

# The Effects of Technological Change on the Workforce:

How A.I. Could Affect Employment and Wages

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# Issues to be discussed regarding the labor market, technology, and AI

- There are concerns about artificial intelligence and the future of work; some have suggested calamitous effects on employment and wages.
- But it is important to remember:
  - AI is an aspect of innovation and technological advance.
  - Productivity enhancement from innovation is a driver of economic growth.
  - Economic growth, sustained over the long-term, is the main source of improvement in standards of living.
- Discuss historical causes innovation and growth.
- Consider how innovation and improvement in living standards played out in the past, especially for the labor market and the recent era of computerization.
- What does this say about AI and the future?

# The Importance of Economic Growth

- Suppose per capita income grows at 2% per year.

Year	Income relative to initial year
0	1
1	1.02
10	1.22
20	1.49
30	1.81
50	2.69
100	7.24
200	52.5

Has anything like this happened economy-wide? Yes.  
(From Jones and Romer (2010), based on Maddison (2008).)

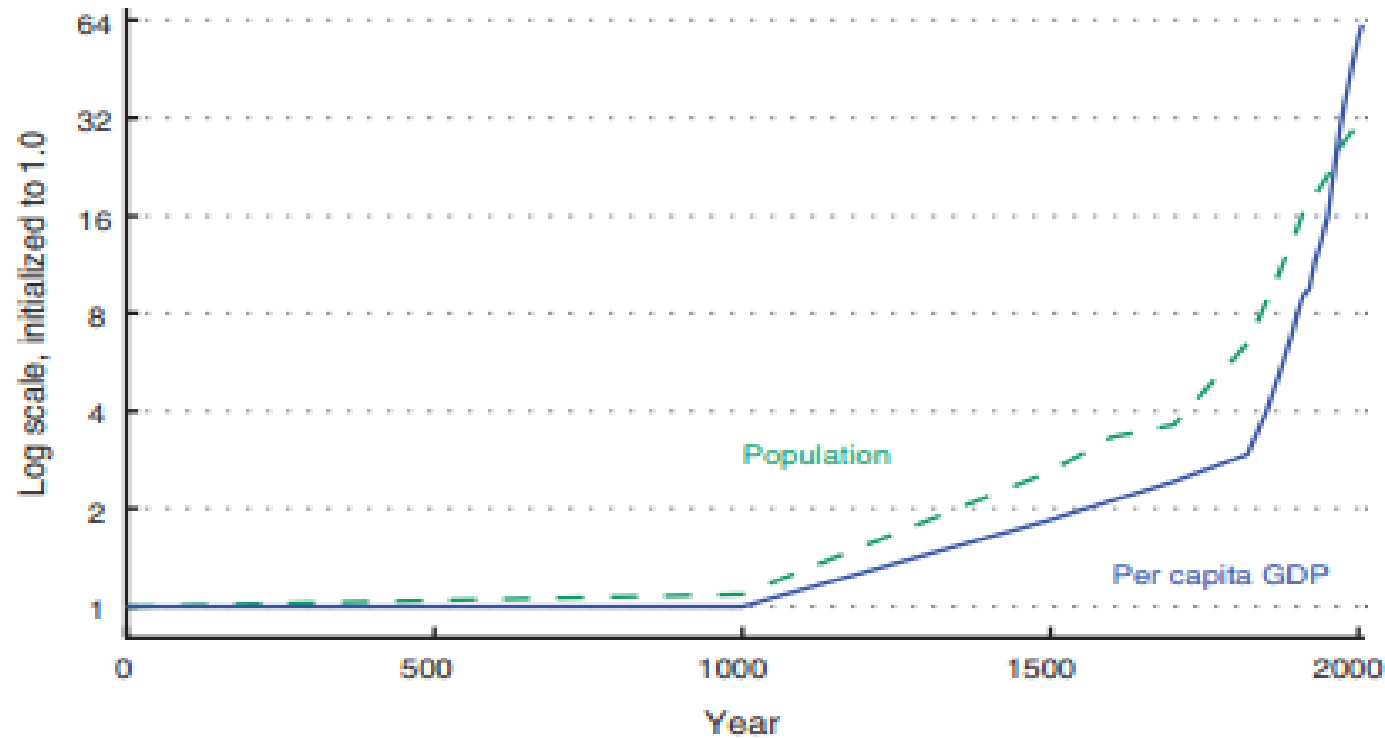


FIGURE 2. POPULATION AND PER CAPITA GDP OVER THE VERY LONG RUN

*Notes:* Population and GDP per capita for “the West,” defined as the sum of the United States and 12 western European countries. Both series are normalized to take the value 1.0 in the initial year, 1 AD.

# Growing per capita income is associated with a host of related patterns.

- Lower infant mortality; better health; increased longevity; greater population
- More and better food, housing, clothing, and other goods; improved quality and variety
- Higher wages; more leisure time
- Greater literacy and education
- The growth the arts and of large charitable organizations

# What accounts for this sustained growth? And how to keep sustaining it?

- How much productivity growth is due to:
  - Differences in physical capital per unit of labor services
  - Differences in human capital per unit of labor services
  - Other, “unmeasured” factors, i.e., the “Solow residual”
- Jones and Romer (2010):

“ . . . the residual is quantitatively at least as important as the measured factor inputs.”
- The “residual” is thought of as innovation and its interplay with:  
human capital, institutions, population (human interaction)

Adam Smith ([1776] (1937)) recognized an important innovation – the division of labor – and its link to growth

“It is the great multiplication of the productions of all the different arts, in consequence of the division of labour, which occasions, in a well-governed society, that universal opulence which extends itself to the lowest ranks of people.”

“Every workman has a great quantity of his own work to dispose of beyond what he himself has occasion for; and every other workman being exactly in the same situation, he is enabled to exchange a great quantity of his own goods . . . [for] a great quantity of theirs.”

“ . . . a general plenty diffuses itself through all the different ranks of society.”

# The interplay of innovation with human capital, human interactions, and “institutions”

- Human interaction, population, and human capital

“In . . . [modern] economies, the increased density that comes with higher population and greater urbanization promotes specialization and greater investment in human capital, and also more rapid accumulation of new knowledge.” (Becker, Glaeser, and Murphy (1999))

- The institution of private ownership

“. . . Western societies had given their enterprises certain rights . . . grant[s] of authority [or freedom] to make a number of decisions which had been made by political or religious authorities in most other societies.” (Rosenberg and Birdzell (1986))

E.g., forming enterprises, deciding on what to sell; introduction of new activities; claim on profits and assets. (Private ownership)

- When thinking about AI: Think of it as innovation and productivity enhancement, as well as what enables innovation.



How does innovation play out . . . for individual industries and for the entire labor market.

