Future Skill Shortages in the U.S. Economy?

David Neumark, Hans Johnson, and Marisol Cuellar Mejia*

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Abstract

The impending retirement of the baby boom cohort represents the first time in the history of the United States that such a large and well-educated group of workers will exit the labor force. This could imply skill shortages in the U.S. economy. We develop medium-term labor force projections of the educational demands on the workforce and the supply of workers by education to assess the potential for skill imbalances to emerge. Based on our formal projections, we see little likelihood of skill shortages emerging by the end of this decade. More tentatively, though, skill shortages are more likely as *all* of the baby boomers retire in later years, and skill shortages are more likely in the medium-term in states with large and growing immigrant populations. We discuss conflicting evidence on skill shortages based on alternative projections as well as criticisms of the definition of skill requirements, concluding that our projections are likely the most reasonable.

Neumark is Professor of Economics at UCI, Research Associate at the NBER, and Research Fellow at IZA. Johnson is a Senior Fellow at PPIC. Cuellar Mejia is Research Associate at PPIC. We are grateful to Ian Salas for outstanding research assistance, and to Peer Ederer, Nicole Smith, Jeff Strohl, and Andrew Sum for helpful comments, This paper was prepared for the European Commission Joint Research Centre's "Catch the Train: Skills, Education and Jobs" conference, Brussels, June 2011. The research on the projections was supported by the Gates Foundation and the AARP Foundation. The views expressed are the authors', and do not reflect the views of PPIC or the AARP or Gates Foundations.

I. Introduction

The impending retirement of the baby boom cohort could pose dramatic challenges for the U.S. labor force for at least two reasons. First, the boomers – adults born between 1946 and 1964 – are large in number. In 2008, boomers made up 34 percent of all adults in the United States, and 38 percent of all workers.[1] Second, boomers are relatively well-educated. Many came into adulthood just as the nation was rapidly expanding postsecondary educational opportunities in relatively low-cost public institutions. For men, the GI bill was instrumental in encouraging greater postsecondary enrollment and the Vietnam War draft provided additional incentive for many male boomers to go to college (Card and Lemieux, 2001; Bound and Turner, 2002). Further, it is likely that increasing labor market opportunities for women from factors as diverse as declining discrimination, changing attitudes, and contraceptive technology spurred them on to higher educational attainment as well (e.g., Goldin and Katz, 2002). As a result, whereas in earlier decades younger workers replacing older workers were much more educated, the baby boomers are nearly as educated as current younger cohorts (Figure 1). Thus, the retirement of the baby boomers will surely slow the growth of skill levels in the workforce, which, depending on projected increases in demand for skill, could imply skill shortages.

In this paper we develop and analyze labor force projections for the early years of the baby boomers' retirements, projecting the educational requirements of jobs, the educational attainment levels of workers, and the potential for skill (i.e., education) imbalances to emerge between workforce needs and supplies. The projections are fairly short-term – extending only through 2018 – because the analysis relies on Bureau of Labor Statistics (BLS) occupational projections that extend only through that year. However, we also use our results plus what we know about the baby boomers and the cohorts that follow to draw implications for projections for the longer-term – specifically the period over which nearly *all* baby boomers will retire.

These kinds of projections are important for policymakers. We argue that skill shortages may prove costly to the economy – most significantly, perhaps, in terms of foregone opportunities for the

[1] There figures are from our calculations using 2008 American Community Survey (ACS) data.

creation of high-wage jobs. Moreover, policy responses to address skill shortages are likely to take effect only slowly. For example, if increased capacity at community colleges is to be used to help meet future skill demands, it is likely that such capacity can only be built up slowly (and would probably be more effective if it is built up slowly).

Our primary findings are as follows. The U.S. economy will generate rising demand for highly-educated workers. In the near term, this rising demand will by and large be met by rising education levels among the U.S. population, so that the United States as a whole does not seem to be in peril of a substantial workforce skills gap, at least through 2018. However, numerous states with large and growing, and less-educated, immigrant populations appear more likely to face significant imbalances (which might be alleviated through interstate migration). And over the longer-term, as more baby boomers retire, there is greater risk of substantial skill shortages.

II. Educational/Skill Demands in 2018

Projected occupational changes

Our starting point, which we take as given, is BLS projections of employment growth by occupation (Woods, 2009; Lacey and Wright, 2009).[2] These projections extend to 2018, and provide a straightforward way to predict future job growth and composition by occupation, including identifying the fastest-growing occupations.[3] These estimates and projections were obtained from the occupational employment and worker characteristics data published by the Employment Projections Program at the Bureau of Labor Statistics.[4] The BLS data contain job counts for 2008 with projections for 2018 at the six-digit Standard Occupational Classification (SOC) level. After aggregating occupation categories at

[2] In the BLS model labor force projections are derived from U.S. Census Bureau population projections, a macroeconomic model generating industrial composition forecasts, and a matrix providing occupational projections based on industry composition and levels (Bartsch, 2009). Below, we discuss evidence from alternative occupation projections constructed by Carnevale et al. (2010).

[3] These projections are also done by industry. However, since our goal is to project skill demands and supplies, and the BLS skill requirements on which we rely for some of the projections of demand are based on occupations, we focus on the occupational projections. In addition, occupations are typically thought about as distinguished by skill, whereas industries can include workers of many skills. The macroeconomic model used to generate these projections takes population and labor force growth as exogenous factors. The projections are not adjusted for educational attainment levels of future populations that could, for example, respond to imbalances that emerge (Wyatt and Byun, 2009).

[4] See BLS (2009), Employment Projections Table 1.6. Note that the military and institutionalized populations are excluded.

the two-digit level (there are 22 two-digit occupations), we calculated the BLS projected change in occupational demand over the designated period.

Figure 2 shows the occupation categories ranked by their growth rates in 2008 and 2018, while also showing the overall size of the category. Although they are relatively small occupational categories, health care and computer science occupations lead the way in terms of projected rates of employment growth. Agricultural and production occupations are the only occupations projected to decline between 2008 and 2018.

Approaches to projections by skill/education

The BLS occupational projections, coupled with information on skill or education requirements by occupation, are the basis of our projected demands for skill. We consider two primary approaches to project the education requirements of future jobs and workers. In both approaches, we project education requirements of workers within occupations, and then using the BLS occupational projections extending to 2018 we project education requirements. The result is a set of projected education requirements for the entire workforce based on how the economy is changing (as reflected by occupational changes).[5]

The first approach relies on but makes minor adjustments to the BLS occupational skills projections (Lacey and Wright, 2009), which are based on a determination of training requirements ranging from short-term on-the-job training to a doctoral degree.[6] First, we adjust the BLS projections to account for individuals holding more than one job, using CPS data on multiple jobholding by education category; and second, we convert the education/training variables the BLS uses into measures defined solely in terms of educational attainment.

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[5] We should note that both approaches are based on the perspective that the educational requirements of workers in particular occupations – whichever way we estimate them – imply that workers with less education would be less productive in these occupations. That is, we adopt the framework of the human capital model (Becker, 1964; Mincer, 1974) where education directly increases productivity, rather than the signaling model, where there is a fixed distribution of ability that is unaffected by schooling, and schooling serves only to "signal" to employers who has high ability (Spence, 1973). In the latter framework, there is really no sensible way to think about changing workforce demands for workers at different skill levels. However, the human capital perspective on education is by far the predominant view of the relationship between education, productivity, and earnings (Willis, 1986). For an alternative view, however, see Weiss (1995).

[6] We adjust the BLS data to account for individuals holding more than one job, as noted in the previous section.

The second approach assumes that empirical employment practices are a good measure of workforce skills needs. In projecting the education requirements of workers by 2018, we assume a steady rate of growth between 2008 and 2018 in the educational distributions within occupations. Specifically, using data from the Census of Population and the American Community Survey for workers aged 16 and over, we calculated compound average annual growth rates between 2000 and 2008 for educational attainment and occupation categories at the 2-digit SOC level (22 occupations).[7] We applied these growth rates to the 2008 ACS by educational attainment and occupation category to arrive at estimated levels of workers by education level in each occupation in 2018. Then, instead of using these totals for the projections, we applied the shares by educational attainment and occupation category to the 2018 BLS population totals (adjusted from the occupational employment totals), to give us levels comparable to those projected by the BLS.

BLS education projections

A couple of preliminary issues with regard to the BLS projections require clarification. First, the BLS reports skill requirements for the occupations for which they do projections. Their occupational forecasts distinguish between job openings due to growth and job openings due to replacement needs (Lacey and Wright, 2009).[8] There is an important distinction, which is sometimes a source of confusion, between projected demands for workers (or jobs) and projected job openings. Projected job openings can create an impression of very large demands for unskilled workers. For the purpose of assessing future workforce skill requirements, this is misleading because low-skilled workers move from job to job and from occupation to occupation at high rates. For example, filling one low-skilled job for one year may require multiple workers because these low-skilled workers may move on to other occupations, whereas filling one high-skilled job for one year may require only one worker because of much lower turnover

[7] It is conceivable that these are not the ideal years to use, as during 2000 there was a very strong economy, and the economy started to weaken (in terms of a rising unemployment rate) during 2008. We are unaware of evidence suggesting that educational attainment within occupations is very sensitive to the business cycle. But additional research assessing the robustness of these findings to using different pairs of years to measure education might be useful. On the other hand, the National Bureau of Economic Research (NBER) business cycle dates (http://nber.org/cycles/cyclesmain.html) list March 2001 and December 2007 as the last two business cycle peaks, and these dates are fairly close to the 2000 and 2008 periods that we use.

[8] There is work underway at BLS to update and improve the measurement of skill requirements by occupation. See http://www.bls.gov/emp/edcatupdate.pdf (accessed October 29, 2010).

rates. Assuming that employers anticipate this, they will project only one high-skilled job opening but more low-skilled job openings. But filling those jobs requires one worker of each type.[9] The projections we use are based on projected demands for workers, since we are ultimately interested in assessing how well the supplies of workers by skill level will meet the demands.

Second, it is important to clarify what the BLS skill requirements mean. The BLS data contain information regarding the most common skills required to perform in a given occupation. For each SOC, the BLS identifies the "most significant source of education and training category,"[10] which combines education and training measures into a single category. Certain categories only identify "work-related training"[11] while not specifying education (e.g., "short-term on-the-job training"). However, postsecondary degree requirements take precedence over work-related training if the degree is generally required, even though additional skills or experience are needed to become fully qualified (Lacey and Wright, 2009, p. 89). We understand this to mean that formal education above a high school degree is not required in those occupations that BLS identifies as requiring no more than work-related training.

The BLS assigns occupation into these classifications using educational attainment data from the ACS, skills information from the Occupational Information Network (O*NET), and other qualitative information from occupational experts. Although a single education/training category is assigned to each occupation, the BLS acknowledges that there is a distribution of educational attainment and training for employees within a given SOC.[12]

Because we also measure skill requirements based on the observed educational distribution using data from the Census Bureau's American Community Survey (ACS), we have to create comparable

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[9] See U.S. Bureau of Labor Statistics (2010a). As an example, Table 3 in Lacey and Wright (2009) shows that between 2008 and 2018, BLS projects that 38.5 percent of all job openings will be in occupations at the lowest skill level (with short-term on-the-job training required), but that these low-skilled jobs will account for only 7.7 percent of the projected net change in employment. At the other end of the educational spectrum, 23 percent of all projected job openings will be in occupations that require at least a bachelor's degree, but these high-skilled jobs account for 77.5 percent of the projected net change in employment.

[10] See Employment Projections Table 1.6: "Occupational Employment and Job Openings Data, 2008-18, and worker characteristics, 2008," available at www.bls.gov (accessed April 11, 2010).

[11] For detailed descriptions of these categories, see "Occupational Variable Data Definitions." at http://www.bls.gov/emp/ep_nem_definitions.htm (accessed October 29, 2010).

[12] For a detailed description of how the BLS develops its education and training categories, see www.bls.gov (accessed April 11, 2010).

categories of skills across the two data sources. Whereas the BLS uses a combination of training and educational attainment to classify workers, the ACS uses solely educational attainment. Thus, we need to convert the education/training variables seen in the BLS into measures of pure educational attainment. To do this we assign each grouping from the BLS into a new education category based on the implied level of education required for these occupations, assuming that jobs requiring only on-the-job training are occupations that require a high school degree or less. The top Panel of Table 1 shows how we map BLS skill categories into education categories, and the bottom panel shows how we map ACS education categories into comparable categories, ending up with the following: high school degree or less; some college; Associate's degree; Bachelor's degree; Master's degree; professional degree beyond Bachelor's; and Doctorate.

Modifications of the BLS projections

The educational distribution in an occupation at a single point in time may miss changes in educational requirements over time. BLS projects occupational growth, but holds education within occupational groups constant in its projections, which ignores the possibility of upgrading. In our projections based on ACS education data we account for changes over time in the educational distribution within occupation category. Specifically, we apply trended estimates of the educational attainment shares within an occupational category that are available in the 2000 Decennial Census and 2008 ACS to the occupational employment projections for 2018 from the BLS.[13]

We focus on educational requirements in terms of the levels of education, but not the academic content of degrees, for two reasons. First, the skill requirements projections on which we base our analysis can be converted into the levels of education (by mapping occupational projections to the educational requirements of those occupations), but not to the academic content. And second, although we have data sources and methods to predict levels of educational attainment in the future, it is much more difficult to project the fields in which academic degrees will be achieved. This is a potential

[13] One might argue that within-occupation changes in education should be forecasted from longer-term past trends. However, the nature of technology that likely drives these changes in education can differ over time, with some research suggesting that it can change quite quickly (Autor et al., 2006). Thus, we think that longer-term changes in education within occupations could be misleading.

limitation that must be kept in mind in interpreting our findings, as our findings do not necessarily speak to shortages in particular fields at the same level of education.

In addition, we are ultimately interesting in comparing the demands for and supplies of skilled workers, but the BLS projections are for *positions*, which can differ from the number of people needed to fill these jobs if people hold multiple jobs. We know that the incidence of multiple jobholding varies by level of educational attainment, and since occupations are differentiated by skill, multiple jobholding likely also varies by occupation. We therefore adjust the projected occupation "counts" from the BLS to turn them into projections for the number of people required to perform these jobs (using Current Population Survey [CPS] data on multiple jobholding by education category).[14] The conversion from positions to people results in an employment count, for 2008, of 146 million employed people. It closely matches BLS' own published employment results from the labor force statistics in the CPS, which are developed independently from the occupational employment projections.[15] Since the moonlighting rate tends to increase with education, occupations requiring more education and training have a larger difference between the level of occupational employment and the number of people holding those occupations.

<u>Projections of skill requirements</u>

Table 2 shows BLS projections of skill requirements. Panel A is based on "positions," and is obtained directly from BLS projections without modification. Panel B shows our projections of workers filling those jobs, and maps the skill requirements into the education categories described in Table 1. The projections indicate that the fastest growing occupations and the greatest increase in demand for additional workers are in occupations that will require some postsecondary education. The rate of growth in the demand for workers with some college is projected to be almost twice as great as for workers with

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[14] We use the January Supplement from the Current Population Survey for 2006 through 2008. In doing these adjustments, we treat multiple job holders as having two jobs, and do not distinguish those with three (or more) jobs. Based on the Current Population Survey (CPS) data, 7.9 percent of multiple job holders have three or more jobs, so ignoring this has negligible effects. The self-employed are treated symmetrically in these calculations. They are included in the BLS projections (2009) and are covered in the CPS multiple jobholding question. Thus, there is no problem regarding the treatment of the self-employed in the adjustment for multiple jobholding.

[15] The BLS published employed population for 2008 is 145.4 million. See the following table from the "Labor Force Statistics from the Current Population Survey,"
: ftp://ftp.bls.gov/pub/special.requests/lf/aa2008/pdf/cpsaat8.pdf (accessed April 11, 2010).

lower levels of education. Despite this faster rate of growth, the BLS projections suggest that the vast majority of jobs have been and will continue to be in occupations that do not require any sort of postsecondary education. In 2018, 61.2 percent of all workers are projected to be in jobs that only require a high school degree or less, a slight decline from 62.5 percent in 2008.

