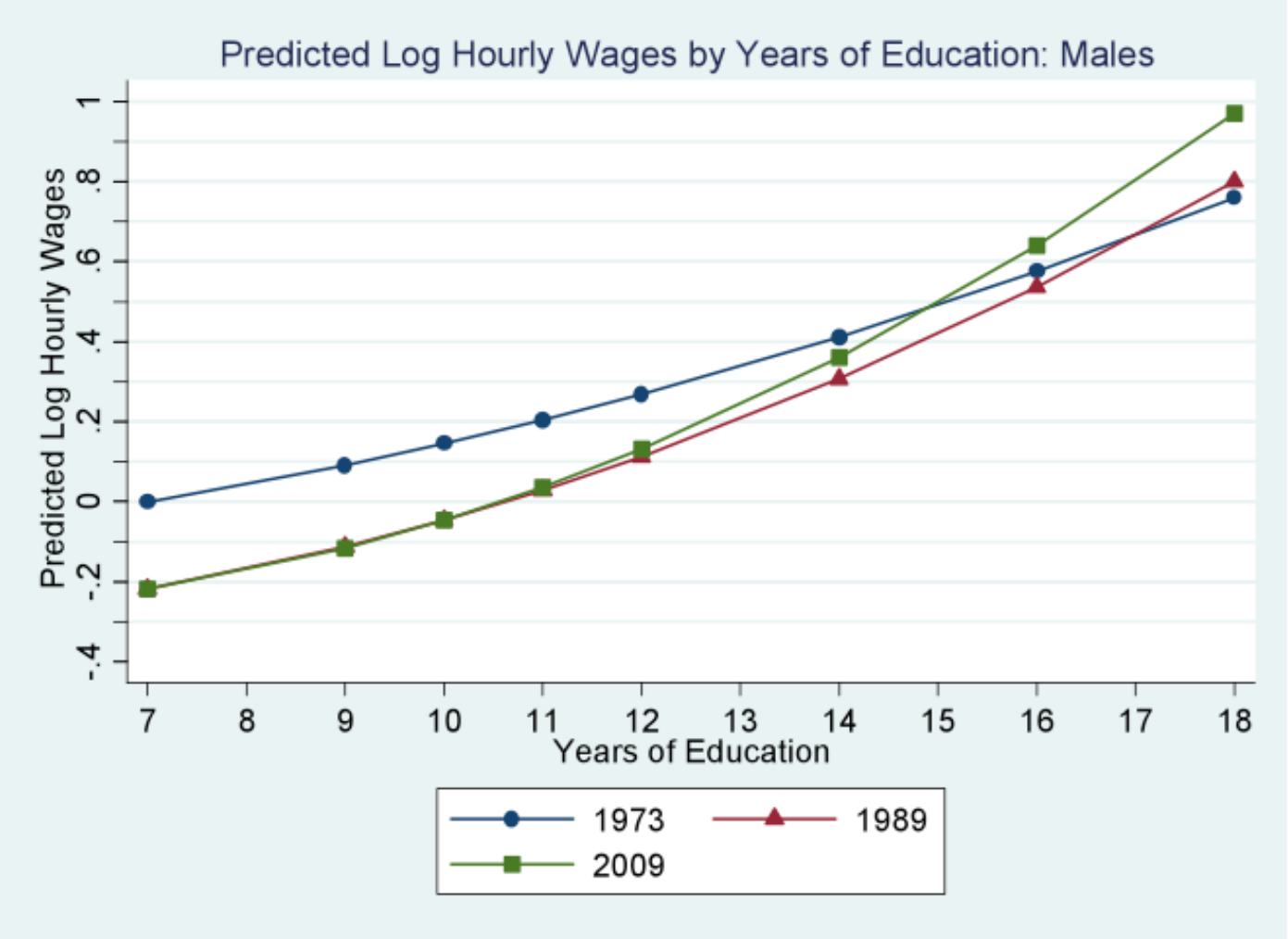
- College premium rose by 12 points between 1992 and 2008. Model predicts a *rise* of 25 log points!
- Model implies demand *decelerated* after 1992 or elasticity (σ) rose

