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# Man and Machine: the macroeconomics of the digital revolution


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LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

# *MAN AND MACHINE:*
# *The Macroeconomics of the Digital Revolution*

Professor Jeffrey D. Sachs
London School of Economics

October 2, 2017

KEYNES, ***Economic Possibilities for Our Grandchildren, 1930***

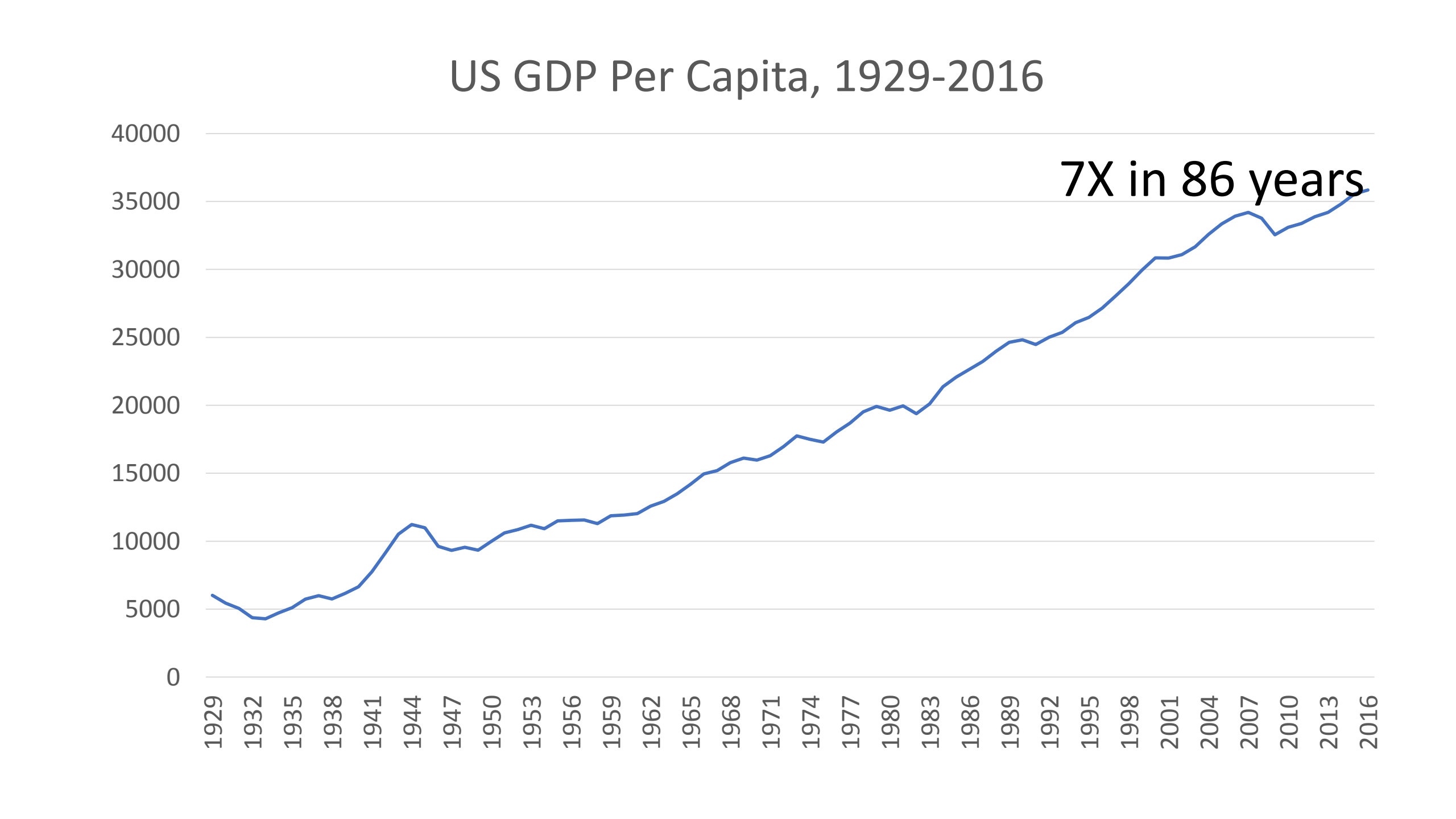
What can we reasonably expect the level of our economic life to be a hundred years hence?
What are the economic possibilities for our grandchildren? …

We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come—namely, ***technological unemployment.*** This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour…

But this is only a temporary phase of maladjustment. All this means in the long run that mankind is solving its economic problem. ***I would predict that the standard of life in progressive countries one hundred years hence will be between four and eight times as high as it is to-day.*** There would be nothing surprising in this even in the light of our present knowledge. It would not be foolish to contemplate the possibility of a far greater progress still…

I draw the conclusion that, assuming no important wars and no important increase in population, ***the economic problem may be solved***, or be at least within sight of solution, within a hundred years. This means that the economic problem is not—if we look into the future—the permanent problem of the human race…

***The love of money as a possession***—as distinguished from the love of money as a means to the enjoyments and realities of ***life—will be recognised for what it is, a somewhat disgusting morbidity***, one of those semi-criminal, semi-pathological propensities which one hands over with a shudder to the specialists in mental disease.

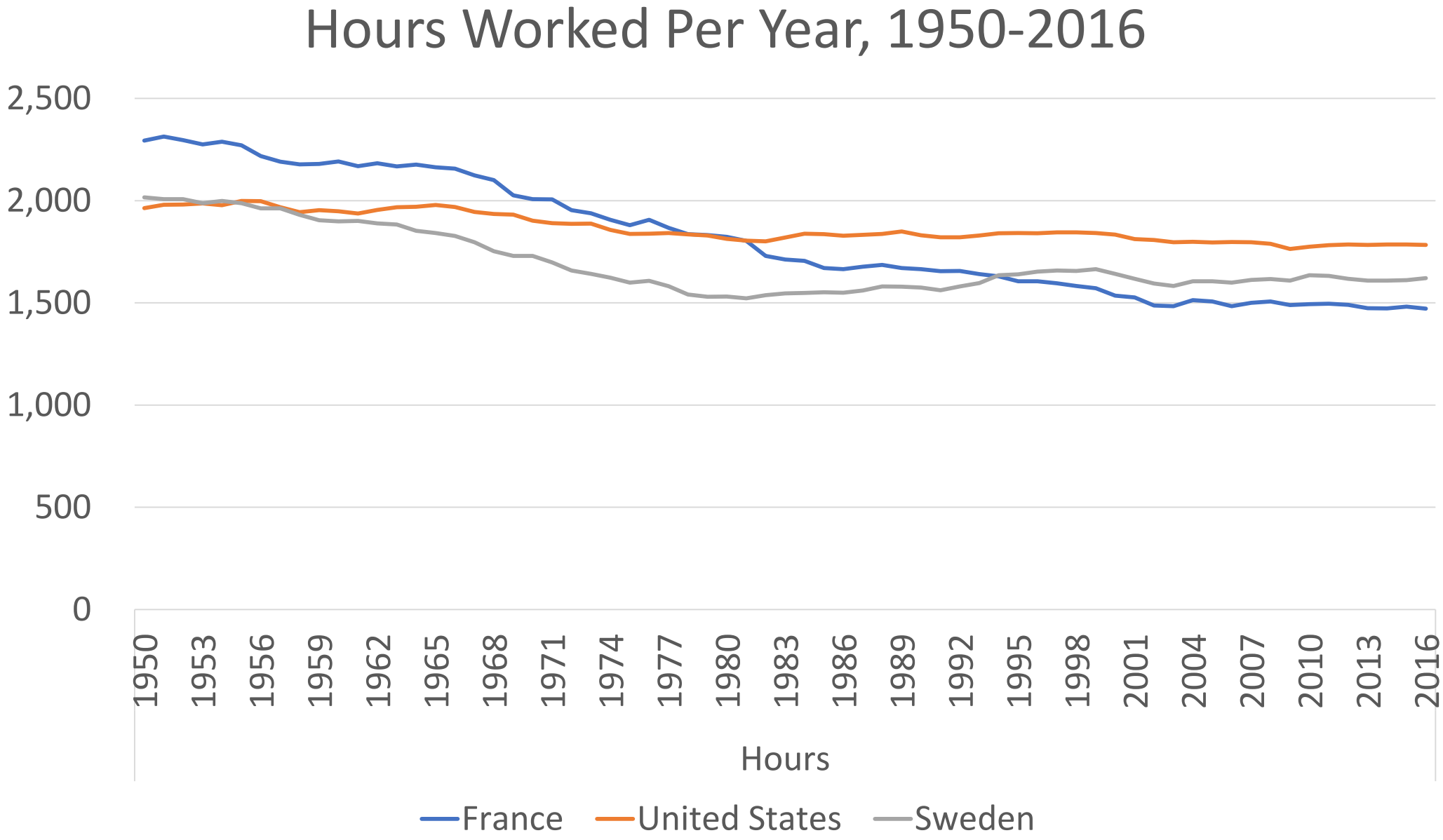

US GDP Per Capita, 1929-2016
7X in 86 years
40000
35000
30000
25000
20000
15000
10000
5000
0
1929
1932
1935
1938
1941
1944
1947
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016

