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Future skill shortages in the U.S. economy?☆

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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 near-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 near-term in states with large and growing immigrant populations.

1. Introduction

The impending retirement of the baby boom cohort could pose dramatic challenges for the U.S. labor force. The boomers – adults born between 1946 and 1964 – are large in number. Based on 2008 American Community Survey (ACS) data, boomers made up 34% of all adults in the United States, and 38% of all workers. Boomers are also relatively well-educated. Many came into adulthood just as the nation was rapidly expanding postsecondary educational opportunities in relatively low-cost public institutions, and higher education was further stimulated by the GI bill and the Vietnam War draft for men (Bound & Turner, 2002; Card & Lemieux, 2001), and increasing labor market opportunities for women stemming from declining discrimination, changing attitudes, and contraceptive technology (Goldin & 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 (Fig. 1). Thus, the retirement of the baby boomers will 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 projections of educational demands and supplies in the labor market during the initial years of the baby boomers' retirements, focusing on the potential for skill (i.e., education) imbalances to emerge between workforce needs and supplies. The projections are fairly short-term – extending only through

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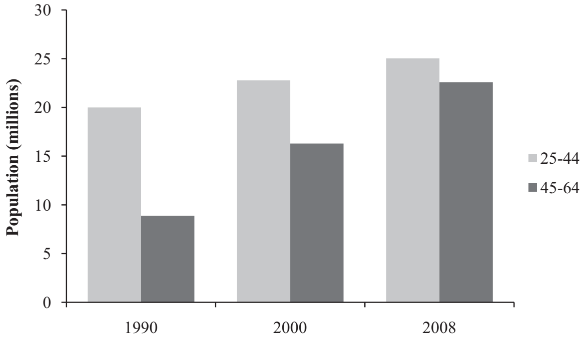

Fig. 1. Number of adults with at least a Bachelor's degree by age group (25–44 and 45–64), 1990, 2000, and 2008. Based on Decennial Census for 1990 and 2000, and the American Community Survey for 2008.

2018 – because the analysis relies on Bureau of Labor Statistics (BLS) occupational projections that extended only through that year when this research was done. 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, as skill shortages can prove costly to the economy. If there is unmet demand for skilled workers then there are foregone opportunities for the creation of high-wage jobs. In addition, imbalances between the skills demanded by employers and the skills supplied by workers lead to skill mismatch in the economy, which can have adverse macroeconomic consequences – raising the rate of unemployment the economy can sustain without causing inflation (e.g., Nickell, 1998). Moreover, policy responses to address skill shortages are likely to take effect only slowly. For example, increased capacity at community colleges to help meet future skill demands can only be built up over time (and would probably prove less effective if rushed).

Our primary conclusion is that the U.S. economy will generate rising demand for highly educated workers, but that in the near-term this rising demand will by and large be met by rising education levels among the U.S. population. Thus, 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. And over the longer-term, as more baby boomers retire, there is greater risk of substantial skill shortages.

2. Educational/skill demands in 2018

2.1. Projected occupational changes

Our starting point is BLS projections of employment growth by occupation extending to 2018 (Lacey & Wright, 2009; Woods, 2009).[1] 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.[2] 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 the level of 22 two-digit occupations, we calculated the BLS projected change in occupational demand over the designated period.

Fig. 2 shows the occupation categories ranked by their growth rates between 2008 and 2018, while also showing the size of the occupation in each year. Health care and computer science occupations, although small, have the highest projected rates of employment growth. Agricultural and production occupations are the only occupations projected to decline between 2008 and 2018.

2.2. Approaches to demand projections by skill/education

The BLS occupational projections, coupled with information on skill or education requirements by occupation (discussed below), are the basis of our projected demands for skill. We construct these by assigning education requirements to workers within occupations, and then combine these assignments with the BLS occupational projections to forecast education demands.

We consider two approaches. The first approach relies on the BLS occupational projections (Lacey & Wright, 2009), coupled with BLS's classifications of training requirements for occupations, ranging from short-term on-the-job training to a doctoral degree. We convert the education/training categories the BLS uses into measures defined solely in terms of degree attainment.

The second approach assumes that empirically observed employment practices are a good measure of workforce skills needs, but also recognizes that the educational requirements of occupations can change over time. Thus, in this approach we account for changes over time in the educational distribution within occupation categories by applying trended estimates of the degree attainment shares within an occupational category based on data from the 2000 Decennial Census and 2008 ACS. Specifically, using data from the Census of Population and the ACS for workers aged 16 and over, we calculate compound average annual growth rates between 2000 and 2008 for degree attainment in occupation categories at the two-digit SOC level.[3] We use data encompassing the entire

[1] 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 of as distinguished by skill, whereas industries can include workers of many skills.

[2] See U.S. Bureau of Labor Statistics (2009). Military and institutionalized populations are excluded.

[3] The within-occupation changes in education could be forecasted from longer-term past trends. However, the nature of technology that likely drives these changes can differ over time, with some research suggesting that it can change quite quickly (Autor, Katz, & Kearney, 2006). Thus, we think that longer-term changes in education within occupations could be misleading. Another potential issue is whether the results are sensitive to using the trends that end in the first full year of the Great Recession (which began in the fourth quarter of 2007); that is, are the trends from 2000

