Long-Run Economic Growth

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Introduction

I thank the New York University Stern Center for Global Economy and Business and, in particular, Kim Schoenholtz, the center's director, for the kind invitation to speak to you this afternoon. The center plays an active role in promoting and supporting faculty research on issues related to global economies, businesses, and policy, and I am honored to be among the center's list of distinguished speakers. I am also happy to be back at NYU. I have very fond memories of my time here, where, as an adjunct professor, I co-taught the Ph.D. Seminar in Financial Institutions for a couple of years in the late 1990s. The world has certainly changed since then. I met Kim for the first time at a conference held several years ago when signs of problems in the financial markets and banking system were just beginning to emerge. I can't speak for Kim, but I can certainly say that at that time I did not fully appreciate the extent of the crisis and deep recession to come.

Since the crisis, supported by extraordinary monetary policy accommodation, the U.S. economy has made substantial progress. We are at or nearly at full employment, and if output and employment growth continue to evolve as I anticipate, inflation will gradually return to the FOMC's goal of 2 percent. But as the economy continues to move back toward normal, the question has arisen: what is normal? The financial crisis and Great Recession destroyed a lot of wealth. At the aggregate level, household net worth fell by more than $10 trillion in 2008, and it took more than three years to make that up. The level of real GDP declined by over $600 billion, or about 4 percent, and the recovery has been relatively slow. But are there longer-term repercussions? Is the economy entering a new normal with a substantially lower growth rate?

This afternoon I'd like to focus on the important topic of long-run economic growth. I call it important because living standards, as measured by income per person, are inextricably tied to long-run growth. Over time, even small differences in growth can translate into large differences in average income per person. For example, based on Census Bureau projections of population growth, if real GDP were to

grow at 2.0 percent per year over the next 20 years, instead of 2.5 percent, the difference in income at the end of that period would amount to about $7,000 per person. As Nobel Laureate Robert Lucas wrote when contemplating the questions raised by cross-country differences in per capita GDP, "Once one starts to think about them, it is hard to think about anything else."[1]

In addition to implications for living standards, changes in the long-run potential growth rate of the economy have implications for policy that are worth discussing. Of course, as always, the views I'll present today are my own and not necessarily those of the Federal Reserve System or my colleagues on the Federal Open Market Committee.

Some Data: Output Growth, Potential Growth, Productivity Growth

Let me start with some data. Over the long term, the U.S. economy has enjoyed solid economic performance. Indeed, as pointed out by growth economists, sustained growth of per capita real GDP of around 2 percent per year has been a hallmark of the U.S. economy over the past 150 years, save for the Great Depression, when real GDP per person fell by about 20 percent.[2] But this longer-run trend obscures some variations over time. From the end of World War II through the end of the 1990s, real GDP increased at an annual rate of 3.5 percent. If we concentrate on recent economic expansions, we see that growth was 4.3 percent over the 1982-1990 expansion and 3.6 percent over the 1991-2001 expansion. In contrast, over the current expansion, growth has been 2.2 percent. The Congressional Budget Office projects that real GDP will grow an average of 2.1 percent per year from 2020 to 2025, at the same pace as its estimate of maximum sustainable or potential growth. This is lower than the CBO's pre-crisis

[1] See page 5 of Robert E. Lucas, Jr., "On the Mechanics of Economic Development," *Journal of Monetary Economics* 22, July 1988, pp. 3-42, https://ideas.repec.org/a/eee/moneco/v22y1988i1p3-42.html.

[2] These figures are from the excellent article by Charles I. Jones, "The Facts of Economic Growth," Stanford University, April 28, 2015, forthcoming in the *Handbook of Macroeconomics*.

potential growth estimate of 3.1 percent for the 1981-2007 period.[3]

It is noteworthy that economists have been revising down their estimates of potential growth almost every year since the Great Recession started. For example, in 2008, the CBO estimated that potential growth between 2008 and 2013 would average 2.5 percent, well above its current estimate of 1.5 percent for that same time period.

Similarly, over time, FOMC participants have lowered their projections for longer-run growth. The FOMC began releasing these longer-run projections in January 2009. At that time, the central tendency of the participants' projections of longer-run GDP growth was 2.5 to 2.7 percent. In the projections released last month, the central tendency was down to 1.8 to 2.2 percent. My current estimate of longer run growth is 2.25 percent, a quarter of a percentage point lower than my previous estimate. My revision reflects the Bureau of Labor Statistics' recent downward revisions to past productivity growth.