# OCCUPATIONAL COMPOSITION OF THE US LABOR FORCE: Decline in Arduous Physical Work

| | 1900 | 2015 |
|---|---|---|
| Agriculture Workers | .36 | .01 |
| Production Workers | .24 | .14 |
| Trade, Transport, Administrative | .16 | .28 |
| Other Service | .19 | .18 |
| Professional (including Government) | .04 | .39 |

MANUAL LABOR HAS DECLINED FROM AROUND 70% TO AROUND 20% OF THE LABOR FORCE

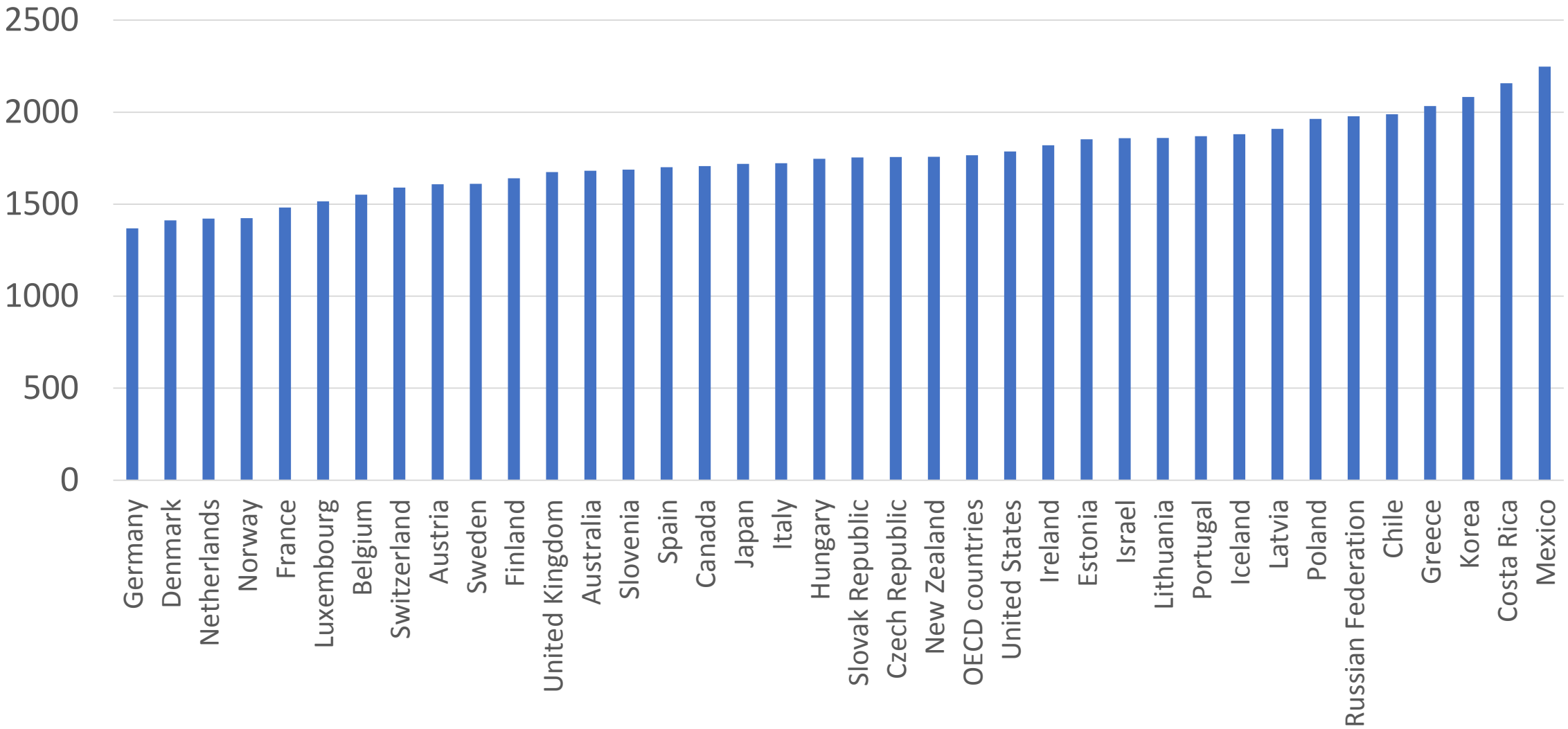
| | 1900 | 2015 |
|---|---|---|
| Percent of Adults Working Monday-Friday | 90% | 54% |
| Working Hours per Day Monday-Friday | 10 hours | 7.9 Hours |
| Percent of Adults Working Saturday-Sunday | 90% | 23% |
| Working Hours per Day Saturday-Sunday | 6 hours | 5.6 hours |
| Working Weeks Per Year Excluding Vacation + Holiday | 51 | 48.5 |
| Total Working Hours Per Adult Per Day (rough) | 7.8 hours per day | 3.18 hours per day |




DIFFERENCE BETWEEN US AND FRANCE IN 2016 IS 311 HOURS, OR 7.8 WEEKS AT 40 HOURS PER WEEK.

France = - 20 WKS
US = -4.5 WKS
Sweden = -9.9 WKS

# HOURS WORKED PER YEAR, 2015




GERMANY = 1368 (34 WEEKS @ 40 HOURS PER WEEK)
MEXICO = 2248 (>52 WEEKS @ 40 HOURS PER WEEK

# JOBS AND THE INFORMATION AGE

**General Purpose Technologies** (Steam, Electricity, ICE, Fordism-Taylorism, Digital):

Raise National Output
Disrupt Production Processes
Restructure Labor Markets
Shift Income and Wealth Distributions
Change Human Geography and Demography

# General Points:

- Machine-Human substitution has predated the Information (Digital) Revolution, but has increased with the IR.
- The Information Revolution is science-based, raising the returns to R&D on a sustained basis, and creating a new and significant professional/technical class (managerial, R&D, design, higher education, healthcare)
- Time sequence of automation, from physical and repetitive tasks to cognitive and contextual tasks.
- Increasing shift of national income from labor to business capital, including both hardware and software (intellectual property), and stagnant or falling wages for basic labor.
- Need four kinds of policies: new training, income redistribution, shared leisure, promotion of human-machine complementarities (humanities along side IR).

