RECENT U.S. ECONOMIC PERFORMANCE AND PROSPECTS FOR FUTURE GROWTH

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Abstract

The sharp slowdown of U.S. productivity growth since the Great Recession in 2008 has been widely noted and there is a vigorous debate about the causes of the slowdown and the outlook for future economic growth[1]. Growth in the medium term will be driven by growth in capital, total factor productivity and revival of participation rates with a smaller role for improvements in educational attainment. Jorgenson, Ho and Samuels (2017), for example, give a 10-year projection of 1.8% per year for GDP growth, derived from a 0.50 percentage point contribution of hours growth, 0.45 points from TFP, 0.76 from capital deepening, and only 0.12 from labor quality growth. Fernald (2016) gives a similar projection of 0.55 points for hours growth and 1.1 points for labor productivity growth. Our overall conclusion is that educational attainment will play a diminished role in future U.S. economic growth.

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[1] For example, Stock and Watson (2012) discuss financial disruptions and secular changes in labor force trends, Fernald et al. (2017) give a growth accounting decomposition of the output shortfall and argue that slow TFP growth and falling participation rates that predated the financial crisis are mainly responsible. Blanchard et al. (2017) argue that the low growth is due to reduced optimism about the future. Byrne et al. (2016) discuss the extent to which mismeasurement could contribute to the slower TFP growth.

1. Introduction

The purpose of this paper is twofold. The first aim of the paper is to organize historical growth accounts in a new way that highlights the role of educational intensity in U.S. economic growth. Previously, the importance of education in economic growth appeared as improvements of labor quality in the sources of growth. Additional investment in human capital appeared in expanded economic accounts that incorporate human capital, such as Fraumeni, Christian, and Samuels (2017).

The second aim of this paper is to incorporate educational intensity into a medium-term projection for U.S. economic growth. We base this projection on the following assumptions: (i) a projection of the population and employment-population ratios, (ii) a projection of industry TFP growth that accounts for educational intensity, and (iii) a projection of capital quality growth. This also includes a projection of labor quality growth, which continues to be low in comparison to our historical estimates.

In this paper we classify industries by educational intensity. This allows us to associate economic growth at the industry level with the educational characteristics of the work force. This approach demonstrates the relationship between educational intensity and U.S. growth and productivity. We are among the first to consider the link between economic growth and characteristics of labor input in a KLEMS framework. For example, we document the relationship between the share of educated workers in an industry and its productivity growth rate.

We develop a set of growth accounts that identifies the 65 industries in the U.S. National Accounts and classifies these according to their intensity of use of highly educated workers. We find that a disproportionate share of the high TFP growth industries are in the educationally intensity group. As part of this TFP calculation, we extend the U.S. growth accounts in Jorgenson et al. (2017) to cover the postwar period 1947-2015.

A substantial literature has discussed the extent and causes of the falling trend in labor force participation rates (LFPR) since the peak in 2000. Earlier studies of the LFPR, such as Kudlyak (2013) and Toossi (2013), took into account the differences among age and gender groups but did not consider the education dimension. Aaronson, Hu et al (2014), Aaronson, Cajner et al. (2014), Jorgenson et al. (2017), Montes (2018) and Abraham and Kearney (2018) included the effects of the sharper drop in participation rates among the less educated workers during the Great Recession.

The strand of papers focused on the LFPR, or employment-population ratios, does not make an explicit link between them and effective labor input. There are at least two possible ways in which they are related. The first is that the differential rise in participation rates among different age and education groups leads to a change in labor quality. The second is that different gender-age-education composition of workers among the various industries could respond differently to an increase in the relative supply of highly educated workers. As we document below, industries have wide range of TFP growth so that uneven recoveries of the LFPR's could affect the growth of aggregate TFP.

Projections by the CBO (2018) take the total number of workers from LFPR models and use this directly in an aggregate output function. The SSA (2018) assumes an aggregate productivity growth rate independent of the labor force projections. The only papers that explicitly recognize the implications of different LFPR's for labor quality are Bosler, Daly, Fernald and Hobijn (2017) and Jorgenson, et al. (2017).

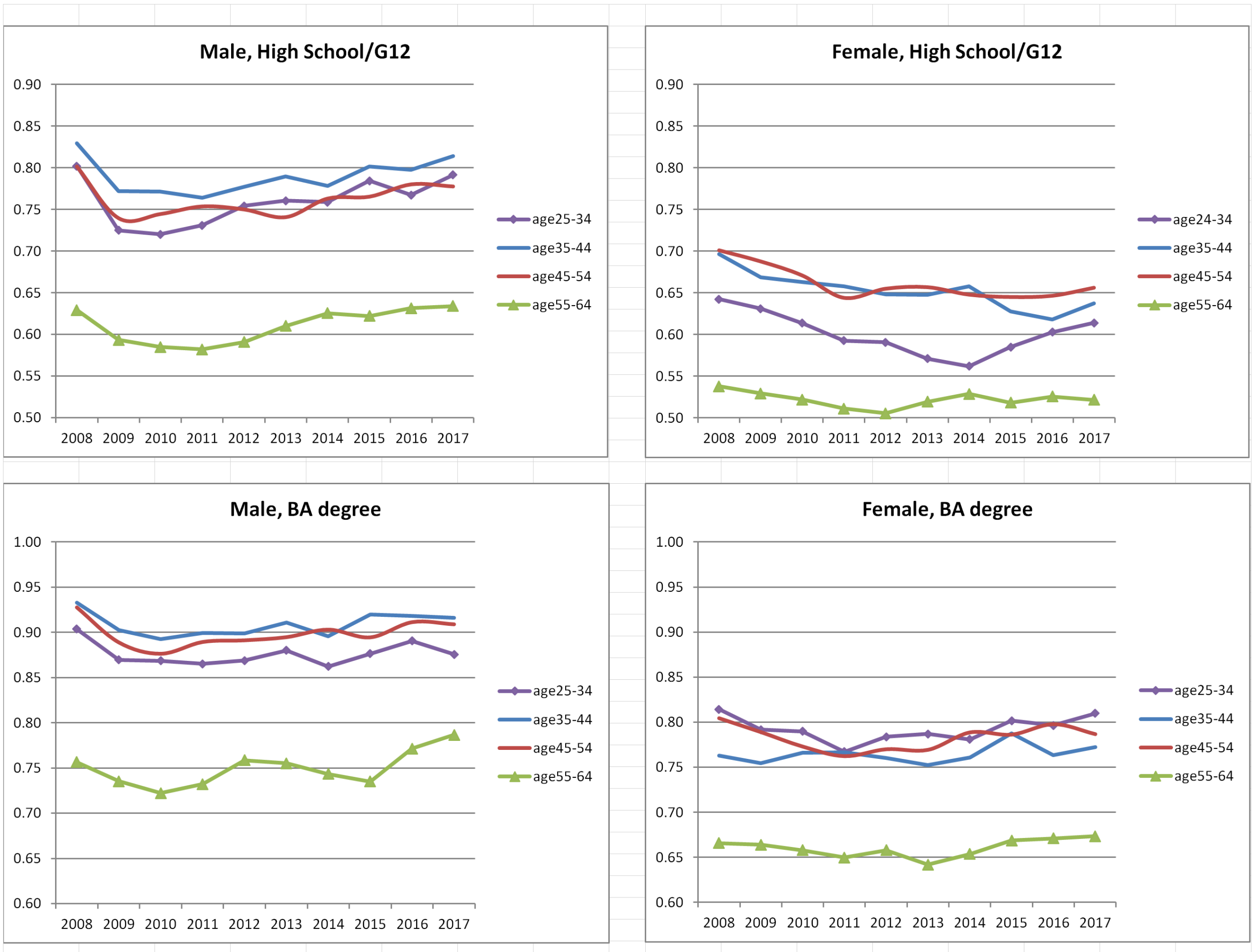
Figure 1 shows how the employment-population ratios differ among the various educational groups[2].

Before projecting the employment-population trends for the medium-term, we first describe the large differences in levels and trends for the various demographic groups in Figure 1. Comparing the male rates in the left-hand graphs with the female rates on the right, we see that there is a gap of 10 percentage points or more. The largest gap is during the peak fertility age. Across the age groups for the college-educated men and women, the differences in employment-participation (EP) rates within the 25-54 age group are small. For women with only High School education, the EP rate for the 25-34 age group is significantly lower than that for the 35-54 group. For prime-age men, those with BA's have EP rates around 90%, while those with High School

[2] These ratios are tabulated from the Annual Social and Economic (ASEC) files in the Current Population Survey. In recent years the ASEC has a sample size of about 180,000 persons. The employment-population ratio counts only those who are working whereas the LFPR includes the unemployed who are in the labor force.

diplomas have rates less than 80%. Prime-age women with BA's have rates around 75-80% compared to the High School group rates around 60-70%[3].

