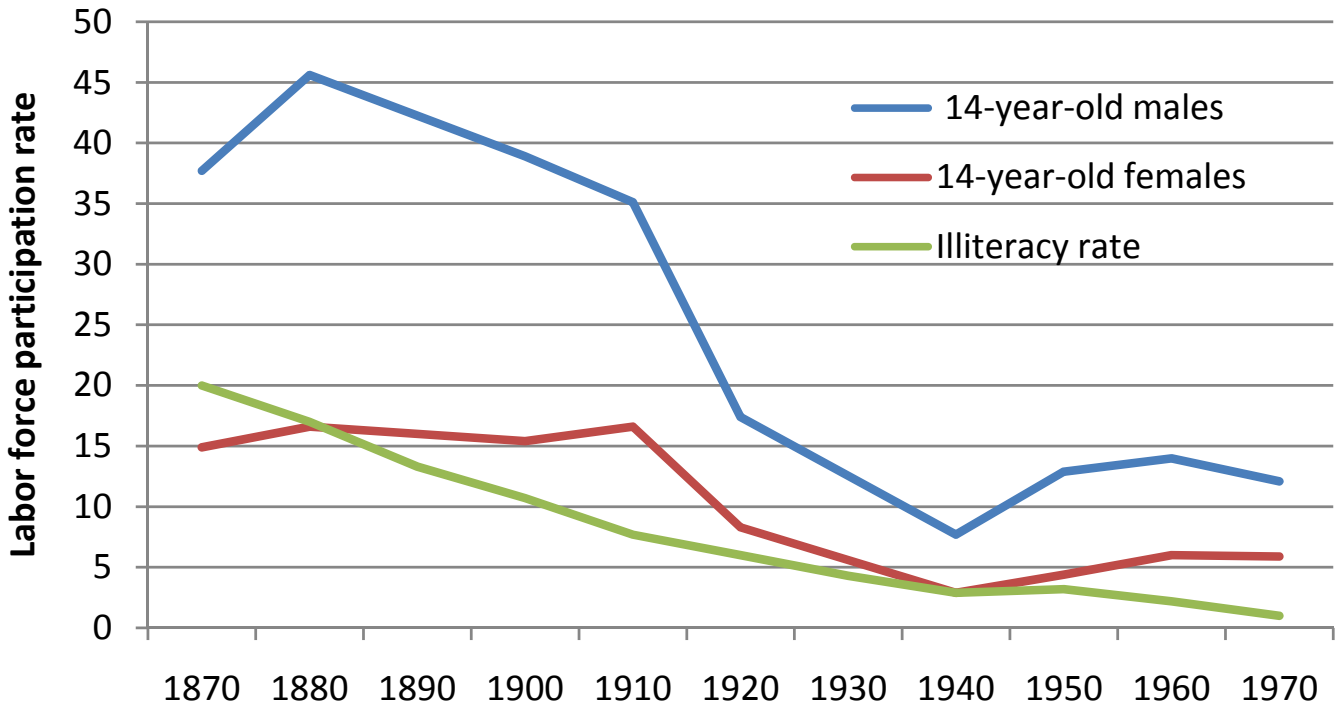
The Rise of an Educated Workforce



The Rise of an Educated Workforce

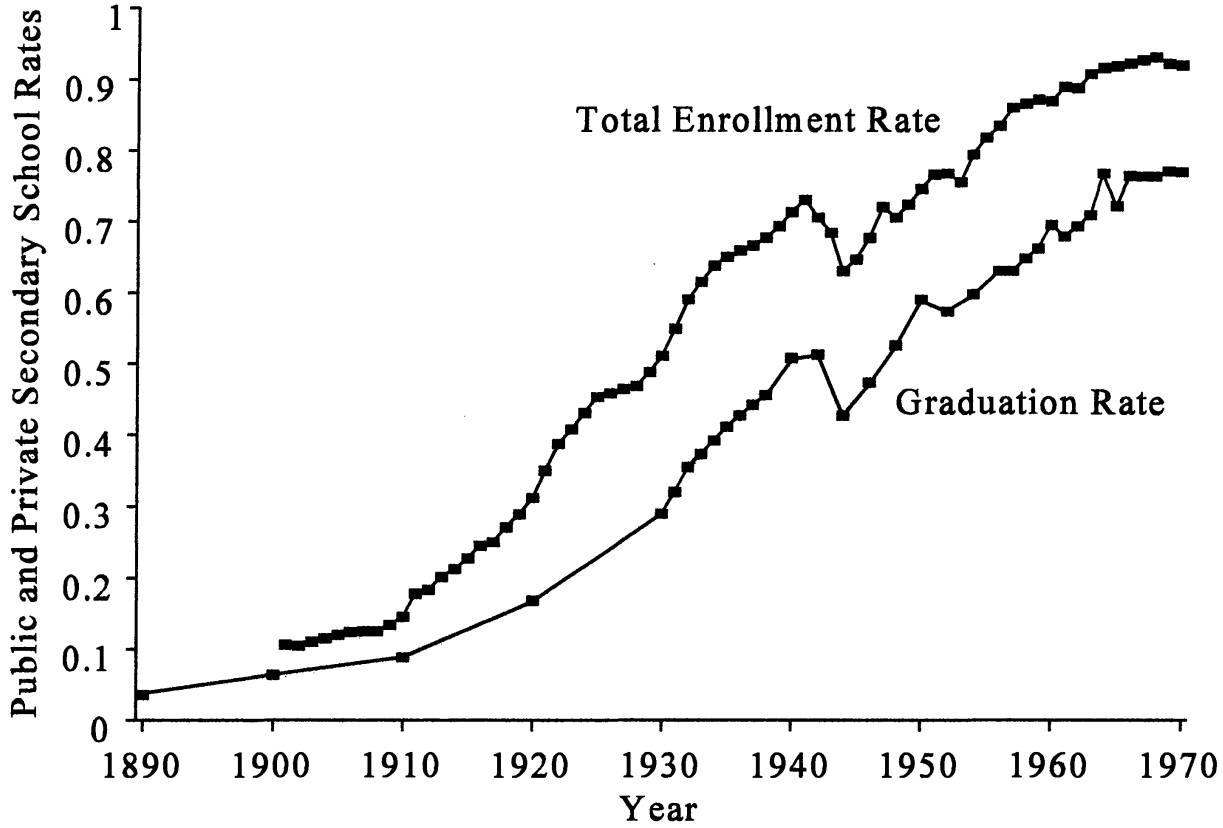
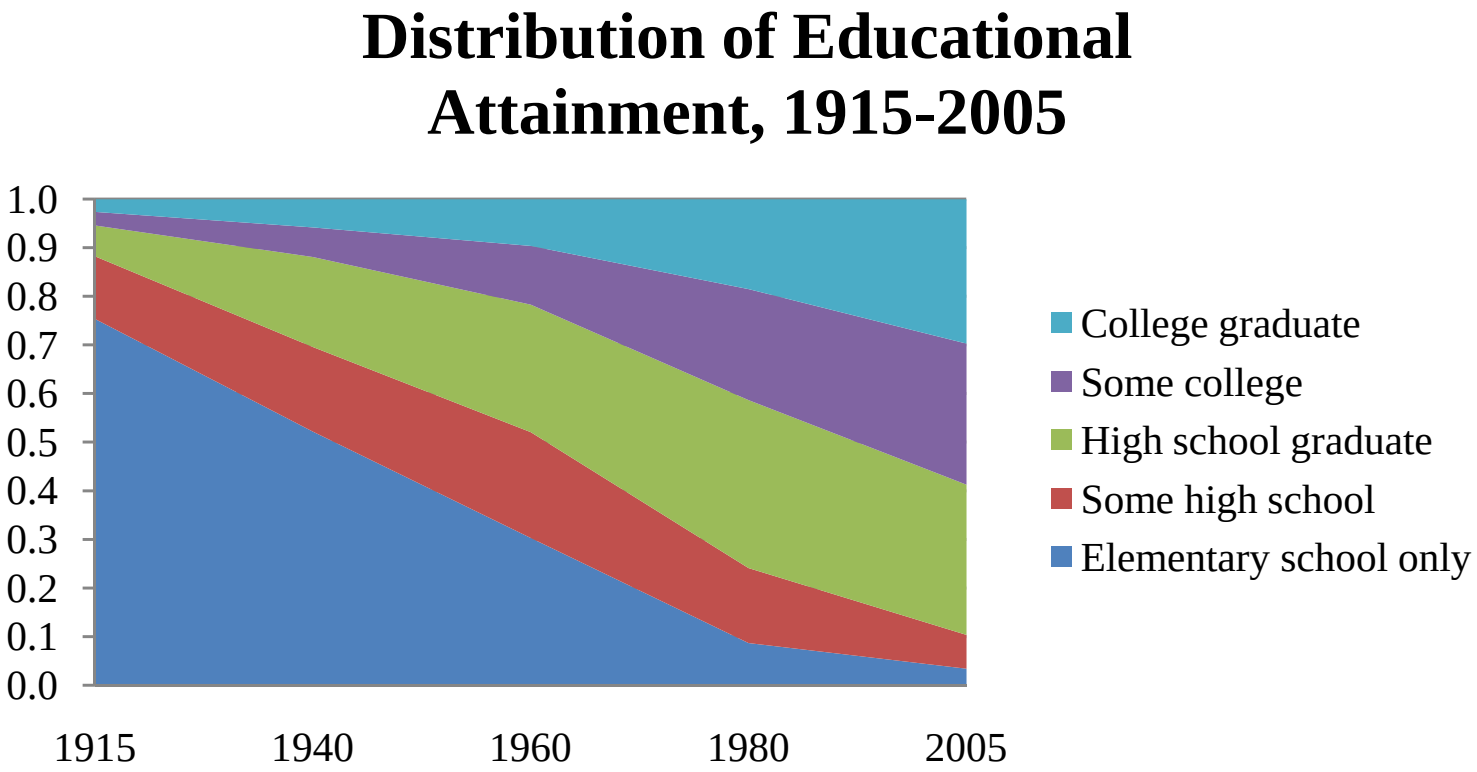