# Milestones of the Information Revolution:

Turing and von Neumann: computation
FDR and Bush: science-led U.S. development
Wiener and Simon: Science of the “artificial”
Shannon and Shockley: microprocessors
Kilby and Noyce: integrated circuitry
Gates and Jobs: e-economy
Page and Brin: public information
Bezos and Ma: e-business
Watson and AlphaGo: artificial intelligence

# Vannevar Bush: ***Science, The Endless Frontier*** (1945)

Responding to President Franklin D. Roosevelt's Questions (1944):

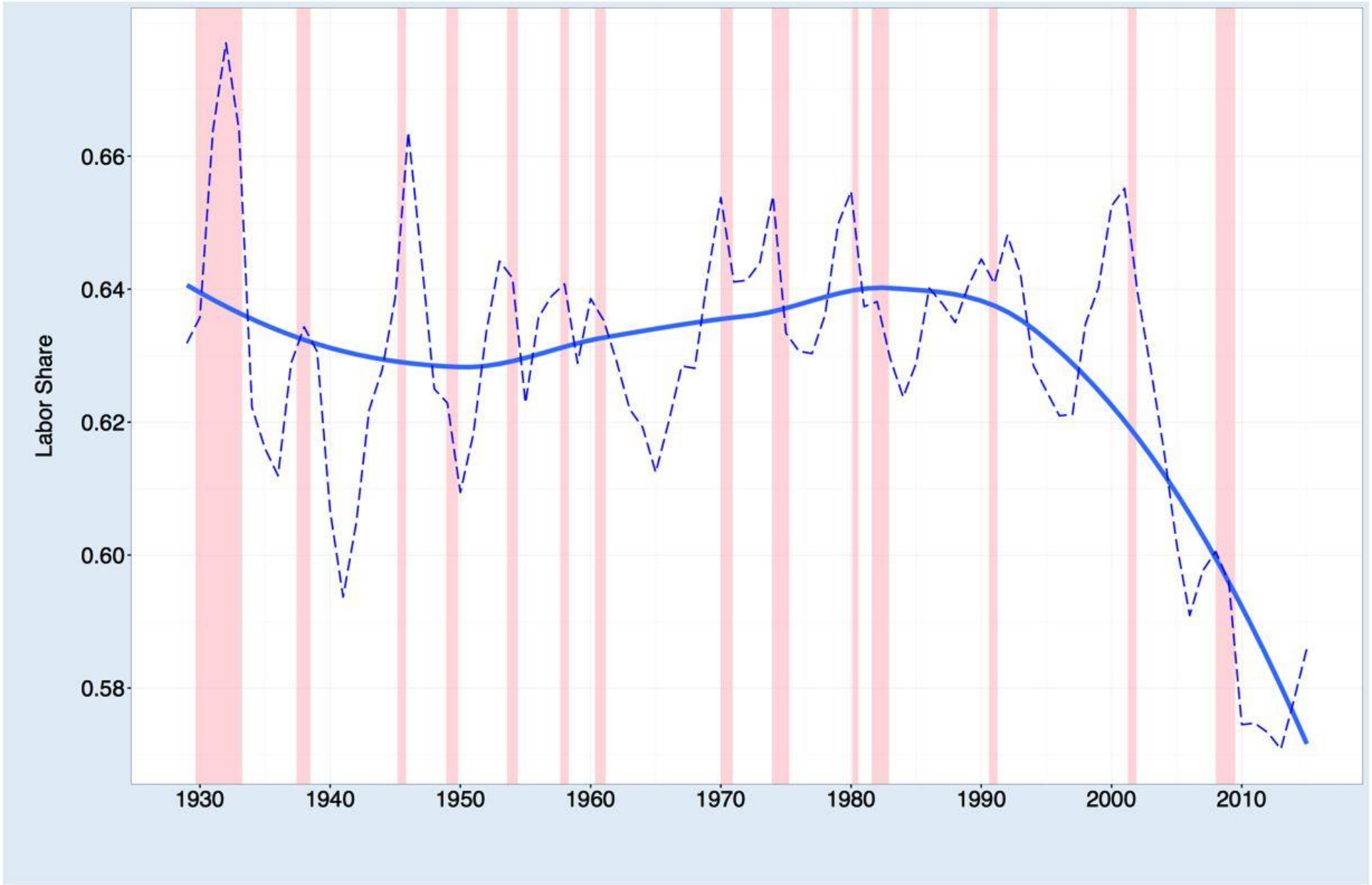
(1) What can be done, consistent with military security, and with the prior approval of the military authorities, to make known to the world as soon as possible the contributions which have been made during our war effort to scientific knowledge?

(2) With particular reference to the war of science against disease, what can be done now to organize a program for continuing in the future the work which has been done in medicine and related sciences?

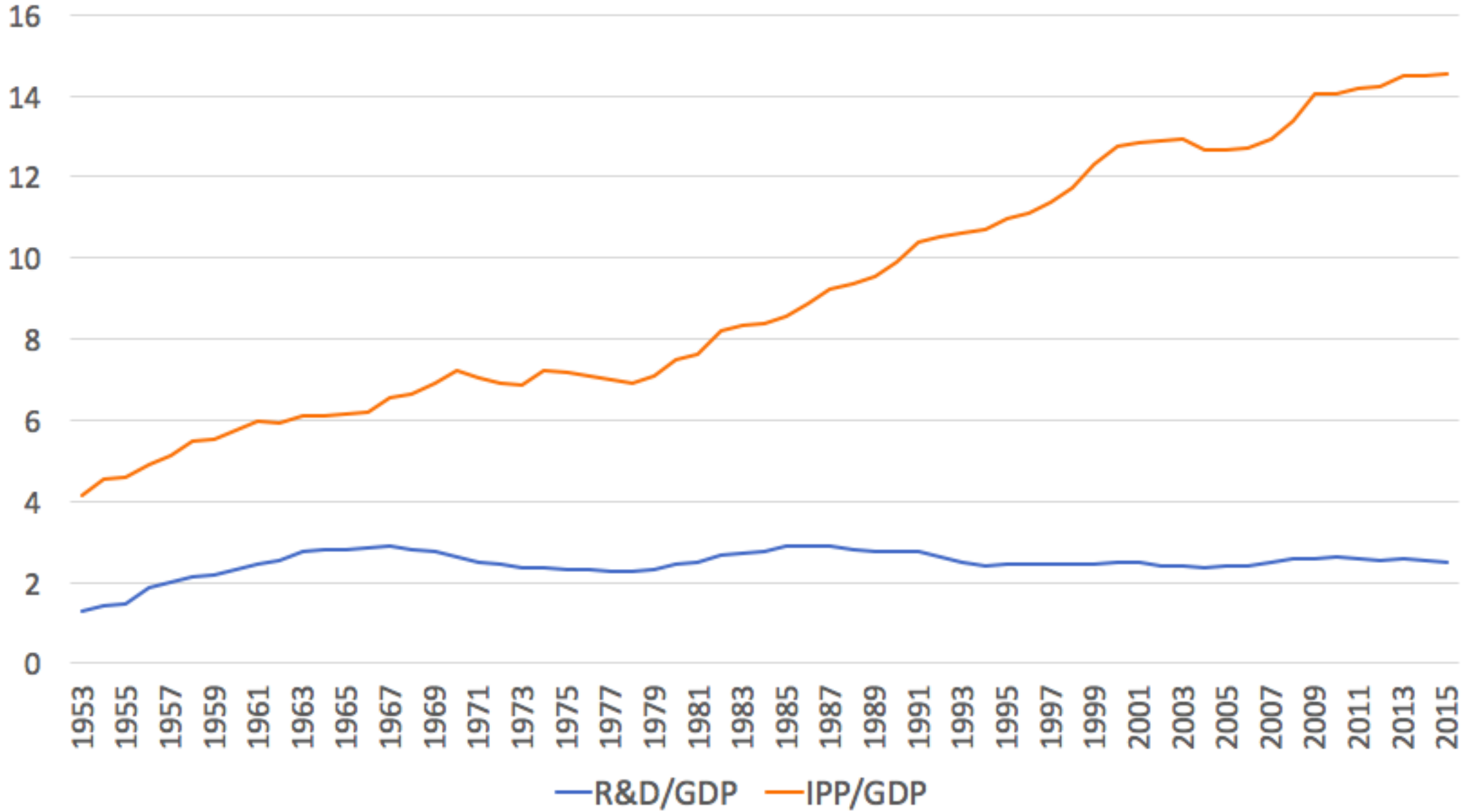
(3) What can the Government do now and in the future to aid research activities by public and private organizations?

(4) Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?

