WAGE INEQUALITY, SKILL DEMAND, & SKILL SUPPLY: RECENT EVIDENCE

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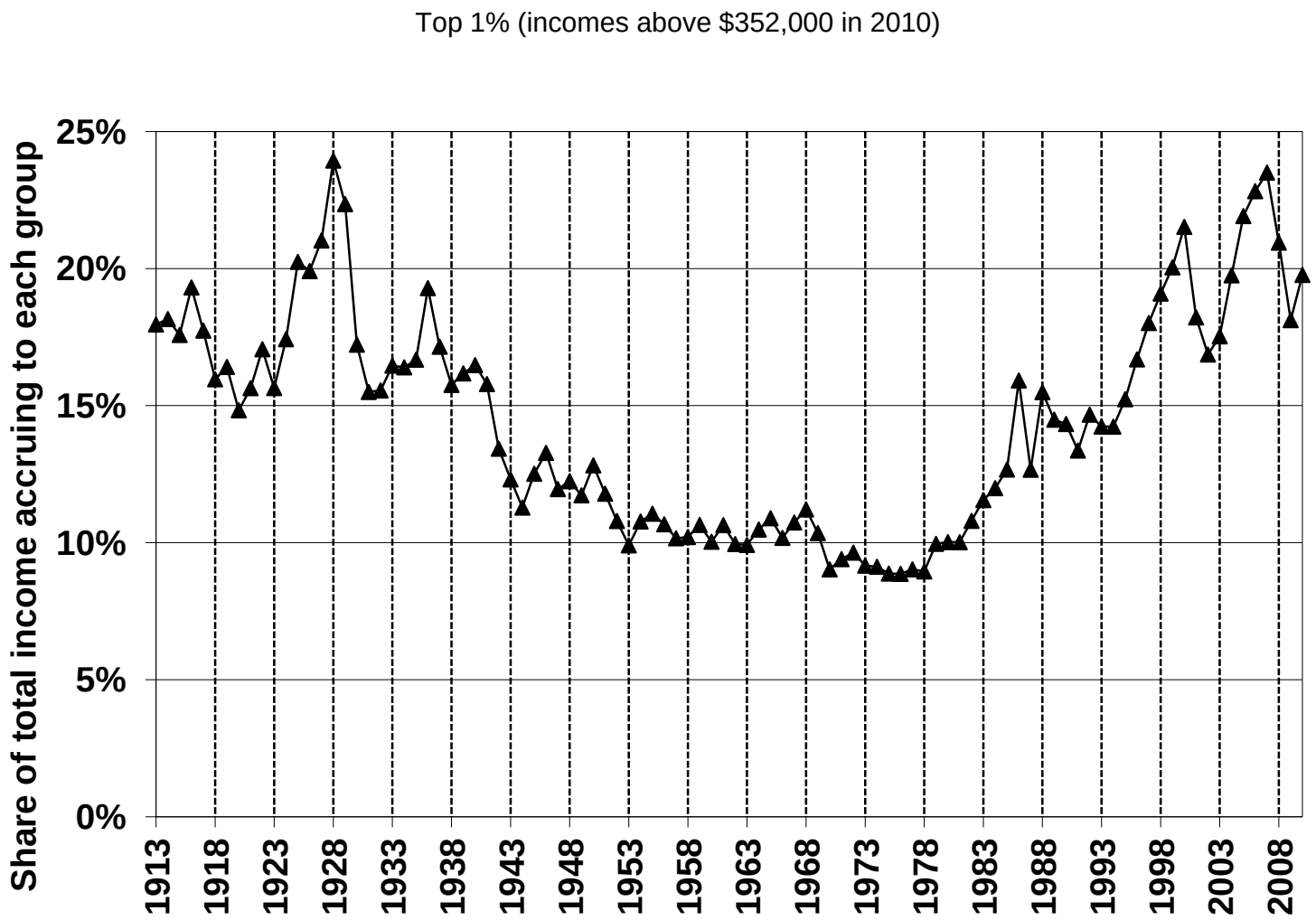
LSE

CENTRE *for* ECONOMIC PERFORMANCE

GREAT RECESSION BRINGS INEQUALITY BACK IN THE NEWS

TOP 1% SHARE OF ALL INCOME: US, 1913-2010

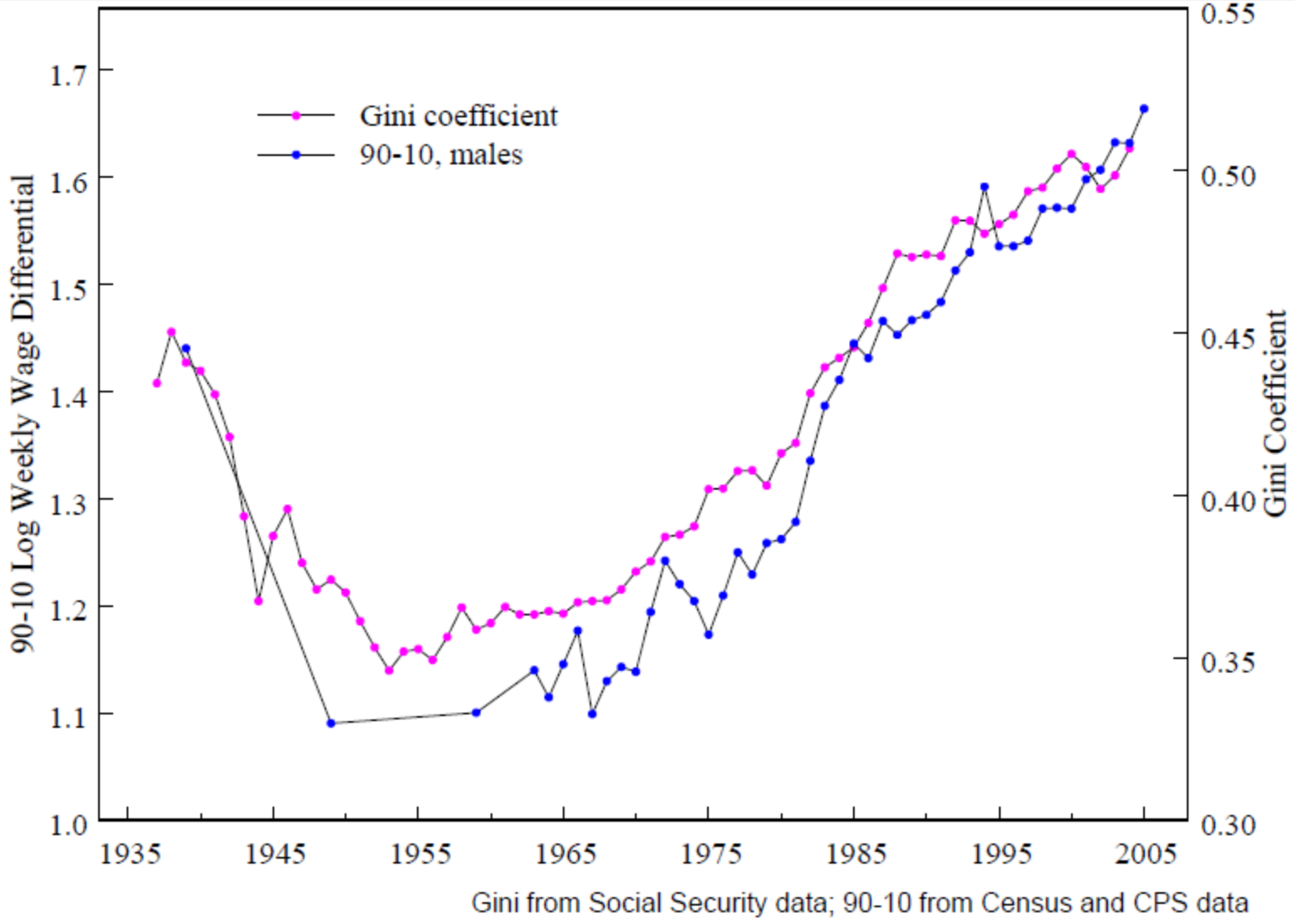


Source: Saez (2012) , http://elsa.berkeley.edu/~saez/

OUTLINE

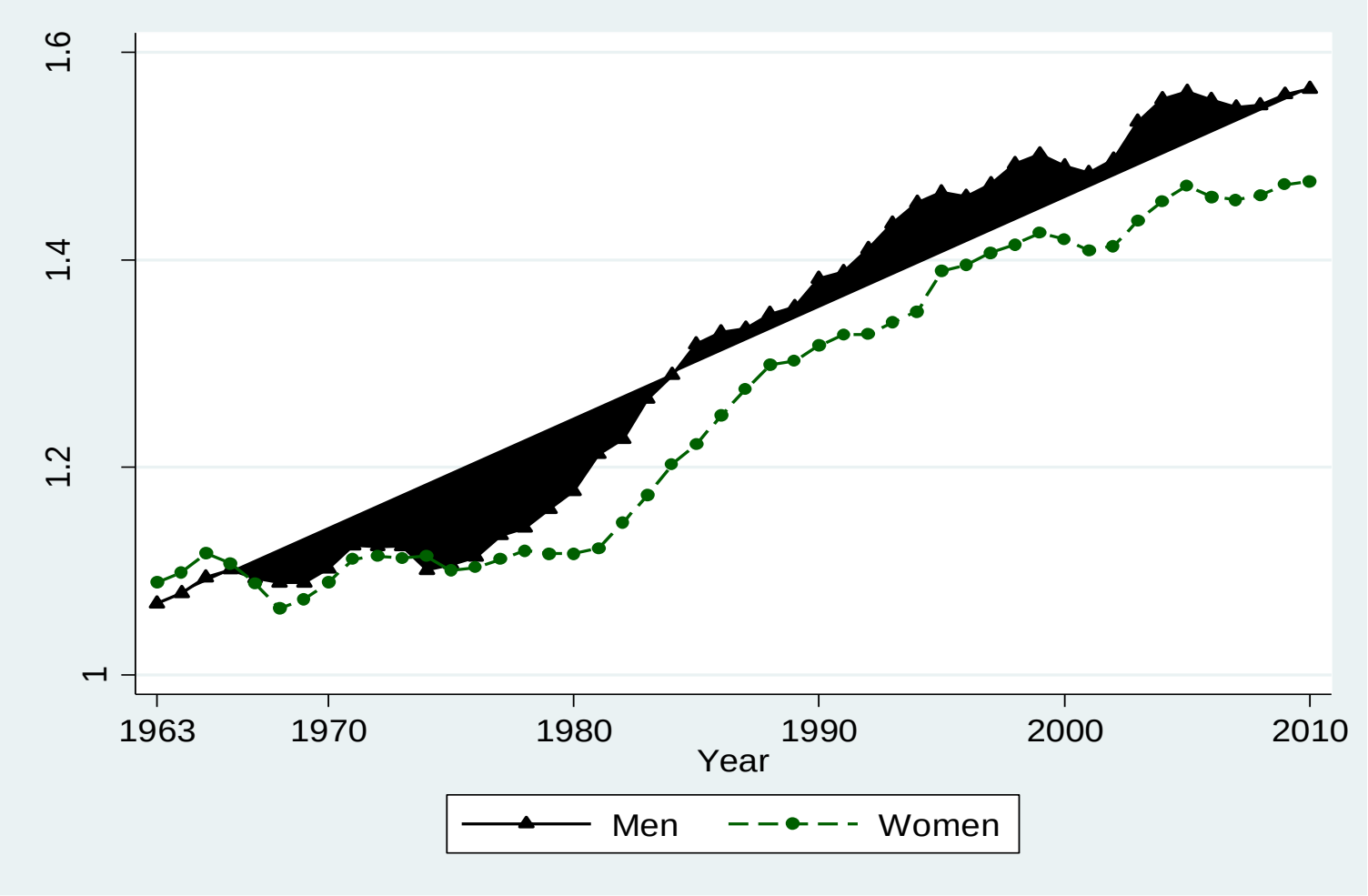
1. **Recent trends in Wages and Skills**
   - **Wage inequality**
   - **Skills**
   - **Polarization**
2. A framework for understanding the changes
3. Polarization and Technology
4. Trade Redux: Trade-induced technical change
5. Policy and future research

US MALE WAGE INEQUALITY, 1937-2005



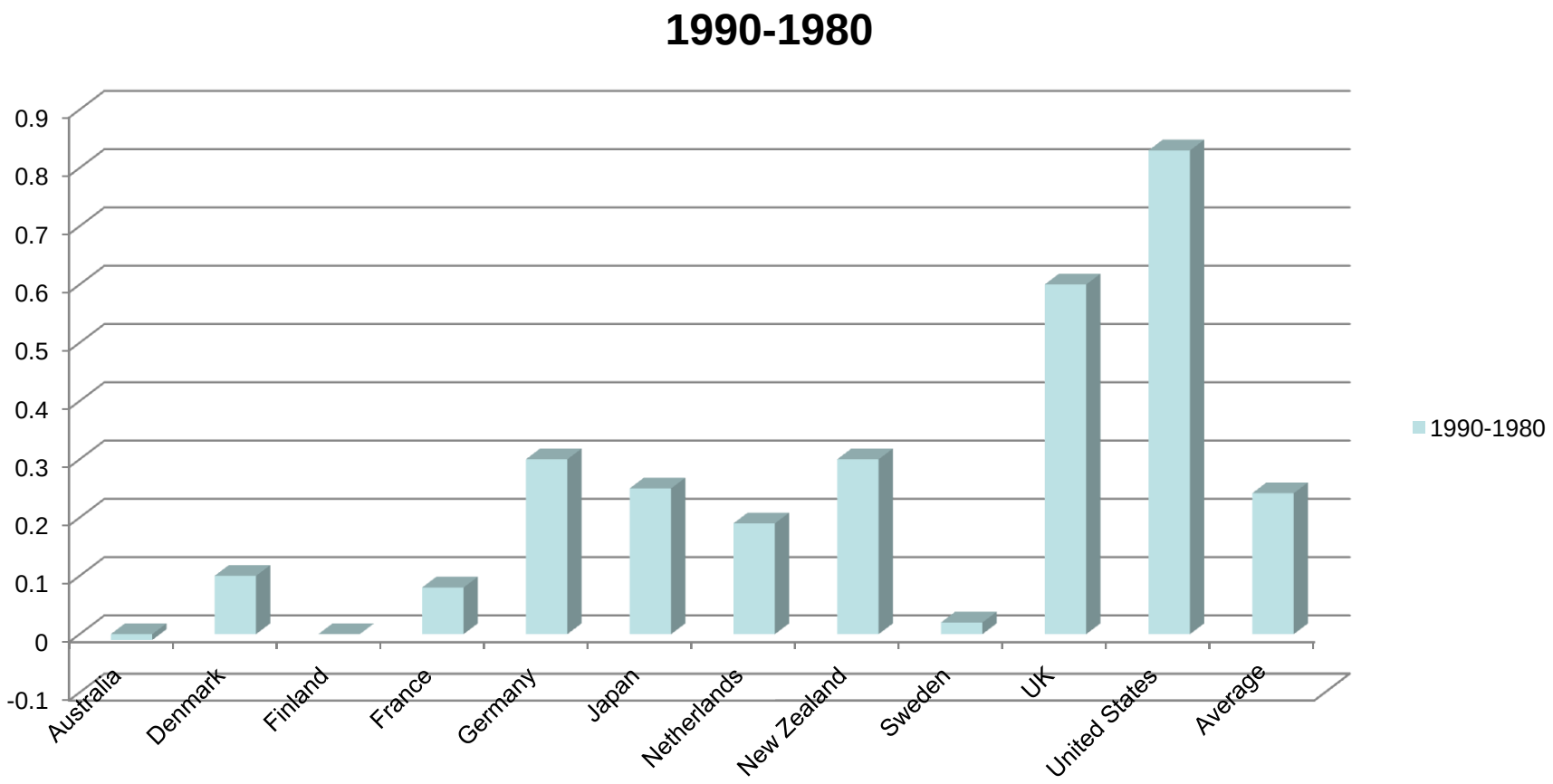
Source: Goldin and Katz (2008)