FIGURE 1
SECONDARY SCHOOL ENROLLMENT AND GRADUATION RATES:
ENTIRE UNITED STATES

The Rise of an Educated Workforce



The Effects of Rising Educational Attainment

- Remember our growth accounting from the start of the semester
- We can decompose the growth in output per worker, g_y, into the components due to growth in natural resources per worker (s), capital per worker (k) and technology (A):

$$g_y = g_A + a \cdot g_k + c \cdot g_s$$

- a and c are the shares of payments to capital and natural resources relative to national income, respectively
- Human capital is actually another crucial input to the economic growth and should be in this equation

The Effects of Rising Educational Attainment

- To think about incorporating human capital, lets ignore growth in natural resources (a very small term in the 20th century) and focus on capital and labor
- Labor isn't what matters, it's effective labor that matters
- Letting L be the number of workers and E be labor in efficiency units:

$$Y = AK^{1-\alpha}(L \cdot E)^{\alpha}$$

$$\frac{Y}{L} = AK^{1-\alpha}E^{\alpha}L^{\alpha-1}$$

$$\frac{Y}{L} = A\left(\frac{K}{L}\right)^{1-\alpha}E^{\alpha}$$

$$y = AE^{\alpha}k^{1-\alpha}$$

The Effects of Rising Educational Attainment

$$y = AE^{\alpha}k^{1-\alpha}$$

$$ln(y) = ln(A) + \alpha ln(E) + (1-\alpha)ln(k)$$

$$\Delta ln(y) = \Delta ln(A) + \alpha \Delta ln(E) + (1-\alpha)\Delta ln(k)$$

$$g_y = g_A + \alpha g_E + (1-\alpha)g_k$$

- When economists didn't account for g_E, its effects were being swallowed by g_A
- If we incorporate g_E into our growth accounting, sources of growth in the twentieth century look a bit different

The Effects of Rising Educational Attainment

Educational Growth Accounting, 1915-2005

Period	Annual percentage change in: Output per worker	Human capital per worker	Fraction of growth explained by human capital	Change in mean years of education
1915-40	2.45	0.50	0.143	1.38
1940-60	2.92	0.49	0.118	1.52
1960-80	2.41	0.59	0.171	1.93
1980-2005	2.18	0.37	0.119	1.08
1915-2005	2.47	0.48	0.136	5.91

The Increased Demand for Education

- So a decent chunk of the increased output per worker we attributed to increased technology is actually coming from increased human capital
- Where did this increase in human capital come from?
- This is where we weren't entirely wrong to be focused on technology
- The basic story is that the technological innovations associated with industrialization created a greater demand for or supply of educated workers
- Possible mechanisms for this:
  - Technology displaced skilled craftsmen, to get jobs they needed to get more education (greater supply of educated workers)
  - Technology required educated workers to be effective (greater demand for educated workers)

Technology and an Educated Workforce

WHEREAS,

Several EVIL-MINDED PERSONS have assembled together in a riotous Manner, and DESTROYED a NUMBER of

FRAMES,

In different Parts of the Country:

