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ABSTRACT

The US Labor Market in 2050: Supply, Demand and Policies to Improve Outcomes*

Current estimates suggest that over the coming decades, slower population growth and lower labor force participation will constrain the supply of labor in the U.S. The U.S. labor force will also become more diverse as immigration and fertility trends increase the size of minority populations. New forms of automation will likely require workers to adapt to keep their old jobs, while many will be displaced or face less demand for their work (while others benefit). Firms will continue to implement alternative staffing arrangements, like turning workers into independent contractors or outsourcing their human resource management to other firms; and many will adopt "low-road" employment practices to keep labor costs low. Exactly whom these changes will benefit or harm remains unclear, though non-college workers will likely fare the worst; higher productivity from new technologies and reduced labor supply could raise average wages, but many workers will clearly be worse off. Policy makers should provide incentives for firms to train current employees, rather than replace them, and should encourage schools and colleges to teach flexible, transferable skills, as the future workforce will likely need to adapt quickly to new and changing job requirements. Lifelong learning accounts for workers could help. Expanding wage insurance and improving unemployment insurance and workforce services could help workers adapt after suffering job displacement. Policies that make work pay, like the EITC, and others designed to increase labor force attachment, like paid family leave, could help mitigate declines in the labor force. Reforms in immigration and retirement policy will help as well, as would policy experimentation at the state and local level (with federal support).

JEL Classification: J2, J3

Keywords: labor market, labor supply, labor demand, employment outcomes, automation

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There seems little question that the US labor market in the next three decades will be buffeted by two major sets of changes. On the *supply* (worker) side of the market, demographic changes caused by Baby Boomer aging and immigration will create an older and more diverse workforce. And, on the *demand* side, ongoing automation and other changes in the nature of work will likely generate more upheaval and instability in worker prospects.

How will both of these trends play out over time? Can we accurately project future trends in worker composition and the occupations/industries in which workers will find jobs? What do these trends imply for worker outcomes like job displacement rates, labor force activity, employment and unemployment, and inequality in compensation? And what policies are indicated by such expected trends, in order to preserve and expand worker opportunities?

Below I explore all of these questions. In Section I, I investigate the likely labor supply- and demand-side changes that will occur over the next few decades. In each case, I will review expected trends and their causes, acknowledging the many forces that render any projections very uncertain. I will also explore the likely implications of these developments for overall worker outcomes such as dislocations, labor force and employment rates, and compensation levels and inequality.

Then, in Section II, I review a range of policy responses that I believe are implied by these forces and trends. Such policies on the supply side of the market include immigration and retirement policies, as well as education and training. On the demand side of the market, they include regulations as well as incentives for employers to create higher-quality jobs. And policies that provide universal and portable worker benefits (like health insurance and pensions) while helping to "make work pay" for those facing low wage prospects create buffers protecting workers from the most unstable forces in the market. On the other hand, I also argue that certain policies that are increasingly growing popular as responses to automation, such as Universal Basic Incomes and guaranteed jobs, are not indicated at this time.

I. Labor Market Forces: Supply, Demand and Their Effects on Worker Outcomes

The standard economic model of the labor market posits that the worker outcomes we care about most – such as the levels of employment and earnings for different demographic and education groups – reflect the interaction of supply and demand-side forces in that market, along with effects of institutions (like firms or unions) plus government policy.

The supply side of the labor market reflects the numbers of workers in the population and their demographic composition; who chooses to participate in the formal labor market; and the levels of education and skills they bring to work. The demand side of the market reflects the jobs created by employers, the occupations in which these jobs are found, the skills that they seek, and other aspects of how they recruit and compensate their workers. Demand-side behaviors and characteristics are heavily affected by impersonal market forces like automation and globalization; as well as institutional changes in the nature of work (e.g., declining unionism

or a shift from regular employment to contractor status for workers) and changes in government regulations such as minimum wage and overtime laws.

Labor economists broadly agree that changes in observed labor market outcomes over the past 30-40 years – such as stagnation in overall earnings, rising inequality, and declining labor force participation of less-skilled workers – reflect the interactions of these market and institutional/policy forces. But they tend to disagree somewhat on the extent to which each of these forces contributes to the observed outcomes in the past.[1] And, of course, there is much less agreement on how they will determine employment and earnings levels over the coming few decades.

Below I present data on how labor supply and demand forces have trended since the year 2000, along with projections on how they will evolve between now and 2050. The supply-side data focus on population growth and composition (by race and age), labor force participation, and higher education attainment. The demand-side data focus on changes in the occupational structure of the labor market to date, along with projections of how automation will change this structure over time and contribute to worker displacement from jobs. The latter forces, of course, involve considerable uncertainty and much speculation. Patterns in international trade and offshoring of work will matter too. I also discuss what we know about institutional trends in the past few decades, and their likely evolution. Finally, I consider likely trends in employment and earnings across different groups of workers, in light of the likely trends in labor supply and demand that are presented.

A. Labor Supply: Population, Labor Force Participation and Education

Figures 1-3 below present data on how population growth, labor force participation and higher education have trended since 2000, and projections of how they will likely evolve between now and 2050. Of course, all such projections are uncertain, and outcomes will no doubt change over time as policies or economic forces change in unpredictable ways. The further into the future we project, the more uncertain our projections become. Still, we can make our best approximations based on what we know, and acknowledge the greater or lesser degrees of uncertainty in each case.[2]

Figure 1 presents data on population growth between 2000 and 2017, and projected growth to 2050, from the US Census Bureau (2018). We present the relevant data for overall population growth in Figure 1A, and for the composition of the US population by race/ethnicity (in other words, for non-Hispanic whites, blacks, Hispanics and Asians) and by age group in Figures 1B and 1C. The projections reflect likely trends in birth and death rates over time among the native-born US population, as well as expected trends in migration (both into and out of the US).

[1] See, for instance, Autor et al. (2009) and Card and Dinardo (2006).

[2] All official projections by the US Census Bureau or the Bureau of Labor Statistics are presented with standard errors, though these are not presented here.

The population data show some clear trends in the recent past that will likely persist in the coming decades. These include:

- Slowing population growth;
- Population aging; and
- Growing diversity, as Hispanic and Asian populations rise as shares of the total.

In particular, we see that annual population growth is projected to slow considerably over time. The share of the population accounted for by those above age 65 will grow, first as Baby Boomers age, but even more generally as health care improves and generates longer life spans. In addition, US birth rates have declined in the past decade, apparently in response to economic hardships on young people during the Great Recession; but these rates have not recovered with the economy in this decade, leading many analysts to predict population slowdowns even greater than what have been officially projected (see the paper by Alicia Munnell and her coauthors in this volume). And the population of native-born, non-Hispanic whites will grow relatively smaller as they age and are increasingly replaced by younger minority populations, especially due to expected immigration from Latin America and Asia.[3]

As the US population ages and becomes more ethnically and racially diverse, expected levels of labor force activity and education will likely change as well. Figure 2 presents estimates of labor force participation rates among those aged 16 and above in the US in 2000 and 2017 from the Bureau of Labor Statistics (US Department of Labor), and the Bureau's projections of these rates in 2050.[4] Figure 2A presents these trends and projections for the overall population, while Figures 2B and 2C represent them by race and age respectively.

The data in Figure 2 illustrate declining labor force activity in the US since 2000, and expected continued declines between now and 2050. In fact, participation declined by about 4 percentage points (from 67 to 63 percent) in the first period and is expected to decline another 5 points (approximately from 63 to 58 percent) by 2050. Declining trends in participation to date reflect both the aging of the Baby Boomer population and declines within age groups, which have occurred most strongly among youth (especially students) as well as non-college educated prime-age women and especially men.[5] The latter declines, in turn, seem to be partly driven by declining relative wages of less-educated workers in the US labor market (which tend to discourage labor force activity among most demographic groups), and other factors such as

[3] See Frey (2015) for an in-depth analysis of growing population diversity, how it will vary by region and age, and on needed policy responses.

[4] Projections are available to 2026 in Toossi (2017). She has graciously provided me with the underlying data estimates through 2050.

[5] See Aaronson et al (2013), Krueger (2017), and Abraham and Kearney (2018). Observed declines among men are understated by the data, because of incarceration and the low representation of low-income and minority men in the Census samples. See Autor and Wasserman (2013), Eberstadt (2016), and Doar et al. (2017) for discussions of the decline specifically among less-educated men.

opioid addictions, the availability of alternative income sources (like Social Security Disability Insurance, or SSDI), and the growing prevalence of criminal records among less-educated men.[6]

And, going forward, BLS projects further declines in labor force participation as the aging of our population continues. Aging will occur both for the overall population and even within specific race and age groups, driving down labor force activity for all groups except those at ages 55 and above. The increasing participation *within* the older groups, likely reflecting better health and longer lifespans among these workers, as well as their frequently insufficient savings for long retirements, will almost certainly not be large enough to counteract declines within other age cohorts; and there will also be an overall population shift *between* age groups, from younger to older, which should also drive down participation rates.[7] Growing ethnic and racial diversity could also affect participation rates, though its likely impacts on labor force participation will be mixed; and potentially ongoing declines in relative or real wages for less-educated workers could affect them as well, as we discuss below.[8]

Finally, Figure 3 presents data on higher educational attainment in the US in 2000 and 2016-17, as well as some simple projections that I've calculated on US educational attainment by the year 2050. Figure 3A presents trends and some projections for our overall populations, while Figure 3B considers a range of projections based on differing underlying assumptions.

The data through 2017 are drawn from Census Bureau or US Department of Education sources; I use both because data on associate (AA) and bachelor's (BA) degree attainment over time and by race were not fully available in either one. In particular, the Census data provide rates of AA and BA attainment in 2000 overall and in 2017 overall and by race; while the Education Department data provide estimates of BA attainment in 2000 and 2016.

I then use these data, plus projections of population racial composition from Figure 1, to project higher education attainment in the US by 2050.[9] To do so, I simply weight measures of higher educational attainment for our four racial groups by their projected shares of the adult US population by 2050. In doing so, I have generated two sets of projections: 1) the expected attainments of AAs and BAs in the population by 2050, assuming no changes in the attainment of any group from 2017; and 2) the expected attainments of BAs by 2050, assuming the same rate of annual improvement in attainment for each group in the period 2016-50 as we observed in the period 2000-16. We can reasonably consider these two projections as lower and upper bound estimates respectively, since it is unlikely that we will see no within-group improvements

[6] Labor force activity can either rise, fall or remain constant as real wages change, depending on whether labor supply elasticities are positive, zero, or negative respectively. But most evidence suggests positive elasticities for all groups except college-educated prime-age men, and including low-income workers (Katz, 1998).

[7] In other words, though the labor force participation rate is rising among those aged 55 and above, their rates remain lower than those of workers aged 25-54, so a shift of population from the latter to the former will lower rates overall.

[8] For instance, Asians have high participation rates, as do Hispanic men, even at low education levels, though Asian and Hispanic immigrant women have lower rates.

[9] Formal educational projections are available from the National Center on Education Statistics only through 2025, and do not contain any projections of higher educational attainment by race.

in attainment over the next few decades or continued improvements as the same pace as has occurred since 2000.[10]

The data in 2000 and 2016-17 indicate that about 10 percent of Americans now hold AA degrees while just over a third hold BAs. Unsurprisingly, rates of BA attainment currently are highest among Asians and non-Hispanic whites and lowest among Hispanics, while AA attainment is more evenly spread across groups (but lowest among Asians). BA attainment also rose for each racial group between 2000 and 2016, with the largest gains for Asians and non-Hispanic whites in percentage points but for blacks and Hispanics in relative (percent) terms.

My projections for 2050 indicate that the rising share of blacks and Hispanics in the US population will likely reduce overall higher education attainment relative to what would have occurred without demographic changes, though the rising share of Asians will partially offset these predicted declines. But the magnitudes of the declines vary with the assumptions I use to generate them. Assuming no improvements over time in within-group higher education attainment, all else equal, generates a drop of 2.3 percentage points in BA attainment (and less than a half percentage point in AA attainment); while assuming ongoing annual improvements into the future generates a much smaller projected decline (of .7 percentage points) in BA attainment. The projected declines are broadly consistent with earlier estimates by Frey (2015) and others.

Of course, all of the projections presented could over- or underestimate changes in population, labor force activity and higher education in the US by 2050. We simply do not know what unanticipated changes will occur in demographic, education and labor market outcomes – some but not all of which might be driven by policy choices in areas like immigration and higher education between now and then. For instance, there has already been a rise in the educational attainment of immigrants in the past decade (Hanson et al., 2017; Frey, 2018) that may or may not last, but that will improve future educational attainment projections, if it does.

But, having said that, the trends and projections highlight some likely important changes on the supply side of the US labor market during the next three decades. In particular, by 2050 we will likely see *an older and more slowly growing labor force with somewhat lower educational improvements* than we observe today.

B. **Labor Demand: Automation and Institutional Changes**

As we noted earlier, the demand side of the labor market represents employer behaviors, and the nature of the jobs they are creating. Technology and globalization have important effects on labor demand, as do employer decisions about the nature of staffing arrangements (e.g., temporary or permanent, regular employee or independent contractor, etc.) and other institutional rules (on recruiting and hiring, measuring and paying for performance, etc.).