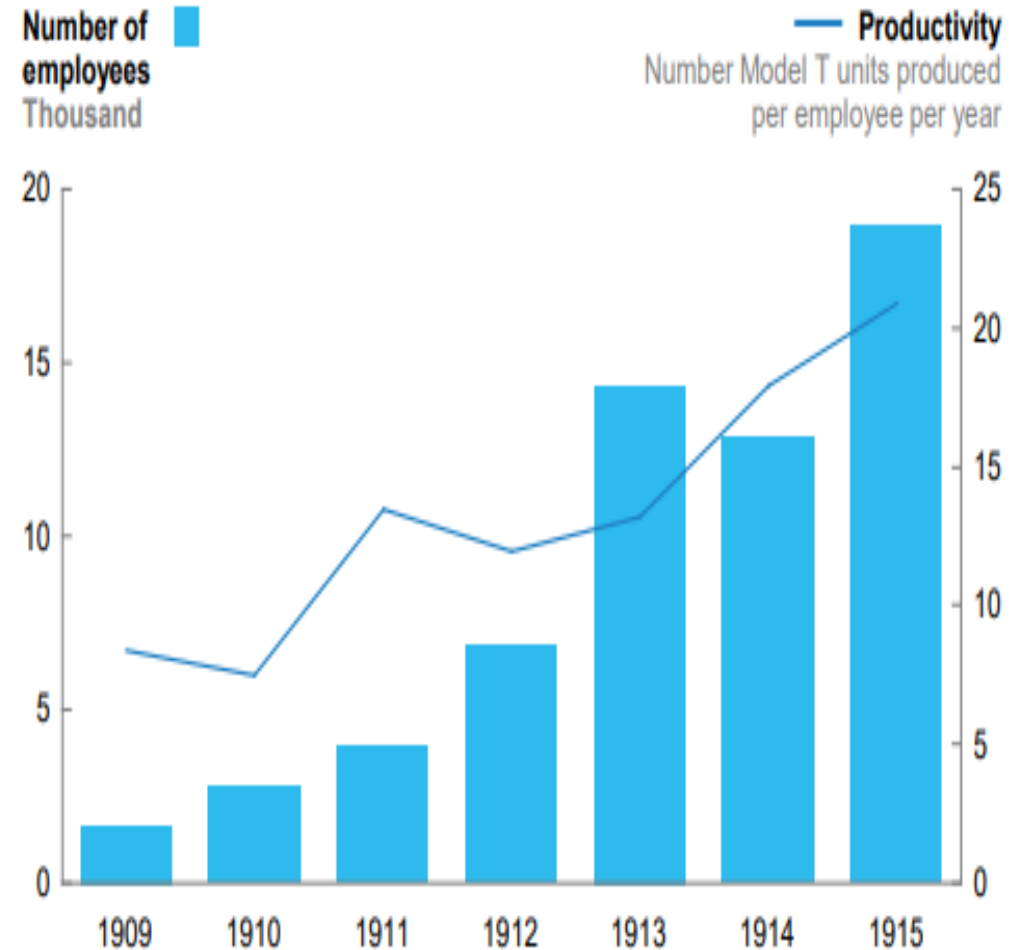
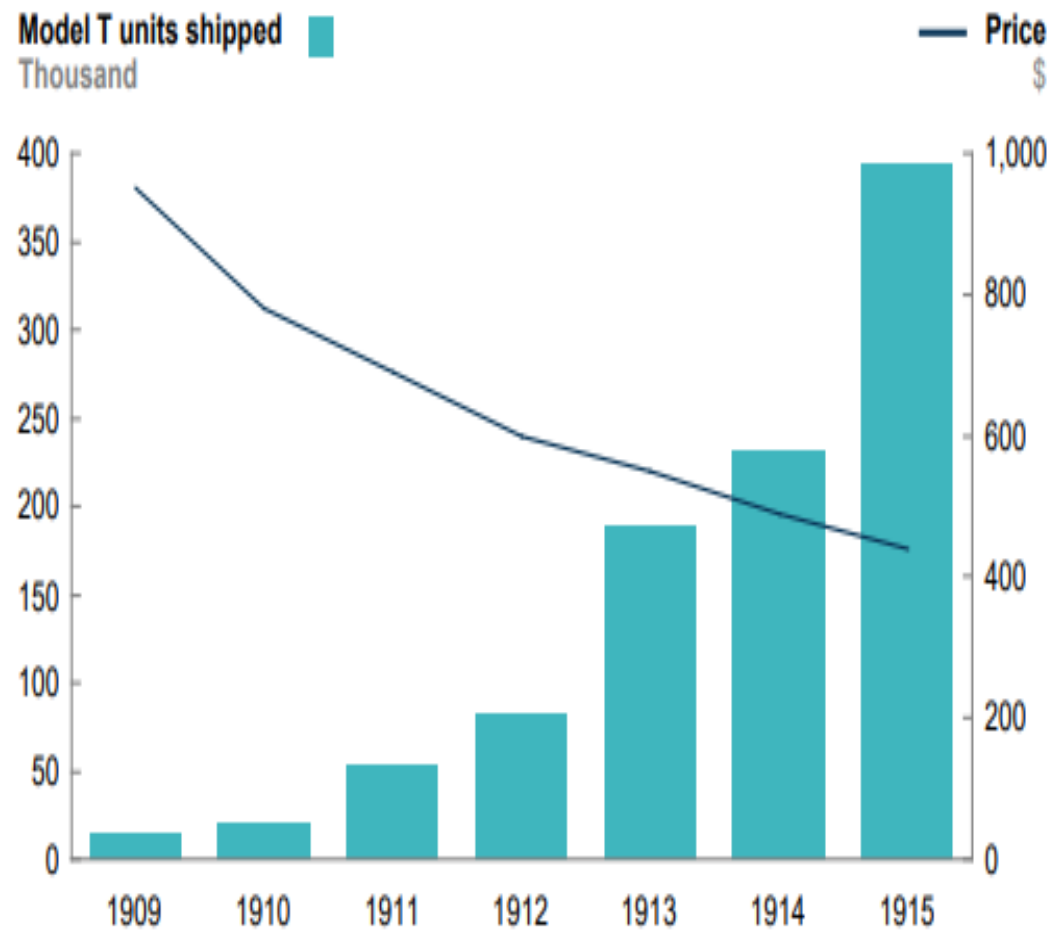
For an industry:

- Productivity growth in an industry means the same output can be produced with fewer workers.
- Productivity growth lowers costs and prices, so customers buy more. If they buy enough more, then more workers are needed in the industry.