THIS IS

TO GIVE NOTICE,

That any Person who will give Information of any Person or Persons thus wickedly

BREAKING THE FRAMES,

Shall, upon CONVICTION, receive

50 GUINEAS

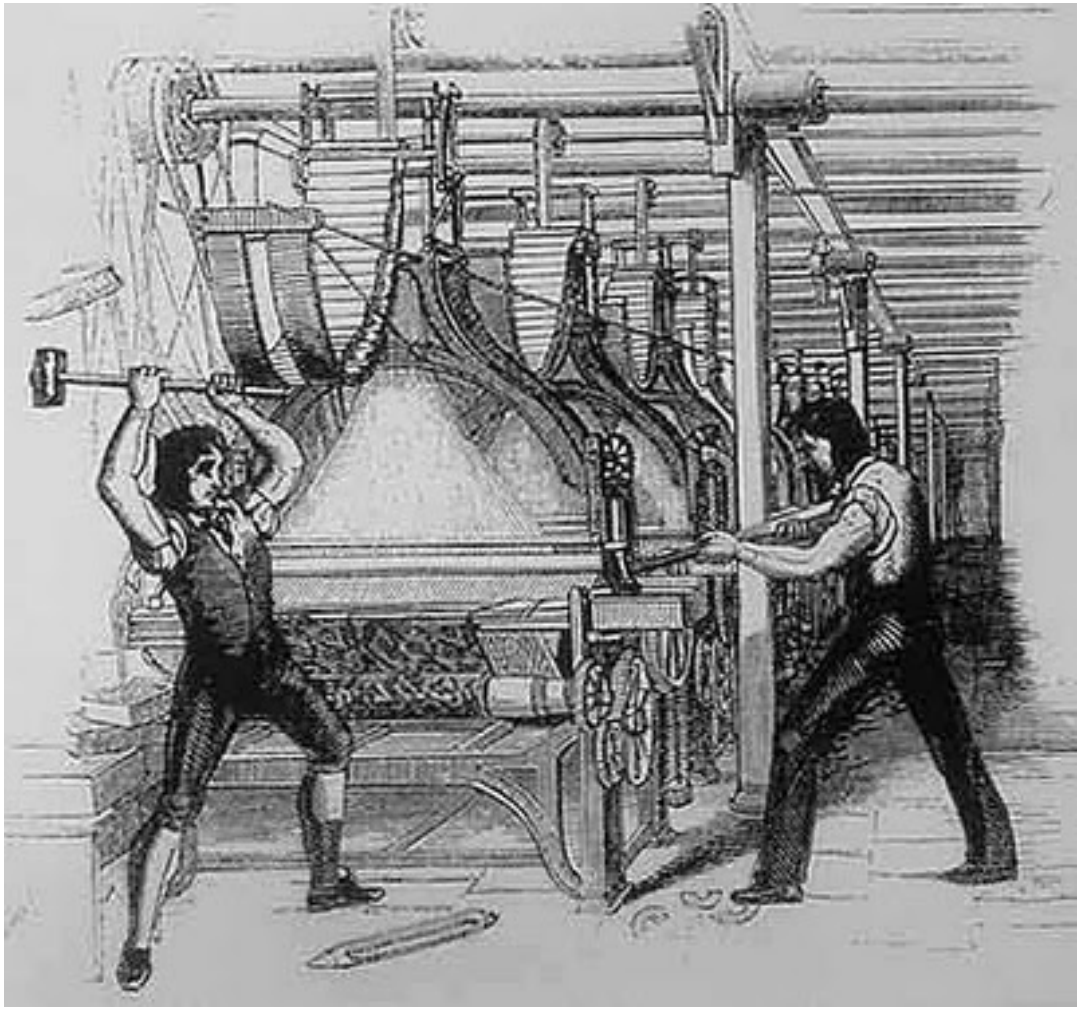
REWARD.

And any Person who was actively engaged in RIOTING, who will impeach his Accomplices, shall, upon CONVICTION, receive the same Reward, and every Effort made to procure his Pardon.

☞ Information to be given to Messrs. COLDHAM and ENFIELD.

Nottingham, March 26, 1811.

Technology and an Educated Workforce



Technology and an Educated Workforce

Foxconn is adding one million ABB Frida robots over the next three years.

What Drove Demand for Education?

- So far, we've talked about industrialization replacing skilled workers with machines and unskilled workers
- This is why we see groups like the Luddites protest the early stages of industrialization (and modern aspects of industrialization)
- It would seem then that industrialization increases demand for unskilled workers, not highly educated workers
- It turns out that this is only partially true

What Drove Demand for Education?

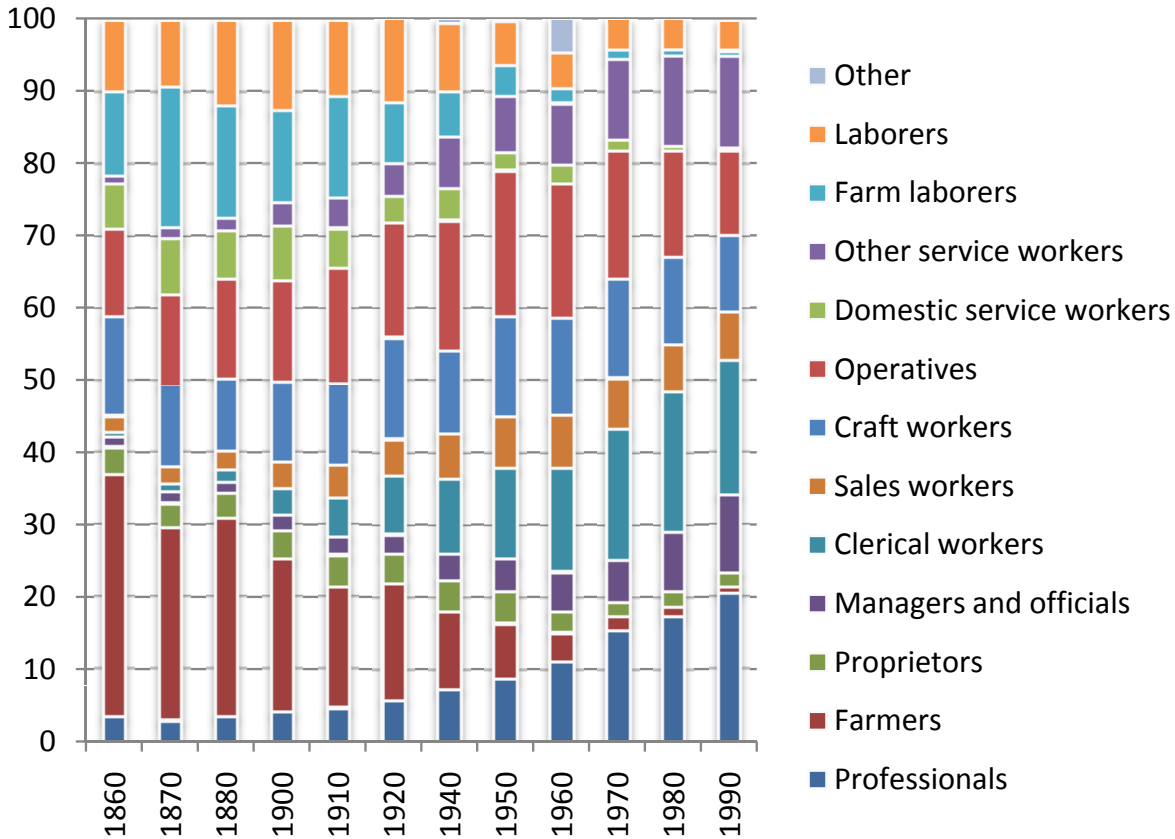
- Industrialization was causing a "hollowing out" of the occupational distribution
- It created unskilled positions (tending machines, assembly line work) and positions requiring highly educated workers (engineers, white collar workers, etc.)
- It did away with certain skilled blue collar jobs in the middle of the occupational distribution
- For the remaining blue collar jobs, education was becoming increasingly important (eg. understanding technical manuals)
- As a consequence, the path to higher income increasingly depended on education