Figure 1. Employment-population Ratios after the Financial Crisis; Differences among Demographic Groups



The period covered in Figure 1, 2008-2017, shows the impact of the Great Recession and the slow recovery of participation rates. We note the following features of these trends. For men in the 25-54 age group, for all education levels, the EP ratios have not recovered to the pre-crisis levels in 2007. For men aged 55-64, the ratio recovered to or exceeded, the 2007 levels. For all age groups of women with High School education the EP ratios have not recovered. For women

[3] We do not present the graphs for those with less than HS since they are quite similar to those with HS, and those with MA+ degrees are somewhat similar to those with BA's.

with BA degrees, the EP ratios have largely recovered, and in the 55-64 age group, exceeded the 2007 level.

We find that projected U.S. economic growth for the decade 2017-2027 will be considerably lower than growth over the past quarter century. Education is likely to continue to buoy economic growth through industries that employ educated workers, rather than upgrading the educational qualifications of the labor force. Our Base Case projection of U.S. GDP growth is 1.86% per year for the period 2017-2027. By comparison average U.S. GDP growth for the period 1990-2015 was 2.37%.

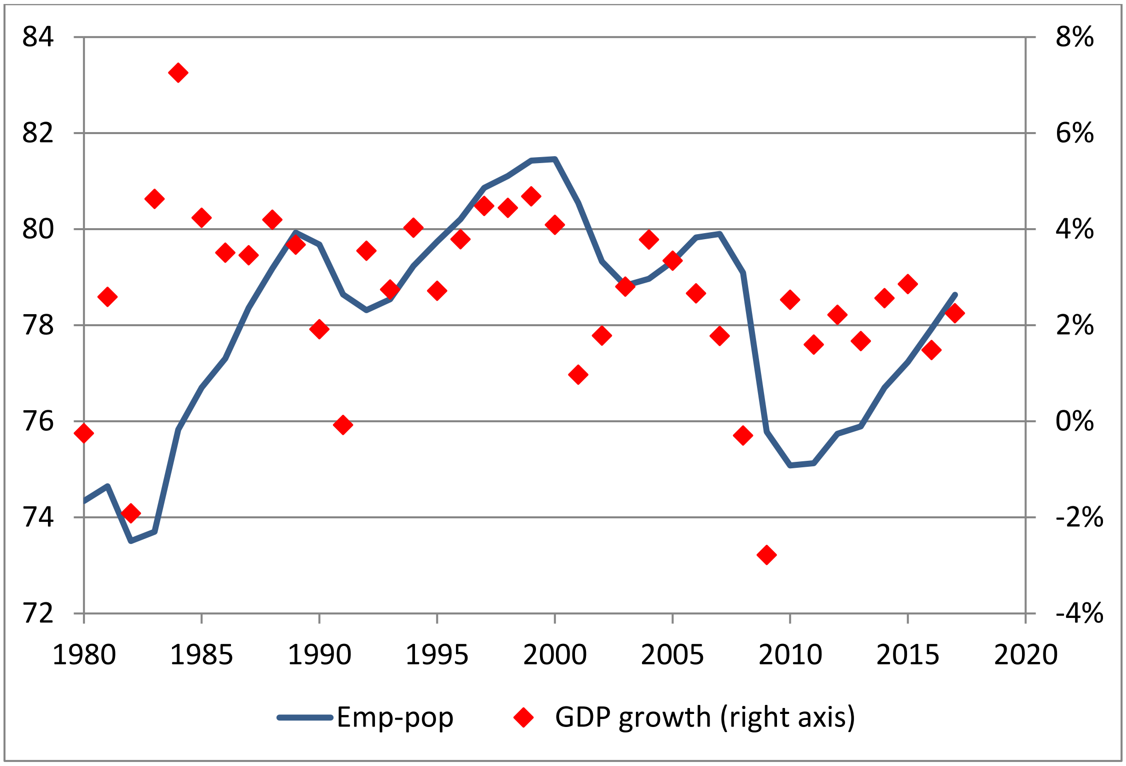
2. Trends in Employment-Population Ratios and Labor Quality.

The long-term decline in the labor force participation rate after 2000 has been widely noted, e.g. Aaronson, Cajner et al. (2014), Aaronson, Hu et al. (2014), CEA (2016), and Abraham and Kearney (2018). Figure 2 plots the employment-population (EP) ratio of the prime age 25-54 group for 1980-2017 together with GDP growth rates to show the business cycle effects[4]. This EP ratio fell to 75.0% in 2010 during the Financial Crisis, from a peak of 81.5% in 2000. While it has since recovered to 78.6% by 2017, many observers believe there a long-term downward trend from the 2000 peak and the current recovery will likely not reach the 2007 pre-crisis peak of 79.9%.

A number of authors and government agencies have fitted statistical models for the participation rates and projected them. Some of these are compared in Aaronson, Cajner et al. (2014, Table 7). Taking into account the aging of the population, the overall LFPR for 16+ is projected to fall even if there is a small rise for the prime-age groups. A more recent projection by the CBO (Montes 2018, Table 4), estimates that the LFPR for 25-54 year-olds would be 0.3 percentage points higher by 2028 compared to 82.0% in 2017. It was 82.9% in 2007. Given these modest improvements, we assume that the employment-population ratio will not rise beyond the base-year levels for each gender-age-education group.

[4] We use the EP ratio instead of labor force participation rate since it is a comparable concept to our labor input by industry. For reference, in 2007 the EP ratio for the whole 16+ population was 63.0% compared to the civilian LFPR for 16+ of 66.0% (also, EP ratio for 25-54 year-olds was 79.9%).

Figure 2. Employment-population Ratio of 25-54 Year-Olds and GDP Growth.



Labor quality

The standard in growth accounting, as reflected in the studies presented in Jorgenson, Fukao and Timmer (2016), is to define effective labor input as an aggregate over demographic types. This incorporates the very different wage rates of various sex-age-educational attainment groups. The index of labor composition, or labor quality, is defined as the ratio of effective labor input to total hours worked. This labor quality index is clearly affected by the differing trends in participation rates noted above for the different age and education groups.

Our method and data sources for calculating effective labor input and labor quality at the industry and aggregate levels are given in detail in Jorgenson, Ho and Stiroh (2005, Chapter 6). With the help of the U.S. Bureau of Economic Analysis we have updated the estimates to cover 1947-2015 as reported in Table 1. The row marked "labor quality" refers to the aggregate index, while the last three rows of "first order indices" give the partial effects of changes in sex (Q^{sex}), age (Q^{age}) and educational attainment (Q^{educ}) composition of the work force.

Labor quality has been rising at about 0.4% per year, averaged over the entire postwar period. While the total growth rate seems stable, there are substantial differences in the underlying contributions over this period. The 1947-2015 period saw a rapid rise of women's participation, shown by the negative contributions of Q^{sex}; the relative wages of women are lower and hence an increase in the female share lowers the quality index. The period immediately after the War, 1947-73, saw a big increase in young workers who have lower wages than the prime-age workers, hence the negative Q^{age} contribution. The boom period of 1995-2000 saw a big rise in the EP ratio of less educated workers, hence the small 0.27% annual growth of Q^{educ}; this is reversed during 2007-2015 when those with High School or less suffered a much bigger fall in employment compared with the highly educated during the Great Recession and Q^{educ} rose significantly at 0.46% per year. This temporary burst of average educational improvement of workers will be reversed if participation rates of the less-educated recover to the same extent as those with BA+ degrees.

Table 1. Growth Rate of Aggregate Labor Input, Quality and Hours, 1947-2015.

	1947-2015	1947-1973	1973-1995	1995-2015	1995-00	2000-07	2007-15
GDP	3.15	3.96	2.86	2.41	4.26	2.42	1.28
Aggregate labor							
Labor input	1.49	1.55	1.72	1.18	2.27	0.92	0.73
Labor quality	0.42	0.44	0.40	0.42	0.36	0.48	0.41
Hours	1.07	1.11	1.31	0.76	1.91	0.44	0.31
First order aggregate labor quality indices							
Q^{sex}	-0.10	-0.10	-0.15	-0.03	-0.07	-0.02	-0.02
Q^{age}	0.09	-0.04	0.17	0.16	0.21	0.17	0.11
Q^{educ}	0.39	0.37	0.40	0.41	0.27	0.46	0.45

Note: figures are average annual growth rates.

3. Skill Intensity and Growth.

In our previous accounting for US growth in Jorgenson et al. (2007) and Jorgenson et al. (2017) we divided the U.S. industries into three groups – IT-producing, IT-using and Non-IT – to reflect their very different output and TFP growth rates. We showed how the tiny IT-producing sector with less than 4% of total value added contributed more than half of aggregate TFP growth during 2000-07, and essentially all of aggregate TFP growth after the Financial Crisis (2007-15). We also showed how college-educated labor made a positive contribution to growth after 2000, but non-college labor made a negative contribution.