Our alternative estimates and projections of employment by educational attainment, based on observed education levels in the Decennial Census and ACS, are shown in Table 3. The data reveal quite different patterns than those based on the BLS skill requirements, both in terms of the skill requirements of jobs currently held in the U.S. economy, and for projections of skill requirements for occupational changes to 2018. In 2008, only 37.5 percent of workers in the United States had a high school degree or less, whereas the BLS occupational requirements suggest that two of every three jobs required a high school degree or less. While both the BLS- and ACS-based projections suggest that occupations with higher degree requirements will have the most rapid rate of growth, the differences in projected rates of growth are large. The ACS-based projections indicate almost no change in the demand for workers with a high school degree or less, increasing by fewer than 200,000 workers between 2008 and 2018, while the BLS projection estimates an increase of 7.2 *million* for the same education group. In contrast, the ACS-based projections call for much more rapid growth in demand for workers with Associate's degrees, Bachelor's degrees, and Doctorates.[16]

<u>Assessment of BLS skill requirements</u>

The preceding analysis makes clear that we get very different answers for skill demands using observed levels of trends of education by occupation versus the BLS skill requirements. This in turn raises the question of whether the ACS educational distributions reflect real demand for more highly-

[16] Note that Table 4 indicates a decline in the demand for workers with professional degrees. What we observe is that from 2000 to 2008 the share of workers with these degrees in the two key occupation categories (legal and health) declined rather substantially, although the absolute numbers increased. This could be due to an increase in the employment of less-educated workers in these fields (for example, an increase in nurses that decreases the share of doctors). These within-occupation trends in education, coupled with our other forecast methods, account for the projected declines in the demand for workers with professional degrees. Recall, though, that we rescale projected 2018 employment to the BLS forecasts (rather than simply taking 2008 ACS employment by education and applying the 2000 to 2008 trends to arrive at 2018 levels). Absent this rescaling, the relative share in demand of workers with professional degrees would still decline, but the absolute number would increase. The difference arises because, although BLS projects that these will be among the fastest-growing occupations in the future (Table 1), they project the rates of growth to slow relative to the 2000 to 2008 period.

skilled workers, or alternatively whether the BLS skill requirements are accurate. To clarify, the question is not simply whether the BLS data fail to capture some skills needs. It is the reliability of using the BLS skill requirements data to project skill needs in an occupation. After all, the BLS data – as noted above – are intended to describe "the education or training that most workers need to become fully qualified in that occupation." This statement does not imply that higher educational levels are not sometimes required or that they are not valuable.

One way to ask whether much higher educational attainment levels as reported in the ACS reflect skill demands is to examine the wages within those occupational categories. If employers pay higher wages to workers with higher levels of education within an occupational grouping, than we can take that as a sign of greater productivity and increased demand for such workers, and conversely, to the extent that there are positive returns to education levels above those indicated as the skill requirement for an occupation in the BLS data, the BLS data will understate the skills needed in an occupation. In that case, relying on the BLS skill requirements data to project skill needs could mask potential skill shortages that would be indicated based on skill needs exceeding those indicated by the BLS data.

We therefore turn to evidence on education wage premia within occupation, asking whether education-related wage premia in an occupation are lower when the education level exceeds skill requirements according to the BLS. Specifically, we take ACS data for 2008 that is used to construct the educational distributions displayed in Table 3, and estimate a regression for log earnings, with controls for the usual ingredients of earnings functions (marital status, age and its square, region, race, ethnicity, and sex), as well as a set of dummy variables corresponding to each education category beyond the lowest omitted group. We estimate this regression for each two-digit occupation; the regression estimated for each occupation, omitting individual subscripts, is:

$$\ln(w) = \alpha + \sum_k \beta_k S_k^R + \sum_j \gamma_j S_j^{NR} + X\delta + \varepsilon \ .$$

This equation is estimated for individuals in each occupation. In this equation w is the wage, S_k^R is a set of dummies for required educational levels, and S_k^{NR} for non-required educational levels. The set of dummies in each of these subsets (indexed by k and j) varies by occupation. Based on these regressions, we examine whether the economic returns to education levels above the highest education required for the occupation (according to the BLS) are smaller than for occupations where these education levels are required. We also test, statistically, the sharper hypothesis that the returns to these higher "unnecessary" levels of education are zero – that is, that the returns to education for levels of education higher than the required level are no higher than for the highest educational level, or that the γ's for an occupation are equal to the β for the highest required education level. As long as the returns to "unnecessary" education are greater than zero, there is reason to believe that the education is to some extent required, even if it is not as important as for occupations where it is required.[17]

The results for the regression analysis are reported for each occupation in Table 4. The grey shading highlights the educational levels in each occupation that are above those required, according to the BLS. The estimated returns to a Bachelor's degree are lower in the occupations that do not require that much education. However, for nearly every occupational grouping, wage returns are higher for more highly-educated workers even if the BLS says such high levels of education are not necessary. For example, in the first panel, for management occupations, the estimated coefficients for Master's, professional, and doctoral degrees are all above the estimated coefficient for a Bachelor's degree, which is the BLS maximum. For the joint test, for each occupation, of the significance of the education coefficients for above-required levels, reported in the last two columns of the table, in every case but one (community and social services) we reject the hypothesis that there are no returns to education levels above those that the BLS states are required.

One could object that if the regression model controls for all other differences in productivity, and there are no important compensating differentials across occupations (or they are captured in the intercepts), then the wage premium for education must be the same in all occupations. Otherwise workers would never work in the occupation paying the lower premium. As a result, we may fail to find evidence

[17] This approach follows the research literature on "over-education" in which the standard human capital earnings function is augmented by measures of how much an individual is over-educated relative to the education level in his or her job (see Hartog, 2000). There are a number of problems with trying to infer whether there is over-education by looking at returns to education above the required amount; the most obvious is that those who have more education than is the norm in their job may have lower innate ability (which is why they need more education to be employed in that job) than those with less education. There is some evidence consistent with this conjecture (Chevalier, 2003; McGuinness and Bennett, 2007).

of lower returns to "unnecessary" education. However, in that case the employer would be paying a wage premium for a worker who is no more productive (or for whom the productivity premium is less than the wage premium), which the employer would never do. Thus, if one thinks markets work well enough that wages reflect these factors, the simple *presence* in an occupation of workers at a higher education level than indicated by the BLS skill requirements constitutes evidence against the over-education hypothesis. In other words, employers would not hire workers and pay them a wage premium unless they were in fact more productive. This implication is clearly illustrated by the ACS education distributions displayed in Table 5, which show substantial representation of workers above the maximum required BLS education category (as assigned by us) for the two-digit occupation, based on the narrower occupations that make up the two-digit occupation. Based on the evidence in Tables 4 and 5, we conclude that the ACS data reflect real educational demands, and we therefore regard the projections based on the ACS data as much more reliable indicators of skill needs.

Finally, there is a potential caveat to some of these projections, given that some occupations require substantial non-education-related skills. To provide some evidence on the importance of this problem, we explore the extent to which the ACS educational profiles within occupations, as measured at the three-digit level, match up with BLS categories on education and training. We do this by aggregating the more detailed occupations that make up the three-digit occupations and computing the shares in each skill requirement (BLS) or education (ACS) categories. The two measures – not surprisingly – are not entirely consistent. In some occupations, especially those where BLS indicates that high levels of educational attainment are required, the ACS is in strong agreement. For example, the BLS training requirements indicate that all postsecondary teachers will need at least some college education, and the ACS shows that 97.4 percent of postsecondary teachers in 2008 had this level of education. On the other hand, there are some occupations where the agreement is weak. For instance, the BLS classifications suggest that one-third of real estate and other sales persons should have at least some college education, but the ACS shows that three-fourths of all people in this occupational category had at least some college.

Overall, the correlation between the ACS education levels and the BLS category is quite high (with a correlation coefficient of 0.73 between the "any college" shares in the two sources).

In addition, there are occupations where it is clear that most of the jobs require skills related to training or work experience, according to the BLS. Our methods are based on educational specifications, and some of these jobs may require high levels of skills but not much education. For occupations such as these our methods are likely less reliable. Note, however, that there is not a clear bias in one direction or the other. That is, one should not assume that just because some occupations have a fairly high degree of "non-educational" skill requirements, that we should project particularly fast-growing demands for workers in those occupations (making shortages more likely, all else being the same). Moreover, in some of the occupations that BLS identifies as requiring long-term on-the-job training (but no college education), we find substantial shares of workers with at least some college. For example, BLS data suggest that 52 percent of law enforcement workers need long-term training, and we find that 78 percent of these workers have attended at least some college. This suggests that in some occupations, college vocational courses (including those in community college programs that lead to certificates) might substitute for long-term training.

III. Population and Educational Attainment Levels of the U.S. Workforce in 2018

Our projections of skill demands based on BLS occupational projections, and within-occupation levels of education *and trends* in the ACS data, suggest negligible increases in demand for workers without postsecondary training, and substantial increases for those with such education. The next question is whether the skills of the U.S. population will keep up with or instead tend to fall behind the changing skill demands of the economy. To answer this question, we develop new population projections that include educational attainment. The U.S. Census Bureau provides population projections by race, ethnicity, gender, and age, but not by nativity (U.S.-born and foreign-born) or by educational attainment. To produce educational attainment projections, we first develop a new set of population projections that includes nativity as well as race, ethnicity, gender, and age. Nativity is strongly associated with educational attainment, even within race/ethnic groups, and therefore is essential for developing educational attainment projections.

Our projections of the population of the United States by educational attainment form the basis for our determination of the future supply of workers. Note that these population supply projections are not based on occupations or specific fields of study. Thus, we are able to compare these projections with our forecasts of workforce requirements by educational attainment across the entire population, but cannot identify specific occupations in our population supply projections.

United States population projections

Our population projections are derived from a standard cohort component model in which the population is aged across time using age, ethnicity, gender, and nativity cohorts. We consider six race/ethnic groups. Although we constrain our projections to be consistent with population projections produced by the Census Bureau, our projections include nativity.

For each cohort, historical trends are used to generate future fertility, mortality, and migration rates. Our projections of these rates are, in the aggregate (that is, combining both the U.S.-born and foreign-born groups), very similar to those used by the Census Bureau in its "middle series" projections (Hollmann et al., 2000) and in its latest projections (U.S. Census Bureau, 2008). In general, they show declining rates of mortality, mostly stable fertility rates at near replacement levels, and slight increases in international migration.

These fertility, mortality, and migration assumptions lead to modest increases in the population of the United States, with annual growth rates of just below one percent and absolute annual changes of about three million. By 2018, the entire U.S. population should reach about 335 million residents, up from 304 million in 2008. The composition of the United States will continue to change in three notable ways: first, the nation is becoming more ethnically diverse; by 2018 the share of the population that is non-Hispanic white will decline to about 60 percent with notable increases in the share of Hispanics and Asians. Second, and corresponding to the increase in diversity, the foreign-born population is growing more rapidly than the U.S.-born population; by 2018 17 percent of all U.S. residents will be foreign-born, up from 13 percent in 2000, with children born to immigrants representing a sizable source of the U.S.-born growth. And third, the American population will continue to age (Figure 3), with the population in prime working ages projected to grow more slowly than the overall population, and the number of seniors projected to grow more rapidly.[18]

Population projections by educational attainment

Educational attainment *distributions* are projected based on a continuation of historic trends for each of our population cohorts and are identified separately by race/ethnicity, gender, age group, and nativity. We apply these projected educational attainment distributions to our population projections, with the product being population counts by educational attainment. Our base year for the projections is 2008, with educational distributions derived from the American Community Survey, and we use 2000 Decennial Census data to examine trends in educational attainment. We develop projections for eight educational categories (Doctorate, professional degree, Master's degree, Bachelor's degree, Associate's degree, some college, high school graduate, and less than a high school graduate) but combine the latter two categories in most of our reporting to be consistent with the BLS education skills categories.

We employ three methods for developing one set of education projections, using both a cohort approach and a period approach depending on the age group. For adults ages 30 to 80 in 2008 we use a dynamic cohort approach. In this method we follow cohorts across time so that educational attainment in 2018 is based on 2008 levels for the cohort with some adjustments. Adjustments are made based on historic patterns of change in educational attainment observed for similarly aged cohorts from 2000 to 2008. This assumes that life-cycle patterns of educational acquisition trump any period-specific effects. Specifically, letting p denote the proportion of adults in an education category, and letting ed, a, e, s, and n denote education category, age group, race/ethnicity, sex, and nativity, we use:

$$p_{ed,a,e,s,n,2018} = p_{ed,a-10,e,s,n,2008} + \left(p_{ed,a,e,s,n,2008} - p_{ed,a-8,e,s,n,2000}\right) \cdot 1.25\,.$$

[18] Despite the overall aging of the population, one notable change visible in Figure 4 is that a younger age group will surpass one of the baby boom age groups as the most populous in the United States: by 2018, young adults ages 25 to 29 will number 23.3 million, compared to 22.1 million for 55-to-59 year-olds (the largest 5 year age group for the baby boomers). This cohort of young adults is very large for two reasons. First and most importantly, it is the echo of the baby boom; that is, it includes the large cohorts of children born to baby boomers. Second, it includes large numbers of immigrants, as most immigrants come to the United States as young adults. In 2018, we project that 18 percent of 25-to-29 year-olds will be foreign born.

This approach allows for continuing improvements in educational attainment across age-specific cohorts, and also allows us to incorporate acquisition of more education by older workers.[19] For example, the educational attainment distribution of people aged 40-44 in 2018 is based on the distribution of people aged 30-34 in 2008, plus any recent changes (between 2000 and 2008) in the distribution that were observed for people aged 40 to 44 in in 2008.

For younger cohorts, those under age 30, we have to use a somewhat different method, since educational attainment levels change so dramatically as people age from childhood and across young adult ages. Instead, historic patterns of change in educational attainment for the age group are allowed to continue at the same pace. Using the same notation as above, our projections are based on:

$$p_{ed,a,e,s,n,2018} = p_{ed,a,e,s,n,2008} + \left(p_{ed,a,e,s,n,2008} - p_{ed,a,e,s,n,2000}\right) \cdot 1.25\,,$$

which assumes that for each of our population subgroups under age 30, changes in educational attainment observed for an age group from 2000 to 2008 will continue from 2008 to 2018.

Finally, for adults ages 80 and over we use a cohort approach but do not allow for any changes in educational attainment. Again using the same notation as above, our projection is simply:

$$p_{ed,a,e,s,n,2018} = p_{ed,a-10,e,s,n,2008}\,.$$

Our education projections show a continuation of recent and modest gains. Among the population ages 25 to 64, the share projected to have at least a Bachelor's degree continues to increase, from 27 percent in 2000 to 29 percent in 2008 to 31 percent in 2018 (Figure 4). Although strong growth in less-educated immigrant populations is expected to continue, a substantial share of immigrants are college graduates. Strong intergenerational progress for immigrants and notable increases in educational attainment for U.S.-born groups more than counteracts the demographic shifts towards groups that historically have relatively low levels of educational attainment. And not all the demographic shifts have a dampening effect on educational attainment. Although relatively small in number, Asians are the best-educated population group in the United States,[20] and are projected to continue to experience strong rates of population growth (Table 6). Finally, we note that young adults in their late 20s and early 30s have

[19] The multiplication by 1.25 accounts for the different lengths of the time periods covered.
[20] This is true of both U.S.-born and foreign-born Asians.

higher educational attainment levels in 2008 than in 2000. We project that this trend will continue to 2018, leading to greater overall gains in educational attainment (Figure 5).[21]

To predict the potential supply of workers ages 16 and over in 2018, we apply labor force participation rates to our population projections, based on 2008 ACS data for each population and education subgroup,[22] yielding labor force projections by educational attainment for each of our population subgroups. Because labor force participation rates are greater for more highly-educated people, the educational attainment levels of the workforce are slightly higher than those of the entire population, even controlling for age.

