What Does Human Capital Do? A Review of Goldin and Katz's *The Race between Education and Technology*

Daron Acemoglu and David Autor
Presentation: Vinzenz Ziesemer

European University Institute

September 2017

Outline

This paper: "book review" of Goldin and Katz (2009)

- Canonical Model of Skill Biased Technical Change (SBTC)
- Successes
- Failures
- Directions for Future Research (and for this series)

More on SBTC:

- SBTC internationally (Berman, Bound, and Machin, 1998)
- SBTC across US states (Ciccone and Peri, 2005)
- KORV (Krusell, Ohanian, Ríos-Rull, and Violante, 2000)
- Endogenous SBTC (Acemoglu, 1998)

Canonical Model of SBTC

- Two distinct skill groups: high (H) and low (L)
- Imperfect substitutes in production:

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

- $\sigma \in [0, \infty)$ elasticity of substitution, θ distribution parameter
- Define *skill premium* $\omega = \frac{w_H}{w_L}$. Competitive factor markets:

$$\ln \omega = \ln\left(\frac{1-\theta}{\theta}\right) + \frac{\sigma-1}{\sigma}\ln\left(\frac{A_H}{A_L}\right) - \frac{1}{\sigma}\ln\left(\frac{H}{L}\right) \tag{2}$$

Canonical Model of SBTC: Predictions

- For given SB growth, increase in skills reduces skill premium:

$$\frac{\partial \ln \omega}{\partial \ln H/L} = -\frac{1}{\sigma} < 0 \tag{3}$$

- If $\sigma > 1$, for given skill supply growth, SB growth increases skill premium:

$$\frac{\partial \ln \omega}{\partial \ln(A_H/A_L)} = \frac{\sigma - 1}{\sigma} \tag{4}$$

- If $\sigma \in (0, \infty)$, any technological growth increases both wages:

$$\frac{\partial \ln w_H}{\partial \ln A_H}, \frac{\partial \ln w_L}{\partial \ln A_H}, \frac{\partial \ln w_H}{\partial \ln A_L}, \frac{\partial \ln w_L}{\partial \ln A_L} > 0 \tag{5}$$

Canonical Model of SBTC: Data (1/2)

- Katz and Murphy (1992) estimate equation 2
- H: college labor, L: high school labor
- Assume $\ln\left(\frac{A_H}{A_L}\right) = \gamma_0 + \gamma_1 t$
- $\hat{\sigma} = 1.4$, $\hat{t} = 0.027$