Real wage levels fall for low-education males

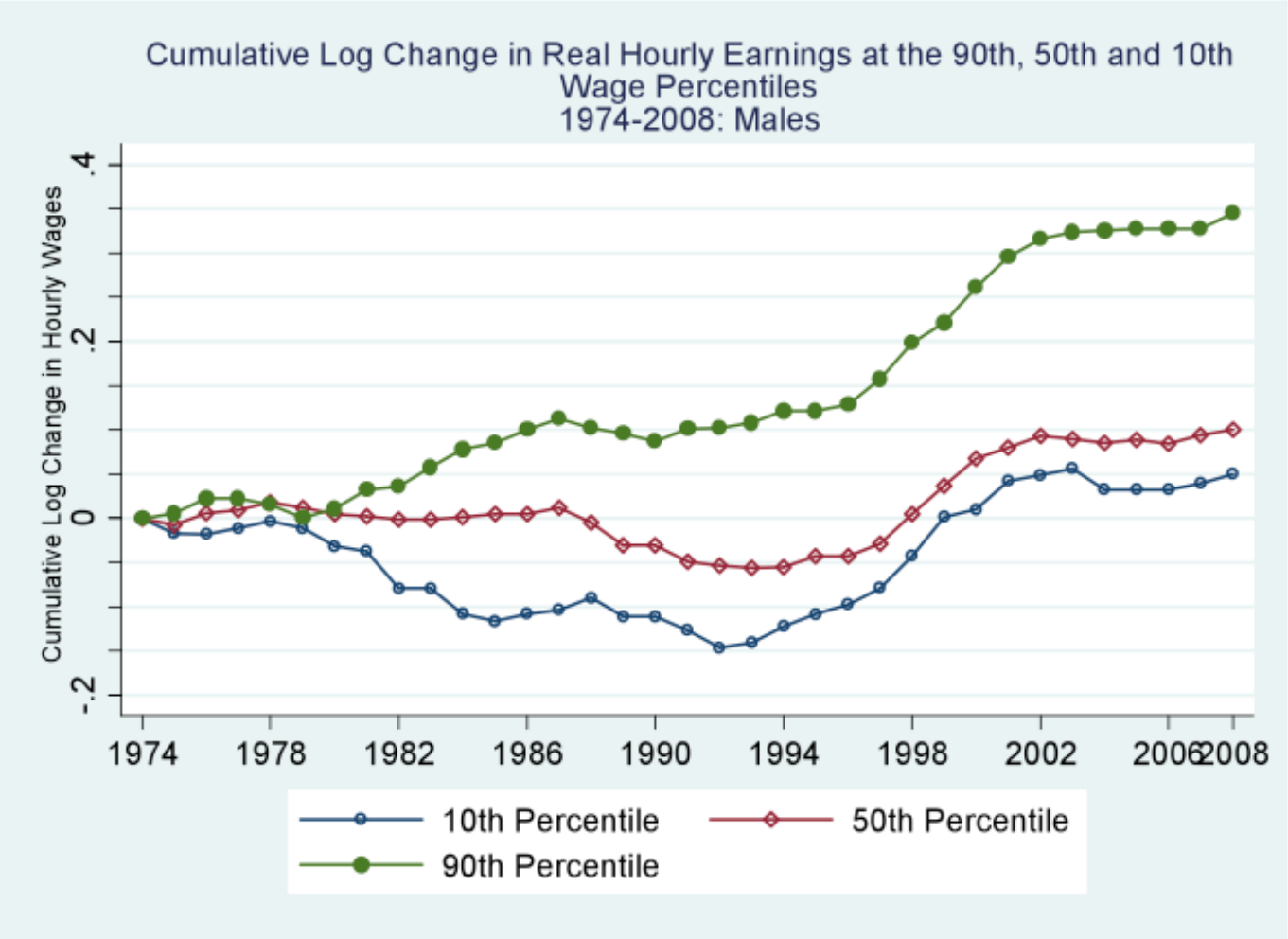


'Convexification' of the Return to Education

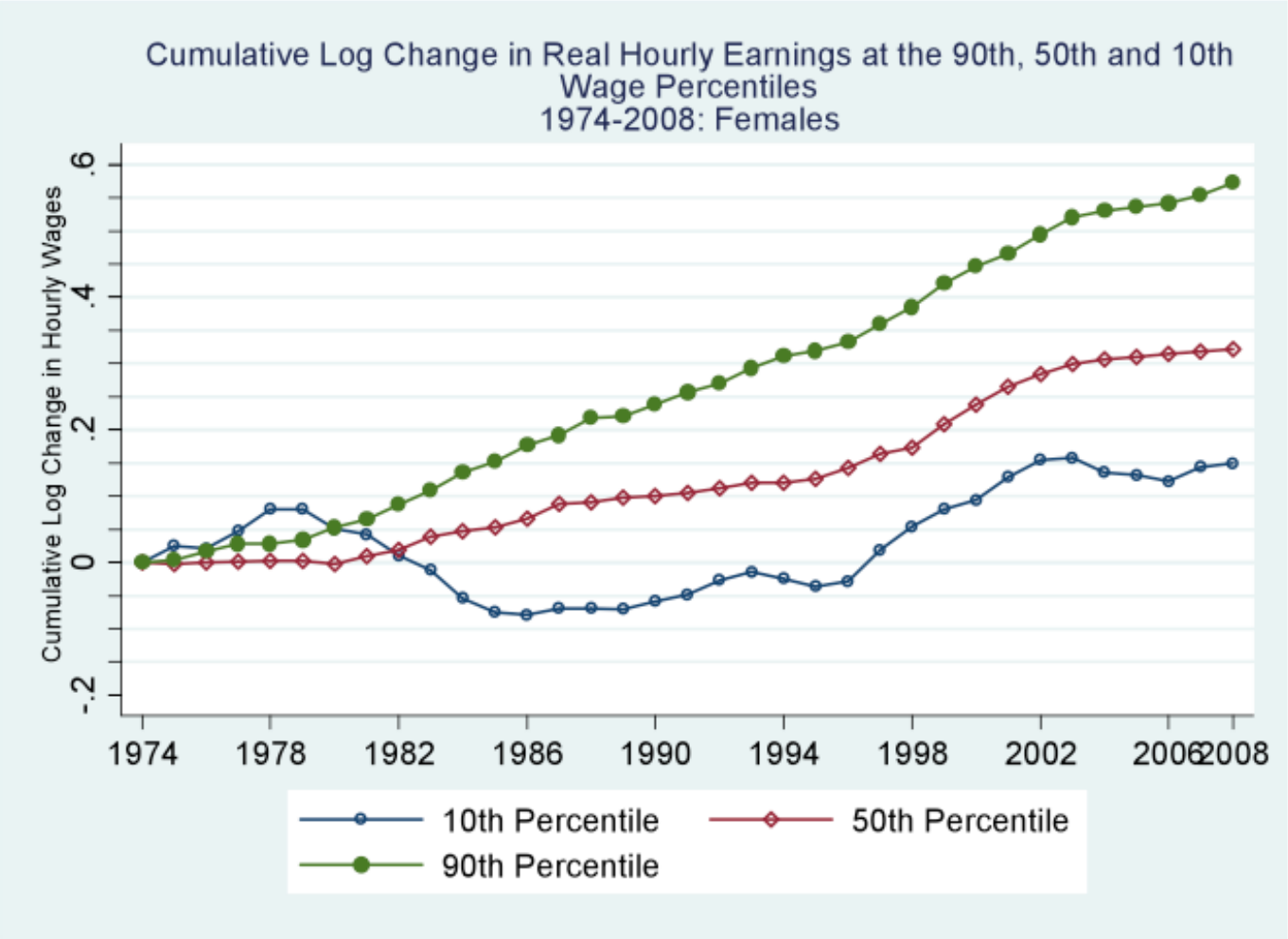
See Lemieux (2006)



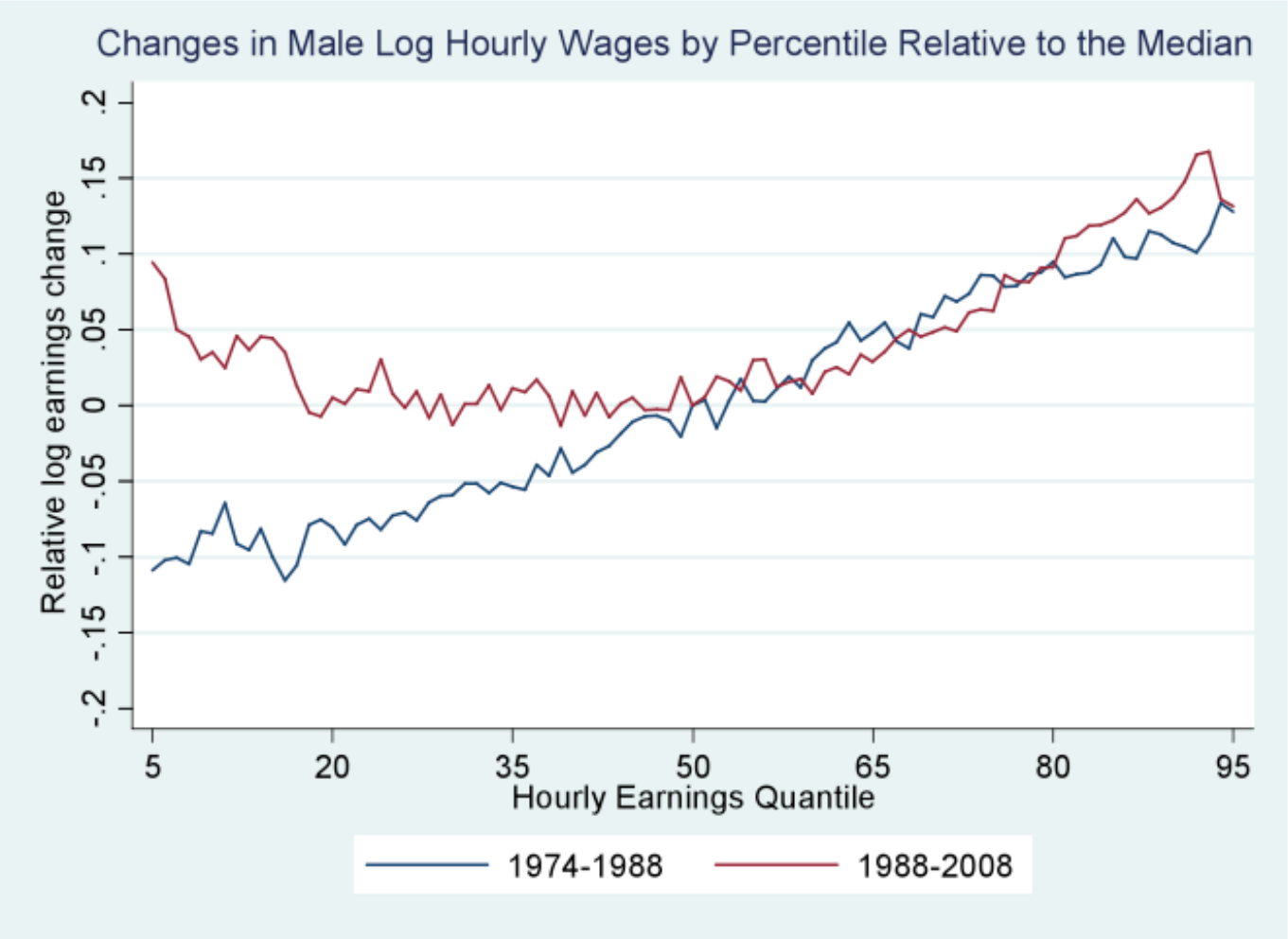
Wage changes non-monotone: Male indexed 90/50/10