Changes in the Occupational Distribution

TABLE II
PERCENTAGE HIGH SCHOOL GRADUATES BY INDUSTRY, 18 TO 34-YEAR OLD MALE BLUE-COLLAR WORKERS: 1940

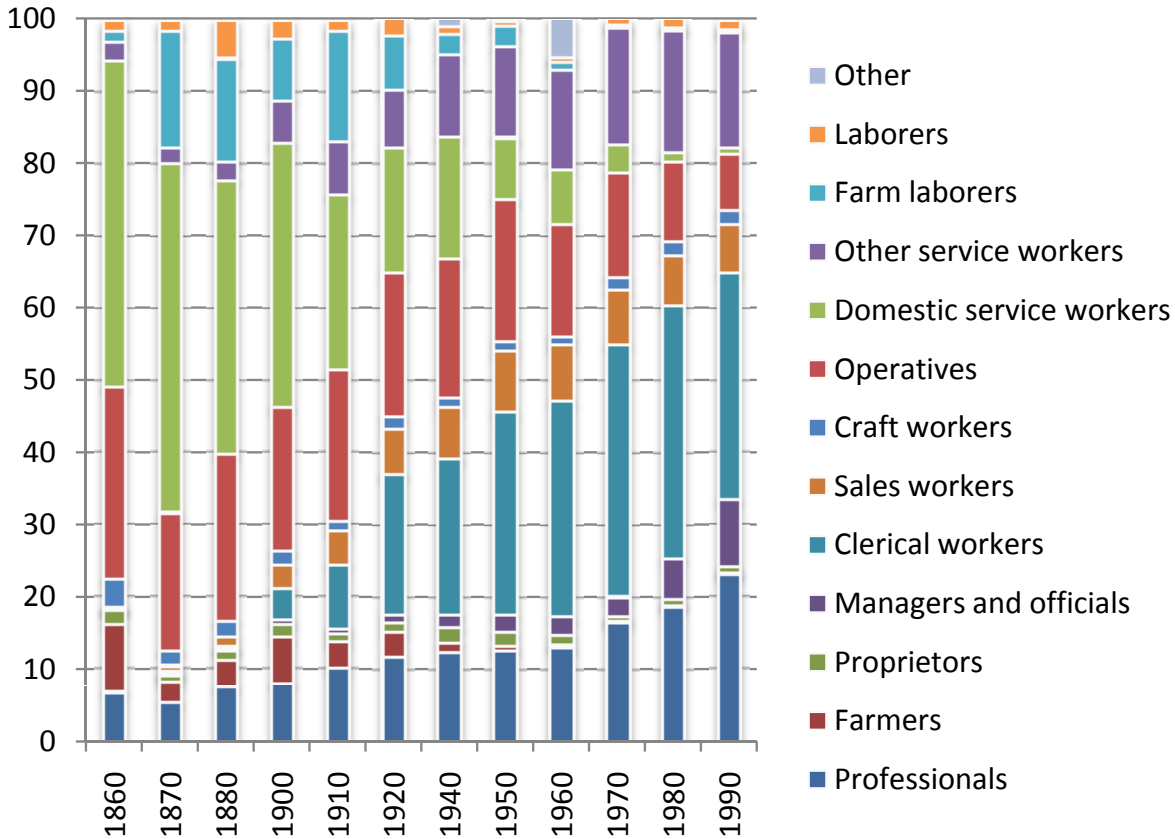
Three-digit SIC manufacturing industries	*% H.S. grad.*	*Number of obs.*	*Three-digit SIC manufacturing industries*	*% H.S. grad.*	*Number of obs.*
High-education industries (from high to low)			*Low-education industries (from low to high)*		
Top 20% by employment			*Bottom 20% by employment*		
Aircraft and parts	52.7	541	Cotton manufactures	10.8	1512
Printing and publishing	44.7	1289	Tobacco	11.6	144
Office machinery	43.7	166	Logging	11.7	706
Petroleum refining	43.3	415	Sawmills and planing mills	14.1	1941
Dairy products	43.2	417	Not specified textile mills	15.6	128
Scientific and photographic equipment	40.8	227	Silk and rayon manufactures	16.6	350
Electrical machinery	40.5	977	Carpets and rugs	16.9	107