[10] Annual improvements in higher educational attainment are unlikely to be as high in the next few decades as they were between 2000 and 2017, as college enrollments rose dramatically in response to the very large rise in the college earnings premium in the labor market between 1980 and 2000. Since 2000, the premium has been relatively flat. On the other hand, it is possible that completion rates among enrollees will rise in this period, causing some continuing increase in higher educational attainment.

Changes in the demand for goods and services – driven by new product development or by demographics – can matter as well. Thus, the Bureau of Labor Statistics (BLS) projects a lasting rise in the demand for health and elder care workers, due to the aging of the population.[11]

1. **The Economics of Automation and the Job Market**

The notion that new forms of technology, and the machines that embody them, can replace workers and reduce employer demand for workers is commonly held. The fear that technological advances will ultimately cause enormous numbers of workers to lose their jobs, and perhaps suffer massive unemployment, derives directly from this view. As far back as the Luddites in 19th century Britain, and during more recent periods in the US as well, these fears periodically emerge when a new form of automation is being developed and implemented broadly in the economy.

But the view that automation inevitably creates job loss and unemployment is simplistic. The ultimate relationship between automation and labor demand rests on the following factors (Levy and Murnane, 2013):

- The extent to which the new technologies reduce cost and therefore prices of the goods and services being produced, while also raising productivity and worker compensation, and how all of this affects *consumer demand*;
- Whether the new technologies and specific groups of workers are *complements* or *substitutes*; and
- The extent to which workers adjust to the new technologies by gaining more *education and skills* - thereby becoming more complementary and less substitutable with the new machines - and by moving across jobs, industries and regions when labor demand shifts.

On the positive side, the numbers of jobs can actually grow in some heavily automating industries, like automobile manufacturing in the 1920s or information technology (IT) in the 1980s and 1990s. This occurs because automation drives down the costs of producing new products so rapidly that prices fall rapidly as well, enabling middle- or even lower-income customers to buy them for the first time. In these situations, the rise in numbers of products demanded by consumers outweighs the reduction in labor needed to produce each one, thereby driving up demand for workers in the industry. On the other hand, automation will almost always tend to reduce labor's overall share of output (and therefore income), and therefore its compensation will rise less rapidly than overall labor productivity, while the share

[11] Since the BLS projects employment demand by occupation and industry for just a decade, and its predictive track record even within that time has been limited (e.g., Freeman, 2007), I do not present these projections below. Still, some projections – like their forecasted increase in the demand for health and elder care workers - are likely accurate, at least to some extent.

of capital will grow, as has clearly been true in the past few decades (Acemoglu and Restrepo, 2018).

Still, if automation raises real standards of living (by raising productivity) in general, consumers will have more income to spend and drive up demand for goods and services, and the labor to produce them, both within the automating industries and elsewhere. Indeed, this is the standard explanation by labor economists of why centuries of new technologies introduced into workplaces have never resulted in a long-term trend towards lower employment.[12] And rising productivity is likely to generate some real compensation growth, at least in the aggregate.[13]

But not all workers will benefit from these changes. Any new technology can replace (or substitute for) some groups of workers, while creating new demand or complementing others. For example, robots can replace workers on assembly lines in manufacturing while creating jobs for engineers or technicians; and personal computers in the 1980s often replaced clerical workers while raising demand for software writers and database managers. More broadly, such technologies can raise demand for a wide range of professionals or managers, or for service workers whose more social tasks are not easily performed by machines, by reducing other costs of production.

In general, empirical evidence suggests that capital and related technologies tend, on average, to be more complementary with highly educated workers, and more substitutable for less-educated workers performing simpler or routine tasks. In fact, many economists believe that this phenomenon, known as *skill-biased technical change* (SBTC), has been one of the primary (but not the only) drivers of rising earnings inequality between college and non-college educated workers since about 1980, when digital technologies and personal computers first began appearing in workplaces around the country.[14] The development and widespread use of the Internet in the 1990s and beyond reinforced this trend, by also making it easier for employers to outsource work to other regions of the US or abroad.[15]

David Autor and his colleagues also argue that SBTC has resulted in a new *polarization* of the labor market since the 1990s, where both earnings and employment have grown at the high and low ends of the skill or earnings spectrum while falling in the middle. More specifically, digital technologies have replaced workers doing routine tasks like product assembly or clerical work while expanding demand both for complex analytical tasks and services requiring a human touch in face-to-face settings, albeit in low-wage jobs (like child or elder care). To the extent

[12] Autor (2015) argues that the extent to which employment grows within heavily automating industries, as costs and prices fall, depends on elasticities of substitution between capital and different categories of workers, as well as income and price elasticities of consumer demand for the relevant products. See also Holzer (2017).

[13] Though wages have lagged behind productivity growth in recent decades for a number of reasons – including measurement issues and the rising cost of health care benefits – the two growth rates remain highly correlated over time (Stansbury and Summers, 2017).

[14] See Autor (2014) or Autor et al. (2009).

[15] See Blinder (2007) for a discussion of trends in the offshoring of labor, though the worst fears that he and others expressed did not come to pass.

that production and clerical jobs have paid relatively well for workers with little postsecondary (or even secondary) education, this polarization can raise inequality between non-college workers who formerly held these jobs (or those who now hold them at lower wages) and those in professional or managerial jobs, while the gaps in earnings between production/clerical workers and those in the services narrows somewhat (Autor, 2010). And, to the extent that there are still middle-wage or middle-skill jobs, they are likely to require more postsecondary education than the middle-wage jobs of earlier eras (Holzer, 2015).[16]

The net effects of these various categories of labor demand shifts on the occupational structure of the US labor market since 1980 can be observed in Figure 4. The data clearly are consistent with some growing labor market polarization, with employment declining in clerical and production jobs while rising in professional and managerial as well as many service jobs. But good-paying jobs for those without BA degrees are still available or even growing in health care, construction and transportation jobs, though they mostly require some postsecondary education or training (Carnevale et al., 2018).

Nevertheless, automation still displaces some workers directly from their existing jobs, while generally lowering demand for workers with similar skills in the labor market. Displaced workers often suffer lengthy bouts of joblessness before regaining employment elsewhere, if at all, while doing so generally at lower wages (Jacobson et al., 1993). In particular, many are no longer rewarded for skills that are specific to that occupation or industry (as well as *tenure*, or seniority, within their firms), forcing them to seek new jobs elsewhere that often pay less than what they earned previously. For older less-educated workers, these losses can be particularly damaging, and their tendencies to regain employment over time after displacement are particularly low. In recent years, permanent worker displacement was particularly high during the Great Recession, when many employers chose to change their workplace organizations and hiring practices (in favor of college graduates), and at least some of these changes appear to have been permanent (Farber, 2015; Hershbein and Kahn, 2018).

And, as noted above, the reduced demand associated with automation can reduce earnings for a broader class of potential workers, beyond those who are directly displaced. For instance, non-college educated men in the US have experienced stagnating or even declining real earnings overall since the 1970s, and have lost ground relative to all other labor market groups. At the same time, women – especially those with BAs and above – have enjoyed real and relative wage growth, at least partly because the growing service sector raised demand for their services while manufacturing and blue-collar jobs were declining (Blau and Kahn, 2017).[17] And, as the employment of less-educated women has risen in the labor market, perhaps in response to the higher demand they face for their labor, employment of less-educated men has declined

[16] Examples of the "new middle" are found in industries like health care, advanced manufacturing, information technology, transportation/logistics, hospitality, and some retail firms.

[17] Other causes of rising relative female earnings include antidiscrimination efforts by the federal government and growing education and experience of female workers relative to males.

quite precipitously over the same periods of time, as demand for their labor and levels of compensation generally diminish (Autor and Wasserman, 2013).[18]

On the other hand, some workers can protect their labor market earnings by *adapting* to the labor market changes generated by automation. They do so primarily by gaining the new education or skills that are now in higher demand in the job market. Indeed, Harvard economists Claudia Goldin and Lawrence Katz have written about the "race between education and technology"(2008), where workers gain new skills in response to those demanded by an automating labor market. According to their analysis, the second Industrial Revolution in the US in the early 20th century generated stronger demand for workers with high school diplomas, while the IT revolution late in the 20th (and early in the 21st) century similarly created demand for those with college degrees.

They note that the universal high school movement of the 1920s and 1930s represented a supply-side response to technology-induced labor demand shifts, thereby reversing the rising inequality earlier generated by shifts in labor demand. Indeed, this process is depicted graphically in Figure 5. Part A of the figure illustrates how SBTC originally generates higher inequality between more- and less-educated workers as demand increases for the former and declines for the latter. But, in response to this rising inequality, more workers invest in the education that the labor market now rewards, allowing labor supply to shift out and catch up with demand (as in part B of Figure 5).

This process, of course, requires an ability of workers to not only enroll in but also to successfully complete new education programs. In the late 20th and early 21st centuries, college enrollment rates have risen rapidly while college attainment rates have done so much more slowly, thereby limiting the ability of supply shifts to offset demand. The expansion of student slots in 2-year and 4-year colleges, especially in high-quality institutions, has also occurred more slowly than did high school slots in the 1920s and 1930s, when free and universal public high schools grew rapidly (Bound et al., 2009). Students who are not well-prepared for the rigors of post-secondary education, either academically or socially, have low completion rates as well (Holzer and Baum, 2017).

And, to be successful, newly educated or trained students must also be mobile across occupations, industries and geographic regions. Since younger workers are more likely than older ones to obtain the kinds of postsecondary education that the labor market rewards – in terms of general analytical or communication skills as well as those more specific to growing occupations and industries – their ability to respond to major labor demand shifts will be greater than those of older workers. Even retraining within existing firms and jobs can help some workers survive automation and adapt by learning skills than enable them to more successfully complement machines in new production processes.[19]

[18] See Doar et al., Eberstadt, and Abraham and Kearney op. cit.
[19] See, for instance, Helper et al. (2018).

And the freedom of younger, more-educated workers to move to regions of the country where labor demand is strong has historically helped them adjust to shifts in the labor market – for instance, of the type that has recently hurt the industrial Midwest while benefiting the strong professional and service economies of the East and West coasts (e.g., Blanchard and Katz, 1992). Accordingly, it is quite troubling that (and not well understood why) such regional migration, as well as that across jobs and firms, has declined over the past few decades - making it harder for workers hurt by industrial declines to adjust to the new economic realities (Austin et al., 2018; Wozniak, 2018).

Finally, a range of other policy changes - like lower minimum wage increases and declining unionization – have also contributed to rising labor market inequality over time. The exact magnitudes of these different factors and their contributions to growing inequality continue to be debated, while new forms of legal and institutional disadvantages experienced by less-educated workers have been identified as well.

Accordingly, preventing or reversing inequality will be not be accomplished by any single policy, but perhaps by a range of policies in response to the full range of market and institutional forces that have hurt the relative and real earnings of less-educated workers in the US since 1980. We discuss these policy options below.

2. Automation in the Labor Market, 2018-50: Will This Time Be Different?

As a group, economists tend to be somewhat more sanguine about the effects of automation on the labor market than are other analysts, even while noting that large groups of workers (like less-educated men) can be hurt by it. This is because, as noted above, new jobs are created while others are destroyed; various adjustment mechanisms enable then workers to adapt by gaining more education, and by moving geographically and across occupations and industries, enabling them to find these new (and sometimes better-paying) jobs.

But, as Holzer (2017) notes, there are scenarios under which the traditional labor market adjustment mechanisms used by workers to find new skills and jobs in response to past forms of automation might be overwhelmed by the pace of such innovation over the next few decades, as well as its new depth and breadth.

Why is this true? The reason for the potentially larger displacement effects of automation going forward is the rapidly growing ability of artificial intelligence (AI) and machine learning (ML) to perform non-routine worker tasks that have heretofore been outside the range of automatable activity. These tasks can include both the social and interactive ones performed by less-educated workers, as well as those more complex and analytical performed by highly educated professionals.

A growing power of machines to recognize patterns in and respond to unstructured physical environments, written text, or human speech and facial patterns potentially enable them to

perform functions now done by highly educated professionals in medicine, law, accounting, finance and criminology (West, 2018). Indeed, it is unclear whether technical change will retain its traditional skill bias in the workplace. At the same time, tasks performed by less-educated workers in a variety of setting will automate as well – with some, like motor vehicle drivers, sales and customer service reps doing so within a few years (Levy, 2018), creating the potential for many millions of workers to be displaced by these new and rapidly improving machines.

In fact, recent empirical evidence (Acemoglu and Restrepo, 2017a; Borjas and Freeman, 2019) shows quite large displacements in manufacturing associated with the introduction of robotics, which are likely to grow over time and spread across industries as AI and ML create a wider range of tasks that robots can perform. Accordingly, the potential exists for such displacements to occur so frequently and with such magnitude that they could overwhelm the labor market adjustment processes outlined earlier, especially if these adjustments occur with significant time lags (which is almost certainly true). In this case, employment and labor force activity could potentially decline over long periods of time while unemployment rises, and while some or even most workers experience earnings declines. And, if so, the worker discontent that has recently led to nationalist and populist movements throughout the industrial world might become even more powerful and widespread, leading to major political as well as economic dislocations (West, Levy op. cit.).

In the meantime, can we estimate the future magnitudes of these displacements and for whom they will occur, albeit very roughly? A recent empirical literature attempts to do so by measuring the following:

1) The tasks currently performed by workers in any given occupation and/or industry; and
2) The potential for machines with AI and ML capabilities to perform these tasks.