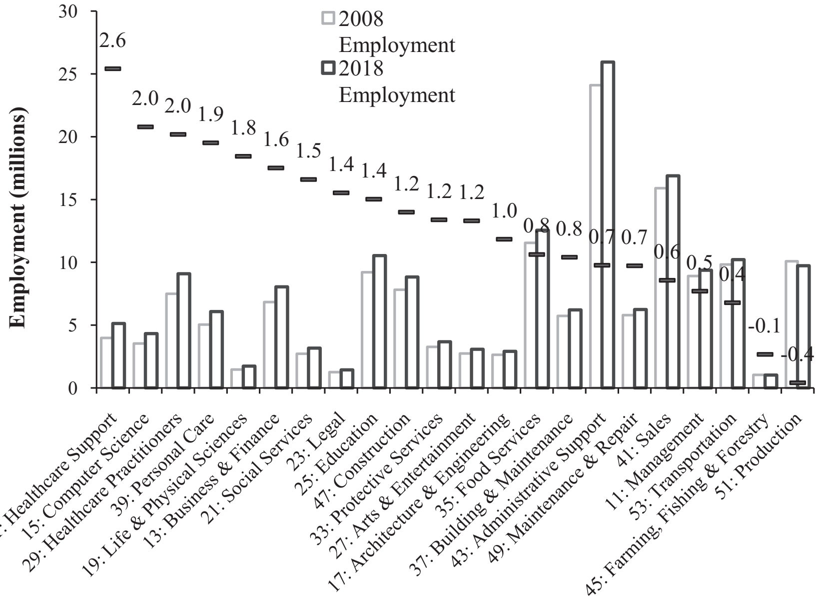

Fig. 2. BLS occupational employment projections 2008 and 2018. Ranked by projected average annual growth rate, displayed by numbers and horizontal bars. Projections are from U.S. Bureau of Labor Statistics, Employment Projections Program (2009).

age range of the workforce because the BLS occupational projections are not restricted by age, and instead cover the entire workforce. We apply the education growth rates within occupations to the 2008 ACS data by degree attainment and occupation category to arrive at estimated shares of workers by education level in each occupation in 2018. Then we apply the projected shares by degree attainment and occupation category to the 2018 BLS projections to give us employment levels by occupation comparable to those projected by the BLS.[4]

2.3. Other issues in the projections

The BLS reports skill requirements for the occupations for which they do projections.[5] Their occupational forecasts distinguish between job openings due to growth and job openings due to replacement needs (Lacey & Wright, 2009). Projected job openings for replacement needs 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. Assuming that employers anticipate this, they will project fewer high-skilled job openings than low-skilled job openings to staff the same number of jobs at each skill level. But filling those jobs requires one worker of each type.[6] We project demands for *workers*, since we are ultimately interested in assessing how well the supplies of workers by skill level will meet the demands.

The BLS skill requirements pertain to the most common skills required to perform a given occupation. For each occupation, the BLS identifies the "most significant source of education and training category," combining education and training measures into a single category, based on degree attainment data from the ACS, skills information from the Occupational Information Network (O*NET), and other qualitative information from occupational experts (Lacey & Wright, 2009). Some categories only identify "work-related training" 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

to 2008 appropriate for the longer time horizon for which we construct our demand projections? To examine this, we computed the correlation between the 2000–2008 and 2000–2010 trends in education within occupations. The correlation was high (0.88). Reflecting this high correlation, when we recomputed our main demand projections (in Table 5, discussed below) using the trends through 2010, the results were very similar. The conclusions were similar if we used trends calculated to end in 2007, before the labor market impacts of the Great Recession set in. The only difference in that case was the distribution of skill demands between high school or less and some college, with the trends through 2007 implying greater relative demand for the high school or less group. More generally, we are unaware of evidence suggesting that educational attainment within occupations is very sensitive to the business cycle.

[4] Both approaches are based on the perspective that the educational requirements of workers in particular occupations imply that workers with less education would be less productive in these occupations, consistent with the human capital model but not a pure signaling model.

[5] Very recent work by BLS updates and attempts to improve on the measurement of skill requirements by occupation. See http://www.bls.gov/emp/ep_finaledtrain.htm (accessed 09.08.12).

[6] See U.S. Bureau of Labor Statistics (2010). As an example, Table 3 in Lacey and Wright (2009) shows that between 2008 and 2018, BLS projects that 38.5% 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% of the projected net change in employment. At the other end of the educational spectrum, 23% 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% of the projected net change in employment.

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.

become fully qualified (Lacey & Wright, 2009, p. 89), implying 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.

Because we also measure skill requirements based on the observed educational distribution using data from the ACS, we need comparable categories of skills across the two data sources. Because the ACS uses solely degree attainment, we convert the BLS education/training categories into measures of pure degree attainment. 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 occupations 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.

We focus on educational requirements in terms of the levels of education, rather than the academic content of degrees, for two reasons. First, the projections on which we base our analysis can be converted into the levels of education but not into academic content. And second, although we have data sources and methods to predict levels of degree attainment in the future, it is much more difficult to project the fields in which academic degrees will be achieved. Therefore, our findings do not necessarily speak to shortages in particular fields at the same level of education.

Finally, we are interested 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 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.[7] 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.[8] 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.

2.4. Projections of skill requirements

Table 2 shows the projections of skill requirements based on BLS projections of employment growth by occupation and the assignment of skill requirements to these occupations. The top panel is based on "positions," and is obtained directly from BLS projections without modification. The bottom panel shows our projections of workers filling those jobs, mapping the skill requirements into the education categories described in Table 1. The projections indicate that the greatest increases in demand are in occupations that will require some postsecondary 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 formal postsecondary education. In 2018, 68.3% of all workers are projected to be in jobs that only require a high school degree or less, a slight decline from 69.7% in 2008.

Table 3 reports our alternative estimates and projections of employment by degree attainment, based on observed degree attainment in the Decennial Census and ACS. 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% 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 Census/ACS-based projections suggest that occupations with higher degree requirements will have the most rapid rates of growth,

[7] 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% 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.

[8] The BLS published employment level 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 11.04.10).

Table 2
Skill requirements based on BLS occupation projections, 2008 and 2018.