IV. Demands versus Supplies

Key findings

Based on educational attainment, our population projections give us a measure of the future *supply* of workers, and the projections of skill requirements by occupation give us a measure of the future *demand* for workers. Comparing them then lets us identify potential imbalances between the demands for and supplies of skilled workers. In Table 7, we compare our preferred educational attainment projections – based on the ACS and Decennial Census data – with the employment projections. The supply shares by educational attainment are based on our population projections (as adjusted for labor force participation), and the demand shares are based on our alternative economic projections. For 2008, these shares are applied to published BLS data on the labor force and employed persons ages 16 and over.[23] Therefore, the difference between supply and demand in 2008 reflects unemployment. That is, the supply represents all workers in the labor force (both those employed and unemployed), while demand represents employed

[21] Our projections of educational attainment levels are not directly comparable to those produced by the National Center for Education Statistics (NCES, 2009). NCES projects the number of degrees awarded each year. It does not project the number of degrees lost to the workforce through retirement or death, nor does it consider the role of international migration.

[22] Alexander et al. (2010) suggest inaccuracies in the ACS data for the labor force participation of adults ages 65 and over, but for our projections, which include workers across all age groups, any such inaccuracies should be inconsequential.

[23] Labor force and employment figures for individuals ages 16 and over are from BLS, "Labor Force Statistics from the Current Population Survey," ftp://ftp.bls.gov/pub/special.requests/lf/aa2008/pdf/cpsaat8.pdf (accessed April 11, 2010). It should be noted that the employment figure of 145.4 million in 2008 is in line with our estimate of employed persons derived from the BLS occupational employment figures after applying the moonlighting rates described in Section II, which we estimated at 146 million employed persons.

workers. Because unemployment rates are higher for the less educated, these supply versus demand comparisons might be viewed as overstating supply relative to demand for the low-education groups [24]

For 2018, we calculate the supply shares by educational attainment using the population projections described in Section III. We calculate demand shares by educational attainment using the dynamic alternative employment projections described in Section II. The demand shares are applied to the total BLS data on projected employed persons, adjusted for moonlighting, which gives us the projected demand for employees by educational attainment.

The primary finding is that, based on our preferred projections, we do not see evidence of a large impending shortage of skilled workers in the United States through 2018. For the most part, our projections of the supply of workers match up quite well with the demand for workers, as evidenced by the similar shares by education. We do see projected shortages for people with an Associate's degree, and the projections point to some excess supply of less-educated workers (those with some college or a high school degree or less) who could be "bumped up" to fill the demand for workers with Associate's degrees. We also see projected shortages for workers with a Doctorate, but this is our smallest education group and it is probably the least precisely projected.

Our comparisons are based on projected total labor force supply of workers, and do not include forecasts of unemployment. Projecting unemployment is tenuous at best, but certainly we would expect some level of unemployment in the future. If we adjust the 2018 supply projections for unemployment rates by education category as observed in 2008, then we would observe a shortage of almost 800,000 workers with an Associate's degree or higher.[25]

For purposes of comparison, the far right column in Table 7 shows demand estimates and projections based on the BLS skill requirements. The BLS-based estimates and projections of employment and worker demand imply that the supply of more highly-educated workers has, and will

[24] In the 2008 ACS data, for example, unemployment rates of workers with a high school degree or less are more than twice as high as for workers who have attended some college or have an associate's degree (9.1 percent compared to 4.4 percent) and are more than three times as high as the unemployment rates for workers who have at least a bachelor's degree (2.8 percent).

[25] Of course, it is not clear what unemployment rates we should consider. For example, our 2018 projection of the supply and demand for workers with a Bachelor's degree implies an unemployment rate of 3.1% for those workers in 2018; this is similar to the observed unemployment rate of 3.3% for such workers in 2008.

continue to, far outstrip the demand for such workers; thus, one certainly gets no *more* evidence of skill shortages from using the BLS data. If the BLS numbers are correct, we might expect to see higher unemployment and greater underemployment of more highly-educated workers in the United States. As noted earlier, we do not find evidence of this kind of underemployment based on earnings data. Similarly, labor force participation rates are higher and unemployment rates are lower for more highly-educated workers.

Important factors underlying the projections

Our finding of no large overall shortage in skills, as measured by educational attainment, relies partly on three key factors that underlie the projections. First, we project that young adults will continue to experience improvements in educational attainment compared to the cohorts that preceded them. Specifically, we project that young adults in their late 20s and 30s in 2018 will be better educated than adults of the same ages in 2000 (as already discussed with reference to Figure 5). Alternative population projections by educational attainment could, of course, lead to different findings with respect to skill shortages. For example, if we do not allow for continued increases in educational attainment for young adults in 2018 as compared to young adults in 2008, we would find substantial projected skill shortages. On the other hand, if we allow for even more increases in educational attainment of young adults, we would project a surplus of highly-educated workers. In particular, our projections of the population by educational attainment, and thus our projections of future shortages or surpluses, are highly dependent on the assumptions we make regarding educational progress of younger adults.[26]

Second, we project continued upgrading of educational attainment levels of older workers. Our projections and analyses of historic trends in skill acquisition (i.e., educational attainment) allow us to identify the extent to which middle-aged workers have continued to acquire new skills. We develop two primary measures of skill acquisition for adults of non-traditional school age: one uses a synthetic cohort

[26] For example, if we change the young age cut-off from age 30 to 35 in our multi-formula approach to projecting educational attainment distributions, the share of workers with at least an Associate's degree would increase from 39.7% of all workers to 40.9% of all workers. This increase yields 2.1 million additional workers with at least an Associate's degree. Increasing the cut-off to age 40 adds 3.4 million workers with at least an Associate's degree as compared to the baseline projection, and implies a surplus of such workers. We believe age 30 is the best cut-off to use, as it allows us to identify different education trajectories of birth cohorts that are old enough to have established clear patterns, but we recognize that this is a subjective decision.

approach, and the second is based on school enrollment rates of middle-aged adults using data from the American Community Survey.

In the synthetic cohort approach, we examine changes in educational attainment reported by adults identified by birth cohort and population subgroup, with the subgroups identified by race/ethnicity, nativity, and gender (characteristics that do not change over time). We project these trends from 2008 to 2018 based on patterns of change observed from 2000 to 2008 (as described in Section III). Because mortality rates are not high for adults under age 60 and international migration rates are relatively low for middle-aged adults, we feel comfortable that our synthetic cohorts reflect true longitudinal changes. We report findings separately by nativity because of notable differences between the U.S.-born and foreign-born, but also because the U.S.-born cohorts are much less likely to be affected by international migration. We use the term "education upgrading" to refer to an increase in educational attainment level.

Results based on our cohort analyses are shown in Figure 6. We project a notable upgrading of educational attainment levels based on recent historic patterns. Overall, among adults ages 40 to 64 in 2018 (ages 30 to 54 in 2008), we project that almost 1 million will have earned a Bachelor's degree between 2008 and 2018, and an additional 1.2 million will have earned a Master's degree.[27] Although these increases represent only a small share of the 104.9 million adults in this age range in 2018, they do represent a substantial share of the net increase in the supply of workers with these degrees.

Enrollment in school among non-traditional-aged students is consistent with this educational upgrading. Although school enrollment declines with age, there is non-negligible enrollment at older ages. Based on ACS data, among those ages 30 to 34 from 2006 through 2008, 5 percent are in undergraduate programs (including community colleges) and 3 percent are in graduate programs.[28] For adults in their late 50s, fewer than 1 percent are in such programs.[29]

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[27] The figures only go through age 64 because there is minimal upgrading at ages 65 and over.

[28] This discussion is based on a restricted sample that only considers enrollment for adults in schooling that is above their current level of educational attainment. The numbers are slightly higher if we include adults enrolled in schooling that is at or below their current level of education, but the patterns remain the same.

[29] The number of students enrolled is much larger than the number that eventually earns a degree. Other research shows that older students take longer and are less likely to earn a degree than younger students (Scott et al., 2006).

A third factor that underlies our projections is that we expect labor force participation rates to continue to rise for more highly-educated older adults, and that past patterns in retirement will prevail for the baby boom as it reaches retirement ages. Specifically, we project greater rates of labor force participation for highly-educated older adults than for those with less education. And because better educated cohorts are entering older adult age groups, our projected overall labor force participation rates among older individuals are even higher in 2018 than they were in recent years (2006 through 2008). Data on older cohorts from the Decennial Census and ACS support these projections. Figure 7 shows that retirement rates are substantially lower for highly-educated older adults than for those with less education. Moreover, retirement rates, which increased notably from 1970 to 1980 and remained near those levels for several decades, have recently declined. For many older age groups, retirement rates are now lower than they were even in 1970. This decrease in retirement rates is consistent with other recent work pointing to modest increases in labor force participation of older individuals. In particular, Toossi (2009) suggests that a number of factors, including good health, the cost of health insurance, the shift from defined benefit to defined contribution pensions, and changes in Social Security, should all engender a shift toward increased labor force participation.

Finally, it is important to note that our projections depend very much on a continuation of recent historical trends as observed in the 2000 Census and 2008 ACS. Use of alternative base periods or alternative data could lead to different projections.

Skill shortages in the longer term?

One reason we might not see evidence of a large skill shortage is that our projection horizon is too short. Our projections extend to 2018 because the BLS projections end there, but the majority of boomers (two of every three) will be younger than age 65 in 2018. Extending the projections to 2030 would much more fully capture the labor market implications of the aging baby boomers

We can, nonetheless, offer some reasoned speculation about the potential for skill shortages in the longer term. The key consideration is the retirement of large numbers of relatively well-educated boomers. In 2018, the oldest boomers will be 72 years old and most of them will be retired. However, the youngest boomers will only be 54 years old and most of them will be working. By 2030, all of the boomers will have reached retirement ages, with the youngest boomers being 66 years old and the oldest reaching 84 years old. As noted earlier, over time there has been dramatic growth in the number of older adults with a Bachelor's degree but only modest growth in the number of younger adults with the same education. This has important implications for the future supply of highly-educated workers. In 1990 highly-educated older adults – who were to retire over the next 20 years – were relatively few in number. Replacing those retirees was not a difficult task given their small numbers. Indeed, the cohort of well-educated younger adults that would replace these retirees was more than two times the size of the retiring cohort (comparing 25- to 44-year-olds in 1990 with 45- to 64-year-olds in that year). But this pattern has changed. By 2008, the number of older well-educated adults set to retire over the next 20 years had more than doubled, and was almost as large as the younger adult cohorts set to replace them in the labor force (Figure 1).

We expect that projections of the U.S. economy to 2030 would show a continuation of current patterns, with greater rates of growth in industries and occupations that employ highly-educated workers, consistent with the long-standing trend in the United States of moving towards a more highly-skilled economy. One certainty is that the aging of the boomer cohorts will drive up the demand for health care. Because health care occupations tend to have higher skill requirements than other occupations, the more rapid growth of this sector will contribute to greater demand for highly-educated workers. Combined with the demographic supply forecasts to 2030, it is plausible, then, that general skill shortages would be more evident in projections extended to 2030.

Skill shortages in some states?

Although we do not find evidence of substantial pending skill shortages nationwide to 2018, many states could experience shortages of highly-educated workers. As shown in Table 8, older adults nearing retirement ages are notably better educated than young adults in at least 20 states, including three of the nation's four most populous states: California, Texas, and Florida. As these older adults exit the labor force and enter retirement they will be replaced by younger cohorts with less education. And because these older cohorts are large in size, the absolute changes will be large as well.

In some of the states that face potential skill shortages the key driver is the changing demographic composition of the state. Large and growing populations of Hispanics, a group that historically has relatively low levels of educational attainment, are entering the labor force in greater numbers in these states, and they are replacing older, better-educated, mostly non-Hispanic cohorts that are reaching retirement ages. States that fit this profile include California, Texas, Florida, Arizona, Colorado, New Mexico, and Nevada. The importance of these demographic changes is illustrated by a simple exercise. In Table 9 we develop new estimates of the supply of workers for the nation, but substitute California's ethnic composition in 2018 for that of the entire United States. In other words, we ask the question, would there be a national skill shortage if the country had California's demographic mix? The answer is yes; we find a deficit of 3.1 million workers with an Associate's degree or higher, and an even larger surplus of workers with a high school degree or less.

A large and growing immigrant share is not the only potential source of skill shortages in the future. In states in which resource extraction is a large sector of the economy (such as Alaska and Wyoming) the pattern might simply reflect the nature of the state economy, with relatively large numbers of blue-collar jobs attracting young adults with low levels of education. And in states such as Hawaii, Oregon, and Washington, college enrollment rates of high school graduates are quite low, while there have been inflows of more-educated older migrants.

V. The Meaning of Skill Shortages

Economists are naturally uncomfortable talking about shortages, because in a market economy shortages are resolved by the market, and hence do not, literally speaking, emerge. But that does not imply that projected differences between demands and supplies of skilled workers do not affect the economy. As a prime example, there is a huge literature in labor economics noting how changes in demands and supplies of skilled workers have affected the distribution of wages (e.g., Goldin and Katz, 2002). Nor does it imply that there is no scope or rationale for policy to respond to projected differences between demands and supplies.[30]

Freeman (2006) suggests that, in this context, the projected "shortages" of skilled workers should include the "changes in prices from long run equilibrium values that could have been avoided if market participants had foreseen the shifts in demand or supply better than they did" (pp. 1-2). The problem is even more complex because adjustments to projected skill shortages are likely to be numerous. First, we should expect supply responses. For example, in reaction to price increases for more skilled labor, we would expect workers to acquire more skills. In addition, higher prices for skilled workers might entice some people to re-enter the labor market (for instance, after childbearing) or to remain in the labor market longer than now occurs (for instance, delaying retirement). Second, we would expect demand responses. Whereas demand projections by skill assume "business as usual" with regard to the types of workers used in particular industries and occupations, if the price of skilled labor rises substantially, employers would likely move away from skilled labor and toward less-skilled labor. In the face of skill shortages, we might also expect more demand for skilled immigration (as well as more supply), in which case the response would depend on immigration policy.[31] And given that capital is more mobile than labor, if the skilled immigration were not forthcoming, U.S. firms would likely find ways to employ skilled workers overseas, and the same might apply to cross-state variation within the United States. Thus, it might be best to think of the projections in this paper as indicating how demands and supplies for skilled workers would evolve in the absence of this entire set of responses.[32]

These considerations suggest that projected skill shortages, as we define them, can have implications for policy. First, even if businesses respond to increases in the price of skilled labor by substituting less-skilled labor, this nonetheless implies real costs for companies. In the simple neoclassical theory of the firm, businesses make cost-minimizing input choices. Increases in the prices of

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[30] Barnow et al. (1998) point out, however, that policy responses are not necessarily beneficial or even benign, arguing that governments may overreact to shortages and hence create countervailing problems, and that efforts to increase supplies to reduce shortages have negative consequences for wages of workers in the shortage occupations.
[31] Freeman (2006) presents evidence that this happened during the 1990s.
[32] Freeman (2006) also discusses other problems with projecting skill needs, many of which are related to the possibility that responses to skill imbalances will lead to differences relative to the "independent" projections of skill demands and supplies.

an input (in this case, skilled labor) will increase employers' marginal costs and consumer prices, reducing overall labor demand. That does not necessarily imply that policy efforts to increase the supply of skilled labor, and hence avoid these cost increases for companies, would increase welfare, since increasing skill levels also entails costs. Moreover, a policy intervention may not be called for, since one might simply rely on individual decisions regarding the acquisition of more skills to generate the "right" market response. However, to the extent that there are barriers to individuals or businesses making decisions regarding investments in higher skills, there may be scope for policy intervention. For example, firms have little incentive to invest in worker skills that lead to the accumulation of general human capital (Becker, 1964). This might not be a concern, as individuals may be relied upon to make decisions about the right amount of investment in general human capital. However, Acemoglu (1997) and Balmaceda (2005) show that if labor markets have non-competitive features, underinvestment in both general and specific training can occur.[33] With respect to investments in schooling, similar concerns arise, as capital market constraints can deter investments in schooling by the young (e.g., Haskel and Holt, 1999). And the analysis discussed earlier shows that projected shortfalls in the supply of educated workers will be more severe where there are growing minority and immigrant populations, and these groups likely face more severe capital constraints.

