Introduction to Education, Skills, and Technical Change: Implications for Future U.S. GDP Growth

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The growth in future living standards in the U.S. will likely depend to a significant degree on the continued evolution in the "knowledge" segments of the economy. These are the high valued-added sectors where product and organizational innovation generates high levels of productivity and creates new goods and markets. They are also the sectors that are the least vulnerable to global competition from low-wage manufacturing economies. Technology has already transformed many sectors with innovations like mobile communication devices, e-commerce, global supply chain management, customization of manufacturing products, and GPS-based transportation management, and there is likely more to come with Big Data, the evolution of automated "workerless" factories and driverless vehicles, and developments in the areas of artificial intelligence, 3-D printing, nano-technology, and genomics. Evidence suggests that such innovations often require a parallel transformation in worker skills in order to implement and operate the new technology and business models. A work force that cannot play this role may limit the rate of innovation and may slow the growth in living standards.

A century ago the U.S. became a world leader in the expansion of secondary and tertiary education, a development that helped propel U.S. productivity growth for decades (Goldin and Katz (2007, 2010)). However, a growing body of evidence suggests that human capital accumulation in the U.S. has slowed down significantly and may not be keeping pace with the evolving demands placed on it. Moreover, as growth in the quantity of education has slowed, the long-standing problem of the *quality* of the U.S. primary and secondary education system has come to the fore. The first international test score comparisons of the 1960s revealed that U.S. students performed poorly relative to those in many other countries, and despite decades of efforts to improve the U.S. education system, the problem continues. The recent "Nation's Report Card" (NAEP (2013)) suggests that the literacy and numeracy skills development of 12th

graders has been stagnant in recent years and that a majority of students are stuck at skill levels that are rated below proficient. Thus, the U.S. continues to lag in the quality of K-12 education and its lead in tertiary education has been shrinking.

What are the implications of the evolution of human capital and its interaction with technology on the future of U.S. growth? This question was the underlying motivation for organizing this Conference on Research in Income and Wealth conference *Education, Skills and Technical Change: Implications for Future U.S. GDP Growth*, held in Bethesda, Maryland on October 16th and 17th, 2015. This volume contains 12 papers ranging over various facets of this question. The authors of these papers span an unusually broad range of expertise, including experts on aggregate productivity growth and the link to labor quality, cross-country comparisons of test scores and skill levels, the skill and task requirements of jobs, broader concepts of labor skills such as "non-cognitive skills," alternatives to traditional education such as on-the-job training and online education, the role of immigration in skill supply, and the structure of the higher education sector.

We start this editorial summary of the proceedings with an overview of some of the main the issues and basic statistics of educational attainment in the U.S. We then review the channels through which the skills and education of the labor force impact GDP growth. This is followed by a discussion of how the demand for and supply of skills interact in a dynamic setting in which frictions may slow the adjustment of skills supply to new demand, but where demand may adapt endogenously to the available supply of skills. We then turn to an overview of each paper in the volume, and how it sheds light on the question about how the current evolution of technology and skills may affect future GDP growth. We conclude with some summary observations.

A. Does Human Capital Contribute to GDP Growth?

Virtually every aspect of economic activity involves human agency of some sort, whether it involves decisions about business models and management procedures, innovation, capital investment, and, perhaps most important of all, the skills and motivation that workers bring to their jobs. The quantity and quality of this agency matters, and this is where the education comes into play. While formal education is not the only way that human capital is built, it provides the foundational infrastructure of literacy, numeracy, and general information that informs the functioning of an advanced society, including its economy. It also provides important vocational and professional skills.

How important is education and the knowledge it imparts compared to other factors that affect economic activity? Hanushek and Woessmann (2015) start their book on *The Knowledge Capital of Nations* with the statement that "*knowledge is the key to economic development. Nations that ignore this fact suffer, while those that recognize it flourish*" (p. 1). They go on to show that there is a positive correlation between income per capita and years of schooling and test scores across the regions of the world. Mokyr (2005) argues that it was those in the upper tail knowledge of the knowledge distribution that drove the industrial revolution. Other studies for developing countries or the historical U.S. suggest that technologies diffuse more quickly when basic literacy and numeracy are more widespread (e.g. Benhabib and Spiegel (2005)). Landes (1998), in his appraisal of the factors that determine the *Wealth and Poverty of Nations*, sums up with the following observation: "*Institutions and culture first; money next; but from the beginning and increasingly, the payoff was to knowledge*" (p. 276).

The importance of acquiring knowledge is well understood by the population at large, if historical statistics on educational attainment are any indication. The proportion of persons over 25 with college degrees, increased from around 5% in 1950 to 30% in 2010. Two-thirds of high school graduates went on to some form of tertiary education in 2012 according to the BLS, up from 50% in 1975. This increase was driven, in part, by the growing wage premium for a college education documented in Goldin and Katz (2007). The dramatic increase in schooling was matched by a large increase in the national commitment to education. Annual real expenditures per student rose over the period 1960 to 2011, from around $3,000 to $11,000, and when private spending is added to public outlays, the combined direct investment rate in education in the U.S. in 2011 was nearly 7% of GDP.

This is an impressive record. There is, however, another important question: does more education necessarily lead to more economic growth? Are past results indicative of future returns? The available evidence seems to point to a slowdown in the growth of educational attainment, as noted above, and the growth in the college wage premium has slowed. There is also evidence that the demand for college graduates may have decreased, and that the macroeconomic contribution of education to aggregate output growth, as measured by the BLS, seems also to have slowed. On the other hand, the underlying factors that have propelled the demand for higher education and more complex skills -- skill-biased and labor-saving technical change and the globalization of the world economy -- proceed apace (for now), and the demand for college educated workers is increasingly a demand for post-graduate and professional education. These are unsettled research issues and are part of the motivation for this conference. They are also issues that high income societies like the U.S. face today in their efforts to sustain the economic growth needed to improve living standards for a broad range of the population.

B. The Channels Through Which Human Capital Affects GDP Growth

Economic growth is a complex process influenced by many factors, and education is a multi-faceted process that affects growth through multiple channels. We identify and comment on five of these channels in this brief overview:

(1) Education operates directly by raising the marginal productivity of workers. The Mincer wage equation is a staple of labor economics, linking education, cognitive skills and other individual characteristics to wage rates, which are in turn linked to the value of the marginal product of labor. At the macro level of analysis, the wage affects the growth in real output in the Jorgenson and Griliches (1967) version of the Solow (1957) sources-of-growth model. The model allows for different types of labor, differentiated by worker characteristics like education, which have different wage rates and marginal products. A labor composition index is derived that links changes in labor composition to output, including those due to increased educational attainment. Estimates of the various sources of growth based on this model show that education has made a relatively small contribution to growth in recent years.