Changes in the Occupational Distribution



Male Occupational Distribution Over Time

Changes in the Occupational Distribution

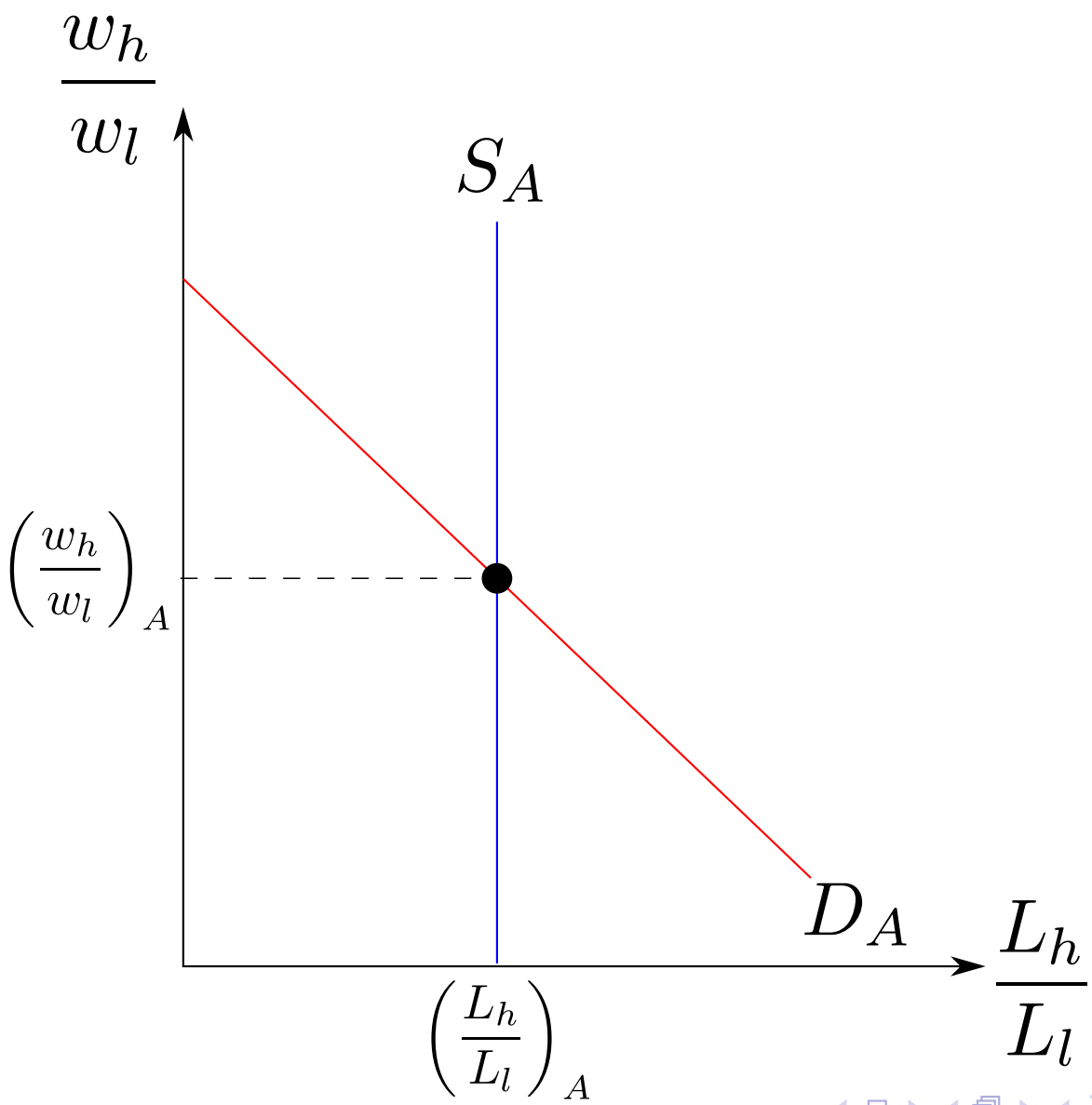


Female Occupational Distribution Over Time

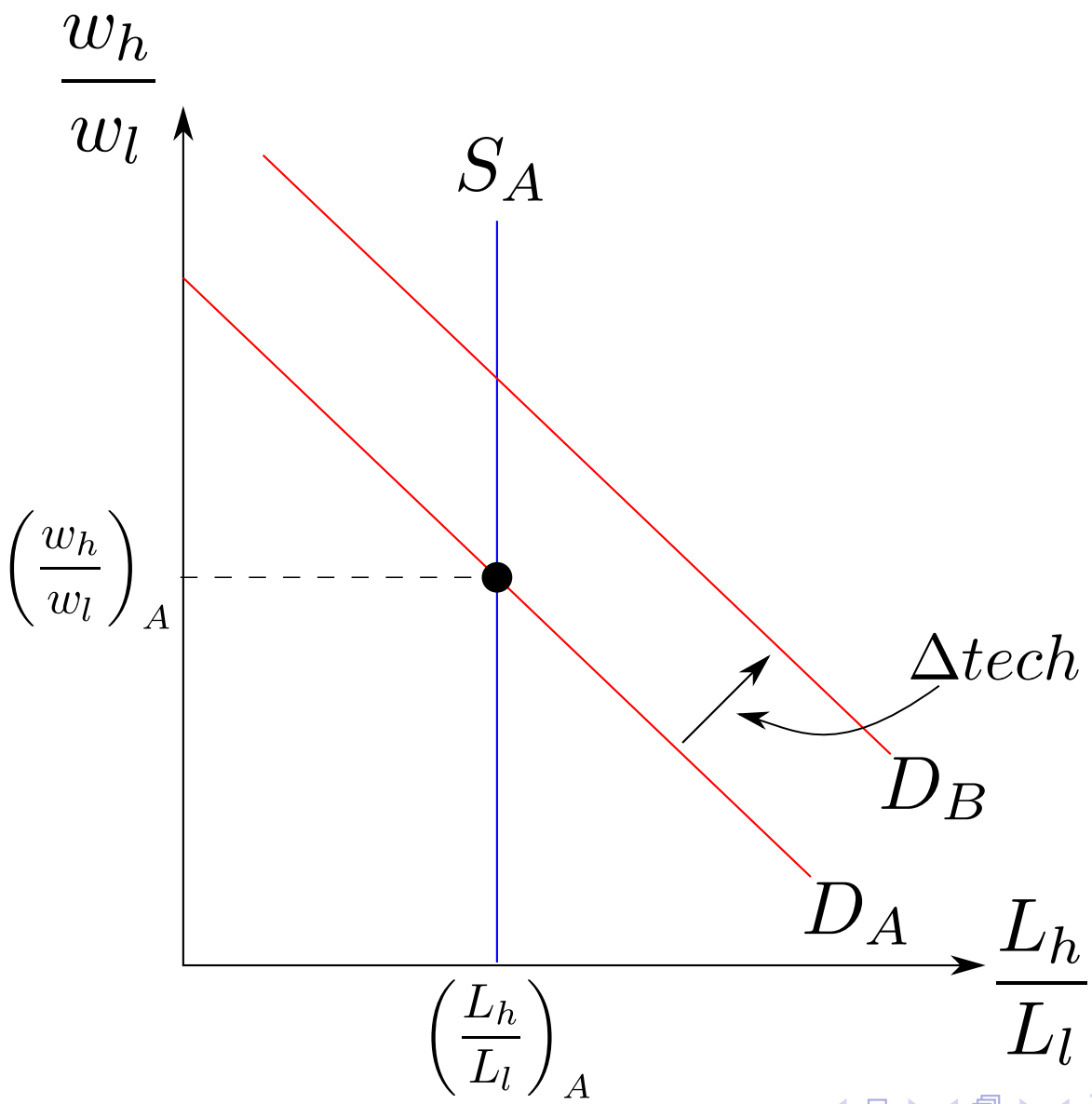
Skill-biased Technological Change and Education

- Goldin and Katz emphasize "skill-biased technological change" in the 20th century (but not 19th century)
- The idea is that the improvements in technology required educated workers to implement
- This drives up the demand for highly educated workers relative to less educated workers
- Increased demand for educated workers means potentially higher wages for educated workers
- The loss of certain skilled blue collar jobs plus the increased returns to education increased the supply of educated workers
- This leads to an ambiguous net effect on worker welfare