BLS education/skills category	New education category	Jobs (thousands)				Distribution	
		2008	2018	Absolute change	Percent change	2008	2018
Occupational employment							
Long-term on-the-job training	High school diploma or less	10,815	11,621	806	7.5%	7.2%	7.0%
Moderate-term on-the-job training	High school diploma or less	24,569	26,531	1963	8.0%	16.3%	16.0%
Short-term on-the-job training	High school diploma or less	54,396	58,593	4197	7.7%	36.0%	35.3%
Work experience in a related occupation	High school diploma or less	14,517	15,697	1180	8.1%	9.6%	9.4%
Postsecondary vocational award	Some college	8787	9952	1164	13.2%	5.8%	6.0%
Associate degree	Associate degree	6129	7297	1168	19.1%	4.1%	4.4%
Bachelor's degree	Bachelor's degree	18,584	21,669	3085	16.6%	12.3%	13.0%
Bachelor's or higher degree, plus work experience	Bachelor's degree	6519	7068	550	8.4%	4.3%	4.3%
Master's degree	Master's degree	2531	2995	464	18.3%	1.7%	1.8%
First professional degree	First professional degree	2001	2354	353	17.6%	1.3%	1.4%
Doctoral degree	Doctoral degree	2085	2430	345	16.6%	1.4%	1.5%
Total		150,932	166,206	15,274	10.1%	100.0%	100.0%

New education category	Fraction of individuals holding more than 1 job	Workers (thousands)				Distribution	
		2008	2018	Absolute change	Percent change	2008	2018
Demand for workers							
High school diploma or less	2.5%	101,752	109,699	7947	7.8%	69.7%	68.3%
Some college	4.6%	8401	9514	1113	13.2%	5.8%	5.9%
Associate's degree	5.5%	5809	6916	1107	19.1%	4.0%	4.3%
Bachelor's degree	5.4%	23,816	27,265	3449	14.5%	16.3%	17.0%
Master's degree	7.1%	2363	2797	433	18.3%	1.6%	1.7%
Professional degree beyond Bachelor's	5.2%	1902	2237	335	17.6%	1.3%	1.4%
Doctorate	6.3%	1961	2286	325	16.6%	1.3%	1.4%
Total		146,005	160,714	14,709	10.1%	100.0%	100.0%

Top panel corresponds to Table 3 in Lacey and Wright (2009). Bottom panel is based on authors' re-categorization of the BLS education/training categories and on authors' calculations of multiple job holders based on the CPS January Supplement, 2006–2008.

the differences in projected rates of growth are large. The Census/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-based projections estimate an increase of close to 8 million for the same education group.[9] In contrast, the Census/ACS-based projections call for rapid growth in demand for workers with Associate's degrees, Bachelor's degrees, and Doctorates.

The projected percentage increase in demand for workers with Associate's degrees is particularly high. This projection is in large part driven by BLS projections of fast growth in occupations with high shares of workers with an AA degree (such as health care practitioners and computer science, for which the shares with AA degrees in 2008 ACS data are 22.7% and 10.5%, respectively). We also find evidence in the recent past that the estimated earnings premium for AA degrees has increased. Using 2000 Census data and 2008 ACS data,[10] the premium for an AA degree relative to high school or less increased from .274 (.001 standard error) to .290 (.002), a 6% increase in 8 years. In contrast, the some college "premium" fell slightly, and the Bachelor's premium was essentially flat (increasing by only .002).

2.5. Assessment of BLS skill requirements

The preceding analysis makes clear that we get very different projections of skill demands using observed levels of and trends in education by occupation versus the BLS skill requirements, which raises the question of which method better captures demand for more highly skilled workers. One way to ask whether much higher degree attainment levels as reported in the ACS reflect skill demands is to examine the education-related wage premia within occupations. If there are positive returns to education levels

[9] We have noted that there is some ambiguity in how to classify educational requirements in occupations where the BLS indicates training or work experience as the most significant requirement. We experimented with upgrading the occupations in the "long-term on-the-job training" category from "high school diploma or less" to "some college," based on inspection of the occupations in this category, which suggested that some college or classroom education might in fact be required in these occupations. (In contrast, this seemed unlikely for occupations in the other three non-education skill requirements classifications.) This upgrading of skill requirements did little to reduce the difference between skill demands based on observed education in the Census/ACS and education or skill requirements from the BLS. In particular, with this upgrading, the projected percentage of workers in jobs requiring only a high school degree or less in 2018 falls from 68.3% to 61.3%, still a large difference from the 34% implied by the Census/ACS data.

[10] The specification is described in the notes to Table 4, discussed below.

Table 3
Alternative projections of educational degree attainment requirements based on ACS/Decennial Census trends.

Education category	Workers (thousands)				Distribution	
	2008	2018	Absolute change	Percent change	2008	2018
High school degree or less	54,539	54,701	162	0.3%	37.5%	34.0%
Some college	35,182	39,560	4378	12.4%	24.2%	24.6%
Associate's degree	12,144	15,879	3735	30.8%	8.4%	9.9%
Bachelor's degree	28,038	32,822	4784	17.1%	19.3%	20.4%
Master's degree	10,614	12,608	1994	18.8%	7.3%	7.8%
Professional degree beyond Bachelor's	3059	2816	−243	−7.9%	2.1%	1.8%
Doctorate	1786	2326	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.

above those indicated as the skill requirement for an occupation in the BLS data – and especially if these wage premia are similar to those in other occupations – then relying on the BLS skill requirements likely substantially understates projected skill demands.

To answer this question, we use 2008 ACS data to estimate, for each two-digit occupation, a regression of log earnings on a set of dummy variables corresponding to each education category beyond the lowest omitted group, as well as the usual earnings function controls (marital status, age and its square, region, race, ethnicity, and sex) and dummy variables for three-digit occupations. The regression estimated for each occupation, omitting individual subscripts, is:

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

In this equation w is the wage, S_k^R is a set of dummies for required educational levels, and S_j^{NR} for non-required educational levels, based on the BLS skill requirements. 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 – 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.[11]

The results are reported in Table 4. The grey shading highlights the educational levels in each occupation that are above those "required," according to the BLS.[12] 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 when BLS does not categorize the higher level of education as required. 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 required level. For the joint test of the significance of the education coefficients for above-required levels, for every occupational grouping we reject the hypothesis that there are no returns to education levels above those that the BLS states are required. Finally, we find evidence of substantial representation of workers above the required BLS education category (Neumark, Johnson, & Mejia, 2011, Table 5), indicating that these results are not driven by a handful of workers with education above the required level according to the BLS, and that employers are willing to hire workers at those higher educational levels and pay them the market premium, which they would have no incentive to do unless the more-educated workers were in fact more productive.