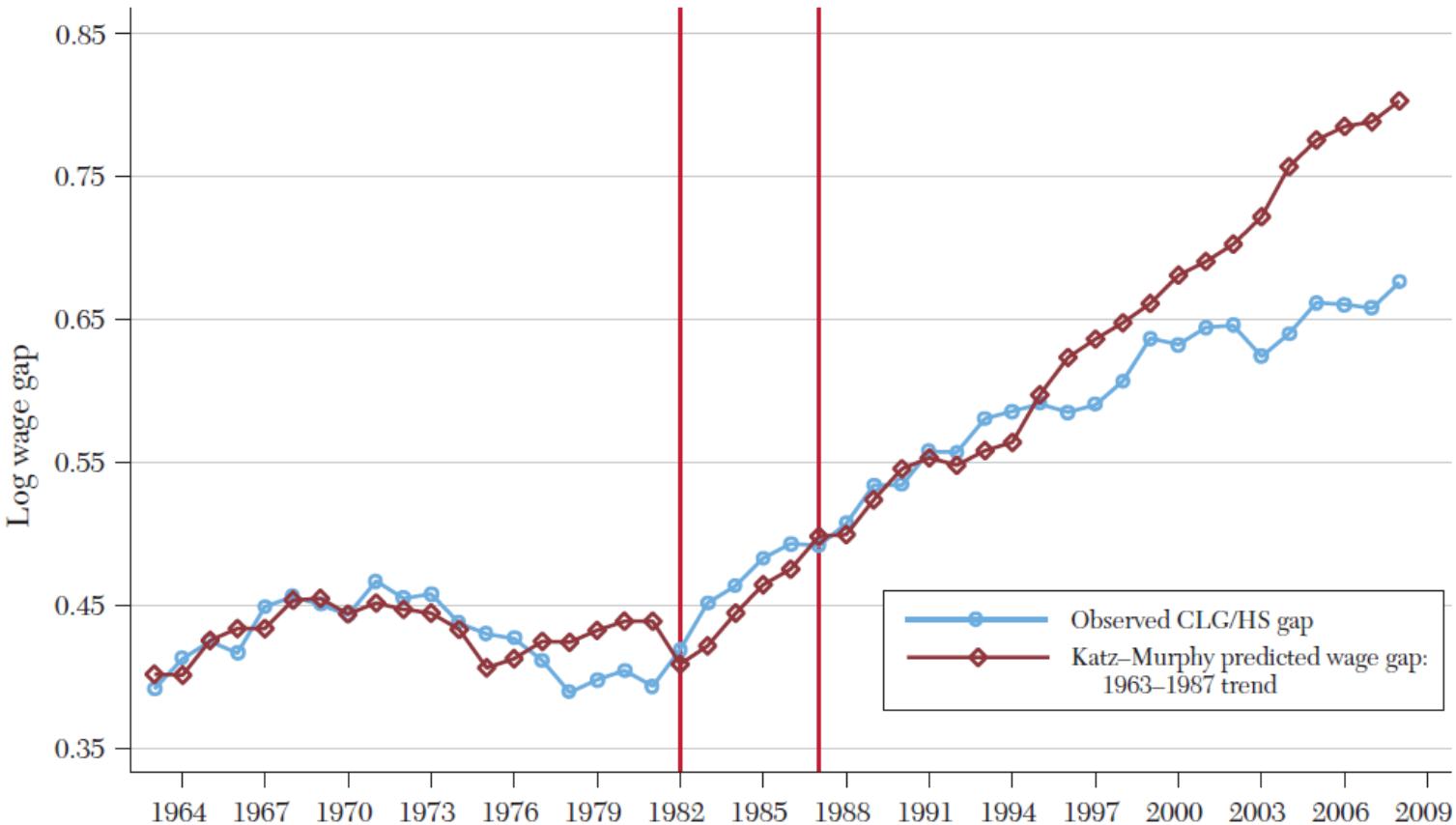


Figure 1. Katz–Murphy Prediction Model for the College–High School Wage Gap

Canonical Model of SBTC: Data (2/2)

- Katz and Murphy (1992) estimate equation 2
- H: college labor, L: high school labor
- Assume $\ln\left(\frac{A_H}{A_L}\right) = \gamma_0 + \gamma_1 t$
- $\hat{\sigma} = 1.4$, $\hat{t} = 0.027$