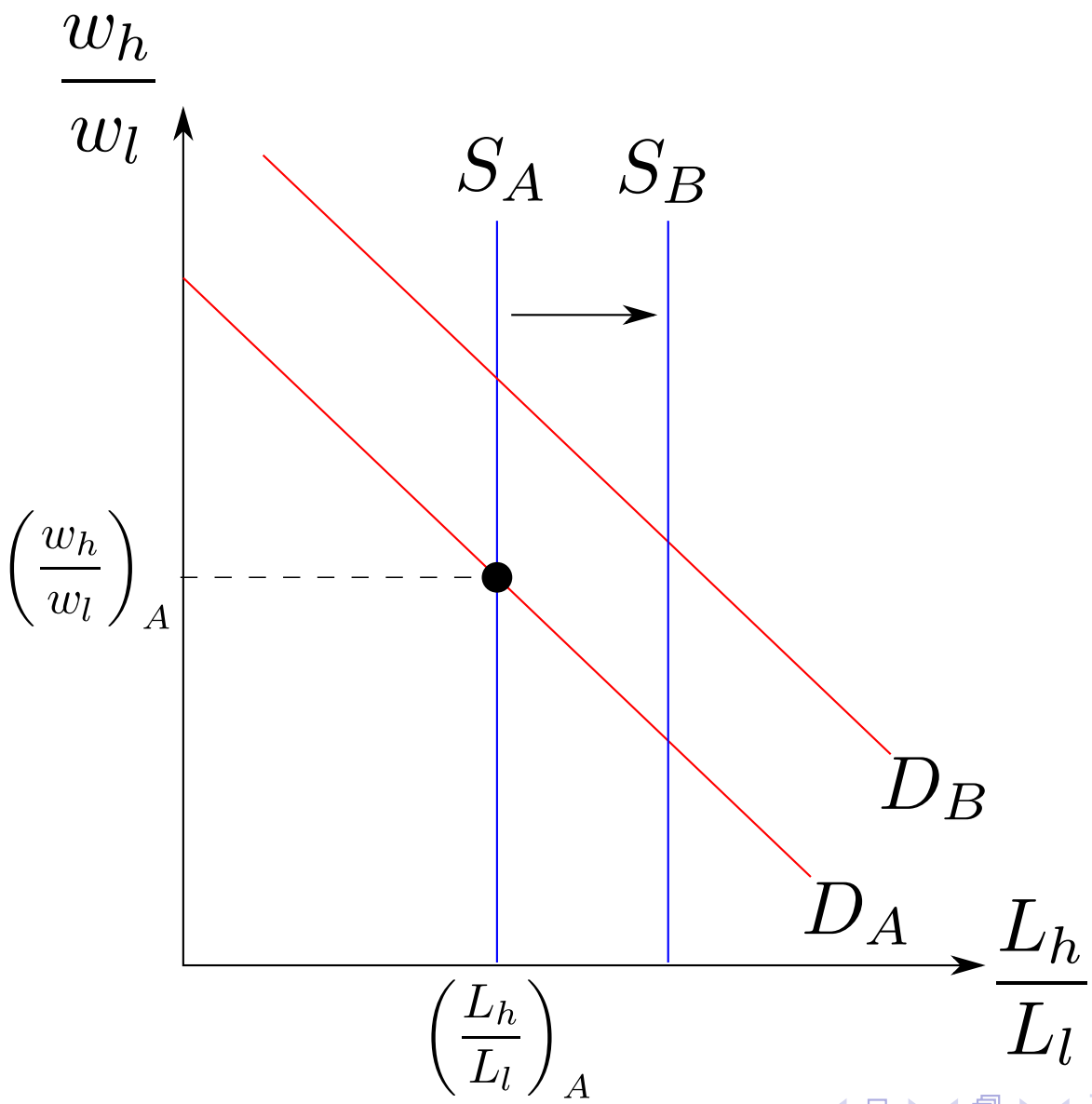
Skill-biased Technological Change and Education



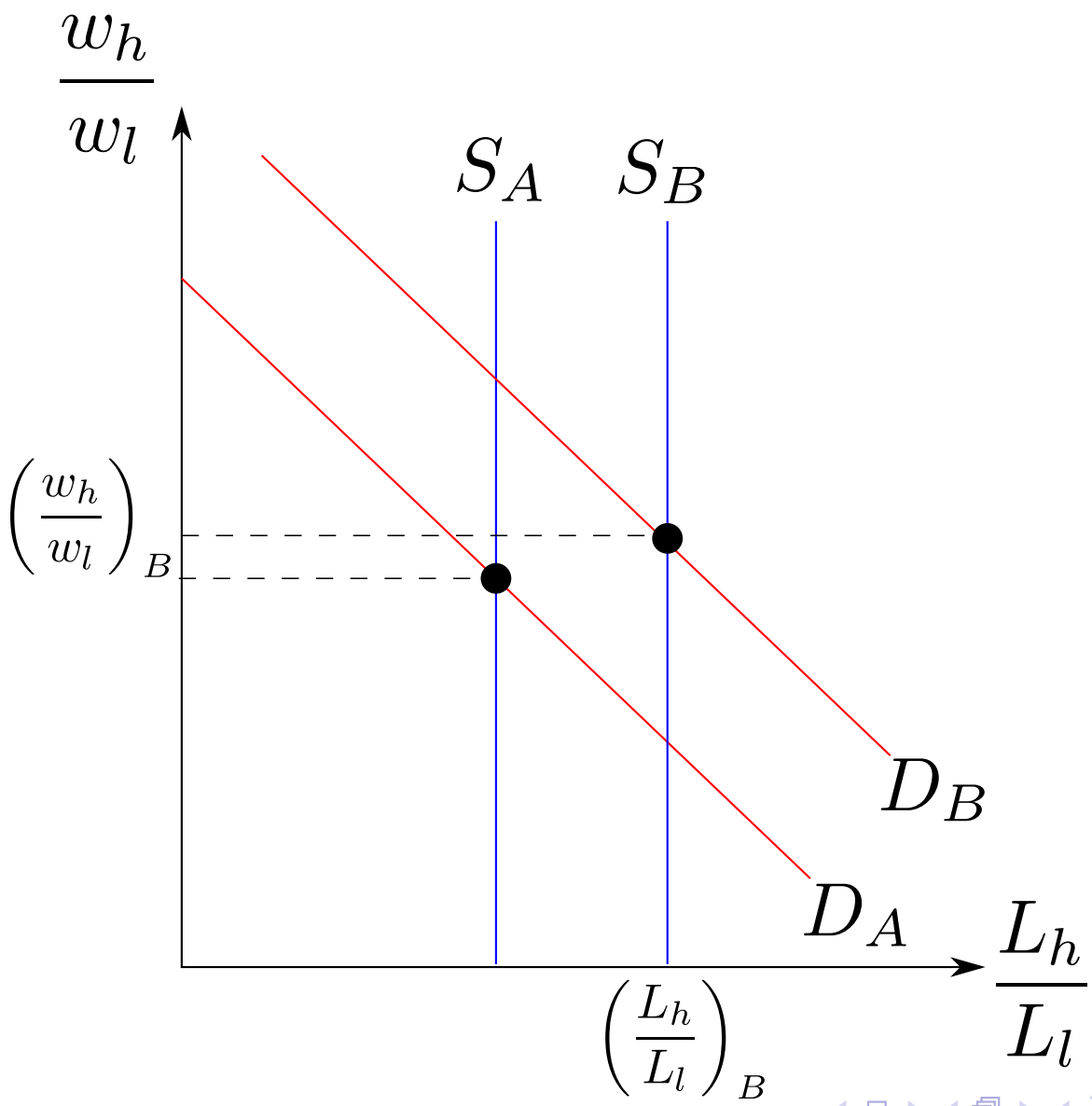
Skill-biased Technological Change and Education