One caveat is that there are occupations that require high levels of skill but not much education. For occupations such as these our approach is 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, 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% of law enforcement workers need long-term training, and we find that 78% of these workers have attended at least some college. This suggests that in some occupations, college vocational courses (including those in community

[11] 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). One problem with this approach that biases the results toward finding lower returns to education above the typical level in the job is that those who have more education than the norm 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 & Bennett, 2007).

[12] We used the highest degree requirement at the six-digit occupation level within the two-digit occupation grouping.

Table 4
Estimated returns to schooling, above and below the maximum BLS required skill category, 2008.

Occupation descriptions	Coefficients relative to lowest category (high school or less)						Joint test	
	Some college	Associate's degree	Bachelor's degree	Master's degree	Professional degree	Doctorate	*p*-Value	D.o.F.
Management occupations	0.146 (0.006)	0.159 (0.008)	0.434 (0.005)	0.614 (0.006)	0.683 (0.014)	0.780 (0.014)	0.0000	3
Business and financial operations occupations	0.114 (0.009)	0.094 (0.011)	0.372 (0.008)	0.589 (0.010)	0.612 (0.020)	0.672 (0.030)	0.0000	3
Computer and mathematical science occupations	0.102 (0.012)	0.075 (0.013)	0.292 (0.011)	0.401 (0.012)	0.397 (0.031)	0.473 (0.022)	na	na
Architecture and engineering occupations	0.061 (0.011)	0.085 (0.012)	0.253 (0.010)	0.386 (0.012)	0.310 (0.026)	0.491 (0.020)	0.0000	3
Life, physical, and social science occupations	0.039 (0.025)	0.053 (0.029)	0.191 (0.021)	0.275 (0.023)	0.315 (0.033)	0.410 (0.023)	na	na
Community and social services occupations	0.054 (0.014)	0.079 (0.017)	0.196 (0.012)	0.383 (0.013)	0.412 (0.023)	0.445 (0.024)	0.0139	2
Legal occupations	0.059 (0.030)	0.066 (0.033)	0.177 (0.029)	0.304 (0.041)	0.510 (0.034)	0.440 (0.042)	na	na
Education, training, and library occupations	0.024 (0.009)	0.064 (0.011)	0.335 (0.008)	0.542 (0.008)	0.623 (0.014)	0.827 (0.011)	na	na
Arts, design, entertainment, sports, and media occupations	0.129 (0.020)	0.129 (0.023)	0.304 (0.018)	0.388 (0.023)	0.484 (0.057)	0.451 (0.055)	0.0000	3
Health care practitioners and technical occupations	0.061 (0.010)	0.157 (0.010)	0.246 (0.010)	0.338 (0.012)	0.838 (0.011)	0.668 (0.015)	na	na
Health care support occupations	0.068 (0.008)	0.121 (0.012)	0.152 (0.014)	0.342 (0.030)	0.575 (0.037)	0.506 (0.067)	0.0000	4
Protective service occupations	0.146 (0.008)	0.202 (0.010)	0.303 (0.009)	0.470 (0.017)	0.405 (0.043)	0.616 (0.062)	0.0000	4
Food preparation and serving related occupations	0.071 (0.007)	0.177 (0.013)	0.202 (0.012)	0.240 (0.034)	0.070 (0.074)	0.411 (0.131)	0.0000	6
Building and grounds cleaning and maintenance occupations	0.089 (0.008)	0.100 (0.014)	0.105 (0.014)	0.245 (0.039)	0.119 (0.065)	0.248 (0.191)	0.0000	6
Personal care and service occupations	0.082 (0.011)	0.138 (0.017)	0.274 (0.014)	0.270 (0.031)	0.241 (0.069)	0.424 (0.153)	0.0000	5
Sales and related occupations	0.123 (0.005)	0.140 (0.008)	0.429 (0.006)	0.606 (0.011)	0.615 (0.028)	0.609 (0.044)	0.0000	3
Office and administrative support occupations	0.084 (0.003)	0.107 (0.004)	0.229 (0.004)	0.366 (0.008)	0.327 (0.023)	0.476 (0.035)	0.0000	4
Farming, fishing, and forestry occupations	0.074 (0.022)	0.188 (0.039)	0.261 (0.032)	0.416 (0.096)	0.095 (0.184)	0.791 (0.231)	0.0000	6

Table 4 (*Continued*)

Occupation descriptions	Coefficients relative to lowest category (high school or less)						Joint test	
	Some college	Associate's degree	Bachelor's degree	Master's degree	Professional degree	Doctorate	*p*-Value	D.o.F.
Construction and extraction occupations	0.101 (0.006)	0.155 (0.010)	0.118 (0.011)	0.116 (0.029)	0.195 (0.055)	0.181 (0.109)	0.0000	6
Installation, maintenance, and repair occupations	0.108 (0.006)	0.162 (0.008)	0.162 (0.011)	0.249 (0.027)	−0.102 (0.068)	0.144 (0.121)	0.0054	2
Production occupations	0.125 (0.004)	0.164 (0.007)	0.232 (0.008)	0.352 (0.018)	0.196 (0.045)	0.431 (0.058)	0.0000	5
Transportation and material moving occupations	0.073 (0.005)	0.062 (0.010)	0.100 (0.010)	0.170 (0.024)	−0.069 (0.062)	0.034 (0.100)	0.0043	1

Standard errors are shown in parentheses. Grey cells represent the education categories above the highest BLS category required for the occupation category (at the six-digit level). 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, three-digit occupation dummy variables, 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 the estimated return to BLS-required education level; we also exclude coefficients above the first negative one.

college programs that lead to certificates) might substitute for long-term training.