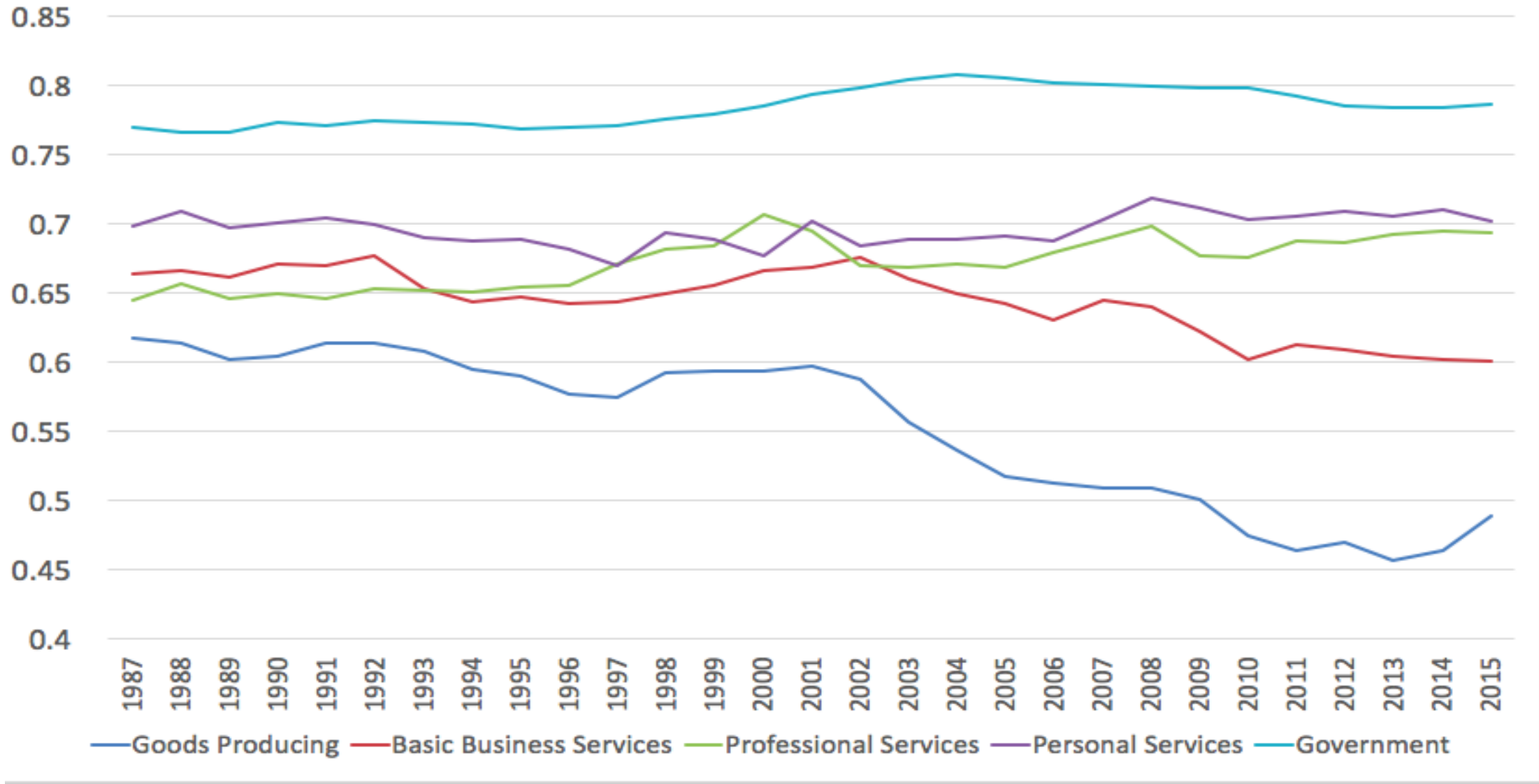
# DECLINING LABOR SHARE: CONVENTIONALLY MEASURED



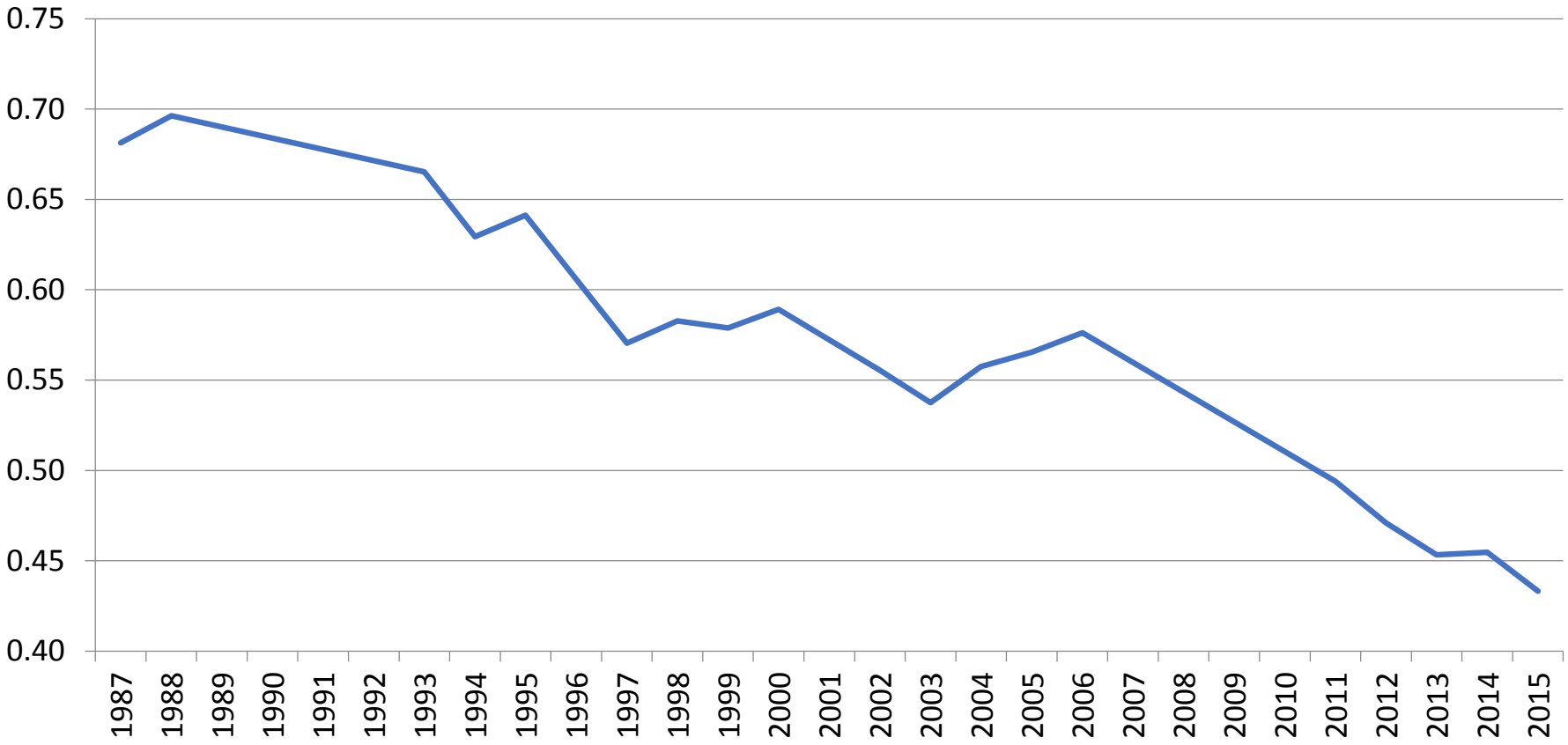
## Figure 6. R&D and Intellectual Property (%GDP)