The IT-producing group and many of the IT-intensive sectors are also intensive users of highly educated workers. There are many models that link human capital, productivity and growth; see, for example, those discussed in Stokey (2018). Thus, one of our objectives is to examine potential relations between educational intensity and productivity growth among U.S. industries. First, in Table 2 we give the share of workers with BA, or higher degrees, out of all workers in each industry in 2007, on the eve of the Great Recession. We also give a measure of the relative size of the industries by showing the share of all workers going to each industry.

The share of highly educated workers ranges from 8.0% in Truck Transportation to 68.2% in Computer Systems and 68.5% in Securities. The national average share is 30.7% and we divide the industries into two groups. The educationally intensive (or skill intensive) group consists of those industries with a share larger than the national average. The other industries are allocated to the non-educationally intensive group. The categories are listed in the column marked "skill intensive." In the final column of Table 2 we indicate which industries are IT-producing, IT-using and Non-IT. All the IT-producing industries are skill-intensive (Computers, Data processing, Computer Systems Design), but are relatively small. The industries with many well-educated workers include Banks, Professional Services, Education, Health Services, Hospitals and the Federal Government.

From our updated industry growth accounts for 1947-2015 we derive the growth rate of total factor productivity (TFP) in a manner described in detail in Jorgenson, Ho and Stiroh (2005). In Figure 3 we plot the industry TFP growth during the Great Recession and Recovery period (2007-2015) versus the skill intensity given in Table 2. There is a weak correlation (0.21) between TFP growth and the share of workers with BA+ degrees. The high skill intensity industries such as Computer Systems, Funds, Computer Manufacturing, and Professional Services have high TFP growth rates.

The low skill intensity industries such as Mining (excluding Oil and Gas), Transit and Ground Passenger Transportation, Rail Transportation, and Fabricated Metal Products have large negative TFP growth rates. There are some service industries with high skill intensities but low TFP growth – Securities, Education, Legal Services and Data Processing and Information Services. These are sectors with well-known difficulties in measurement. We next account for differences in TFP growth more systematically.

Sources of U.S. Economic Growth 1947-2015

We have taken the latest available industry accounts from the BEA and constructed measures of output and capital, labor and intermediate inputs for 65 industries[5]. We then aggregate over the two groups of industries in the manner described in Jorgenson, Ho and Stiroh (2005, Chapter 8). The contributions to aggregate value added of the educationally intensive (EI) and non-educationally intensive (NEI) groups are given in Figure 4. The contribution of an industry is its growth rate of value-added, multiplied by its share of total value-added (GDP)[6]. The sum over all industries in the educationally intensive (EI) group is given by the dark bars in Figure 4 while the light bars gives the non-educationally intensive (NEI) group.

Table 2. Skill Intensity by Industry, 2007.

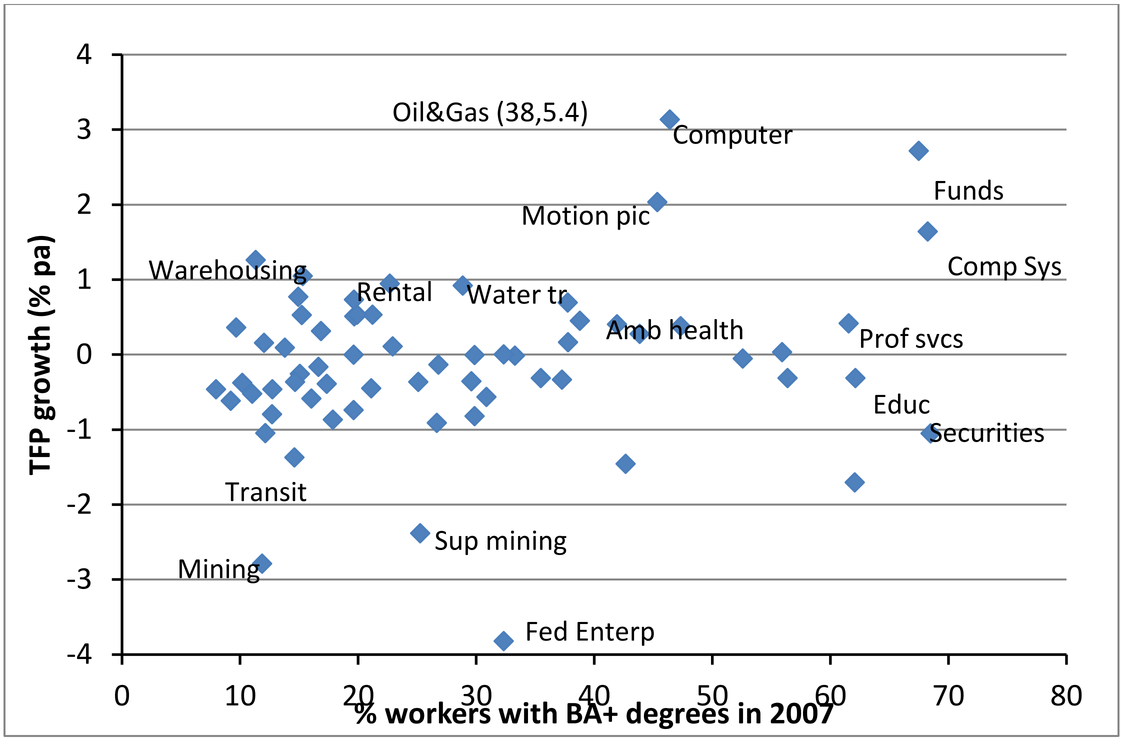
		Industry share of workers (%)	Workers with BA+ (%)	Skill intensive	IT category
1	Farms	1.01	14.9		
2	Forestry, fishing, and related activities	0.40	13.8		
3	Oil and gas extraction	0.10	38.1	Yes	
4	Mining, except oil and gas	0.15	11.9		
5	Support activities for mining	0.20	25.3		
6	Utilities	0.36	26.7		
7	Construction	6.32	11.0		
8	Wood products	0.35	9.7		Using
9	Nonmetallic mineral products	0.33	15.1		
10	Primary metals	0.30	15.3		
11	Fabricated metal products	1.03	12.7		
12	Machinery	0.78	21.1		
13	Computer and electronic products	0.83	46.4	Yes	Producing
14	Electrical equipment and components	0.28	25.1		
15	Motor vehicles and parts	0.65	21.2		
16	Other transportation equipment	0.47	37.3	Yes	Using

[5] The methods and data sources of our industry growth accounts is given in detail in Jorgenson et al. (2005) and the update from SIC to NAICS is described in Jorgenson, Ho and Samuels (2017). The capital input updates are from the BEA-BLS Integrated Industry-level production account and the output and intermediate input data are from the BEA GDP by Industry Accounts.

[6] We use a production possibility frontier method to aggregate over the value-added of each industry (Jorgenson, Ho and Stiroh (2008, equation 8.21).

17	Furniture and related products	0.37	12.7		Using
18	Miscellaneous manufacturing	0.46	26.8		Using
19	Food, beverage and tobacco	1.11	16.0		
20	Textile mills and textile product mills	0.23	12.0		
21	Apparel and leather products	0.18	15.2		
22	Paper products	0.30	17.4		
23	Printing and related support activities	0.43	19.7		Using
24	Petroleum and coal products	0.08	30.9	Yes	
25	Chemical products	0.56	42.6	Yes	
26	Plastics and rubber products	0.49	14.7		
27	Wholesale trade	4.05	29.6		Using
28	Retail trade	10.83	16.9		Using
29	Air transportation	0.32	35.5	Yes	Using
30	Rail transportation	0.13	12.1		
31	Water transportation	0.04	28.9		Using
32	Truck transportation	1.14	8.0		
33	Transit and ground passenger transp.	0.32	14.6		
34	Pipeline transportation	0.03	29.9		Using
35	Other transportation activities	0.83	17.9		Using
36	Warehousing and storage	0.44	11.3		
37	Publishing, ex. internet (incl software)	0.65	55.9	Yes	Using
38	Motion picture and sound recording	0.29	45.3	Yes	
39	Broadcasting and telecommunications	0.92	38.8	Yes	Using
40	Data proc, internet pub., and info. svc	0.22	56.4	Yes	Producing
41	Fed Res banks, credit intermediation	1.91	37.8	Yes	Using
42	Securities, comm contracts, and inv.	0.63	68.5	Yes	Using
43	Insurance carriers	1.59	43.9	Yes	Using
44	Funds, trusts, and financial vehicles	0.06	67.5	Yes	
45	Real estate	1.30	37.8	Yes	
46	Rental and leasing services	0.45	22.7		Using
47	Legal services	0.91	62.1	Yes	Using
48	Computer systems design and services	0.99	68.2	Yes	Producing
49	Misc. professional, scientific, tech svcs	3.89	61.5	Yes	Using
50	Management of companies	1.21	52.6	Yes	Using
51	Administrative and support services	5.77	19.6		Using
52	Waste management and remediation	0.25	10.2		
53	Educational services	2.09	62.1	Yes	Using
54	Ambulatory health care services	3.83	41.9	Yes	Using
55	Hospitals, Nursing and resid care	4.89	33.3	Yes	Using
56	Social assistance	1.94	29.9		Using
57	Performing arts, spectator sports	0.58	47.3	Yes	
58	Amusements, gambling, and recreation	0.98	19.9		
59	Accommodation	1.24	16.6		
60	Food services and drinking places	6.42	9.2		
61	Other services, except government	5.19	22.9		Using
62	Federal government	3.31	32.3	Yes	Using
63	State and local government	12.61	19.6		
	National average		30.7		