Data on task performance by employees in specific occupations generally derive from two sources: a) the O-NET database prepared and made available by the US Department of Labor; and b) the Survey of Adult Skills administered by the Programme for the International Assessment of Adult Competencies (PIAAC) in over 30 OECD countries, including the US. Data on the potential of machines with AI and ML capabilities to perform these tasks have been derived from subjective predictions of computer scientists as well as recent quantitative data, though these are newer and less forward-looking than the subjective measures estimated by computer scientists.[20]

Using these methods and data, Frey and Osborne (2013) created a stir by arguing that 44 percent of all current workers in the US face a strong likelihood (i.e., 70% or higher) of potential displacement by robots over the next few decades. But Arntz et al. (2016) correctly pointed out Frey and Osborne had ignored the great heterogeneity of workers within broad occupations, in

[20] Going forward, the Electronic Frontier Foundation AI Progress Measurement will provide more objective measures of automation and its impacts on employment.

terms of task performance and risks of automatability. Their preferred estimate for workers facing a high probability of automation is just 9%, based on "currently available technologies."

The most recent and highest in quality of studies using these methods was recently completed by OECD researchers Novelkaska and Quintini (N&Q, 2018), and I have reproduced a few of their tables below.[21] First, Table 1 shows the O*NET variables for job characteristics that computer scientists regard as creating the greatest "engineering bottlenecks" to automatability. The three broad categories are: 1) Perception manipulation, which includes finger or manual dexterity and working in cramped spaces or awkward positions; 2) Creative intelligence, which includes originality and abilities to perform artistically; and 3) Social intelligence, which covers a range of interpersonal skills, such as perceptiveness, negotiation, persuasion, or assisting others.

Figure 6A then illustrates the fractions of jobs in the US and other comparable industrial economies that the authors estimate as having high (>70%) risk of automation or risk of "significant change" (50-70%). The results show that, like Arntz et al., N&Q estimate that just 10% of workers in current jobs in the US face high probabilities of automation, while another 28% face significant risk. Workers in most other industrial countries face somewhat higher risks (based on their responses to PIAAC questions on task performance, whether due to differences in their occupational and industrial structures or simply to structures of work within these categories).

Finally, Figure 6B illustrates detailed occupations in OECD countries with the highest and lowest probabilities of automation. The results show that a range of professional and managerial jobs have the lowest estimated probabilities of automation, while a number of manual, service, clerical or sales jobs have higher probabilities. If accurate, these results suggest that technical change will continue to have a strong skills bias, with less-educated workers facing the highest average risks of displacement.

Of course, a number of important caveats need to be stressed about these results. First, a great deal of uncertainty remains regarding the time periods over which automation will be implemented by employers, which will likely depend on their costs, employer or managerial preferences, or other institutional characteristics (National Academy of Sciences, 2017). Second, even when chosen, the timing over which these innovations will be applied to products commercially and diffused into the labor market remains very unclear; for any given kind of automation, years or even decades may be needed for large transitions.[22] Third, the nature of the automation being considered in these projections is itself ambiguous – since it depends on what computer scientists think of as currently existing or available. As more time is considered,

[21] Studies and projections on the impacts of automation on employment have also been provided by a number of consulting firms like Accenture (2016), McKinsey Global (2016) and Price Waterhouse Cooper (2017).

[22] For instance, McKinsey estimates that its projected employment changes will occur by the mid-2030s, though they also acknowledge that they could occur a decade earlier or later.

more dramatic changes in automatability could potentially be implemented, each with its own time lags, but it is not clear exactly where the expert respondents have drawn lines in this regard.[23]

Fourth, while new tasks on existing jobs and completely new jobs will be created, the extent to which employers will choose to retrain their incumbent workers for somewhat new complementary tasks, as opposed to displacing them and hiring new workers, remains highly uncertain as well (Helper, op. cit.). And employer willingness to implement new technologies and create new job categories might themselves depend on their perceptions of the ease with which they can fill such new jobs, or whether some "mismatch" will exist between needed and available skills that might inhibit the automation and resulting job creation in the first place (Acemoglu and Restrepo, 2018).

Finally, exactly how new automation interacts with other ongoing changes in labor demand, associated with outsourcing or offshoring of tasks and other institutional features (discussed below) remains unclear as well. The pace and nature of automation will likely be "endogenous" to labor force developments and policy changes. For instance, very large increases in the minimum wage (to $15 an hour, for instance) could generate more rapid automation of "fast food" and other fairly unskilled service jobs, while employer difficulties finding workers in specific job categories – such as health and elder care workers - might speed automation in these sectors too.

Nevertheless, what seems quite likely is that large fractions of US workers between now and 2050 will face some substantial likelihood that their jobs will be at least partially automated, which will cause them to either be displaced or to require significant retraining to stay on their current jobs. New jobs will also be created that require a somewhat different skill set than many workers now have. Importantly, an older workforce and one with significantly more less-educated minority workers might face greater difficulties adapting to this situation than one that is younger or more highly educated.

3. Other Market/Institutional Changes in Labor Demand

Automation is likely to be just one of several ongoing trends on the demand side of the labor market. Others include international trade and a range of dimensions over which the labor market continues to "fissure," in David Weil's (2014) well-known formulation, over time. As indicated above, these trends will likely interact with the various kinds of automation described above, in ways that are hard to predict.

[23] Price Waterhouse Cooper (2017) discusses three phases of automation over the next three decades: an "algorithm wave," "augmentation wave" and "autonomy wave," where predictions of employment impacts grow more difficult with each wave.

Future patterns in international trade, and how they will affect the labor market, are hard to predict. Growing global integration generally implies that imports as well as the offshoring of production of goods and services by US firms could weaken labor demand in the US, as happened when China's entrance into the World Trade Organization drove down US employment in manufacturing quite substantially (Autor et al., 2016). On the other hand, rising incomes overseas can raise demand for goods and services produced by US workers. And whether the current strain of populism in both US and international politics will have lasting impacts that slow further integration remains to be seen as well.

Regarding institutional changes, new staffing arrangements may grow in frequency. These can include positions in what we now call the "Gig Economy" – such as Uber drivers who work on an online, on-call basis; temporary (or "contingent") workers, whose jobs are more regular in any given day or week but only for short periods of time; those working permanent jobs but as independent contractors, who are technically self-employed; those working permanent jobs but for a company that is contracting out work from another employer; working for franchises, whose human resource practices will be partly decided by themselves and partly by larger parent companies; and workers in "supply chain" companies whose practices might be determined by other firms in other parts of those chains.

In his book, Weil argues that most such "fissuring" is bad for worker outcomes when not chosen by them voluntarily, since it limits the extent to which employers share product market "rents" with workers or invest in training them, while it can also limit worker access to benefits or legal protections (such as coverage by minimum wage, antidiscrimination laws, occupational safety and health rules, etc.).[24] These practices can also shift the risk of unstable customer demand from employers to employees. Overall, direct empirical evidence on how these effects vary across the categories cited above remains limited, but it is likely that these practices overall reduce worker training, benefits and hours stability, on net.

But whether there has been a large trend over time towards more frequent use of such alternative staffing arrangements remains unclear. In a recent well-known paper, Katz and Krueger (2016) found evidence of a rapid rise in independent contractor status among employees between 2005 and 2015 (from 11 to 16 percent of the workforce). But a report issued recently by the Bureau of Labor Statistics (2018) found no such evidence. In addition, BLS reported that the vast majority of employees in these categories choose them voluntarily and are quite happy with these arrangements.

Katz and Krueger (2019) analyze the causes of the differing trends in the above studies, and conclude that the likely increase in alternative staffing arrangements is real but smaller than they previously thought – e.g., 1-2 percentage points. But they also point to a rise in other kinds of informal work arrangements, as do Abraham and Houseman (2019). A growth of unstable

[24] Autor et al. (2017) argue that the low labor intensity of many "superstar" firms with high profit rates already reduces labor's share of US income; if Weil is correct, fissuring will exacerbate any such trend.

work hours for low-wage workers in some parts of the service sector (Lambert et al., 2014) is also consistent with a shift towards more contingent employment (in a form not captured in the BLS report), though it is important to separate those that are voluntarily chosen by workers and those that are not.

Still, it seems likely that at least some of these categories, like "gig employment," will be used more frequently over time, as the digital and institutional infrastructures through which they are implemented improve. Whether we implement changes in labor rules to help protect workers in some such circumstances, like those employed by temp agencies or other intermediaries (Harris and Krueger, 2016), remains unclear, as is the extent of worker disadvantage if we don't.

Separate from the question of growth in alternative staffing arrangements, there are other sources of concern about growing employer labor market power, relative to their employees; and their increasing willingness to engage in a range of human resource practices that lower worker compensation, including restrictive clauses in their contracts (such as non-compete clauses and those limiting worker access to information about others' pay) that reduce employer competition and hurt workers while also making labor markets less efficient.[25] Some of this might be driven by pressure from the capital markets, at least for publicly-owned companies, for high quarterly profits at all times, though growing market power might generate some such outcomes for employers even absent such pressure.

Of course, a decline in collective bargaining and in statutory minimum wage levels (relative to median wages) will also reduce worker compensation, especially at lower education levels. The fraction of private-sector workers covered by collective bargaining has fallen from about 35 percent in the mid-1950s to 6 percent today, though there has been some increase in public sector unionism in this time period. The federal minimum wage has also declined relative to the median wage, though the variation across states in minimum wages has grown in recent years. Even these changes likely reflect both market and institutional forces over time (Hirsch, 2008), as more competitive labor markets are often hard to organize collectively for bargaining.

Finally, there has long been evidence that, even within a particular industry and region, employers can choose either "low-road" employment practices, where they choose to compete primarily through minimizing labor costs, rather than "high road" practices where they invest in worker skills and compete through better job performance (or some in between). Many high-road practices could be consistent with profit-maximization, but these are generally more beneficial to their workers than others, creating a "public good" for them. [26] Though more

[25] Shambaugh et al. (2018) shows evidence of some growing concentration of firms in product and labor markets, where the latter can be most harmful to worker wage outcomes. They also provide evidence that wages are positively correlated with labor supply elasticities across local labor markets, indicating that the lack of mobility of many workers geographically impedes their wage growth.

[26] Ton (2014) argues that companies can adopt "good jobs strategies" and improve worker outcomes while not sacrificing, or even improving, company profits and overall performance. This argument is at least broadly

evidence on this issue is needed, a broad shift to "low-road" employer practices seems to be occurring, and might therefore justify some public policy interventions to encourage the adoption of more "high-road" employment practices - like apprenticeships, internal promotion ladders, and even profit-sharing.[27]

C. Implications for Labor Market Outcomes

What do all of these labor supply and demand trends imply for likely employment outcomes between now and 2050?

Our best predictions are that aggregate labor markets in the next three decades will be characterized by:

- Higher worker productivity and earnings;
- Higher earnings inequality;
- Growing instability in employment, as displacement rates rise;
- Lower rates of employment and labor force participation among older or less-educated workers; and
- Periodic shortages of skilled workers in growing occupations and industries.

Widespread adoption of automation should increase worker productivity in the aggregate, which should then increase worker compensation. Of course, in the past few decades we've learned that rising aggregation does not necessarily translate into rising wages, especially for the median worker, though a strong correlation over time between productivity and real wages remains in effect. The share of labor in total income will almost certainly continue to decline.

Growing inequality will likely be driven by an ongoing "skill bias" in technical change, as well as the somewhat lower levels of higher education attainment that will be driven the growing diversity of the population. More educated workers will not only face relatively higher demand for their labor as automation proceeds, but they will likely be more successful in adapting to labor market changes by obtaining new skills that complement the new automation. Inequality will likely rise not only between workers with different levels of education, but also between racial/ethnic groups, as Asians/whites adapt to labor market changes more easily than blacks

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consistent with decades-long evidence from labor economists that, in any industry or locality, firms pay positive or negative wage premia relative to market averages (Abowd and Kramarz 1999; Andersson et al., 2005). Wage premia vary across industries, firm sizes (with large firms historically paying more, though less so recently) and other dimensions of human resource policy. But the reason for why some employers choose to pay higher wages and others don't has remained somewhat unclear. Wage pressure from unions and higher minimum wages appear to matter somewhat, as do employer or managerial choices based on personal history, experiences, and values (Appelbaum et al., 2003)

[27] Despite Ton's confidence in the ability of firms to successfully implement such strategies, Osterman (2017) shows that the evidence to date is quite weak on whether these strategies are consistent with profit maximization in all industries and market situations.

and Latinos (partly due to gaps in educational attainment and partly to other forces, like those in information/contacts and discrimination, which make it more difficult for the latter groups to adapt to market shifts).

Whether gender inequality in the labor market continues to decline, as it has in recent decades, depends on whether women are relatively more or less vulnerable than men to displacement from growing automation in the service sector; on the other hand, the higher levels of educational attainment of women than men could make their adjustments to labor market disruptions more successful than those of male counterparts. Finally, the labor market returns to age and experience might well decline over time, if younger workers are more adept at adjusting to disruption from automation (by obtaining new education or training) than older workers.