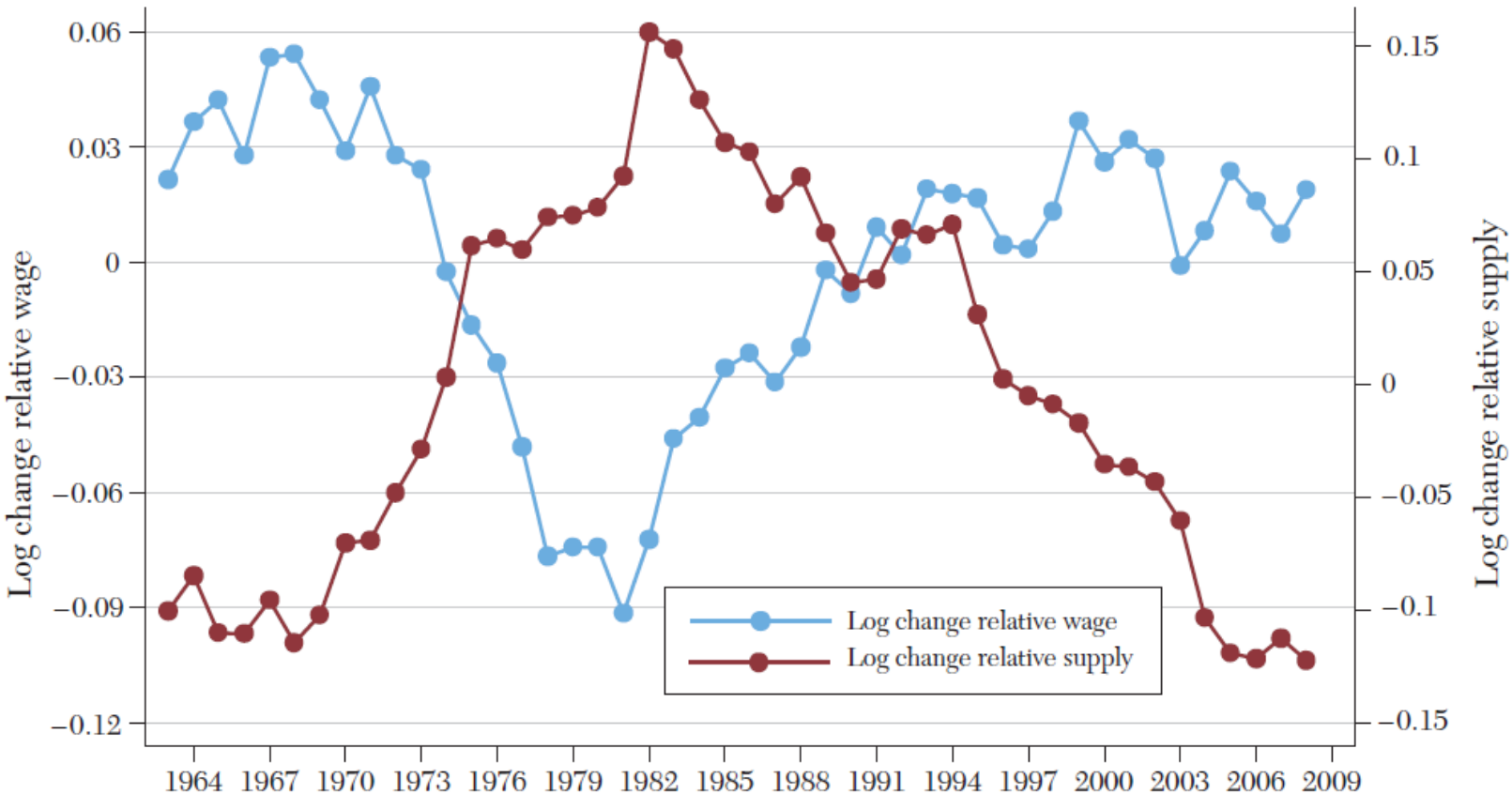


Figure 2. Detrended Changes in College–High School Relative Supply and Relative Wages