Figure 3. TFP Growth (2007-15) versus Skill Intensity by Industry



We divide the post-war period into three eras, reflecting the well-known break points in productivity growth – the Post-War Recovery, 1947-73, the Long Slump, 1973-1995, and Growth and Recession, 1995-2015. The last era is further sub-divided among the Investment Boom,1995-00, Jobless Growth, 2000-07, and the Great Recession, 2007-15. Over the entire 1947-2015 period the two groups made almost the same contribution to aggregate value-added.

The educationally intensive (EI) group was smaller during the period 1947-1973, but dominated after that. In the Growth and Recession period, the EI group contributed 1.6 percentage points, compared to 0.8 points for the NEI group. The bottom half of Figure 4 shows the dramatic change between these two groups. During the Investment Boom they contributed about equally (2.3 versus 2.0 percentage points). In the Jobless Growth period the EI group contributed 1.69 versus 0.67 points and during the Great Recession (2007-15) the EI group contributed 0.98 versus 0.16 points. Many NEI sectors had negative growth in value-added, including Furniture and Related Products, Apparel and Leather and Allied Products, Textile Mills and Textile Product

Mills, Paper Products, and Construction. Most of these were manufacturing industries (excluding Computers and Electronic Products).

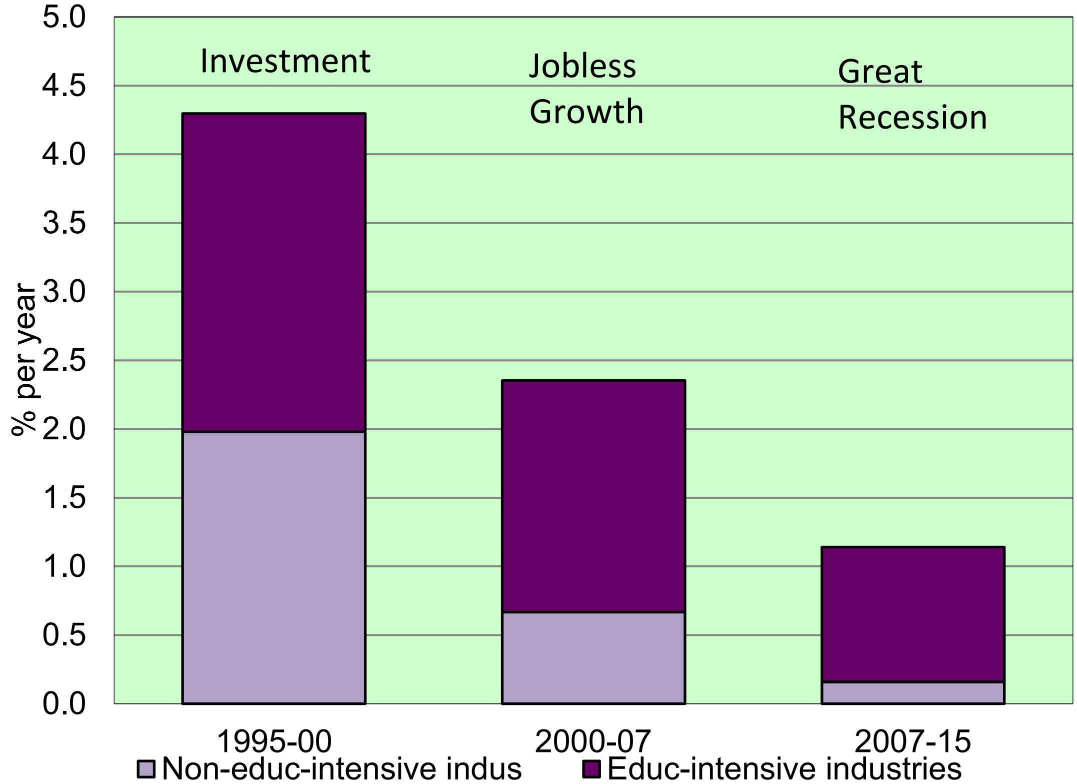
Next, we give the sources of growth in Figure 5 for the same sub-periods. Over the entire 69-year postwar period, aggregate value-added growth was 3.05% per year. Capital input contributed 1.57 percentage points, labor input 0.83 percent and TFP 0.64 percent. Total factor productivity thus contributed about 21% of GDP growth during the post-war period. The largest TFP contribution was during the Post-War Recovery period 1947-73, when it contributed 1.12 points out of 3.85% per year, a 29% share. At the peak of the Information Age (1995-2000) TFP contributed only 20%. When growth fell sharply during the Jobless Growth period (2000-07), TFP growth remained strong and contributed 28% of aggregate value-added growth. During the Great Recession and Recovery GDP growth slowed to 1.14% per year and TFP growth fell sharply to 0.11%.

Our measure of capital input is aggregated over about 100 types of assets. We divide these assets between Information Technology (IT) and Non-Information technology (NIT) capital. Of the 1.57 percentage points capital contribution over the post-war period 1947-2015, IT capital contributed 0.36 percent and Non-IT capital contributed 1.21 percent -- the dark and light blue areas of Figure 5, respectively. The IT equipment and software alone contributed almost a quarter of the annual flow of capital services, while everything else – land, structures, Non-IT equipment, intellectual property – contributed three quarters. The IT capital contributed the most during the Investment Boom of 1995-2000, making up 1.12 percentage points of the 2.11 percent contribution of capital input. A similar large IT share was also observed for the Jobless Growth period, but the share fell in the Great Recession.

Educational Intensity and Sources of Growth

In Figure 4 we give the contribution of the educationally intensive (EI) and non-educationally intensive (NEI) groups to GDP growth, showing how the EI group dominated after the Financial Crisis. We next discuss the sources of growth for these groups. Figure 6 gives the contributions of capital, college-labor, non-college labor and TFP to growth in the two groups for the three sub-periods of the Growth and Recession era (1995-2015).

Figure 4. Contributions of Industry Groups to Value Added Growth.