Indeed, sluggish productivity growth has garnered a lot of attention. Since the start of the recovery, productivity growth has averaged just over 1 percent.[4] But the slowdown actually began before the recent crisis; indeed, productivity growth has averaged only a bit over 1 percent for the past decade. This is down significantly from the 3 percent seen during the tech boom of the mid-1990s through 2005, and the 2.7 percent seen after World War II and through the mid-1970s. The current slow productivity growth is not without precedent: between the mid-1970s and mid-1990s, productivity growth averaged just 1.5 percent.

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[3] Congressional Budget Office, "An Update to the Budget and Economic Outlook: 2015 to 2025," August 25, 2015 https://www.cbo.gov/publication/50724.

[4] The numbers I am citing are labor productivity, as measured by the annual rate of change in real output per hour worked in the nonfarm business sector. Multifactor productivity measures the quantity of output that can be produced by a fixed ratio of capital to labor. Changes in labor productivity reflect changes in this multifactor productivity, as well as changes in the ratio of capital per worker.

In looking at these numbers, it is important to remember that the productivity statistics are subject to measurement error, and because new technologies are diffusing throughout the economy, that measurement error may be rising. The introduction of new products, the difficulty of constructing quality-adjusted prices for these products, and the rising importance of intangible investment have all complicated the measurement of output and suggest that we may be underestimating the economy's true rate of productivity growth.[5] It is also good to remember that the productivity numbers undergo considerable revision, so that inferring a persistent change in productivity growth is quite difficult. Jacobs and van Norden document that revisions can change measured productivity growth rates by a factor of two or more and large revisions can come even as much as 20 years after release of the initial estimates.[6,7] During the late 1990s, policymakers struggled to understand whether productivity growth was truly picking up, consistent with anecdotal information, even though a pickup wasn't reflected in the data. This led former Fed Chairman Alan Greenspan to comment during the February 1997 FOMC meeting: "The one thing we know about the official data on productivity is that they are wrong."[8]

Of course, the considerable work that is being done to estimate and understand productivity developments underscores how important productivity growth is. To understand why slow productivity growth is a concern, we need to turn to some economic growth accounting.

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[5] Nakamura documents the shift of the U.S. economy from one characterized by mass production and tangible investment to one characterized by new products tailored to individuals and intangible investment, and discusses the difficulties this shift poses for the usual measures of output. See Leonard I. Nakamura, "Intangible Assets and National Income Accounting," *Review of Income and Wealth*, Series 56, Special Issue 1, June 2010, pp. S135-S155, https://ideas.repec.org/a/bla/revinw/v56y2010is1ps135-s155.html.

[6] See Jan P.A.M. Jacobs and Simon van Norden, "Why Are Initial Estimates of Productivity Growth So Unreliable?" manuscript under revision for the *Journal of Macroeconomics*, July 15, 2015, http://svannorden.org/about/jvnproductivity_july2015_jmacro/.

[7] Anderson and Kliesen document that the revisions to productivity growth primarily reflect revisions to measured output rather than measured employment or aggregate hours. See Richard G. Anderson and Kevin L. Kliesen, "The 1990s Acceleration in Labor Productivity: Causes and Measurement," *Review*, Federal Reserve Bank of St. Louis, May/June 2006, pp. 181-202.

[8] This quote appears in Richard G. Anderson and Kevin L. Kliesen, "FOMC Learning and Productivity Growth (1985-2003): A Reading of the Record," *Review*, Federal Reserve Bank of St. Louis, March/April 2010, pp. 129-154. See p. 101 of the transcript of the February 4-5, 1997 FOMC meeting at http://www.federalreserve.gov/monetarypolicy/files/FOMC19970205meeting.pdf.

Determinants of Long-Run Economic Growth

How much output of goods and services an economy can produce depends on the amount of inputs it has – its capital and labor – and on how productively it can combine those inputs to create output. For the economy to grow, there needs to be an increase in inputs or an increase in productivity, or both. Things that affect both the quantity and quality of its inputs, such as labor force growth, the level of skills in the labor force, infrastructure, and institutional arrangements such as the rule of law and well-developed financial markets, can all impact an economy's ability to create output. In the elegant and seminal neoclassical growth model developed by Robert Solow and Trevor Swan, a higher savings rate will lead to higher investment and higher income per capita in the long run, but this can't happen indefinitely; eventually the economy reaches a new steady state.[9] Only growth in productivity can lead to sustained increases in output, that is, to long-run economic growth and increasing standards of living.