Lower employment and labor force participation will reflect an aging population, plus potentially lower wages (relative or real) among unskilled workers. The growth of automation, with its ongoing skill bias and ongoing declines in labor's share of output, will likely reduce earnings for some workers and therefore their incentives to participate in the job market**.** A rise in worker displacements might reinforce this trend, especially among older workers, who will sometimes choose to leave the labor market rather than undertake major adjustment costs or work for much lower wages**.**

On the other hand, might an aging population and reduced worker participation generate labor shortages that could boost employment opportunities and earnings for some workers? On net, whether our labor markets operate with surpluses or shortages might depend on the magnitudes of reduced labor demand associated with AI versus the potential declines in labor force participation noted above. At cyclical peaks (like we currently enjoy), labor shortages may prevail; during recessions, the opposite will more frequently be true. Across industries and regions, some growing sectors will experience usually temporary labor shortages, while others in decline (like those of small metropolitan and rural areas in the industrial Midwest) will be perpetually in surplus. "Mismatches" between employer needs for workers and skills in the former, and the availability of workers (though not as many skills) among the latter, will certainly be true in some areas and time periods.[28]

Of course, labor markets have a variety of adjustment mechanisms in response to shifts in labor demand, such as wage adjustments and worker migrations; but these have grown less powerful in recent years.[29] Indeed, the absence of stronger wage growth in the currently tight labor market has been disappointing for many, and suggests that employers are finding ways to meet their production and profitability needs in ways that do not always benefit workers.[30] This also

[28] See National Academies of Sciences, Engineering and Medicine (2017).
[29] See Blanchard and Katz and Austin et al*., op. cit*.
[30] For instance, very high corporate profit rates (as percentages of GDP) seem to currently coexist with lax productivity growth and very moderate earnings growth.

might imply that "mismatches" between available jobs and worker characteristics might persist over time, creating a need for a stronger policy response.[31]

Accordingly, one can envision a variety of possible scenarios, in which the magnitudes of displacement shocks and worker/firm responses and outcomes vary a great deal. In more encouraging scenarios, the positive impacts of automation on aggregate worker productivity and earnings are relatively large, and rising real wages counteract the effects of potential increases in earnings inequality on labor force participation. To the extent that we generate new institutional arrangements giving workers more "voice" in the workplace, and perhaps a better share of market rents, their earnings will rise as well.

In other scenarios, overall earnings increases are somewhat smaller and increases in inequality are relatively larger, potentially driving older or less-educated workers from the labor market. The extent to which employers help their incumbent workers obtain new training to keep them employed, and the extent to which workers themselves obtain adjustments through "lifelong learning" (potentially assisted through policy), could have large effects on the extent to which different labor market scenarios are realized.[32]

Two more major caveats should be mentioned. First, automation will likely have a range of positive effects on worker adjustments to the labor market. Technology makes telecommuting more easily done, and it will likely improve worker access to new education and training over the lifetime through a variety of online options that either do not now exist or will undergo substantial improvement. All else equal, these technological improvements will tend to improve worker outcomes, though whether they help reduce or exacerbate skill biases in displacements from automation remains unclear.

Second, as noted earlier, automation will likely be *endogenous* to other market developments. For instance, employers are more likely to implement labor-saving technologies if they face potential skilled labor shortages, high minimum wages (such as $15 or higher), or any other large new labor costs. To the extent this is true, automation will act somewhat less as an exogenous shock to these markets and more as part of the adjustment mechanisms occurring in such markets as demographic and policy changes proceed.

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[31] The NAS report on the skilled technical workforce presents evidence that a variety of market failures (such as imperfect information about labor market opportunities and occupational licensing requirements at the state level that generate a degree of monopoly power among incumbent workers) impede the adjustment process to demand shocks across industries and regions. But Freeman (2007) argues that automation and globalization effects will likely swamp aging and retirement effects in magnitude, thus counteracting tendencies toward labor market shortages.

[32] Projections of real wage growth over the next several decades are included in official forecasts by the Congressional Budget Office and by reports on the future solvency of Social Security and Medicare programs. Others forecasts are generated by private entities, such as the Urban Institute and its DYNASIM model. But all such forecasts mostly extrapolate recent labor market trends into the future, and none likely capture effects of automation and other market changes that might differ substantially from recent experience.

II. What Do These Labor Market Forces Imply for Policy?

Given the future trends that we expect (with considerable uncertainty) for labor supply, labor demand, and employment outcomes over the next few decades, what policies should we begin to consider in the meantime? Will a moderate set of changes be sufficient to offset potential negative effects on less-educated or older workers, or will more dramatic policy changes be necessary?

A. Labor Supply

1. Retirement and Immigration Policy Reform

Since we expect population growth to flatten and labor force participation to decline, while college attainment grows more slowly than recently, we should consider major changes in retirement and immigration policy over the next few decades of the following form:

- Reforms in Social Security and Medicare that encourage longer working lives and later retirements among employees; and
- Immigration reforms that raise current levels of immigration while shifting its relative emphasis from family unification to skills and labor market needs.

Retirement policies, in particular Social Security and Medicare, should be reformed to encourage greater labor force participation among the elderly. This, of course, would contribute to even more aging in the labor force, but it would counteract the drop in labor force activity that we will otherwise likely observe. Encouraging greater labor force activity among our elderly population would help address the major fiscal shortfalls in trust funds for these programs that we expect, and it would improve the financial readiness of many low-saving workers whose assets now may be insufficient for retirement (Engen et al.,2000), in addition to improving overall labor force and economic growth. A range of potential policies to encourage workers to delay retirement and to help employers accommodate them might be needed to accomplish this (Munnell, 2007).

All of this makes sense in a world where average worker life expectancy and health at older ages are growing. On the other hand, the improvements in health and lifespans have themselves been very uneven across demographic groups, with much greater improvements observed among high-income and highly-educated workers than among others. Potential reforms, such as raising retirement ages or diminishing the benefits workers receive when they first retire, should be implemented in ways that do not penalize those with poorer health,

especially workers now in their middle and later years who have been counting on retirement with full benefits at the current age of 67.[33]

Regarding immigration policy, I do not believe our expected labor market trends imply a need for lower levels of immigration overall. As with retirement policy, changes in immigration rules could be used to counter the shrinkage of population growth and labor force activity, as well as overall economic growth, which we will otherwise likely observe. Higher rates of immigration will also contribute at least somewhat to greater fiscal balance at the federal level, which will be sorely needed as expenditures in Social Security and Medicare grow dramatically with the aging of the Baby Boomers (Congressional Budget Office, 2013).

But a shift in the relative composition of such immigration is also warranted. In the recent past, roughly two-thirds of US immigration has been based on family reunification rules, which generate many less-educated immigrants – particularly from Latin America. Only a few programs, such as the controversial H1B visa program, encourage immigration of those with BA degrees or above, and these are quite limited in magnitude.[34]

At the same time, immigration into the US of less-skilled immigrants has already dropped considerably, perhaps reflecting economic and demographic trends in "sender" countries as well as improved enforcement in workplaces and the border (Hanson et al., op. cit.). Whether these changes remain permanent or not, absent reinforcing policy changes, is somewhat harder to predict.

There is a consensus among economists that highly-educated immigrants contribute not only workers in high-demand sectors (such as IT) where employers now have some difficulty finding and retaining qualified applicants, but also business startups and innovation that contributes to economic growth overall (Hunt and Gauthier-Loiselle, 2008). Such immigrants can therefore be viewed primarily as *complements* to most American workers, who will benefit from their presence in greater numbers (Ottaviano and Peri, 2008), and their numbers in the US should grow.

It is also incorrect to argue that less-educated immigrants contribute little or nothing to the US economy. For instance, even less-educated immigrants tend to reduce labor costs and therefore consumer prices in a number of key sectors, such as health and elder care (where labor demand in the coming decades will be very high), agriculture, and housing (Cortes, 2008); they contribute to long-term fiscal balance, especially as subsequent generations rise in

[33] Because of this issue, the bipartisan Bowles-Simpson commission recommended raising the retirement age only modestly in order to improve funding of the Social Security system, while the report of the Bipartisan Policy Center headed by Peter Domenici and Alice Rivlin declined to do so, instead suggesting other reforms to increase work among the elderly.

[34] Every year, just 60,000 H1B visas for highly-educated STEM workers are sold to US companies, who claim there is much more unmet demand for the top employees in this market. While some authors claim that H1B workers substitute for and reduce employment among US workers, Mayda et al. (2017) refute this claim.

education and income levels; and they also contribute to labor force growth which will be needed for economic growth in subsequent years (Holzer, 2011). And, since immigrant families become American consumers as well as producers, their net effects on the total demands facing native-born workers in the US should not be presumed to be negative.

Still, though the evidence on this topic remains mixed, there is at least some plausible research showing that less-skilled workers *substitute* for native-born less-educated workers, and therefore reduce their employment and earnings over time.[35] Even though immigration is not the only or even the primary cause of stagnant earnings and declining employment among less-educated workers and especially men (Abraham and Kearney, 2018), it likely contributes at least somewhat to these deteriorating outcomes, thus generating more of a tradeoff in outcomes for American workers than does immigration among highly-educated workers (or in high-demand fields).

Accordingly, there is not a strong case for either a major reduction or increase in the immigration of less-skilled workers to the US, while there is a strong case for increasing the arrivals of those more educated. Of course, an appropriate balance of economic- vs. values-based immigration is also necessary, and one can argue that family-based unification (as well as more open borders to refugees from poor or violent countries) serves American values. The political process will ultimately determine the extent to which those two sources of immigration determine future flows of workers.

It also seems that the arguments outlined above support some type of comprehensive immigration reform, perhaps along the general lines of the bill that passed the US Senate (but not the House of Representatives) in 2013. In my view, this bill was designed to encourage greater future flows of legal immigrants that serve our economic interests, and smaller flows of illegal ones, through a mix of greater enforcement activity and economically-based visas; it also would have created a path to citizenship for the undocumented immigrants already here, which is sensible as well (CBO, 2013). While future reform efforts will no doubt differ, if they are to have any chance of being enacted, the broad principles underlying the 2013 effort seem consistent with our expected future trends in the labor market.

2. Education and Training

Since the greater diversity of American workers in the next few decades will likely limit the overall growth in educational attainment among workers, which itself could contribute to

[35] For conflicting perspectives on the extent to which less-educated immigrants compete with their native-born counterparts see Borjas (2003) and Card (2005). Holzer (2011) argues that Borjas and Card likely present upper and lower bounds to the true negative effects of such immigration on employment, and Yasenov's paper in this volume is broadly consistent with such a view (as well as the view that immigrants can complement highly-skilled Americans). If anything, the biggest negative impacts of such immigration are on the earnings of previous immigrants with similar backgrounds and characteristics.

stagnating earnings and growing inequality (as well as to the difficulties workers will have adjusting to future automation and trade), our education and training policies should be reformed in a variety of ways. These reforms should:

- Improve the ability of US students, especially those who are disadvantaged and first-generation college enrollees, to obtain postsecondary credentials with labor market value;
- Expand student attainment of "21st Century Skills" that will likely make them more complementary with and less substitutable by new automation; and
- Create systems of "lifelong learning" in which workers who have experienced (or are at high risk of) technological displacement can more easily obtain new skills that better complement automation in the workplace.

As is widely known, our current system of primary, secondary and postsecondary education already suffers from a number of flaws that limit educational attainment and economic opportunity among disadvantaged and/or minority students. While college enrollments have risen dramatically in the past few decades, in response to rising labor market returns to college attainment, completion and therefore educational attainment rates have failed to keep pace; many students obtain terminal degrees, especially at community colleges, with little market value; and student debt levels and default rates have risen beyond what is needed for sensible human capital investments (Holzer and Baum, 2017). In addition, too few students have opportunities for high-quality career and technical education (CTE) or work-based learning that would give them alternative pathways to labor market success.

The causes of these weak educational outcomes have been summarized elsewhere (Holzer and Baum, op. cit.); they include the characteristics of disadvantaged students – such as weak academic preparation, lack of relevant information and "social capital, insufficient liquid assets with which to finance higher education, and the need for adult students to work full-time while supporting families. But they also reflect the characteristics of the schools these students disproportionately attend at all levels of education, including too few resources per student, high concentrations of under-achieving students, and weak incentives to respond to the labor market. The growing concentration of low-income students at for-profit postsecondary institutions seems to contribute to their weaker educational outcomes as well (Cellini et al., 2017).

Accordingly, even in the absence of the future labor market trends noted above, substantial reforms in education policy are warranted. These would likely include increasing the availability of high-quality pre-kindergarten (pre-K), making more resources available for schools with many low-income students, and implementing sensible accountability and choice mechanisms - for K-12 schools and postsecondary institutions, such as community and for-profit colleges. Expanding other forms of labor market education and training that generate strong labor

market returns for disadvantaged students, such as Career Academies, sector-based training and apprenticeships, also makes sense.[36]

But, given the likelihood that automation will increasingly displace workers who have trained for specific occupations and industries in the future, additional changes in education and training policies are needed as well. For instance, a National Academies of Science report (2014) identifies a set of general "21st Century skills" that will complement future automation and lay the groundwork for further education and training. These skills include collaboration, communication, critical thinking and self-management skills.

This is not to say that disadvantaged students today should not obtain more specific forms of training for currently available high-wage jobs (or those in high-demand sectors, like health care or IT). Such training would no doubt improve the current and future earnings prospects of many low-income youth and adults, which would generate better outcomes for them and their families. If anything, the persistence of earnings gains generated by some forms of firm- or sector-specific training have been better than was previously expected, in a world where low-income workers frequently change jobs or careers (e.g., Elliott and Roder, 2017).