It is reasonable to ask how much scope there actually is for schooling to respond to changes in the economic returns to education. We know that in the latter part of the 20th century, there were sharp increases in the returns to schooling (e.g., Goldin and Katz, 2007). Yet there is essentially no evidence that there was a supply response in terms of increased shares of workers with higher education. Indeed the most serious part of the run-up in schooling wage premia is attributed to the rising demand for educated workers in the face of a *decline* in the growth rate of educated workers (Blackburn et al., 1990; Goldin and Katz, 2007). According to Goldin and Katz the decline in the growth rate of education is not principally due to rapid growth in immigration beginning in 1965, but instead to developments among the

[33] There may also be more idiosyncratic barriers to investment in particular fields. For example, consider demand for workers in "green jobs." Workers contemplating investing in retraining for green industries may have legitimate concerns that government subsidies for these industries may be withdrawn in the future (as has happened in the past for wind energy, e.g., Gipe, 1995), and hence may only engage in the retraining if there are subsidies.

native-born (p. 155). Note that this apparent absence of a supply response is among *young* cohorts who *can* respond easily by staying in school. In contrast, we might expect less response among older cohorts who have already finished full-time schooling – a factor that would impede the extent to which skill levels among workers might rise in response to greater demand for more highly-educated labor. On the other hand, there may be some scope for a supply response among older workers via labor supply, rather than additional investments in skill. For example, rising wage premia for more highly-educated workers may induce older educated workers to remain in the labor force a bit longer, or induce educated women who may have left the workforce for childrearing to re-enter the labor market. And at the state level there may be more scope for supply responses, in part because internal migration in the United States is unrestricted.

As Freeman (2006) emphasizes, in a global economy U.S. firms would also likely respond to skill shortages by hiring skilled workers in other countries. This would mitigate the cost increases entailed by any projected skill shortages. But state or federal policymakers might prefer to foster high-wage, high-skilled employment at home, rather than importing the products of skilled workers from abroad, especially if part of the problem is barriers to investment in the skills of their workers. There are many reasons for governments to prefer a high-skilled to a low-skilled workforce, including a larger tax base, more technological progress, and fewer of the socioeconomic problems (and related government costs) associated with low-skilled work.

VI. Conflicting Evidence

Alternative projections

In a recent study, Carnevale et al. (2010) examine the same time horizon we do, but reach a very different conclusion, specifically: "By 2018, the postsecondary system will have produced 3 million fewer college graduates than demanded by the labor market" (p. 16). Contrast this with what our projections in Table 7 show: a shortfall of 356,000 workers with Associate's degrees, an excess of 1 million workers with Bachelor's degrees, and an excess of 679,000 workers with more-advanced degrees, or, on net, excess supply of those with an Associate's degree or higher of 1.3 million workers.[34] Clearly it is important to understand the differences between our projections and theirs, and to see if we can arrive at a firmer idea of the likely imbalances between demands for and supplies of skilled workers.

There are a number of potential sources of differences in the projections of future imbalances between demands for and supplies of skilled workers. First, we project educational imbalances for the entire stock of workers in the economy, while Carnevale et al. do this based on job openings. Second, they compare demand and supply projections from different data sources that could be non-comparable. Their demand forecasts combine dynamic forecasts of education within occupations using March Current Population Survey (CPS) with occupational employment forecasts provided by Economic Modeling Specialist Incorporated (EMSI) that are calibrated to total employment forecasts from Macroeconomic Advisors (MA), whereas their supply forecast comes from an independent source (NCES) that projects degrees conferred annually. In contrast, we use Census and ACS data as the basis for both our demand and supply projections, and rely on BLS occupational employment projections. Moreover, our supply projections implicitly take into account immigration, an important source of additional workers to the United States, whereas the NCES projections of degrees conferred is restricted to U.S. colleges and the Carnevale et al. adjustments do not appear to include immigration.

Carnevale et al. report projections of both *total* educational demand by occupation and educational demand for *job openings*, although they base their main conclusions on the latter. We, on the other hand, limited our projections to *total* educational demand by occupation. Given that their projections of future imbalances between demand for and supplies of skilled workers are based on educational demand for *job openings,* and ours are based on the entire stock of workers of the economy, a direct comparison is not possible. However, we can compare the *total* educational demand projections in both studies and see how different or similar they are. And this comparison is informative because if we put their projected total educational demands up against our supply forecasts, we reach a conclusion

[34] Note that they group as college graduates those with an Associate's degree or higher; so this final number is the most comparable one. Carnevale et al. do not include projections of unemployment, nor do we in these comparisons.

similar to *theirs* – that there will be shortage of more than 3 million workers with Associate's degrees or better by 2018. Specifically, as shown below, Carnevale et al. project a total demand for workers with Associate's degree or better of 44.6% by 2018, which is 4.9 percentage points higher than our projected supply of workers with this level of qualification (39.7%), implying a shortage of about 3.4 million workers. Thus, either using job openings or total jobs for their educational demand projections the conclusion is the same. The advantage of focusing on their *total* demand projections is that we can then do some comparisons with our projections.

In general terms, the structure of the *total* educational demand projections in the Carnevale et al. study is similar to ours.[35] Both take the same approach to estimating the educational requirements of occupations, foregoing using the BLS skill requirements and instead using the observed educational distribution and trends. The difference, however, is that we use Decennial Census and ACS data, while Carnevale et al. use CPS data.[36] Furthermore, their approach for forecasting educational demand provides an estimate of the number of jobs within each occupation that require an educational level, rather than the number of total employees (i.e. people) required to fill these positions, and the two can differ because some people hold more than one job at a time. For this reason we converted their projected numbers of jobs into projections of numbers of people, using CPS data on multiple jobholding by education category to make their demand projections and ours directly comparable.

Table 10, which compares the total educational demand projections from both studies, shows a big discrepancy in the projected distribution of educational requirements by 2018. Specifically, Carnevale et al. project a 2.2 percentage point higher demand share for Associate's degrees, and a 2.3 percentage point higher demand share for Bachelor's degrees. (These are offset slightly by a 1.2 percentage point *lower* demand share for degrees above the Bachelor's.) In aggregate terms, this means a 3.3 percentage point higher demand share for workers with Associate's degrees or better.

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[35] Carnevale et al. summarize their educational demand projections, including their methods and data sources, in Figure 1 of their Technical Appendix. The first step in their educational demand projection process is forecasting the educational distribution within occupations; the second step is estimating long-term employment projections; the third step is estimating change in the occupational structure; and finally, the fourth step is projecting educational demand to 2018.

[36] Moreover, Carnevale et al. restrict education requirements to the attainment levels of prime age workers (25-54) rather than workers 16 and over.

It turns out using the CPS data leads to a quite different projection of demand for educated workers, and this helps account for the differences between Carnevale et al.'s total educational demand projections and ours. In particular, as Table 11 shows, the CPS data show a higher share with college degrees at a point in time, and faster growth rates in these shares over time, both of which (as explained earlier) affect the projected demand for workers with college degrees. The difference in the distribution at a point in time is likely because of the different questions in the two surveys. For options between "high school graduate" and "Bachelor's degree," the ACS responses include "Some college credit, but less than 1 year," "1 or more years of college, no degree," and "Associate's degree (for example, AA, AS)." In contrast, the CPS responses include "Some college but no degree," "Associate degree in college – Occupational/vocational program," and "Associate degree in college – Academic program." As a result, more people in the CPS get coded as having an Associate's degree, once the two categories are combined, likely because some CPS respondents treat occupational or vocational certificates as Associate's degrees. Moreover, for reasons that are less clear, over the 2000 to 2008 period the CPS show a faster decline in the share of less educated workers (high school or less and some college) and faster growth in the share of Associate's degrees or better, driven by *much* faster growth rates in the shares with Bachelor's degrees or higher. Another difference between the two studies is that we apply our projected education distribution by occupation to BLS 2018 occupational employment projections, while Carnevale et al. their projected educational distribution to different occupational employment projections.

Given the different data sources, the discrepancies between Carnevale et al. demand projections and ours could be attributable to differences in the projected educational requirements within occupations (baseline and trend), and/or differences in the occupational employment projections. We modeled five alternative scenarios to assess the role of each of these. For this exercise we are not using Carnevale et al.'s actual education distribution, because all the information is not available in their report, but instead our calculations of this distribution using the CPS data, which is what they used.

We first established that differences in baseline and projected occupational employment do not matter, by applying our projected distribution of educational requirements by occupation to Carnevale et al.'s 2018 occupational employment totals. As shown in Table 12, column (2), this change results in nearly the same projected demand shares by education (compare to column (1)). Next, we examined how using CPS data as our baseline education distribution changes our demand projections. Specifically, we started with the 2008 CPS education distribution by occupation and then we applied projected growth rates based on the Census and ACS data on education by occupation to arrive at estimated levels of workers by education level in each occupation in 2018. Just changing the baseline education distribution to use the CPS data leads to a much higher projected share of workers requiring Associate's degrees or better in 2018, increasing from 41.35% to 44.44% (column (3)). In the next scenario, we retained the ACS baseline education distribution by occupation, but used the projected trends in education within occupation that we get from the CPS data, instead of from the Census and ACS data. This, too, leads to a considerably higher projected demand for workers with Associate's degrees or higher in 2018 – 43.61% compared with 41.35%. Given that both the CPS baseline and growth rates lead to higher demand for more-educated workers, it seems likely that using both – i.e., relying solely on the CPS data – would exacerbate this difference. Column (5) shows that this is actually the case. Finally, in the last scenario we used both CPS baseline distribution and growth rate and we also used Carnevale et al. occupational employment figures. We see, again, the differences in occupational projections matter little (column (6)). Overall, then, the difference in the demand-side projections is driven by differences between the ACS/Census and the CPS in the measured distribution of education, and changes in this distribution.

Although we have an explanation for why the CPS and Census or ACS data give different baseline distributions by education (and think that the CPS overstates the number of Associate's degrees), the difference in growth rates depicted in Table 11 is more puzzling. Visual inspection of graphs of the shares in each education category by year revealed that 2008 was anomalous. In particular, in the CPS data the shares with Bachelor's and Master's degrees (and to a lesser extent Associate's degrees) jumped up sharply relative to the ACS data in 2008, after tracking growth rates in the ACS closely through 2007.

In the ACS, the shares with different degrees did not jump, although the share with some college did. In both data sets, there was a fairly steep decline in the share with a high school degree or less from 2007 to 2008; the difference is that in the ACS the redistribution is towards the some college category, whereas in the CPS it is towards the Bachelor's and Master's degree categories, which is particularly hard to understand.[37]

Given that the two data sets track educational trends much more closely through 2007, we redid the demand-side forecasts using data from 2000-2007 (rather than 2000-2008) to estimate the within-occupation trends in education. These projections are shown in the last two columns of Table 12. The projections using the ACS/Census data, in column (8), are very close to our original projections (column (1)) with regard to college degrees, although the high school degree or less versus some college distribution differs. When we redid the column (5) projections using these alternative estimates of within-occupation trends in education, however, there is a larger change; the growth in demand for workers with college degrees falls back across all degrees, and is much closer to the column (3) projections, which used our original estimates from the Census and ACS of trends in education within occupations. In other words, the projections using the CPS data are quite sensitive to the particular year used to estimate the within-occupation education trends. Moreover, once we use a different ending year (and it clear from inspection of the data that using 2005 or 2006 would yield similar results), the difference in demand-side projections using the CPS versus the Census and ACS is solely attributable to the different baseline educational distribution in the CPS, which we have called into question because of how occupational and vocational programs likely get coded.

Finally, a potential problem with the Carnevale et al. projections is that the data used for the supply-side projections are not connected to the data used for the demand-side projections. Differences between supply and demand could emerge simply because the data sources are incompatible. Using the CPS on both sides of the market should help resolve these issues. By the same token, given the

[37] We are also skeptical about the sharp changes in the ACS (of about two percentage points) in the shares with a high school degree or less and some college. However, these changes do not affect projections of the demand for workers with college degrees. The graphs of shares by education over time in the alternative data sources are available from the authors upon request.

differences between the CPS and Census/ACS data discussed, comparing demand-side projections using CPS data to our supply-side projections using the Census and ACS data is invalid. Thus, to more accurately assess the implications of using the CPS data, we replicate our supply and demand projections as described earlier, but using CPS data on *both* sides of the market.

Using CPS data, we end up with a shortage of 668,000 skilled workers by 2008 (see Table 13), which contrasts with the 1.3 million oversupply of skilled workers that we project using Census/ACS data. This is mainly attributable to the faster growth in the shares with college degrees in the CPS data, as the higher shares in *each* year are largely offsetting on the demand and the supply side. Our population projections show greater growth in groups that tend to have lower levels of educational attainment, for example foreign-born Latinos, and the gains in educational attainment shown in the CPS are moderated by these demographic composition effects. Most important, though, using the CPS data on both sides of the market leads to much milder projections of skill shortages than the dramatic shortages that Carnevale et al. project.

Thus, although using the CPS data leads to somewhat more evidence of a shortage, it is two factors – the combination of demand forecasts from one source and supply forecasts from a non-comparable source, and the difference in baseline education distributions in the CPS – that underlie the lion's share of the skill shortage projected by Carnevale et al. At the same time, we recognize that all projections are subject to uncertainty – from many sources in addition to those we have discussed. The fact that the projections look somewhat different with the CPS – even if we are more skeptical of the CPS-based projections – serves to emphasize that a range of uncertainty surrounds these projections.

Criticism of using education to measure skill requirements

Harrington and Sum (2010a, 2010b, forthcoming) have been highly critical of the projections in Carnevale et al. (2010). These criticisms pertain to using observed education in an occupation to infer the required level of education, rather than BLS skill requirements. Given that we use the same methods, their criticism applies equally well to our projections, and we therefore address it here. A direct quote best summarizes the issue they raise, recalling, as shown earlier, that the BLS skill requirements point to much lower demands for educated workers:

> "Could BLS, the most objective, impartial and certainly data rich observer of American labor markets, so grossly underestimate the projected demand for college graduates for such a relatively short time horizon? Our answer to this is no! Instead, after a careful review of their data and methods we find that the Georgetown authors [i.e., Carnevale et al.] radically overstate the size of the college labor market …" (Harrington and Sum, 2010a).

Instead, in their view the problem is that many college workers are in jobs that do not require college degrees, which Harrington and Sum refer to as "mal-employment." They define mal-employment as the "inability of a college graduate to find a job that effectively uses the knowledge, skills and abilities acquired in college …" and characterize mal-employment as "perhaps the most pressing problem facing college graduates in the nation today …" (Harrington and Sum, 2010a).

What is the evidence in support of this view? Using 2006-2008 ACS data, Harrington and Sum (forthcoming) first classify occupations as belonging to the "college labor market" (CLM) based on the share of workers in the occupation with a college degree. They did not mention any cutoff for this share, but provided an appendix with a list of occupations they classify as CLM occupations. This list includes all occupations with 2-digit SOCs from 11 to 27, plus a small subset of occupations in the remaining SOCs.[38] Given this classification, they estimate a standard log earnings regression for 22-64 year-olds that estimates the economic returns to each type of degree (Associate's, Bachelor's, or advanced), but that distinguishes between those who – according to their classification – are in jobs that do not require a college degree. They find (their Table 5) large returns for those in jobs that *do* require a college degree: 47.1% for an Associate's degree (relative to high school graduates), 63.1% for a Bachelor's degree, and 79.9% for a more-advanced degree. In contrast, for the "mal-employed," the corresponding returns are a paltry 9.9%, 14.5%, and 18.9%, suggesting that the economic return to these degrees for those who they classify as mal-employed are less than one-quarter as large as those not mal-employed. These estimates

[38] To gauge how this list stacks up against alternative ways of defining the college labor market, we took the skill requirements from the BLS and the education requirements from O*NET (discussed below), and created indicators for whether an occupation required a Bachelor's degree or higher, according to these sources. Cross-tabs with the CLM classification from Harrington and Sum indicate that most of the occupations classified by them as *not* belonging to the college labor market are also classified the same way under the other two classifications. However, there is a weaker correspondence for the occupations they classified as belonging to the CLM, with quite a number of these not being classified as requiring a Bachelor's degree or higher based on the other two methods.

are shown in column (1) of Table 14; here, instead of showing the separate returns for those in jobs that do and do not require a college degree, we show, in the lower panel, the implied interactions between degree held and whether an individual is not in what they call the college labor market – or education-"mal-employment" interactions – which measure the difference between the two groups.[39]

In our view, there are good reasons to be skeptical of this evidence, and therefore of the conclusions that Harrington and Sum reach that education of workers *in* jobs badly overstates the required education for those jobs. First, the evidence they present appears directly at odds with the findings reported in Table 4 earlier in the paper, which show substantial economic returns to higher educational degrees in occupations where, according to the BLS skill requirements, those degrees were not required. In general, the returns to degrees when the degrees are not required are smaller than in other occupations, but nothing like the estimates Harrington and Sum report, which are lower by more than 75% for Associate's, Bachelor's, and more-advanced degrees. Second, there is a large literature on the question of "overeducation," and although this literature does tend to find, as in Table 4, that workers classified as overeducated (in a number of alternative ways) earn a smaller education premium on their "surplus" education, these returns to overeducation are not close to zero, but are more likely to be in the range of at least one-half the return earned by those who have the required level of education.[40]

Third, their estimates come from regressions with occupation dummy variables excluded. On a priori grounds this is likely to lead to lower estimated returns to education for those in occupations that use less-educated workers, and this is confirmed in the data. Clearly for this kind of exercise occupational controls should be included, since otherwise what we identify as an education premium, or as a differential in the education premium depending on whether a person is in a job requiring his or her education level, may simply be an occupation effect. The education-"mal-employment" interaction would be biased downward if, as seems plausible, conditional on education "mal-employed" workers are concentrated in lower-paying occupations. For example, Harrington and Sum (2010a, forthcoming) tell

[39] The 9.9% return to an Associate's degree for those mal-employed, for example, comes from subtracting 0.372 from 0.471.