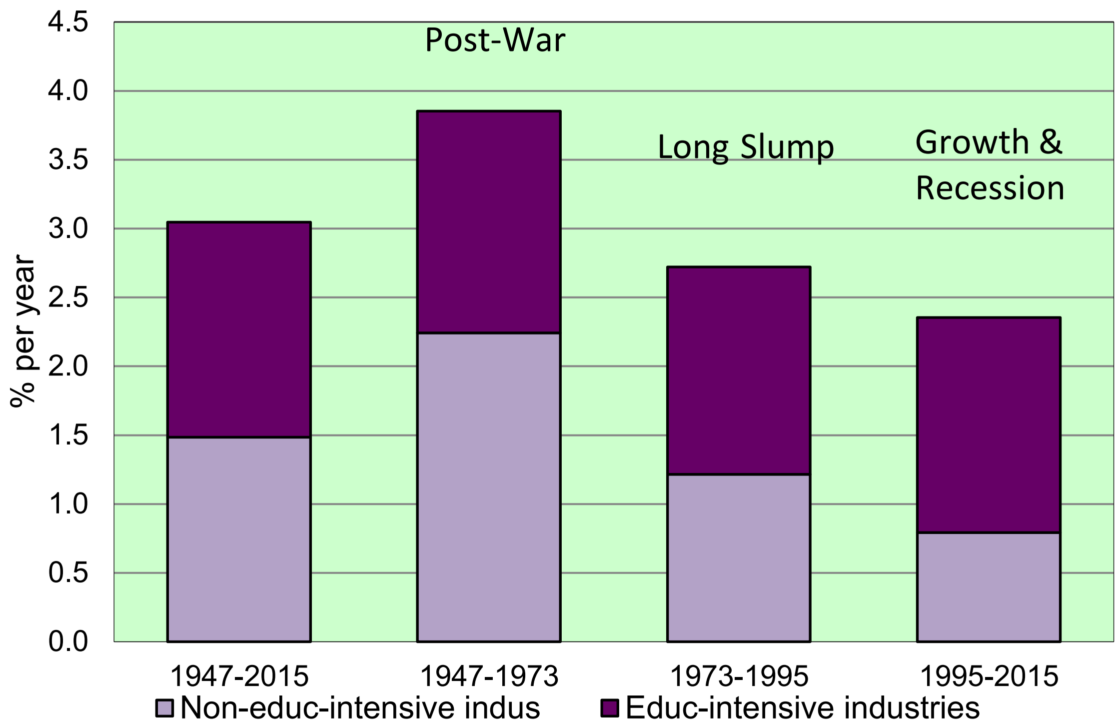
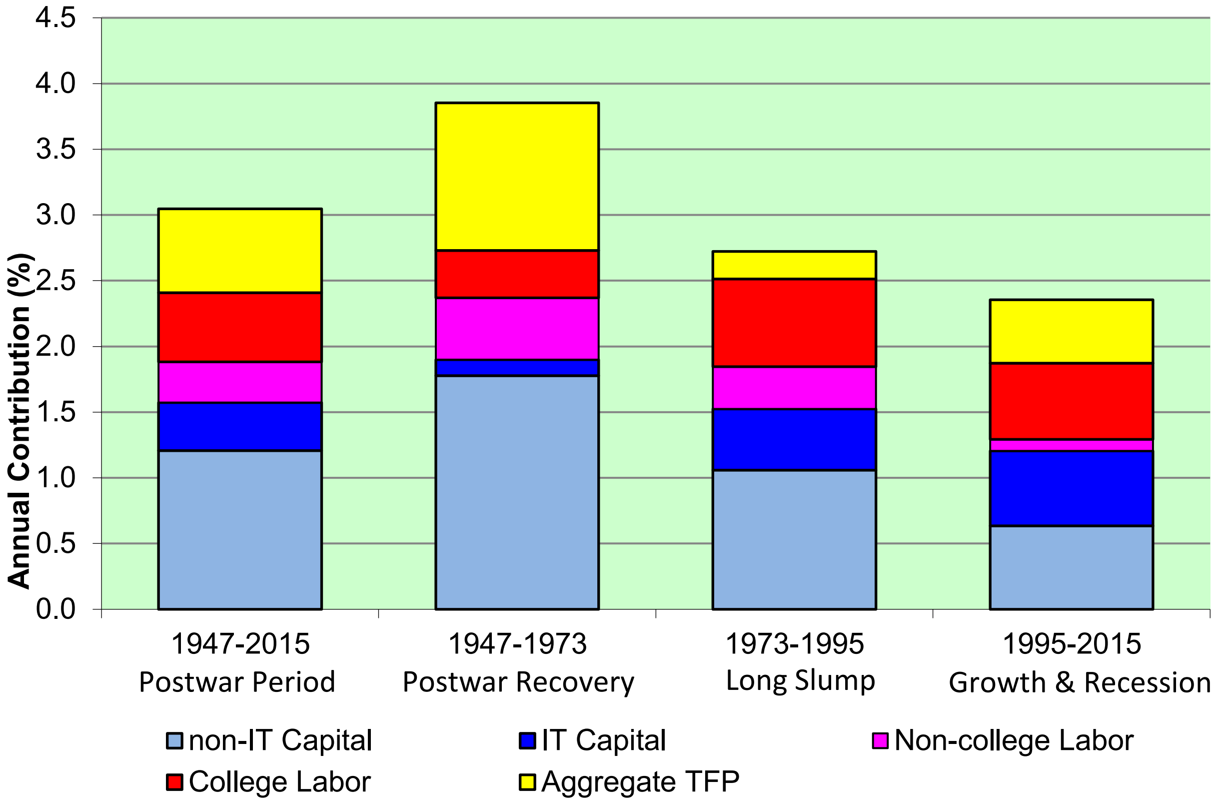
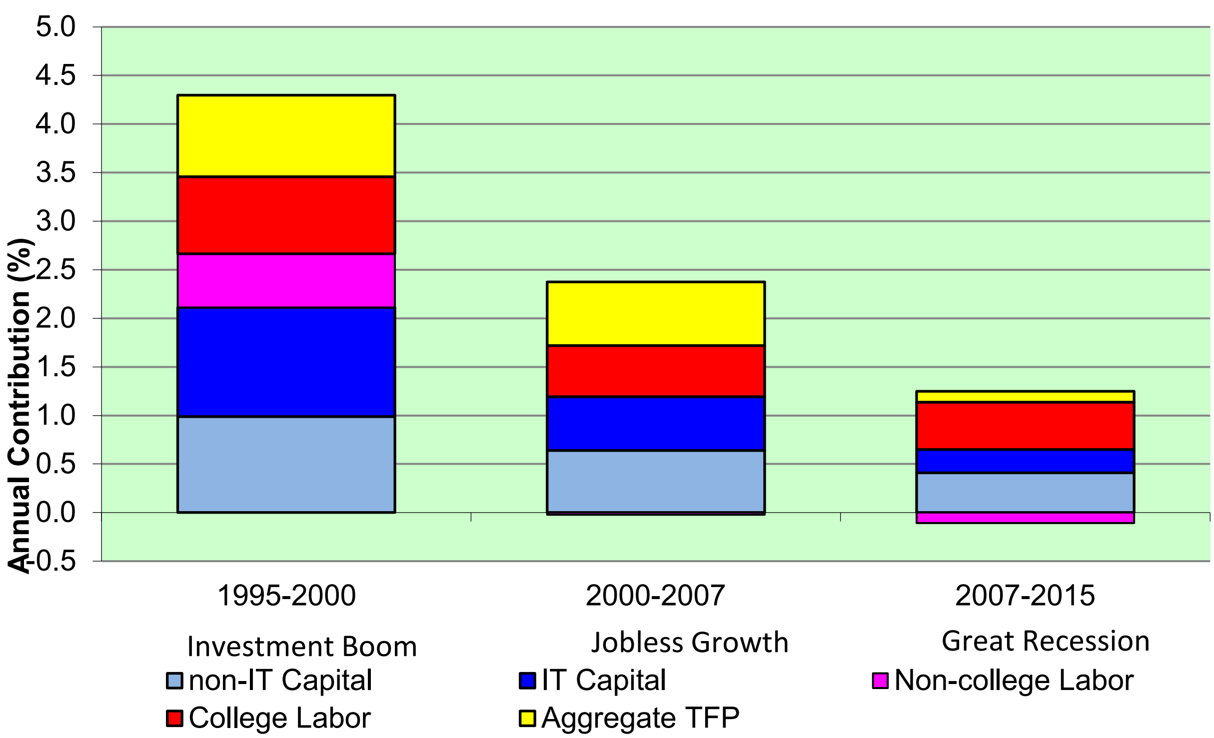


Figure 5. Sources of U.S. Economic Growth.





First, we see that the growth of value-added in the EI group is higher in all three sub-periods. Second, college labor contributed positively to both groups after 2000, but non-college labor contributed negatively. This came after the Investment Boom of 1995-2000 when non-college labor grew rapidly, especially in the NEI group. The college labor contribution to value-added growth is a higher share in the EI group for all three sub-periods. During the Great Recession and Recovery the college-labor share reached 34% in the EI group, compared to the average 25% share for the whole economy during the entire 1995-2000 period.

Third, the TFP contribution is significantly different between the EI and NEI groups. During the Investment Boom TFP growth was high and contributed more than 17% to value-added growth in both groups. During the Jobless Growth period TFP growth remained strong in the EI group, rising to a contribution to growth of 27%. In the NEI group TFP growth remained positive and contributed about 16% to growth. However, in the Great Recession period (2007-2015) TFP growth was positive in EI (a 28% contribution) but negative in the NEI group.

Figure 6. Sources of Growth of Education Intensive and Non-education Intensive Industries.