UK 90-10 LOG WEEKLY EARNINGS RATIOS, FULL-TIME, 1970-2010

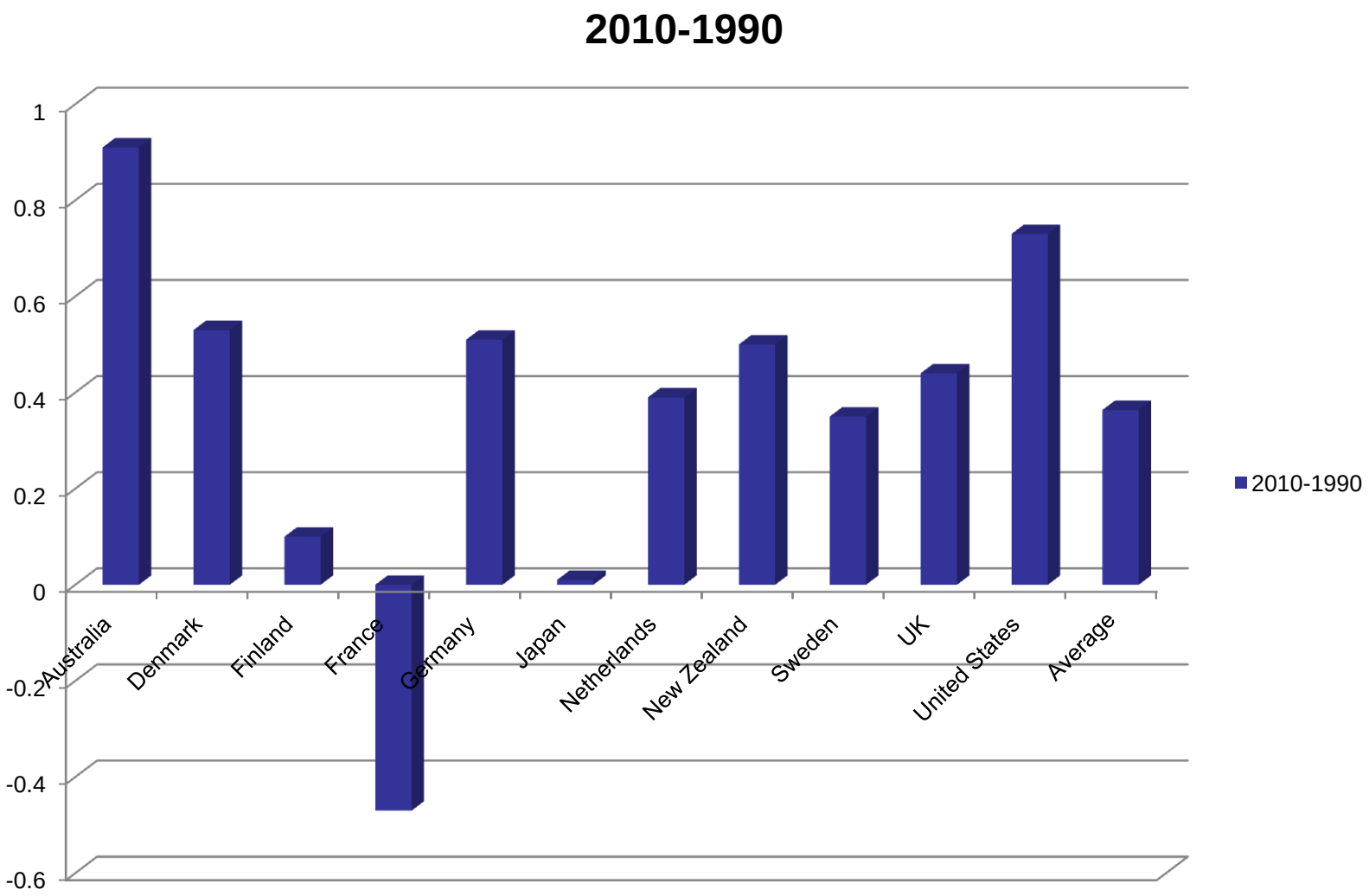


Notes: UK data, 1968-96 (NES) 1997-2010 (ASHE);

CHANGE IN MALE LN(WAGE) INEQUALITY (90-10) IN OECD IN 1980s: US & UK STAND OUT

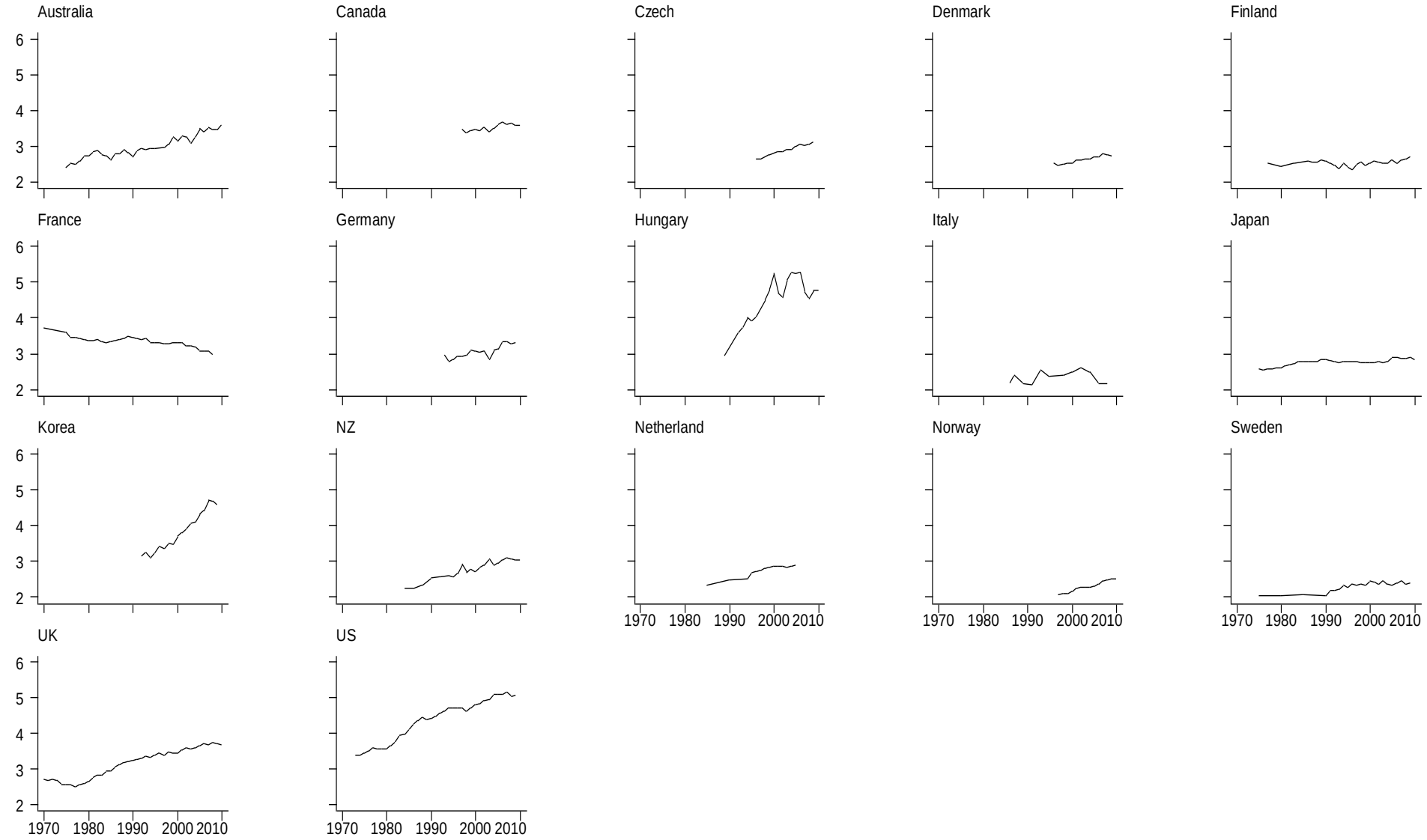


CHANGE IN MALE LN(WAGE) INEQUALITY (90-10) IN OECD AFTER 1990: MORE GENERAL INEQUALITY GROWTH



Source: OECD

Note: Netherlands has a break in series in 1993

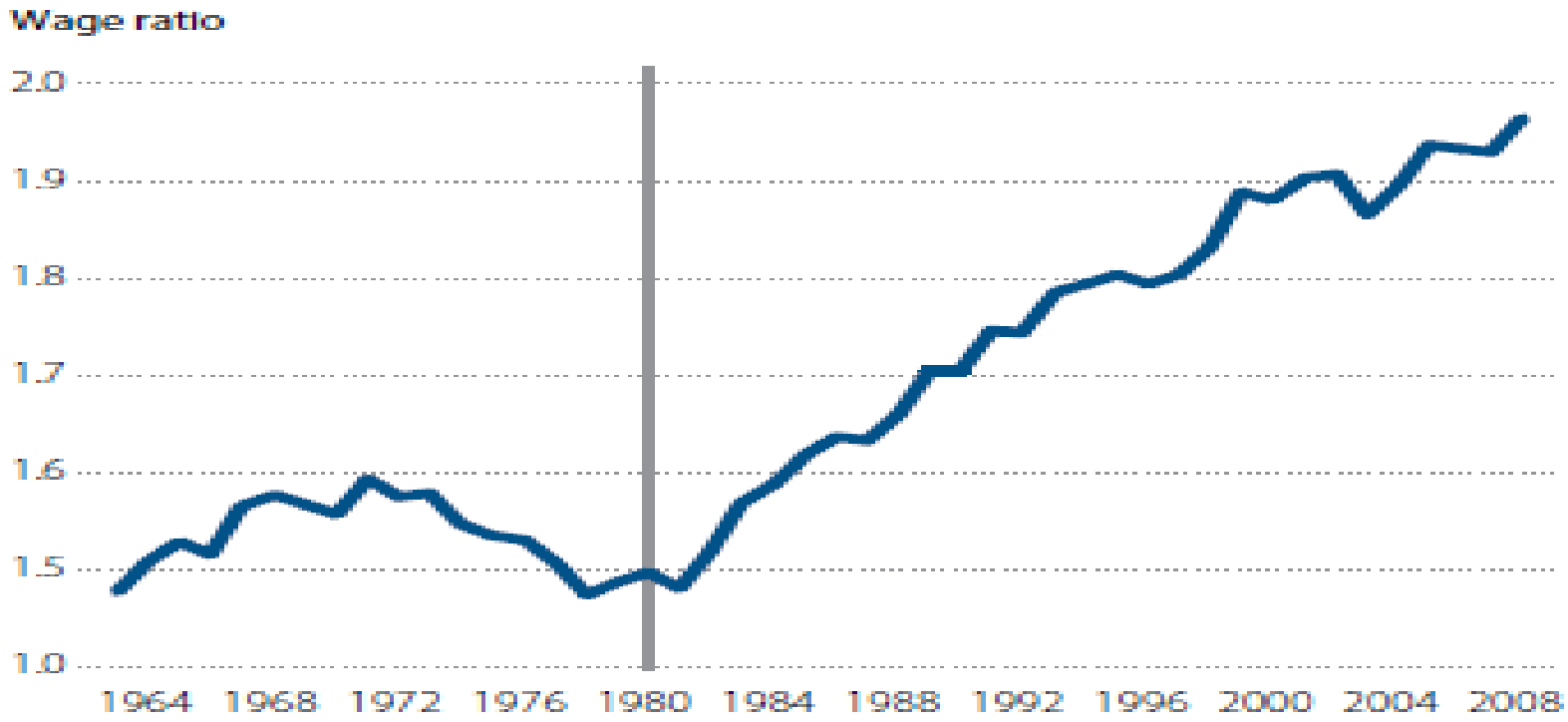


90-10 male ln(wage) differential, 1970-2011.
Rising wage inequality in most countries

SKILL DIFFERENTIALS

- **Education/skill differentials in wages are an important part of the reason for increased inequality**

COLLEGE DEGREE VS. HIGH SCHOOL DIPLOMA WEEKLY WAGE RATIO (COMPOSITION ADJUSTED) 1963-2008, US, ALL WORKERS



Source: Acemoglu & Autor (2011), March CPS, log(weekly wages) for full-time full year workers.
Notes: Series is adjusted for experience, race and gender (not unobservables).