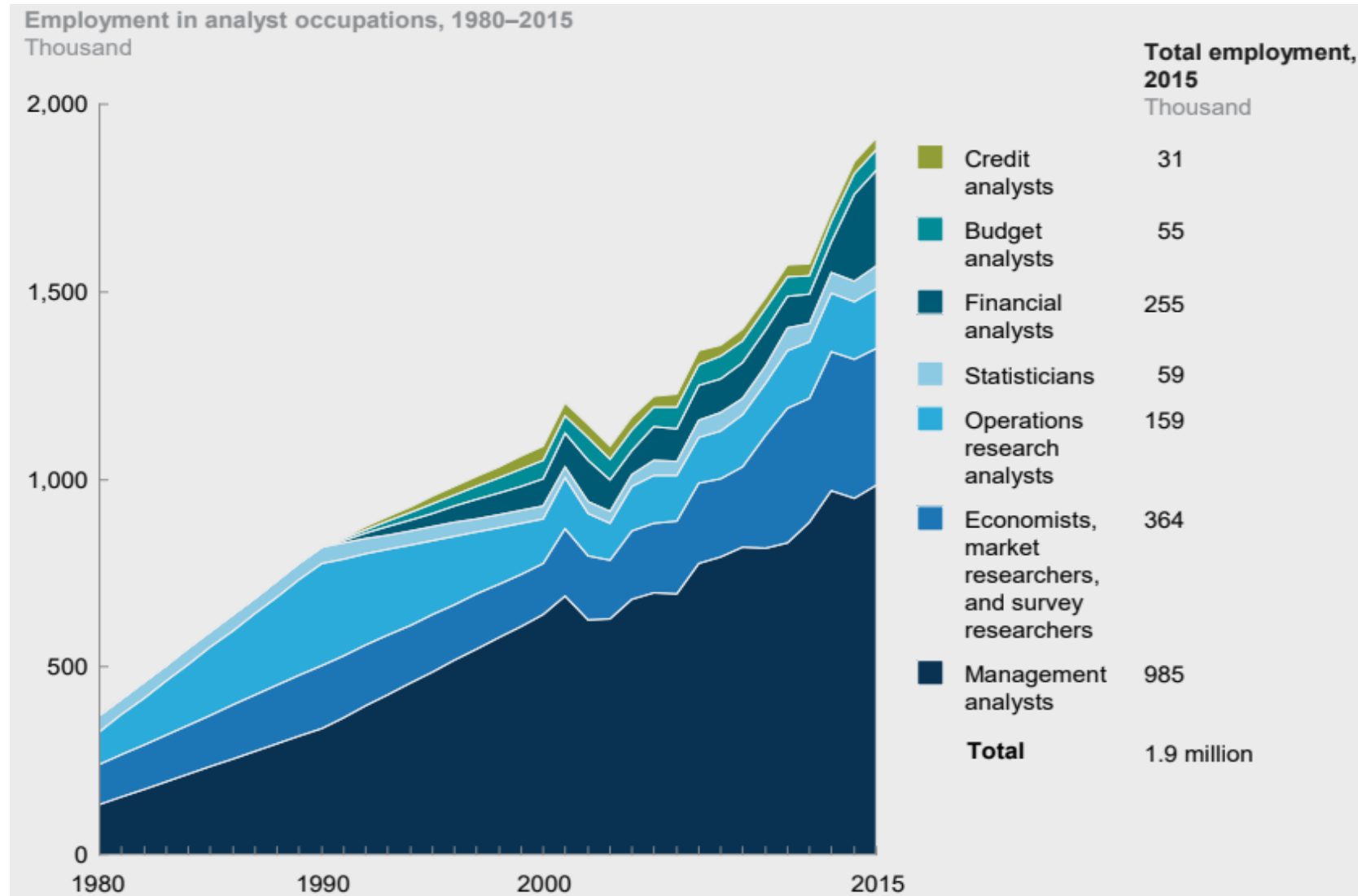
For the entire labor market:

- Jobs “move around.” But the greater productivity implies higher per capita output and income. More of *something* is purchased, thus creating jobs.