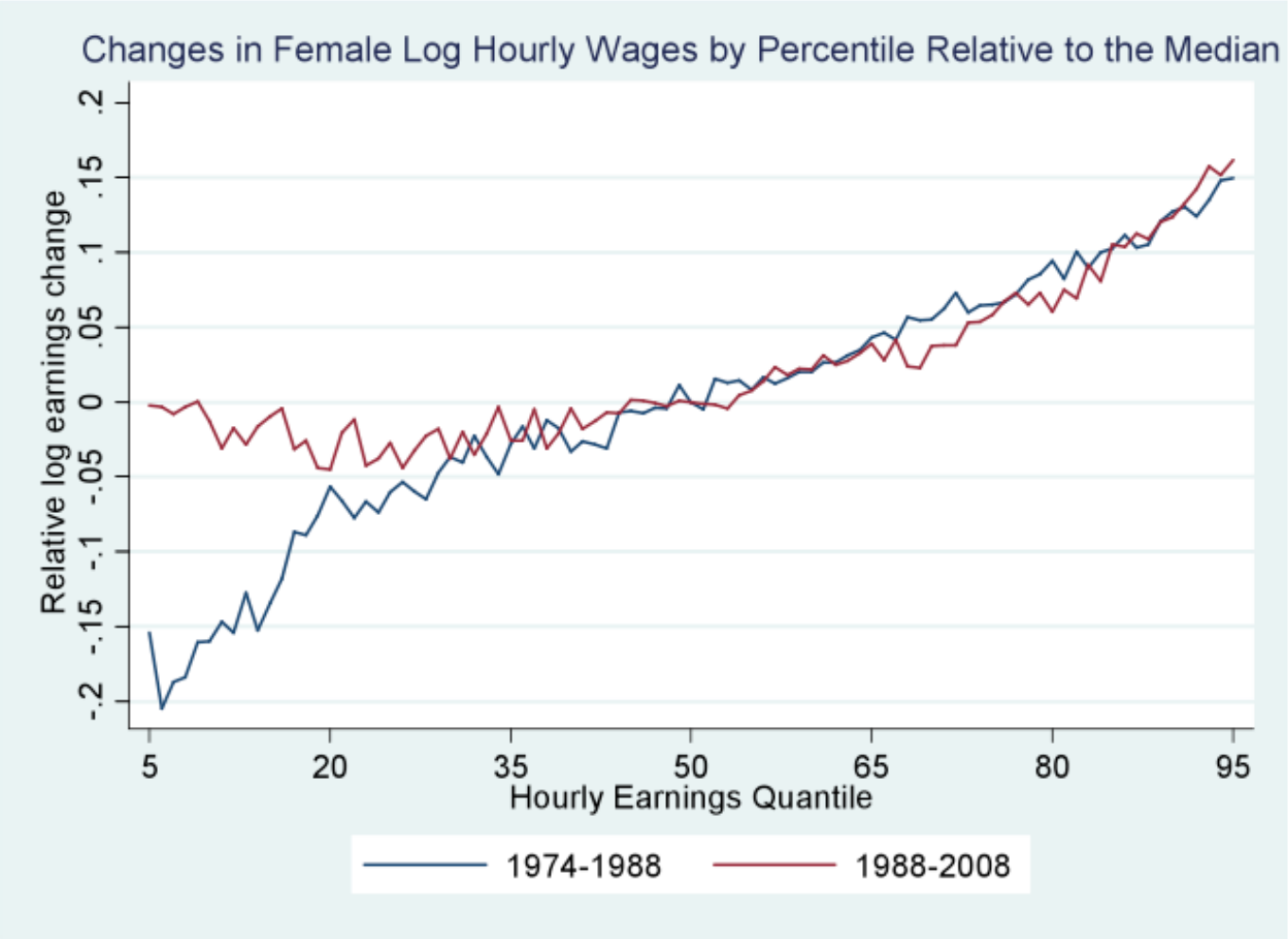
Wage changes non-monotone: Female indexed 90/50/10