3. Population and educational degree 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 Census/ACS data, suggest negligible increases in demand for workers without post-secondary training, and substantial increases for those with such education. The next question is whether the skills of the U.S. workforce 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 and labor force projections that include educational degree attainment. 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 demands by degree attainment, but cannot project the supply of workers to specific occupations.

The U.S. Census Bureau provides population projections by race, ethnicity, sex, and age. However, Census does not project population by degree attainment, which is an essential input for our study. Nor does Census project population by nativity (U.S.-born and foreign-born). Nativity is strongly associated with degree attainment, even within ethnic groups,[13] and therefore is essential for developing degree attainment projections. Thus, to produce degree attainment projections, we first develop a new set of population projections that includes nativity as well as race, ethnicity, sex, and age. We constrain our overall projections to be consistent with population projections produced by the Census Bureau, so our projections do not differ from the Bureau's in terms of the overall size of the projected population, but rather only in composition.

Our population projections are derived from a standard cohort component model in which the population is aged across time using age, ethnicity, sex, and nativity cohorts. We consider six race/ethnic groups. 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 just below 1% and absolute annual changes of about three million. By 2018, the 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,

[13] For example, in 2008 ACS data, the share with less than a high school education is 28.1% among native-born Hispanics, vs. 51.6% for immigrants. And the corresponding numbers with some college are 44% and 24.3%.

Table 5
Estimated and projected supply and demand for workers by degree attainment, 2008 and 2018.

Education category	Workers (thousands)			Shares			BLS Demand
	Supply	Demand	Diff	Supply	Demand	Diff	
2008 Supply and demand for education by education category							
High school or less	60,013	54,539	5474	38.9%	37.5%	1.4%	69.7%
Some college	36,852	35,182	1670	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	3109	3059	49	2.0%	2.1%	−0.1%	1.3%
Doctorate	1815	1786	29	1.2%	1.2%	−0.1%	1.3%
All education categories	154,286	145,362	8924	100.0%	100.0%	0.0%	100.0%
Education category	Workers (thousands)			Shares			BLS Demand
	Supply	Demand	Diff	Supply	Demand	Diff	
2018 Supply and demand projections for education by education category							
High school or less	59,626	54,701	4925	35.0%	34.0%	0.9%	68.3%
Some college	43,173	39,560	3613	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	1005	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	3024	2816	208	1.8%	1.8%	0.0%	1.4%
Doctorate	2245	2326	−81	1.3%	1.4%	−0.1%	1.4%
All education categories	170,579	160,713	9866	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.

the nation is becoming more ethnically diverse; by 2018 the share of the population that is non-Hispanic white will decline to about 60% 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% of all U.S. residents will be foreign-born, up from 13% in 2000, with children born to immigrants representing a sizable source of the U.S.-born growth. And third, the population will continue to age, with the population in prime working ages growing more slowly than the overall population, and the number of seniors growing more rapidly.

3.1. Population projections by educational degree attainment

Degree attainment *distributions* are projected based on the continuation of historic trends for each of our population cohorts, and are identified separately by race/ethnicity, sex, age group, and nativity. Applying these projected degree attainment distributions to our population projections yields projected population counts by degree 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 estimate trends in degree 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 the education projections, using a cohort approach or a period approach depending on the age group. For adults ages 30–80 in 2008, we use a dynamic cohort approach. We follow cohorts across time so that degree attainment in 2018 is based on 2008 levels for the cohort, with adjustments made based on changes in degree attainment observed for similarly aged cohorts from 2000 to 2008. This assumes that life-cycle patterns of educational acquisition trump 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:

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

This approach allows continuing improvements in degree attainment across age-specific cohorts, and the acquisition of more education by older workers.[14] For example, the degree attainment distribution of people aged 40–44 in 2018 is based on the distribution of people aged 30–34 in 2008, plus changes between 2000 and 2008 in the distribution that were observed for people aged 40–44 in 2008.

For younger cohorts, those under age 30, we have to use a somewhat different method, since degree attainment levels change so dramatically as people age from childhood

[14] The multiplication by 1.25 accounts for the different lengths of the time periods covered.

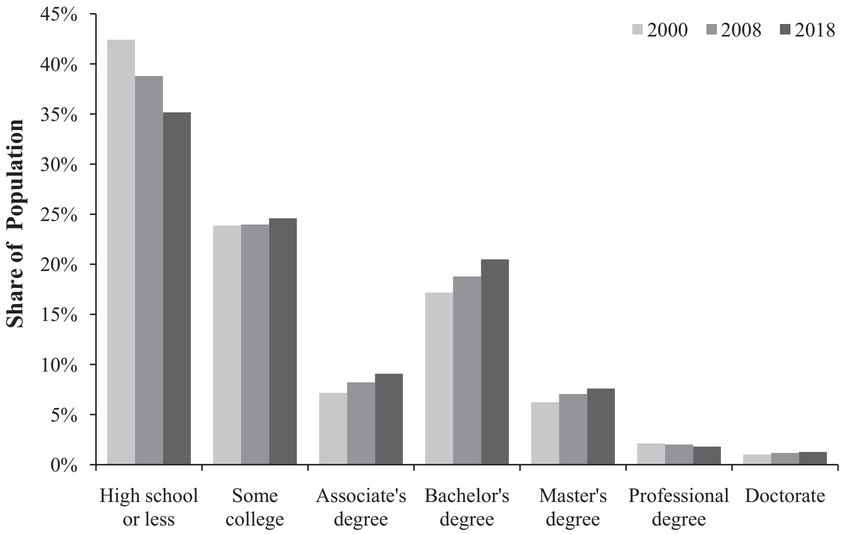

Fig. 3. Educational degree attainment of U.S. adults ages 25–64, 2000, 2008, and 2018. Based on 2000 Decennial Census, 2008 ACS, and projections described in the text.

and across young adult ages. Instead, historic patterns of change in degree attainment for the age group are allowed to continue at the same pace. Using the same notation as above, our projections are based on:

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

which assumes that for each of our population subgroups under age 30, changes in degree 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 degree 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 25–64, the share projected to have at least a Bachelor's degree continues to increase, from 27% in 2000 to 29% in 2008 to 31% in 2018 (Fig. 3). 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 degree attainment for U.S.-born groups more than counteract the demographic shifts towards groups that historically have relatively low levels of degree attainment. And not all the demographic shifts have a dampening effect on degree attainment. Although relatively small in number, Asians are the best-educated population group in the United States,[15] and are projected to continue to experience strong rates of population growth (Neumark et al., 2011, Table 6). Finally, we note that young adults in their late 20s and early 30s have higher degree attainment levels in 2008 than in 2000. We project that this trend will continue to 2018, leading to greater overall gains in degree attainment.[16]

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,[17] yielding labor force projections by degree attainment for each subgroup.[18] Because labor force participation rates are greater for more highly educated people, the degree attainment levels of the workforce are slightly higher than those of the entire population, even controlling for age.

4. Demands versus supplies

4.1. Key findings

Table 5 compares the demand and supply projections. The supply shares by degree attainment are based on our population projections adjusted for labor force participation, and the demand shares are based on our alternative demand projections. For 2008, these shares are applied to published BLS data on the labor force and

[15] This is true of both U.S.-born and foreign-born Asians.

[16] 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.

[17] Alexander, Davern, and Stevenson (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.

[18] We also experimented with allowing for increases in labor force participation rates for each of the groups (defined by age, education, sex, nativity, and race/ethnicity), projecting changes from 2008 to 2018 based on observed changes over the 2000–2008 period. However, this had only negligible effects on the projected supplies by skill.

Table 6
Percentage of adults with a bachelor's degree or above by state, 2008.

State	Percent with a Bachelor's degree or above				% Latino in state		% Asian in state	
	Age 25–34 to age 55–64, sorted (1)	Total (2)	Latinos (3)	Asian (4)	2000 (5)	2010 (6)	2000 (7)	2010 (8)
New Mexico	−11.4%	26%	14%	53%	42%	46%	1%	1%
Alaska	−8.9%	28%	23%	24%	4%	6%	4%	6%
Utah	−8.5%	30%	12%	39%	9%	13%	2%	3%
Hawaii	−7.2%	32%	19%	32%	7%	9%	50%	49%
Arizona	−7.0%	26%	10%	54%	25%	30%	2%	3%
Colorado	−6.1%	38%	13%	48%	17%	21%	2%	3%
Wyoming	−6.0%	23%	6%	32%	6%	9%	1%	1%
Oregon	−5.3%	30%	12%	48%	8%	12%	3%	4%
Montana	−4.5%	30%	22%	55%	2%	3%	1%	1%
California	−4.5%	31%	11%	51%	32%	38%	11%	13%
Nevada	−4.4%	23%	9%	38%	20%	27%	5%	8%
Maine	−4.2%	25%	21%	20%	1%	1%	1%	1%
Washington	−3.8%	32%	11%	47%	7%	11%	6%	8%
Texas	−3.6%	27%	12%	56%	32%	38%	3%	4%
Florida	−3.4%	28%	23%	45%	17%	22%	2%	2%
Idaho	−3.0%	26%	8%	44%	8%	11%	1%	1%
Vermont	−2.9%	35%	21%	42%	1%	1%	1%	1%
Georgia	−2.5%	30%	13%	52%	5%	9%	2%	3%
New Hampshire	−2.2%	36%	36%	67%	2%	3%	1%	2%
South Dakota	−1.8%	27%	29%	66%	1%	3%	1%	1%
Oklahoma	−0.9%	24%	11%	45%	5%	9%	1%	2%
Virginia	−0.8%	36%	24%	58%	5%	8%	4%	6%
Arkansas	−0.5%	21%	10%	38%	3%	6%	1%	1%
Louisiana	−0.5%	22%	18%	37%	2%	4%	1%	2%
South Carolina	−0.3%	26%	11%	48%	2%	5%	1%	1%
Mississippi	−0.1%	21%	9%	46%	1%	3%	1%	1%
Kansas	0.2%	32%	14%	58%	7%	11%	2%	2%
Alabama	0.4%	24%	13%	52%	2%	4%	1%	1%
Rhode Island	0.7%	33%	14%	51%	9%	12%	2%	3%
Delaware	0.7%	29%	15%	65%	5%	8%	2%	3%
Nebraska	0.8%	31%	8%	38%	6%	9%	1%	2%
Tennessee	1.2%	25%	11%	53%	2%	5%	1%	1%
North Carolina	1.5%	28%	14%	53%	5%	8%	1%	2%
Maryland	1.7%	38%	20%	65%	4%	8%	4%	6%
Missouri	1.8%	28%	19%	50%	2%	4%	1%	2%
West Virginia	1.8%	19%	29%	68%	1%	1%	1%	1%
Wisconsin	2.0%	28%	12%	46%	4%	6%	2%	2%
Michigan	2.0%	27%	17%	63%	3%	4%	2%	2%
Kentucky	2.4%	21%	11%	53%	1%	3%	1%	1%
Indiana	2.4%	25%	10%	58%	4%	6%	1%	2%
Ohio	2.9%	27%	20%	66%	2%	3%	1%	2%
Connecticut	3.0%	39%	16%	65%	9%	13%	2%	4%
New Jersey	3.3%	38%	17%	70%	13%	18%	6%	8%
Illinois	4.0%	33%	12%	65%	12%	16%	3%	5%
North Dakota	4.6%	29%	0%	20%	1%	2%	1%	1%
Minnesota	4.8%	35%	18%	42%	3%	5%	3%	4%
Pennsylvania	6.0%	29%	14%	55%	3%	6%	2%	3%
Iowa	6.5%	27%	12%	53%	3%	5%	1%	2%
New York	6.7%	35%	16%	48%	15%	18%	5%	7%
Massachusetts	8.4%	42%	17%	60%	7%	10%	4%	5%
District of Columbia	16.8%	52%	29%	80%	8%	9%	3%	4%

"Asian" includes Pacific Islanders. Columns (1)–(4) are calculated from 2008 ACS data; columns (2)–(4) are for the population aged 25–64. Columns (5)–(8) are from 2000 and 2010 Decennial Census and are calculated for total population of any age. States are sorted in order of entries in column (1).

employed persons ages 16 and over.[19] 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 workers. Because unemployment rates are higher for the less educated,[20] these supply versus demand comparisons might be viewed as overstating supply relative to demand for the low-education groups. For 2018, we calculate the supply shares by degree attainment using the population projections described in Section 3. We calculate demand shares by degree attainment using the methods described in Section 2.