The neoclassical growth model is consistent with many, but not all, of the empirical facts. For example, research concludes that differences in measured inputs explain less than half of the large cross-country differences in GDP per capita, consistent with the model.[10] On the other hand, empirically, there is a strong positive correlation between savings rates and growth across countries. The model implies that there would be no correlation, provided countries are in the steady state.[11]

Partly in response to dissatisfaction with some of the empirical implications of the model and partly to provide a model that explains productivity growth rather than take it as given, Bob Lucas, Paul Romer,

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[9] Robert M. Solow, "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics* 70, 1956, pp. 65-94, http://piketty.pse.ens.fr/files/Solow1956.pdf, and Trevor W. Swan, "Economic Growth and Capital Accumulation," *The Economic Record* 32, 1956, pp. 334-361, https://ideas.repec.org/a/bla/ecorec/v32y1956i2p334-361.html.

[10] See Charles I. Jones and Paul M. Romer, "The New Kaldor Facts: Ideas, Institutions, Population, and Human Capital," *American Economic Journal: Macroeconomics* 2, 2010, pp. 224-245, https://ideas.repec.org/a/aea/aejmac/v2y2010i1p224-45.html.

[11] See N. Gregory Mankiw, "The Growth of Nations," *Brookings Papers on Economic Activity* 1, 1995, pp. 275-326, http://www.brookings.edu/~/media/projects/bpea/1995-1/1995a_bpea_mankiw_phelps_romer.pdf.

and others developed the endogenous growth model.[12] In contrast to the neoclassical model, here the marginal return to capital to the economy overall is not diminishing. The theory emphasizes the important role of investment in human capital to increase the knowledge and skills needed to productively use capital, and investment in research and development, whose returns are not necessarily captured only by the firm doing the investing. New ideas, knowledge, and discoveries spill over into the wider economy, as one idea leads to another and that idea leads to yet another, and so on. When talking about scientific progress and the buildup of knowledge, economists often quote Sir Isaac Newton: "If I have seen further it is by standing on the shoulders of Giants."[13] The important insight from the endogenous growth model is that if human capital increases with the stock of physical capital, then there need not be diminishing returns to capital, or if increases in R&D lead to innovative products and processes, increased productivity can offset any declines in the marginal return to capital. Thus, ongoing growth can be sustained by investments in human capital and new technology.

Some economists, like Robert Gordon at Northwestern University, are quite pessimistic about the future growth prospects of the U.S. economy.[14] Others, like Joel Mokyr, also at Northwestern, Barry Eichengreen, at the University of California, Berkeley, and Erik Brynjolfsson and Andrew McAfee at MIT, are more optimistic.[15] The difference in views largely stems from different assessments of the

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[12] Two early contributions are the Lucas article cited above, and Paul Romer, "Increasing Returns and Long-Run Growth," *Journal of Political Economy*, October 1986, pp. 1002-1037, http://pages.stern.nyu.edu/~promer/IncreasingReturns.pdf.

[13] This was written by Newton in a letter to Robert Hooke on February 5, 1676. In their textbook, *Macroeconomics* (12th Edition, NY: McGraw Hill, 2014, p.83), Rudiger Dornbusch, Stanley Fischer, and Richard Startz point out that Paul Samuelson included this famous quote in his textbook, *Foundations of Economic Analysis*, 1970.

[14] See Robert J. Gordon, "Secular Stagnation: A Supply-Side View," *American Economic Review: Papers and Proceedings* 5, May 2015, pp. 54-59, https://ideas.repec.org/a/aea/aecrev/v105y2015i5p54-59.html, and Robert J. Gordon, "The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections," National Bureau of Economic Research, Working Paper 19895, February 2014, https://ideas.repec.org/p/nbr/nberwo/19895.html.

[15] See Joel Mokyr, "The Next Age of Invention," *City Journal*, Winter 2014, http://www.city-journal.org/2014/24_1_invention.html; Barry Eichengreen, "Secular Stagnation: The Long View," *American Economic Review: Papers and Proceedings* 5, May 2015, pp. 66-70, https://ideas.repec.org/a/aea/aecrev/v105y2015i5p66-70.html; and Erik Brynjolfsson and Andrew McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, NY: W.W. Norton and Company, 2014.

prospects for investments in human capital and technology.