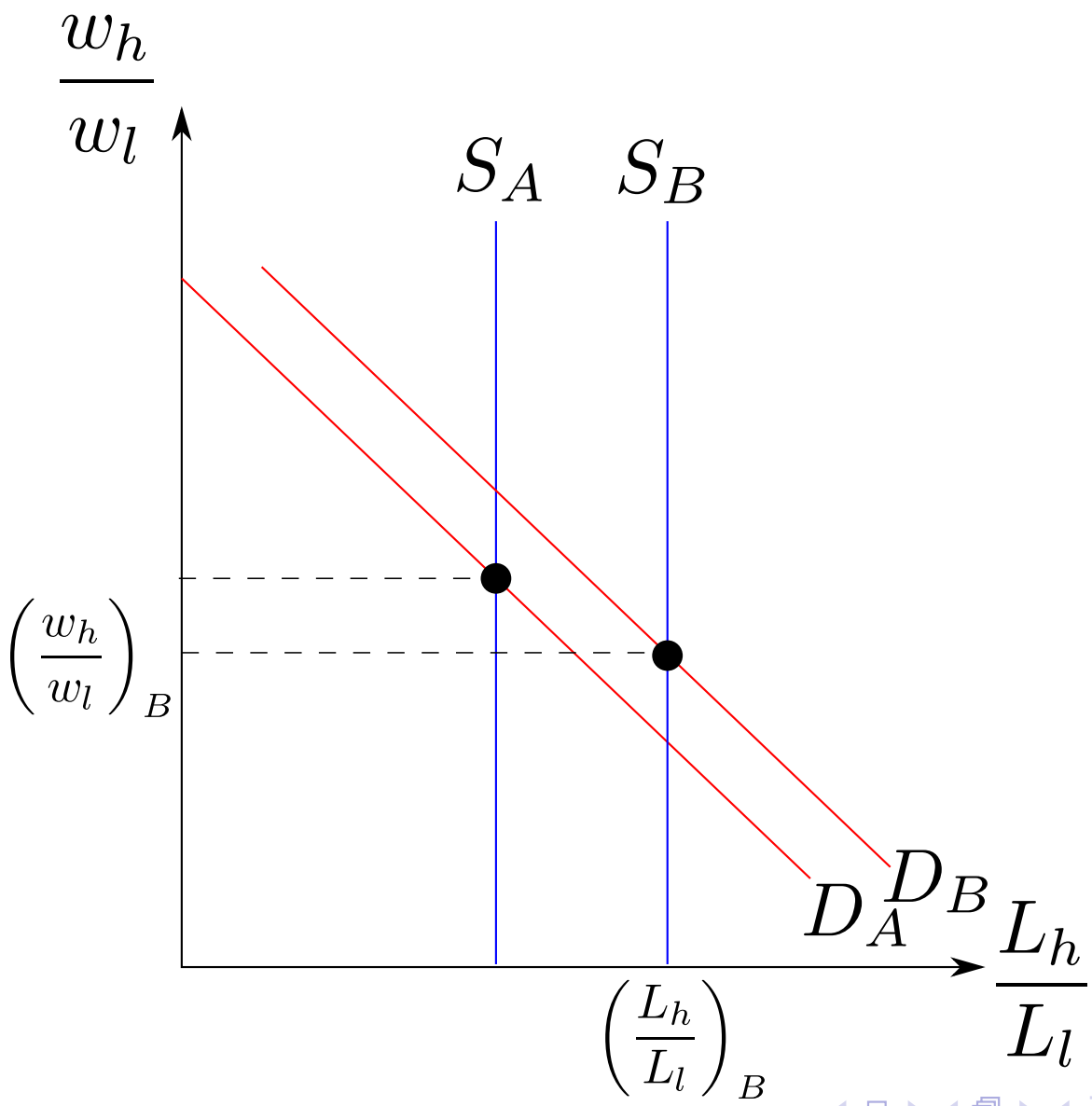
Skill-biased Technological Change and Education



Skill-biased Technological Change and Education



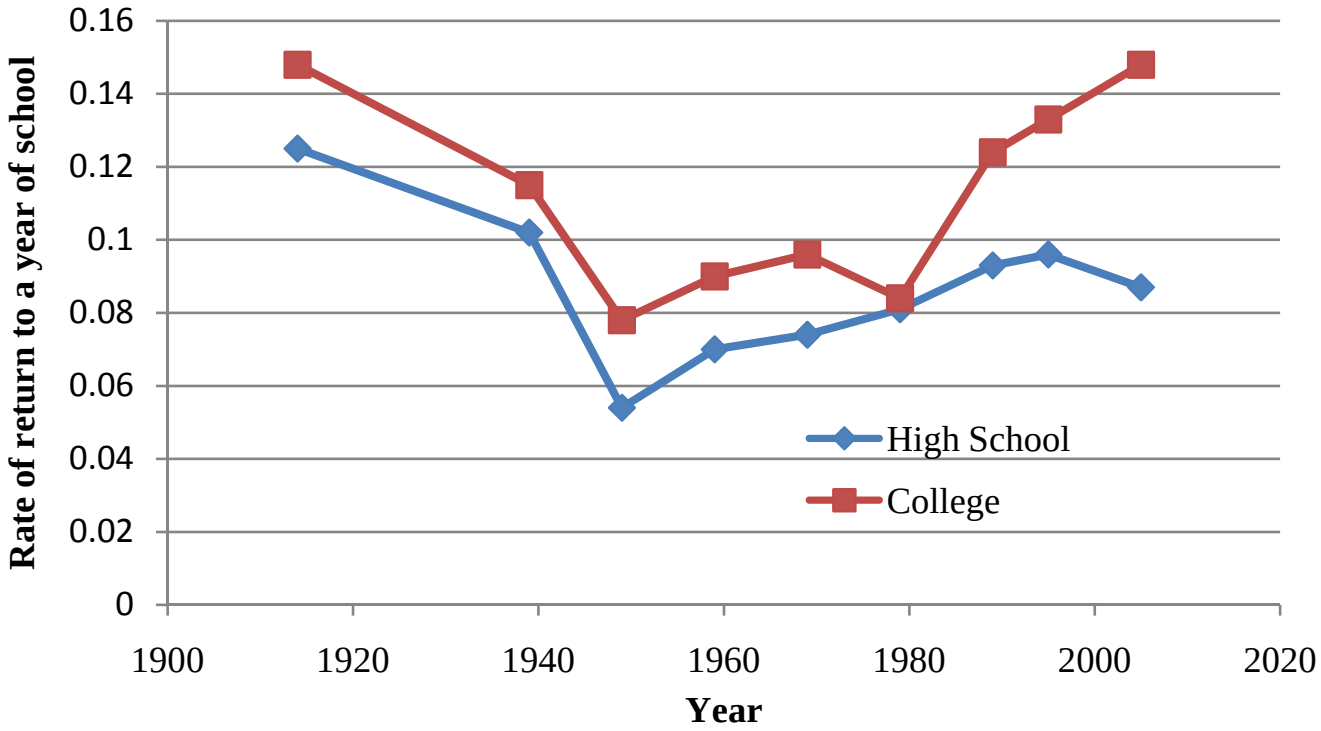
Skill-biased Technological Change and Education



The Race Between Education and Technology

- So whether the wages of educated/skilled workers rise relative to other workers depends on whether demand is shifting out faster than supply
- This is what Goldin and Katz refer to as the race between education and technology
- If the supply of educated workers expands faster than technology, wages of educated workers relative to other workers will fall
- If the supply can't keep up with changes in technology, wages of educated workers will rise
- The outcome of this race has been changing over the past century