Non-monotone wage changes: Males full distribution

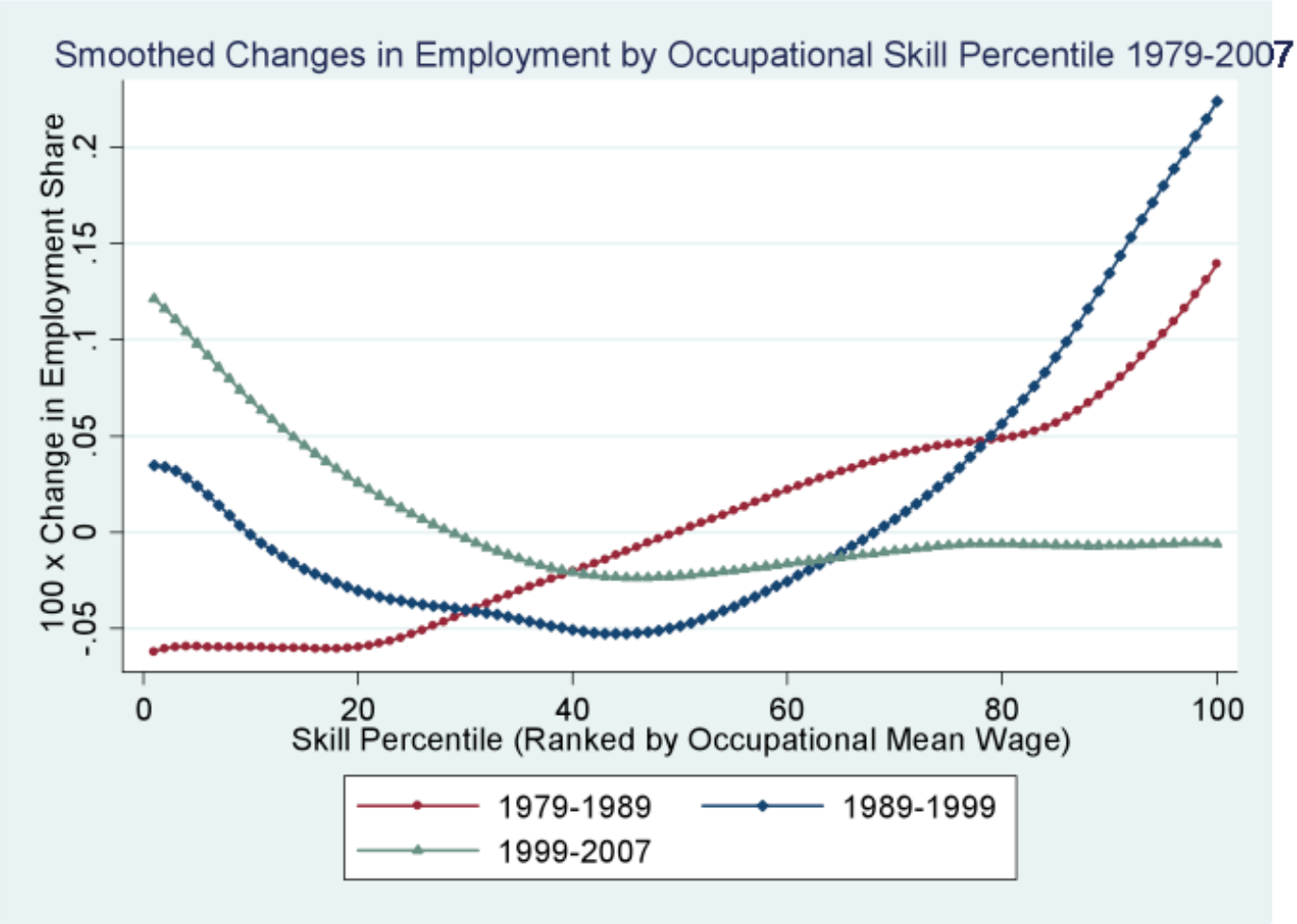


Non-monotone wage changes: Females full distribution



Polarization of Emp. Growth by Occupational Skill

Monotone in 1980s, Concentrated in Tails in 1990s and 2000s



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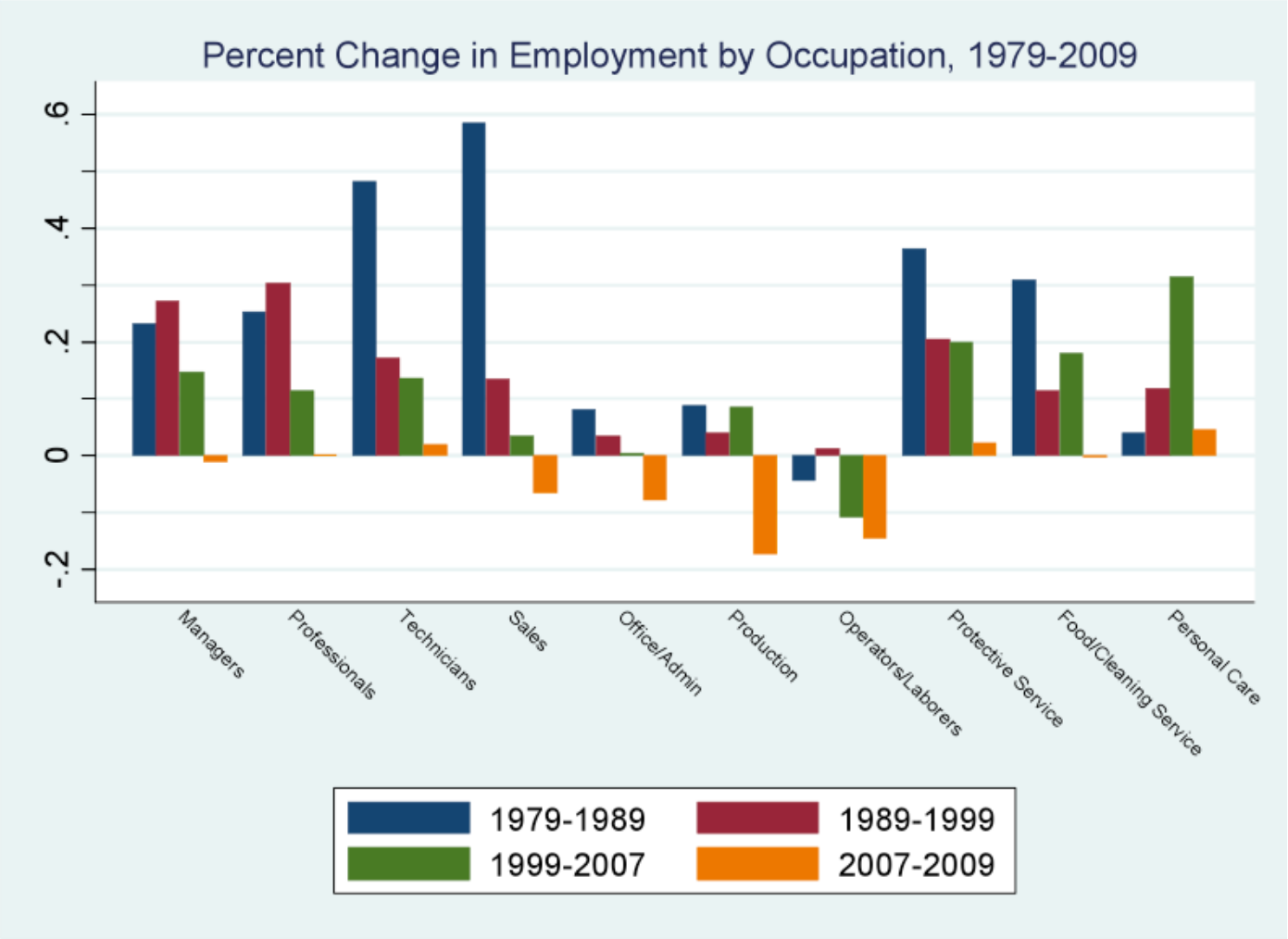
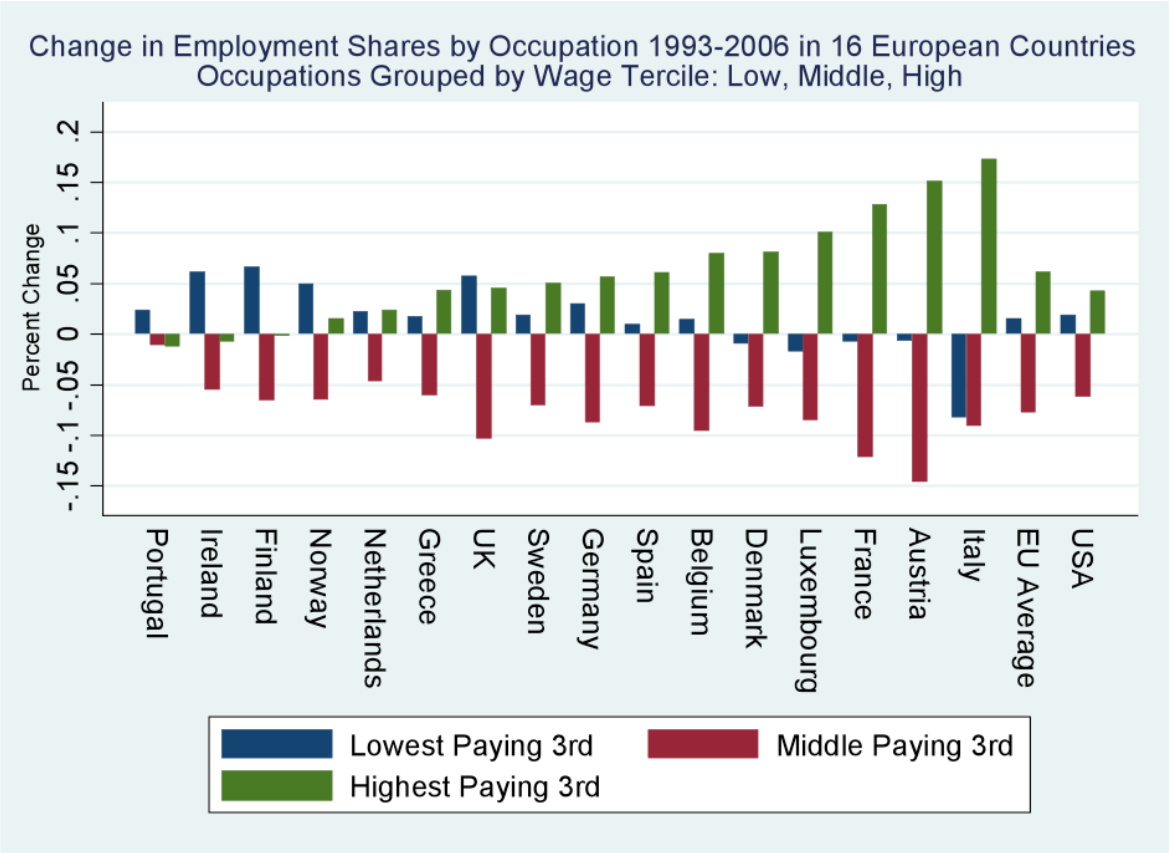