Human Capital

Human capital and technology are intricately linked. For physical capital to be used productively, workers need to have the abilities and knowledge to apply it. Those abilities and knowledge are what we call human capital. For any given type of capital, a more knowledgeable worker is a more productive worker. But changes in technology demand even more highly skilled workers. Investment in human capital may have a positive externality on investment in innovation in that firms are more likely to develop and adopt a new technology if they are more certain they will be able to hire workers with the requisite skills to use the technology. Many studies have documented the importance of investment in human capital to a nation's economic growth and well-being.[16]

The benefits of investing in human capital are also evident at the individual level. Better education is correlated with higher wages and lower levels of unemployment. For example, the current unemployment rate for those with a college degree is 2.5 percent, compared to 5.2 percent for those with a high school diploma, and 7.9 percent for those who didn't graduate from high school. The gap in wages between those with a college degree and those without, the so-called skill premium, has widened substantially over time, more than doubling since the 1970s. Median hourly wages for those with a bachelor's degree are now about 80 percent higher than wages for high school graduates.[17] And over a lifetime, in present

[16] For a discussion of educational attainment and its contributions to economic growth, see J. Bradford DeLong, Claudia Goldin, and Lawrence H. Katz, "Sustaining Economic Growth," in Henry Aaron, ed., *Agenda for the Nation* (Washington: Brookings Institution, 2003). The importance of education to economic well-being can even be found at the state level. For example, Cleveland Fed researchers found that over a 75-year period, education levels were consistently one of the most reliable indicators for each state's per capita income growth. See Paul W. Bauer, Mark E. Schweitzer, and Scott A. Shane, "Knowledge Matters: The Long-Run Determinants of State Income Growth," *Journal of Regional Science* 52, 2011, pp. 240-255, and "Altered States: A Perspective on 75 Years of State Income Growth," Federal Reserve Bank of Cleveland 2005 Annual Report.

[17] Jonathan James, "The College Wage Premium," Federal Reserve Bank of Cleveland *Economic Commentary*, August 2012.

value terms, a college graduate can expect to earn nearly twice as much as a high school graduate.[18,19]

Evidence suggests that the rising skill premium is being driven by technological change that has increased the demand for skilled workers relative to unskilled workers. This is consistent with the fact that even industries often viewed as less skill-intensive have increased their demand for skilled labor and that mathematical achievement is a fairly good predictor of future earnings.[20]

There are positive externalities from education, which may mean we are under-investing in education from society's viewpoint. Less-educated workers appear to benefit in the form of higher wages from working in areas populated with more-educated workers.[21] And cities with more highly educated populations experience lower unemployment rates, higher productivity growth, and higher growth in entrepreneurship than what would have been predicted by considering only the educational levels of individuals.[22]

It is important to note that the statistics I've quoted on the skill premium and the social return to education

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[18] Kartik B. Athreya and Janice Eberly, "The College Premium, College Noncompletion, and Human Capital Investment," Federal Reserve Bank of Richmond Working Paper 13-02R, February 2015.

[19] Other research shows that the skill premium has grown even more for those with a post-graduate degree, even controlling for changing demographics. Those with a graduate degree now earn about 30 percent more than those with a four-year college degree. See Rob Valletta, "Higher Education, Wages, and Polarization," Federal Reserve Bank of San Francisco *Economic Letter*, 2015-02, January 12, 2015.

[20] Jonathan James, "The Surprising Impact of High School Math on Job Market Outcomes," Federal Reserve Bank of Cleveland *Economic Commentary*, November 2013.

[21] Enrico Moretti estimated spillovers from college education by comparing wages for similar individuals who work in cities that differ by the proportion of college graduates in their labor force, being careful to consider unobserved differences in the individuals and the cities. He found that each percentage point increase in the share of college graduates between 1980-1990 was associated with 1.6 percent higher wages of high school graduates and 0.4 percent higher wages of college graduates. See Moretti, "Estimating the Social Return to Higher Education: Evidence from Longitudinal and Repeated Cross-Sectional Data," *Journal of Econometrics* 121, 2004, pp. 175-212, http://econpapers.repec.org/article/eeeeconom/v_3a121_3ay_3a2004_3ai_3a1-2_3ap_3a175-212.htm.