The Race Between Education and Technology



The Race Between Education and Technology

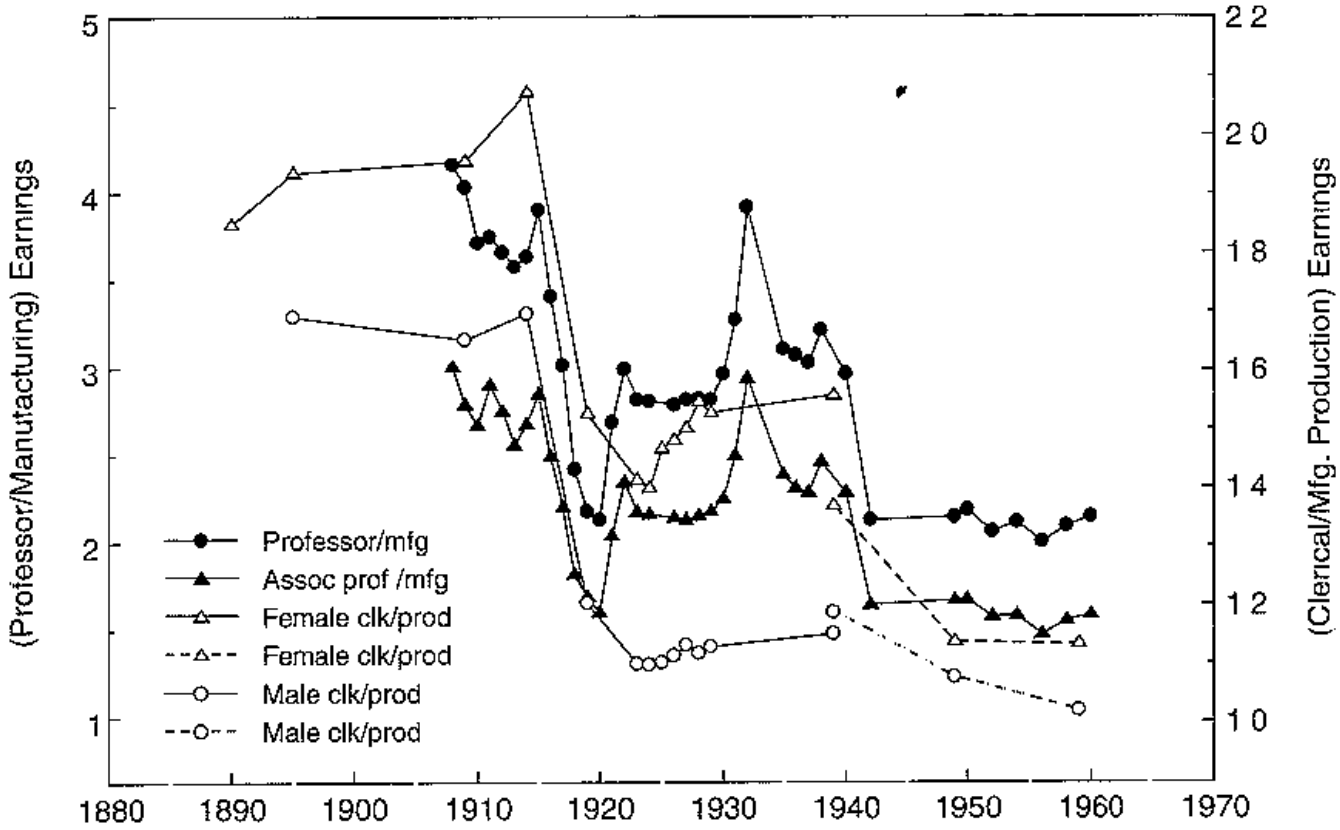


Figure 2.8 Ratios of White-Collar to Blue-Collar Earnings. Sources: See Tables 2.2 and 2.3

The Race Between Education and Technology

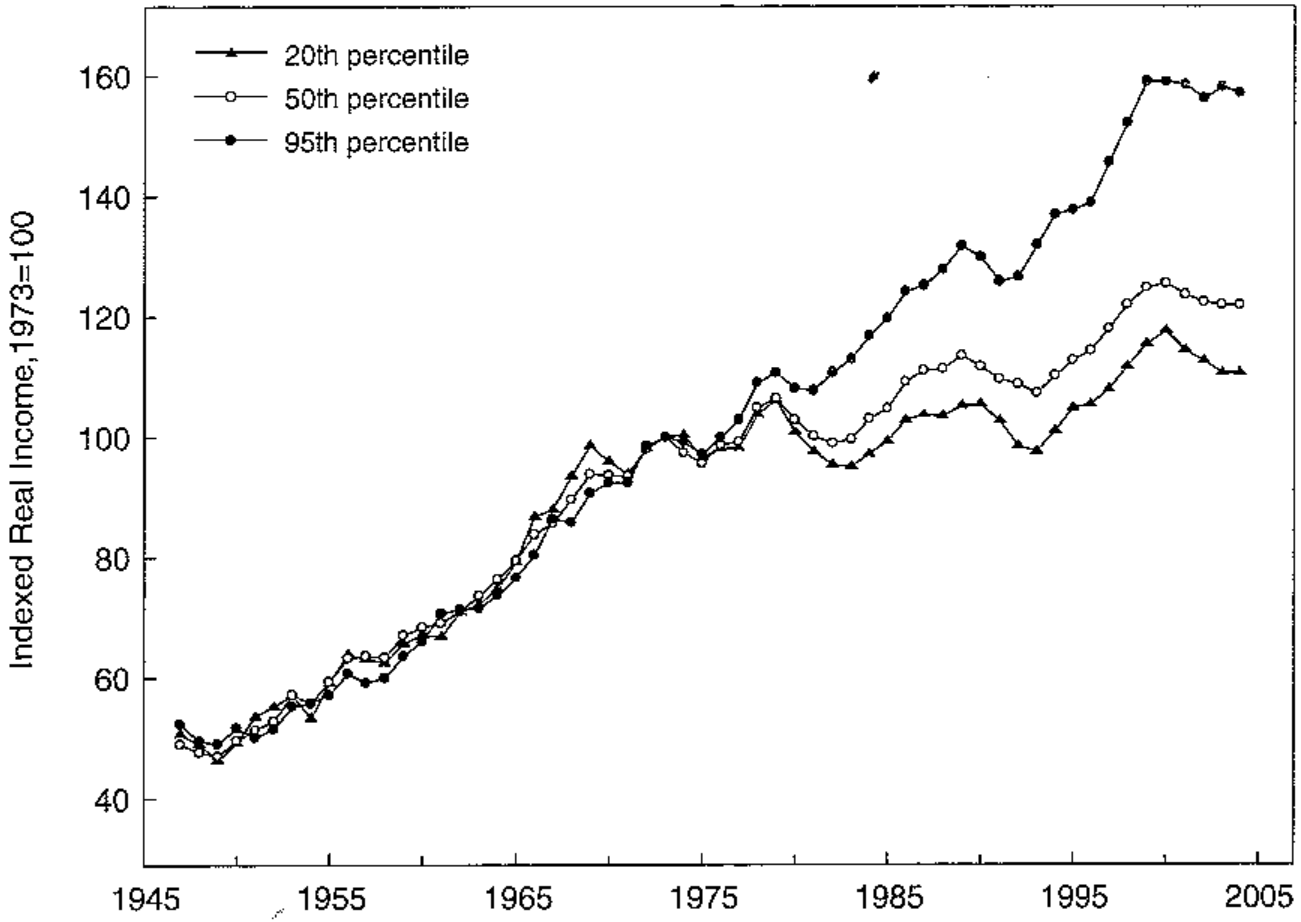


Figure 2 3 Evolution of Low, Middle, and High Family Incomes, 1947 to 2005