(2) Education operates indirectly through skill-biased technical change, which can affect output growth above and beyond the marginal product effect. A great deal of attention has been focused in the labor economics literature on skill-biased technical change as a mechanism

through which skill-development affects output. The production function involved in this formulation has the factor augmenting form rather than the Hicksian form of the Solow-Jorgenson-Griliches-BLS model. Acemoglu and Autor (2011, 2012) show that the skill-biased technical change model may add an additional term to the TFP residual that affects output growth above and beyond the direct productivity effect of the Solow model. Empirical interest in this possibility was greatly increased by the path-breaking article by Autor, Levy, and Murnane (2003), who showed that the demand for skills had shifted in favor of non-routine cognitive skills.

(3) Education is a prime source of the new ideas and perspectives that lead to technical innovation, and education is important for the adoption and diffusion of technology. Nelson and Phelps' (1966) classic paper discusses two alternative ways in which human capital can promote TFP growth: first, in the production of new ideas, which pushes out the technological frontier; and second, in the ability to adopt and implement new technologies, which governs the speed of diffusion of new technologies. They conclude that the standard way of including educational attainment in the production function *"may constitute a gross misspecification of the relation between education and the dynamics of production*" (Nelson and Phelps (1966), p. 75). The endogenous growth model of Romer (1986, 1990) allows for endogenous changes in technology arising from investments in R&D capital. Corrado, Hulten and Sichel (2009) take this idea further by allowing for firm-specific investments in the activities of marketing, worker training, and organization capabilities, as well as R&D. Sources-of growth estimates based on the later find a large contribution to growth from investments in innovation, with a corresponding reduction in the importance of measured TFP.

(4) The endogenous growth models of Romer (1986, 1990) and Lucas (1988) involve yet another channel linking education to growth: spillover externalities that enter TFP. In the Lucas model, the social return to education exceeds the private return because educated people interact in ways that are not mediated by a labor-market return. The output associated with the excess return appears as a costless increase in TFP associated with education. In the Romer model, the externality is generated by the knowledge spillover arising from the inability of innovators to completely protect their property rights against diffusion to other users.

(5) Education is part of foundational infrastructure that sustains social, political, and economic institutions. This mechanism is perhaps not so much a specific channel as an investment in building or maintaining social capital. It involves the Landes emphasis on institutions and culture as a source of national prosperity, but the following quote, attributed to Thomas Jefferson, perhaps says it best: *"If the children are untaught, their ignorance and vices will in future life cost us much dearer in their consequences than it would have done in their correction by a good education"*.

C. The Demand and Supply of Skills and Education

Demand. The distribution of skills in an economy and the market return to those skills is the outcome of a complex interaction between demand and supply in a dynamic setting. On the demand side of the market, the standard model of factor demand involves the equilibrium condition equating the value of the marginal product of each input included in the production function to the corresponding factor price. The derived demand for labor of various skills, at any point in time, is a function of the output demand, technology, and factor prices, and the demand for skills and education is derived from these factor demands. This is the first channel mentioned above.

The second channel focuses on how worker skills are matched with jobs, which are shaped by *job tasks* that comprise the production of output (Acemoglu and Autor (2011, 2012)). A change in the technology that changes the composition of tasks thereby changes the demand for the skills needed for the tasks. When raised to the macro level of analysis, technology is characterized by skill-biased factor-augmenting technical change, and in the era of the Digital Economy, the bias is in the direction of more complex conceptual skills. An alternative approach is to dispense with an aggregate production function and work directly at the micro level of activity analysis, as in the Hulten contribution to this volume. In this approach, the demand for skills is mainly a question of the choice of technique and the business model of the firm. In the strict form of activity-analysis model, there is only a very limited degree of substitutability at the task/activity level, implying that each input to an activity (including the requisite labor skills) is necessary. Changes is the technology of production certainly affect the choice of techniques, but in the digital age, it is innovation in the development and design of new products, not just process innovation, that shapes the business models and activities of firms in many sectors. In other words, it is product-biased technical change that influences the demand for skills.

The endogeneity of innovation is the third channel considered above. Product and process R&D is one of the activities in which firms engage, along with the design and marketing of new products. Overall investment in these activities, along with organizational development, has grown to be the dominant for of business investment and a major source of productivity growth. This growth has led to an increased demand for more complex conceptual skills and occupations requiring higher educations. Skill-biased process innovation may also affect the demand for those skills in scarce supply through the development of labor-saving technology (the famous Habakkuk Thesis).

The final two channels, externalities and social capital, involve a social rate of return to education that exceeds the private return. This generates a demand for education that exceeds private demand, and is the rationale for public support for education.

Supply. We have already described the basic supply-side statistics of the U.S. education system, with its strong increase in education attainment (if not quality) and college wage premium. There is, at present, a controversy over whether the supply side response had been adequate to meet the demand imposed by an increasingly technological economy. This is the so-called "skills gap". Its purported existence suggests an on-going disequilibrium in the market for skills and education. However, this possibility must be viewed against the labor-market mechanism that produces skill premia in response to market conditions. There may be periods during which demand outstrips supply (hence the premia), but this not a sign of a persistent disequilibrium. Rather, the problem is that skill supply responds slowly and imperfectly to market signals.

The skill accumulation process is complex and lengthy, with many stages shielded from market incentives. At least three features slow or limit the supply response to changes in skill premia. First, the educational production function depends not only on the standard labor (teachers) and capital (books and schoolrooms) inputs, but also on the characteristics of the students themselves. Research suggests that the cognitive and noncognitive skills developed by age three have fundamental effects on the ability to learn. Thus, K-12 schools have little control over a key input into their production functions. At the college level, research by James Heckman and colleagues has emphasized the importance of "college readiness" and the limits it imposes on the higher education process and resulting value of college degrees. Second, "time-to-build" in skill formation can lead both to long lags in the response of supply, as well as to "boom-and-bust" cycles. For example, entry into college majors and graduate programs can be very responsive to current wages, resulting in large increases in supply that depress the wages students face upon graduation several years later. Third, school curricula do not respond readily to changes in skill demand. The professional educators who design curricula may not have the incentive to respond to market signals or to stay current on the latest skills needed in the marketplace. It is therefore no surprise that the U.S. can experience long periods in which wage premia for certain skills grow dramatically, but adjustment costs should not be mistaken for structural disequilibrium problem. It is interesting to note, in this regard, that a recent strand of research associated with Beaudry et al. (2016) suggests that the demand for higher-order skills has undergone a reversal since 2000.