# Example of rising industry employment: The Model T (McKinsey Global Institute (2017))

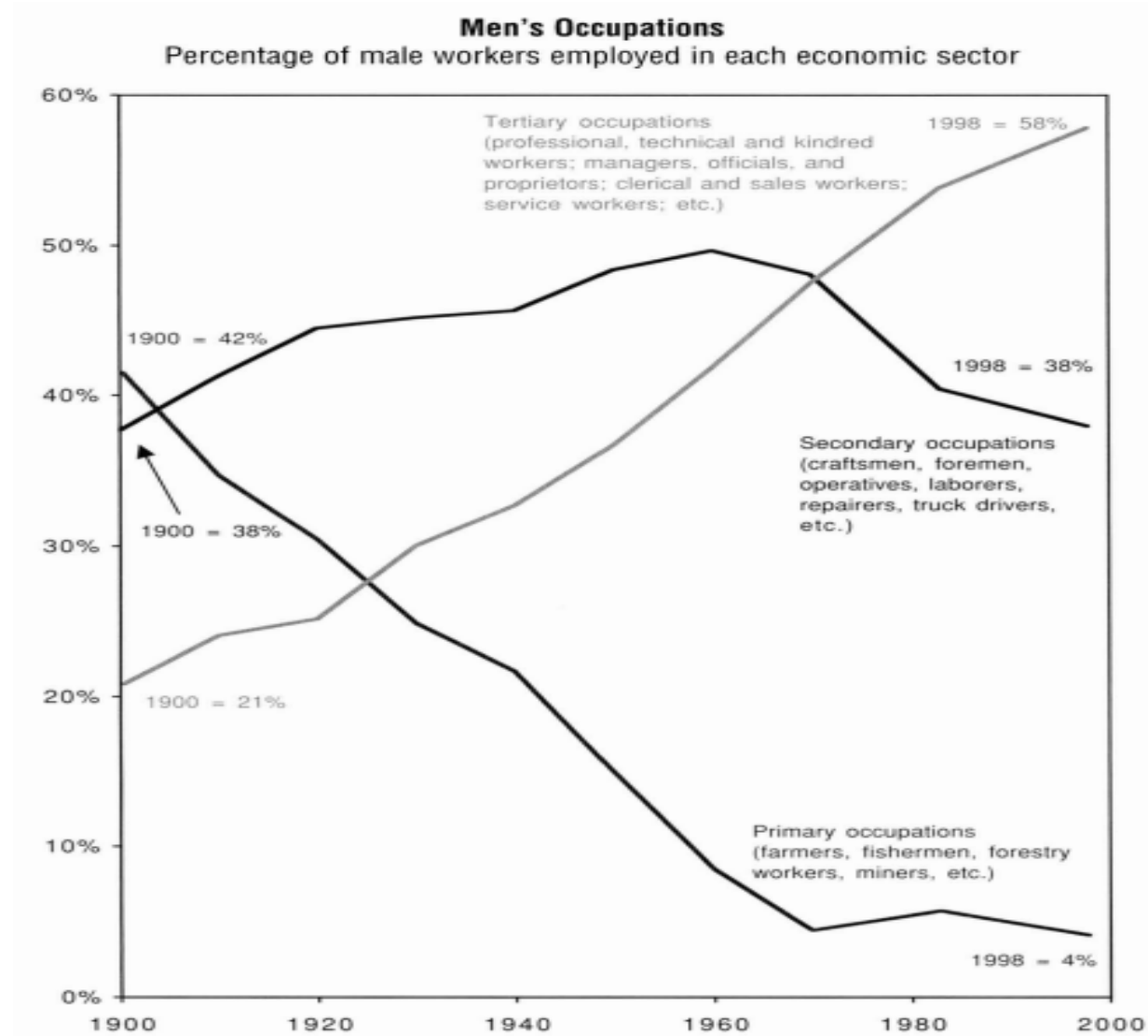


# Another example: Employment of information analysts, 1980-2015 (McKinsey (2017))

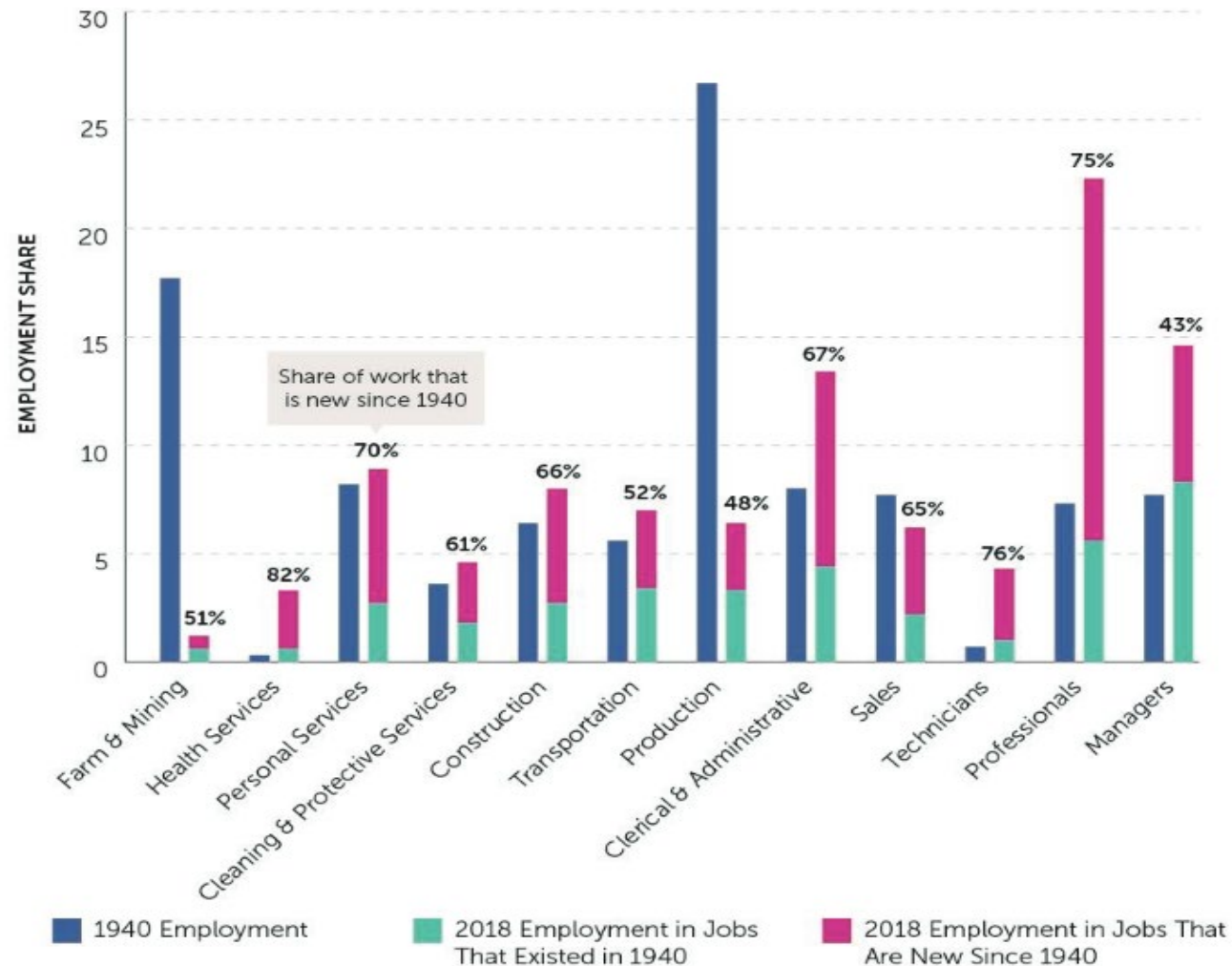


# Overall: Large sectoral shifts

(Caplow, Hicks, and Wattenberg (2001))



New occupations. More than 60% of occupations in the U.S. in 2018 did not exist in 1940. (Autor (2022))



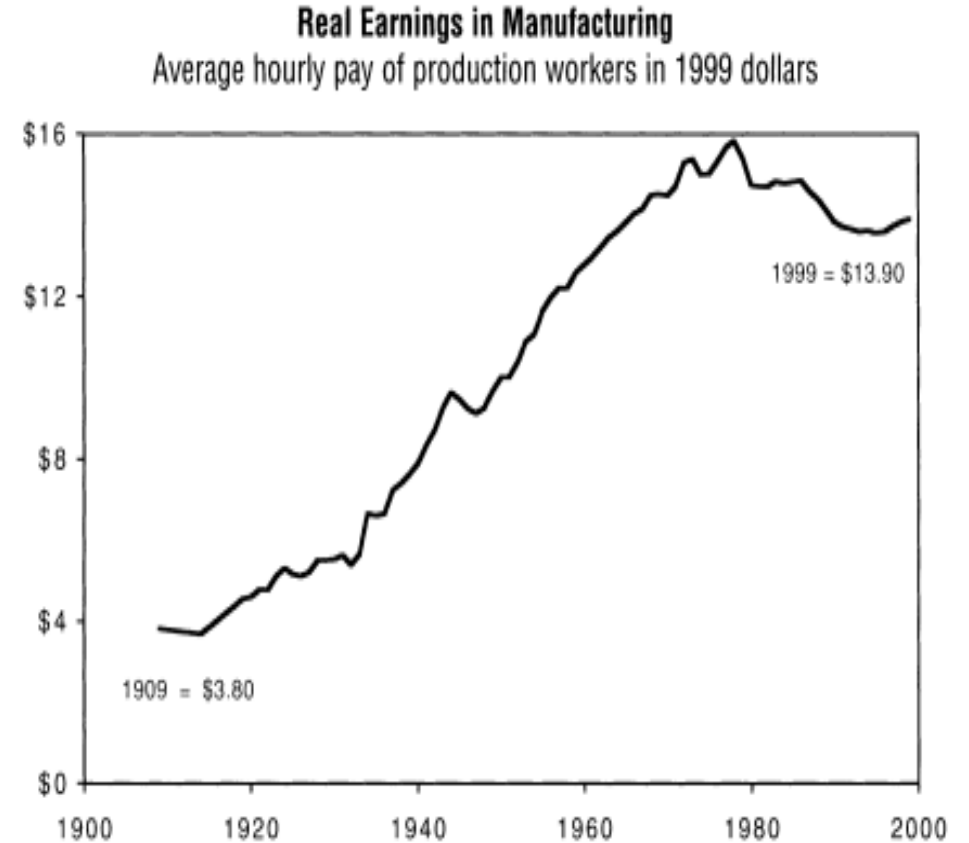
# More employment and higher wages (mostly?)

<https://fred.stlouisfed.org/>

[https://www.census.gov/library/publications/1975/compendia/hist\\_stats\\_colonial-1970.html](https://www.census.gov/library/publications/1975/compendia/hist_stats_colonial-1970.html)

Caplow, Hicks, and Wattenberg (2001)

<u>Year</u>	<u>Employment (thousands)</u>	<u>Emp. to Pop. Ratio</u>
1900	27,378	50.2
1950	58,892	56.1
2000	136,901	64.4
2022	161,048	60.3



# Jobs and wages in the more recent era of computerization

- Autor (2015) and Autor and Price (2013) consider:

“Routine tasks” (physical or mental) can be fully codified and hence automated.