## Figure 2. Labor Share by Sector



# LABOR SHARE OF VALUE IN MOTOR VEHICLE PRODUCTION (SMOOTHED OVER PEAK YEARS)



# AUTOMOBILE ASSEMBLY LINE

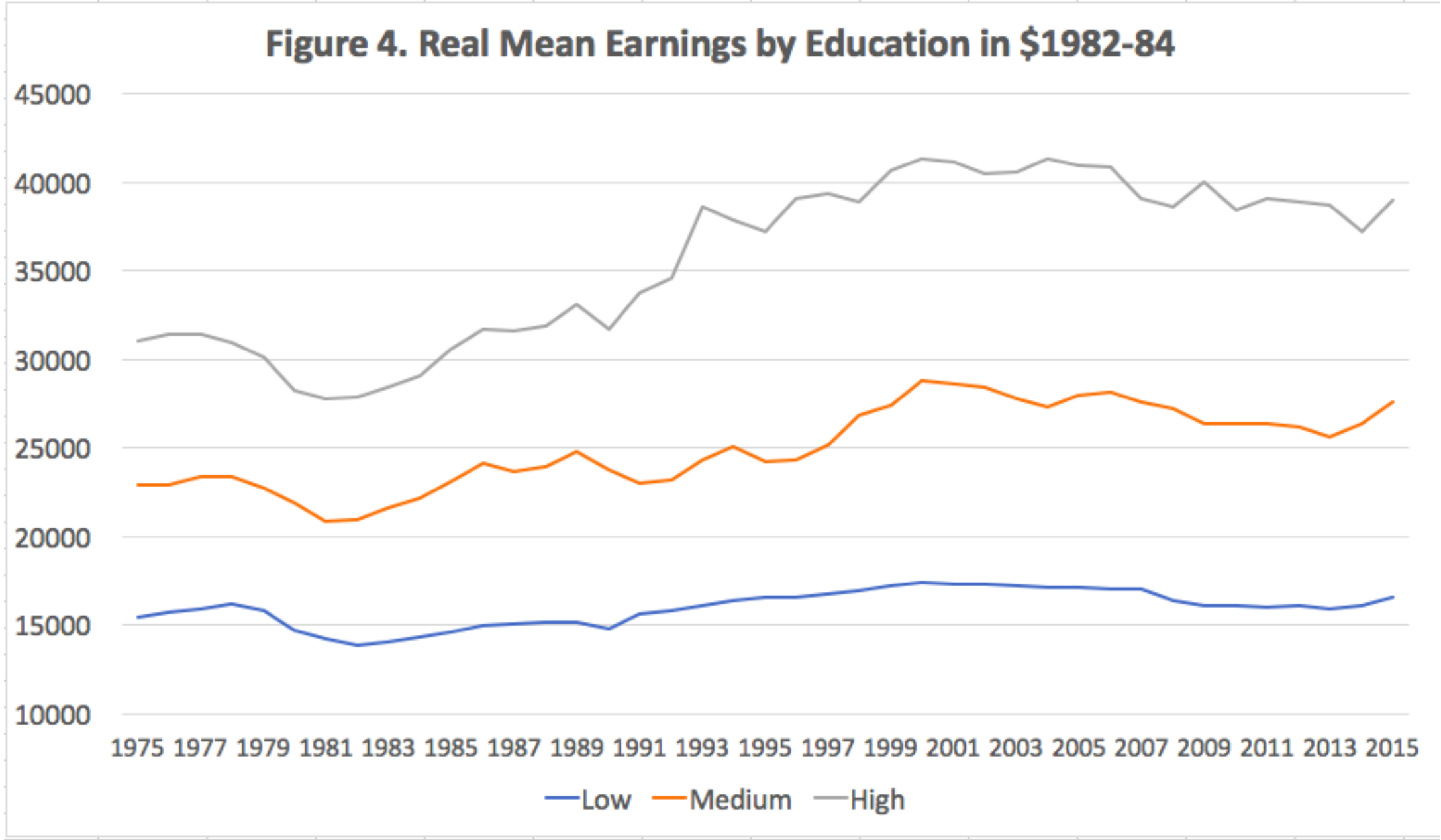
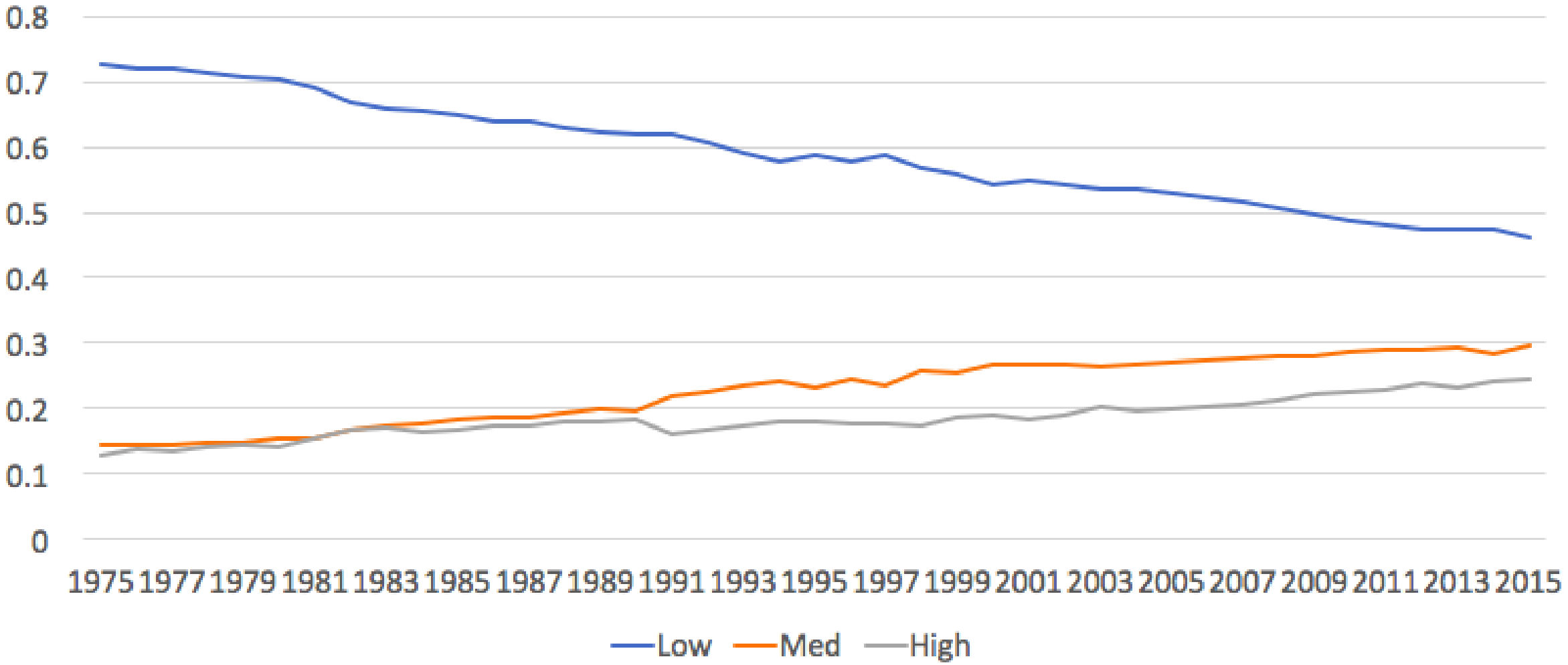
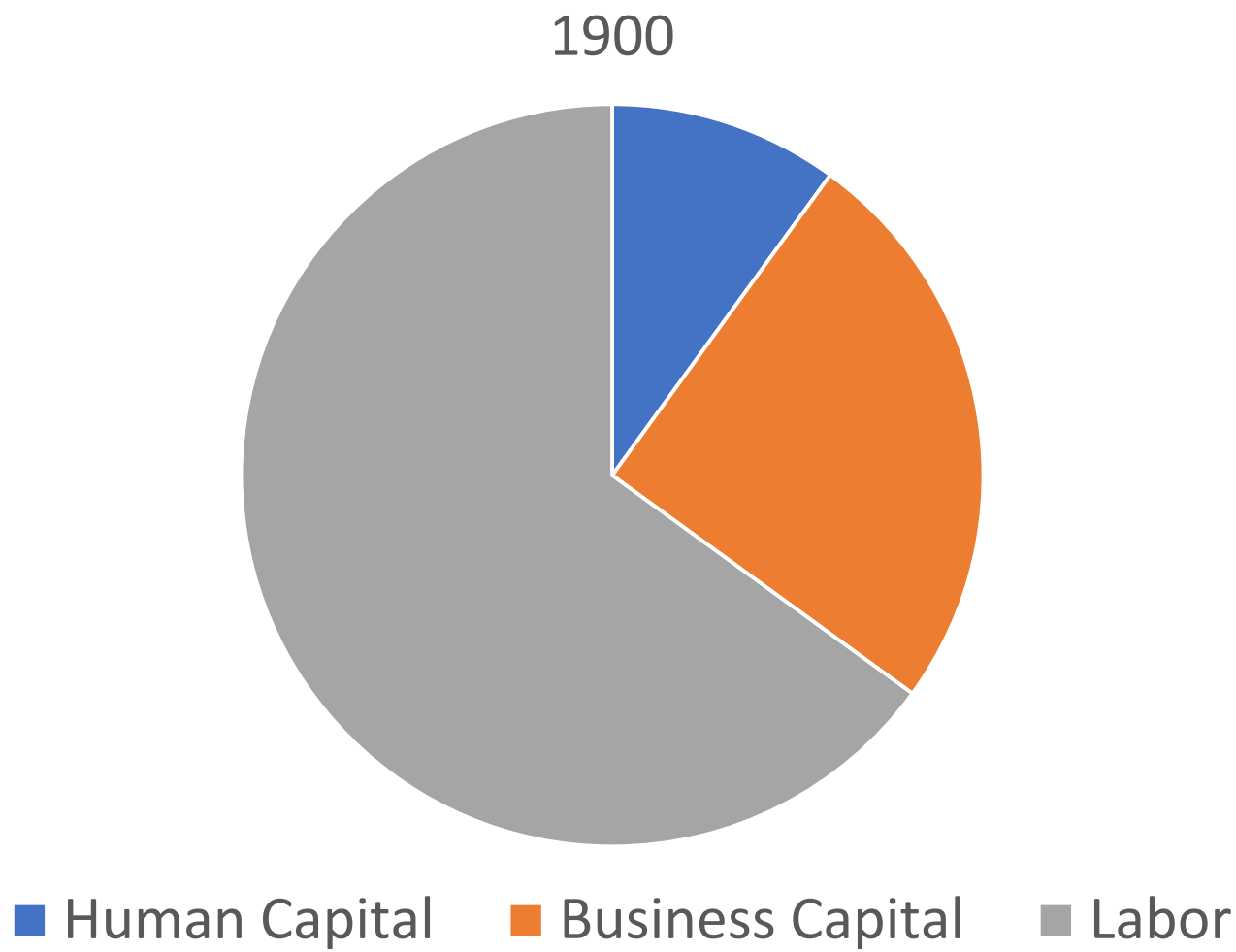