Adequate supply of skills for sustaining economic growth is not the only concern. Technological innovation can be very disruptive and the benefits shared unequally across the income distribution. Affluent and well-educated families often start their children on a path to reap the gains from education at an early age (e.g. Ramey and Ramey (2010)), giving then an advantage relative to the children of lower socio-economic backgrounds. This contributes to the widely-discussed labor-market polarization dynamic. Some of the recent problems may be due to the prolonged slump in the job market following Great Recession, but the education premium and the shift in the demand for skills predate the Great Recession.

II. Summary of the Papers in the Volume

The papers in this volume touch on one or more of the links between human capital and growth in the U.S. or on skill demand and supply. We now summarize the papers and discuss how they help answer the issues addressed in the preceding discussion.

A. The Macroeconomic Link between Education and Real GDP Growth

The volume begins with three chapters that use a growth accounting model to measure the contribution of labor quality to GDP growth. These are the chapters by Jorgenson, Ho and Samuels; Bosler, Daly, Fernald and Hobijn; and Hulten.

These papers are based on the Jorgenson and Griliches (1967) extension of the Solow (1957) growth accounting framework as a starting point. The great advantage of this framework is its ability to sort out the contributions of the three general factors responsible for growth: labor, capital, and technology. Jorgenson and Griliches took this a step further by adding the labor "quality" to this list, defined as the shift in the composition of the labor force characteristics (including education) to those with higher or lower marginal products. They disaggregate labor into its various characteristics and assume that wage rates accurately reflect the corresponding marginal products. They then resolve the results into indexes of the quantity of labor input and it composition/quality.

"Education, Participation, and the Revival of U.S. Economic Growth" by Jorgenson, Ho, and Samuels follows the basic Jorgenson-Griliches approach in their analysis of the recent past and projected future of labor quality growth and overall GDP growth. They construct a new KLEMS 65-industry data set from 1947 through 2014, building on earlier work by Jorgenson and co-authors and the dataset now maintained at the Bureau of Economic Analysis. In addition to the detailed data on capital inputs, Jorgenson et al. also compile detailed data on labor inputs by characteristics, such as education and age.

They begin by highlighting some trends in capital inputs. In particular, they note the increasing shares of information technology (IT) capital and intellectual property (IP) capital in total capital stocks. However, both IT and IP shares hit a peak in 2000, and have fallen since.

Moving to labor inputs, they decompose labor input into raw hours and an index of labor quality. They use educational attainment and age, as Bosler et al. do, but Jorgenson et al. also include gender. Bosler et al. do not include gender because of concerns that there may be a wedge between compensation and true marginal product due to gender discrimination.

Considering capital and labor inputs together, Jorgenson et al. estimate that almost 80 percent of the growth of GDP since 1947 has been due to growth of capital and labor. This estimate contrasts with Solow's (1957) finding for the first half of the 20th Century that only half of the growth of GDP was due to growth of capital and labor, and with the "official" BLS sources-of-growth estimates for the private economy alone, which attribute 50 percent of the growth in output per hour to TFP over the period 1947 to 2012. The private sector accounts for around 85 percent of total value added and 80 percent of employment.

Using their labor quality series, Jorgenson et al. review the trends since 1947 in labor quality growth, as well as its decomposition into the education, age, and gender components. As they have noted in previous work, in the period from 1947 – 1973 educational attainment contributed to labor quality growth, but movements in age and gender composition exerted negative influences in some periods. Post-1973, the gender contribution was less negative and the age and education contributions were positive. Despite an overall slowdown in educational attainment of the population, Jorgenson et al.'s labor quality series shows a continuing significant contribution of educational attainment to labor quality from 2007 through 2014. The source of this discrepancy is the decline in employment participation of the less educated, so the average educational attainment of the employed continued to rise. This is the same composition effect highlighted by Bosler et al.

Considering the sources of average annual growth of U.S. GDP, labor quality growth accounted for 0.24 percentage points of the GDP growth of 3.12% from 1947-2014 and 0.24 percentage points out of 2.32% from 1995-2014. Looking forward, Jorgenson et al. project that labor quality growth will contribute only 0.08 percentage points out of 2.49% from 2014 to 2024 in their base case. Their base case assumes a reversal of the decline in the employment participation rate of the less educated. This means that hours will contribute significantly to GDP, but labor quality growth will be slow.

One empirical challenge in the Jorgenson-Griliches framework is the construction of the labor-quality index, since it is not directly observable. The paper "The Outlook for U.S. Labor Quality Growth" by Canyon Bosler, Mary Daly, John Fernald, and Bart Hobijn begins by addressing this problem. The standard way to estimate labor quality is to invoke the assumption of competitive factor markets and use wages as a measure of marginal product. One approach used in the labor economics literature regresses the wages of individual workers on their observable characteristics, such as education level, gender, experience, etc. and then uses the estimated coefficients to derive weights in order to construct a labor quality index. As Bosler et al. explain, researchers face a trade-off: as one adds more detailed characteristics, one can explain more of the variation of wages across workers, but at the same time the precision of the marginal product estimates is reduced because the number of workers in each cell falls. Bosler et al. explicitly show the trade-off across almost 2,000 specifications that vary in the number of worker characteristics included, how finely these characteristics are disaggregated, and the functional form; they also include stratum-based specifications. Interestingly, they find that a parsimonious Mincer regression, which includes a quadratic polynomial in experience plus five education dummy variables, produces results on the preferred part of the trade-off frontier. Augmenting the specifications with occupation, the Mincer regression with occupation also does well on the trade-off.

The authors then construct an index of labor quality both for their preferred specification and several of the leading alternatives. They measure the growth in labor quality between 2002 and 2013 and find that it grew on average 0.5 percent per year, matching the average growth rate between 1992 and 2002. The fact that there was no deceleration of labor quality growth post-2002 is surprising both because educational attainment has slowed and the oldest (most experienced) baby boomers are retiring. Bosler et al.'s analysis finds that the much-discussed decline in the employment-population ratios of the less educated has contributed to labor quality growth through a composition effect on the employed.

These same employment-population movements create uncertainty about the future growth rate of labor quality. If the employment of the less educated recovers, labor force will grow faster than otherwise expected but labor quality growth will be slower. Bosler et al. offer several projections of future labor quality growth, where scenarios differ by the behavior of the age-education specific employment-population ratios. One scenario assumes they return to their 2007 levels, a second assumes they remain at their 2013 levels, and a third extrapolates the recent trends.

The authors' preferred projections are for labor quality to grow relatively slowly, from 0.1 to 0.25 percent per year, for the longer run reaching 2025. If these projections are borne out, they mean that labor quality growth will be a less important part of GDP growth in the future than it has been in the past.