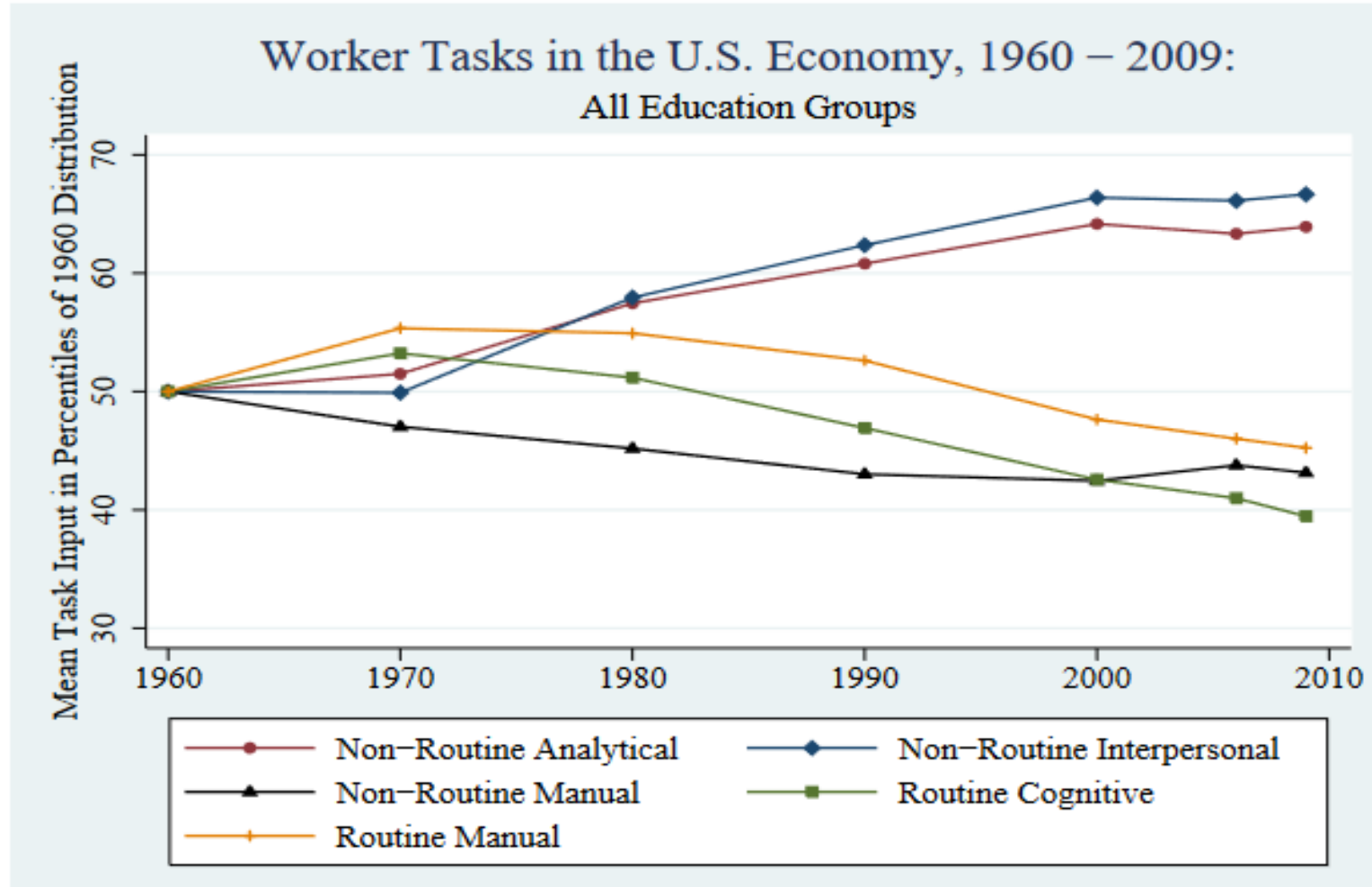
“Abstract” tasks, which require problem-solving, intuition, persuasion, and creativity. Many are tacitly understood and neither computer programmers nor anyone else can enunciate the explicit “rules” or procedures.

Autor, Levy, and Murnane (2003)

“ . . . computer capital (1) substitutes for workers in performing cognitive and manual tasks that can be accomplished by following explicit rules; and (2) complements workers in performing nonroutine problem-solving and complex communications tasks.”

# Content of Worker Tasks Relative to 1960: The Growth of 'Abstract' and Decline of 'Routine'

(Autor and Price (2013))

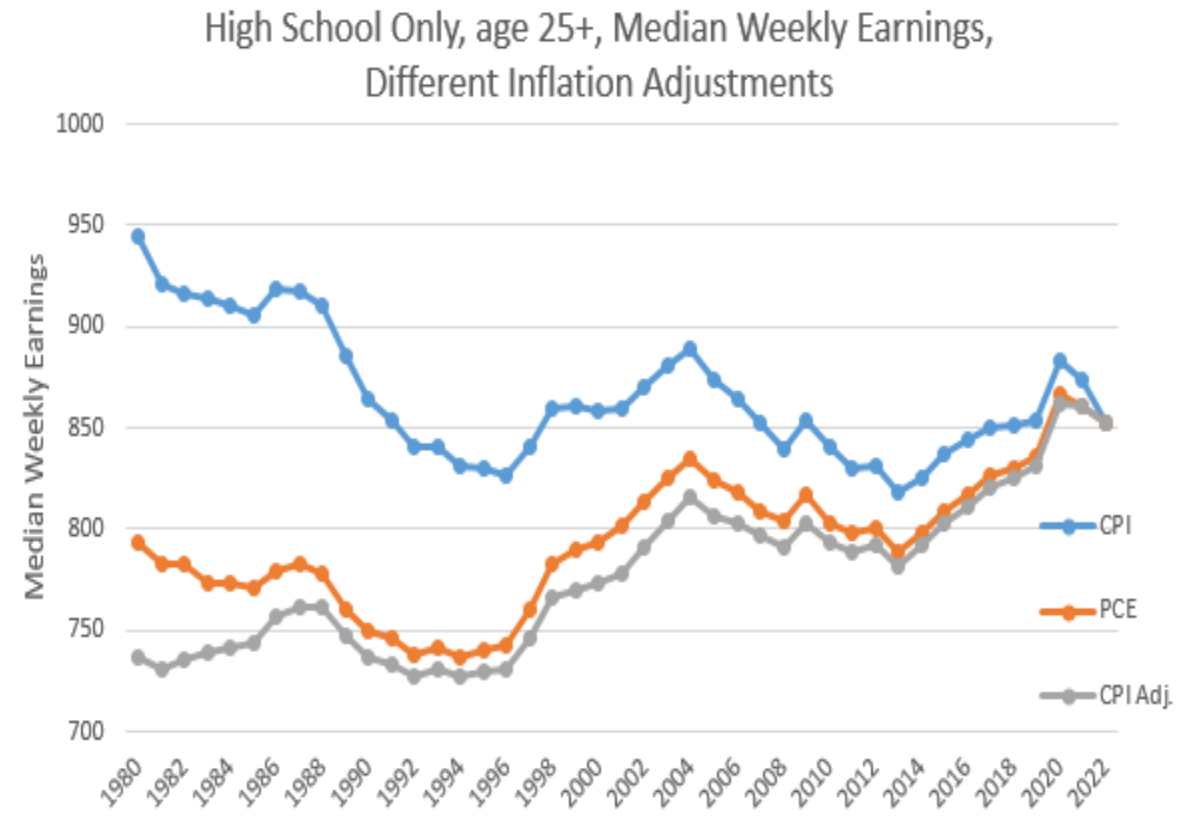
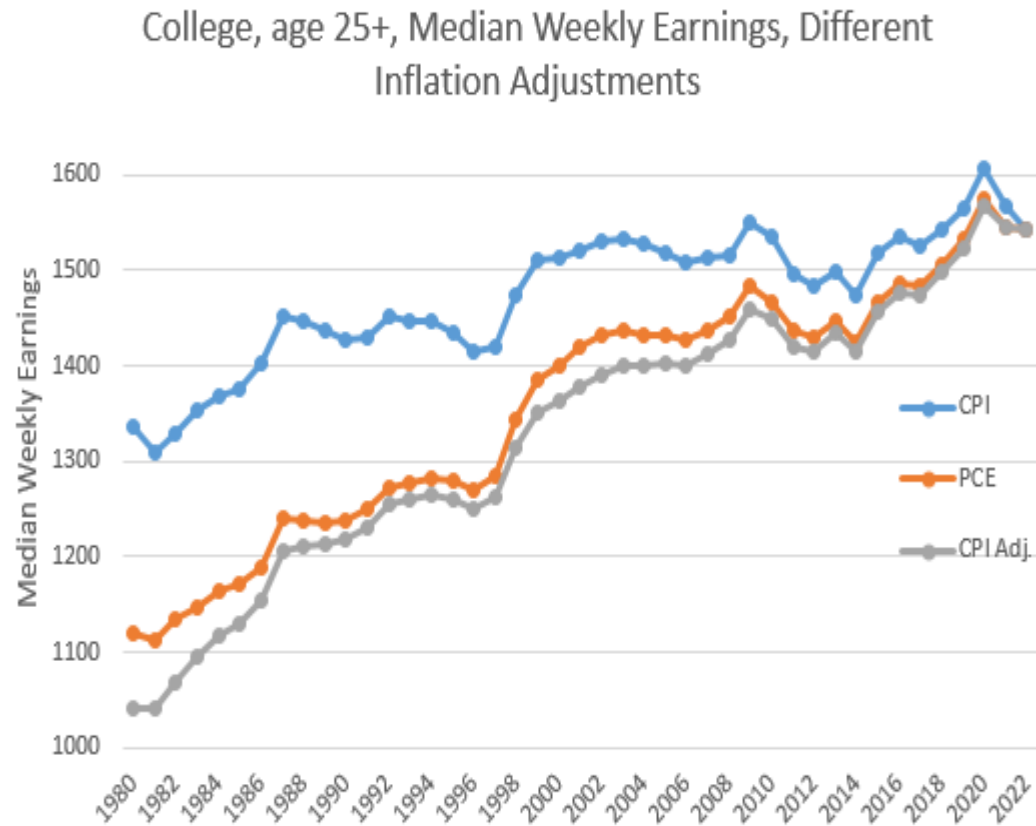