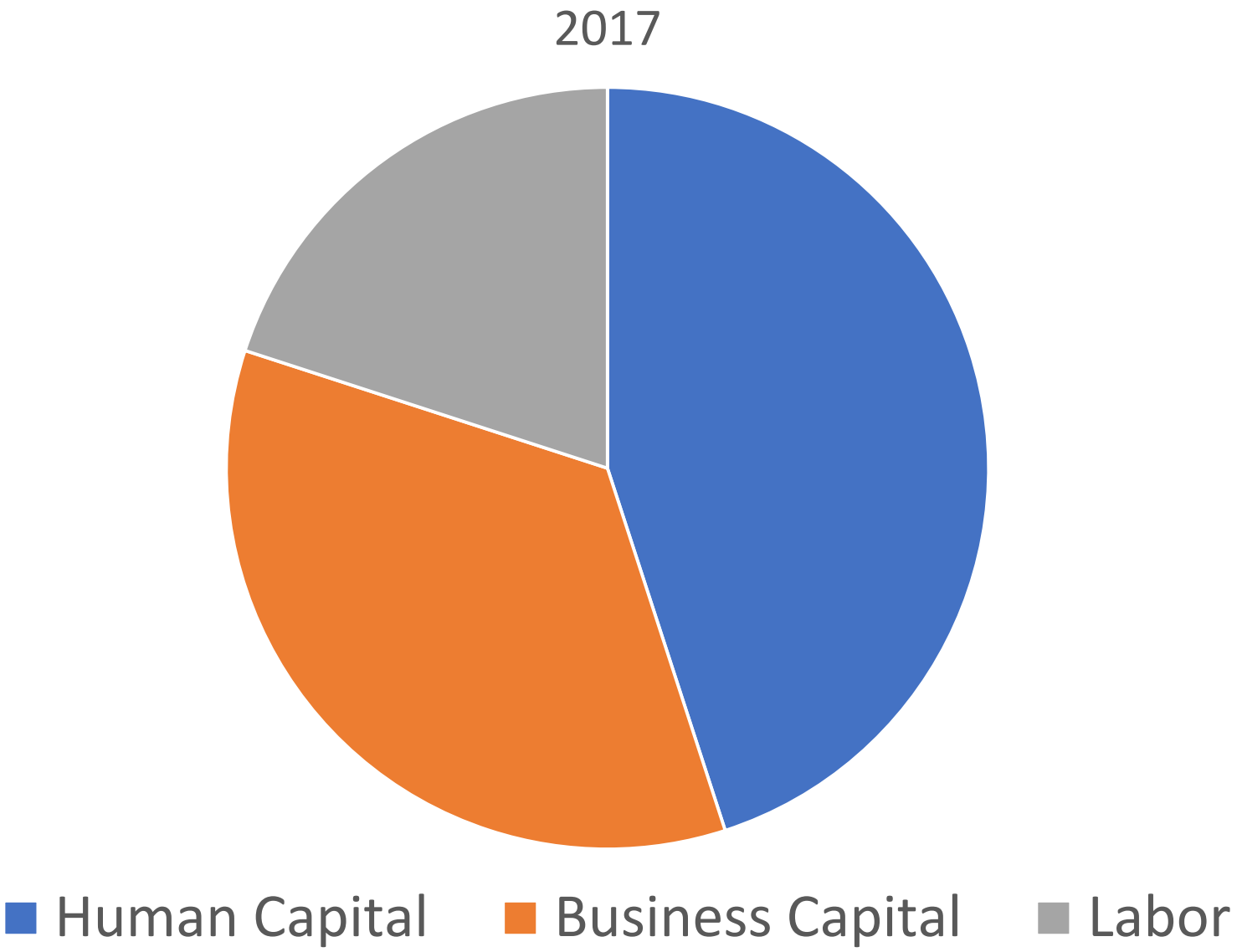
Figure 4. Real Mean Earnings by Education in $1982-84
45000
40000
35000
30000
25000
20000
15000
10000
1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Low
Medium
High