The primary finding is that our projections do not provide 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 educational degree. 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 might possibly 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.[21]

For purposes of comparison, the far right column of Table 5 shows demand estimates and projections based on the BLS skill requirements. The BLS-based demand projections imply that the supply of more highly educated workers has, and will continue to, far outweigh 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.

4.2. Important factors underlying the projections

Our finding of no large overall skill shortage, as measured by degree attainment, rests on three key factors. First, we project that young adults will continue to experience improvements in degree 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 or 2008.

Second, we project continued upgrading of degree attainment levels of older workers. Our projections and analyses of historic trends in degree attainment allow us to identify the extent to which middle-aged workers have continued to acquire new skills. In the synthetic cohort approach, we examine changes in degree attainment reported by adults identified by birth cohort and population subgroup. We project these trends from 2008 to 2018 based on patterns of change observed from 2000 to 2008. 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. Based on our cohort analyses, among adults ages 40–64 in 2018 (ages 30–54 in 2008), we project that almost 1.2 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.[22] Although these increases represent only a small share of the 104.9 million adults in this age range in 2018, they 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 30–34 from 2006 through 2008, 5% are in undergraduate programs (including community colleges) and 3% are in graduate programs.[23] For adults in their late 50s, fewer than 1% are in such programs.[24]

Moreover, the projected upgrading is consistent with recent historical experience. Skill upgrading from 2000 to 2008 also occurred. For example, the actual increases in those with Bachelor's degrees and Master's degrees from 2000 to 2008 were 0.6 and 1.1 million (based on Census and ACS data). We would also expect the upgrading to be concentrated among younger people with more years to accrue the benefits. The projections reflect this. For example, the

[19] 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 11.04.10).

[20] 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% compared to 4.4%) and are more than three times as high as the unemployment rates for workers who have at least a Bachelor's degree (2.8%).

[21] 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.

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

[23] These figures are based on a restricted sample that only considers enrollment for adults in schooling that is above their current level of educational attainment. They 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.

[24] 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).

projected increase in Bachelor's degrees is 513,000 for 40–44 year-olds, declining monotonically across five-year age groups to 44,000 for 60–64 year-olds. The corresponding numbers for Master's degrees are 493,000 and 28,000 (also declining monotonically).

The third important factor underlying the projections is the greater labor force participation of highly educated older adults relative to 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. Moreover, retirement rates, which increased notably from 1970 to 1980 and remained near those levels for several decades, have recently declined and for many older age groups are now lower than they were even in 1970.[25]

4.3. Skill shortages in the longer term?

One reason we might not see evidence of a large impending skill shortage is that our projection horizon is too short. Our projections extend to 2018, 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 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 these 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 (Fig. 1).

We expect that projections to 2030 would show a continuation of current patterns, with greater rates of growth in industries and occupations that employ highly educated workers and rising education demands within industries and occupations, consistent with the long-standing trend in the United States of moving towards a more highly skilled economy. This will likely be reinforced as the aging of the boomer cohorts drives up the demand for health care, in which occupational skill requirements are quite high. Combined with the demographic supply forecasts to 2030, it is likely, then, that general skill shortages would be more evident in projections extended to 2030.

4.4. 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 even in this time frame. As shown in Table 6, older adults nearing retirement ages are notably better educated than young adults in around 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.

As Table 6 shows, many states also have increasing Asian populations, which are relatively highly educated. But the increases in the Asian share are generally much smaller, in large part because the base is so much lower. Thus, the lower education of Hispanics combined with their more pronounced growth implies that some states with growing Hispanic populations may face substantial skill shortages, even if the proportion of Asians in the state population is also rising.[26]

The importance of rising shares of Hispanics in the population is illustrated by a simple exercise. In Table 7 we develop new estimates of the supply of workers for the nation, but substitute California's projected 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 were to have California's projected demographic mix?[27] The answer is yes; we find a deficit of

[25] 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.

[26] A large and growing immigrant share is not the only potential source of skill shortages in the future. For example, 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.

[27] That is, we project California's population by race, ethnicity, and nativity using the same methods as for the national projections described earlier. We then scale these up to the U.S. population, and then we project

Table 7
Education supplies and demands if the United States had California's Projected Ethnic Distribution, 2018.

Education category	Workers (thousands)			Share		
	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	−1933	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	2794	2816	−22	1.6%	1.8%	−0.1%
Doctorate	2159	2326	−168	1.3%	1.4%	−0.2%
All education categories	170,579	160,713	9866	100.0%	100.0%	na

Based on projections described in text.

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. Note that this occurs despite an increase in the share of the population that is Asian.

5. Conflicting evidence

5.1. Alternative projections

In a recent study, Carnevale, Smith, and Strohl (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). This contrasts markedly with our projections (Table 5) of 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.[28]

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, project total educational demand by occupation. At the same time, if we put their projected total educational demands up against our supply forecasts, we reach a conclusion similar to theirs – that there will be shortage of more than 3 million workers with Associate's degrees or better by 2018. Specifically, 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, so we can examine the two projections for total educational demand to try to understand why they are so different.