SKILL DIFFERENTIALS

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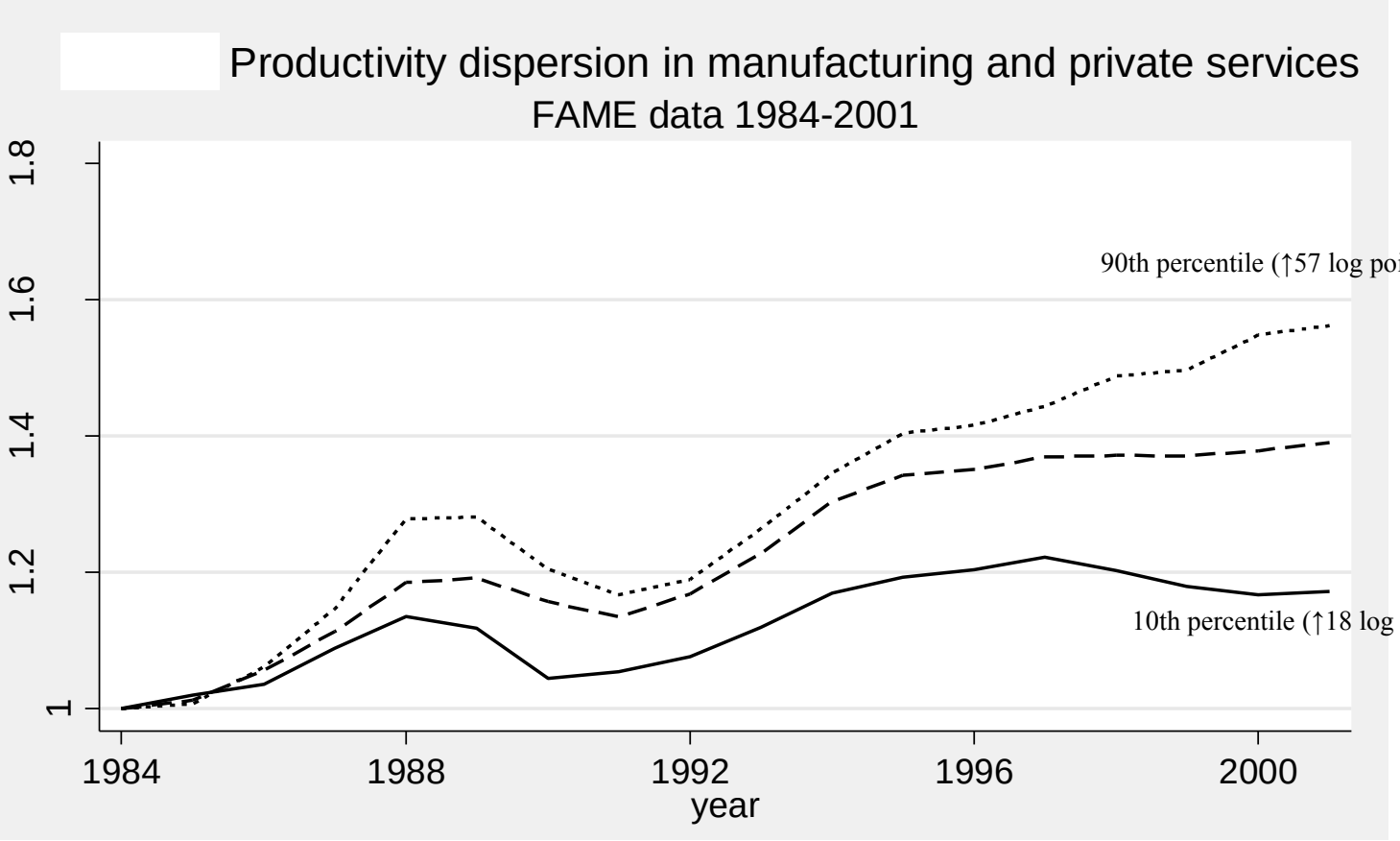
- **But not the whole story:**
  - Some within group inequality growth (e.g. Lemieux, 2006). Related to increase in firm productivity dispersion (Faggio, Van Reenen & Salvanes, 2010)

LIKE WAGES, A BIG INCREASE IN DISPERSION OF WITHIN SECTOR PRODUCTIVITY ACROSS UK FIRMS



Source: Faggio, Van Reenen & Salvanes (2010)

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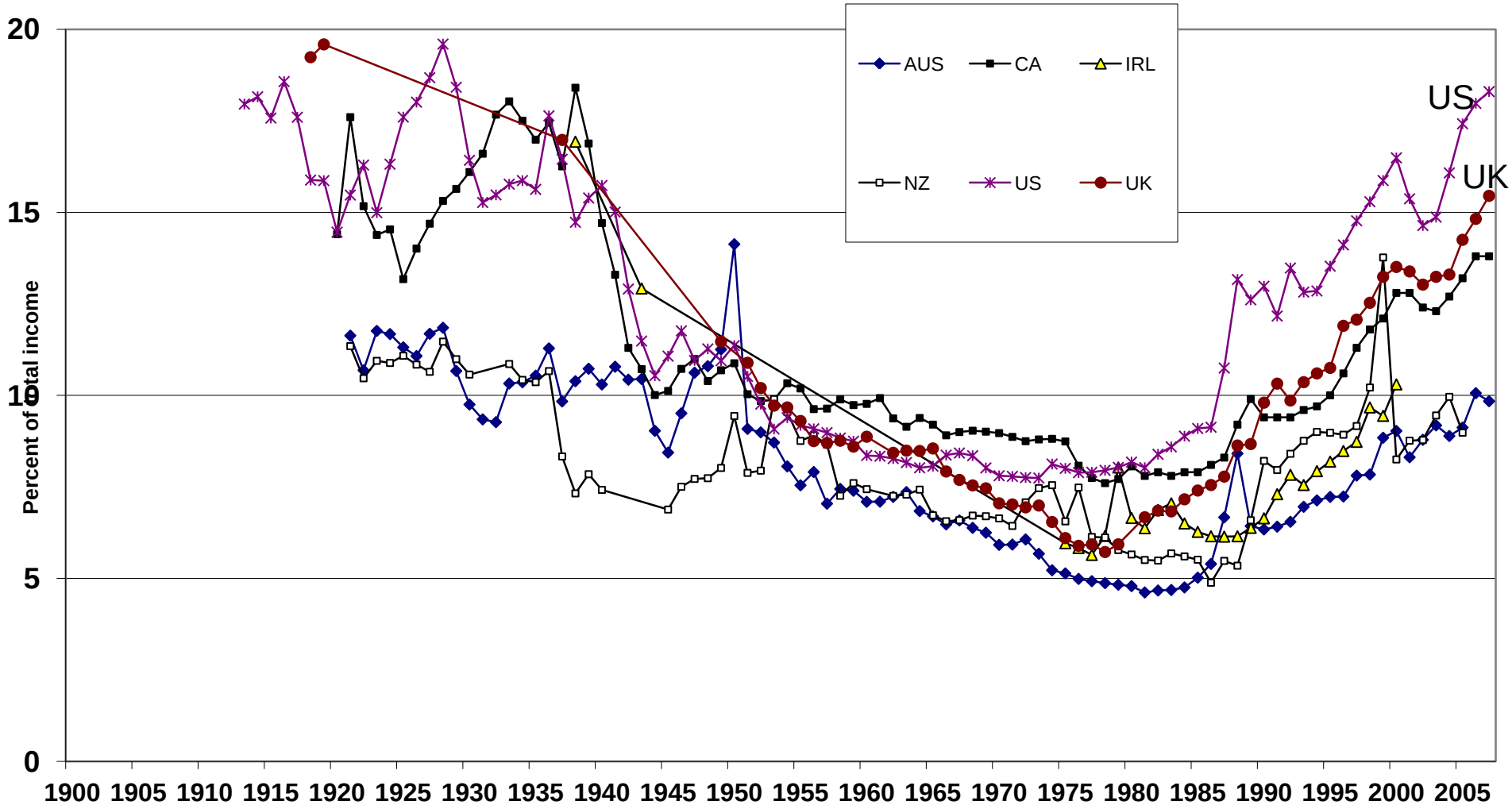
  - **And the very rich (1%) have pulled away from the rest (Atkinson et al, 2011) in some nations**

TOP 1% SHARE OF ALL INCOME: ENGLISH SPEAKING COUNTRIES, 1910-2007



Source: Atkinson (2010) update of Atkinson, Piketty & Saez (2009); see Bell & Van Reenen (2012) on role of Bonuses in the financial sector

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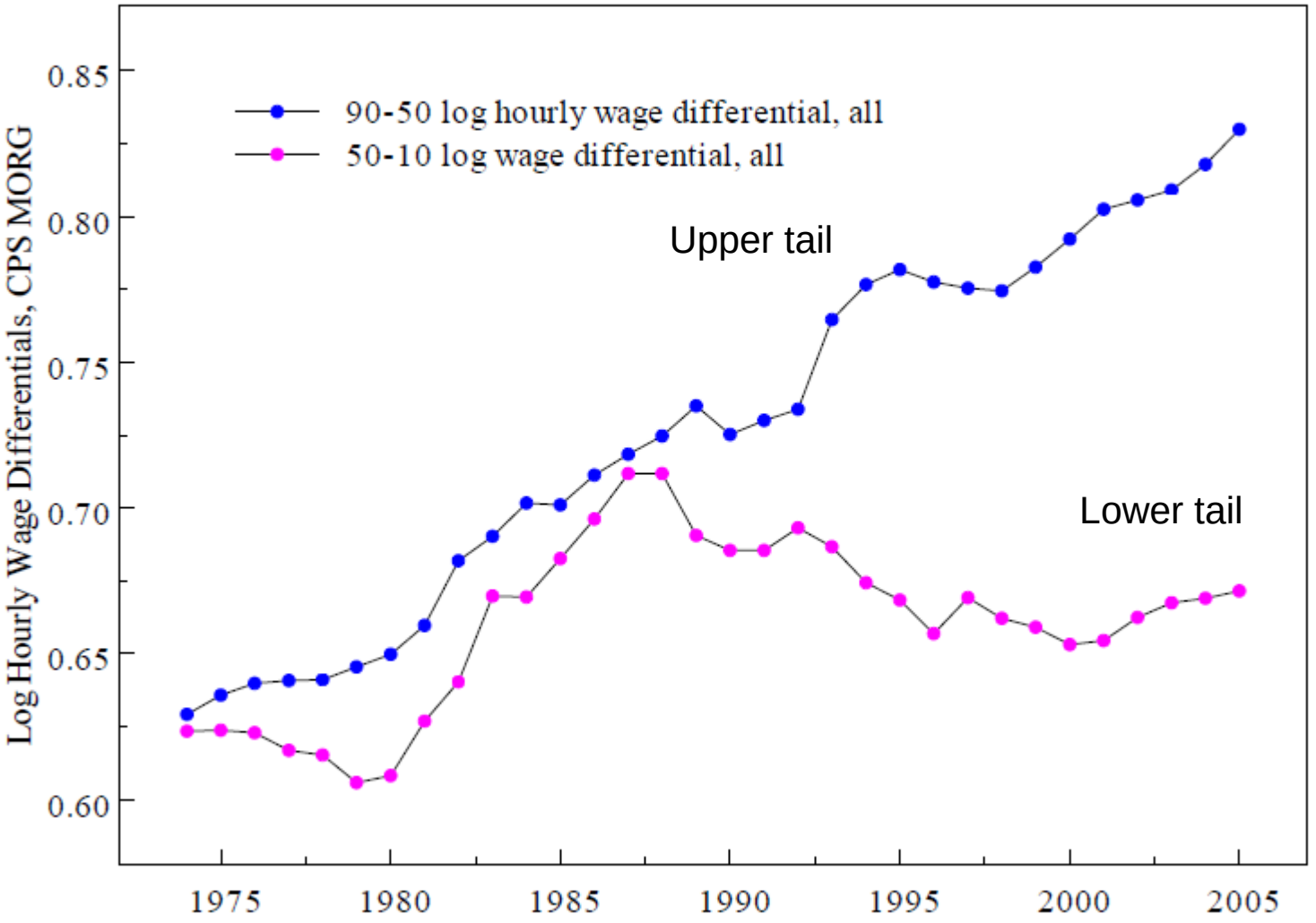
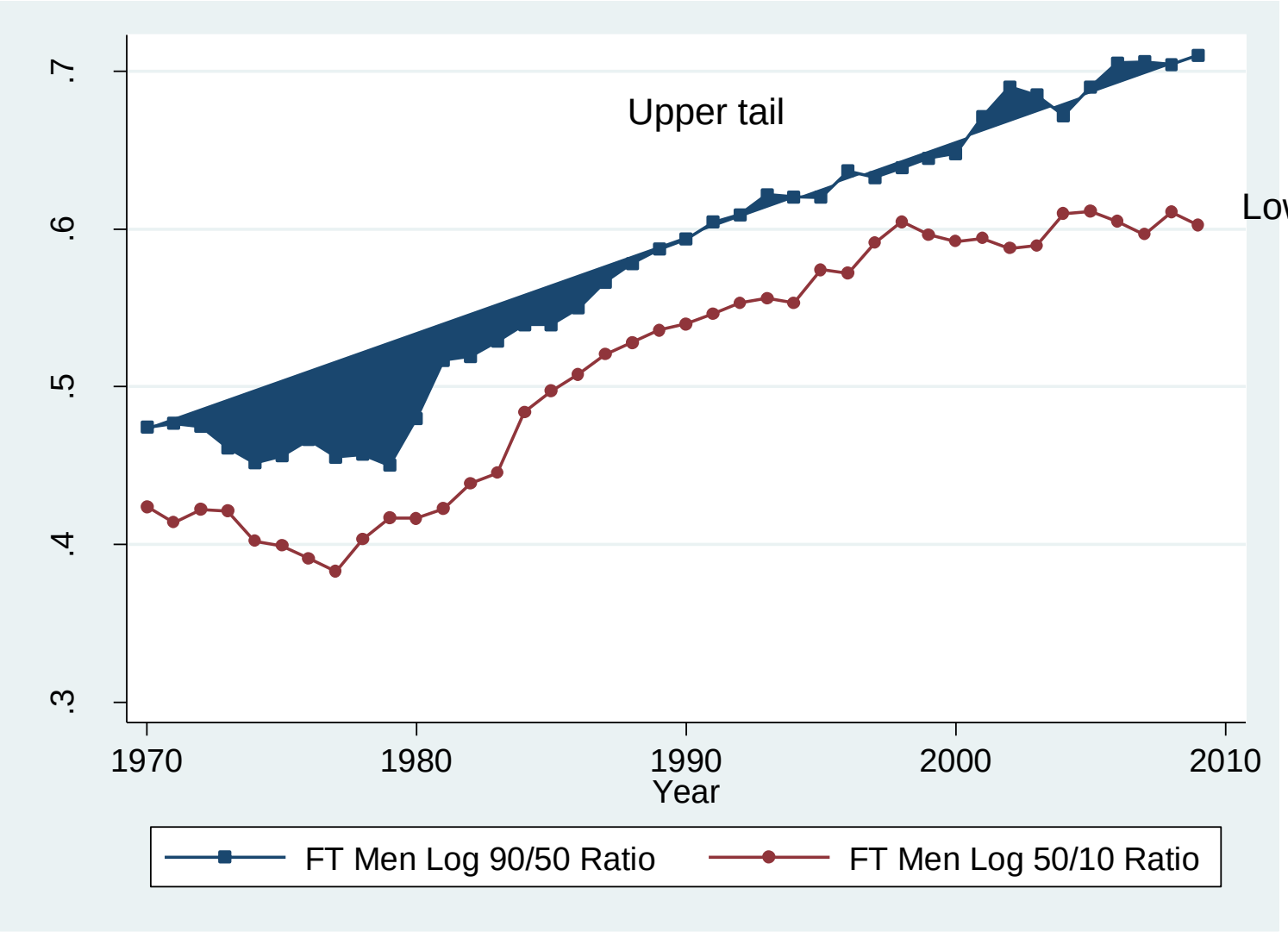
  - And the very rich (1%) have pulled away from the rest (Atkinson et al, 2011)
  - **Increase in transitory component of earnings shocks (Blundell & Preston, 1998; Meghir & Pistaferri, 2011)**
  - **Recent evidence on "polarization"....**