How is this reflected in wages? To evaluate this, an appropriate measure of inflation is important.

- Consumer Price Index (CPI) (<https://www.bls.gov/cpi/>)  
Problems with a static bundle of goods; quality changes; new goods.
- Personal Consumption Expenditure (PCE) Price Index (<https://www.bea.gov/data/personal-consumption-expenditures-price-index>)  
Changing bundle of goods dealt with more satisfactorily.
- Approximate CPI adjustment (80% of CPI change, see Sacerdote (2017)) to estimate the true price index.

To approximate the wage effects regarding “abstract” and “routine” workers: College and high school grads, age 25+, median weekly earnings, inflation adjusted, 1980-2022 (<https://www.bls.gov/cps/> )

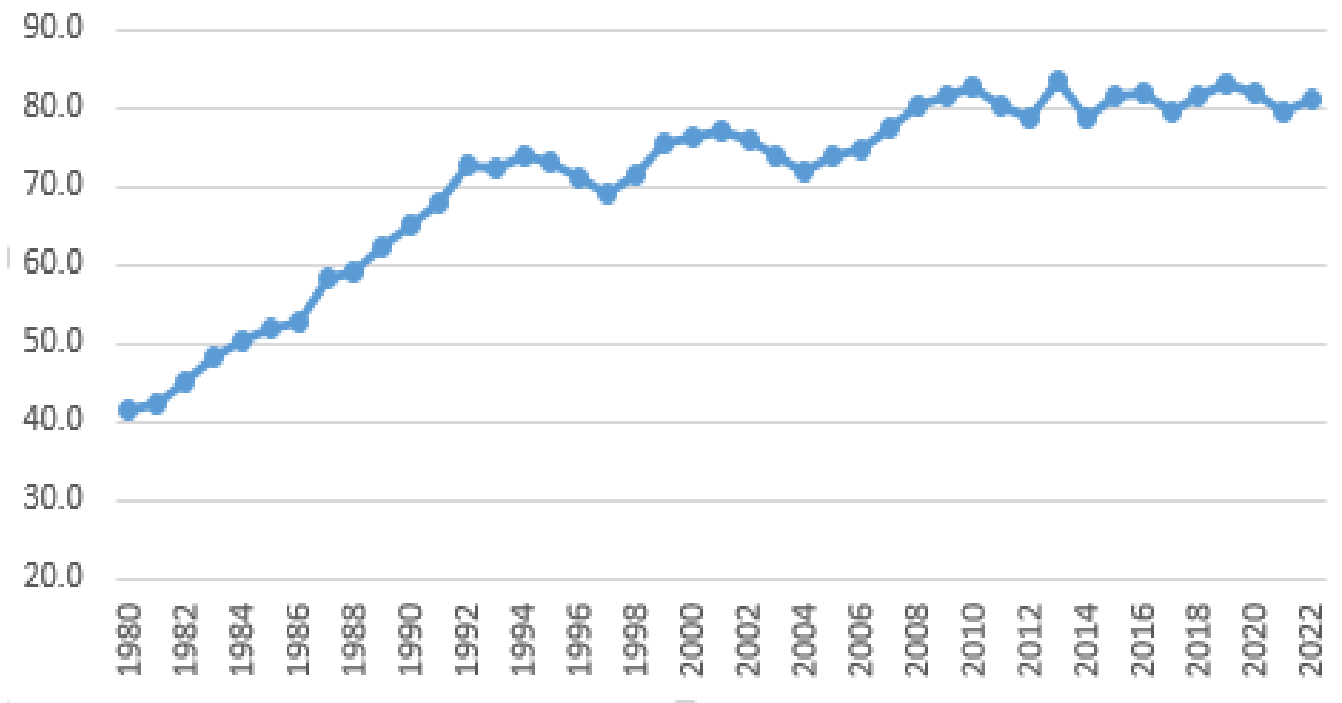


# Summary of Inflation-Adjusted Earnings Growth, 1980-2022

<u>1980-2022 Pct</u> <u>Earnings Gth.</u>	<u>With CPI</u>	<u>With PCE</u>	<u>With Adj.</u> <u>CPI</u>
High School grad	-9.7%	7.6%	15.90%
College grad	15.6%	37.8%	48.40%