## Figure 3. Share of Earnings by Educational Attainment

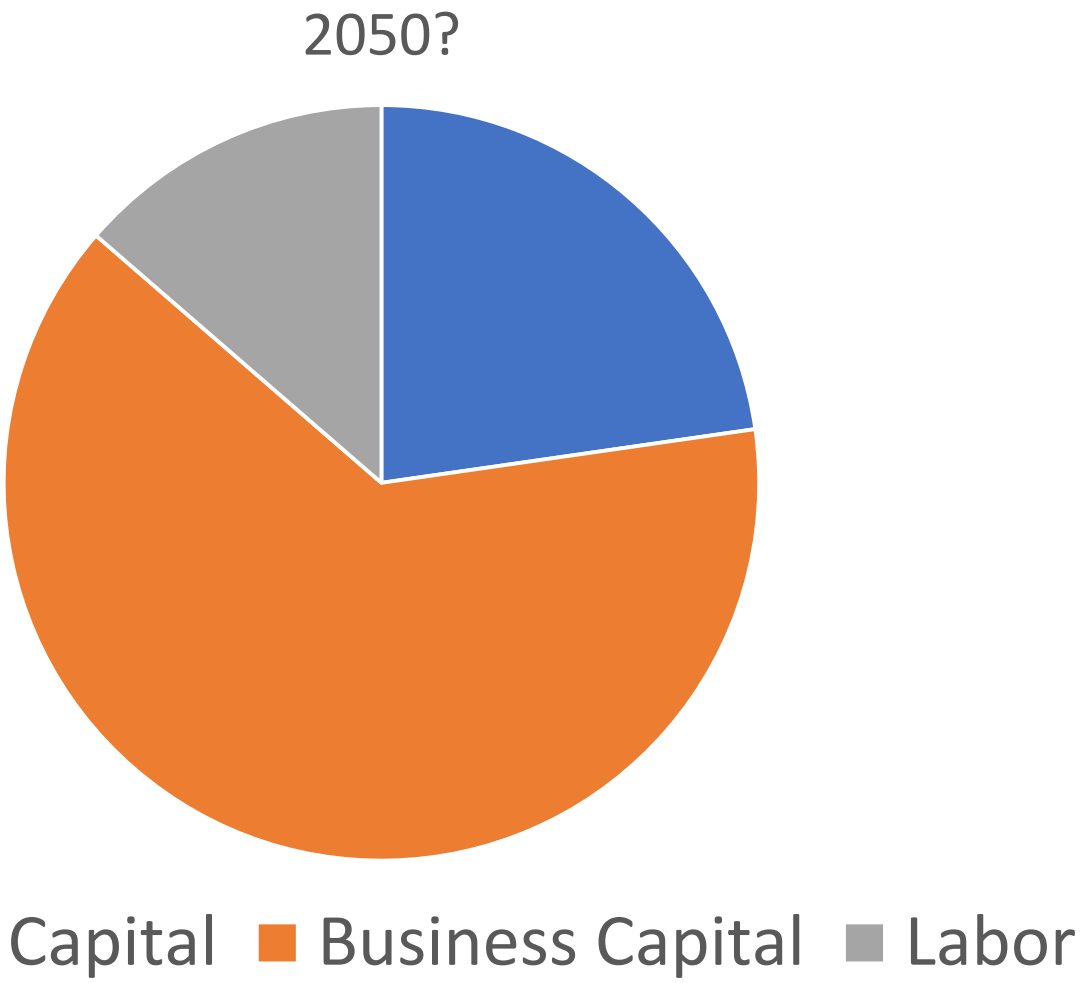


# Stylized Depiction for 1900, 2017, 2050




2017
Human Capital
Business Capital
Labor

# BY 2050, A SHIFT AGAINST BOTH LABOR & HUMAN CAPITAL?



# SUSCEPTIBILITY TO AUTOMATION

| | Typical Expertise | Typical Workflow Predictability |
|---|---|---|
| **Goods Producing** | Low to Moderate | High |
| **Basic Business Services** | Moderate | Moderate to High |
| **Personal Services** | Low to Moderate | Low to Moderate |
| **Professional Services** | High | Low |
| **Government** | Moderate to High | Moderate to High |