DIVERGENCE OF UPPER HALF (90-50 LOG HOURLY WAGE) & LOWER HALF (50-10) INEQUALITY, 1975-2005, US



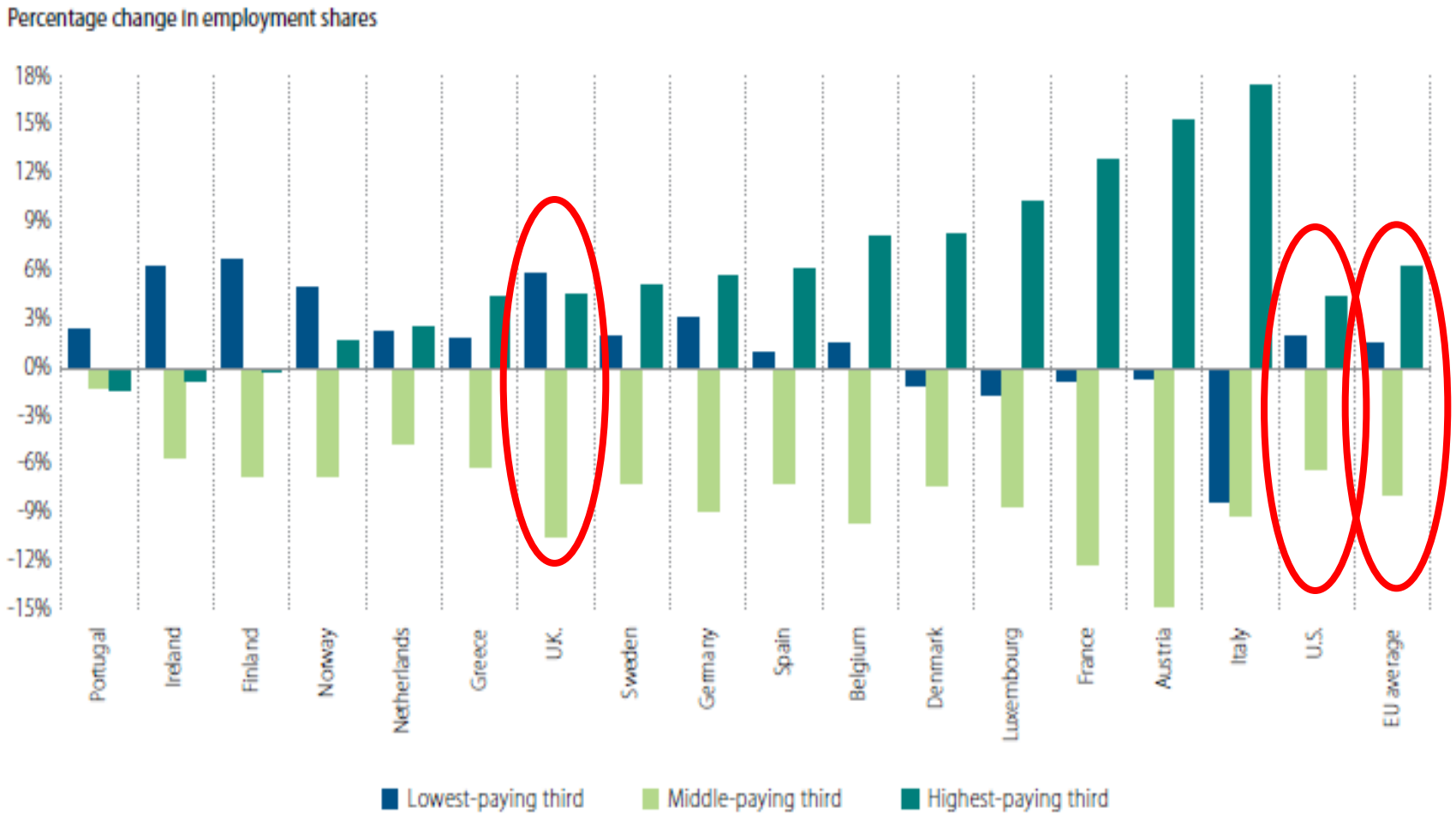
Note: US CPS MORG; **Source:** Goldin and Katz (2010)

DIVERGENCE OF UPPER (90-50 LOG EARNINGS) & LOWER HALF (50-10) INEQUALITY, FULL-TIME MEN, 1970-2009, UK



Source: NES/ASHE

CHANGE IN EMPLOYMENT SHARES BY OCCUPATION IN OECD OCCUPATIONS GROUPED BY WAGE TERCILE 1993-2006

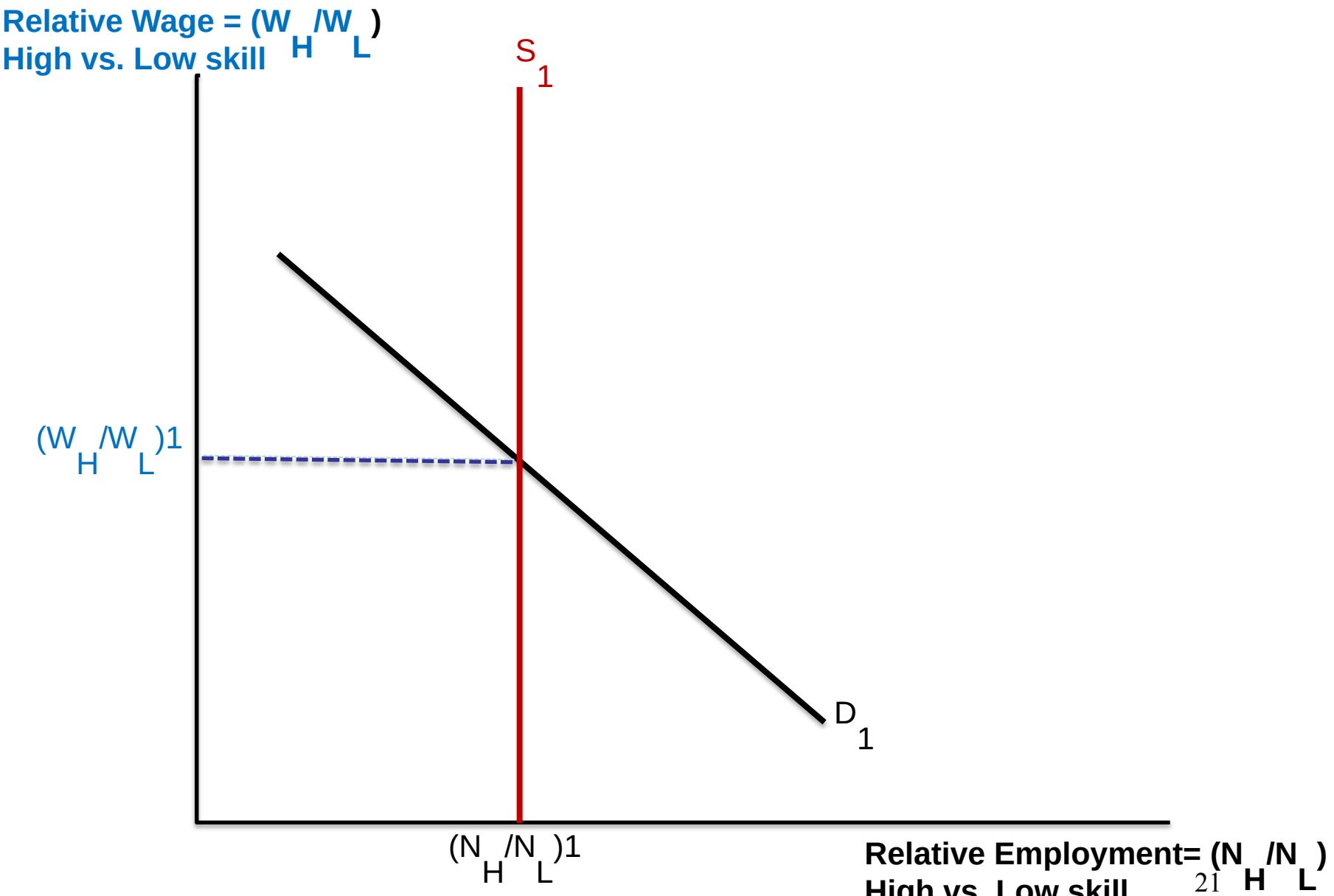


Source: Autor (2010) based on data in Goos, Manning & Salomons (2010)

OUTLINE

1. Recent trends in Wages and Skills
2. **A framework for understanding the changes**
3. Polarization and Technology
4. Trade Redux: Trade-induced technical change
5. Policy and future research

THE CANONICAL MODEL: SHIFT IN RELATIVE SUPPLY.....



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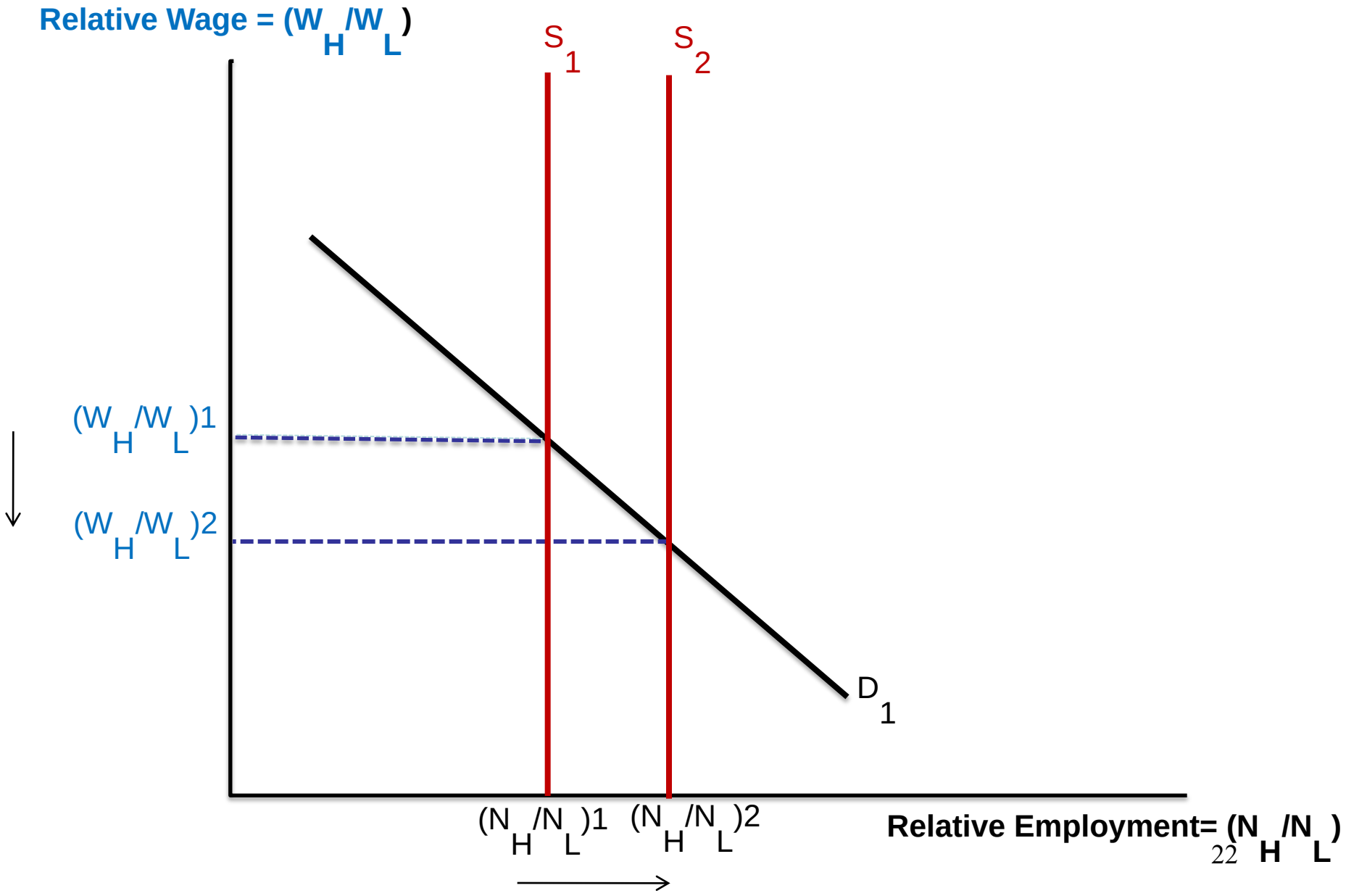
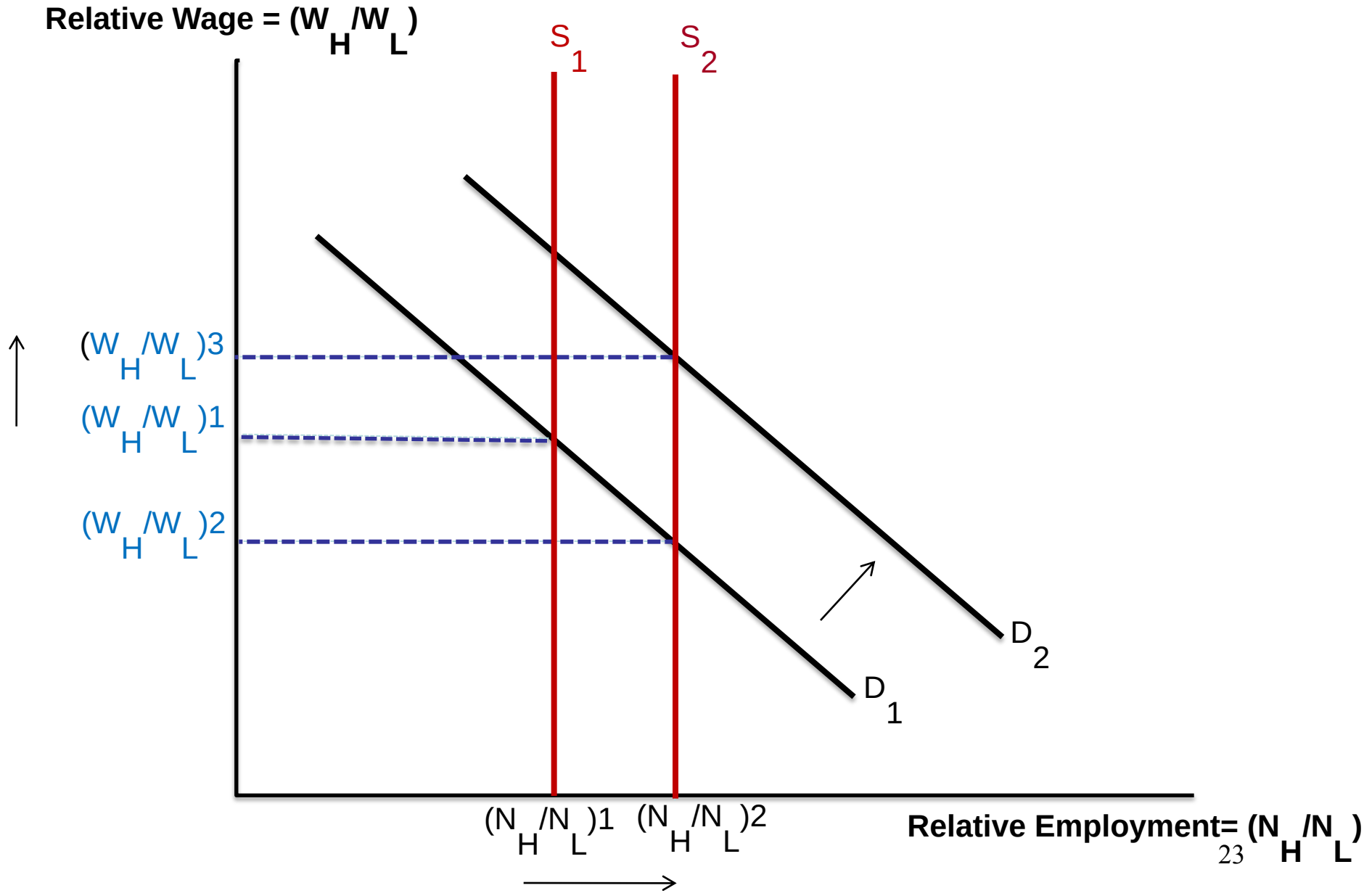