Canonical Model of SBTC: What the Future May Hold

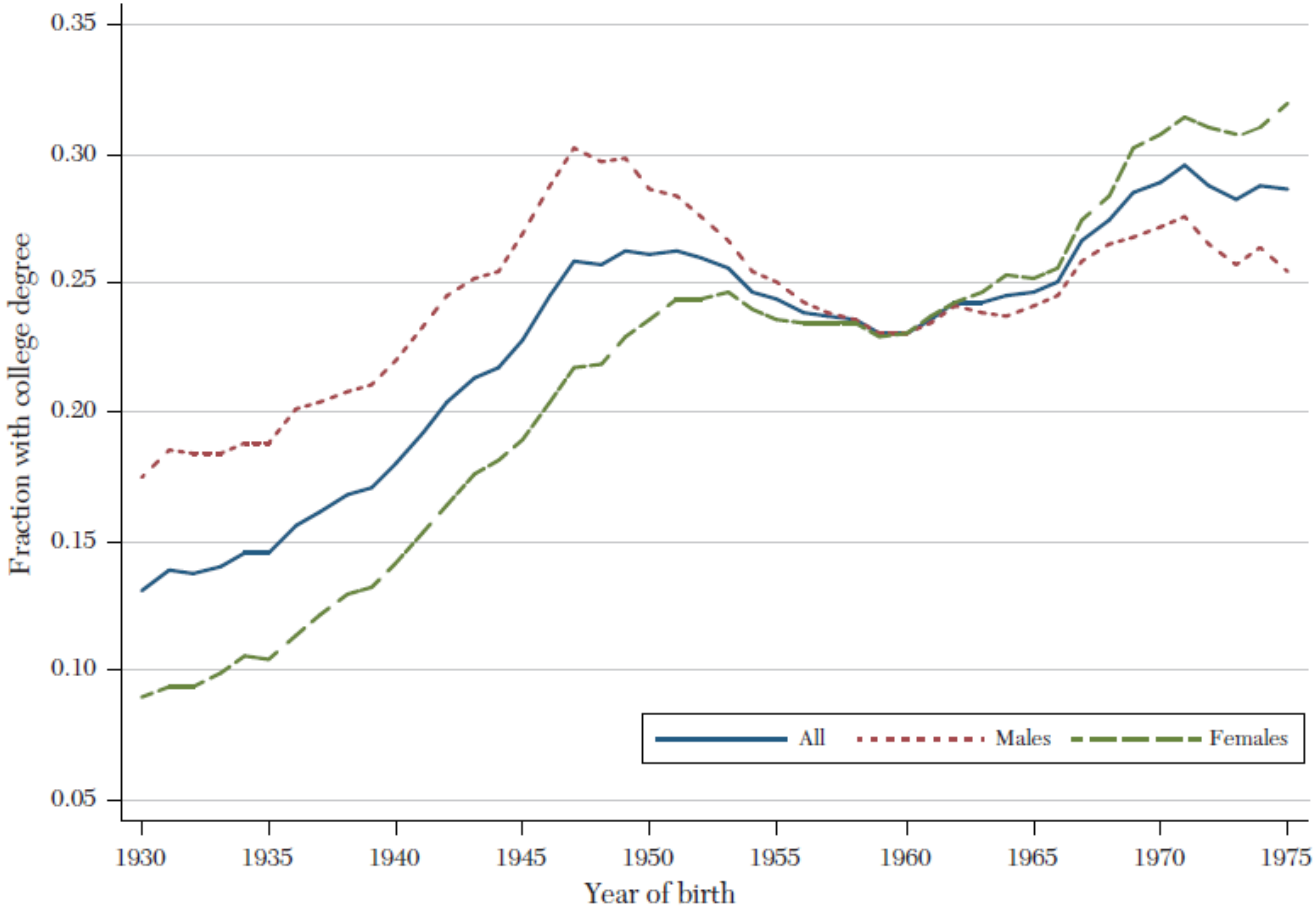


Figure 8. College Completion Rates by Birth Cohort: 1930–1975

- High-school completion has leveled off even more dramatically
- Education policy?
- Literature on policy effects on schooling is relevant, e.g. Abbott, Gallipoli, Meghir, and Violante (2013)