The paper by Hulten, "The Importance of Education and Skill Development for Economic Growth in the Information Era", is the third of the papers in the volume that deals with growth accounting. Where the methodology of Jorgenson et. al. essentially follows the approach of Jorgenson and Griliches (1967), and Bosler et al. explore alternative ways of measuring the labor-composition term of that model, the Hulten paper proposes an alternative way of looking at the technology that underpins the growth accounting framework. This alternative approach is motivated, in part, by the view that education plays a more fundamental role in enabling economic activity than is implied by the labor-composition effect, and that this might help explain the relatively small role in output growth over the course of the Information Revolution. It is, indeed, hard to imagine today's digital economy having evolved with a work force in which 40% of the workers had less than a high school degree, as in 1960, and less than 10% had a college degree.

Acemoglu and Autor note this problem in their 2012 review of the 2010 book by Goldin and Katz and propose an alternative model in which the nature of individual tasks determines the demand for specific skills. They use this insight to motivate their more aggregate skill-biased technical change, and interpret the shift in the demand for skill in this light. Hulten also starts with the task-skill link, but develops it in the context of disaggregated activity analysis. In this framework, the business model of a firm specifies the kinds of goods to be produced and how they are marketed, and the execution of these decisions is broken down into various activities within the firm. In the strict version of this model, each activity uses inputs in a fixed proportion, meaning that each type of skilled labor and capital is a necessary input. This provides a mechanism through which the more complex forms of capital are linked to the higher-order labor skill need to operate that capital. This "necessary input" model contrasts with the conventional aggregate production function approach to growth accounting, which groups input into capital and labor aggregates and assumes a high degree of substitutability between them.

In the dynamics of the activity-analysis model, the changing input requirements of the economy are determined by changes in the mix of outputs in the activities at the firm level, the diversity of activities across firms in an industry, and the diversity of industries in the larger economy. In the case of the Information Revolution, product innovation has led to the changes in sectoral composition of GDP toward knowledge-intensive industries, and with this, changes in employment in favor of education-intensive skills and occupations (the higher-order cognitive and non-routine skills documented by Autor, Levy, and Murnane (2003)). However, this dynamic is driven as much by product-based innovation as it is by an actual skill-bias in technology.

One goal is to examine the implications of this "necessary input" feature of the activity-analysis model for conventional aggregate sources-of-growth estimates. This leads to the paper's most salient result: it is shown the empirical sources-of-growth results reported by BLS *could equally have been generated by the activity-analysis model*. This enables these results to be interpreted in a very different way than under the standard Solow aggregate production function interpretation, and in a way that assigns a greater importance to labor skills and education. The sources-of-growth model used for this purpose is from Corrado, Hulten and Sichel (2009), which include both the stocks and flows of intangible knowledge-based capital as well as the usual BLS inputs. These estimates show that, for the period 1995 to 2007, intangible capital and information technology equipment accounted for 40 percent of the growth in output per hour in the U.S. Private Business sector (with TFP contributing 42 percent and labor-composition seven percent). The activity-analysis interpretation of these results is that the shift toward complex-skills and education was a necessary enabler of the 40 percent contribution by knowledge-based capital, because skilled labor and complex knowledge capital are strong complements in the strict form of the activity model. This provides an answer to the question of whether the Information Revolution could have occurred with the education levels of the 1960s -- one that is more consistent with the views of economic historians and educational specialists.

B. Jobs and Skills Requirements

Preparing students for jobs is not just a matter of inducing them to attend school for a certain number of years, since there is no guarantee that the skills students learn in school will match those demanded by employers. The two papers in this section shed light on the issue of this match and the demand for skills. The first paper studies the outcomes of recent college graduates and the second surveys the skill requirements of jobs.

"Underemployment in the Early Careers of College Graduates Following the Great Recession" by Abel and Deitz studies an issue that has received much attention from the press: are recent college graduates finding jobs that match their education level? Following the Great Recession, newspapers published a number of stories about recent college graduates who ended up working as baristas in coffee shops. Abel and Deitz study the validity of this picture by constructing and analyzing detailed data on the unemployment and underemployment experiences for recent college graduates.

An important contribution of the paper is the creation of new data series that provide relatively direct evidence. Unemployment rates by education are readily available, but *underemployment* rates are not part of the standard government statistics. Abel and Deitz construct series on underemployment rates of recent college graduates using information from the Department of Labor's O*Net database, which contains information on the characteristics of hundreds of occupations based on interviews of incumbent workers and occupational specialists. They classify occupations according to whether 50 percent of more of the respondents said that a college degree was required for the occupation. A college-educated worker would be considered underemployed if he or she worked in an occupation in which less than 50 percent of the respondents said that a college degree was necessary. They are interested in recent college graduates, so they focus on individuals who are 22 to 27 years old. They also combine their occupational classifications with The Conference Board's Help Wanted Online (HWOL) series to create labor demand by occupational category.

The series on unemployment rates show that the rate for recent college graduates typically lies above the rate for all college graduates but below the rate for all workers. Moreover, they show the same pattern of increases and decreases since 1990, though the unemployment rate for recent college graduates has not fallen as much in recent years as for all college educated workers. Turning to their new series on underemployment of recent college graduates, Abel and Deitz find that underemployment of this group is not a new phenomenon.

In fact, their series shows a rough V-shape since 1990. The current level of 45 percent underemployment of recent college graduates still lies below the level that prevailed in the first half of the 1990s.

The demand series created from the occupational data and HWOL series reveals that in recent years help-wanted postings rose more robustly for jobs that did not require a college degree than those that did. A question that arises is what sort of jobs do the underemployed recent college graduates take? The Abel-Deitz results show that most underemployed recent college graduates did not end up working in low-paid service jobs (e.g. baristas). Rather, nearly half ended up in relatively high paying occupations, such as information processing and office and administrative support. Only nine percent of all recent college graduates began their careers in low-paying service jobs. Thus, even if a college degree did not guarantee an initial placement in an occupation requiring a college degree, it did give individuals a competitive advantage in the occupations that did not require a college degree.

The authors also shed additional light on the determinants of initial jobs. They find that the probability of being underemployed varies significantly by college major. Few engineering majors started in occupations not requiring a college degree whereas two-thirds of all majors in performing arts started in such occupations. The authors also study the role of gender, race, marital status and other individual characteristics.

Overall, Abel and Deitz's results show that the "college graduate working as a barista" is not a typical outcome and that recent trends in the early careers of college graduates are not unprecedented. Furthermore, their analysis also shows the importance of the heterogeneity in outcomes across college majors, suggesting that differing demands for skills across majors is of primary importance in understanding the match between skill demand and skill supply.