THE CANONICAL MODEL: SHIFT IN RELATIVE SUPPLY NEEDS SHIFT IN RELATIVE DEMAND TO RATIONALIZE INEQUALITY



THE CANONICAL MODEL: DETAILS

$$Y = \left[\lambda N_H^{\frac{\sigma-1}{\sigma}} + (1-\lambda) N_L^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

CES Production Function
skilled N_H and unskilled labor N_L

Competitive labor market at wages W_H and W_L

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$$\ln\left(\frac{W_H}{W_L}\right) = \ln\left(\frac{\lambda}{1-\lambda}\right) - \frac{1}{\sigma}\ln\left(\frac{N_H}{N_L}\right)$$

Combine First Order Conditions

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Combine First Order Conditions

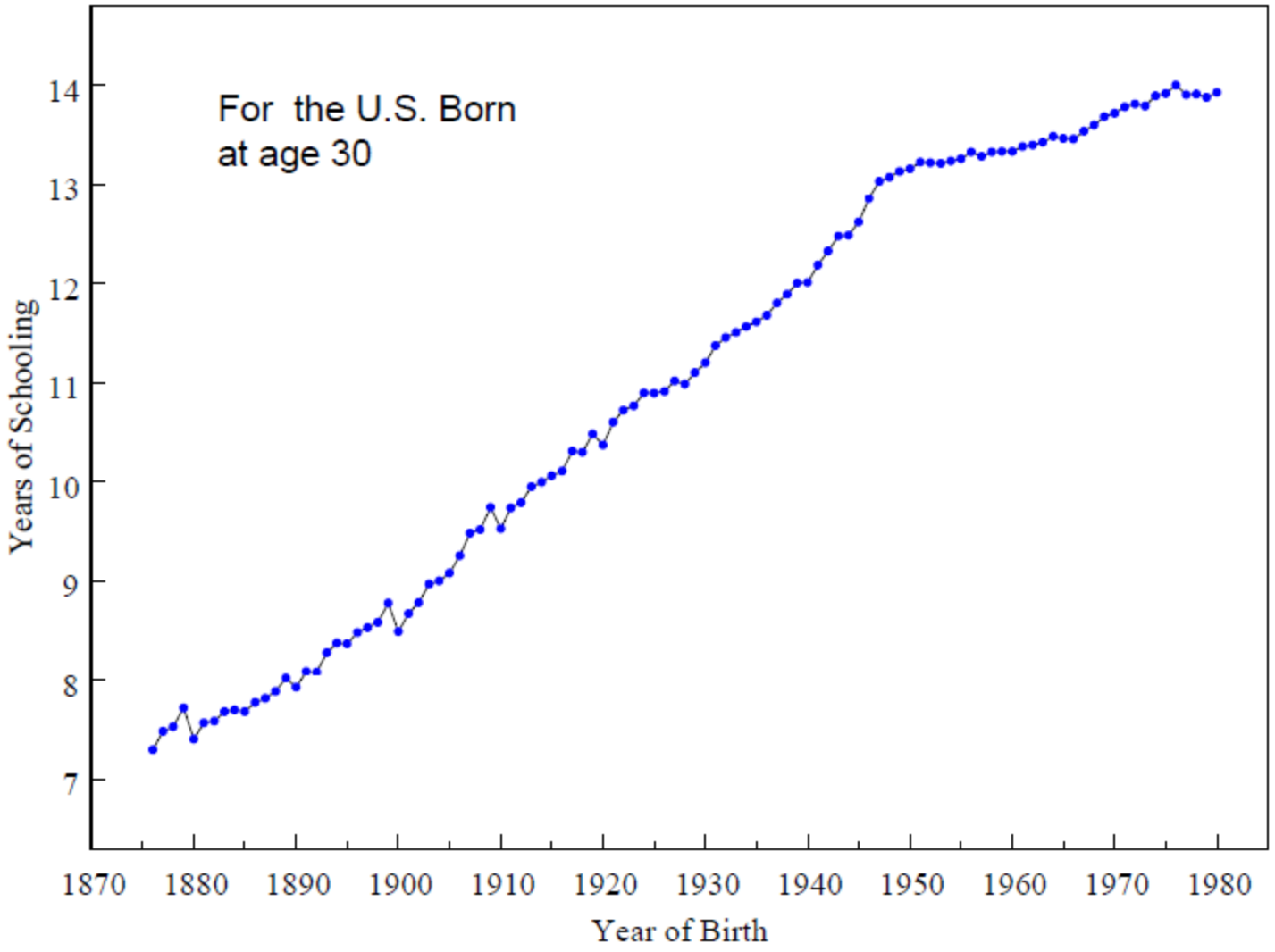
$$\ln\left(\frac{W_H}{W_L}\right) = \gamma_0 + \gamma_2 trend - \frac{1}{\sigma}\ln\left(\frac{N_H}{N_L}\right)$$

"Tinbergen" assumption of technology proxied by trend yields Katz-Murphy (1992) equation: Substitution elasticity ~1.4 & trend ~3.3% p.a.

WHAT CAUSES SHIFT IN RELATIVE DEMAND?

- Trade with developing countries? Discuss later.
- **Skill Biased Technical Change (SBTC)**
  - Technology measures (ICT, R&D) strongly correlated with demand growth for more skilled workers
  - US: Berman, Bound & Griliches (1994); Autor, Katz & Krueger (1998)
  - International: Machin and Van Reenen (1998).
- But SBTC is a long-run force through much of Twentieth Century (Goldin & Katz, 2008). Tinbergen's (1974) "Race between technology & education"
- The post 1980 US increase in skill premium related to a **deceleration** of the growth of education (Card & Lemieux, 2001, cohorts), not an **acceleration** in SBTC

MEAN YEARS OF SCHOOLING BY BIRTH COHORT



Source: Goldin & Katz (2010), IPUMs, MORG

PROBLEMS WITH CANONICAL MODEL

- Does a reasonable job at accounting for trends in skill premium. But....

1. **Polarization/"non-monotonicity" (task-based models). We focus here.**
2. Is technology really exogenous? (e.g. Trade-induced technical change; supply-induced demand)
3. What firm-level mechanism where ICT affects skill demand? Organizational change (e.g. Caroli & VR, 2001; Bartel et al, 2007; Bloom, Sadun &VR, 2012)
4. Cross country differences (role of labor institutions)

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POLARIZATION AND THE EFFECT OF ICT (INFORMATION AND COMMUNICATION TECHNOLOGY) ON TASKS

- Extension of technological explanation for changing skill demand. Developed to explain “polarization”: middle skilled group losing demand to both high and low skilled

- Nordhaus (2007) labor cost of performing a standardized set of computational tasks fell by at least 1.7 trillion fold 1850-2006, the bulk of this in last 30 years

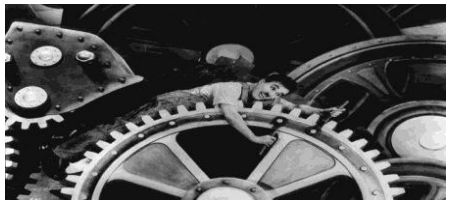
- Routinization is the key

ICT AND TASK-BASED DEMAND (E.G. ROBO-ONE ANNUAL ROBOT COMPETITION IN TOKYO)

EXAMPLES OF “AMAZING” THINGS ROBOTS CAN DO

- http://www.youtube.com/watch?v=CsS1jnlxf4s&feature=related
- Osaka Robocup tournament

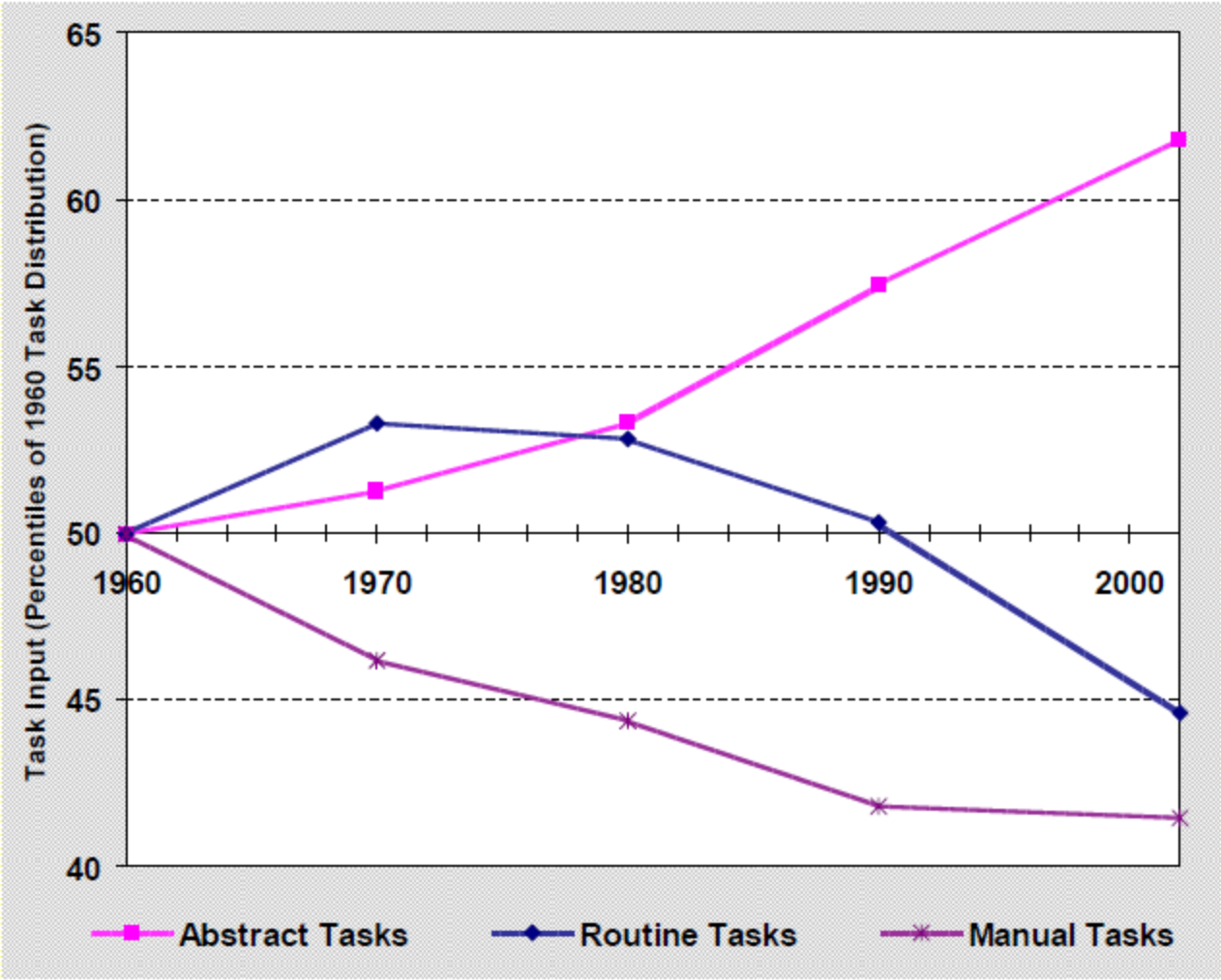
A TAXONOMY OF TASKS: CLASSIC

Task type		Task description	Example of occupations	Effect of ICT	Education Levels
Routine	Manual	Rules based; repetitive; procedural	Assembly line workers; 	Direct substitution	Low
Non-Routine	Non-Manual	Abstract problem solving; mental flexibility	Managers; doctors; lawyers; scientists 	Strongly complementary	High

A TAXONOMY OF TASKS: NUANCED

Task type		Task description	Example of occupations	Effect of ICT	Education Levels
Routine	Manual	Rules based; repetitive; procedural	Assembly line workers;	Direct substitution	Low
	Cognitive		Clerical ; Book-keepers	Direct substitution	Middle
Non-Routine	Cognitive	Abstract problem solving (analytic); mental flexibility	Managers; doctors; lawyers; scientists	Strongly complementary	High
	Manual	Environmental adaptability; Interpersonal adaptability	Maids/Janitors; security guards; waiters; drivers	Broadly Neutral	Low

Representative Evidence: Trends in Job Task Content 1960 – 2002 from ALM (2003) updated to 2002



POLARIZATION AND THE EFFECT OF ICT (INFORMATION AND COMMUNICATION TECHNOLOGY) ON TASKS

- **Indirect Evidence**:
  - Autor, Levy and Murnane (2003)
  - Goos and Manning (2007). UK
  - Autor, Katz and Kearney (2006, 2008). US
  - Goos, Manning and Salomons (2010). Other OECD
  - Firpo, Fortin & Lemieux (2009)