Failures: Falling Wages at the Bottom

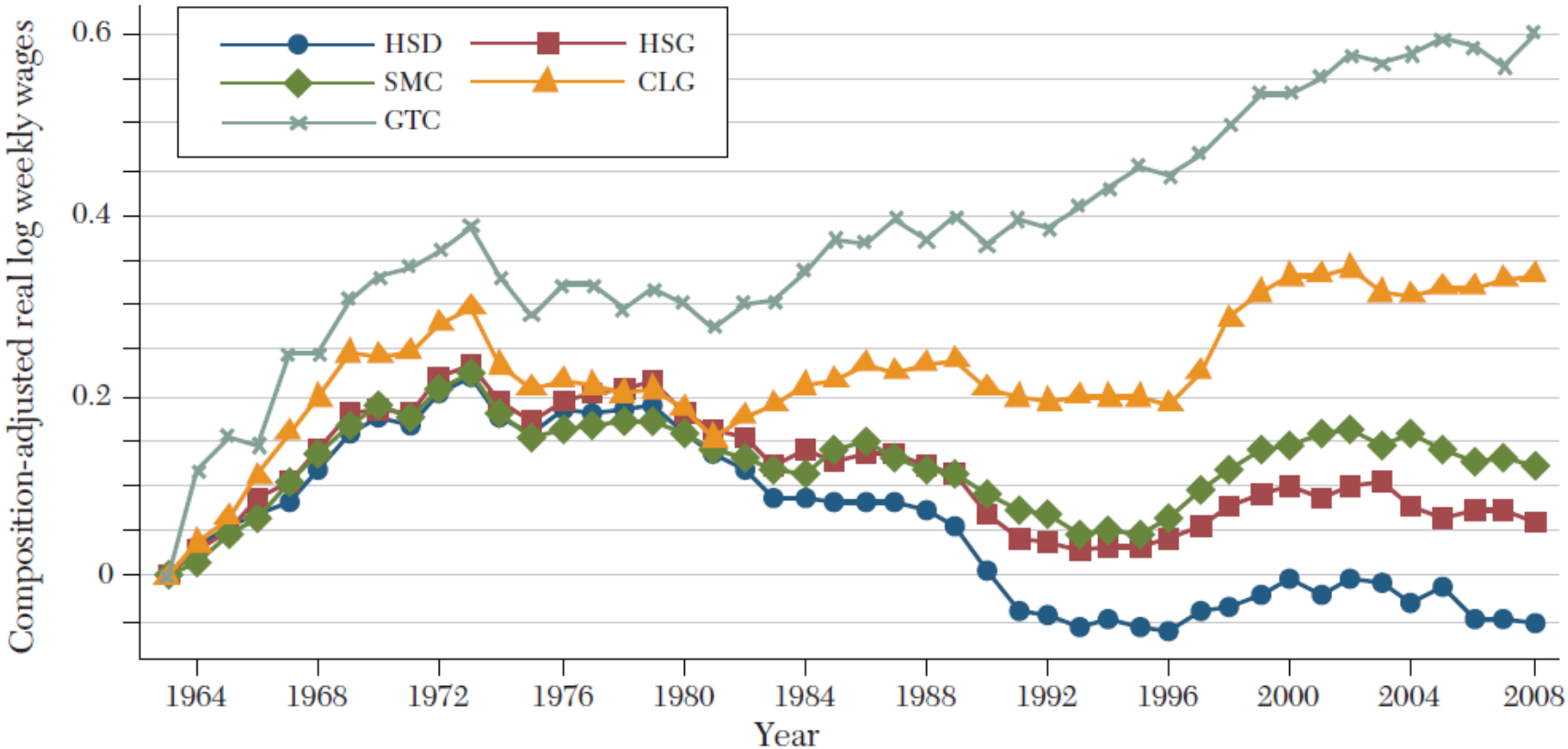