At the same time, preparing students for future employment in these fields, given the high risks of displacement that many could face, should entail giving them a wide range of general and specific skills that will prepare them for existing jobs as well as the likelihood that they will change jobs, firms, and/or sectors in the future. Ensuring that all students obtain strong grounding in the "21st Century Skills" should be a primary goal in K-12 education, including CTE, as well as in 2-year or 4-year degree programs.[37]

But, since ongoing automation will likely require at least some skills retooling over the course of their careers among a wide range of workers, creating systems of "lifelong learning" are important as well. Going beyond the typical clichés, what would be the characteristics of such a system?

At a minimum, it would include making available funding for all workers who might need retraining over their lifetimes. At least two states – Maine and Washington- have created individual accounts into which workers can divert small amounts of funding through payroll deduction on an ongoing basis (Pollack, 2018); one could imagine these funds also including matching savings from state or federal governments that would be inversely related to worker earnings or income.

In addition, reforms in federal financial aid programs available through Title IV of the Higher Education Act could make these funds more accessible for adults who need retraining and more effective as well. For instance, Baum and Scott-Clayton (2013) propose reforms to Pell Grants

[36] See Kemple (2008), Maguire et al. (2010), and Reed et al. (2012).

[37] See also Gormley (2017) for a discussion of how critical thinking skills will be important for rising numbers of workers in the coming decades, including among CTE students.

for independent students, who constitute a growing share of recipients and will continue to do so over time; these reforms include simplifying eligibility rules, strengthening academic performance incentives, and providing much stronger counseling for students choosing an institution to attend and a program of study. Other reforms to Title IV funds, which might make them more accessible to students in shorter-term training programs, should be considered as well.[38]

Identifying the kinds of postsecondary education or training for different kinds of workers that would successfully prepare them for future employment might also not be trivial. The track record of cost-effectiveness for displaced worker training programs to date has not been terribly impressive, though such training clearly works for some groups of students and workers (Andersson et al., 2013; Jacobson et al., 2005).

And ensuring robust workforce policies, with enhanced worker access to career counseling and other career services now available at One-Stop centers, will be crucial as well. In this case, technologies that create new online education platforms and "digital tutoring," as well as those that enhance the abilities of employees filling jobs and workers seeking them to more effectively communicate about their skills and capabilities they seek and offer respectively with each other, will also help ensure such access over time.[39]

Maintaining/Raising Labor Force Attachment

As we noted earlier, labor force participation among workers with high school or less education in the US has already declined in recent decades, especially among men; and such declines might continue to occur in the coming decades, especially if automation tends to further reduce the wage levels which these workers might be offered over time. To improve labor force attachment among such workers, we should:

- "Make Work Pay" more for low-skill or displaced workers;
- Address barriers to participation, such as opioid addictions and criminal records; and
- Provide more access for lower-wage workers to paid family leave.

Besides enhancing education or training, a set of policies to help "make work pay" for those with low skills or who have recently been displaced from jobs are needed to encourage greater labor force participation. For low-skill workers in low-income families, the Earned Income Tax Credit (EITC) seems to improve incentives to work while raising their net incomes (Nichols and

[38] For instance, the Jumpstart Our Businesses by Supporting Students (JOBS) Act, proposed by Senators Tim Kaine and Rob Portman, would expand eligibility for Title IV funds to include students in short-term programs at accredited institutions. Whether eligibility to use these funds at non-accredited institutions should also be allowed, as long as they provide training with proven records of success, has been debated recently as well.

[39] For instance, the Aspen Institute's "Skillful" project explores the use of online technologies to enhance the ability of workers to demonstrate their skills and competencies beyond the usual educational credentials and experience measure. LinkedIn, among other social media, is heavily involved in such work as well.

Rothstein, 2015). Federal and state EITCs should be expanded, especially for those who have little access to them right now – such as childless adults (including non-custodial parents). Recent evidence from a pilot program called Paycheck Plus in New York provides some grounds for optimism, though evidence on employment impacts has been mixed.[40]

For displaced workers, expanding "wage insurance" (WI) should help improve work incentives. Publicly funded wage insurance could provide displaced workers with partial wage replacement for a limited period of time, such as two or more years, if they accept a new job that pays less than what they lost. Though many economists endorse wage insurance, it has only been available in the US on a very limited basis – for instance, for older workers who have lost manufacturing employment.

In addition, reforms in Unemployment Insurance (Kugler, 2015) as well as WI could together incentivize workers to accept low-wage jobs that they can obtain, instead of remaining unemployed for the maximum allowable time period and then leaving the labor force altogether. Assistance to workers to help them relocate after displacement, to regions with stronger labor markets, makes sense.[41] And creating a labor market where benefits like health care and pensions are universally available and fully portable across jobs is critical as well, given the growing level of employment instability we might see in the coming decades.

The barriers to labor force activity among those with opioid addictions or criminal records are substantial and appear to hurt large numbers of workers (Krueger, 2017). Policies to prevent more workers from being ensnared in these difficulties, plus remedies for those who have been to date, are reviewed elsewhere but should be high on our policy agendas. These might require not only treatments aimed at individuals, but also publicly subsidized employment for some periods of time for those who are "hard to employ" in the private sector (Dutta-Gupta et al., 2018).

And public provision of some forms of Paid Family Leave would help parents, especially women, remain attached to the workforce after childbirth or when family members need periods of care; virtually all other industrial countries provide this much more widely than does the US, and its contribution to female labor force participation seems quite clear (Schanzenbach and Nunn, 2017).

B. Labor Demand

On the demand side of the labor market, policy approaches that would help workers adapt to the many challenges we face in future decades might include the following:

[40] In their evaluation of Paycheck Plus, Miller et al. (2017) find positive effects on employment of disadvantaged adults without children, though these are significant only for women.

[41] See, for instance, Ludwig and Raphael (2010). But relocation assistance will generally be opposed by state and local officials whose regions risk losing even more population under such plans.

- Engaging employers more in the training and retraining of their employees;
- Moderately regulating employer-employee relations without reducing employer incentives to hire; and
- Rewarding and assisting employers for engaging in "high road" employment practices.

As we noted earlier, training programs for disadvantaged workers that engage employers in the training – such as sector-based training and apprenticeship – appear to have strong and somewhat lasting impacts on worker earnings, while presumably helping employers meet their skill needs. A question often asked, given these positive impacts, is: why we don't see more such activity on the part of employers? A likely answer is that a variety of market failures impede such activity, especially on the part of smaller employers (though the decisions of some to pursue "low road" employment practices might also play some role). [42]

And, if that is the case, then public actions to encourage more such training are appropriate. Indeed, a number of state and federal efforts are now underway to encourage more sector partnerships and more apprenticeships, though we don't yet have strong evidence on their likely impact. Given our uncertainty about what kinds of training will be needed in future decades, it is often best to encourage firm- or industry-specific training that also includes broad general education, as when apprenticeships also provide for community college enrollments in an associate degree program (Lerman, 2014).

As future automation and trade will likely displace many workers and render some of their more specific training obsolete, the argument for engaging employers in other forms of incumbent worker training grow stronger. Such programs at the state level have had some modest success, mostly with entry-level workers (Holzer et al., 1993; Hollenbeck, 2008). But now they might focus more on retraining workers to help them remain in jobs where automation has rendered some, though not all, of their previous training and task performance obsolete.

Employers might provide some such training on their own, if they think it worthwhile to retain at least some workers whom they know to be good employees; but a public effort could assist and incentivize more of them to do so, given the likelihood that market failures will impede such efforts on their own. Agencies like the Manufacturing Extension Partnership, which currently helps small manufacturers implement technology and improve productivity, could be refashioned to play such a role, while perhaps tax credits could be extended to firms that engage in such activity. Of course, it would be important to experiment and evaluate such approaches before bringing them to any real scale.

[42] Holzer (2016) argues that such market failures might include imperfect information about training among smaller employers, wage rigidities that keep them from sharing the costs of general training with their employees, and coordination failures that prevent smaller firms from sharing the fixed costs of setting up training systems. In addition, pressures from the capital markets for short-term profits in publicly-owned firms likely makes it harder for such firms to invest in longer-term skill-building.

To the extent that at least some employers increasing engage in anti-competitive behaviors, such as demanding employees sign no-compete and no-disclose agreements (though admittedly our evidence to date is mostly anecdotal), some modest regulation of these activities are in order (Shierholz, 2017; Krueger and Posner, 2018).

More broadly, very low wages and increasingly unstable work schedules for employees contribute greatly to their difficulties. Efforts to regulate unstable hours should be modest and not impose the costs of great inflexibility on employers; these might include some amount of early warning for employees of major schedule changes, perhaps with exceptions for a few industries where customer demand is extremely unstable.

Other efforts to impose mandates on employers to improve worker outcomes – like raising statutory minimum wages or imposing "ban the box" rules with regards to hiring workers who might have criminal records – should proceed cautiously and with some balance towards meeting the needs of workers and employers. While moderate minimum wage increases likely impose only small costs on employers and small drops in employment, at least in the shorter term, the recent rend to $15 an hour in many cities and states will likely reduce employment more substantially, especially in the longer term when employers can respond to such changes by relocating or automating more quickly than they otherwise would have done.[43] And, since most evidence suggests that "Ban the Box" actually reduces the hiring of less-educated blacks or black men (Doleac and Hansen, 2017; Agan and Starr, 2018), there is even more reason to proceed cautiously in imposing such mandates.

But, absent a rebounding of unionization (which seems unlikely), we should encourage employers to provide workers with some other forms of "voice" in the workplace, such as work councils (Kochan and Kimball, 2019). Some rewriting of the National Labor Relations Act – to strengthen worker bargaining right but also to allow other forms of worker "voice" – is likely necessary.

And rewarding employers who adopt "high road" employment practices has some merit (Holzer, 2018). These practices can often leave employers just as competitive and profitable as if they engaged in "low road" activities, while the former provide a "public good" for the workers hired there. Accordingly, government policies to encourage more such activity seem warranted. While some kinds of policies – like high minimum wages – might encourage more "high road" activity but with a potential cost to employment, others that emphasize "carrots" as well as "sticks" should be explored.

[43] The Congressional Budget Office (or CBO, 2014) summarizes most available evidence on the employment losses generated by minimum wage increases, finding that a 10 percent would most likely reduce employment in the US quite modestly, by about 500,000 workers. But Sorkin (2015) argues that longer-term estimates of such losses are much greater than the usual short-term estimates cited in the CBO study. In addition, the employment losses are likely nonlinear, with much larger losses per dollar of additional minimum wage mandated at higher than lower levels, since adjustment costs of relocating or introducing automation likely limit employer responses to small wage increases but not larger ones (Hamermesh, 1989).

Again, this is another area where we have very little evidence of what works. State and local economic development policies sometimes involve assistance to high-road employers, though they more frequently involve throwing tax breaks and other subsidies at large employers in a largely "zero-sum" battle with other states to attract such employers. A better approach would be for political leaders at all levels to first embrace a goal of creating more high-wage employment from the "bully pulpit"; and then they should experiment with a range of policy tools – including tax credits, grants, technical assistance, preferences in procurement, and the like, while we evaluate such efforts to see which, if any, really work. Federal grants to states and localities to pursue and then evaluate such efforts seem very sensible.

Many unanswered questions – such as whether to focus more on "high road" practices or outcomes, or both – would hopefully be answered along the way. And, as new forms of automation gradually but consistently are adopted by employers in these markets, "high-road" practices such as incumbent worker training to help such workers better adapt to their use would become an increasingly important dimension on which to measure firm activity.

The preceding discussion leaves one major question unanswered: should we adopt policies to slow automation in any way, or at least to limit its effects on displacement? Bill Gates' well-known call for a "robot tax" has been strongly criticized as a policy that would dampen innovation and productivity growth. A narrower version of this, like a modest "displaced worker tax," might be somewhat more appealing, since it would encourage firms to retain their incumbent workers when they implement new automation, while helping to finance costly ameliorative policies when they don't. It could also be seen as an extension of "experience rating" in the Unemployment Insurance system. But, even in this case, taxes on worker "churn" that are part of the process by which the labor market encourages economic efficiency could be counterproductive, especially given the extent to which the US labor market has already become sluggish (Wozniak, op. cit.).

III. Conclusion

Predicting the characteristics of labor markets over the next three decades – and the challenges both old and new that will confront us along the way – is a very uncertain exercise. Projections for change on both the supply and demand sides of the market might turn out to be inaccurate, especially the further into the future our projections go.

Still, our best judgments now suggest that, on the supply side of the labor market, we will find slower population growth, less labor force participation, growing diversity, and less increase in educational attainment than we would otherwise see. On the demand side, new forms of automation (and perhaps trade) will likely require workers to adapt to maintain their old jobs or find new ones that pay reasonably well; while automation will likely also enable both firms and workers to implement more "alternative staffing" arrangements – some of which will benefits workers with greater flexibility and choice, while others will be imposed on them involuntarily

and likely will reduce their training and earnings growth. An ongoing movement to more "low-road" employment practices might well accompany these changes, though that is far from certain.