[40] Rubb (2003, Tables 1 and 2) presents an extensive meta-analysis of these results. For specific examples, see Duncan and Hoffman (1981, Table 4); Rumberger (1987, Table 3); and Cohn and Kahn (1995, Table 2). A spreadsheet summarizing these studies is available from the authors upon request.

the "story" of bartenders (for which a college degree is likely not required) and compensation and benefits managers (for which it is). The question is not whether bartenders earn less than compensation and benefits managers, but whether the return to education *within* the bartender occupation is much less than the return within the compensation and benefits manager occupation, which is answered by including occupation dummy variables. Note, by the way, that our regressions in Table 4 parallel the inclusion of occupation dummy variables. There, we estimate the regressions occupation-by-occupation, which allows a different intercept for each occupation.

To examine the effect of the exclusion of occupation dummy variables, we began by replicating Harrington and Sum's results using ACS data for 2008. As reported in column (2) of Table 14, the estimates were nearly the same. Second, we restricted the specification to only include interactions of the "mal-employed" indicator with Bachelor's and more-advanced degrees, dropping the interaction with "less than high school," "some college," and "Associate's degree," as it does not make sense to think of someone without a Bachelor's degree in a job that does not require a Bachelor's degree as "mal-employed," based on Harrington and Sum's definition.[41] The estimates of this more-restricted specification, in column (3), are very similar.

However, column (4) shows that including the occupation dummy variables is very important; the estimates indicate that the exclusion of occupation dummy variables from the specifications drives Harrington and Sum's results. In column (3), where occupation dummy variables are excluded, the estimated returns to college degrees when they are beyond a job's required education level are significantly lower, with 50.3 percentage points, or 75%, of the 66.9% earnings premium for a Bachelor's degree evaporating. However, when the occupation dummy variables are included, the difference is much smaller; although the earnings premium for a Bachelor's degree in jobs not in their college labor market is lower by a statistically significant amount (12.7%), this is a much smaller differential – especially in absolute terms. The same is true for more-advanced degrees.

[41] Moreover, if one did want to include these interactions, there would be no reason to exclude the interaction with the dummy variable for high school degree.

Given that the original thrust of Harrington and Sum's work (as quoted above) was to defend the BLS skill requirements, and to criticize Carnevale et al. for not using them, it is of greater interest to explore this question using these skill requirements. We also do this for another "expert" analysis of education requirements based on the O*NET.[42,43] In these estimations, reported in columns (5)-(8), the interactions are a little different, indicating that the individual has a degree higher than the required degree; as such, these specifications give us a sharper test of the "mal-employment" or "over-education" hypothesis.

With the BLS and O*NET education requirements, the evidence against claims of severely lower earnings for those with more education than deemed required is even sharper. It is true that, with the occupation dummy variables left out in columns (5) and (7), the estimated returns to Associate's and Bachelor's degrees are considerably lower for those in jobs that do not require these degrees. However, the differential return for Bachelor's degrees is more modest than using Harrington and Sum's "college labor market" definition (compare, e.g., the estimates of −0.288 in column (5) and −0.503 in column (3); in addition, the differential is much smaller for those with Master's degrees.[44] But when the occupation dummy variables are included the differences in earnings premiums for college degrees for those in jobs where BLS or O*NET deems the degrees not required are small (e.g., the estimate of −0.042 in column (6)). Most interesting, perhaps, for Associate's degrees there is no longer *any* evidence of a lower return

[42] See, e.g., http://www.onetcenter.org/overview.html (accessed May 26, 2011). The O*NET database reports a distribution of the required level of education for each occupation (12 categories) based on the responses of a sample of job incumbents or occupational experts. To provide a summary measure for each occupation, we computed the "average" required level of education by translating the distribution of responses into a 12-point scale and taking the weighted mean, using the percentage of respondents in each education level as weights (if the mean was fractional, we rounded down).

[43] In Table 4, we had to assign a degree requirement to each 2-digit occupation, although these are defined at a more disaggregated level. One advantage of the analysis of the "pooled" regression in Table 14 is that we can look at each individual's 6-digit occupation and define whether or not they are "over-educated" relative to BLS or O*NET education requirements. Note also that the educational degree classifications are slightly different. To match our projections, in Table 4 we combined high school degree and less than high school; and we distinguished Master's, Professional, and Doctoral degrees. None of this bears on the main estimates of interest, though – for Associate's and Bachelor's degrees.

We took the education requirements from the BLS and O*NET classifications, both at the 6-digit SOC level, and merged it with occupations in the ACS 2008 sample; in cases when two or more occupation codes were bundled together in the ACS, we assigned the maximum of the education requirements to the bundled occupation.

[44] This could be because in the Harrington and Sum analysis all we have is a classification based on Bachelor's degrees, so Master's degree holders could, in a sense, be more over-educated in columns (3) and (4) than in columns (5)-(8), where they are only deemed over-educated if they are in a job that does not require a Master's degree.

to education for those with Associate's degrees in jobs that, according to BLS or O*NET, do not require them. The estimated interactions are actually positive.

There is additional evidence that the specifications without the occupation dummy variables are uninformative about "mal-employment." In particular, note that in columns (1) and (2) there are also large negative estimates of the interactions between "less than high school" and "some college" and being in a job that does not require a college degree – of roughly the same magnitude as the estimates for Associate's and Bachelor's degrees. Clearly these estimates should not be interpreted as "mal-employment" of those *without* a college degree. Instead, what these similar estimates for those who *cannot* be mal-employed indicate is that the occupations with fewer college-educated workers are simply lower-paying occupations. In addition, notice that the economic returns Harrington and Sum report for those who are *not* mal-employed are extraordinarily high. If we look at the standard labor economics literature on the returns to schooling, the consensus estimate of the return to a year of education is about 8-9%, implying 16-18% for an Associate's degree, 32-36% for a Bachelor's degree, etc. In contrast, their estimates (cited above) were 47%, 63%, and 80%. Again, this reflects the omission of occupation controls, coupled with the fact that more-educated people work in higher-paying occupations.

As an empirical description it is true, as Harrington and Sum (2010a) indicate, that "at every level of college attainment … large negative earnings impacts were associated with failure to find work in the college labor market." However, their analysis confuses earnings differences *across* occupations and earnings differences *within* occupations. The weak interactions between college degrees and the indicator for degree higher than required imply that, although all workers in the occupations in which these supposedly "overeducated" college graduates work are paid less, the occupation-related earnings differences are not very different for college degree holders and non-degree holders. But there are lots of reasons people choose to work in particular occupations even if they pay less.[45] To answer the question

[45] The original discussion goes back to Adam Smith: "the wages of labour vary with the ease or hardship, the honourableness or dishonourableness, of the employment. Thus in most places, a tailor earns less than a weaver. His work is much easier. A weaver earns less than a smith. His work is not always easier, but it is much cleanlier. The trade of a butcher is a brutal and odious business; but it is in most places more profitable than most trades. The most detestable of employments, that of public executioner, is, in proportion to the quantity of work done, better paid than any other. The keeper of a tavern, who is never master of his own house, and who is exposed to the

of whether there are returns to education *within* an occupation, one clearly has to include the occupation dummy variables, and that analysis shows that there are returns to college degrees even when the BLS (or O*NET) suggest that these degrees are not required.[46] As a consequence, we conclude that the Harrington and Sum critique of using observed rather than "required" education to capture skill demands is largely unfounded.

VII. Conclusions and Implications

Our analysis does not point to national-level evidence of substantial shortages of skilled workers over the near term. Nonetheless, there are potential benefits to efforts to improve educational outcomes and increase worker skills. First, over the longer term, as more of the baby boomers retire, skill imbalances are more likely as long as demands for skilled workers continue their long-term secular increase, because, unlike past retirements, the baby boomers will not be replaced by cohorts with much higher education levels. Second, there is suggestive evidence that some states – in particular those with greater representation and expected population growth from less-educated demographic groups – could face some skill shortages. Third, our research focuses on the supplies of and demands for workers classified by educational degrees, and it is possible and in fact probably likely that shortages will emerge in specific skilled occupations. And finally, policymakers have some degree of choice over how to respond to potential imbalances between demands for skilled workers and supplies of skilled workers. Improvements in worker skills and increases in educational attainment could help maintain and spur the creation of higher-paying jobs, which has numerous potential benefits for individual citizens and the economy as whole.

Future research should expand on the issues we consider in this paper – state-specific shortages and migration and other responses; particular occupations and education fields that might be in short

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brutality of every drunkard, exercises neither a very agreeable nor a very creditable business. But there is scarce any common trade in which a small stock yields so great a profit" (Smith, p. 202, 1776). For a modern treatment and application, see Killingsworth (1987).

[46] To make this even more clear, Harrington and Sum (forthcoming) argue that "If no such thing as "mal-employment" exists … then there should be no weekly earnings differences among young college graduates regardless of whether they worked in a college labor market occupation or not" (p. 17). But their definition of mal-employment is that workers are overeducated "relative to their job" (p. 13). In the latter case, though, we would expect no earnings premium for college degrees in jobs in which the degrees are not required. Clearly, then, the right test is to estimate the earnings regression including occupation dummy variables.

supply; reconciling conflicting projections; and perhaps most important, exploring longer-term projections. This would help to better understand the possible large-scale skill shortages that could emerge despite our findings at present. Our research identified substantial upgrading of skills of middle-aged and even older workers. More research could be done to identify determinants for participation in such educational upgrading, to see what the effects are in terms of labor force outcomes, and to locate where this upgrading is occurring institutionally. We strongly suspect that more systematic study of how community colleges can better enable workers to make investments in skills to meet changing workforce demands would be particularly useful.

We also caution that our approach took the BLS projections as an accurate prediction of where the U.S. economy is headed in terms of the mix of occupations. Our analyses based on the 2008 distribution of occupations shows substantial differences between the American Community Survey and the BLS. For example, managerial occupations and legal service occupations seem to be substantially underrepresented in the BLS 2008 occupational employment numbers relative to the ACS. Both of these occupational categories disproportionately employ highly-educated workers. In contrast, the BLS estimates for 2008 show greater numbers of workers in food preparation and serving occupations, jobs that tend to require relatively low levels of education. Future research should resolve these differences and could lead to alternative occupational projections.

More generally, there are clear sources of uncertainty in any forecasts, and our context is no exception. We have discussed some sources of disagreement about future skill needs and supplies. There are also issues of the statistical precision of forecasts that have not been incorporated into our analysis. Finally, policy changes – perhaps most importantly health care and Social Security reform – could substantially affect labor supply decisions of the baby boomers, in turn affecting the supply of skilled workers available to employers.

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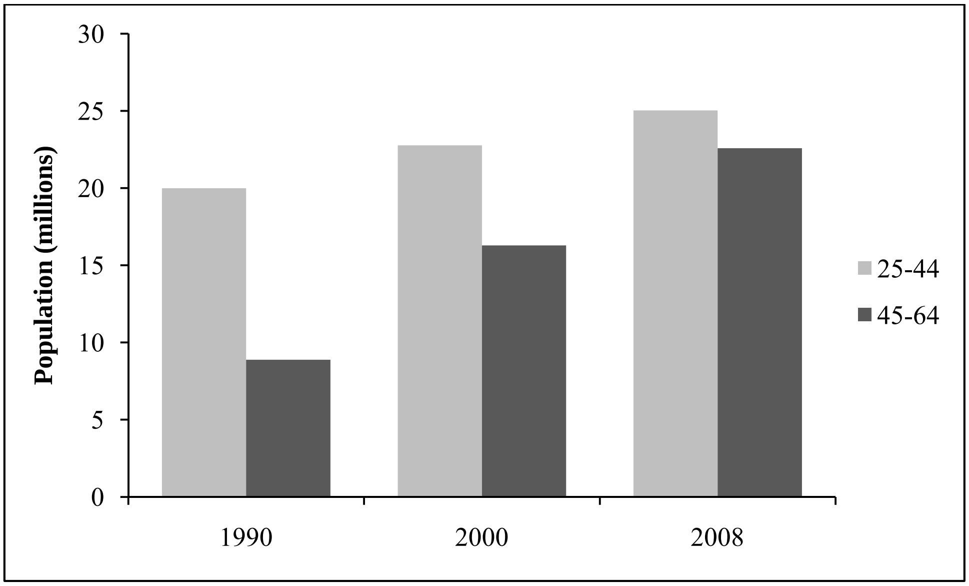
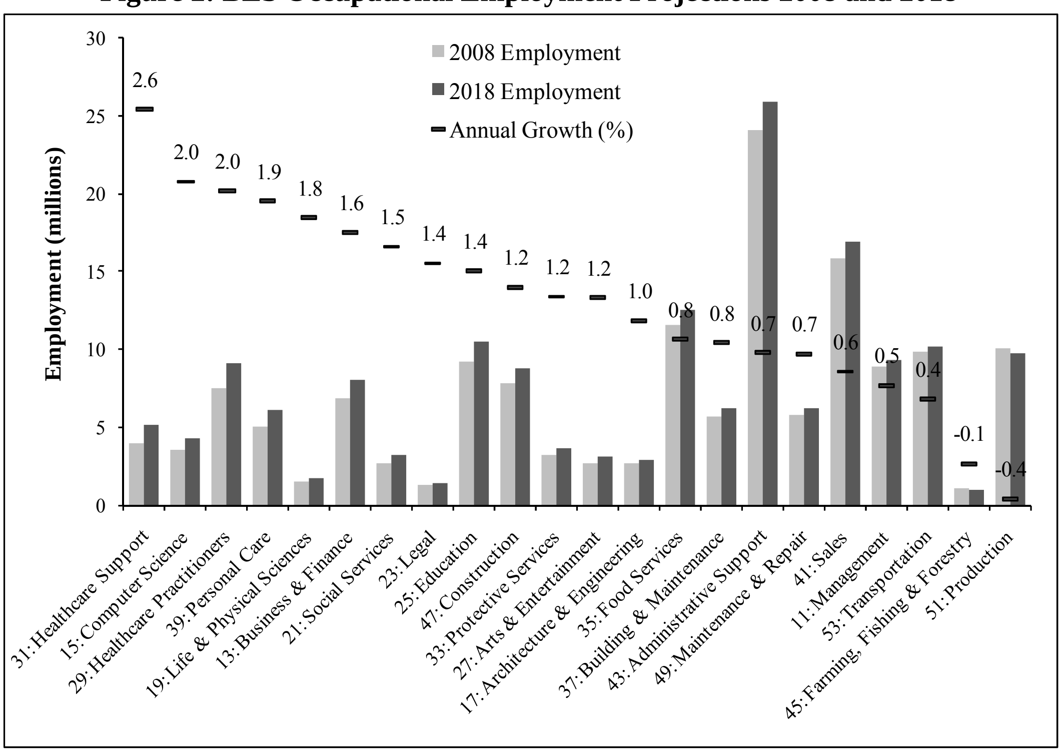
Figure 1: Number of Adults with At Least a Bachelor's Degree by Age Group (25-44 and 45-64), 1990, 2000, and 2008