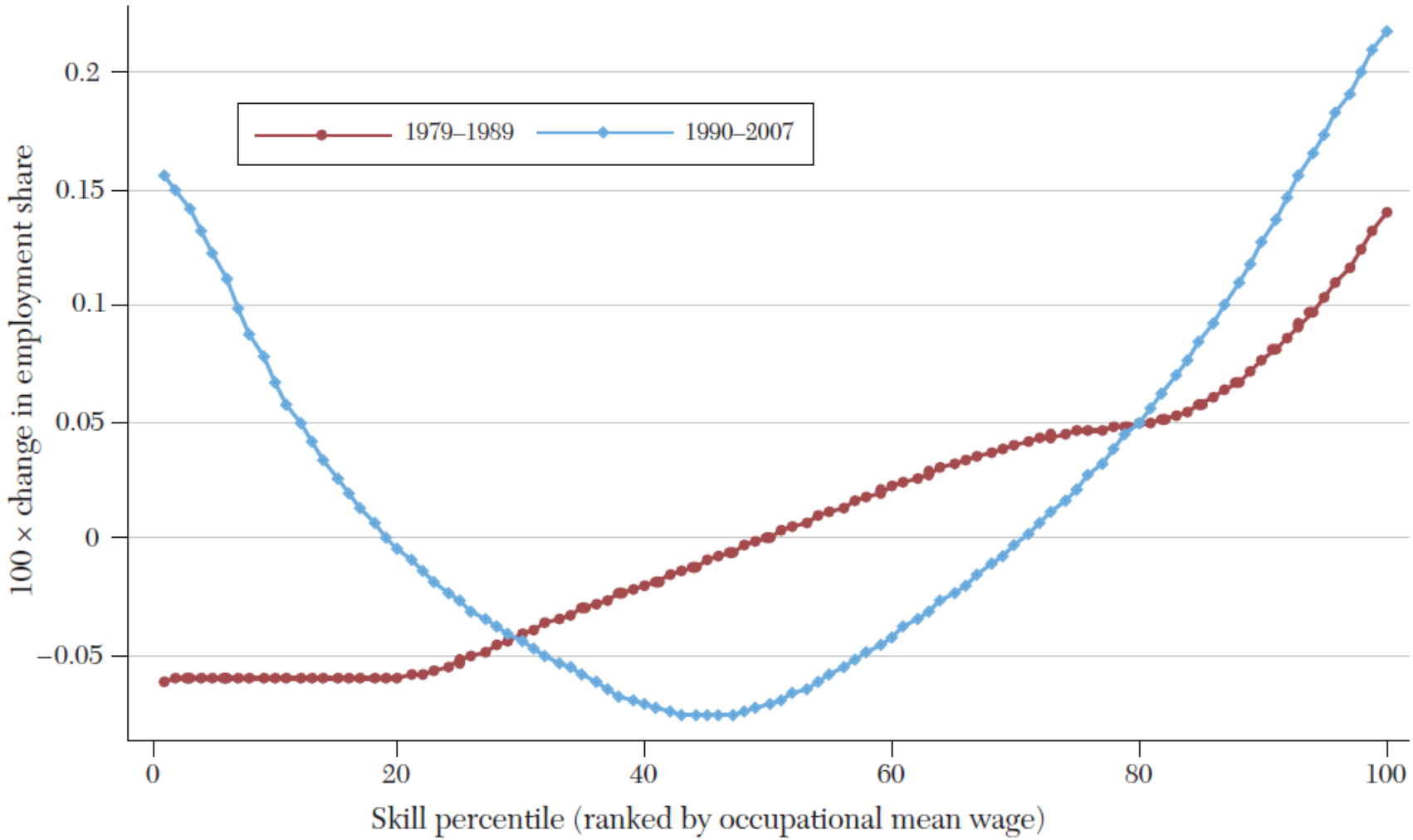