"The Requirements of Jobs: Evidence from a Nationally Representative Survey" by Gittleman, Monaco, and Nestoriak describes a new survey conducted by the Bureau of Labor Statistics (BLS) and reports findings from the pre-production test survey. The BLS launched the *Occupational Requirements Survey* (ORS) in collaboration with the Social Security Administration as a data source in disability adjudication. The rich information from the survey can be used to answer a number of other economic questions, including the demand for and returns to education and skills in occupations.

The ORS collects four categories of information about occupations: (i) educational requirements; (ii) mental and cognitive elements; (iii) physical demands; and (iv) environmental conditions. The pre-production sample contacted 2,459 establishments, of which 1,851 provided useable data. The data collection extended from October 2014 through May 2015.

Gittleman et al. use these data to study the requirements of jobs. The first finding they highlight is that fewer than 25 percent of jobs require a college degree or higher degree, somewhat less than reported in the O*Net data (around 27 percent). This relatively small fraction stands in contrast to the common assertion that earning a college degree has become *de rigueur* for employment in the 21st Century U.S. economy. The bottom line is that three-quarters of all current jobs do not *require* a four-year college degree.

The authors then tabulate a measure of *Specific Vocational Preparation* (SVP), which adds up required formal education, specific occupational training, required prior work experience in related jobs, and time needed in the job to reach average performance. In this measure, years in high school are not counted nor are the first two years of college (since they tend to cover general education). Across all workers, they find that 33 percent of jobs require one month or less of SVP, 17 percent require one month to one year, 32 require one year to four years, and 18 require more than four years. Of course, this distribution varies widely across broad occupations and industries and they show more detail by these categories.

Gittleman et al. move on to consider mental and cognitive demands, based on the part of the survey that asked about the complexity of the tasks involved in a job. They find that half of all jobs were in the simplest tasks category and only 15 percent were in the most complex category. Again, these vary widely across occupations. Over 80 percent of the jobs in transportation and service occupations required only simple tasks. They also consider how closely controlled the work is in a job. They find that almost 60 percent of jobs involve very close control and only 13 percent involve very loose control. They find that the jobs involving the simplest tasks involve the most work control.

These results suggest there are a lot of jobs that do not require complex tasks, or allow only loose control, just as there only a quarter of all jobs require a college degree (as an aside, only about 30 percent of the population have such a degree). Any policy aimed at significantly increasing college enrollments should take note of these findings. However, it is also important to note that these results do not diminish the importance of a higher education for those jobs for which it is needed. The authors find that the jobs that involve the most complex tasks and the loosest work control also have the highest educational requirements. They report that "both task complexity and work control are strongly ordered by the amount of education required" (p. 22). The same is also true for the jobs with the longest SVPs. Thus, the jobs that do involve complex skills also rely heavily on higher education. More than 40 percent of those with BA degrees are in jobs that require complex or very complex skills, and nearly 80 percent of those with graduate or professional degrees are in jobs with complex/very complex skill requirements. Since the ORS is, at this point, a survey for a single year, a comparison with past years is not possible. However, the 2003 paper by Autor, Levy, and Murnane (and the work that followed) suggests the degree of skill complexity has increased significantly over time.

Gittleman et al. then analyze the average wages by job characteristic. It is already widely-recognized that the education premium has risen since 1980, and their results reflect those same large premiums for education. The average wage for a job that requires only literacy but no degree (not even high school) is $12.84, whereas a job that requires a four-year college degree pays on average $39.53 and one that requires a graduate degree pays $47.73. There are similarly large ranges by task complexity, SVP, and work control. Thus, the more nuanced interpretation of the Gittleman et al. results is that while there are many of jobs available for individuals with low education and skill levels, those jobs pay much less than those with higher education and skill levels.[1]

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[1] We emphasize that these wage outcomes should not interpreted as a type of "demand" for skills indicator irrespective of supply. The creation of a job or occupation is the outcome of the interaction of particular demands in the face of a supply of skills in an economy. Thus, firms facing a badly educated workforce would be expected to adapt by fashioning their job requirements around the supply of skills and using technology in ways that overcome gaps in skill supply.

C. Skills, Inequality and Polarization

The papers in this section expand the analysis of skills in several ways. One paper branches out to consider non-cognitive skills and the other three consider the distribution of skills rather than just the average.

"Non-Cognitive Skills as Human Capital" by Shelly Lundberg discusses both what we know about the importance of non-cognitive skills in individuals' outcomes and the measurement challenges for quantifying these types of skills. The standard measures of human capital include years of education, cognitive test scores, and/or IQ-related measures (such as the Armed Forces Qualifying Test (AFQT)). A literature that emerged in the 2000s showed that it might be valuable for economists to broaden their concept of human capital to include "non-cognitive skills." Numerous papers showed that some of the personality measures long studied by psychologists were associated with a number of outcomes of interest to economists, such as educational attainment, labor market outcomes, and criminal behavior. For example, personality traits, such as conscientiousness, impulse control, and emotional stability, were shown to have additional explanatory power for outcomes over and above standard cognitive measures such as IQ. In addition, evidence has emerged that non-cognitive skills can be shaped in the early years of life, suggesting more promising returns to early intervention than the standard cognitive traits.

As Lundberg points out, however, measures of non-cognitive skills are not always reliable in all applications. She cites a lack of consensus on what non-cognitive skills really are as well as a lack of a consistent set of metrics across studies. Part of her paper points out the current gaps and what would be needed to consider the role of non-cognitive skills in economic growth. Among the challenges are establishing a *causal* channel based on estimated relationships in which unobserved factors may be playing a role and evidence on the heterogeneity of returns to non-cognitive skills across different environments.

Lundberg discusses the key findings from the literature, as well as specific challenges to interpreting those findings. To illustrate the issues involved, she uses the NLSY97 and the Add Health surveys to estimate the relationships between non-cognitive skills and outcomes. The various surveys include a combination of measures based on self-assessments, parent/teacher assessments, and administrative records, such as school suspensions. A number of interesting results emerge that show the difficulty of interpreting results. First, the correlation between various measures of non-cognitive skills is surprisingly low. For example, the correlation between parent and youth reports of problem behavior is below 0.3. Second, the important and statistically significant effects of many of the non-cognitive skill measures on wages and employment often disappear once educational attainment is included in the regressions. These results suggest that a key channel of influence of non-cognitive skills on labor market outcomes might be through educational attainment and not through the direct channel of on-the-job performance. Third, there is evidence that measured non-cognitive skills might be influenced by other factors, such as parental resources and environmental influences. Lundberg gives the example of the famous marshmallow experiments, which found that young children who were willing to delay gratification in return for promised rewards had better life outcomes. Follow-up research suggests that the reluctance to delay gratification may be correlated with a child's unstable home environment, which could have effects on life outcomes through separate channels. Fourth, the importance of certain measures of non-cognitive skills in predicting outcomes such as crime are not necessarily robust to adding other measures of non-cognitive skills.