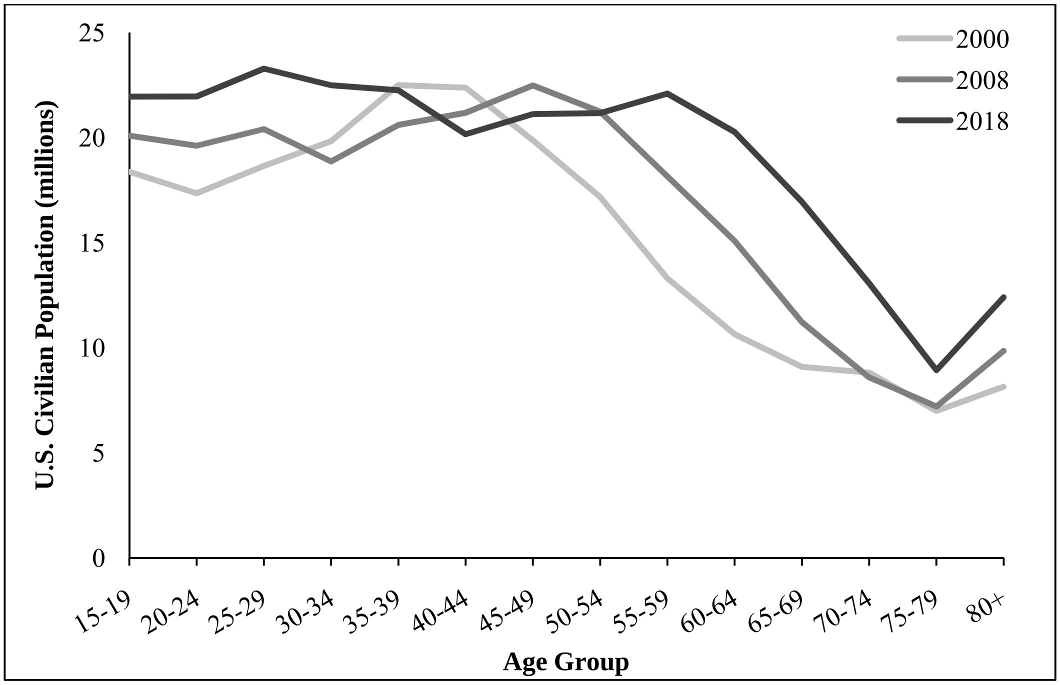
Based on Decennial Census for 1990 and 2000, and the American Community Survey for 2008.

Figure 2: BLS Occupational Employment Projections 2008 and 2018



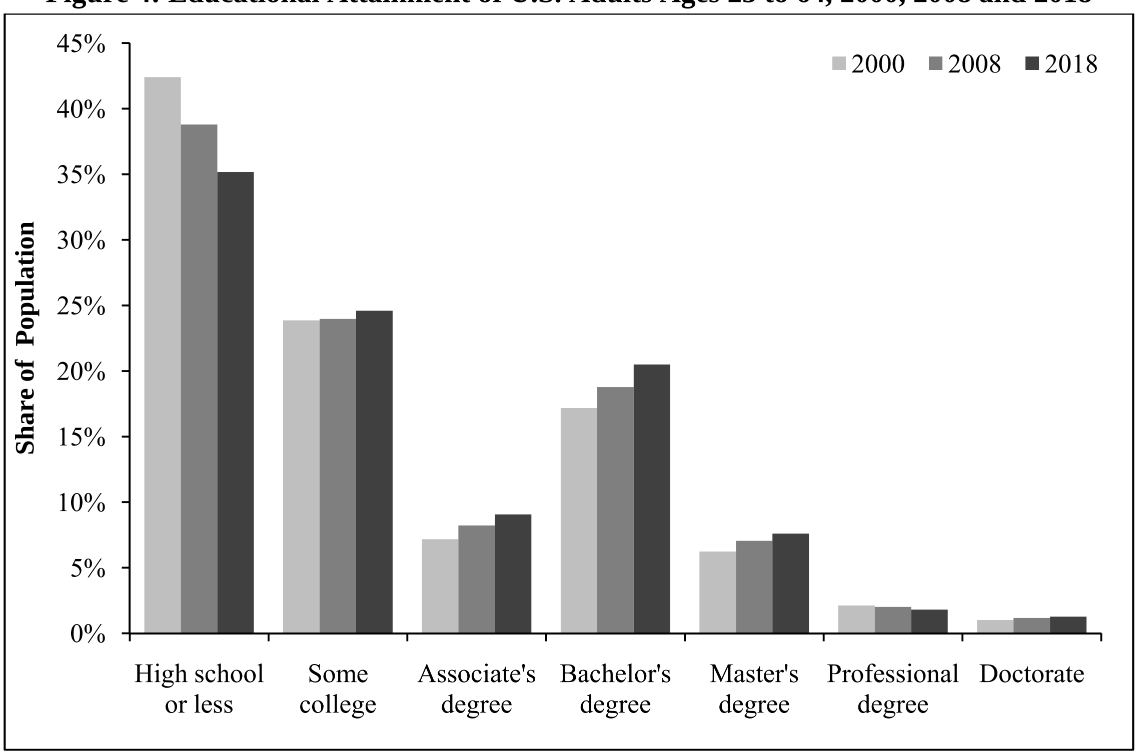
Ranked by projected average annual growth. Projections are from U.S. Bureau of Labor Statistics, Employment Projections Program (2009).

Figure 3: U.S. Population by Age Group, 2000, 2008, and 2018



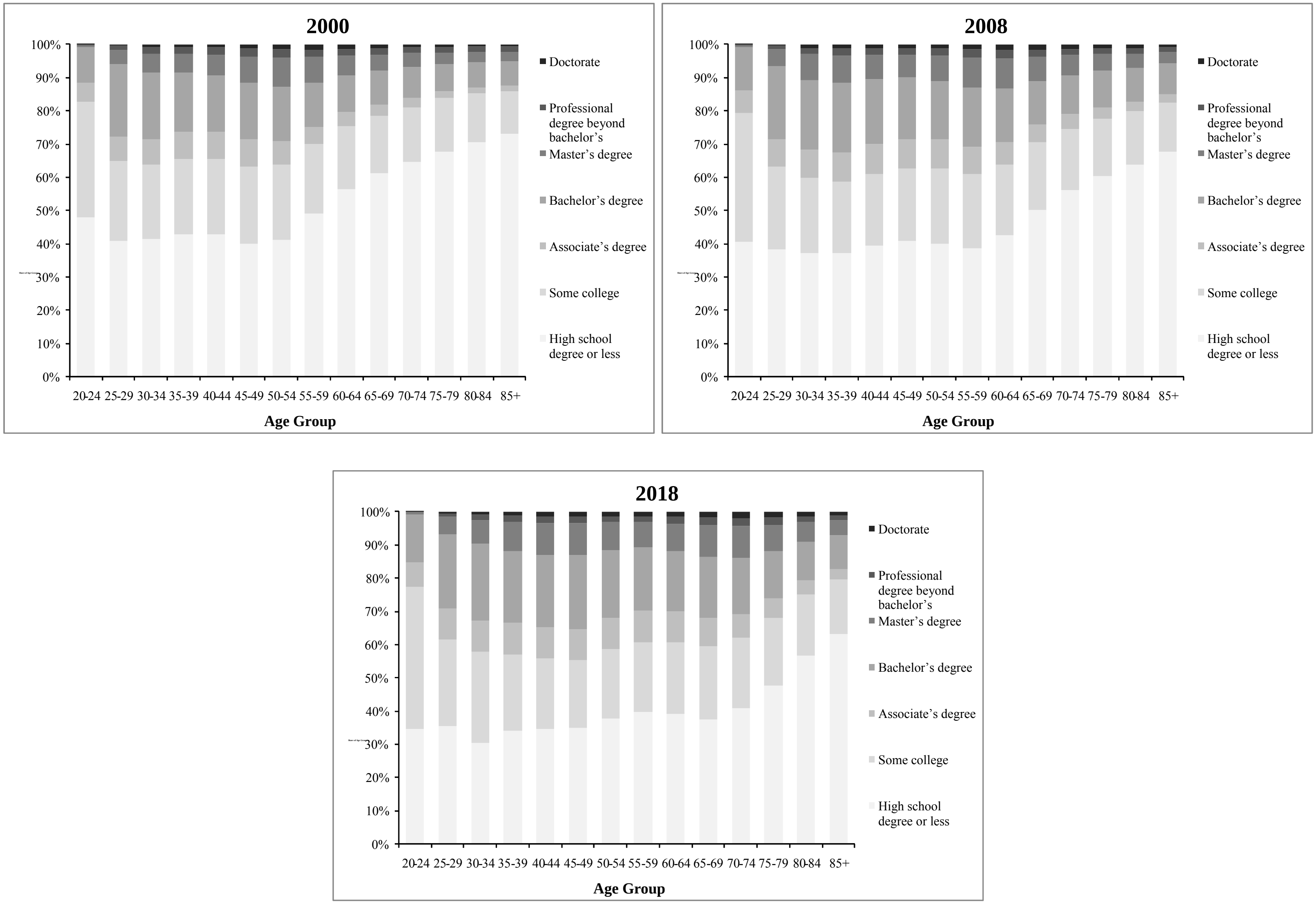
Data are from 2000 Decennial Census, 2008 ACS, and projections described in the text. Covers population aged 15 and over.

Figure 4: Educational Attainment of U.S. Adults Ages 25 to 64, 2000, 2008 and 2018



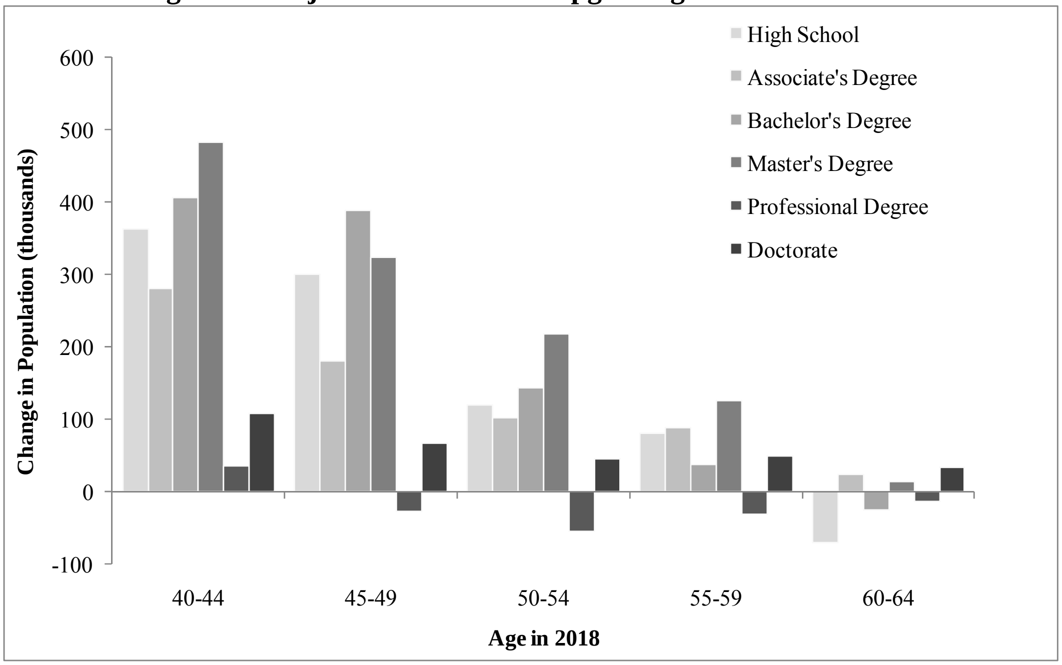
Based on 2000 Decennial Census, 2008 ACS, and projections described in the text.

Figure 5: U.S. Educational Attainment by Age Group, 2000, 2008, and 2018



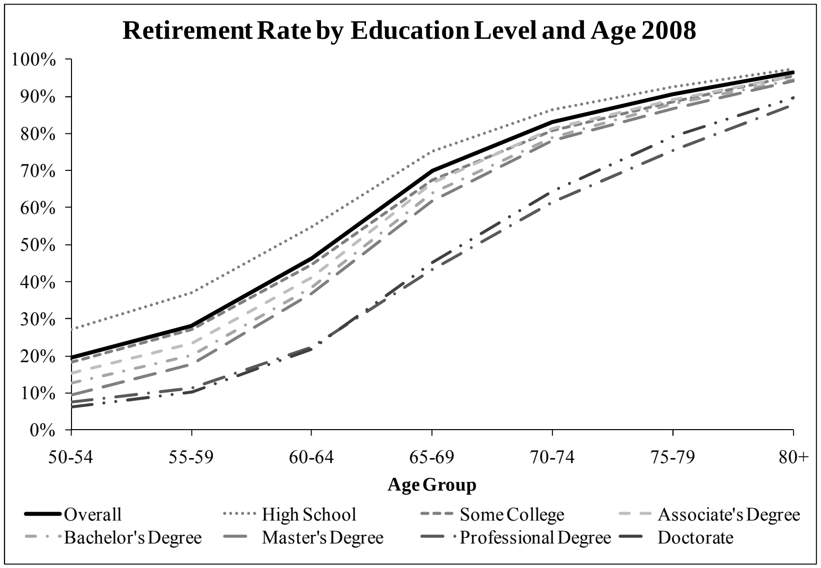
Based on 2000 Decennial Census, 2008 ACS, and authors' forecast.

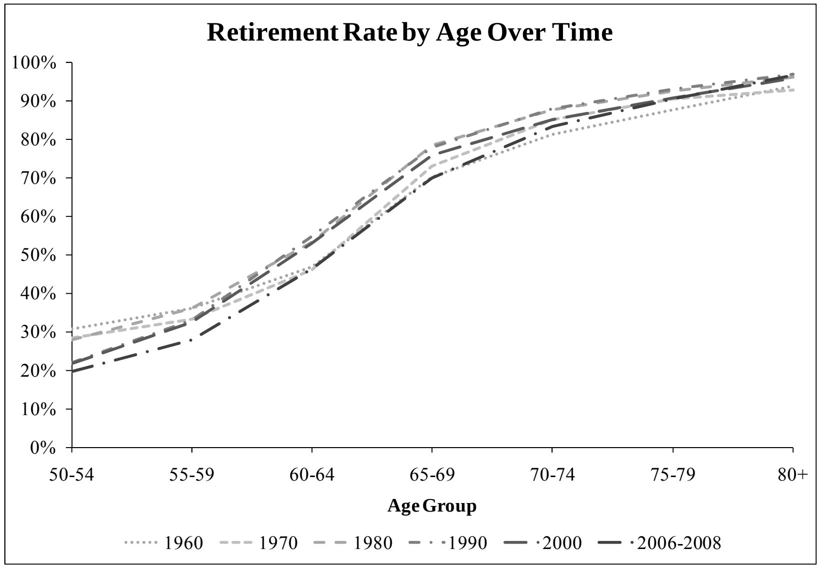
Figure 6: Projected Educational Upgrading from 2008 to 2018



Based on projections described in text.

Figure 7: Retirement Rates by Education Level and Age for Older Adults





Retirement is defined as those who are not actively participating in the labor force. Data come from Decennial Censuses 1950-2000 and 2008 ACS.