Figure 3. Real, Composition-Adjusted Log Weekly Wages for Full-Time Full-Year Workers 1963–2008 Males

Failures: Polarization (1/3)

Figure 4. Changes in Male Log Hourly Wages by Percentile Relative to the Median

Failures: Polarization (2/3)



Failures: Polarization (3/3)

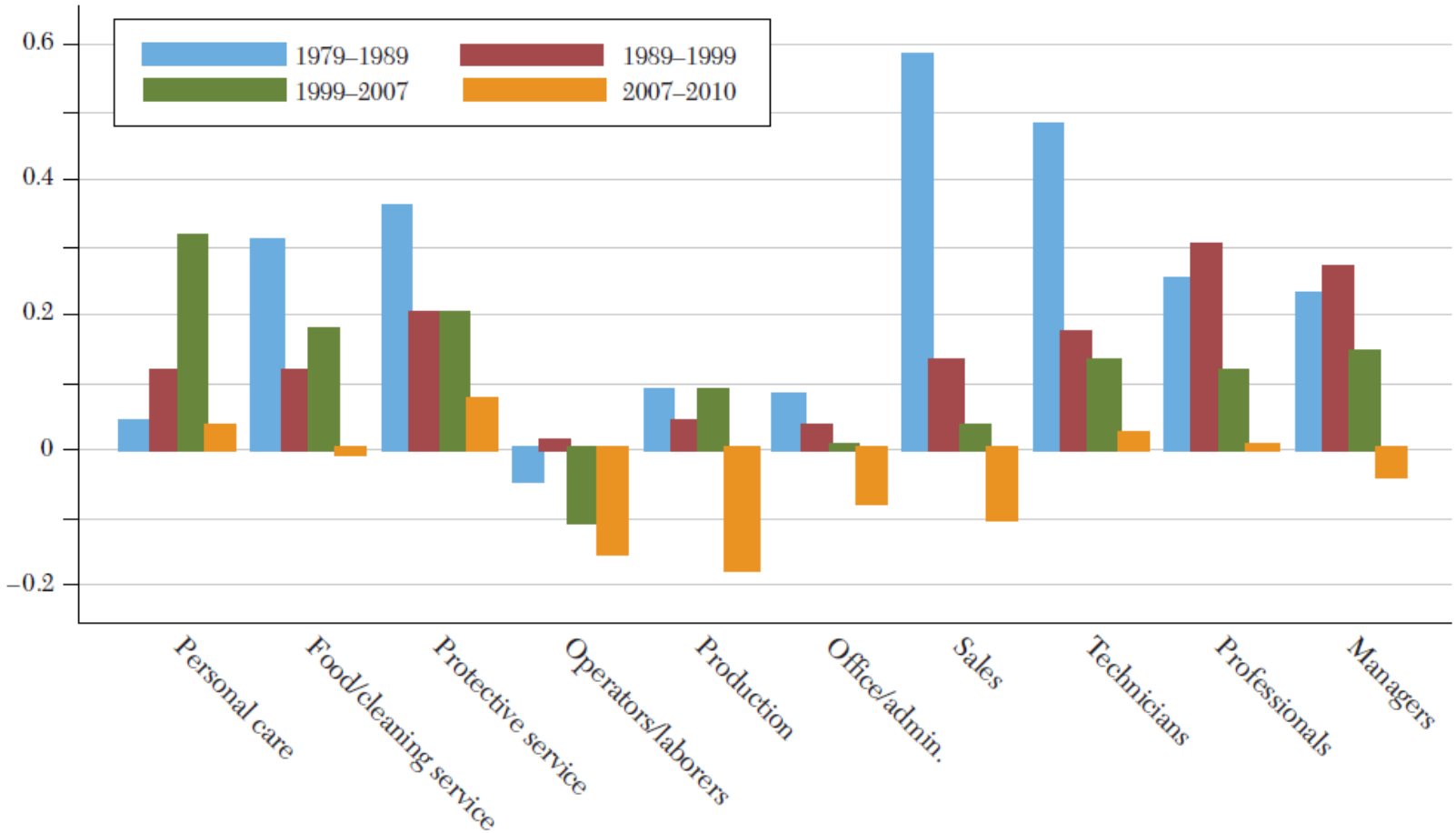


Figure 6. Percent Change in Employment by Occupation, 1979–2010

Failures: Growth Accounting

- Adding capital, we have a growth model:

$$Y = \tilde{F}\left(K, [(A_L L)^{\frac{\sigma-1}{\sigma}} + (A_H H)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}\right) \tag{6}$$

- Growth rates:

$$g_Y = g_A + \frac{RK}{Y} g_K + \frac{w_L L}{Y} g_L + \frac{w_H H}{Y} g_H \tag{7}$$

- In a standard growth accounting exercise, human capital growth explains less than 15% of US growth
- Low, hard to re-unite with Goldin and Katz (2009) narrative of US growth and exceptionalism
- Acemoglu and Autor (2012): have to account for more dimensions, evolving set of tasks
- There is relevant work: see Manuelli and Seshadri (2014) for a model-based approach, and Lagakos, Moll, Porzio, Qian, and Schoellman (2016) who use immigrant data

Future Research: Tasks (Acemoglu and Autor, 2011)

- Continuum of tasks y_i, $i \in [0,1]$
- Imperfect substitutes, η elasticity of substitution

$$Y = \left[\int_0^1 y(i)^{\frac{\eta-1}{\eta}} \, \mathrm{d}i \right]^{\frac{\eta}{\eta-1}} \tag{8}$$

- Three types of workers, fixed aggregate supplies L, M, H; capital K; competitive factor markets
- Task production functions:

$$\begin{aligned} y(i) = & A_L \alpha_L(i) l(i) + A_M \alpha_M(i) m(i) + A_H \alpha_H(i) h(i) \\ & + A_k \alpha_K(i) k(i) \end{aligned} \tag{9}$$

- A_X factor augmenting technology, $\alpha_X(i)$ task productivity
- Assume $\alpha_L(i)/\alpha_M(i)$ and $\alpha_M(i)/\alpha_H(i)$ decreasing in i (strictly and continuously)
- Now i is an index of task complexity

Future Research: Results from Acemoglu and Autor (2011)

Equilibrium:

- Partitioned equilibrium: three types respectively supply tasks $0 \leq i \leq I_L$, $I_L < i \leq I_H$, and $I_H < i \leq 1$
- Unique I_L and I_H endogenously determined
- Tasks at cut-off supplied at same cost by two groups, but competitive advantage for tasks in interior

Dynamics:

- Non-monotone changes possible
- Technological change can lead to reduced wages: e.g. increase in A_H can reduce w_M
  - Loosely: if I_H shifts down sufficiently more than I_L

Machine-task substitution:

- Suppose r fixed, $\alpha_K(i)$ increases over $i \in [I', I''] \subset [I_L, I_H]$, $\alpha_K(i) = 0$ if $[I', I''] \not\subset [I_L, I_H]$
- If increase sufficiently large, M type workers replaced by capital for $i \in [I', I'']$
- This can reduce w_M while raising Y