# College – High School Earnings Differential, 1980 to 2022. Has its widening run its course?

Pct. Difference, College and HS Median Weekly Earnings

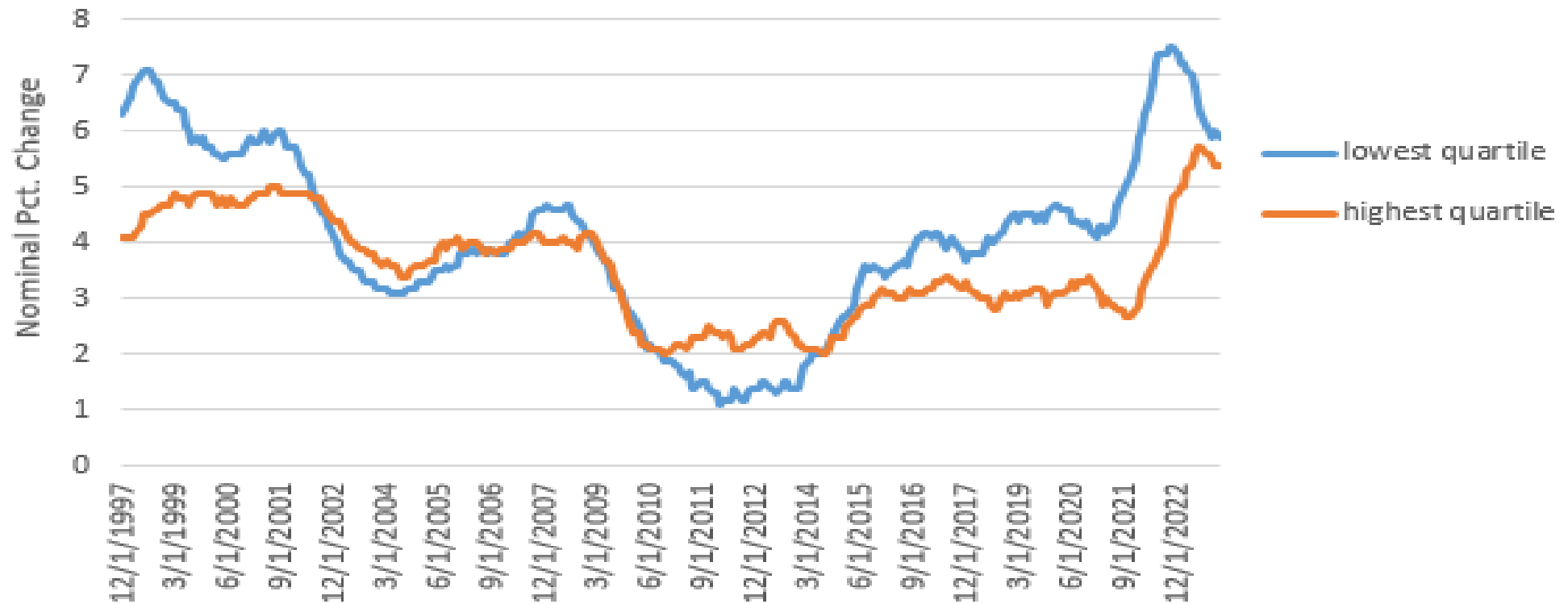


<u>Year</u>	<u>Coll. -HS Pct. Earnings Diff.</u>
1980	41.4%
2000	76.4%
2022	81.0%

# Recent Evidence on Wage Growth, Lowest and Highest Quartile Earners

(Federal Reserve Bank of Atlanta, <https://www.atlantafed.org/chcs/wage-growth-tracker>)

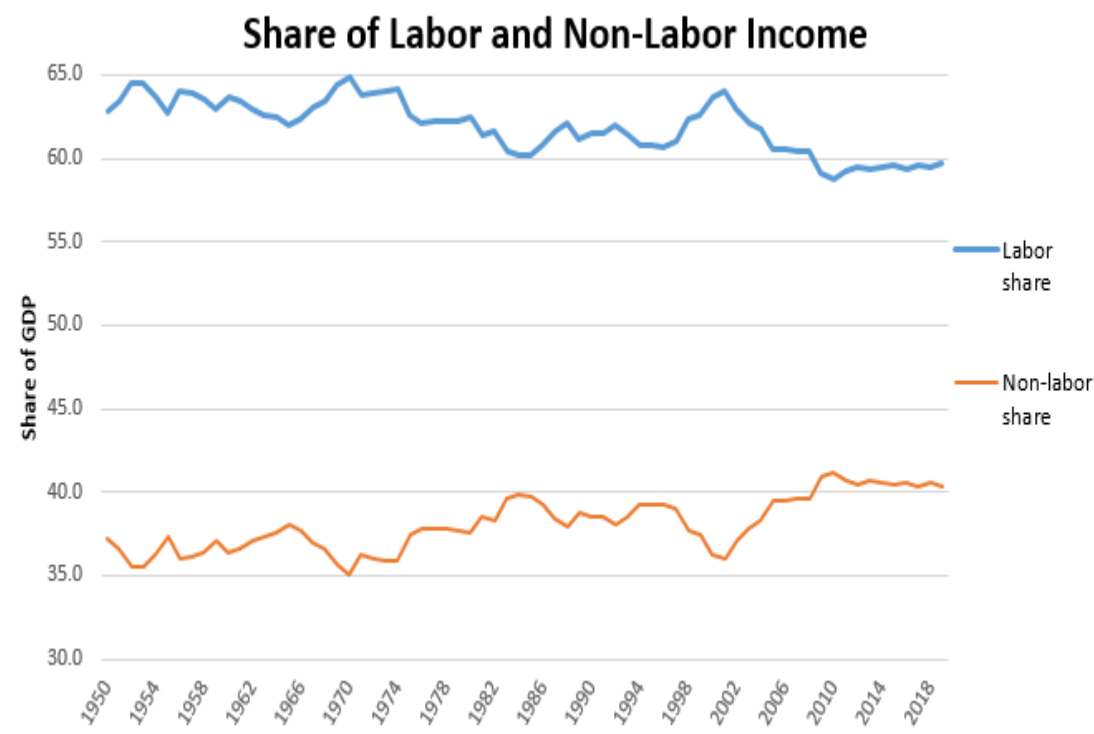
Median Wage Growth, 12-Month Moving Average,  
Nominal Pct.Changes (not adjusted for inflation)



# Has labor's share of total income changed?

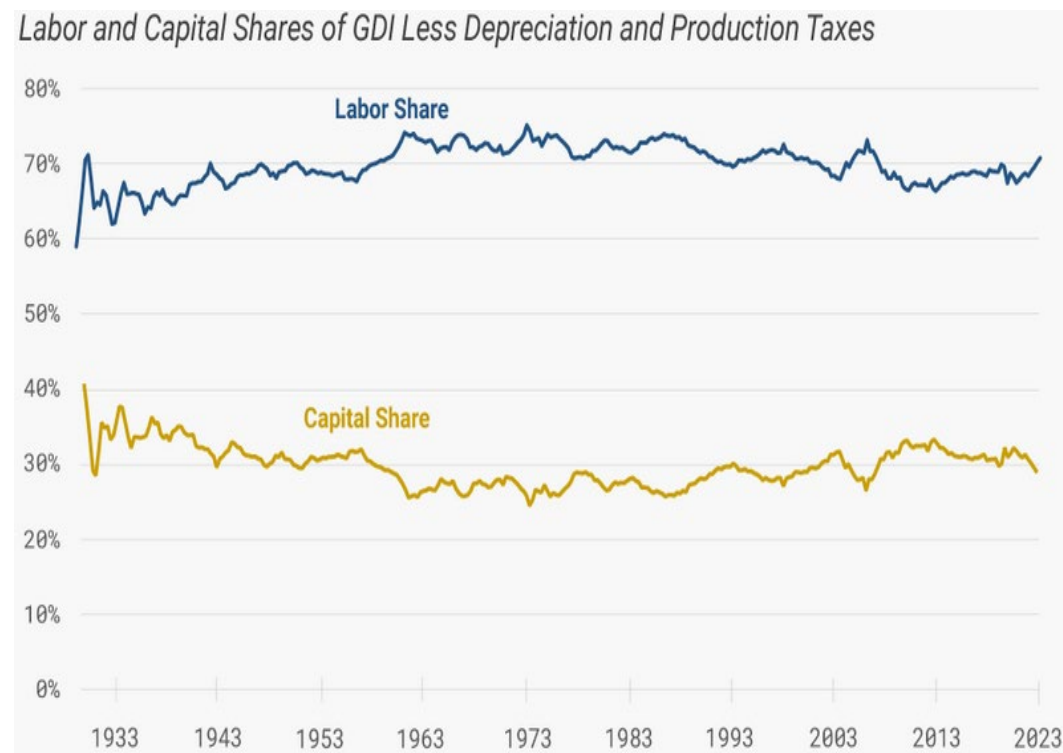
## Typical computation (Fed. Res. Data)