[22] See Edward L. Glaeser, Giacomo A.M. Ponzetto, and Kristina Tobio, "Cities, Skills, and Regional Change," *Regional Studies* 48, 2014, pp. 7-43, and the discussion in Lisa Nelson and Francisca Richter, "The Prospects of Non-College Bound Workers in the Fourth District," Federal Reserve Bank of Cleveland *A Look Behind the Numbers*, February 2014.

are based on people who actually obtain their degrees. Those who are pessimistic about the long-run rate of economic growth are pessimistic about the level of educational attainment we can anticipate in the future. According to Goldin and Katz, educational attainment rose rapidly for people born in the 1876-1950 period but has slowed since then. For example, each generation born in the first half of the twentieth century had about two more years of education than their parents, while people born in 1975 have only three-quarters of a year more education than their parents. And in the most recent cohorts, education attainment has now flattened out.[23]

So, while increasing returns to education over the past 35 years have spurred more people to get their degrees – for example, the percent of the U.S. labor force that is college-educated has more than doubled since the 1970s – in recent years, the pace of increase has slowed. While enrollments in college are near historic highs, non-completion rates are also quite high. According to data from the National Center for Education Statistics, only about 55 percent of students who start college earn bachelor's degrees within five years.[24]

Several factors are likely at play. First, some people aren't prepared for college when they enter. Research is increasingly pointing to the fact that the foundation has to be laid very early in life – at the pre-school level.[25] Second, college has become increasingly expensive over time. The average cost of tuition and fees at four-year institutions is now over $14,000 a year, and has more than doubled since

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[23] Claudia Goldin and Lawrence F. Katz, "Long-Run Changes in the U.S. Wage Structure: Narrowing,Widening, Polarizing," *Brookings Papers on Economic Activity* 2, 2007, pp. 135–165, http://www.brookings.edu/~/media/Projects/BPEA/Fall-2007/2007b_bpea_goldin.PDF.

[24] See Digest of Education Statistics, table 302.60, for enrollment rates (http://nces.ed.gov/programs/digest/d13/tables/dt13_302.60.asp) and table 326.10, for completion rates (http://nces.ed.gov/programs/digest/d13/tables/dt13_326.10.asp).

[25] Research shows that when children fall behind early on, it is often difficult to catch up. See, for example, James Heckman, Rodrigo Pinto, and Peter Savelyev, "Understanding the Mechanisms Through Which an Influential Early Childhood Program Boosted Adult Outcomes," *American Economic Review* 103, 2013, pp. 2052- 2086, https://ideas.repec.org/a/aea/aecrev/v103y2013i6p2052-86.html, and Douglas Almond and Janet Currie, "Human Capital Development Before Age Five," in *Handbook of Labor Economics*, vol. 4B, Orley Ashenfelter and David Card, eds., Amsterdam: Elsevier, North-Holland, 2011, pp. 1315–1486.

2000.[26] Subsidies for higher education fell during the Great Recession, shifting costs to students. According to data compiled by the New York Fed, more people are borrowing to go to school: The share of 25-year-olds with student debt rose from 27 percent in 2004 to about 45 percent in 2013. And the average debt per borrower has increased from about $15,000 in 2004 to $27,000 in 2014.[27] Some students do not have the financial wherewithal to start or to complete their degrees.

A third factor affecting enrollment and completion rates is that some people may have a personal preference to enter the workforce after high school rather than to go to college. The proportion of 25-year-olds with college degrees has moved up from 25 to 30 percent over the past 15 years, but that means the U.S. is now ranked twelfth among developed nations.[28] The choice to enter the workforce might really reflect a person's view that he or she is unprepared to succeed in college or that the return to a college education does not justify the tuition expense or the burden of student loan debt. In other words, while, on average, the return to investing in education is positive, for some individuals it is not, especially if they have to take on high levels of debt.

New Technologies

What about technological change? There is no doubt that technical innovations such as the steam engine, railroads, electricity, and the automobile led to higher productivity growth, economic growth and, living standards. Those pessimistic about the future don't expect to get the same type of productivity gains from today's innovations such as robotics, artificial intelligence, and computers, and believe that technological advances have been slowing since the 1970s.

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[26] See Digest of Education Statistics, table 330.10, for enrollment rates (https://nces.ed.gov/programs/digest/d13/tables/dt13_330.10.asp). For further discussion, see Loretta J. Mester, "Community Development and Human Capital," speech at the 2015 Policy Summit on Housing, Human Capital, and Inequality, sponsored by the Federal Reserve Banks of Cleveland, Philadelphia, and Richmond, Pittsburgh, PA, June 19, 2015.