Table 1: Assignment of BLS Occupational Skills and ACS Educational Attainment Groups to Common Educational Categories

BLS Skill Category	**New Category**
Short-term on-the-job training	High school degree or less
Moderate-term on-the-job training	High school degree or less
Long-term on-the-job training	High school degree or less
Work experience in a related occupation	High school degree or less
Postsecondary vocational award	Some college
Associate's degree	Associate's degree
Bachelor's degree	Bachelor's degree
Bachelor's or higher degree, plus work experience	Bachelor's degree
First professional degree	Professional degree beyond bachelor's
Master's degree	Master's degree
Doctorate	Doctorate
ACS Education Category	**New Category**
Less than high school	High school degree or less
High school graduate or GED	High school degree or less
Some college	Some college
Associate's degree	Associate's degree
Bachelor's degree	Bachelor's degree
Master's degree	Master's degree
Professional degree beyond bachelor's	Professional degree beyond bachelor's
Doctorate	Doctorate

Based on reclassification of BLS skill categories and ACS education categories.

Table 2: Skill Requirements Based on BLS Occupation Projections, 2008 and 2018

Occupational Employment						
	Jobs (thousands)				Distribution	
Education/Skills Category	**2008**	**2018**	***Absolute change***	***Percent change***	**2008**	**2018**
High school degree or less	105,184	113,446	*8,262*	*7.9%*	69.7%	68.3%
Work experience in a related occupation	14,640	15,837	*1,197*	*8.2%*	9.7%	9.5%
Long-term on-the-job training	10,907	11,725	*818*	*7.5%*	7.2%	7.1%
Moderate-term on-the-job training	24,778	26,768	*1,990*	*8.0%*	16.4%	16.1%
Short-term on-the-job training	54,859	59,116	*4,257*	*7.8%*	36.3%	35.6%
Some college	8,685	9,839	*1,154*	*13.3%*	5.8%	5.9%
Associate's degree	6,005	7,152	*1,147*	*19.1%*	4.0%	4.3%
Bachelor's degree	24,620	28,196	*3,576*	*14.5%*	16.3%	17.0%
Master's degree	2,443	2,892	*449*	*18.4%*	1.6%	1.7%
Professional degree beyond bachelor's	1,966	2,314	*347*	*17.7%*	1.3%	1.4%
Doctorate	2,028	2,364	*337*	*16.6%*	1.3%	1.4%
All education categories	150,932	166,205	*15,273*	*10.1%*	100.0%	100.0%

Demand for Workers						
	Workers (thousands)				Distribution	
Education Category	**2008**	**2018**	***Absolute change***	***Percent change***	**2008**	**2018**
High school degree or less	91,200	98,360	*7,160*	*7.9%*	62.5%	61.2%
Some college	8,401	9,514	*1,113*	*13.2%*	5.8%	5.9%
Associate's degree	5,809	6,916	*1,107*	*19.1%*	4.0%	4.3%
Bachelor's degree	34,367	38,602	*4,235*	*12.3%*	23.5%	24.0%
Master's degree	2,364	2,797	*433*	*18.3%*	1.6%	1.7%
Professional degree beyond bachelor's	1,902	2,237	*335*	*17.6%*	1.3%	1.4%
Doctorate	1,961	2,286	*325*	*16.6%*	1.3%	1.4%
All education categories	146,005	160,713	*14,707*	*10.1%*	100.0%	100.0%

Top panel is based on BLS employment projections. Bottom panel is based on calculations of multiple jobholders from the CPS and BLS employment projections.

Table 3: Alternative Projections of Educational Attainment Requirements Based on ACS/Decennial Census Trends

		Workers (thousands)				Distribution	
	Education Category	**2008**	**2018**	***Absolute change***	***Percent change***	**2008**	**2018**
1	High school degree or less	54,539	54,701	*162*	*0.3%*	37.5%	34.0%
2	Some college	35,182	39,560	*4,378*	*12.4%*	24.2%	24.6%
3	Associate's degree	12,144	15,879	*3,735*	*30.8%*	8.4%	9.9%
4	Bachelor's degree	28,038	32,822	*4,784*	*17.1%*	19.3%	20.4%
5	Master's degree	10,614	12,608	*1,994*	*18.8%*	7.3%	7.8%
6	Professional degree beyond bachelor's	3,059	2,816	*-243*	*-7.9%*	2.1%	1.8%
7	Doctorate	1,786	2,326	*541*	*30.3%*	1.2%	1.4%
	All education categories	145,362	160,713	*15,351*	*10.6%*	100.0%	100.0%

Total workers in 2008 is from U.S. Bureau of Labor Statistics (2008). Shares in 2008 are calculated from the 2008 ACS. Total workers in 2018 is the same calculation as above; 2018 education shares are calculated from dynamic forecasts described in text.

Table 4: Estimated Returns to Schooling, Above and Below the Maximum BLS Required Skill Category, 2008

Occupation Descriptions	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Professional Degree	Doctorate	Joint Test P-value	Joint Test D.o.F.
	Coefficients Relative to Lowest Category (High School or Less)							
Management occupations	0.165	0.171	0.465	0.630	0.702	0.775	<.0001	3
	(0.006)	(0.008)	(0.005)	(0.006)	(0.014)	(0.014)		
Business and financial operations occupations	0.114	0.099	0.379	0.596	0.620	0.670	<.0001	3
	(0.009)	(0.011)	(0.008)	(0.010)	(0.020)	(0.030)		
Computer and mathematical science occupations	0.102	0.074	0.293	0.403	0.404	0.481	na	na
	(0.012)	(0.013)	(0.011)	(0.012)	(0.031)	(0.022)		
Architecture and engineering occupations	0.075	0.117	0.400	0.547	0.419	0.663	<.0001	3
	(0.011)	(0.012)	(0.010)	(0.011)	(0.026)	(0.020)		
Life, physical, and social science occupations	0.056	0.091	0.294	0.406	0.422	0.541	na	na
	(0.025)	(0.029)	(0.020)	(0.021)	(0.032)	(0.022)		
Community and social services occupations	0.055	0.084	0.202	0.386	0.374	0.412	0.2522	1
	(0.014)	(0.017)	(0.012)	(0.013)	(0.023)	(0.025)		
Legal occupations	0.048	0.044	0.198	0.433	0.821	0.740	na	na
	(0.030)	(0.033)	(0.029)	(0.040)	(0.026)	(0.036)		
Education, training, and library occupations	0.036	0.095	0.458	0.673	0.746	0.926	na	na
	(0.009)	(0.012)	(0.008)	(0.008)	(0.014)	(0.010)		
Arts, design, entertainment, sports, and media occupations	0.137	0.129	0.328	0.426	0.533	0.507	<.0001	3
	(0.020)	(0.023)	(0.018)	(0.023)	(0.056)	(0.054)		
Health care practitioners and technical occupations	0.059	0.294	0.418	0.544	1.075	0.902	na	na
	(0.010)	(0.009)	(0.009)	(0.011)	(0.010)	(0.015)		
Health care support occupations	0.081	0.181	0.182	0.371	0.597	0.547	<.0001	4
	(0.008)	(0.011)	(0.014)	(0.030)	(0.038)	(0.068)		
Protective service occupations	0.204	0.278	0.376	0.550	0.497	0.679	<.0001	4
	(0.008)	(0.010)	(0.009)	(0.018)	(0.045)	(0.066)		
Food preparation and serving related occupations	0.097	0.235	0.242	0.279	0.127	0.447	<.0001	6
	(0.008)	(0.013)	(0.012)	(0.035)	(0.075)	(0.134)		
Building and grounds cleaning and maintenance occupations	0.107	0.121	0.149	0.282	0.129	0.238	<.0001	6
	(0.008)	(0.015)	(0.014)	(0.039)	(0.066)	(0.193)		
Personal care and service occupations	0.087	0.150	0.287	0.288	0.252	0.372	<.0001	5
	(0.011)	(0.017)	(0.014)	(0.032)	(0.070)	(0.156)		
Sales and related occupations	0.163	0.191	0.525	0.708	0.707	0.701	<.0001	3
	(0.005)	(0.008)	(0.006)	(0.011)	(0.029)	(0.045)		
Office and administrative support occupations	0.091	0.117	0.248	0.402	0.370	0.523	<.0001	4
	(0.003)	(0.004)	(0.004)	(0.008)	(0.023)	(0.035)		
Farming, fishing, and forestry occupations	0.092	0.190	0.292	0.497	0.145	0.863	<.0001	6
	(0.022)	(0.040)	(0.032)	(0.098)	(0.187)	(0.235)		
Construction and extraction occupations	0.111	0.162	0.145	0.145	0.195	0.179	<.0001	6
	(0.006)	(0.011)	(0.011)	(0.029)	(0.056)	(0.112)		
Installation, maintenance, and Repair occupations	0.120	0.172	0.190	0.290	-0.089	0.174	0.0003	3
	(0.006)	(0.008)	(0.011)	(0.027)	(0.069)	(0.122)		
Production occupations	0.153	0.198	0.287	0.427	0.234	0.493	<.0001	5
	(0.004)	(0.008)	(0.008)	(0.019)	(0.047)	(0.060)		
Transportation and material moving occupations	0.108	0.123	0.287	0.411	0.105	0.157	<.0001	1
	(0.005)	(0.010)	(0.010)	(0.024)	(0.064)	(0.104)		

Standard errors are shown in parentheses. Grey cells represent the education categories above the highest BLS category required for the occupation category. Occupation categories for which the entire range is shaded grey indicate that high school or less is the highest required BLS category. Each row reports the estimated coefficients on dummy variables for the indicated schooling categories, using 2008 ACS data. The dependent variable is log earnings, and the regressions are estimated for full-time (30 or more hours) and full-year (40 or more weeks) workers. The regression includes controls for race, ethnicity, sex, age and its square, and decennial census region. The test statistic reported is the p-value (and d.o.f.) for the test of no returns to education levels higher than BLS requirement, for the subset of higher education levels with point estimates larger than estimated return to BLS-required education level.

Table 5: ACS Distribution of Workers Above and Below the Maximum BLS Required Skill Category, 2008

2-Digit Occupations	High School or Less	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Professional Degree	Doctorate	Share Above Highest BLS
Management occupations	19.8%	21.4%	7.8%	32.3%	15.2%	1.7%	1.7%	18.7%
Business and financial operations occupations	11.5%	18.4%	9.1%	44.0%	14.3%	1.9%	0.9%	17.1%
Computer and mathematical science occupations	6.9%	18.7%	10.5%	43.8%	17.7%	0.8%	1.7%	0.0%
Architecture and engineering occupations	9.8%	16.0%	11.7%	41.6%	16.9%	1.3%	2.6%	20.8%
Life, physical, and social science occupations	7.2%	9.8%	4.2%	33.2%	21.8%	3.4%	20.3%	0.0%
Community and social services occupations	10.0%	14.6%	5.8%	33.7%	30.8%	2.6%	2.4%	5.0%
Legal occupations	6.7%	10.5%	6.3%	13.5%	3.5%	54.0%	5.6%	5.6%
Education, training, and library occupations	8.5%	11.8%	4.8%	34.6%	31.7%	2.4%	6.2%	0.0%
Arts, design, entertainment, sports, and media occupations	14.6%	21.6%	8.9%	42.1%	10.7%	1.1%	1.1%	12.8%
Health care practitioners and technical occupations	7.8%	15.5%	22.7%	26.4%	9.0%	15.1%	3.6%	3.6%
Health care support occupations	43.1%	36.3%	11.0%	7.2%	1.3%	0.7%	0.2%	9.5%
Protective service occupations	30.4%	35.6%	12.4%	17.7%	3.3%	0.5%	0.2%	21.6%
Food preparation and serving related occupations	60.6%	26.9%	5.3%	6.4%	0.6%	0.1%	0.0%	39.4%
Building and grounds cleaning and maintenance occupations	72.2%	17.7%	4.3%	4.9%	0.7%	0.2%	0.0%	27.8%
Personal care and service occupations	47.8%	30.9%	7.5%	11.3%	2.0%	0.4%	0.1%	21.3%
Sales and related occupations	37.1%	29.1%	7.3%	21.8%	3.9%	0.5%	0.2%	4.7%
Office and administrative support occupations	37.2%	35.6%	10.3%	14.2%	2.3%	0.3%	0.1%	16.9%
Farming, fishing, and forestry occupations	78.5%	12.6%	3.4%	4.8%	0.5%	0.1%	0.1%	21.5%
Construction and extraction occupations	67.4%	21.2%	5.2%	5.1%	0.7%	0.2%	0.1%	32.6%
Installation, maintenance, and repair occupations	53.1%	28.4%	11.4%	6.0%	0.9%	0.1%	0.1%	7.1%
Production occupations	64.6%	22.1%	6.0%	6.1%	1.0%	0.2%	0.1%	13.3%
Transportation and material moving occupations	65.6%	22.7%	4.9%	5.8%	0.9%	0.1%	0.1%	1.1%

Grey cells represent the education levels above the highest BLS category reported for the occupation category. Based on 2008 ACS data include all employed persons age 16 and over.

Table 6: U.S. Educational Attainment and Population Share by Race and Ethnicity, 2000, 2008, and 2018

	Percent of Total Population		
Race/Ethnicity	**2000**	**2008**	**2018**
White	71.5%	67.5%	61.9%
Hispanic	11.2%	14.2%	17.4%
African American	11.0%	11.4%	12.6%
Asian and Pacific Islander	4.1%	5.0%	6.0%
	Education Distribution within Race/Ethnicity		
	2000	**2008**	**2018**
White			
High school degree or less	38.8%	34.1%	30.3%
Some college	23.3%	23.1%	23.7%
Associate's degree	7.8%	9.1%	10.3%
Bachelor's degree	19.4%	21.6%	22.9%
Master's degree	7.3%	8.6%	9.3%
Professional degree	2.3%	2.3%	2.1%
Doctorate	1.1%	1.2%	1.4%
Hispanic			
High school degree or less	67.9%	63.2%	57.6%
Some college	16.5%	17.5%	19.7%
Associate's degree	4.6%	5.7%	6.8%
Bachelor's degree	7.1%	9.5%	11.7%
Master's degree	2.2%	2.8%	3.3%
Professional degree	1.4%	0.9%	0.4%
Doctorate	0.3%	0.4%	0.4%
African American			
High school degree or less	52.4%	45.8%	39.1%
Some college	25.0%	26.6%	29.4%
Associate's degree	6.6%	8.3%	9.8%
Bachelor's degree	10.8%	13.0%	14.7%
Master's degree	3.8%	4.8%	5.5%
Professional degree	0.9%	0.9%	0.8%
Doctorate	0.4%	0.6%	0.6%
Asian and Pacific Islander			
High school degree or less	31.6%	26.9%	21.6%
Some college	14.8%	13.5%	14.2%
Associate's degree	7.1%	7.2%	7.1%
Bachelor's degree	28.2%	31.2%	33.5%
Master's degree	11.4%	13.9%	16.3%
Professional degree	4.0%	3.8%	3.5%
Doctorate	2.9%	3.4%	3.8%
	Percent with Bachelor's Degree or Beyond by Race/Ethnicity		
Race/Ethnicity	**2000**	**2008**	**2018**
Asian and Pacific Islander	46.6%	52.3%	57.1%
African American	16.0%	19.3%	21.7%
Hispanic	11.0%	13.6%	15.8%
Multi-race	24.4%	27.5%	33.5%
White	30.1%	33.7%	35.7%

Decennial Census 2000 and ACS 2008 data are used for historical trends. Data on the 2018 population is forecasted according to the Census Bureau methodology using Decennial Census 2000 data as the base population. The sample only includes 25-to-64 year-olds.