Polarization of Emp Growth by Occupational Skill

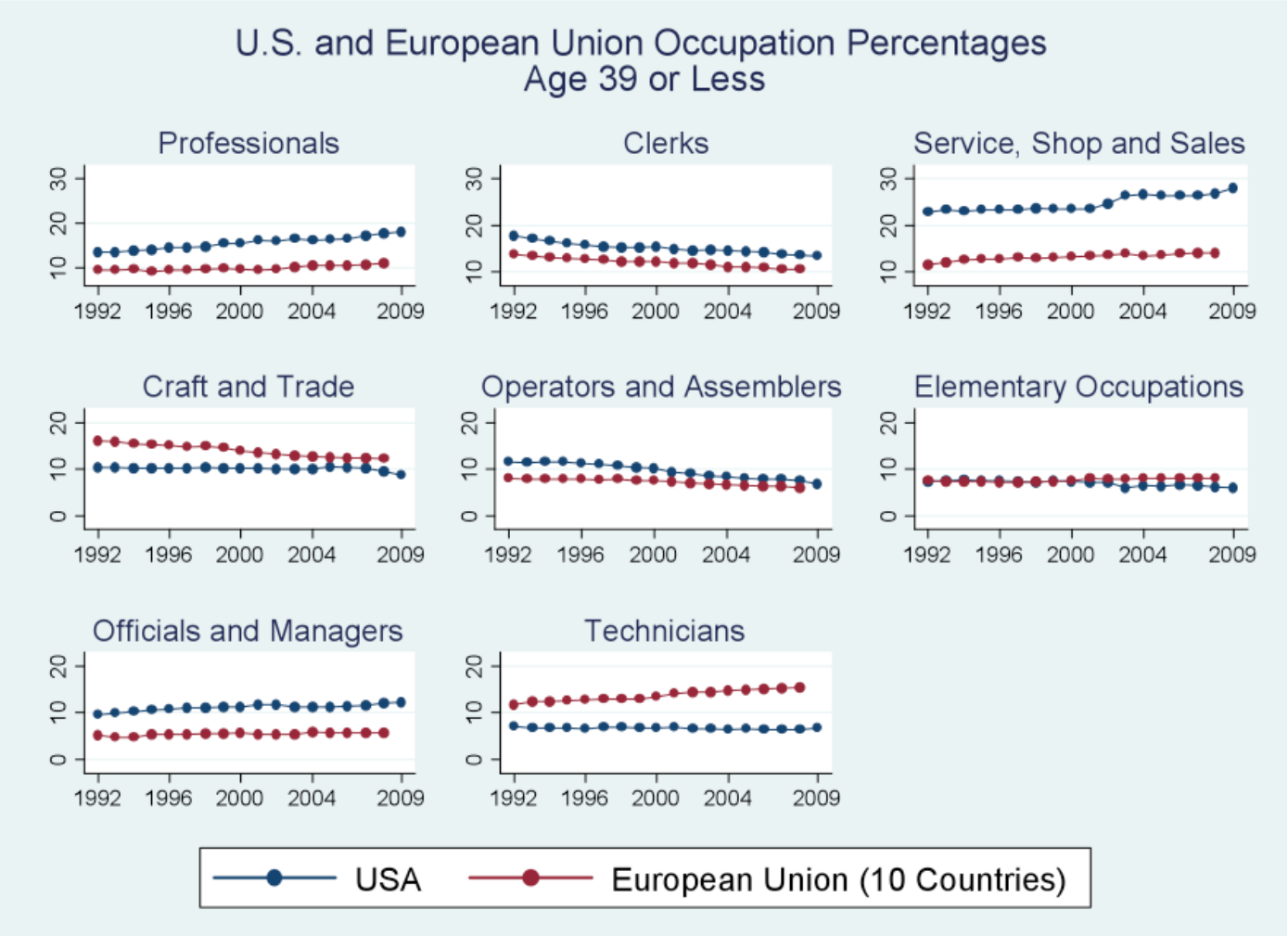
Harmonized European LFS Data from Goos, Manning and Salomons (2009)



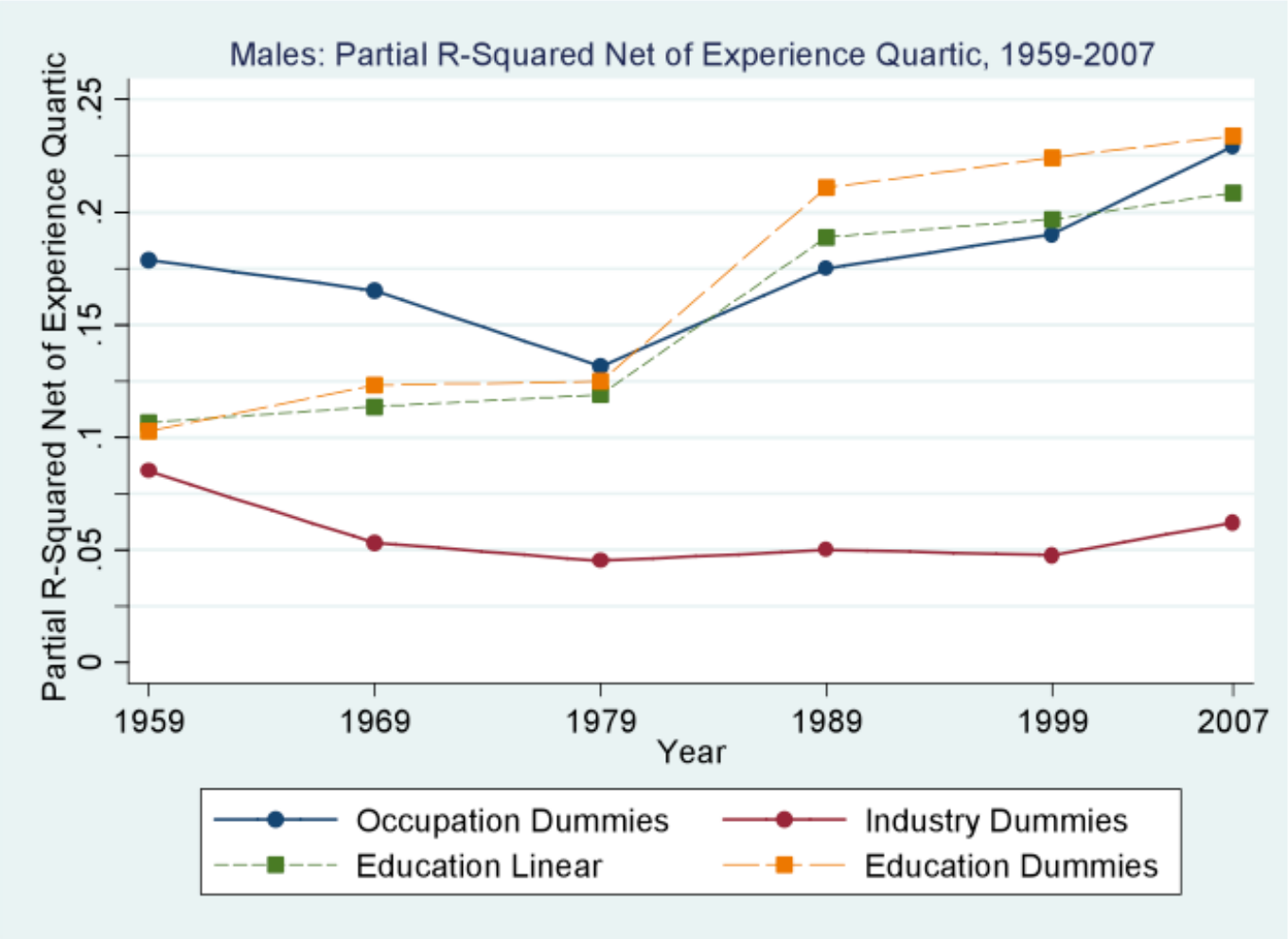
- See also Dustmann, Ludsteck and Schonberg (2009), *QJE*