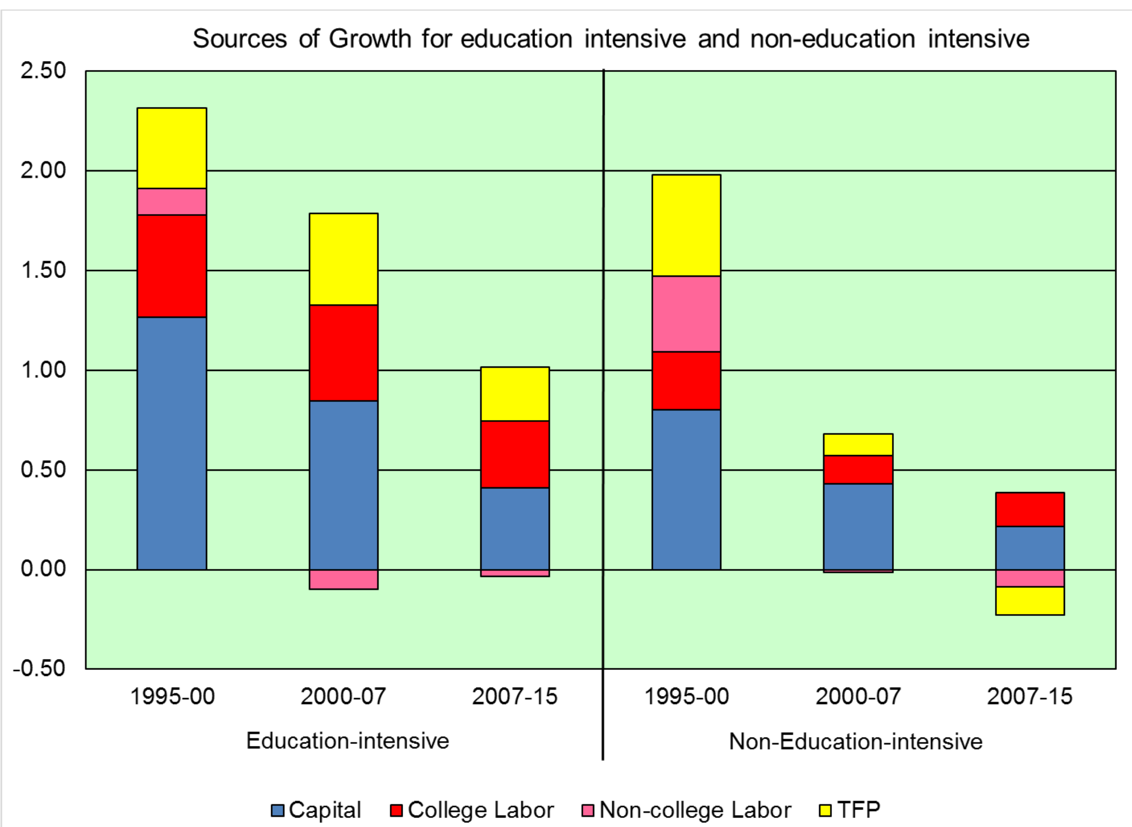


Figure 7. Contribution of industry groups to Aggregate Productivity

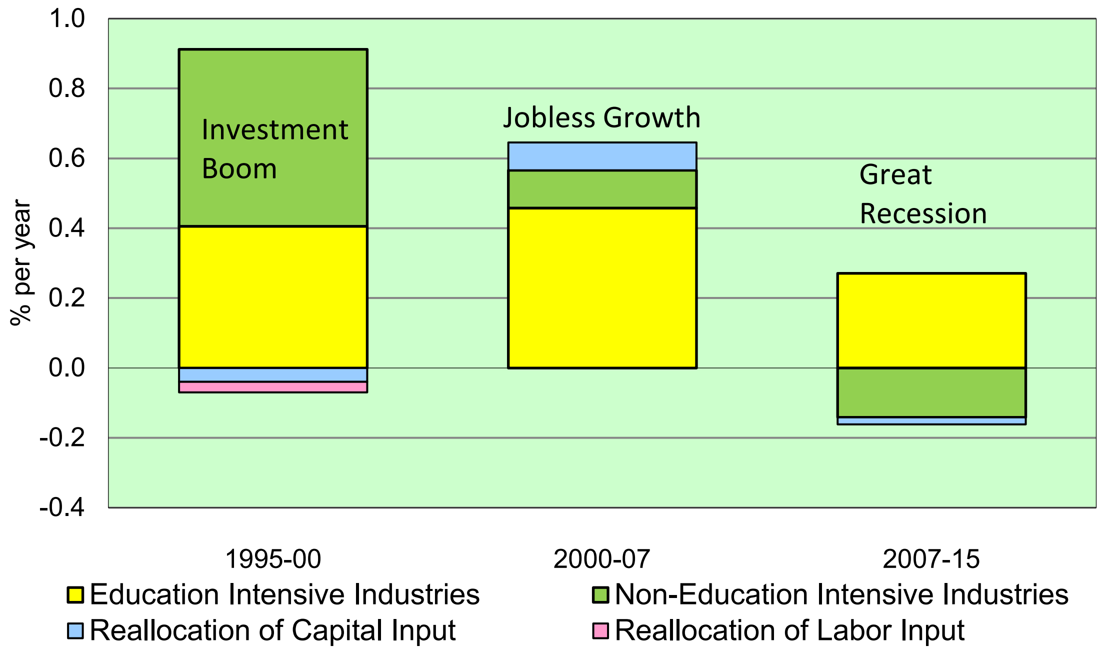


Figure 7 shows the U.S. productivity record in another ay by giving the decomposition of aggregate TFP growth into the sum over industry TFP growth, reallocation of capital and reallocation of labor[7]. Aggregate TFP growth reaches a peak of 0.84% per year during the Investment Boom, remains high at 0.65% during Jobless Growth, but crashes to 0.11% after the Financial Crisis. During the Jobless Growth period the EI group contributes 0.46 percentage points to the 0.65% total, while the NEI group contributes 0.11 points and reallocation effects contribute 0.08 points. During the 2007-2015 period, the EI group contributes 0.27 points to the 0.11% while NEI contributes -0.14 points.

In summary, there are substantial differences between the two groups of industries. The differences in both output and TFP growth performance widened during the Great Recession and the current recovery. Next, we incorporate this information into our outlook for medium term economic growth.

[7] The decomposition is explained in Jorgenson, Ho and Stiroh (2005) equation 8.34. The contribution of TFP from an industry group to aggregate TFP is the Domar-weighted sum of the TFP growth in each of the member industries.

4. Projecting Medium Term U.S. Economic Growth

Medium term projections of economic growth are essential components of policy analysis and public program planning. The Congressional Budget Office is an important source of carefully considered outlooks for the U.S. economy (see CBO 2018), including an analysis of labor force participation trends. The BLS and Federal Reserve provide projections of LFPR and output growth, e.g. Toossi (2013), Lacey et al. (2017) and Aaronson, Hu et al. (2014). The Social Security Administration (2018) also considers labor supply and productivity issues but over a much longer horizon.

Projections of the GDP use methods ranging from projections from growth accounts to Solow-type growth models. Here we present a method of projecting medium term growth that takes into account labor quality, capital quality and TFP growth. This method is described in detail in Jorgenson, Ho and Stiroh (2008) and Jorgenson, Ho, and Samuels (2017). We first express labor productivity growth (output per hour worked) as a function of capital quality growth, labor quality growth, TFP growth and an adjustment for the share of reproducible capital in total capital. That equation is derived under the long-run assumption that output growth equals capital growth. Output growth is then the sum of productivity and hours growth.

We present three alternative projections for U.S. economic growth for the period 2017-2027 in Table 3 – Base Case, Low Growth, and High Growth. This enables us to quantify the uncertainty in projections of the growth of capital quality and productivity growth. We present the three alternative projections in Figures 8, 9 and 10 where we also give historical data for 1990-2015 for comparison.

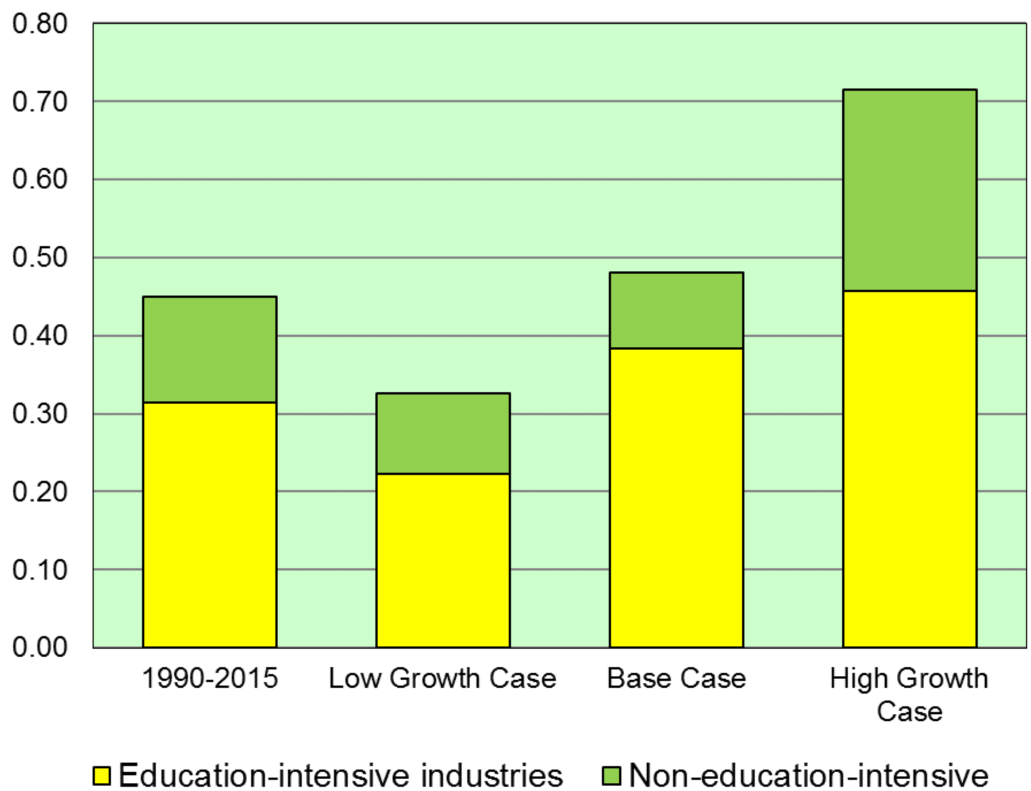
Table 3. Medium-term projections of output and labor productivity