- **Direct Evidence:**
  - Autor and Dorn (2010)
  - **Michaels, Natraj & Van Reenen (2012**)

IMPLICATIONS OF ICT AND TASK-BASED DEMAND

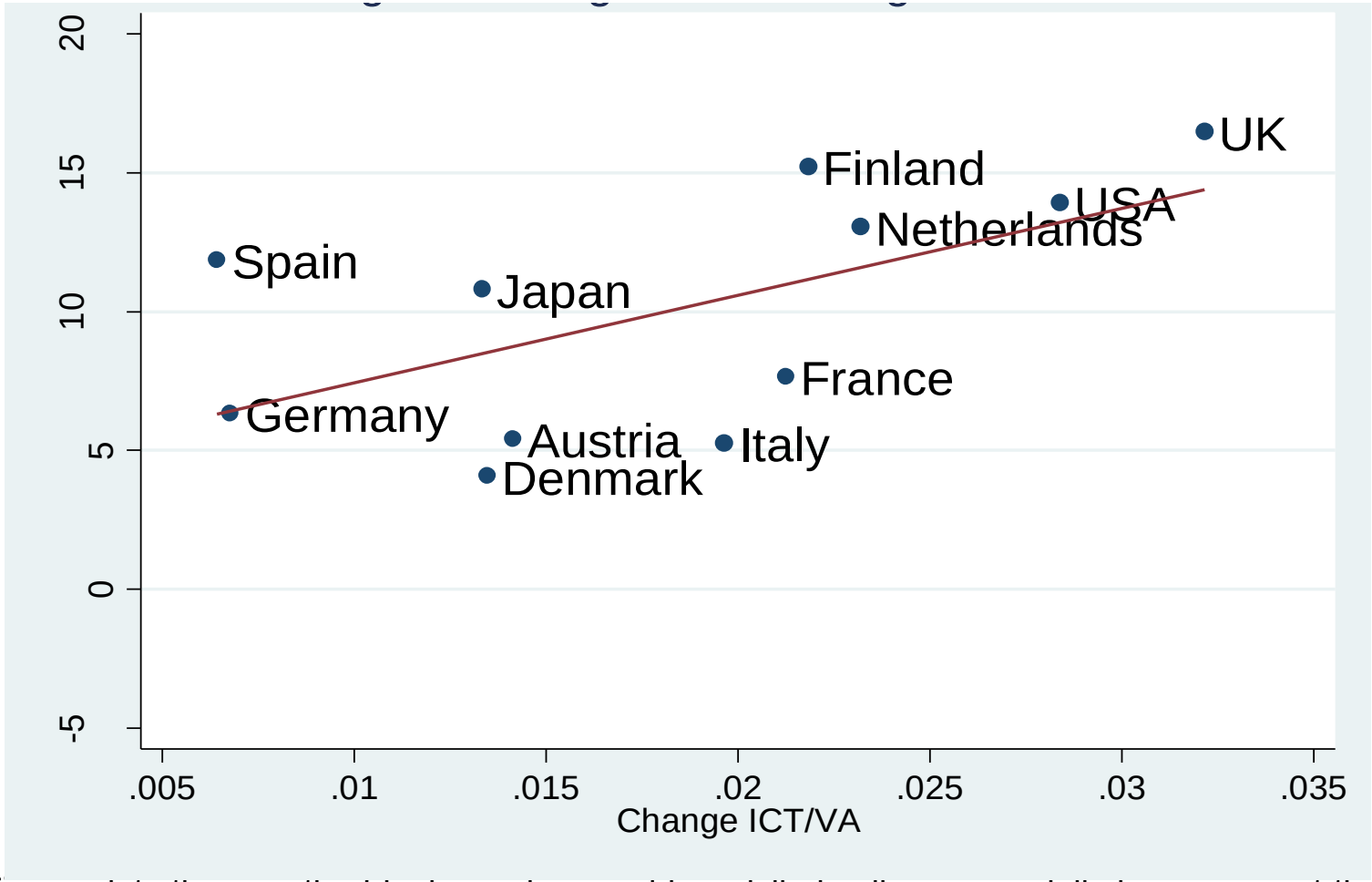
- ICT ("computers") a substitute for **routine** tasks, complements **analytical** tasks, but is neutral wrt to **non-routine manual tasks**

- **Implies that technology**
  - increases demand for most educated (analytical)
  - reduces demand for middle educated (routine non-manual),
  - little effect on the least educated (now, manual non-routine)

DATA (EU-KLEMS)

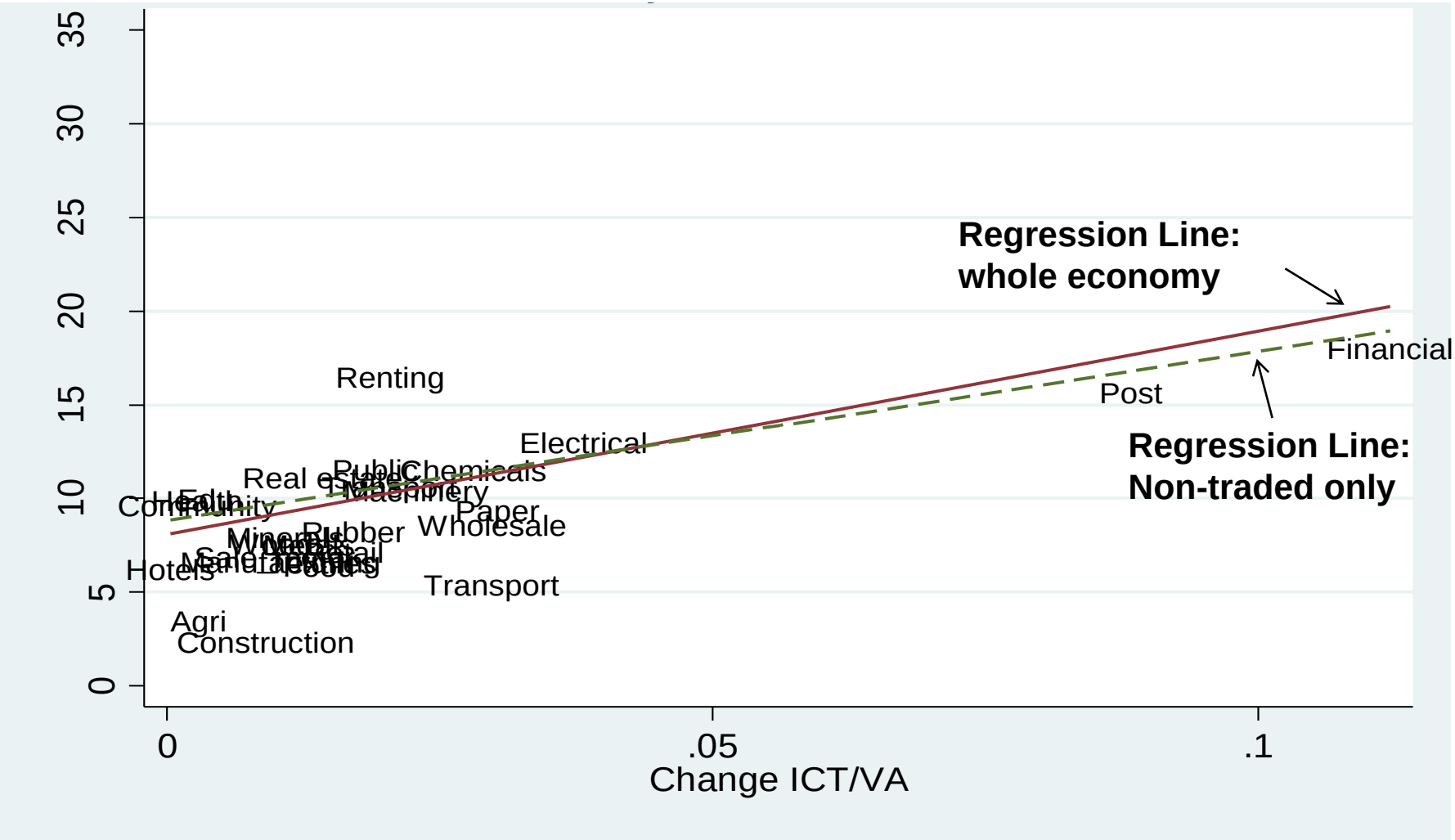
- Industry (~SIC3) by OECD country (11), 1980-2004 (Jorgenson et al, 2008; Timmer et al, 2008)
- Based on aggregation of Census Bureau production data matched with other sources (e.g. CPS, LFS)
  - ICT capital: depreciated past investments on hardware, software & communication equipment
- Education broken down into three groups
  - **High** (e.g. College degree or above)
  - **Middle** (e.g. High school grads, some college)
  - **Low** (e.g. High school drop outs)
- Since division of middle/low is hardest, important to control for country fixed effects
- Demand measured by wage bill share of a skill group

CROSS COUNTRY VARIATION IN GROWTH OF COLLEGE WAGE BILL SHARE AND ICT INTENSITY, 1980-2004



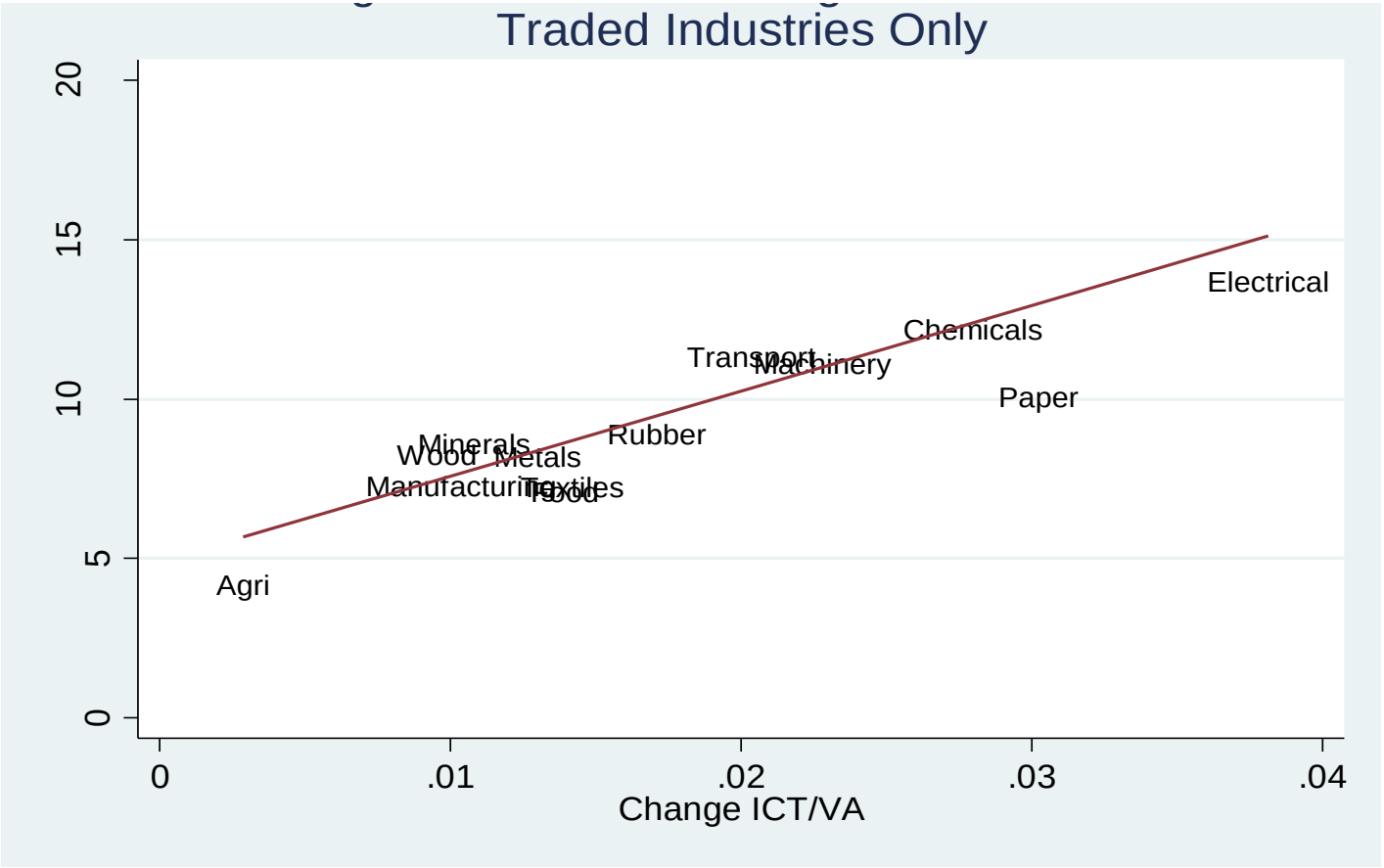
Note: Figure plots the growth of high, medium and low-skilled college wage bill shares against the growth of ICT intensity (ICT/VA) for 11 OECD countries (see Table 1). Lines show regressions of the growth of each wage bill share against growth of ICT intensity.

CROSS INDUSTRY GROWTH IN COLLEGE WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS COUNTRIES, 1980-2004



Note: Figure plots the growth from 1980-2004 of high-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry's share in 1980 employment (solid line for entire economy, dashed line for non-trade industries only).