The extent to which these labor market forces largely improve average worker outcomes – by raising productivity in a way that also raises average worker compensation – remains unclear. But it seems likely that higher inequality and greater job instability will also characterize these markets, with some workers likely to be "losers" in the process – especially those who remain substitutes for automation rather than complements to it.

Accordingly, a major goal of labor market policy should be to help workers adapt to such changes – especially by gaining more education and training of both a general and specific nature – while encouraging employers to help them adapt and to engage in related "high-road" practices (while limiting anti-competitive behaviors). Technology itself can play a more positive role in helping workers gain the needed skills and in better matching those skills to employer needs, and policy could encourage the use of these technologies in the marketplace. And sensible reforms in retirement and immigration policies would help maintain labor force and economic growth while also contributing to a more skilled workforce.

Educational institutions will also need to adapt, by providing newer mixes of general, 21st century skills as well as those for specific occupations and industries that are now in high demand and offer good worker compensation. Policy will need to encourage "lifelong learning" in a variety of ways.

Whether the moderate set of policies that I've outlined above will be sufficient to allow most workers to gain from automation, and prevent the kinds of large dislocations and increases in inequality that might otherwise occur, is unclear. If they do not, we might experience not only economic challenges, but political turmoil and declining social cohesion of the types we have glimpsed in national and populist movements around the industrial world in the past few years, or worse.

Still, I am reluctant to embrace at least two types of more dramatic policies that are frequently advocated on the political left (or occasionally the right): 1) Universal Basic Incomes (UBI); and 2) Guaranteed public employment.

UBI has gained popularity in the past few years among those who expect very widespread and persistent nonemployment among workers due to ongoing automation. These authors (e.g., Lowery, 2018) typically expect automation to permanently reduce demand for labor among employers, especially in well-paying jobs. As I argued above, I do not embrace such a view, even though worker displacement might become widespread.

My fear is that UBI, unlike policies to "make work pay" (which only generate payments when workers accept low-wage jobs), will reduce work incentives among less-educated workers. Much like the "negative income tax" experiments of the 1970s, UBI would raise the

attractiveness of not working relative to working, and potentially for large numbers of people. In addition, UBI could be enormously expensive – especially when the US is not adequately paying for existing entitlement programs like Social Security and Medicare, which are generating trillions of dollars in unfunded future liabilities.

Likewise, depending on its characteristics, a publicly guaranteed jobs program (e.g., Paul et al., 2018) could potentially draw millions of workers out of low-wage private jobs with lower pay or less appealing nonwage characteristics at very high public expense. While a role for publicly subsidized jobs no doubt exists, turning them into entitlements for workers does not seem economically or fiscally prudent anytime soon.

There is little question that we will experience large changes on the supply and demand sides of the labor market between now and 2050. Whether the benefits to most workers outweigh the costs, and exactly how our policy toolkit should adjust to these changes over time, remain unclear. But we should begin the process of experimenting with a variety of such approaches right now, and evaluating them rigorously. The federal government should actively encourage such experimentation and evaluation at the state and local levels, as we try to learn how best to meet the challenges we will face.

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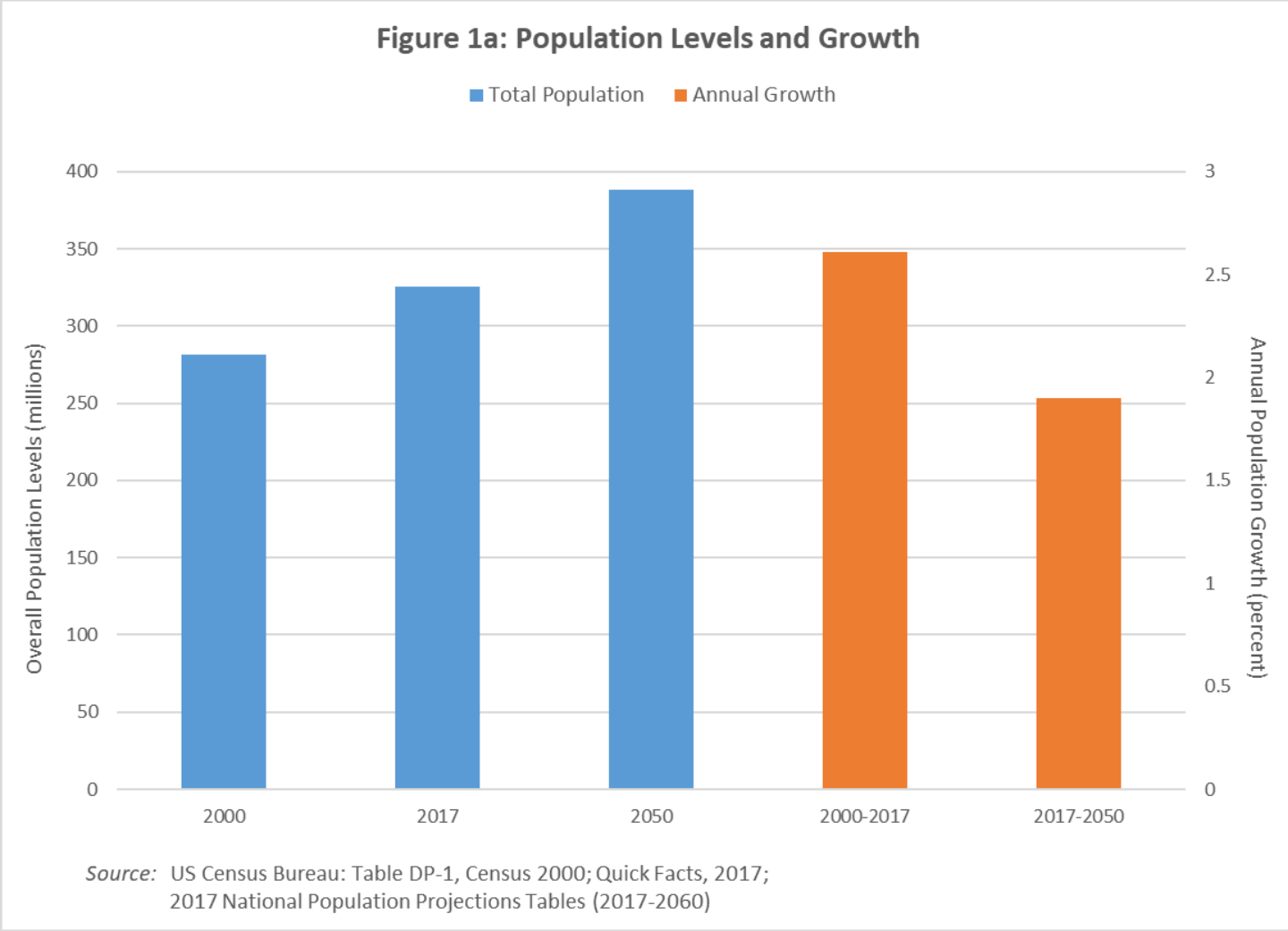
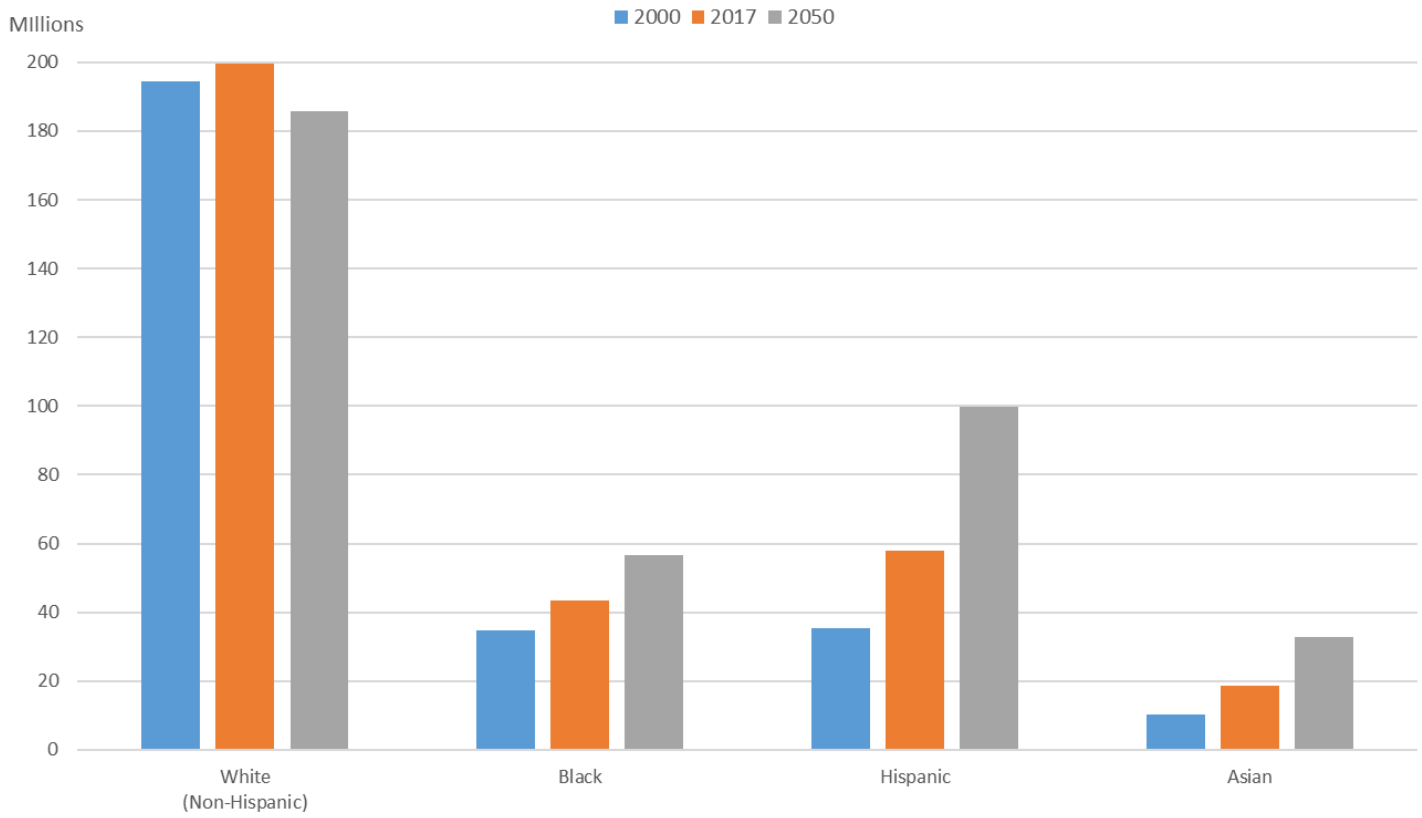
Figure 1: U.S. Population Trends and Projections



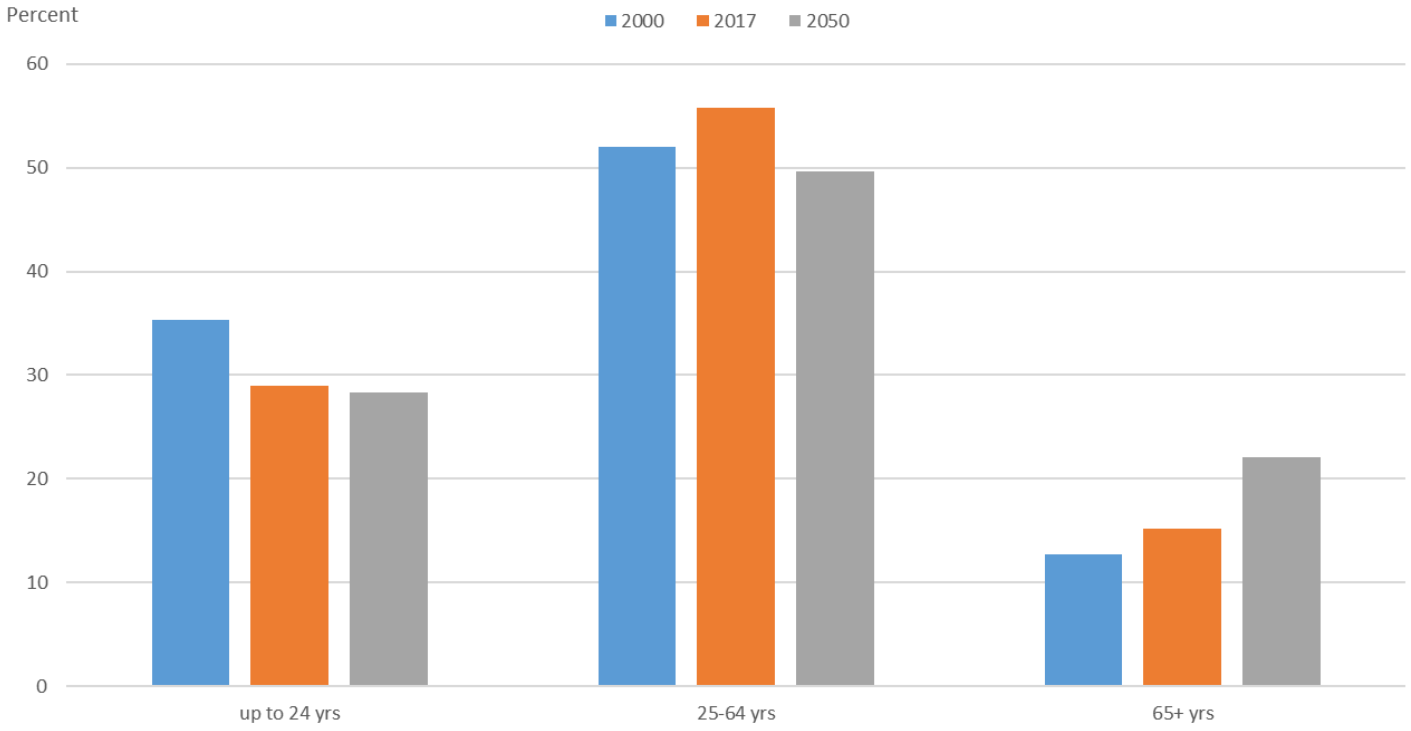
Source: US Census Bureau: Table DP-1, Census 2000; Quick Facts, 2017; 2017 National Population Projections Tables (2017-2060)