	Actual	**Projections**		
	1990-2015	**Low**	**Base**	**High**
		Projections, 2017-2027		
Value Added Growth	2.37	1.65	1.86	2.47
ALP Growth	1.59	1.18	1.38	2.00
Effective Capital Stock	2.19	1.25	1.41	1.87
		Common Assumptions		

Hours Growth	0.77	0.47	0.47	0.47
Labor Quality Growth	0.43	0.21	0.21	0.21
Capital Share	0.424	0.44	0.44	0.44
Education Intensive Industry Output Share	0.853	0.88	0.88	0.88
Non Education Intensive Industry Output Share	0.938	0.91	0.91	0.91
Reproducible Capital Stock Share	0.668	0.76	0.76	0.76
		Alternative Assumptions		
TFP Growth in Education Intensive Industries	0.37	0.25	0.43	0.52
Contribution of TFP in Education Intensive Industries	0.31	0.22	0.38	0.46
TFP Growth in Non-Education Intensive Industries	0.14	0.11	0.11	0.29
Contribution of TFP in Non-Education Intensive Ind.	0.14	0.10	0.10	0.26
Reallocation of Capital and Labor Contribution	0.01	0.00	0.00	0.00
Capital Quality Growth	0.88	0.90	0.86	1.27
Implied Capital Deepening Contribution	0.88	0.73	0.78	1.16

Notes: Capital share and reproducible capital stock shares are 1947-2015 averages, and output shares are averages for 2000-2015. Low growth projections use 1973-2015 average growth of capital quality and TFP growth. Base case projections use 1995-2015 averages and high growth projections use 1995-2007 averages. Output shares are defined as gross output over aggregate value added. Projections of hours and labor quality assume that employment-population ratios remain constant at 2017 levels and weekly hours worked remain constant at 2015 levels.

Figure 8. Contribution of Industry Groups to Aggregate TFP growth, 2017-2027



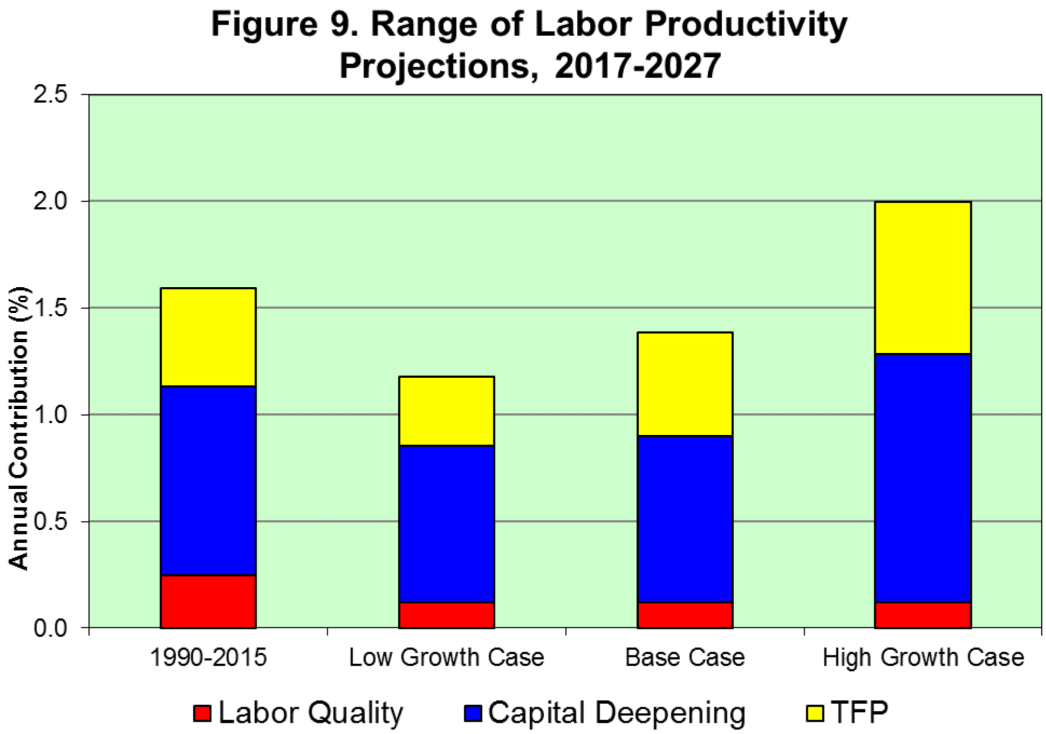


Figure 9. Range of Labor Productivity Projections, 2017-2027
Annual Contribution (%)
2.5
2.0
1.5
1.0
0.5
0.0
1990-2015
Low Growth Case
Base Case
High Growth Case
Labor Quality
Capital Deepening
TFP

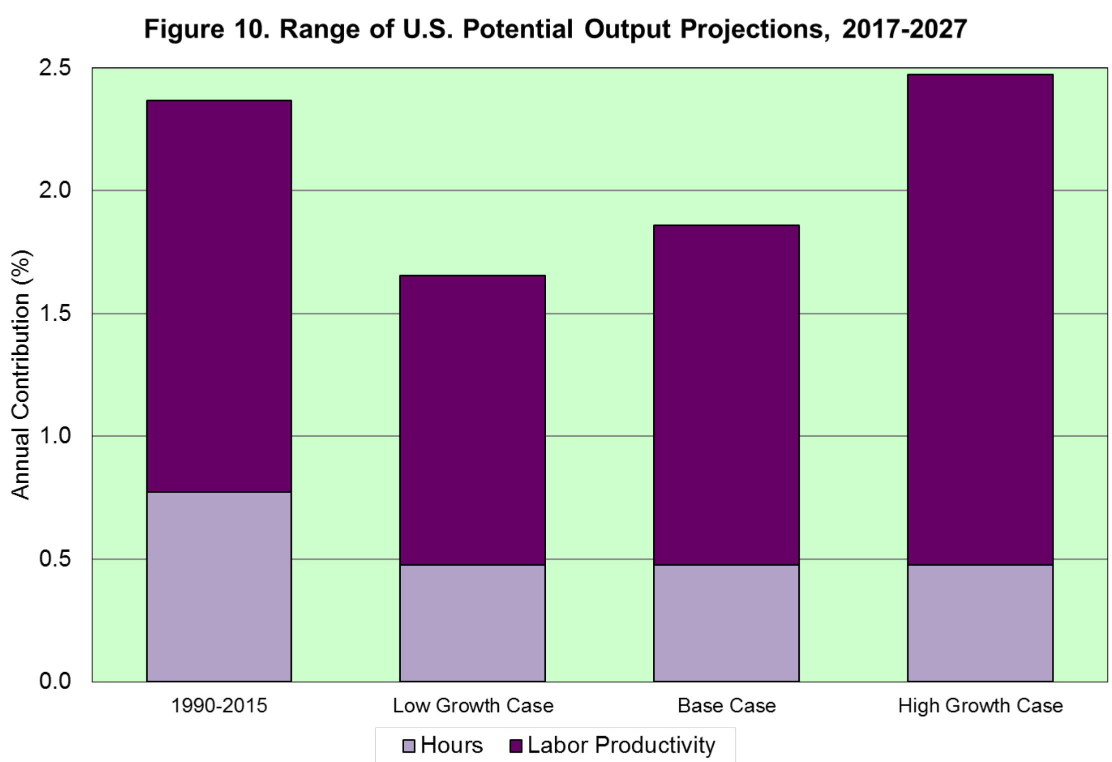


Figure 10. Range of U.S. Potential Output Projections, 2017-2027
Annual Contribution (%)
2.5
2.0
1.5
1.0
0.5
0.0
1990-2015
Low Growth Case
Base Case
High Growth Case
Hours
Labor Productivity

Figure 8 includes three alternative projections of total factor productivity growth for the period 2017-2027. For the Base Case we set future TFP growth rates for educationally intensive, and non-educationally intensive industries equal to growth rates for the period of Growth and Recession, 1995-2015. The Low Growth projection is based on productivity growth rates for the period 1973-2015, which includes the Long Slump of 1973-1995. The High Growth projection incorporates the period 1995-2007, which includes the Investment Boom and the Jobless Recovery of 2000-2007, but excludes the Great Recession.