[27] James McAndrews, "Student Debt and Higher Education Financing: A Public Finance Perspective," remarks at the National Association of College and University Business Officers, New York, NY, February 5, 2015.

[28] Gordon (2015), p. 57.

Other observers note that it is very difficult to predict where future technology is going, and they are much more optimistic that the impact of computerization, nanotechnology, genome mapping, and other advances in biology has yet to be fully harnessed.[29]

I tend to be more in the optimistic camp in that I don't think we should underestimate the potential for creative innovations. I am saying this as someone who remembers sitting at a computer terminal – not a laptop – typing my dissertation and having to pick up printed drafts in clear plastic bags at the mainframe window at Princeton. Each new important insight – or typo – necessitated another trip to the computer center. Now, I have unlimited ability to express new ideas – or fix typos – at any time of the day or night. The world has certainly changed.

Barry Eichengreen offers a useful way to think about the effect of technological innovations on productivity and growth. He distinguishes between two dimensions of technology: the range of applicability and the range of adaptation.[30] A technology that has only a limited range of applicability won't have a large effect on productivity and growth because it is used only in a narrow range of sectors or activities. A technology that requires a large range of adaptation of other processes in the economy will take longer to have a positive effect on productivity and growth. In fact, the initial impact of such technology could be negative. Eichengreen points to the steam engine as having had an immediate positive effect on output and productivity in textiles because its use was concentrated in that sector and disrupted few other production processes. In contrast, electricity had a broader impact but required considerably more adaptation by others in the economy, including the laying of transmission lines and the reorganization of factories, before its positive effect on productivity was felt.

We are already seeing ways in which the diffusion of new technologies is affecting how work is organized. As I already discussed, technological change is a likely driver of the widening skill premium.

[29] See Mokyr (2014), and Brynjolfsson and McAfee (2014).

[30] Eichengreen (2015).

Data suggest that since 2000, jobs have become "polarized," meaning that while high-skill and low-skill occupations have seen job growth, medium-skill occupations have experienced job losses.[31,32] These medium-skill jobs are more likely to be the types of jobs that involve routine, non-physical work, the kind of work that can be handled by computers. This shift in the distribution of jobs helps to explain the wider gap in wages for highly skilled vs. lower skilled workers, and the increasing return to gaining the education required to obtain those skills.

Economic Policy

The transition path to an economy with new technology can be a difficult one. Those with the skills to adapt to the new technology will gain, but others will lose. My optimism that the economy will be able to garner productivity gains from new technologies is dependent on having the right policies and institutions in place to ease the transition. For example, the introduction of robotics in automobile manufacturing has reduced the number and changed the type of workers needed on the plant floor to those with more advanced computer skills to manage the robots. Retraining programs can help those without the requisite skills return to the workforce.

College enrollments and completion rates might be increased by programs that help prepare students to enter college – starting with early childhood education – and programs that help ensure that financial support is available to students who have the desire and qualifications to earn a college degree. Student loan programs should be designed to encourage students to choose colleges or other types of educational programs that maximize the return on the student's investment in human capital. Moreover, the way

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[31] See Daron Acemoglu and David Autor, "Skills, Tasks, and Technologies: Implications for Employment and Earnings," in *Handbook of Labor Economics*, vol. 4B, Orley Ashenfelter and David Card, eds., Amsterdam: Elsevier-North Holland, 2011, pp. 1043-1171, https://ideas.repec.org/h/eee/labchp/5-12.html. Valletta (2015) provides an accessible explanation of the polarization hypothesis.

[32] See Valletta (2015) and Jaison R. Abel and Richard Deitz, "Job Polarization and Rising Inequality in the Nation and the New York-Northern New Jersey Region," Federal Reserve Bank of New York *Current Issues in Economics and Finance* 18, 2012.

colleges and other training programs deliver education as well as the type of education they deliver will also likely need to change. Technology is already increasing the on-line component of educational programs, which, if done right, can make training more available. In addition, rather than being vocational programs for the current job market, colleges will need to increasingly focus on equipping students with the ability to adapt, think creatively, handle changing technologies and paradigms, and be comfortable making decisions under uncertainty.