CROSS INDUSTRY GROWTH IN COLLEGE WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS COUNTRIES, 1980-2004, TRADED SECTORS ONLY



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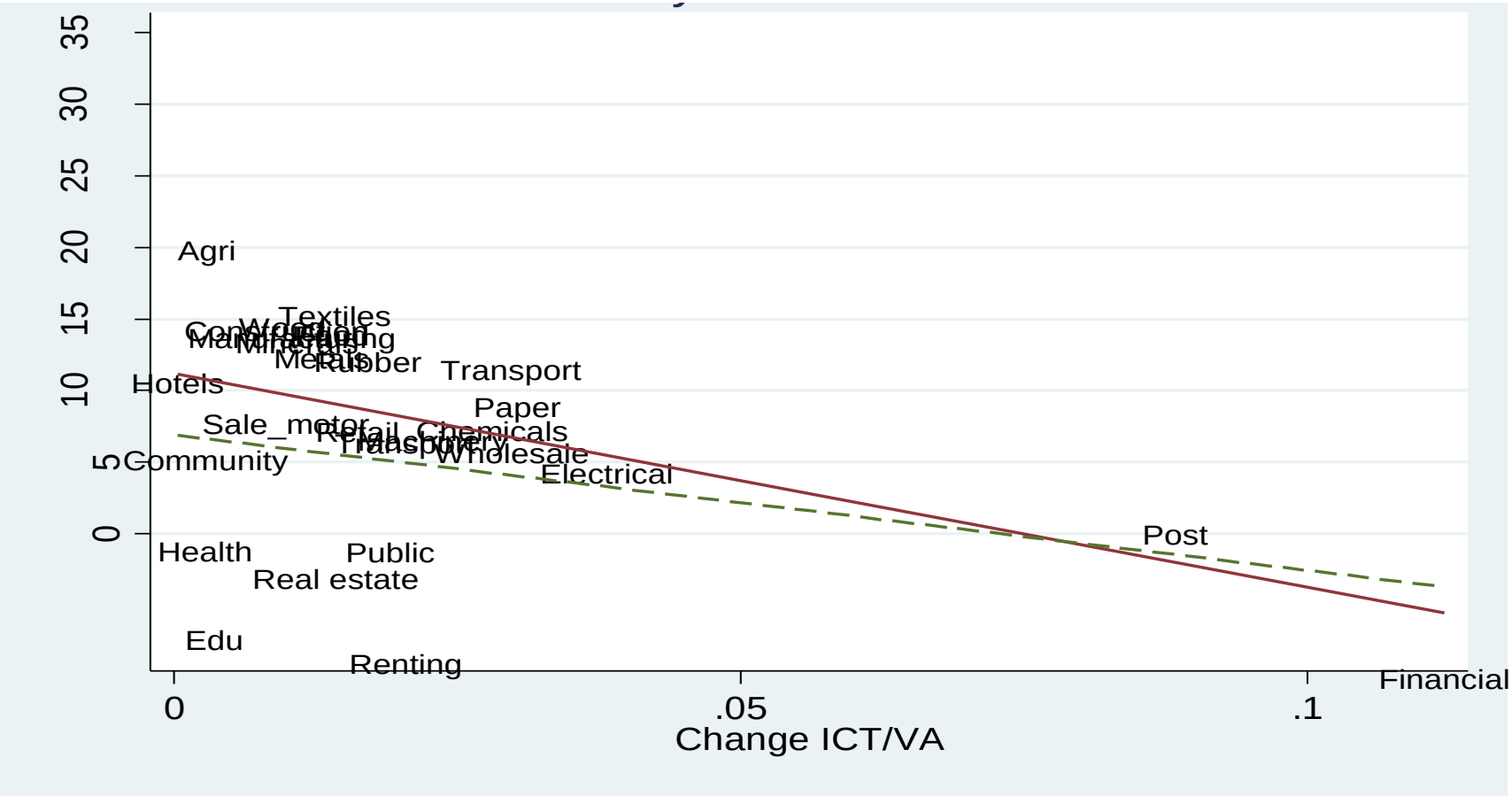
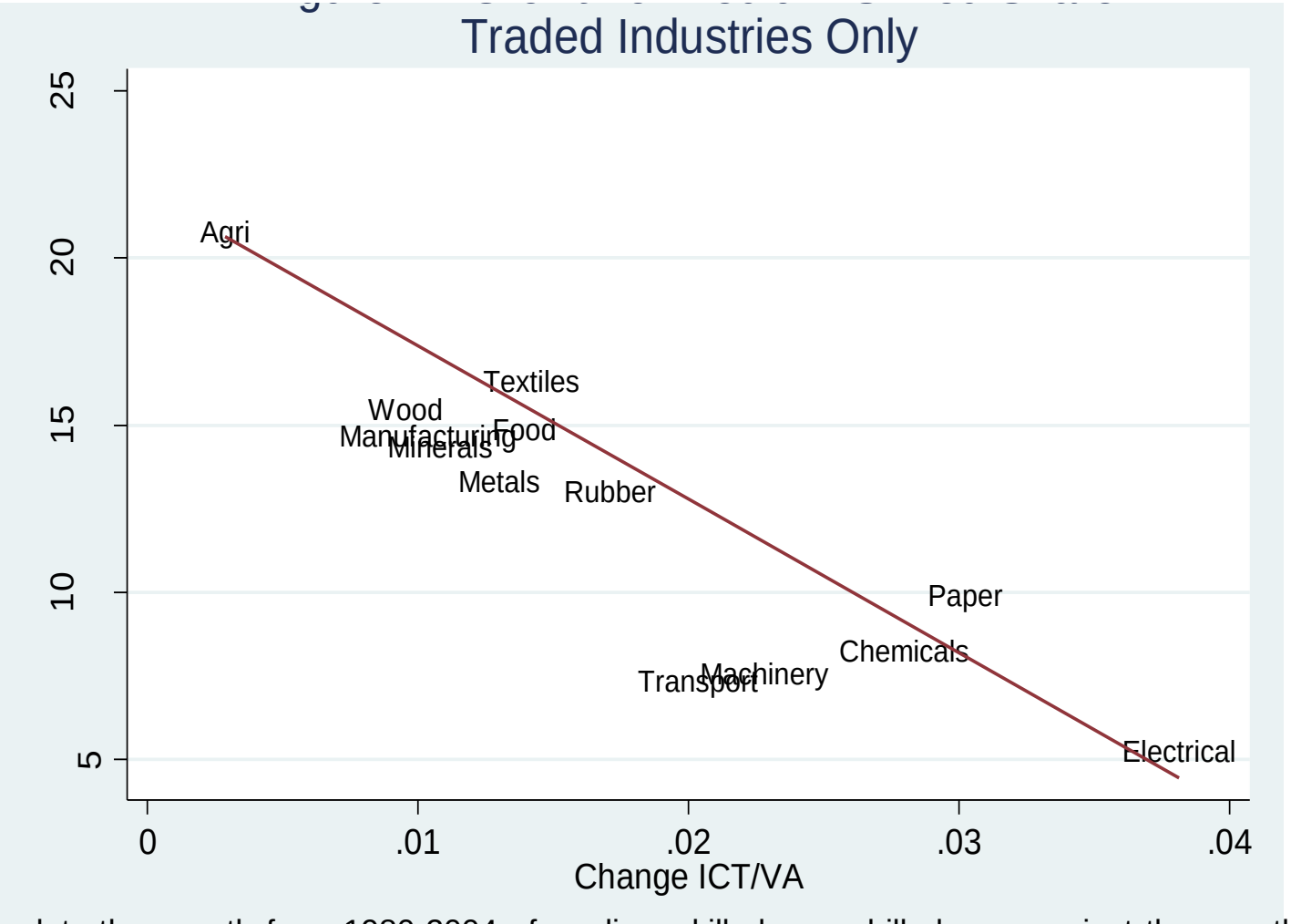
CROSS INDUSTRY GROWTH IN MEDIUM EDUCATED WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS 11 COUNTRIES, 1980-2004, ALL SECTORS



Note: Figure plots the growth from 1980-2004 of medium-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry's share in 1980 employment (solid line for entire economy, dashed line for non-trade industries only).

CROSS INDUSTRY GROWTH IN MEDIUM EDUCATED WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS 11 COUNTRIES, 1980-2004, TRADED SECTORS



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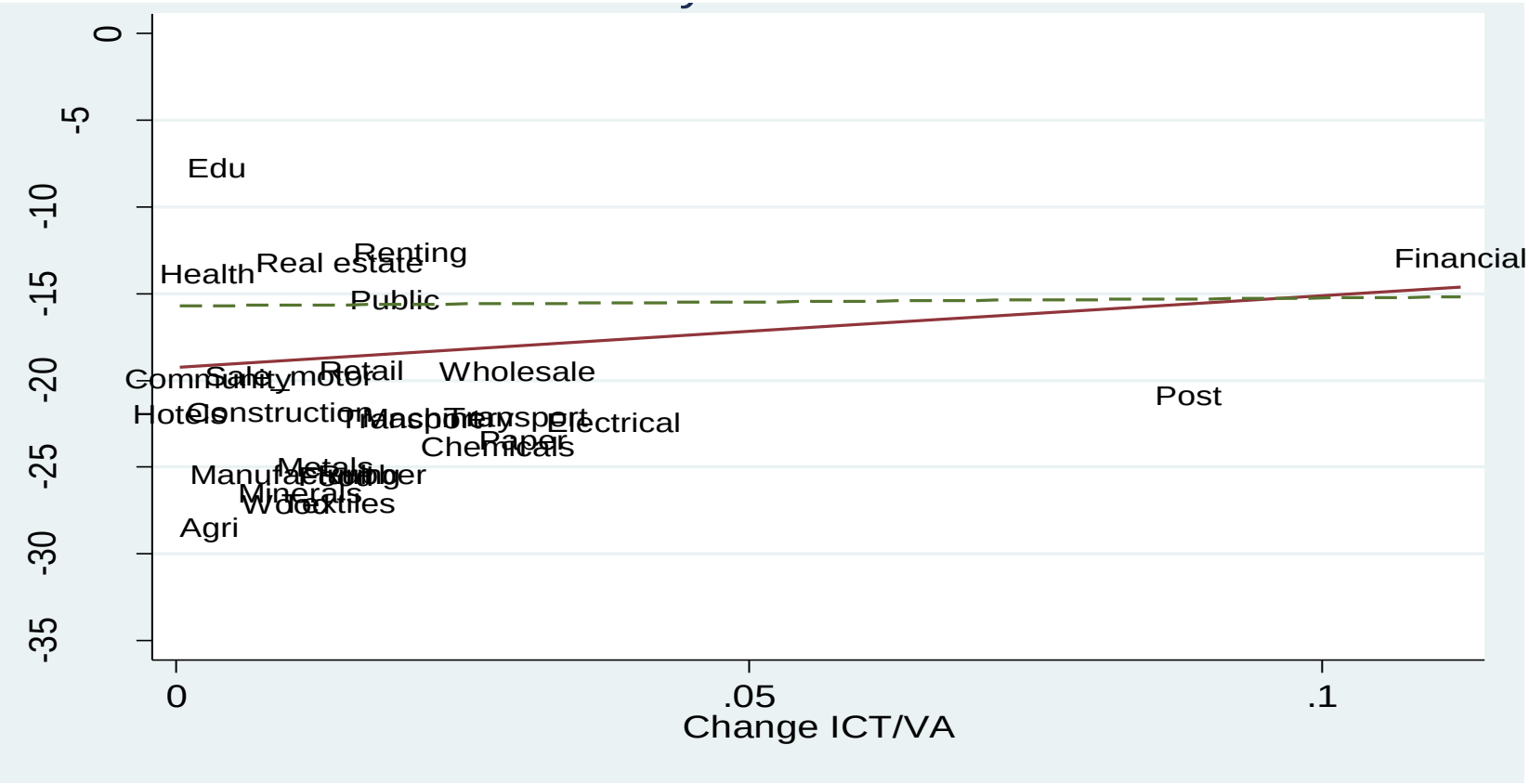
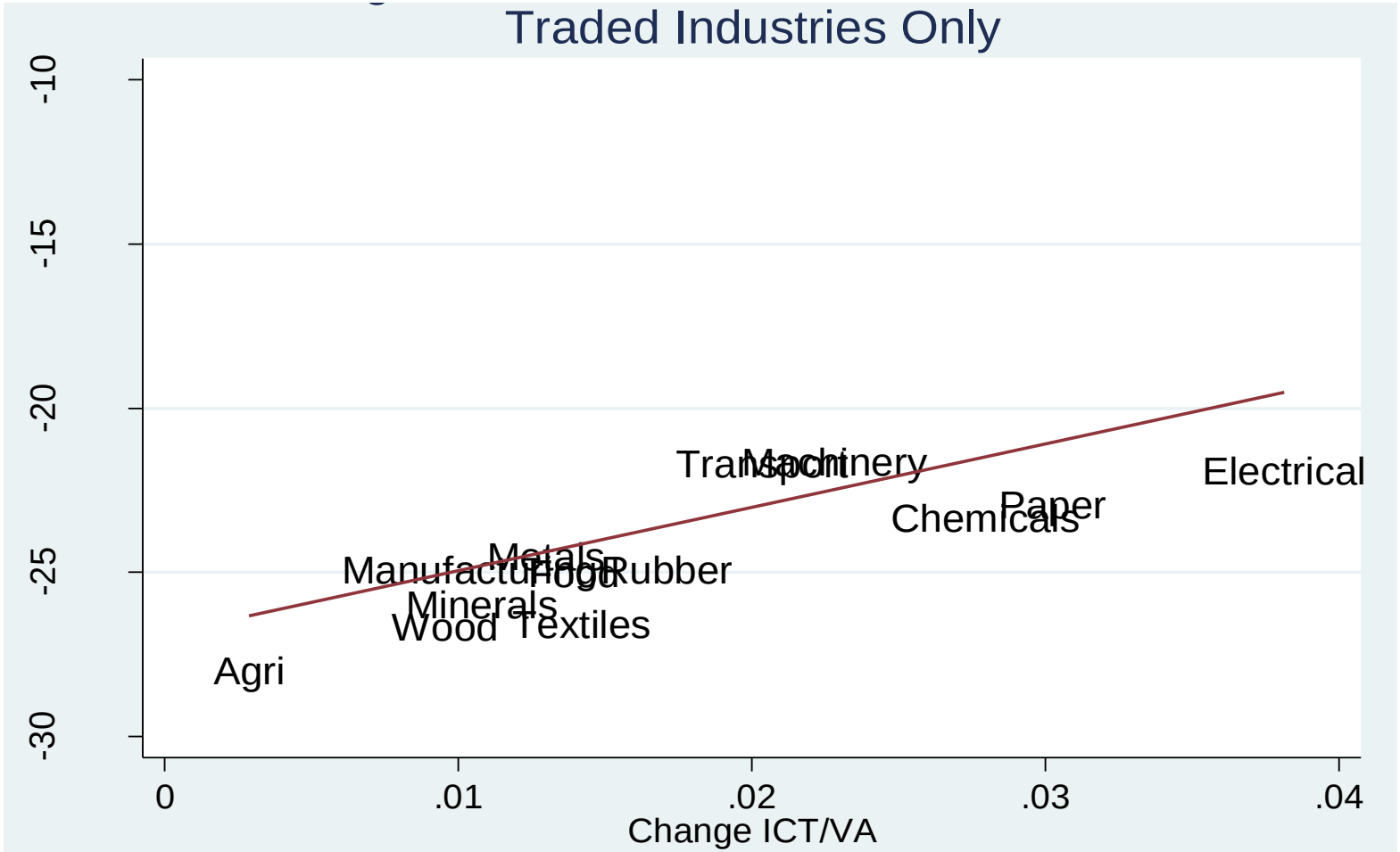
CROSS INDUSTRY GROWTH IN LOW EDUCATED WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS 11 COUNTRIES, 1980-2004, ALL SECTORS



Note: Figure plots the growth from 1980-2004 of low-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry's share in 1980 employment (solid line for entire economy, dashed line for non-trade industries only).