<https://fred.stlouisfed.org/series/LABSHPUA156NRUG>



## Adjusted Computation (Tax Foundation)

<https://taxfoundation.org/blog/labor-share-net-income-within-historical-range/>



# What about the future for automating jobs? Will wages and employment keep growing?

Some forecasts:

- “[ . . . . ] famously foresaw the steady increase in per capita income . . . from the introduction of new technologies, but . . . predicted that this would create widespread technological unemployment as machines replaced human labor.”  
John Maynard Keynes (1930)
- “[ . . . ] confidently stated that ‘as machines continue to invade society . . . it is human labor itself . . . that is gradually rendered redundant.’”  
Robert Heilbroner, Professor, New School for Social Research (1965)
- “Labor will become less and less important... More and more workers will be replaced by machines. I do not see that new industries can employ everybody who wants a job.”  
Nobel Laureate Wassily Leontief (1983)

(Above taken from Acemoglu and Restrepo (2018).)

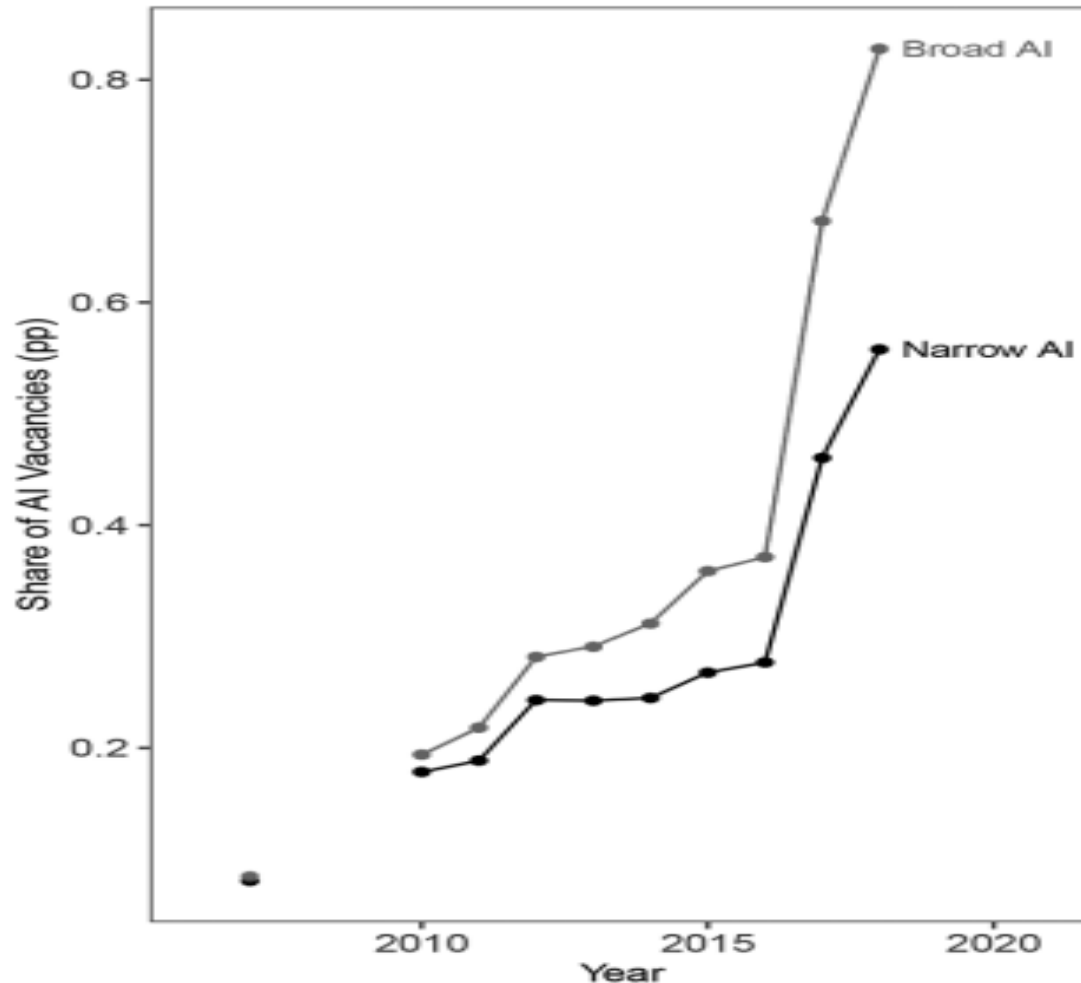
# Is it different this time?

- How might AI deal with hard-to-codify tacit knowledge and skills. Two approaches (from Autor (2015)):
  - “ . . . regularizing the environment, so that comparatively inflexible machines can function semi-autonomously.”
  - “ . . . rather than teach machines rules that we do not understand, engineers develop machines that attempt to infer tacit rules from context, abundant data, and applied statistics.” (Machine learning.)
- Can these developments reduce wages? Can there be perfect substitutes for labor such that labor is “redundant.” (See discussion in Korinek and Juelfs (2022).)



A recent paper focuses on the newer and dramatic growth of AI jobs, 2010-2018 (Acemoglu, et. al. (2022))

Share of AI job vacancies of online job listings



# Findings

- As AI has grown, firms in industries with heavy AI use (“AI-exposed” firms):
  - hire more AI related workers
  - reduce employment of non-AI workers
- The skill mix of workers at these firms changes toward increasing demands for skills relating to engineering, analysis, marketing, finance, and information technology.
- For the labor markets with many AI-exposed firms:
  - No discernable effects on wages or employment are found; non-AI workers find jobs elsewhere.
- This is a similar pattern to the past . . . so far.
- It’s also consistent with the theoretical model of Acemoglu and Restrepo (2018) where innovations may create new tasks that are complementary to labor, as well as those that substitutes for labor.

# Final Thoughts

- The long history of technological change is that it leads to increased productivity, increased employment, and overall higher wages.
- However, there also has been a large amount of shifting of jobs, causing job loss in some sectors and gains in others. This can cause short-term hardship even while the overall economy and wages are growing.
- Will this pattern continue to hold with future innovations in AI and related areas?
- It is difficult to say with absolute certainty.
- However, I expect that the many of Autor's findings will continue to hold. That is, the best employment and wage prospects for those with abstract thinking and complex communication skills. How those skills are applied will undoubtedly change, though.
- Moreover, sustaining a rising tide of economic growth seems likely to lift wages generally.

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