$$Q = P^{a} N^{b} B^{(1-a-b)}$$

$$P = L_P + t_P * M_P$$

$$N = L_N$$

$$L_U = L_{PU}$$

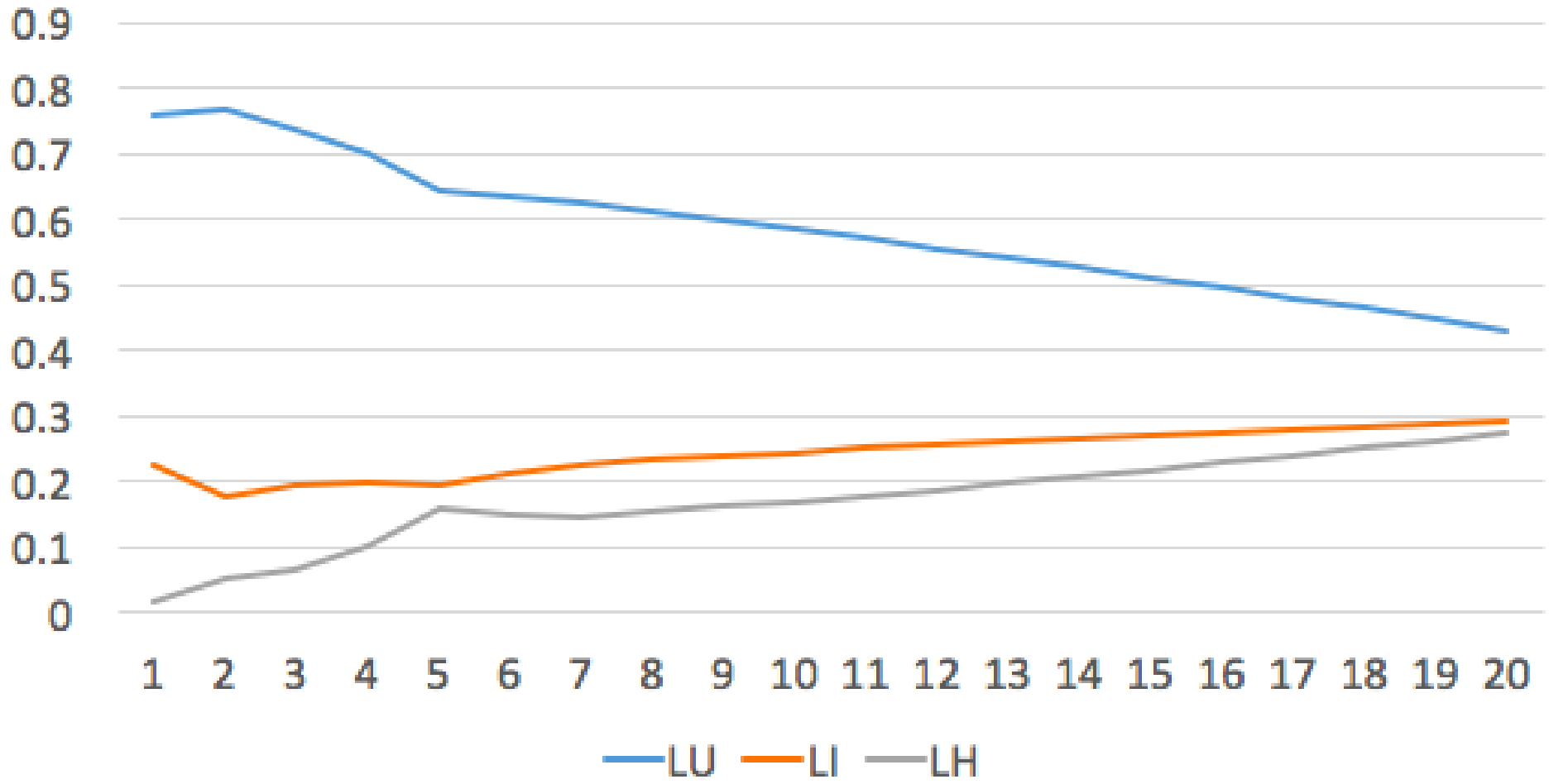
$$L_I = L_{NI} + L_{PI}$$

$$K = B + M_P$$

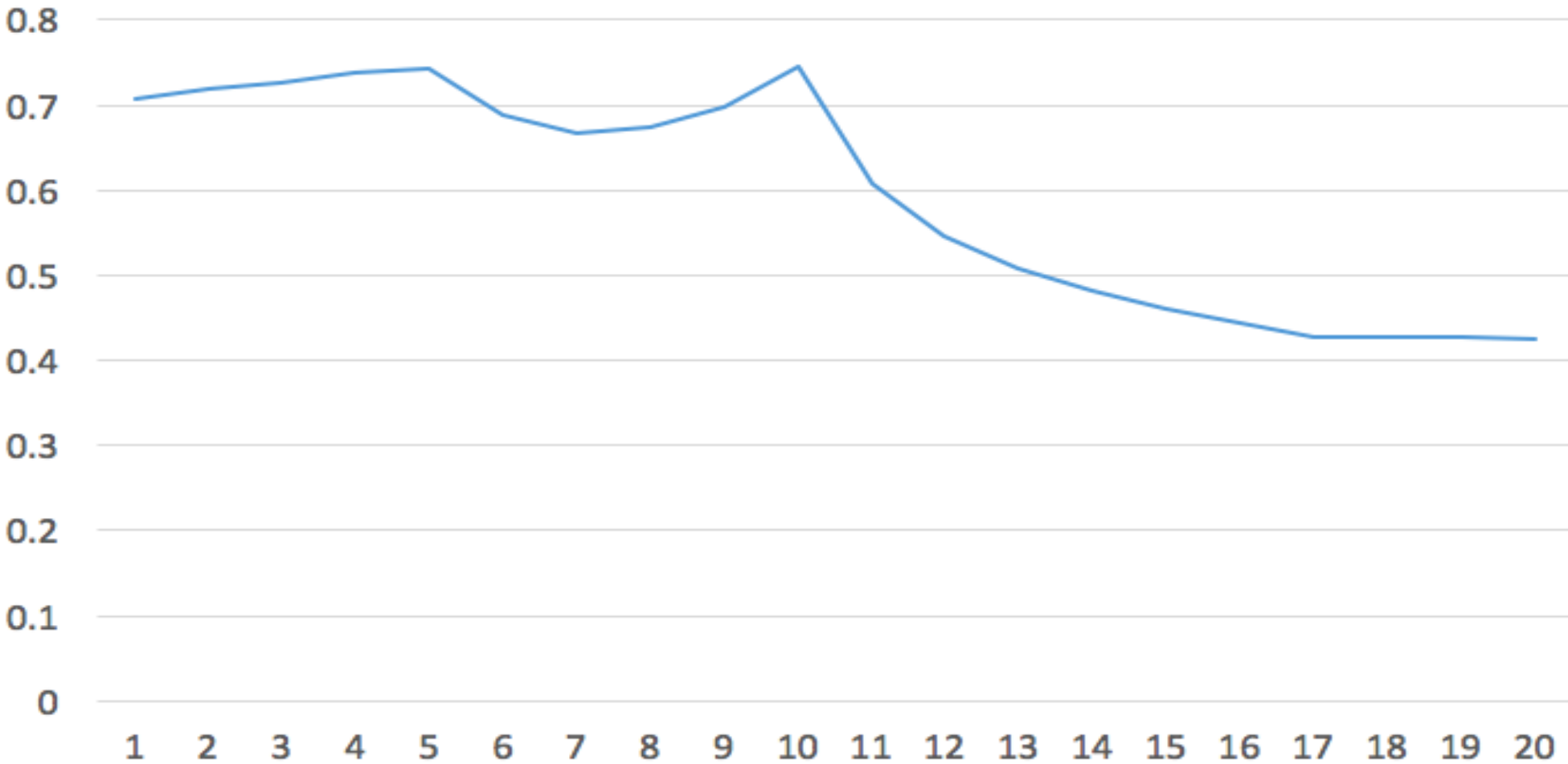
$$W_U = a*(L_U + t_P*M_P)^{(a-1)} L_I^{b} S^{(1-a-b)}$$

$$W_I = b*(L_U + t_P*M_P)^{a} L_I^{(b-1)} S^{(1-a-b)}$$

## Figure 7. Labor by Educational Attainment

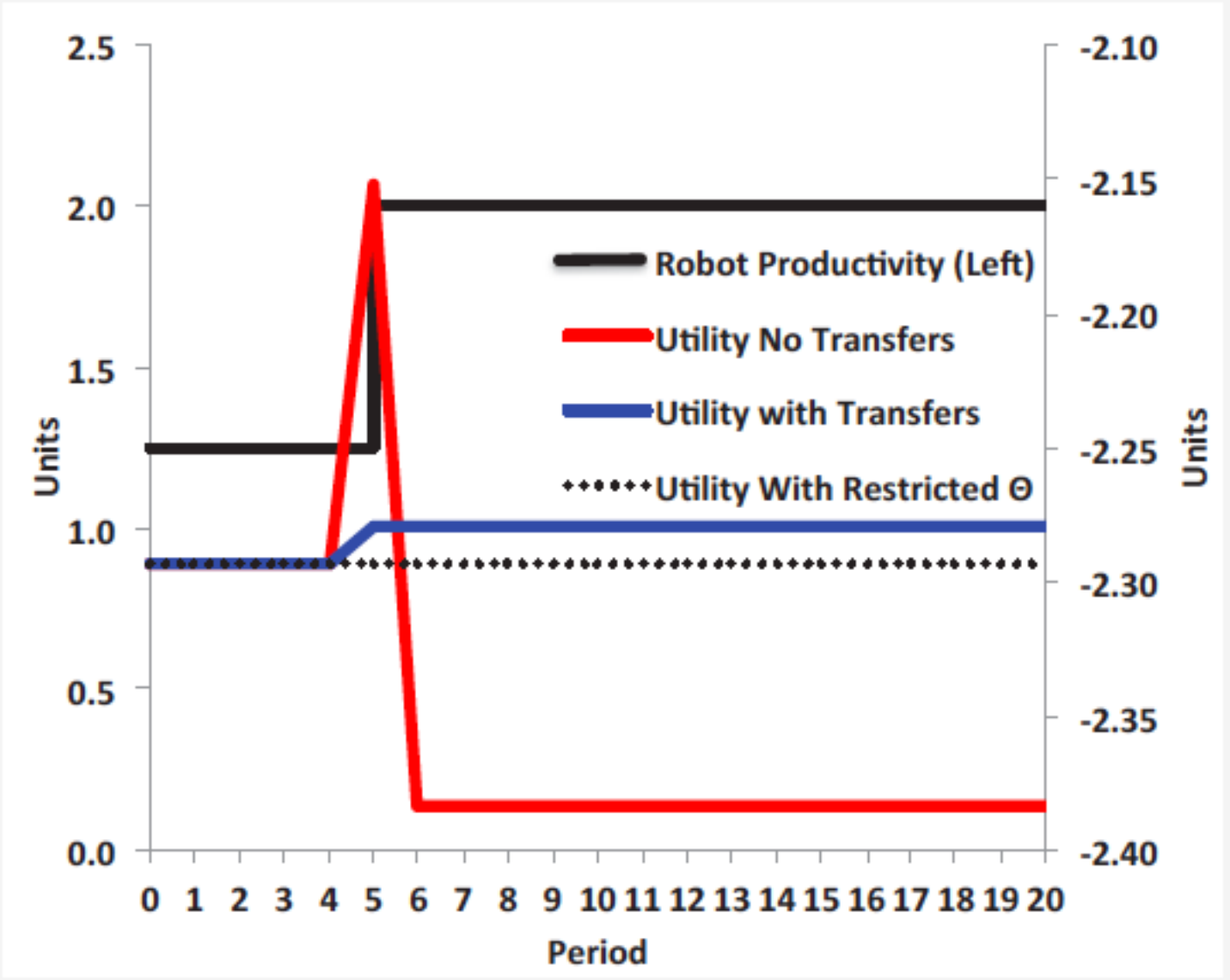


## Figure 9. Labor Share of GDP



# DISTRIBUTIONAL CONSEQUENCES OF AUTOMATION

# Robots: Curse or Blessing?



In order for all parts of society to benefit from the advancing technologies:

Tax the capital owners and redistribute the earnings to the young and poor through free tuition for skill training and tax credits for lower-wage workers;

Without such transfers, income inequality will rise and large parts of the society will be immiserized;

Important decisions will need to be made on the ownership of information and big data;

Rather than STEM education, humanity should be trained in our main comparative advantage: humanism.

John Maynard Keynes, The Economic Possibilities of Our Grandchildren, continued

The pace at which we can reach our destination of economic bliss will be governed by four things—our power to control population, our determination to avoid wars and civil dissensions, our willingness to entrust to science the direction of those matters which are properly the concern of science, and the rate of accumulation as fixed by the margin between our production and our consumption; of which the last will easily look after itself, given the first three.

Meanwhile there will be no harm in making mild preparations for our destiny, in encouraging, and experimenting in, the arts of life as well as the activities of purpose. But, chiefly, do not let us overestimate the importance of the economic problem, or sacrifice to its supposed necessities other matters of greater and more permanent significance. It should be a matter for specialists—like dentistry. If economists could manage to get themselves thought of as humble, competent people, on a level with dentists, that would be splendid!