SBTC internationally (Berman, Bound, and Machin, 1998)

- Are patterns of SBTC a global phenomenon? Yes!
  - Use UN data for a broad set of (mostly developed) countries
  - Also look within industries, especially manufacturing
- If it had not been, a number of problems would arise
  - Why does technology not spread?
  - Theory does not actually work if global open economy, unless *pervasive* SBTC

SBTC across US states (Ciccone and Peri, 2005)

- SBTC within US states? Yes!
- Look for causal evidence, using state level changes in child labor and compulsory school attendance laws
- Preferred estimate: $\hat{\sigma} = 1.5$

KORV (Krusell, Ohanian, Ríos-Rull, and Violante, 2000)

- Essentially: can capture "technological change" in observables
- Equipment capital K_e (growing quantity, falling price) and structures capital K_s (stable)

$$Y = K_s^{\alpha}[\theta L^{\sigma} + (1-\theta)(\lambda K_e^{\rho} + (1-\lambda)H^{\rho})^{\sigma/\rho}]^{(1-\alpha)/\sigma} \tag{10}$$

- $1/(1-\sigma)$ elasticity of substitution between skilled and unskilled labor, also equipment and unskilled labor
- $1/(1-\rho)$ elasticity of substitution between equipment and skilled labor
- Falling relative prices for equipment exogenous (but observed), returns on two capital types assumed equal
- Estimate σ and ρ, latter smaller: capital-skill complementarity
- Can explain most of skill premium variation
- Labor and capital shares of income quantitatively stable

Endogenous SBTC (Acemoglu, 1998)

- Essentially: endogenizes "technological change" variables
- Question 1: Why would technology be skill-biased?
- Question 2: Coincidence that skill premium does not drift off?
- Suppose technology is produced by R&D
- Efforts to innovate focus on input which has greater benefit
- Increase in supply of skilled workers then has two potentially offsetting effects:
  - Reduced price of high-skilled labor
  - Increased efforts to augment high-skilled labor
- Result: model of skill premium as function of relative supply and fundamentals

Conclusion

- SBTC works well to explain college wage premium
- Has problems beyond that:
  - Falling wages
  - Non-monotone movements in wages and employment
  - Too rough to capture full importance of human capital
- Research has moved towards a task-based approach

Literature I

Abbott, B., G. Gallipoli, C. Meghir, and G. L. Violante (2013). Education policy and intergenerational transfers in equilibrium.

Acemoglu, D. (1998). Why do new technologies complement skills? directed technical change and wage inequality. *The Quarterly Journal of Economics 113*(4), 1055–1089.

Acemoglu, D. and D. Autor (2011). Skills, tasks and technologies: Implications for employment and earnings. *Handbook of Labor Economics 4*, 1043–1171.

Acemoglu, D. and D. Autor (2012). What does human capital do? a review of goldin and katz's the race between education and technology. *Journal of Economic Literature 50*(2), 426–463.

Berman, E., J. Bound, and S. Machin (1998). Implications of skill-biased technological change: international evidence. *The quarterly journal of economics 113*(4), 1245–1279.

Literature II

Ciccone, A. and G. Peri (2005). Long-run substitutability between more and less educated workers: evidence from us states, 1950–1990. *The Review of Economics and Statistics 87*(4), 652–663.

Goldin, C. D. and L. F. Katz (2009). *The race between education and technology*. Harvard University Press.

Katz, L. F. and K. M. Murphy (1992). Changes in relative wages, 1963–1987: supply and demand factors. *The Quarterly Journal of Economics 107*(1), 35–78.

Krusell, P., L. E. Ohanian, J.-V. Ríos-Rull, and G. L. Violante (2000). Capital-skill complementarity and inequality: A macroeconomic analysis. *Econometrica 68*(5), 1029–1053.

Lagakos, D., B. Moll, T. Porzio, N. Qian, and T. Schoellman (2016). Life-cycle human capital accumulation across countries: Lessons from us immigrants. Technical report, National Bureau of Economic Research.

Literature III

Manuelli, R. E. and A. Seshadri (2014). Human capital and the wealth of nations. *The American Economic Review 104*(9), 2736–2762.