Figure 1b: Population Levels by Race



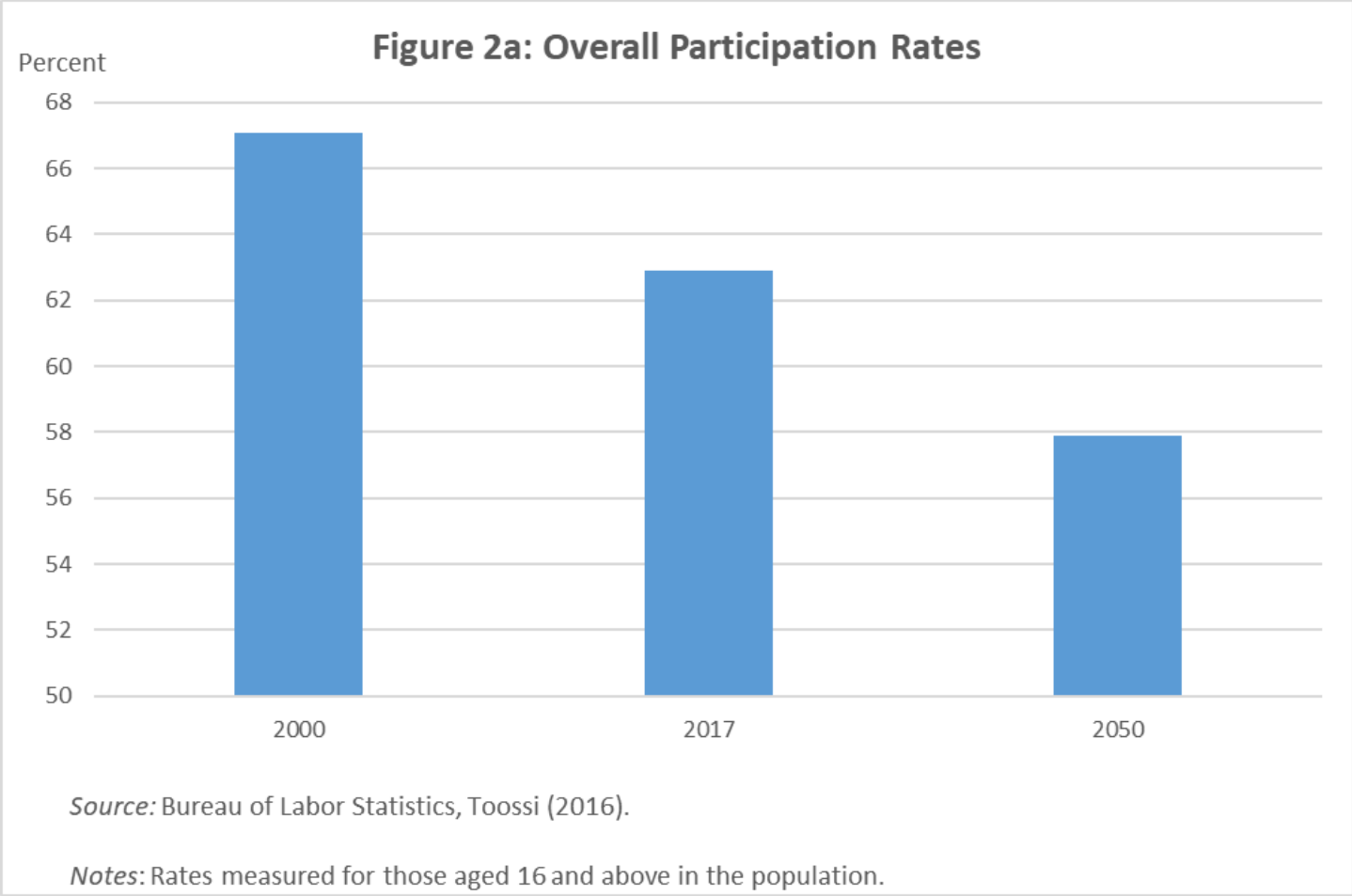
Source: US Census Bureau: Table DP-1, Census 2000; Quick Facts, 2017; 2017 National Population Projections Tables (2017-2060)

Figure 1c: Population Composition by Age



Source: US Census Bureau: Table DP-1, Census 2000; Quick Facts, 2017; 2017 National Population Projections Tables (2017-2060)

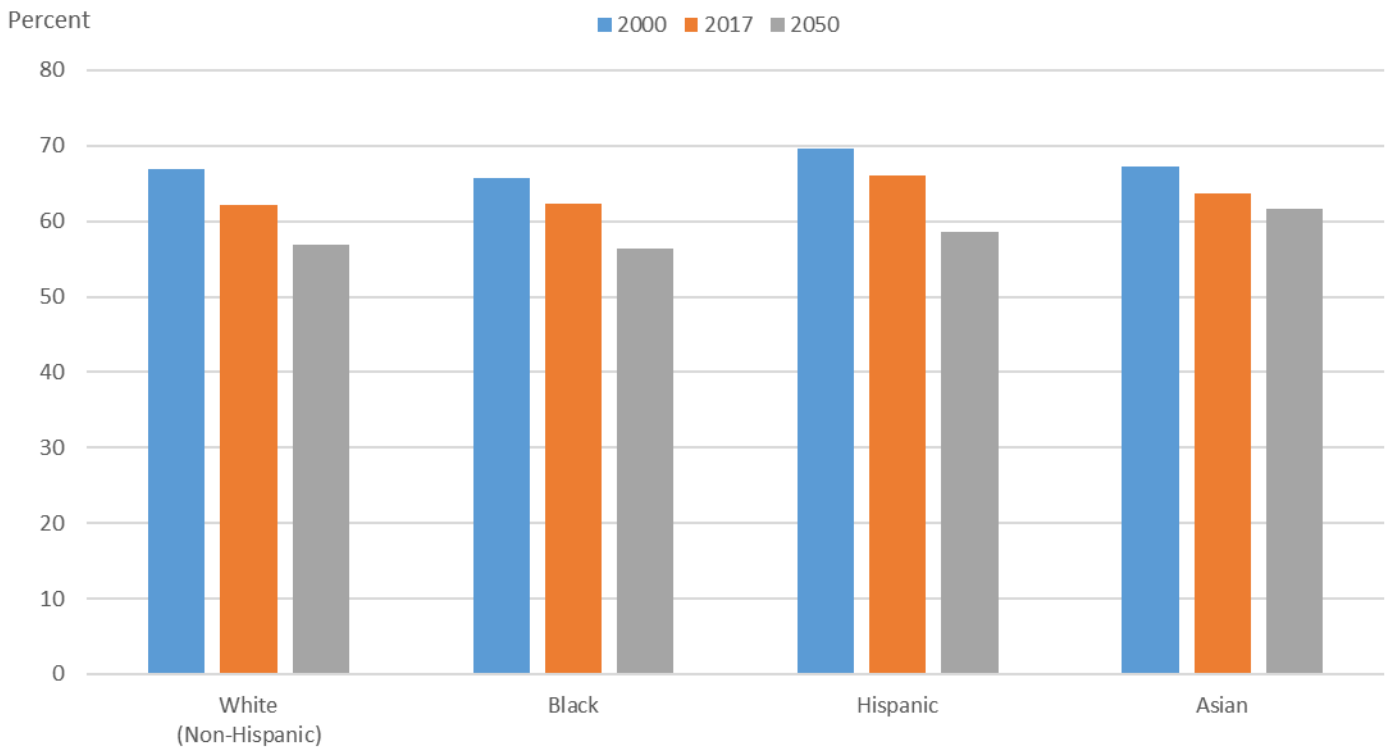
Figures 2: U.S. Labor Force Participation Trends and Projections



Source: Bureau of Labor Statistics, Toossi (2016).

Notes: Rates measured for those aged 16 and above in the population.

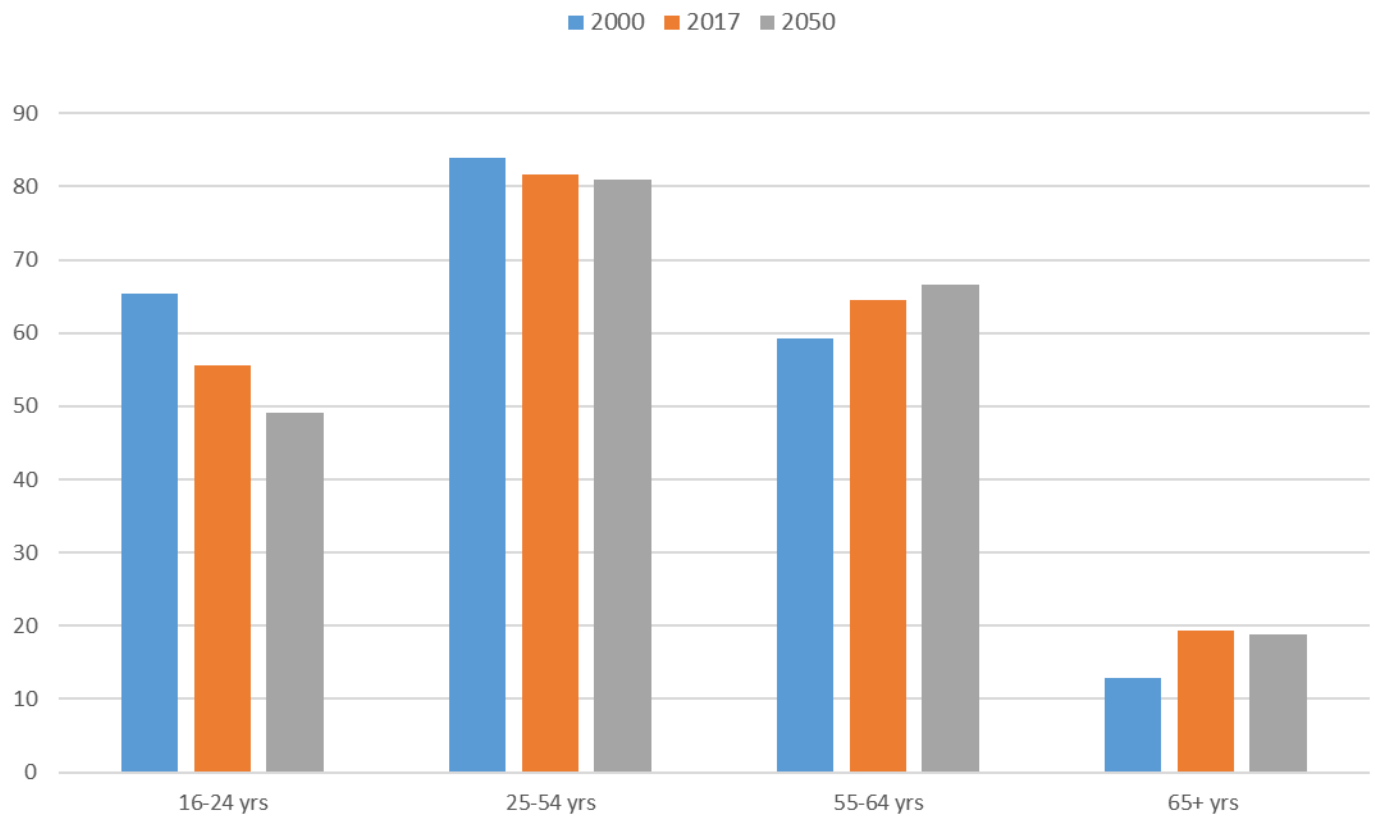
Figure 2b: Participation Rates by Race



Source: Bureau of Labor Statistics, Toossi (2016).

Notes: Rates measured for those aged 16 and above in the population.