Table 7: Estimated and Projected Supply and Demand for Workers by Education Attainment, 2008 and 2018

2008 Supply and Demand for Education by Education Category	Workers (thousands)			Shares			BLS
Education Category	Supply	Demand	Diff	Supply	Demand	Diff	Demand
High school or less	60,013	54,539	5,474	38.9%	37.5%	1.4%	69.7%
Some college	36,852	35,182	1,670	23.9%	24.2%	-0.3%	5.8%
Associate's degree	12,657	12,144	512	8.2%	8.4%	-0.2%	4.0%
Bachelor's degree	28,987	28,038	949	18.8%	19.3%	-0.5%	16.3%
Master's degree	10,853	10,614	240	7.0%	7.3%	-0.3%	1.6%
Professional degree	3,109	3,059	49	2.0%	2.1%	-0.1%	1.3%
Doctorate	1,815	1,786	29	1.2%	1.2%	-0.1%	1.3%
All education categories	154,286	145,362	8,924	100.0%	100.0%	0.0%	100.0%

2018 Supply and Demand for Education by Education Category	Workers (thousands)			Shares			BLS
Education Category	Supply	Demand	Diff	Supply	Demand	Diff	Demand
High school or less	59,626	54,701	4,925	35.0%	34.0%	0.9%	68.3%
Some college	43,173	39,560	3,613	25.3%	24.6%	0.7%	5.9%
Associate's degree	15,523	15,879	-356	9.1%	9.9%	-0.8%	4.3%
Bachelor's degree	33,827	32,822	1,005	19.8%	20.4%	-0.6%	17.0%
Master's degree	13,161	12,608	553	7.7%	7.8%	-0.1%	1.7%
Professional degree	3,024	2,816	208	1.8%	1.8%	0.0%	1.4%
Doctorate	2,245	2,326	-81	1.3%	1.4%	-0.1%	1.4%
All education categories	170,579	160,713	9,866	100.0%	100.0%	0.0%	100.0%

Supply and demand shares by educational attainment for 2008 are from the 2008 American Community Survey, these shares are applied to published BLS total labor force and employed persons aged 16 and over. Supply and demand projections are described in the text. The last column in both panels is from BLS Employment Projections 2008-2018.

Table 8: Percentage of Adults with a Bachelor's Degree or Above by State, 2008

State	Percentages with a Bachelor's Degree or Above: Total	Latinos	Ages 25-29	Ages 30-34	Ages 55-59	Ages 60-64	Cohort Differences (Sorted)	% Latino in State: 2005	2025
(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)	(9)
New Mexico	26%	14%	18%	26%	32%	35%	-23%	41%	48%
Alaska	28%	23%	23%	25%	30%	37%	-19%	5%	7%
Utah	30%	12%	25%	28%	33%	37%	-17%	7%	9%
Hawaii	32%	19%	25%	32%	38%	34%	-15%	9%	10%
Arizona	26%	10%	21%	26%	30%	31%	-14%	24%	32%
Colorado	38%	13%	32%	36%	40%	41%	-13%	15%	21%
Wyoming	23%	6%	19%	22%	28%	24%	-11%	7%	11%
Nevada	23%	9%	21%	23%	26%	27%	-9%	17%	25%
Oregon	30%	12%	24%	32%	33%	32%	-9%	7%	10%
California	31%	11%	27%	31%	33%	34%	-9%	36%	43%
Maine	25%	21%	20%	28%	28%	29%	-9%	1%	1%
Montana	30%	22%	28%	29%	36%	29%	-8%	3%	3%
Texas	27%	12%	24%	25%	29%	27%	-7%	31%	38%
Washington	32%	11%	28%	33%	34%	34%	-7%	7%	10%
Florida	28%	23%	24%	27%	29%	29%	-7%	17%	24%
Vermont	35%	21%	34%	37%	40%	37%	-6%	1%	2%
Idaho	26%	8%	21%	28%	27%	28%	-6%	8%	12%
South Dakota	27%	29%	27%	27%	25%	34%	-5%	1%	2%
Georgia	30%	13%	25%	30%	31%	29%	-5%	3%	4%
New Hampshire	36%	36%	32%	38%	37%	37%	-4%	2%	2%
Oklahoma	24%	11%	22%	25%	26%	23%	-2%	4%	6%
Virginia	36%	24%	34%	37%	36%	36%	-1%	4%	6%
South Carolina	26%	11%	26%	27%	27%	27%	-1%	1%	2%
Arkansas	21%	10%	19%	22%	23%	19%	-1%	1%	2%
Louisiana	22%	18%	22%	23%	24%	22%	-1%	3%	4%
Mississippi	21%	9%	20%	23%	23%	20%	0%	1%	1%
Alabama	24%	13%	24%	24%	26%	21%	1%	1%	1%
Kansas	32%	14%	31%	33%	34%	29%	1%	6%	9%
Nebraska	31%	8%	32%	32%	32%	31%	1%	4%	6%
Delaware	29%	15%	28%	32%	31%	28%	1%	4%	6%
Rhode Island	33%	14%	34%	35%	34%	33%	2%	9%	15%
Tennessee	25%	11%	24%	26%	24%	24%	2%	1%	2%
Maryland	38%	20%	36%	41%	38%	36%	3%	5%	7%
Indiana	25%	10%	26%	27%	26%	23%	4%	3%	4%
West Virginia	19%	29%	21%	20%	19%	18%	4%	1%	1%
Michigan	27%	17%	26%	30%	26%	26%	4%	3%	4%
North Carolina	28%	14%	27%	31%	29%	25%	4%	2%	2%
Missouri	28%	19%	28%	31%	29%	26%	4%	2%	3%
Wisconsin	28%	12%	29%	31%	28%	27%	5%	3%	4%
Kentucky	21%	11%	23%	24%	21%	21%	5%	1%	1%
Ohio	27%	20%	27%	30%	26%	25%	6%	2%	3%
Connecticut	39%	16%	39%	43%	38%	37%	7%	10%	15%
New Jersey	38%	17%	37%	42%	37%	35%	7%	14%	19%
Illinois	33%	12%	34%	36%	32%	30%	8%	12%	17%
North Dakota	29%	0%	29%	40%	29%	30%	10%	1%	2%
Minnesota	35%	18%	33%	41%	32%	31%	11%	2%	4%
Pennsylvania	29%	14%	33%	35%	30%	25%	13%	3%	5%
Iowa	27%	12%	33%	32%	27%	25%	13%	2%	3%
New York	35%	16%	38%	41%	33%	32%	14%	17%	22%
Massachusetts	42%	17%	46%	50%	42%	37%	17%	8%	14%
District of Columbia	52%	29%	63%	62%	44%	47%	34%	9%	12%

The "Cohort differences" column is the difference in Bachelor's degree attainment between younger and older cohorts ([Cols. 4+5] – [Cols. 6+7]). Data are from 2008 ACS. The estimates and projections in columns (8) and (9) are from the Census Bureau (http://www.census.gov/population/projections/state/stpjrace.txt, accessed June 30, 2011).

Table 9: Education Supplies and Demands if the United States had California's Projected Ethnic Distribution, 2018

	Workers (thousands)			Share		
Education Category	**Supply**	**Demand**	***Diff***	**Supply**	**Demand**	***Diff***
High school degree or less	67,589	54,701	*12,888*	39.6%	34.0%	*5.6%*
Some college	39,643	39,560	*83*	23.2%	24.6%	*-1.4%*
Associate's degree	13,946	15,879	*-1,933*	8.2%	9.9%	*-1.7%*
Bachelor's degree	32,430	32,822	*-392*	19.0%	20.4%	*-1.4%*
Master's degree	12,018	12,608	*-590*	7.0%	7.8%	*-0.8%*
Professional degree	2,794	2,816	*-22*	1.6%	1.8%	*-0.1%*
Doctorate	2,159	2,326	*-168*	1.3%	1.4%	*-0.2%*
All education categories	170,579	160,713	*9,866*	100.0%	100.0%	*na*

Based on projections described in text.

Table 10: Total Educational Demand Projections (Shares), Comparison of Our Projections to Carnevale et al.

	Ours	Carnevale et al.		Diff.
		Jobs	Workers	
	(1)	(2)	(3)	(4)
High school or less	34.0%	37.1%	37.8%	-3.8%
Some college	24.6%	17.6%	17.6%	7.1%
Associate's degree	9.9%	12.2%	12.1%	-2.2%
Bachelor's degree	20.4%	23.0%	22.7%	-2.3%
Master's degree or better	11.0%	10.1%	9.9%	1.2%
Associate's degree or better	41.3%	45.3%	44.6%	-3.3%
All education categories	100.0%	100.0%	100.0%	na

Sources for each column are as follows: (1) demand shares from second panel of Table 7; (2) Carnevale et al. (2010) Appendix 3 (p. 125); (3) calculated from imputed employment levels. Imputed employment levels were calculate adjusting Carnevale et al. projected number of jobs using CPS data on multiple jobholding by education category; and (4) difference between columns (1) and (4).

Table 11. Education Distribution Employed Persons, Census/ACS versus CPS (2000 and 2008)

	2000			2008			00-08 Growth rate	
Education Category	**Census**	**CPS**	**Diff.**	**ACS**	**CPS**	**Diff.**	**Census**	**CPS**
High school diploma or less	41.1%	43.8%	*-2.8%*	37.5%	38.9%	*-1.4%*	-8.7%	*-11.2%*
Some college	24.3%	20.4%	*4.0%*	24.2%	19.7%	*4.6%*	-0.6%	*-3.5%*
Associate's degree	7.3%	8.3%	*-1.0%*	8.4%	9.5%	*-1.1%*	14.7%	*14.0%*
Bachelor's degree	17.6%	18.5%	*-0.8%*	19.3%	21.0%	*-1.7%*	9.4%	*13.7%*
Master's degree	6.4%	6.2%	*0.2%*	7.3%	7.9%	*-0.6%*	13.7%	*28.1%*
Professional degree	2.2%	1.6%	*0.6%*	2.1%	1.7%	*0.4%*	-3.8%	*6.8%*
Doctorate	1.1%	1.2%	*-0.2%*	1.2%	1.3%	*-0.1%*	15.5%	*7.4%*
Associate's degree or better	34.6%	35.8%	-1.2%	38.3%	41.4%	-3.1%	10.7%	15.7%
All education categories	100.0%	100.0%	*0.0%*	100.0%	100.0%	*0.0%*		

Data are from Integrated Public Use Microdata Series. Minneapolis, MN: Minnesota Population Center.

Table 12: 2018 Educational Requirements for Workers: Alternative Scenarios

	Ours	Using Carnevale et al. Occupational Employment	Using CPS 2008 Education Distribution	Using 2008-2018 Growth Rate in CPS Education Distribution	Using CPS Baseline Education Distribution and Trend	Using Carnevale et al. Occupational Employment and CPS Education Distribution and Trend	Carnevale et al.	Column (1) using 2007 for calculating the compound growth rate	Column (5) using 2007 for calculating the compound growth rate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
High school or less	34.04%	34.03%	35.49%	33.01%	34.25%	34.43%	37.81%	38.31%	38.12%
Some college	24.62%	24.72%	20.07%	23.39%	19.02%	19.09%	17.55%	20.22%	17.78%
Associate's degree	9.88%	9.90%	11.27%	9.63%	10.97%	10.95%	12.06%	9.85%	10.88%
Bachelor's degree	20.42%	20.43%	21.92%	21.23%	22.78%	22.71%	22.70%	20.38%	21.51%
Master's degree	7.85%	7.77%	8.30%	9.53%	10.11%	9.98%	7.23%	8.17%	8.44%
Professional degree	1.75%	1.72%	1.36%	1.92%	1.55%	1.52%	1.41%	1.74%	1.69%
Doctorate	1.45%	1.44%	1.60%	1.29%	1.33%	1.32%	1.24%	1.32%	1.58%
Associate's degree or better	***41.35%***	***41.25%***	***44.44%***	***43.61%***	***46.73%***	***46.48%***	***44.64%***	***41.46%***	***44.10%***
Difference from Our Demand Projections									
High school or less	0.00%	0.00%	1.45%	-1.03%	0.22%	0.39%	3.77%	4.28%	4.08%
Some college	0.00%	0.10%	-4.54%	-1.23%	-5.60%	-5.53%	-7.06%	-4.39%	-6.83%
Associate's degree	0.00%	0.02%	1.39%	-0.25%	1.08%	1.07%	2.18%	-0.03%	1.00%
Bachelor's degree	0.00%	0.01%	1.49%	0.80%	2.35%	2.29%	2.28%	-0.04%	1.09%
Master's degree	0.00%	-0.08%	0.45%	1.69%	2.26%	2.14%	-0.62%	0.32%	0.60%
Professional degree	0.00%	-0.04%	-0.39%	0.17%	-0.20%	-0.23%	-0.34%	-0.01%	-0.06%
Doctorate	0.00%	-0.01%	0.16%	-0.16%	-0.12%	-0.13%	-0.20%	-0.12%	0.13%
Associate's degree or better	***0.00%***	***-0.10%***	***3.09%***	***2.26%***	***5.38%***	***5.14%***	***3.29%***	***0.11%***	***2.75%***

Carnevale et al. occupational employment figures used in the calculations for columns 2 and 7 come from Part 3 of their study; CPS education distribution comes from IPUMS; 2008-2018 growth rates are calculated using the compound average annual growth rates between 2000 and 2008 for educational attainment and occupation categories; and finally, data in column 7 come from Carnevale et al. Appendix 3, p. 125.

Table 13: 2018 Supply and Demand for Education by Education Category Using CPS Data

Education Category	Workers (thousands)			Shares		
	Supply	**Demand**	**Diff**	**Supply**	**Demand**	**Diff**
High school or less	62,585	55,051	7,534	36.7%	34.3%	2.4%
Some college	33,563	30,563	3,000	19.7%	19.0%	0.7%
Associate's degree	17,293	17,623	-330	10.1%	11.0%	-0.8%
Bachelor's degree	36,754	36,604	150	21.5%	22.8%	-1.2%
Master's degree	15,327	16,244	-918	9.0%	10.1%	-1.1%
Professional degree	2,808	2,492	315	1.6%	1.6%	0.1%
Doctorate	2,250	2,136	114	1.3%	1.3%	0.0%
All education categories	170,579	160,713	9,866	100.0%	100.0%	0.0%

Table 14: Estimated Returns to Degrees Above Required Degrees, 2008

Estimates	H&S results	Replication of H&S						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Required education:	H&S CLM	H&S CLM	H&S CLM	H&S CLM	BLS skill requirements		O*NET education requirements	
Less than high school	0.102	0.163	-0.268	-0.151	-0.265	-0.149	-0.264	-0.149
		(0.008)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Some college	0.373	0.432	0.183	0.070	0.183	0.066	0.182	0.065
		(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Associate's degree	0.471	0.525	0.322	0.113	0.536	0.087	0.568	0.065
		(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)
Bachelor's degree	0.631	0.671	0.669	0.272	0.675	0.235	0.662	0.223
		(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Master's degree or better	0.799	0.841	0.838	0.474	0.831	0.486	0.883	0.505
		(0.003)	(0.003)	(0.003)	(0.004)	(0.007)	(0.004)	(0.007)
Interactions with:	**In job that does not require college degree**				**Degree higher than required degree for the job**			
Less than high school	-0.425	-0.476	…	…	…	…	…	…
		(0.008)						
Some college	-0.343	-0.366	…	…	…	…	…	…
		(0.003)						
Associate's degree	-0.372	-0.380	…	…	-0.354	0.023	-0.366	0.049
		(0.005)			(0.005)	(0.005)	(0.005)	(0.005)
Bachelor's degree	-0.486	-0.504	-0.503	-0.127	-0.288	-0.042	-0.218	-0.028
		(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
Master's degree or better	-0.610	-0.609	-0.608	-0.297	-0.078	-0.095	-0.156	-0.133
		(0.007)	(0.007)	(0.007)	(0.005)	(0.008)	(0.005)	(0.007)
Occ. dummies included:	No	No	No	Yes	No	Yes	No	Yes
N	3,869,456	1,147,081	1,147,081	1,147,081	1,143,478	1,143,478	1,128,972	1,128,972

Column (1) is from Harrington and Sum (forthcoming, Table 5), using 2006-2008 ACS data. Estimates in other columns are from 2008 ACS data. Sample restricted to non-enrolled 22- to 64-year-old workers with annual earnings greater than $1,000 and less than $200,000. Other controls include: age, age squared, male, native-born, black, Hispanic, Asian, and other race. The BLS classification is based on Table 1.6 of the BLS' Employment Projections Program (EPP) Tables (U.S. Bureau of Labor Statistics, 2010b), while the O*NET classification is based on O*NET database version 13 released in June 2008 (National Crosswalk Service Center, 2011). The occupation dummy variables are defined at the finest level of occupational detail available in the ACS; in most cases, this is at the 6-digit SOC level (the exceptions are when several occupations were bundled together in the ACS). Sample sizes are slightly lower in columns (5) to (8) because some occupations had missing education requirements in the BLS and O*NET classifications.