We use the following assumptions for all three projections. The capital share in value added and the share of reproducible capital in total capital stock are set equal to the averages for the postwar period, 1947-2015. The shares of nominal GDP for EI and NEI sectors are set at the averages for the recent period 2000-2015 to reflect changes in the relative importance of the educationally intensive group, as shown in Figure 4.

Figure 9 gives the growth rates of labor productivity and its components for the Base Case, Low Growth and High Growth projections; the components are labor quality, capital deepening and aggregate TFP. Figure 10 presents the projected growth rates of output as the sum of hours and labor productivity. We have now discussed all the ingredients for the projections except for the projections of hours and labor quality, described in the Base Case below.

Base Case

In our discussion of Figure 1 we noted that the employment-population ratios differ by gender, age, and education. They have slowly recovered towards the pre-recession peak in 2007. Our projections of hours worked incorporate these differences for the two genders, seven age groups and six educational attainment groups. For each demographic category we assume that the employment-population ratio remains equal to the ratio in 2017. We fix weekly hours for each gender-age-education group at the 2015 levels.

In Table 1 we show how the educational intensity of workers had temporarily grown, due to the higher unemployment of the less-educated after 2000. A similar education index for the general population shows a steady fall in the growth rate after 2000 when the rapid rise in college enrollment decelerated. We examined the education attainment of the population for each gender-age cell in 2000, 2010 and 2015 using the Censuses and ASEC survey in comparison to the 1977-2000 history described in Jorgenson, Ho and Stiroh (2005).

We see a rapid deceleration of improvement in educational attainment, especially for men. We therefore project a modest further improvement in educational attainment over the next ten years, as discussed in greater detail in Jorgenson, Ho, and Samuels (2017, eqn. A6, A7). The projection of the population by gender and age taken from the Census Bureau, combined with our projection of educational attainment and assumed EP ratios, gives the implied projection of labor quality. Our projections of the growth rates of labor quality for 2017-2027 are considerably below the averages for the period 1990-2015, due to declines in the rates of growth of average educational attainment and the entry of young workers who are the echo of the Baby Boomers.

In the Base Case we assume that the growth rates of capital quality and productivity growth for the next ten years will equal average growth rates for the period of Growth and Recession, 1995-2015. To recall, the Investment Boom of 1995-2000 combined rapid accumulation of IT capital and robust productivity growth. The Jobless Recovery of 2000-2007 had strong productivity growth but slower growth of IT capital. The Recession and Recovery of 2007-2015 had weak productivity growth and much slower accumulation of IT capital.

The growth rate of capital quality during the period 1995-2015 used in the projection is below the growth rate for the period 1990-2015. In the projection period 2017-27, capital deepening makes the largest contribution to labor productivity growth (0.86 points out of 1.38) while the growth of TFP in the education intensive sector makes the second largest contribution (0.38 points). We project that productivity growth in the non-education intensive sector will be smaller than its contribution during 1990-2015, reflecting the observed deceleration.

Our Base Case projection of labor productivity growth over the period 2017-2027 is lower than growth during the period 1990-2015, 1.38% per year versus 1.59%. Our projection of labor quality growth in the Base Case is half that in 1990-2015. Total hours worked are projected to grow at 0.47% per year, compared to 0.77% during 1990-2015, reflecting the future changes in the age-structure and the assumption of fixed annual hours at 2015 levels for each demographic group.

Combining our projected growth rates in hours worked and average labor productivity, we project the GDP growth rate at 1.86% per year over the period 2017-2027. This is a substantial decline from the growth rate of 2.37% per year during the period 1990-2015. The slower growth in hours worked is reinforced by the slower growth of average labor productivity. We conclude by emphasizing that we do not model the determinants of employment, but rely on extrapolations of trends from the historical data.

Low Growth Case.

Our first alternative assumption to the Base Case is that capital quality and productivity growth over the period 2017-2027 will equal the averages over 1973-2015, a period that includes the Long Slump and the Recession and Recovery. By including the Long Slump we dampen the growth rates compared to the Base Case. This Low Case takes averages over 1973-2015, and for capital quality growth this yields a rate that is very close to the growth rate for the period 1990-2015.

Our procedure gives a TFP growth in the education intensive sector that is below the rate for 1990-2015 (0.25 versus 0.37% per year). Using the 2000-2015 average share of that sector in output, we obtain a substantial contribution of TFP growth from the education intensive sector to growth of labor productivity. We project that the growth of productivity in the non-education intensive sector will be slightly below that for the period 1990-2015 (0.11 versus 0.14).

In the Low Growth Case our projected labor productivity growth for the period 2017-2027 is 1.18% per year, compared to 1.38% in the Base Case and 1.59% observed for 1990-2015. The growth of hours worked is assumed to be the same in both scenarios. Summing the growth rates in hours worked and labor productivity, the Low Growth Case projects output growth at 1.65% for the period 2017-2027 compared to 1.86% in the Base Case.

High Growth Case.

For the High Growth Case we assume the same growth of hours and labor quality as the Base Case. We assume that growth rates of capital quality and productivity for the period 2017-2027 will equal their averages over the period 1995-2007. This includes the Investment Boom and the Jobless Growth periods but excludes the Long Slump and the Great Recession as temporary slowdowns in economic growth. Taking averages over 1995-2007 yields a capital quality growth rate significantly higher than the growth rate over the period 1990-2015, 1.27% versus 0.88%.

In the High Growth Case TFP growth in the education intensive sector is more rapid than in the Base Case (0.52% versus 0.43%). This translates into a relatively high contribution of growth in total factor productivity to growth in average labor productivity. The growth of TFP in the NEI sector is also projected at a higher rate than in the Base Case (0.29% versus 0.11%). Adding over the capital quality, labor quality and TFP components, the growth rate of labor productivity is 2.00% per year compared to 1.38% in the Base Case.

Combining projections of growth in labor productivity and hours worked, the High Growth projection of GDP growth is 2.47% per year, only slightly above the growth rate of 2.37% during the period 1990-2015. Higher growth of productivity and capital quality are offset by lower growth of labor quality and hours. Only if there is a recovery of participation rates to the 2000 peak during the Investment Boom will hours growth be much higher.

Discussion and comparison to other projections

Fernald, Hall, Stock and Watson (2017) attribute the slow recovery since 2009 to the slow growth of TFP and decline in labor force participation (adjusted for demographic changes), arguing that the capital shortfall was due to the fall in trend output. Our growth accounts are consistent with those observations and our projections reflect the slow growth of TFP and the slow growth of hours. Fernald (2016) presents a number of alternative projections of U.S. GDP growth and chooses a modal forecast of 1.6% per year as the most likely outcome.

The Congressional Budget Office (2018, Table 1-2) presents potential GDP projections for 10 years. For the 2018-2028 horizon they project labor productivity at 1.4% per year (1.8% for nonfarm business) and hours worked at 0.4%, very close to our Base Case values. Their projection of TFP is 1.1% per year; however, their definition of TFP would include our measures of TFP (0.54), labor quality (0.21*labor share) and capital quality (0.86*capital share).

The BLS (Lacey et al. 2017) projects the labor force to grow at 0.6% over the 2016-2026 period. This combines the Census Bureau population projections with their participation rate projections. They also make macro projections using a model from Macroeconomic Advisers, and project GDP to grow at 2.0%. These numbers are slightly higher that our base case hours growth of 0.5% and GDP growth of 1.9%.

4. Conclusion

Previous research across fields and disciplines has documented the importance of education as a driver of earnings and economic growth. However, educational attainment in the U.S. has plateaued, as has the wage premium for earning a college degree. Improvements in the educational attainment of the workforce are unlikely to play an important role in the medium-term economic outlook.

In this paper, we have identified a new empirical link between education and economic growth, namely, the relationship between educational intensity of workers in an industry and the industry's economic performance. Our growth accounting results suggest that this link is important, especially over the more recent period. Industries that are relatively education intensive have faster value added and productivity growth. When this is incorporated into projections of growth from the supply side, it highlights the ongoing importance of education in future economic growth.

Education is likely to continue to buoy economic growth in the medium term through industries that employ educated workers, not through the historical channel of upgrading of the labor force. On balance, projections that meld this information with the other components of economic growth point to output and labor productivity projections that are considerably slower than historical economic growth over the past quarter century.

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