Polarization of Emp Growth by Occupational Skill

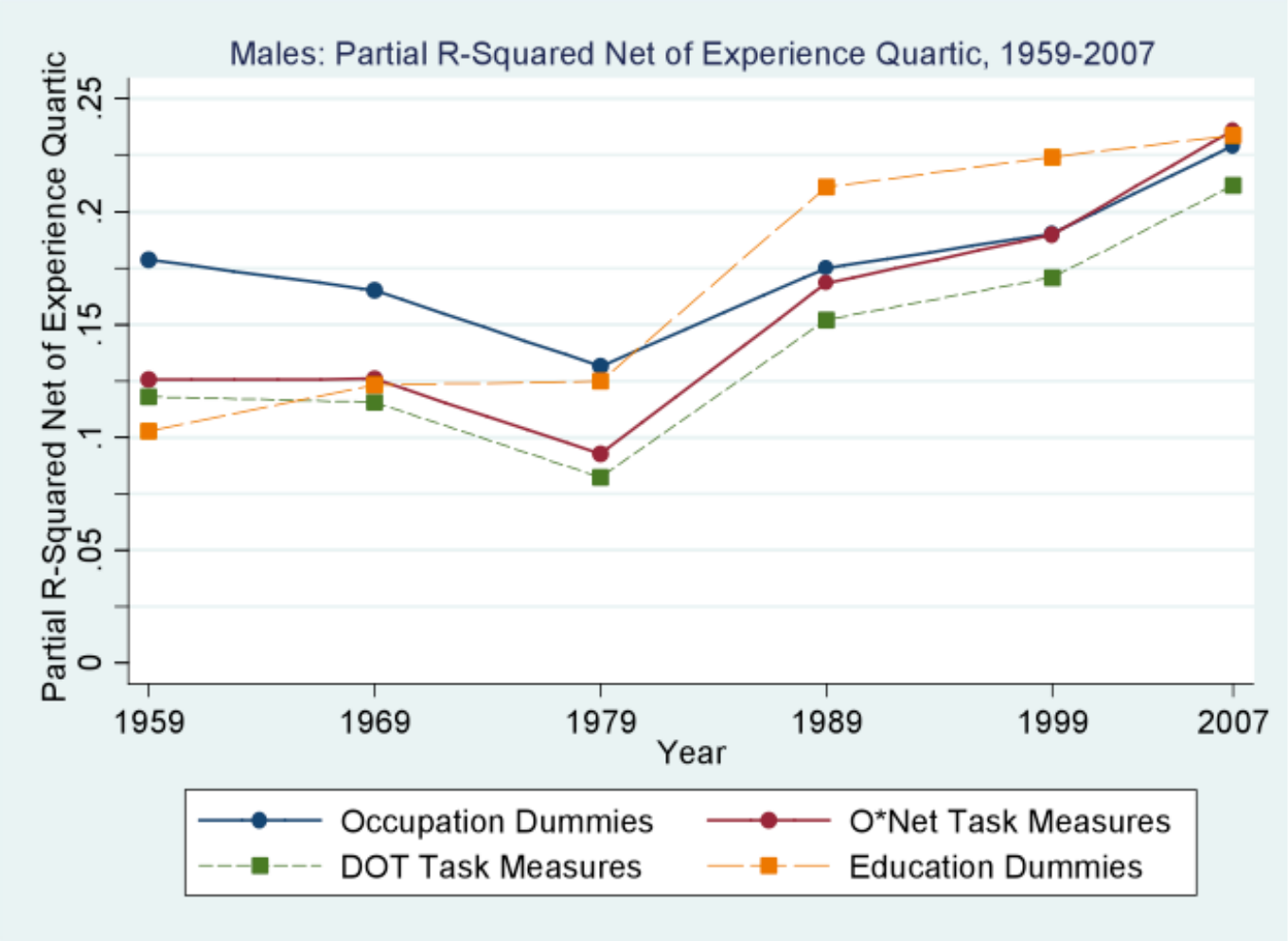
U.S. + Eurostat Data: 10 Countries, 1992-2008. Correlation(US, EU)=0.67



Rising importance of *occupation* as a predictor of earnings



Rising importance of *job tasks* as a predictor of earnings



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   - Directly skill-replacing technologies commonplace
   - Offshoring may function like a skill-replacing technology

Beyond the 'Canonical Model' of Skills and Wages

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What should an amended model offer?

Objectives

1. Explicit distinction between *skills* and *tasks*
   - Tasks—Unit of work activity that produces output
   - Skill—Worker's endowment of capabilities for performing various tasks
2. Allow for *comparative advantage* among workers in different tasks
   - Assignment of skills to tasks is *endogenous* (as in Roy, 1951)
3. Allow for multiple sources of competing task 'supplies'
   - Workers of different skill levels
   - Machines—Task can be routinized/automated
   - Offshoring—As per Grossman and Rossi-Hansberg (2008)
4. Incorporate at least three skill groups—To study polarization
5. Goal: well-defined set of skill demands, as in canonical model
6. Ability to endogenize task-biased technological change

A Ricardian Model of Skills, Tasks and Technologies

- Related models
  - Heckman and Sedlacek (1985)
  - Heckman and Scheinkman (1987)
  - Acemoglu and Zilibotti (2001)
  - Autor, Levy and Murnane (2003)
  - Gibbons, Katz, Lemieux, Parent (2005)
  - Grossman and Rossi-Hansberg (2008)
  - Autor and Dorn (2009)
  - Goos, Manning and Salomons (2009)
  - Costinot and Vogel (2010)
- Our model is *less* general than Costinot and Vogel, but quite broadly applicable

A Ricardian Model of Skills, Tasks and Technologies

Production technology: Tasks into goods

- Static environment with a single final good, Y
- Y produced with continuum of *tasks* on the unit interval, $[0, 1]$
- Cobb-Douglas technology mapping tasks to the final good:

$$\ln Y = \int_0^1 \ln y(i) di,$$

  where $y(i)$ is the "service" or production level of task i
- Price of the final good, Y, is numeraire

A Ricardian Model of Skills, Tasks and Technologies

Supply of skills to tasks

Three types of labor: High, Medium and Low

- Fixed, inelastic supply of the three types. Supplies are L, M and H
- Workers are homogeneous within groups
- Later introduce capital or technology (embedded in machines)

Each task i defined on the on continuum has linear production function

$$y(i) = A_L \alpha_L(i)\, l(i) + A_M \alpha_M(i)\, m(i) + A_H \alpha_H(i)\, h(i) + A_K \alpha_K(i)\, k(i),$$

- Inputs are perfect substitutes
- A terms are factor-augmenting technologies
- $\alpha_L(i)$, $\alpha_M(i)$ and $\alpha_H(i)$ are *task productivity schedules*
- For example, $A_L \alpha_L(i)$ is the productivity of low skill workers in task i, and $l(i)$ is the number of low skill workers allocated task i

A Ricardian Model of Skills, Tasks and Technologies

Role of comparative advantage

- All tasks can be performed by low, medium or high skill workers

$$y(i) = A_L \alpha_L(i)\, l(i) + A_M \alpha_M(i)\, m(i) + A_H \alpha_H(i)\, h(i) + A_K \alpha_K(i)\, k(i)$$

- *But comparative advantage by skill differs via* $\alpha_L(i)$, $\alpha_M(i)$, $\alpha_H(i)$

Comparative advantage schedule

- **Assumption:** $\alpha_L(i)/\alpha_M(i)$ *and* $\alpha_M(i)/\alpha_H(i)$ *are continuously differentiable and strictly decreasing:* $\dfrac{\alpha_L(i)}{\alpha_M(i)} \downarrow i$; $\dfrac{\alpha_M(i)}{\alpha_H(i)} \downarrow i$
- Higher indices correspond to "more complex" tasks
- In all tasks, H has absolute advantage relative to M, M has absolute advantage relative to L
- But *comparative advantage* determines task allocations

A Ricardian Model of Skills, Tasks and Technologies

Consider an equilibrium without capital: $\alpha_k(\cdot) = 0$

Equilibrium objects: Task thresholds, I_L, I_H

- In any equilibrium there exist I_L and I_H such that $0 < I_L < I_H < 1$ and for any $i < I_L$, $m(i) = h(i) = 0$, for any $i \in (I_L, I_H)$, $l(i) = h(i) = 0$, and for any $i > I_H$, $l(i) = m(i) = 0$

Allocation of tasks to skill groups determined by I_H, I_L

- Tasks $i > I_H$ will be performed by high skill workers (Abstract)
- Tasks $i < I_L$ will be performed by low skill workers (Manual)
- Middle tasks $I_L \leq i \leq I_H$ will be performed by medium skill workers (Routine)

Boundaries of these sets are determined by the model

- Given skill supplies, firms (equivalently workers) decide which skills perform which tasks $\rightarrow$ *Substitution of skills across tasks*