Overall, Lundberg's paper highlights the fact that non-cognitive skills are potentially very important for thinking about human capital and productivity more broadly. There are still many problems to be solved in making this analysis more concrete and filling in the causal steps. Lundberg's paper is very useful for pointing out the key gaps that need to be filled in the literature.

The next paper in the session considers the link between measures of adult skill levels and wage inequality. "Wage Inequality and Cognitive Skills: Re-Opening the Debate" by Stijn Broecke, Glenda Quintini, and Marieke Vandeweyer uses data from the latest survey of the Programme for the International Assessment of Adult Competencies (PIAAC) to determine how much of the differences in wage inequality across countries can be explained by differences in the endowments of and return to skills across countries. Their paper contributes to a debate about whether a difference in skill distributions or institutions can best explain differences in inequality across countries.

The findings reported in this paper are based on data from the PIAAC (2013) survey, which assesses the proficiency of adults across 24 countries in literacy, numeracy and problem solving. It also collects information on individual's wages, demographic characteristics and the extent to which they use their skills in the workplace. Broecke et al. begin by comparing the distribution of skills – they concentrate on numeracy in particular – and the distribution of wages. They focus on comparisons between the 90^{th}, 50^{th}, and 10^{th} percentiles of the distributions. Several interesting features emerge from the basic summary statistics about the U.S. in comparison to the average of the PIAAC countries. First, the U.S. has one of the lowest average levels of adult skills and has one of the highest dispersions of skills. Second, the U.S. has among the highest average levels of PPP adjusted wages and is near the top in wage inequality. Third, the returns to skills (based on a Mincer regression) are the highest in the U.S.

Broecke et al. then analyze the extent to which the endowment of skills and the return to skills can explain wage inequality differences across countries. They first conduct a simple accounting exercise. They measure how much wage inequality would change if (i) the U.S. had the reference country's (e.g. Germany) endowment of skills but the U.S. returns to skills vs. (ii) the U.S. had the reference country's average returns to skills but the U.S. endowment of skills. The most important finding, which is also consistent with some of the previous literature, is that differences in the *returns to skills* in the U.S. is much more important than differences in the *endowment of skills* in accounting for the inequality of wages in the U.S. relative to other countries.

The authors point out that some papers in the earlier literature were too quick to take this type of result as implying that the main source of differences in inequality across country is labor market institutions, such as minimum wages, etc. They also point out that the returns to skills are the *endogenous* outcome of supply and demand for skills. In particular, the high return to skills in the U.S. could be the outcome not only of a high relative demand for skills but also of the low supply of skills.

To analyze this possibility, Broecke et al. construct an index of relative net supply of skills by country. This index uses both the relative endowments of skills and the occupation/industry mix of employment interacted with skill demand. They find that this measure can explain almost

30 percent of the 90th to 50th percentile ratio of wages. It does not explain the other measures of inequality as well. However, even when measures of labor market institutions are included in the regressions, the net supply measure continues to perform well.

Overall, this paper shows how concrete measures of skills and their returns can help explain differences in inequality across countries. An additional outcome of their study is the clear demonstration that the average skill level of American adults lags behind many other OECD countries. It is also apparent, however, that the demand for skills in the U.S. remains high, as evidenced by the high skill premium.

Erik Hanushek's paper "Education and the Growth-Equity Tradeoff" considers a number of the important issues concerning the link between cognitive skills, growth and inequality. He first considers the role of human capital in growth models. As he points out, in neoclassical models, a rise in human capital will raise the *level* of output, but not the steady-state growth rate of output. In contrast, in endogenous growth models, a rise in human capital can potentially raise the steady-state growth rate of output. The second point he makes is how years of educational attainment is a poor measure of human capital. Hanushek notes that the quality of educational systems differs dramatically across countries, and even possibly across time. Illustrating the findings from his earlier work with co-authors, he shows that in a cross-section regression of long-run growth rates, average years of education performs poorly relative to his preferred measures which use the results of international assessments of test scores and similar metrics.

Hanushek also considers the possibility that the correlations do not imply causality from skills to growth. It is difficult to establish a causal link directly, but he offers some auxiliary evidence for a causal link from skills to growth being an important explanation for the correlation. However, he also discusses the evidence for higher growth leading to higher returns to skills, which creates a causal channel from growth to more education.

In addition, Hanushek considers the benefits to education before and after formal education. He first surveys the findings on the importance of preschool for later life outcomes, noting the mixed results. He then considers life-long learning.

Another theme he explores is the trade-off presented by vocational education. While vocational education can have important short-run returns in terms of initial job placement, that type of education may not be general enough to help a worker prosper in a changing economy.

Robert Valletta's paper "Recent Flattening in the Higher Education Wage Premium: Polarization, Deskilling, or Both?" focuses on trends in wage premia. He particularly studies possible sources for the documented flattening in the returns to education. Valletta first updates the data and confirms the trends highlighted in the literature. Since 1980, educational wage premia have increased, but they have done so at a decreasing rate. The premium for college only (i.e. four-year college degree, but no graduate school) over high school rose the fastest in the 1980s, slightly less fast in the 1990s, and then stalled since 2000. The premium for graduate degrees rose more robustly during most decades, but appears to have stalled since 2010.

Valletta then considers the extent to which two possible hypotheses can explain these trends. One hypothesis is the job polarization hypothesis (e.g. Autor, Katz, and Kearney (2008), Acemoglu and Autor (2011)), which argues that skill-biased technological change has reduced the demand for routine jobs that can be computerized. In this hypothesis, the middle-educated (e.g. some college or college only) lose their jobs and are forced to move down to non-routine, non-cognitive jobs which pay much less. A second hypothesis, which expands on the polarization hypothesis, is "skill downgrading" by Beaudry, Green and Sand (2016). They argue that the rise in educational premia was in part a transitional effect of moving to a higher level of intangible organizational capital. Demand for cognitive skills was high when investment in IT was high during the transition to the new steady state, but once the new state was reached, there was less demand for those types of cognitive skills.

As Valletta notes, distinguishing between these two hypotheses is not straightforward because the skill downgrading hypothesis is an extension of the polarization hypothesis. To shed some light on the forces at play, Valletta analyzes changes in premia within and between broad occupation categories as well as shares of workers by education in those groups. He finds that part of the slowdown in the growth of educational premia is occurring across occupational categories, which is consistent with the polarization hypothesis. However, he also finds a slowdown within occupational categories, which he argues is consistent with the downgrading hypothesis. The changing shares of workers in nonroutine cognitive occupations and routine cognitive occupations is consistent with college-educated workers moving down to the routine category as they are displaced by workers with graduate degrees. Valletta views these results as suggesting rising competition among educated workers for high paying jobs that are becoming scarcer. He argues that even if the social return to higher education might be slowing down, the private returns are still large because it enables workers to compete for the best paying jobs.