CROSS INDUSTRY GROWTH IN LOW EDUCATED WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS 11 COUNTRIES, 1980-2004, TRADED SECTORS



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EMPIRICAL MODEL

Representative firm in an industry's cost function, CV(.)

$$CV(W^H, W^M, W^L; C, K, Q)$$

3 groups, *S, Wages, W*
H = highly educated
M = middle educated
L = low educated

C = ICT capital
K = non-ICT capital
Q = value added

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Assume CV(.) translog. By Shephard's Lemma wage bill *SHARE* of skill group *S* in total variable costs (the wage bill) is:

$$SHARE^S = \phi_{HS} \ln(W^H / W^L) + \phi_{MS} \ln(W^M / W^L)$$
$$+\alpha_{CS} \ln(C/Q) + \alpha_{KS} \ln(K/Q) + \alpha_{YS} \ln(Q)$$

EMPIRICAL MODEL

- Estimate in 25 year differences
- Assume national labor markets so relative wages controlled for country*year dummies
- 3 equations education group *S*, industry *i*, country *j*

$$\Delta SHARE_{ijt}^{S} = c_j^S + \beta_1^S \Delta(C/Q)_{ijt} + \beta_2^S \Delta(K/Q)_{ijt} + \beta_3^S \Delta \ln(Q)_{ijt} + u_{ijt}^S$$

ICT capital **Non-ICT capital** **Value added**

Hypotheses:

- Coefficient on ICT capital intensity **positive** for high skilled?
- Coefficient on ICT capital intensity **negative** for middle skilled?

Potential instrumental variables:

- Initial level of ICT in industry in US in base year (1980)
- Initial share of routine tasks in US in base year (1980), DOT, O*NET, Autor and Dorn (2009)

GROWTH OF WAGE BILL SHARES, 1980-2004 (ALL SECTORS)

A. Dependent variable: ΔCollege Wage Bill Share				
Δ ((ICT capital) / (Value Added))		72.29	64.56	46.92
		(18.28)	(17.31)	(14.94)
Intercept	10.02	8.69	2.22	
	(0.57)	(0.63)	(1.67)	
Country fixed effects (11)	No	No	No	Yes
Control for Δ(non-ICT capital/value added)	No	No	Yes	Yes
Control for Δln(value added)	No	No	Yes	Yes

Note: Estimated by OLS in long differences (robust standard errors) 208 observations
Source: Michaels, Natraj & Van Reenen (2010)

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		(18.28)	(17.31)	(14.94)
Intercept	10.02	8.69	2.22	
	(0.57)	(0.63)	(1.67)	
B. Dependent variable: ΔMedium-skilled Wage Bill Share				
Δ ((ICT capital) / (Value Added))		-100.78	-77.76	-64.52
		(30.21)	(25.44)	(20.24)
Intercept	8.73	10.59	27.24	
	(1.29)	(1.49)	(3.73)	
C. Dependent variable: ΔLow-skilled Wage Bill Share				
Δ ((ICT capital) / (Value Added))		28.55	13.21	17.71
		(27.34)	(25.66)	(16.41)
Intercept	-18.74	-19.26	-29.5	
	(1.12)	(1.31)	(3.27)	
Country fixed effects (11)	No	No	No	Yes
Control for Δ(non-ICT capital/value added)	No	No	Yes	Yes
Control for Δln(value added)	No	No	Yes	Yes

Note: Estimated by OLS in long differences (robust standard errors) 208 observations
Source: Michaels, Natraj & Van Reenen (2010)

SUMMARY ON ICT AND TASK-BASED DEMAND

- ICT story plausible: substitution away from middle towards top (& bottom)

- **Alternative stories:**
  - Consumption of the better off supports (local) demand for low skilled (e.g. Mazzolari & Ragusa, 2008)
  - Household labor supply (e.g. Ngai-Pissarides, 2007)
  - Trade and offshoring (next...)

- Short on evidence

OUTLINE

1. Recent trends in Wages and Skills
2. A framework for understanding the changes
3. Polarization and Technology
4. **Trade Redux: Trade-induced technical change**
5. Policy and future research

TRADE AS A CAUSE OF RISING SKILL DEMAND

- Early analyses of demand shock against unskilled pointed to trade with developing countries (e.g. Wood, 1994). Standard Heckscher-Ohlin/Stolper-Samuelson

- Consensus emerged that trade not the culprit
  - Aggregate growth of skill shares mainly *within* industries (indeed, within plants)
  - No clear fall in skill premium in developing countries
  - Magnitudes of trade changes too small to account for changes (both in GE models & factor content analysis)
  - Trade variables dominated by technology in “horse race”

TRADE AND TECHNOLOGY (TRADED SECTORS ONLY). NO TRADE EFFECT AFTER CONTROLLING FOR TECHNOLOGY

Dependent variable: ΔCollege Wage Bill Share, 2004-1980

Sample	All	All	Drop Austria & Spain (no R&D data)		
Δ ((Imports+ Exports) / (Value Added))	0.71	0.59	0.50	0.24	0.11
	(0.25)	(0.15)	(0.19)	(0.30)	(0.25)
Δ ((ICT capital) / (Value Added))		107.61	94.25		73.59
		(31.70)	(34.07)		(31.41)
1980 (Research and Development				34.18	28.04
Expenditure/ Value Added)				(18.23)	(17.59)
Observations	84	84	65	65	65

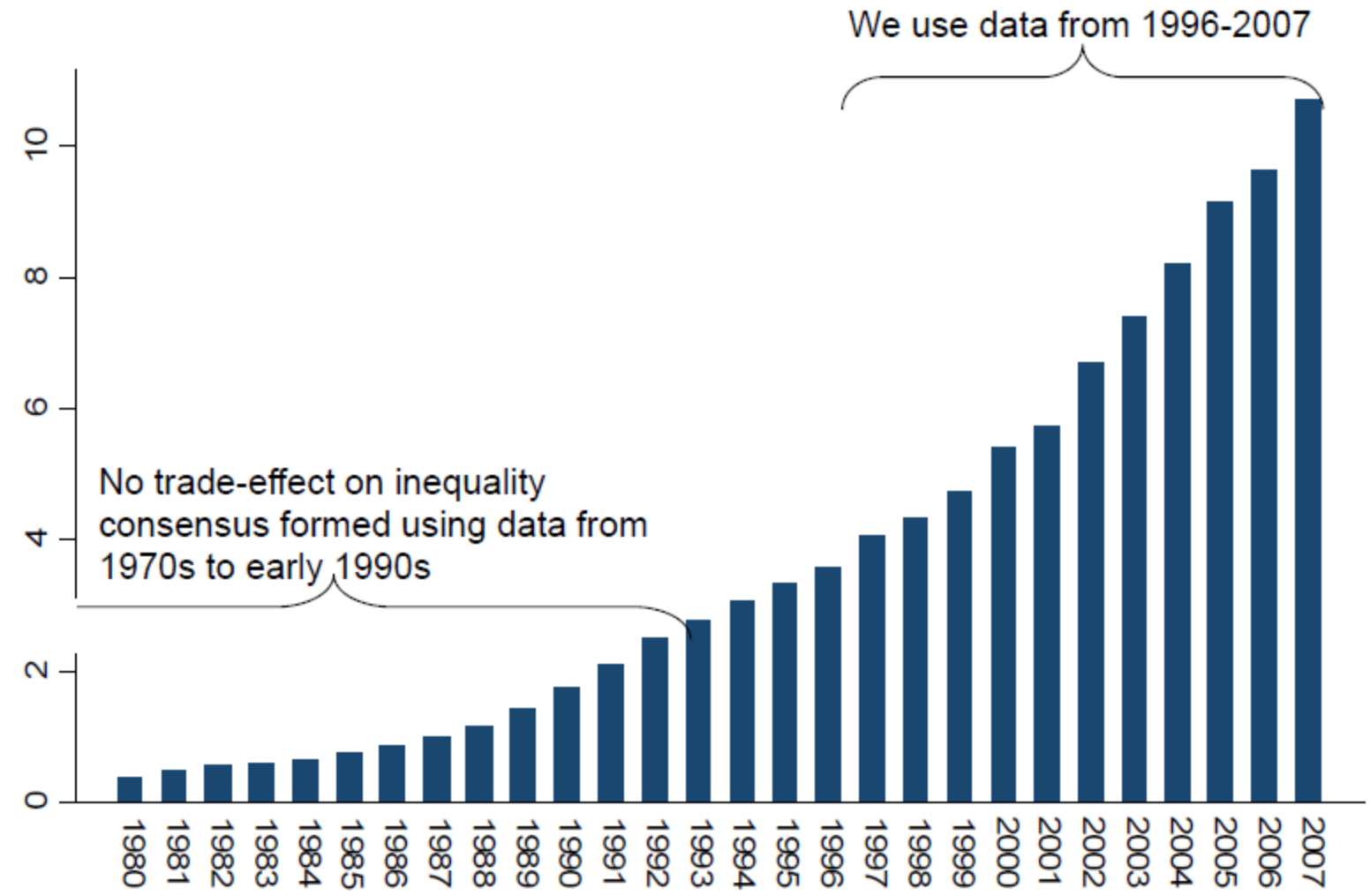
Note: Estimated by OLS in long differences (robust standard errors), all columns include: country dummies, non-ICT capital/value added, growth of value added

Source: Michaels, Natraj & Van Reenen (2010)

TWO LIMITATIONS OF THE CONCENSUS THAT TRADE DID NOT MATTER

1. Studies mainly conducted using data through early 1990s – before rise of China (over)

CHINA'S SHARE OF ALL EU AND US IMPORTS



Source: UN Comtrade data

TWO LIMITATIONS OF THE CONCENSUS THAT TRADE DID NOT MATTER

1. Studies mainly conducted using data through early 1990s – before rise of China (over)

2. **Technology assumed exogenous (e.g. Acemoglu, 1999, 2002, 2008). In particular trade could induce faster technical change**

TRADE- INDUCED TECHNICAL CHANGE
(Bloom, Draca & Van Reenen, 2011)

- Examine impact of Chinese import growth 1995-2007 on technical change in 12 European countries (~0.5m firms)
- **Technical change within firm increases when Chinese import competition rises**
  - ICT adoption (Harte-Hanks)
  - Patents & citations (European Patent Office)
  - R&D (BVD Osiris)
  - TFP (BVD Amadeus)
  - Management (Bloom & Van Reenen surveys)
- **Reallocation**
  - Chinese import competition causes low-tech firms to shrink and exit
- **<u>Both forces imply faster technology upgrading</u>**

GROWTH OF CHINESE IMPORTS INCREASE TECHNICAL CHANGE

	(4)	(5)	(7)	(9)
Dependent Variable:	Δln(IT/N)	Δln(PATENTS)	Δln(R&D)	Δln(TFP)
Change in Chinese Imports $\Delta\left(M_{jk}^{China} / M_{jk}^{World}\right)$	0.354***	0.610***	2.145*	0.447***
	(0.120)	(0.182)	(1.186)	(0.132)
Years	2007-2000	2005-1996	2007-2000	2005-1996
Country-Industry pairs	2,902	1,571	151	411
Observations	7,409	7,022	322	2,549

Industry coefficients almost double the firm/plant coefficients, Implies reallocation effect about the same size as the within effect.

Source: Draca, Bloom and Van Reenen (2011)

Note: 5 year differences. Industry (SIC4)*country (11) regressions

OUTLINE

1. Recent trends in Wages and Skills
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SUMMARY

- Wage inequality, especially for top half has risen steadily in US and UK since end of 1970s
- Most other OECD countries also seeing increases in wage inequality, albeit later and slower
- Canonical model: technology creates long-term demand for more skilled workers and supply races to keep up.
- But richer model of task-based technical progress where ICT replaces routine tasks & has non-monotonic effect on skill demand – middle is mainly suffering
- Trade with less developed countries has an indirect effect on skills through inducing faster technical change

POLICY IMPLICATIONS

- Trade has additional welfare effects on innovation in addition to lower prices, etc. Need to smooth transitions for displaced workers & compensate those who lose
- Building human capital still main way of addressing problem. Why do more men not go to college?
- But polarization is challenging
  - Improving education so that high school drop outs get high school diploma not enough
  - Middle classes stronger political force than poor. Recession highlights the fact that they are losing out.
  - On one hand, from social planner view less bad that poor are not getting poorer. On other, political economy problems.

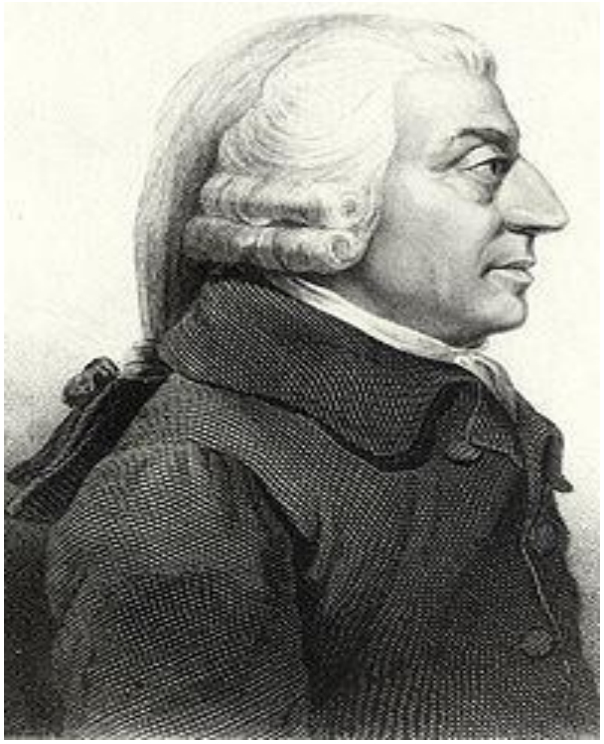
RESEARCH IMPLICATIONS ("Do not ask me to write the music of the future")

- Task-based models more complex, but great potential to explain puzzling facts
  - Need for more rigorous testing of these theories

- Trade has subtle effects on labour market, e.g. By influencing technology. Trade & labour literatures are converging around worker and firm heterogeneity.
  - Empirics
  - Adjustment process

- "Inside the firm" - Organizational change & management

THANK YOU!



Further Reading

- http://cep.lse.ac.uk/pubs/download/occasional/op028.pdf
- http://cep.lse.ac.uk/pubs/download/dp0821
- Michaels paper:
- http://cep.lse.ac.uk/pubs/download/dp0987.pdf.pdf
- Machin-Van Reenen http://cep.lse.ac.uk/textonly/people/vanreenen/papers/skillstructure.pdf
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