On the technology side, an individual firm might not find investment in basic R&D to be profitable, since the firm cannot fully capture the returns. Basic R&D has a public good aspect to it because its benefits can be widely applied throughout various parts of the economy. This suggests a continued and perhaps expanded role for government support of basic R&D to foster higher long-run productivity growth.

Of course, at a time when funding is scarce and the needs are plentiful, any educational, training, or R&D program receiving either public or private funding should be subject to rigorous evaluation of its effectiveness to ensure that the social return justifies the expense.

Monetary Policy

The astute listener will notice that I haven't talked about monetary policy. That's because for the most part monetary policy cannot affect the long-run growth rate of the economy. However, it can contribute to the economy's ability to reach that potential by promoting price stability. Price stability allows markets to work more effectively at allocating resources; it allows households and businesses to focus on productive activities rather than on ways to protect the purchasing power of their money and to make long-term plans and commitments without having to deal with uncertainty about the value of their money.

While monetary policy cannot affect the economy's long-run growth rate, it does need to consider it. The economy's long-run equilibrium real rate of interest, that is, the level of the policy rate that is consistent

with stable prices and maximum employment in the long run, is determined by the long-run rate of the growth of consumption and, therefore, output.

A reassessment of the economy's longer-run equilibrium rate may tell us something about the neutral fed funds rate toward which monetary policy normalization is headed over the longer run, but we need to be cautious about its implications for short-run policy. First, as we've discussed, estimates of productivity growth and long-run growth are imprecise and subject to revision. This means there is considerable uncertainty around the neutral fed funds rate as well. And research has shown that over-reliance on mismeasured objects such as output gaps, unemployment gaps, or equilibrium real rates can lead to poor policy decisions that induce undesirable fluctuations in the economy.[33]

Second, if the neutral fed funds rate is lower than we've thought it to be, then that might suggest that the current funds rate is less accommodative than we thought. But, all else equal, it also means that there is less of a gap between current growth and potential growth, so a less accommodative stance would be appropriate. Of course, all else might not be equal; a reassessment of long-run growth might also be met by changes in current spending, which would need to be taken into account.

Finally, the implications of any reassessment of the long-run growth rate for current policy need to be put into context both in terms of the size of the reassessment and the difference between the current policy rate and the long-run neutral rate. I recently revised down my assessment of the longer-run nominal fed funds rate to 3.5 percent from 3.75 percent, consistent with my revision of longer-run output growth. Of

[33] Athanasios Orphanides has done substantial work in documenting this. See, for example, Athanasios Orphanides and Simon van Norden, "The Reliability of Inflation Forecasts Based on Output Gap Estimates in Real Time," *Journal of Money, Credit, and Banking* 37, 2005, pp. 583-601, https://ideas.repec.org/a/mcb/jmoncb/v37y2005i3p583-601.html Athanasios Orphanides and John C. Williams, "Robust Monetary Policy with Imperfect Knowledge," *Journal of Monetary Economics* 54, 2007, pp. 1406-1435, https://ideas.repec.org/a/eee/moneco/v54y2007i5p1406-1435.html, and Athanasios Orphanides and John C. Williams, "Robust Monetary Policy Rules with Unknown Natural Rates," *Brookings Papers on Economic Activity* 2, 2002, pp. 63-145, http://www.brookings.edu/~/media/Projects/BPEA/Fall-2002/2002b_bpea_orphanides.PDF.

course, given the error bands around long-run estimates, I admit this is not a statistically significant change. The revision means I expect the neutral fed funds rate to be somewhat lower than it's been in earlier periods. However, the current funds rate is still well below that rate.

Based on my current assessment of the outlook and the risks around the outlook, I believe the economy can handle an increase in the fed funds rate and that it is appropriate for monetary policy to take a step back from the emergency measure of zero interest rates. A small increase in interest rates from zero is not tight monetary policy. Indeed, I anticipate that beyond liftoff, economic developments will likely mean it will be appropriate for monetary policy to remain very accommodative for some time to come, supporting continued expansion and providing some insurance against downside risks, with rates expected to move up only gradually to more normal levels and with the decisions about that path dependent on incoming information on the economy's performance and risks to that performance. Given the outlook, delaying the start of liftoff for too long risks having to move rates up more aggressively later on, but I see benefits of our being able to take the gradual path.

One benefit of the gradual approach is precisely what we have been discussing today: it will allow us to recalibrate policy over time as some of the uncertainties surrounding the underlying economy in the post-crisis world, like the longer-run economic growth rate, are resolved.