D. The Supply of Skills

Our opening comments describe some of the frictions arising in formal education sector in the U.S. that tend to slow the supply response of skills to shifts in demand. In the same vein, this section begins with a paper that examines the sources of the rise in college tuition in the U.S. and then moves on to consider some non-traditional means for increasing the supply of educated workers.

A potentially important impediment to the growth in educational attainment of the U.S. population is the dramatic rise in college tuition. Tuition and fees, even net of institutional aid, grew by 100 percent between 1987 and 2010. This rise dwarfs even the rise in health care costs. In "Accounting for the Rise in College Tuition," Gordon and Hedlund seek to understand the sources of this rise since 1987. They specify a quantitative model of the market for higher education and calibrate it in order to determine how much of the rise in tuition is due to exogenous changes to non-tuition revenue, demand-side changes due to the expansion of loans and grants, and demand-side changes due to macro forces such as skill-biased technological change.

Assessing the importance of each factor would be difficult to do with purely empirical methods, since tuition and many of the candidate factors are all trending up together. To answer the question, Gordon and Hedlund thus turn to quantitative methods. In particular, they specify a theoretical model that embeds a college sector in an open economy model. They model the decisions of youths, who first make a one-time decision about whether to work or go to college. If they go to college, they must decide how many loans to take out, etc. They assume a representative college that seeks to maximize quality, which depends on the academic ability of the student body and the investment per student. The college has two sources of revenue: tuition and non-tuition sources, which include returns on endowment and government appropriations. They then calibrate the model to match key data moments since 1987. Their model can match some features of the data well, but it does fall short on other features. Notably, it can explain all of the rise in college tuition, suggesting that there are no missing factors.

They then use the calibrated model to assess the sources of the rise in college tuition between 1987 and 2010. They find that demand changes due to changes in financial aid can account for virtually all of the rise in tuition. The rise in the college wage premium (due to skill-biased technological change) alone can account for 20 percent of the rise. In contrast, they find a *negative* role for Baumol's cost disease. They explain that while the cost disease might explain tuition increases at a given university, in equilibrium students are substituting into cheaper universities so this factor does not raise *overall* tuition.

The Gordon and Hedlund paper represents an important first step in using quantitative models to study the sources of the rise in college tuition. As they point out, there are several aspects of the model that might lead to an exaggeration of some of the findings. Their analysis lays a foundation for future research that generalizes the model.

The role of education in innovation and the production of output has been a general theme of this conference. "The Returns to Online Postsecondary Education" by Caroline M. Hoxby turns this around and looks at one of the most notable innovations in higher education itself. Enrollment in online education has experienced explosive growth in recent years, with "exclusively online" programs grown from around 25,000 students in 2000 to 425,000 in 2013; "substantially online" program increase from over 300,000 to around 1,100,000 over the same period (both accounting now for around 7 percent of enrollments). Hoxby notes that the online postsecondary education sector (OLE) has been hailed by as the wave of the future by its enthusiasts, and takes a close look at the evidence, examining both its pros and cons in comparison with traditional "in-person" brick-and-mortar institutions (B&M), including those that are less "competitive" and also have an online presence.

On the “pros” side, online education is thought to have low marginal costs and greater cost-effectiveness, even if it does not improve students' outcomes more than in-person schools. They also lend themselves to technical education, particularly those in which the use of computers is an important part of the learning process. This, in turn, suggests the OLE may be particularly well-suited for training people for employment in the more rapidly growing technology-oriented industries or occupations. OLE also provides flexibility in both time commitment and location, which may limit the ability of some qualified people from pursing a higher education. On the “cons” side, the very flexibility that the OLE permits also puts a premium on self-discipline and may not be for all students. Drop-out rates are found to be higher, and OLE generates a disproportionate share of student loan defaults and other repayment issues. It accounts for a disproportionate share of government subsidies, including tax expenditures on tuition and fees.

Hoxby subjects the pros and cons to close examination using longitudinal data from the IRS on nearly every person who engaged substantially in online postsecondary education between 1999 and 2014 (supplemented, in places, by NCES data). These data permit the study of student characteristics as well as the costs, tuition, and subsidies of the OLE and B&M schools. The basic objective is to calculate the “Return on Investment” to see if students recoup enough in additional discounted life-time wages to cover the cost of the OLE, inclusive of the opportunity cost of time. In addition, the study computes a social return that includes the cost of public subsidies. Also considered is the question of whether the OLE student is subsequently more productive or in a more technical job as a result of the OLE.

This first in-depth study of the returns to online education is very comprehensive, resulting in a large number of figures and tables that analyze the many dimensions and permutations of the new data. Several highlights include the fact that the average OLE enrollee is much older than those in the B&M schools (around 10 years). They have considerably higher average incomes in the same calendar year in which they are enrolled, and some 90 percent are enrolled at least half-time, suggesting they are balancing work and school (and not just taking single courses). Around 60 percent are enrolled as undergraduates.

Hoxby finds that OLE institutions are not selective in their entry criteria. Moreover, they allocate less instructional spending per FTE student than their B&M counterparts. Yet, the undergraduate tuition paid by the OLE students is actually higher than that paid by of those in *non-selective* B&M institutions. In other words, as Hoxby notes, students themselves pay more for online education than those in comparable in-person education even though the resources devoted to their instruction are lower.

The calculation of ROIs is complicated by a possible selection bias arising from the personal circumstances that impel students (on average much older) to enrolled in OLE (the "Aschenfelter Dip"), and the diversity in perseverance in staying in school. Many ROIs are calculated, with the overall conclusion that the earnings of most online students do not increase by enough to cover even their private costs, thought there are exceptions — those online students who "persist through unusually long enrollment episodes (4 or 5 calendar years) experience earnings increases that usually cover their private costs". Moreover, while online enrollment episodes do usually raise students' earnings, it is almost never by an amount that covers the *social* cost of their education.

Finally, there is only "slight evidence" that online enrollment moves people toward jobs associated with higher productivity growth. Online enrollment appears to have little or no effect on a person's probability of holding a high technology job or a job that requires abstract skills.

Last, but by no means least, in the topic of skill supply is the important issue of immigration as a source of supply for the skills needed in high-technology employments. The paper "High Skilled Immigration and the Rise of STEM Occupations in US Employment" by Gordon Hanson and Matthew Slaughter explores the contribution of immigrants to employment in U.S. STEM (Science, Technology, Engineering and Math) fields. Their paper documents a number of important new facts and then offers some suggestive evidence useful for distinguishing various hypotheses. The data analyzed come from the Census, the American Community Survey (ACS), and the Current Population Survey (CPS). They define STEM occupations similarly to the Department of Commerce, but drop some of the lower-skilled occupations.