Solving the model

- As workers are homogenous within each group:

$$W_L(i) = p(i)A_L\alpha_L(i) = p(i')A_L\alpha_L(i') = W_L(i') = W_L$$
$$\Rightarrow p(i)\alpha_L(i) = p(i')\alpha_L(i') = P_L$$

- Similar expressions for M and H
- From cost minimization $\Rightarrow p(i)y(i) = p(i')y(i')$
- Taking logs and integrating over i' get $p(i)y(i) = P_y Y = Y$, using $P_Y = 1$

Solving the model

$$\overbrace{p(i)\,\underbrace{\alpha_L(i)\,l(i)}_{y(i)}}^{P_L} = \overbrace{p(i')\,\underbrace{\alpha_L(i')\,l(i')}_{y(i')}}^{P_L}$$

$$\Rightarrow l(i) = l(i')$$

$$l(i) = \frac{L}{I_L} \text{ for } i < I_L$$

and by analogous reasoning:

$$m(i) = \frac{M}{I_H - I_L} \text{ and}$$

$$h(i) = \frac{H}{1 - I_H}$$

Equilibrium Task Thresholds: No Arbitrage Across Skill Groups

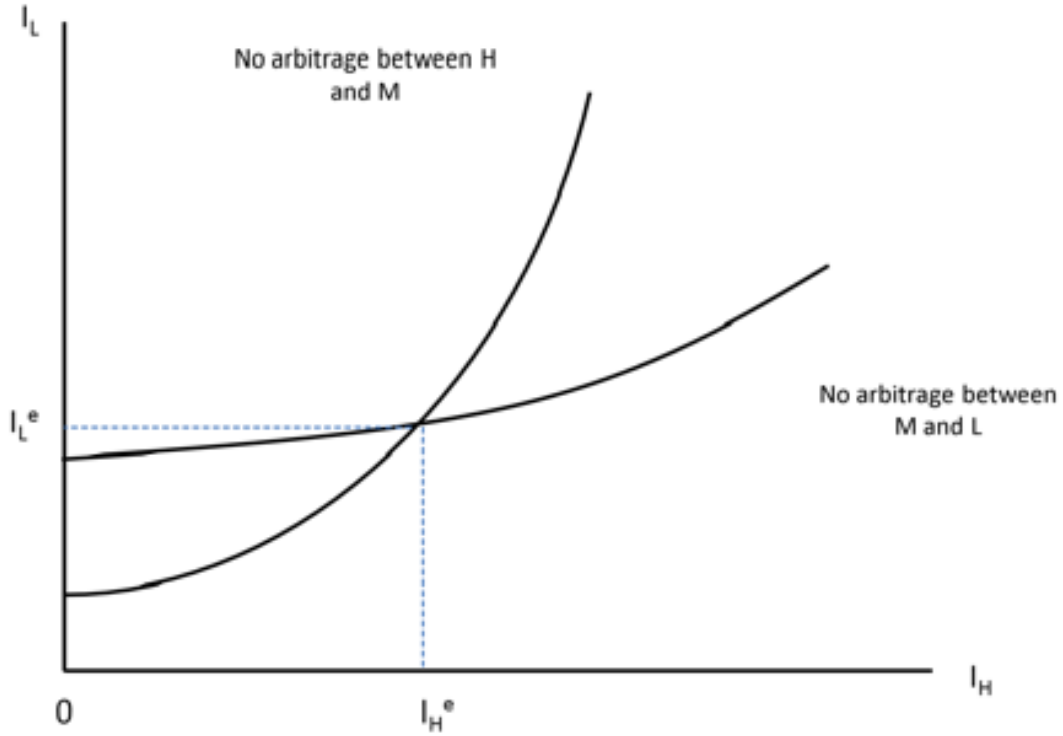
Notice that for task $i = I_H$ high and medium skill workers are equally productive and so are medium and low skill workers at $i = I_L$ we get:

No arbitrage between H and M: $$\frac{A_H \alpha_M(I_H) M}{I_H - I_L} = \frac{A_H \alpha_H(I_H) H}{1 - I_H}$$

No arbitrage between M and L: $$\frac{A_L \alpha_L(I_L) L}{I_L} = \frac{A_M \alpha_M(I_L) M}{I_M - I_L}$$

Equilibrium Task Thresholds: No Arbitrage Across Skill Groups

Figure 22. Determination of Equilibrium Threshold Tasks



Relative wages in the Ricardian model

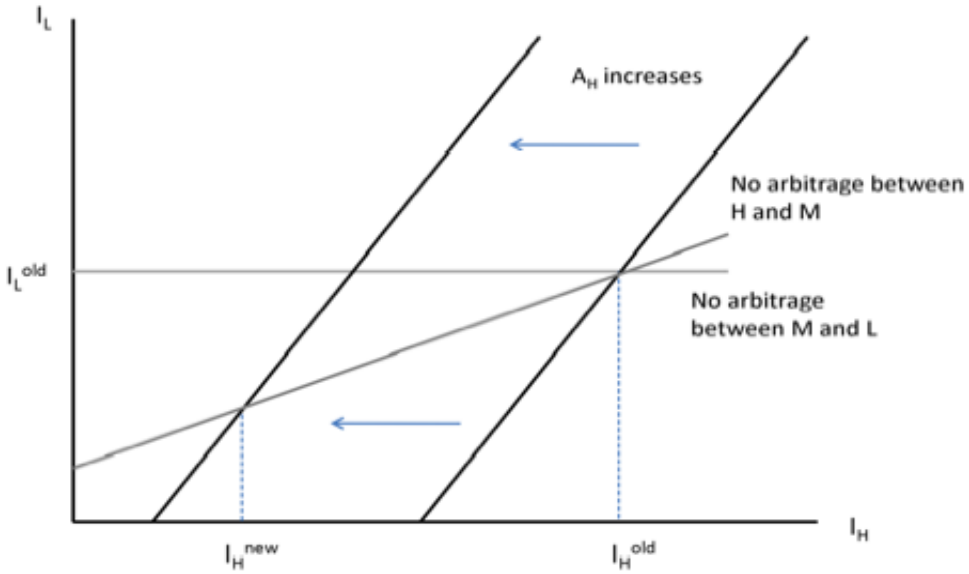
- Relative wages solely a function of labor supplies and task thresholds

$$\frac{w_H}{w_M} = \left(\frac{1 - I_H}{I_H - I_L}\right)\left(\frac{H}{M}\right)^{-1},$$
$$\frac{w_M}{w_L} = \left(\frac{I_H - I_L}{I_L}\right)\left(\frac{M}{L}\right)^{-1}$$

- So, labor supplies L, M, H plus comparative advantage schedules $\alpha(L)$, $\alpha(M)$, $\alpha(L)$ determine task allocation, I_L and I_H, and hence wages

Skill-biased Technical Change: A Rise in $A(H)$

Figure 25. Comparative Statics



- Rise in productivity of H workers broadens their task set, lowers I_H
- Squeezes M workers (excess supply of M) so I_L also falls

Some Key Comparative Statics

Consider a rise in A_H (SBTC):

- Increase share of tasks done by H
- Raises W_H/W_M and W_H/W_L
- Lowers W_M/W_L! Why? Because H and M are closer substitutes than H and L

Consider a rise in high-skilled labor supply H:

- Increase share of tasks done by H
- *Lowers* W_H/W_M and W_H/W_L
- Lowers W_M/W_L (Rise in A_H is isomorphic to rise in H)

Identical comparative statics for rise in A_L or L

Change in productivity or supply of middle-skill workers

Subtle effects

What happens when either M or A_M rises?