In brief, the difference is due to two factors.[29] The first is the use of CPS data, rather than the Decennial Census and ACS data we use, coupled with some oddities in the CPS data that make the projections very sensitive to the base year used. The second is the failure to use the same data source to capture both sides of the labor market. 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 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 education questions in the two surveys, which lead more people in the CPS get coded as having an Associate's degree because some CPS respondents appear to treat occupational or vocational certificates as Associate's degrees. Moreover, for reasons that are less clear, from 2000 to 2008 the CPS data show 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. Given that both the CPS baseline and growth rates lead to higher demand for more-educated workers, relying on the CPS data results in much higher projected demand for more-educated workers, and these two differences in the CPS data account for the difference in the demand-side projections.

The alternative data sources track educational trends much more closely through 2007. We therefore redid the demand-side forecasts using data from 2000 to 2007 (rather than 2000–2008) to estimate the within-occupation trends in education. The projections using the ACS/Census data are very close to our original projections with regard to college degrees, although the high school degree or less versus some college distribution differs. In contrast, 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 is 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.

supply of workers by education by applying the national education and labor force participation figures by race, ethnicity, and nativity to these population projections.

[28] Note that Carnevale et al. group as college graduates those with an Associate's degree or higher; so this final number is the most comparable one. Our "excess" supply can include the unemployed.

[29] The detailed analysis on which this summary is based is provided in our working paper (Neumark et al., 2011).

The second factor is that the Carnevale et al. projections use data for the supply side projections that 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. To assess this, we replicated the supply and demand projections as described earlier, but using CPS data on *both* sides of the market. Doing this, we end up with a shortage of 668,000 skilled workers by 2018, which is much closer to the 1.3 million oversupply of skilled workers that we project using Census/ACS data (Table 5). Thus, Carnevale et al.'s (2010) projection of large skill shortages in the near term appears to be unfounded.

5.2. Criticism of using education to measure skill requirements

Harrington and Sum (2010a, 2010b, 2010c) strongly criticize the strategy (which both we and Carnevale et al. follow) of using observed educational distributions to project skill demands, and instead defend the BLS skill requirements that, as we showed in Table 5, imply a vast oversupply of educated workers. Consistent with that vast oversupply, in their view the fundamental skills problem is that many college workers are in jobs that do not require college degrees, which Harrington and Sum refer to as "mal-employment," defined as "inability of a college graduate to find a job that effectively uses the knowledge, skills and abilities acquired in college ..." (Harrington & Sum, 2010a).

To make their case, Harrington and Sum (2010c) first classify occupations as belonging to the "college labor market" (CLM) based on the share of workers in the occupation with a college degree.[30] Given this classification, they estimate (using 2006–2008 ACS data) 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 which distinguishes between those who – according to their classification – are in jobs that do and 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 are shown in column (1) of Table 8.[31]

This evidence is likely suspect. It is directly at odds with the findings reported in Table 4, which show substantial economic returns to higher educational degrees in occupations where, according to the BLS skill requirements, those degrees were not required. The inconsistency arises because Harrington and Sum's regressions exclude occupation dummy variables. Excluding occupational controls implies that the Harrington and Sum's low estimated education premia for mal-employed workers likely reflect omitted occupation effects. Most important, 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.[32]

To test this explanation, we first replicated Harrington and Sum's results using ACS data for 2008. As reported in column (2) of Table 8, 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.[33] The estimates of this more-restricted specification, in column (3), are very similar.

Column (4) shows 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 (according to BLS) 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 percentage points), this is a much smaller differential – especially in absolute terms. The same is true for more-advanced degrees.[34]

There is additional evidence that the specifications without the occupation dummy variables are

[30] They provided us with an appendix listing the 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.

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

[32] For example, Harrington and Sum (2010a, 2010c) tell 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 occupation-by-occupation regressions in Table 4 parallel the inclusion of dummy variables for each occupation.

[33] 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.

[34] As reported in Neumark et al. (2011), we reached the same – and in fact stronger – conclusions when we redid the same type of estimation using another "expert" analysis of education requirements, based on the O*NET.

Table 8
Estimated returns to degrees above required degrees, 2008.

Estimates	H&S results	Replication of H&S		
	(1)	(2)	(3)	(4)
Required education:				
Less than high school	0.102	0.163 (0.008)	−0.268 (0.003)	−0.151 (0.003)
Some college	0.373	0.432 (0.003)	0.183 (0.002)	0.070 (0.002)
Associate's degree	0.471	0.525 (0.004)	0.322 (0.003)	0.113 (0.003)
Bachelor's degree	0.631	0.671 (0.002)	0.669 (0.002)	0.272 (0.003)
Master's degree or better	0.799	0.841 (0.003)	0.838 (0.003)	0.474 (0.003)
			In job that does not require college degree	
Interactions with:				
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 (0.005)	–	–
Bachelor's degree	−0.486	−0.504 (0.004)	−0.503 (0.004)	−0.127 (0.004)
Master's degree or better	−0.610	−0.609 (0.007)	−0.608 (0.007)	−0.297 (0.007)
Occ. dummies included:	No	No	No	Yes
N	3,869,456	1,147,081	1,147,081	1,147,081

Column (1) is from Harrington and Sum (2010c, 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 $1000 and less than $200,000. Other controls include: age, age squared, male, native-born, black, Hispanic, Asian, and other race. The occupation dummy variables are defined at the finest level of occupational detail available in the ACS; in most cases, this is at the six-digit SOC level (the exceptions are when several occupations were bundled together in the ACS).

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.

6. 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 larger 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. Barriers to migration, including moving costs, could prevent those shortages from being resolved.[35] Third, our research focuses on the supplies of and demands for workers classified by educational degrees, and it is possible and in fact 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.

[35] An analysis of California's projected skill shortages suggests that interstate migration flows are not likely to fully eliminate the shortages. High housing costs in California are another kind of migration cost. The size of the projected shortage for California would require unprecedented in-migration to the state (Johnson & Reed, 2007).

Future research should expand on the issues we have considered – state-specific shortages and migration and other responses; particular occupations and education fields that might be in short supply; 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 with regard to health care or Social Security – 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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