Hanson and Slaughter initially present an overview of all STEM employment, including both native and immigrant workers. First, the STEM share of total employment rose from 4.5 to 6 percent from 1993 to 2013. Second, by 2012 over 50 percent of STEM workers with a bachelor's degree and over 40 percent of STEM workers with an advanced degree work in software and programming. Third, younger cohorts account for relatively more hours in STEM than older cohorts. Thus, STEM workers tend to have much higher formal education than the average worker, but also tend to be younger than the average worker.

The authors then consider the contribution of immigrants. Considering only those with BAs, MAs, or Ph.D.s, they show that immigrants account for between 15 percent (for BAs) and 31 percent of total employment in 2013. Focusing solely on STEM employment, the immigrant share is much higher, between 20 percent (for BAs) and 60 percent (for Ph.D.s). Moreover, these shares have risen significantly since 1993. For example, among STEM workers with a Masters, the immigrant share has risen from 20 percent in 1993 to over 40 percent in 2013.

Hanson and Slaughter then consider possible explanations for the foreign-born comparative advantage in STEM fields. The first hypothesis is that American K-12 training in technical areas is weak compared to the training in many other countries. They point out, however, that international test comparisons show that American K-12 performs poorly across the board, in technical and non-technical subjects. Thus, it does not explain the differential shares across STEM and non-STEM. The second hypothesis is that it is relatively more difficult for foreign-born higher educated workers to gain entry into non-technical occupations because many of those occupations require elevated knowledge of the subtleties of U.S. culture that are important for face-to-face communication with customers. The third hypothesis is the H-1B visas favor STEM immigrants. The authors present evidence that suggests this is somewhat unlikely. The authors go on to compare wages and find that, while the foreign-born have significantly lower wages than natives in the non-technical occupations, the foreign-born have similar wages to natives in the STEM occupations. Hanson and Slaughter's findings suggest that, to the extent that STEM occupations are important for technological change and growth in the U.S., then immigrants with college and advanced degrees have played an important role in U.S. growth.

We have not summarized the comments made by discussants of the various papers because many are long and detailed and their inclusion would make our overview too lengthy. However, the discussants are eminent experts and their discussions are well worth reading as contributions in their own right.

III. Summary and Final Thoughts

The papers and discussion in the conference proceedings cover a wide range of issues. There is still considerable debate over many of the issues touched on in this volume -- the roles of college and vocational education, the size and nature of the "skills gap", and a host of others. We see one of the main strengths of the papers as the amount of new data they bring to bear on some the issues. Another strength is the attempt to link different bodies of research (growth accounting, skill-development, issues in higher education, immigration, etc.) to get at the question of how well students are being prepared for the current and future world of work. However, the broad scope of the proceedings also makes them hard to summarize. This said, the following six broad takeaways are our attempt at a summary of what we see as the main points. They reflect our reading of the papers, as well as our own research and understanding of the issues, and they should not necessarily be attributed to any individual author or discussant whose work appears in the volume.

(1) A strong education system is essential for the proper functioning of modern economies, and is the hallmark of an advanced society. Evidence suggests that those societies with the highest income per capita are also those with the greatest educational attainment. Education played a particularly key role in the transition over the last half century to a globalized "knowledge economy" by helping provide the requisite non-routine cognitive and noncognitve skills. Without the appropriate supply response to the changing demand for skills, it is hard to see how this revolution could have occurred in its current form.

(2) More is involved in skill development and learning than formal education alone. Home environment is an important determinant of skill formation, with the cognitive and noncognitive skills developed in early childhood playing a fundamental role in a child's ability to learn. The socio-economic status of the family also matters, as do idiosyncratic factors such as ability.

Moreover, skill development does not stop at graduation. Research at the BLS has found that the formal school preparation is in third place behind training and job experience as a source of skill development. On the other hand, education does provide the general skills of literacy and numeracy needed for the further development of many task-related skills, and is the main *systematic* way that children are prepared for the adult life and the world of work. It also provides vocational training and preparation for various professions, and educational attainment has been found to be positively correlated with employment in jobs requiring more complex cognitive and non-cognitive skills.

(3) Much of the recent focus on the demand side of skill development has been on the higher-order cognitive and non-cognitive skills needed for the growing complexities of the technology revolution. This is appropriate, given that these skills are a necessary enabler of that revolution and the income growth it has created. However, it is also true that only a fraction of all jobs involve complex tasks (around 15 percent, according to BLS estimates), and only a quarter of all jobs require a college degree. Any discussion of the demand for skills must acknowledge the fact that the education system needs to prepare students for a broad range of skills and vocations, not just those at the top-ends of the skill and educational attainment scales. This is all the more important because the requirements of many “routine” skills have shifted as a result of sectoral changes in the structure of the economy and the growing presence of information technology.

(4) Education is a process that unfolds over time for any individual and is fraught with uncertainty and institutional problems and rigidities. Thus, the adjustment of the supply of new graduates to a change in demand for a skill or occupation cannot occur immediately, leading to periods in which demand growth may outstrip supply. Goldin and Katz argue that this phenomenon occurred as the Information Revolution increased the demand for complex skills and higher education, and a lagging supply response led to a college wage premium as the natural market outcome. Some have interpreted this as a worrisome “skills gap”, but standard economic logic sees it as a period of labor market adjustment. Indeed, recent evidence suggests that the uptake of college graduates may be slowing, along with wage premium for college.

(5) Quality matters as well as quantity. In this regard, the success of the U.S. education system in preparing students with the skills needed for the economy of the 21st century gets a mixed report card. Most students today finish high school (some 90 percent), and two-thirds go on to some form of tertiary education. Not all succeed in obtaining a four-year college degree, as only around one third of the population end up with a four-year college degree or more. The quality of U.S. higher education is very high in international comparisons, but the quality of K-12 education is a salient problem. High school test scores have been largely stagnant in recent decades, with a quarter of graduating seniors performing at the "below basic" in reading proficiency and one-third in math in the 2013 NAEP survey.

(6) Combined with those students who do not finish high school, the test score results suggest that a substantial portion of the U.S. youth is not being well prepared for the needs of the knowledge economy and the affluence it conveys, or for the remaining mid-skill jobs that in the past have provided middle-class affluence. While higher education, with its large wage premium, is a pathway to higher economic incomes for some, many others are left behind. Finding an answer to this equity versus growth conundrum is one of the great educational and economic challenges of the years ahead.

We emphasize, again, that these points reflect our own views and understanding of the subjects covered and should not be attributed to any individual author or discussant.

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