- Depends critically on this term:

$$\left|\beta_L'(I_L)\, I_L\right| \gtreqless \left|\beta_H'(I_H)\,(1-I_H)\right|$$

- $\beta_H(I) \equiv \ln \alpha_M(I) - \ln \alpha_H(I) \qquad \beta_L(I) \equiv \ln \alpha_L(I) - \ln \alpha_M(I)$
- β_H and β_L measure the *comparative advantage* of L versus H workers in M tasks
- If $\beta_L'(I_L)$ is low relative to $\beta_H'(I_H)$), high skill workers have *strong comparative advantage* for tasks above I_H

Hence, rise in M displaces L workers more than H iff:

$$\frac{d \ln (w_H / w_L)}{d \ln M} > 0 \text{ iff } \left|\beta_L'(I_L)\, I_L\right| < \left|\beta_H'(I_H)\,(1-I_H)\right|$$

- Implicitly I_L falls more than I_H rises

How Technology Enters

Easy to model a 'task replacing technology'

- Both K and Labor can supply tasks (all are perfect substitutes)
- K will supply task if can accomplish more cheaply than L, M, or H

Example: Routine Task Replacing technology

- Capital that out-competes M in a subset of tasks i' in the interval $I_L < i' < I_H$

Own wage effects

- Immediately lowers wage of M by narrowing set of M tasks

Cross-price effects on W_L and W_H?

- Again depend on $|\beta'_L(I_L)\, I_L| \gtreqless |\beta'_H(I_H)\,(1 - I_H)|$
- If M workers better suited to L than H tasks, then W_H / W_L rises

Routine Task Replacing Technology

Focal case

- Task replacing technology concentrated in middle-skill/routine tasks
- Strong comparative advantage of H relative to L at respective margins with M

Leads to wage and employment 'polarization'

1. Wages:
   - Middle wages fall relative to top and bottom.
   - Top rises relative to bottom
2. Employment:
   - Middle-skill/routine tasks mechanized
   - Declining labor input in routine tasks
   - Given comparative advantage, middle-skill workers move disproportionately downward in task distribution

Offshoring

Offshoring works identically to capital that competes for tasks

- In this sense, model is like that of Grossman and Rossi-Hansberg (2008)
- But the comparative advantage setup here is more general (plausible)

First extension

Endogenous choice of skills

- Factor augmenting technical change (or introduction of skill substituting capital) will affect wages inducing a response in the supplies of skills (e.g. medium skill workers may start supply low skills)
- Workers can have a bundle of l, m, and h skills
- When comparative advantage of one skill sufficiently eroded, may switch skills
- Example: Former manager, now driving delivery truck

Endogenous choice of skills

- Assume that each worker j is endowed with some amount of "low skill," "medium skill," and "high skill," respectively l_j, m_j and h_j
- Workers have one unit of time, which is subject to a skill allocation constraint

$$t_l^j + t_m^j + t_h^j \leq I$$

- The workers income is

$$w_L t_l^j l^j + w_M t_m^j m^j + w_H t_h^j h^j,$$

- The worker with skill vector (l_j, m_j, h_j) will have to allocate his time between jobs requiring different types of skills

Endogenous choice of skills

- Aggregate amount of skills of different types:

$$L = \int_{j \in E_l} l^j dj, \quad M = \int_{j \in E_m} m^j dj, \quad H = \int_{j \in E_h} h^j dj,$$

  E_l, E_m and E_h are the sets of workers choosing to supply their low, medium and high skills respectively

- The worker will choose to be in the set E_h only if:

$$\frac{l^j}{h^j} \leq \frac{w_H}{w_L} \quad \text{and} \quad \frac{m^j}{h^j} \leq \frac{w_H}{w_M}$$

Endogenous choice of skills

- We impose a type of *single-crossing* assumptions in supplies: h^j / m^j and m^j / l^j are both strictly decreasing in j and $\lim_{j \to 0} h^j / m^j$ and $\lim_{j \to 1} m^j / l^j = 1$
- This assumption implies that lower index workers have a comparative advantage in high skill tasks and higher index workers have a comparative advantage in low skill tasks

Endogenous choice of skills

- *For any ratios of wages w_H/w_M and w_M/w_L:*
  - *there exist $J^*(w_H/w_M)$ and $J^{**}(w_M/w_L)$ such that:*
    1. $t_h^j = 1$ *for all* $j < J^*(w_H/w_M)$;
    2. $t_m^j = 1$ *for all* $j \in (J^*(w_H/w_M)J^{**}(w_M/w_L))$;
    3. $t_l^j = 1$ *for all* $j > J^{**}(w_M/w_L)$
  - $J^*(w_H/w_M)$ and $J^{**}(w_M/w_L)$ are both strictly increasing in their arguments
- $J^*(w_H/w_M)$ and $J^{**}(w_M/w_L)$ are defined such that

$$\frac{m^{J^*(w_H/w_M)}}{h^{J^*(w_H/w_M)}} = \frac{w_H}{w_M} \text{ and } \frac{l^{J^{**}(w_M/w_L)}}{m^{J^{**}(w_M/w_L)}} = \frac{w_M}{w_L}$$

Endogenous choice of skills

- Therefore:

$$H = \int_0^{J^*(w_H/w_M)} h^j dj, \qquad M = \int_{J^*(w_H/w_M)}^{J^{**}(w_M/w_L)} m^j dj \quad \text{and}$$
$$L = \int_{J^{**}(w_M/w_L)}^{I} l^j dj$$

Endogenous choice of skills

- $J^*(w_H/w_M)$ and $J^{**}(w_M/w_L)$ are both strictly increasing in their arguments

$$\frac{H}{M} = \frac{\int_0^{J^*(w_H/w_M)} h^j dj}{\int_{J^*(w_H/w_M)}^{J^{**}(w_M/w_L)} m^j d_J} \quad \text{and} \quad \frac{M}{L} = \frac{\int_{J^*(w_H/w_M)}^{J^{**}(w_M/w_L)} m^j d_J}{\int_{J^{**}(w_M/w_L)}^{1} l^j dj} \tag{1}$$

- Therefore holding w_M/w_L constant, an increase in w_H/w_M increases H/L and holding w_H/w_M constant, an increase in w_M/w_L increases M/L

Second extension

Endogenous technical change

- Endogenous technical change favoring *skills* is well understood from Acemoglu (1998, 2007)
- We can also consider endogenous technical change *favoring tasks* in this model

Ricardian Model: Summary

Model's inputs

1. Explicit distinction between *skills* and *tasks*
2. Allow for *comparative advantage* among workers in different tasks
3. Allow for multiple sources of competing task 'supplies'

What the model delivers

- A natural concept of occupations (bundles of tasks)
- An endogenous mapping from skill to tasks via comparative advantage
- Technical change (offshoring) that can raise and *lower* wages
- Migration of skills across tasks as technology changes
- Polarization of wages and employment as *one possible outcome*

Where the Canonical Model is Silent (or Mis-speaks)

Can the Ricardian model rationalize these facts?

1. Wage inequality rises less than predicted
2. *Real wage levels fall* for some groups
3. Wage changes non-uniform in skill
4. Polarization of employment growth across high/low-skill occupations (also non-monotone)
5. Rising importance of *occupation* as a predictor of earnings
6. Casual empiricism only
   - Directly skill-replacing technologies commonplace
   - Offshoring may function like a skill-replacing technology

Beyond the 'Canonical Model' of Skills and Wages

Outline

1. The canonical model: Implications and empirical successes
2. Where the canonical models fall short
3. What should an amended model offer?
4. A Ricardian model of skills, tasks and technologies
5. *Some potential empirical directions*
6. Conclusions

Some potential empirical directions

Some loose observations only

- Model suggests that we want to relate technical change to prices of skills via *changes in comparative advantage*
  - Measuring comparative advantage is difficult, but not impossible
  - One idea is to look at patterns of occupational specialization from 'pre-period' as a measure
- More generally, model makes conceptual link btwn skills, tasks and occupations
  - Occupations *do not really exist* in standard competitive wage models
  - Here, they do exist. But there is *still a 'law of one price' for skill*

Conclusions

Canonical model has been a major conceptual and empirical success

- But does not shed light on some key phenomena of interest:
  - Falling real wages for some groups
  - Non-monotone wage changes
  - Polarization of employment
  - Reallocation of skill groups across occupations
  - Rising power of occupation as predictor of wages

Possible additional insights gained by

1. Distinguishing between *skills* and *tasks*
2. Allowing for *comparative advantage* among workers in different tasks
3. Allowing for multiple sources of competing task 'supplies'