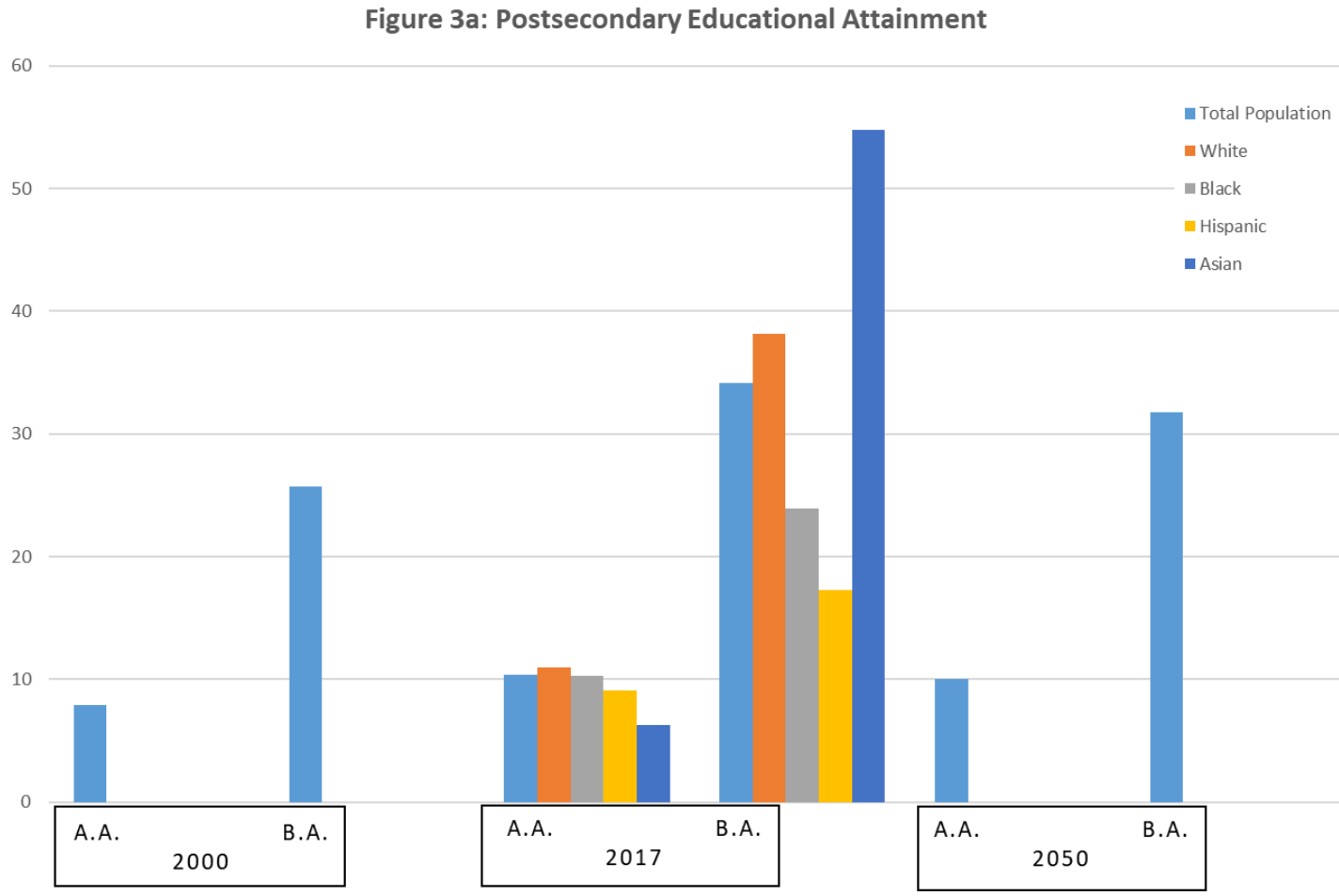
Figure 2c: Participation Rates by Age



Source: Bureau of Labor Statistics, Toossi (2016).

Notes: Rates measured for those aged 16 and above in the population.

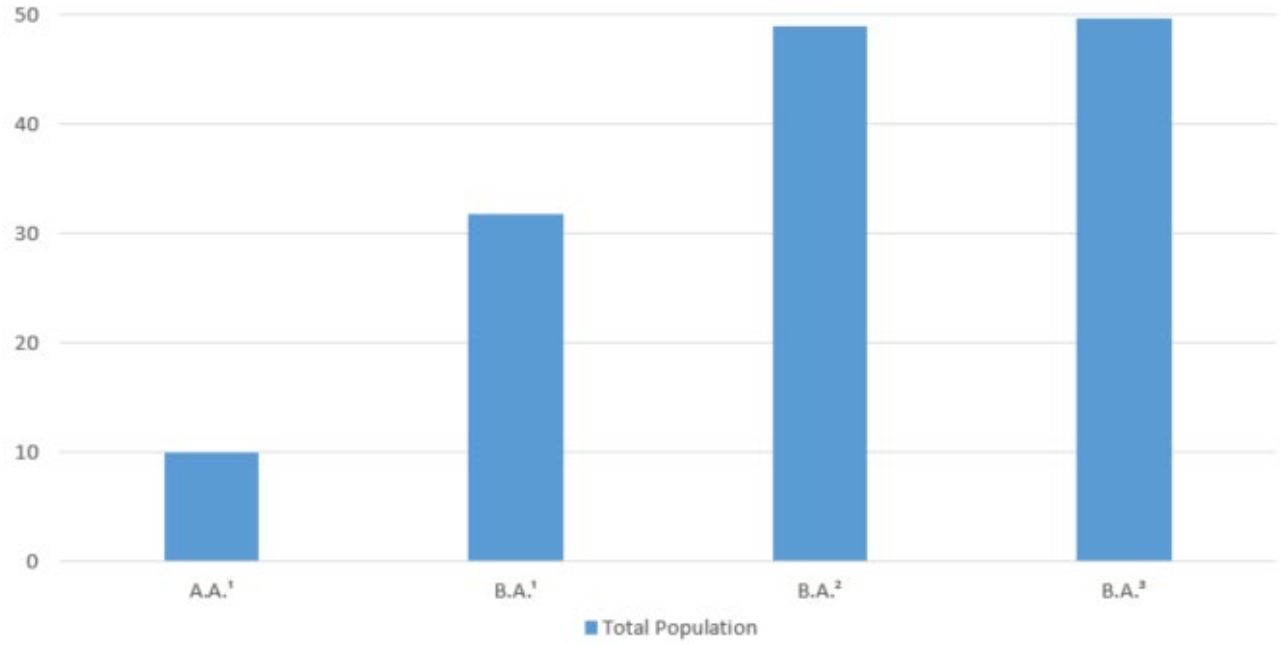
Figures 3: U.S. Postsecondary Education Trends and Projections



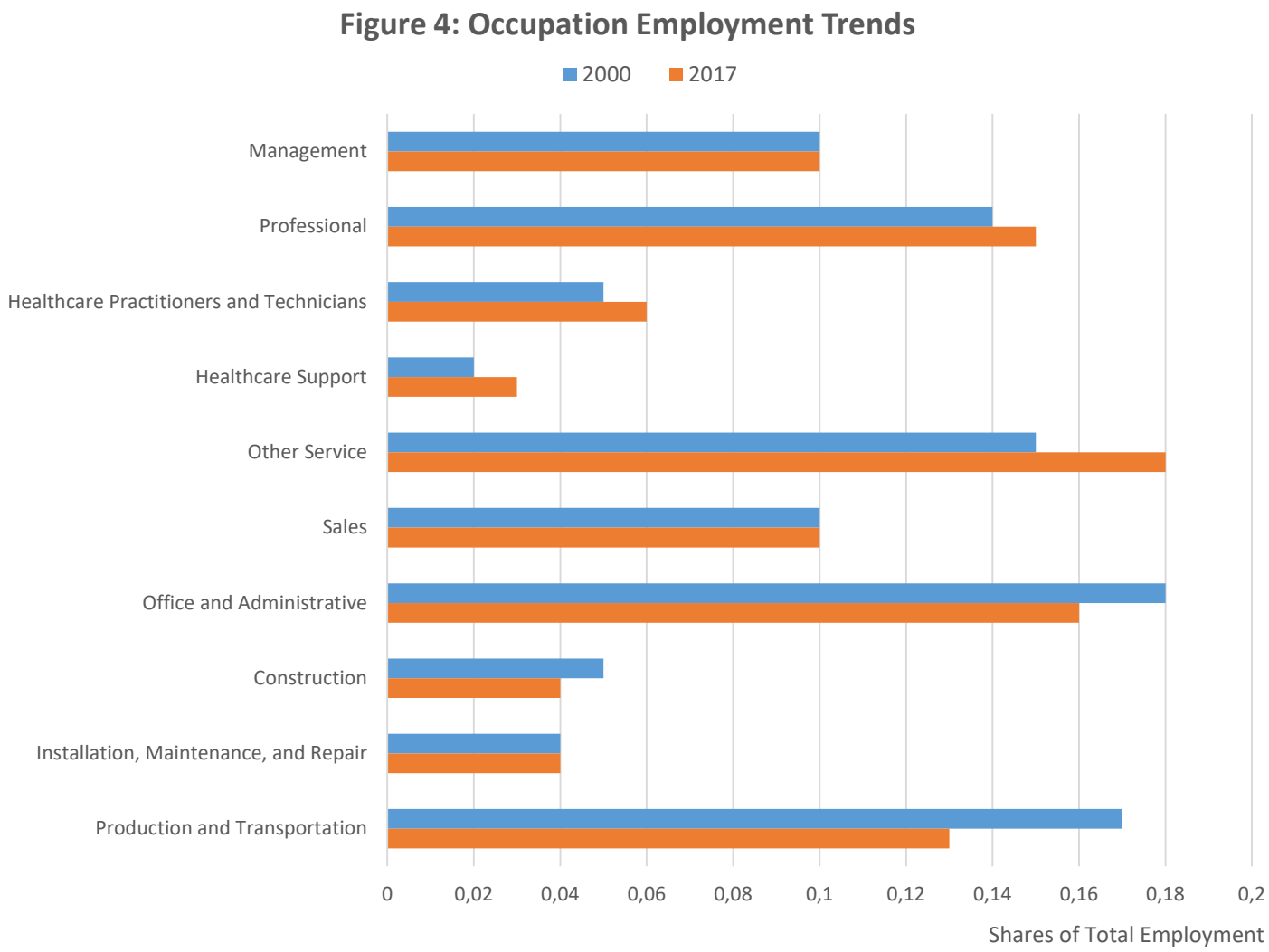
Source: U.S. Census Bureau CPS Historical Time Series; 2018 Table A.4.; and National Center for Education Statistics, Digest of Edcation Statistics, 2018, Table 104.10.

Notes: Educational Attainment measured for population aged 25 years and older. Projections to 2050 are based on calculations using annual rates of educational attainment by race in 2017 weighted by projected population shares by race/ethnicity in 2050.

Figure 3b: Alternative Projected Trends in Overall Attainment



Notes: 1. Same as FIgure 3a projections to 2050.
2. Based on calculations using annual rates of education growth between 2000 and 2017 by race, weighted by projected population shares by race in 2050.
3. Based on calculations using the same annual rate of education growth before 2000 and 2017 by race, but weighted by population shares by race in 2017.



Source: Occupational Employment Statistics, Bureau of Labor, 2000 and 2017.

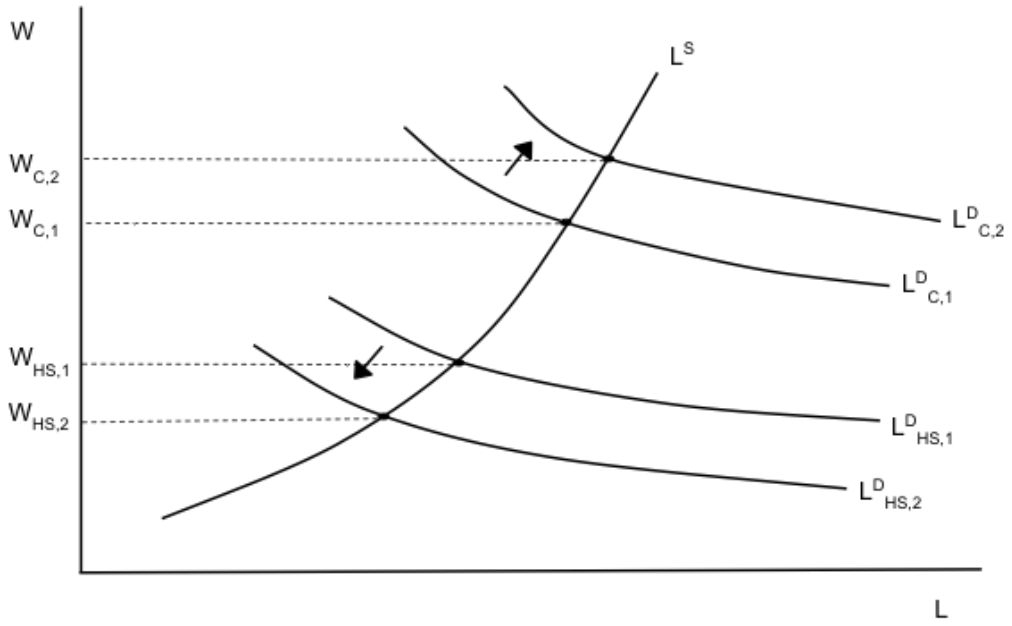
Table 1: Tasks Difficult to Automate

	Variable	Definition
Perception manipulation	Finger dexterity	The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects.
	Manual dexterity	The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.
	Cramped work space, awkward positions	How often does this job require working in cramped work spaces that requires getting into awkward positions?
Creative intelligence	Originality	The ability to come up with unusual or clever ideas about a given topic of situation, or to develop creative ways to solve a problem.
	Fine arts	Knowledge of theory and techniques required to compose, produce, and perform works of music, dance, visual arts, drama, and sculpture.
Social intelligence	Social perceptiveness	Being aware of others' reactions and understanding why they react as they do.
	Negotiation	Bringing others together and trying to reconcile differences.
	Persuasion	Persuading others to change their minds or behaviour.
	Assisting and caring for others	Providing personal assistance, medical attention, emotional support, or other personal care to others such as coworkers, customers, or patients.

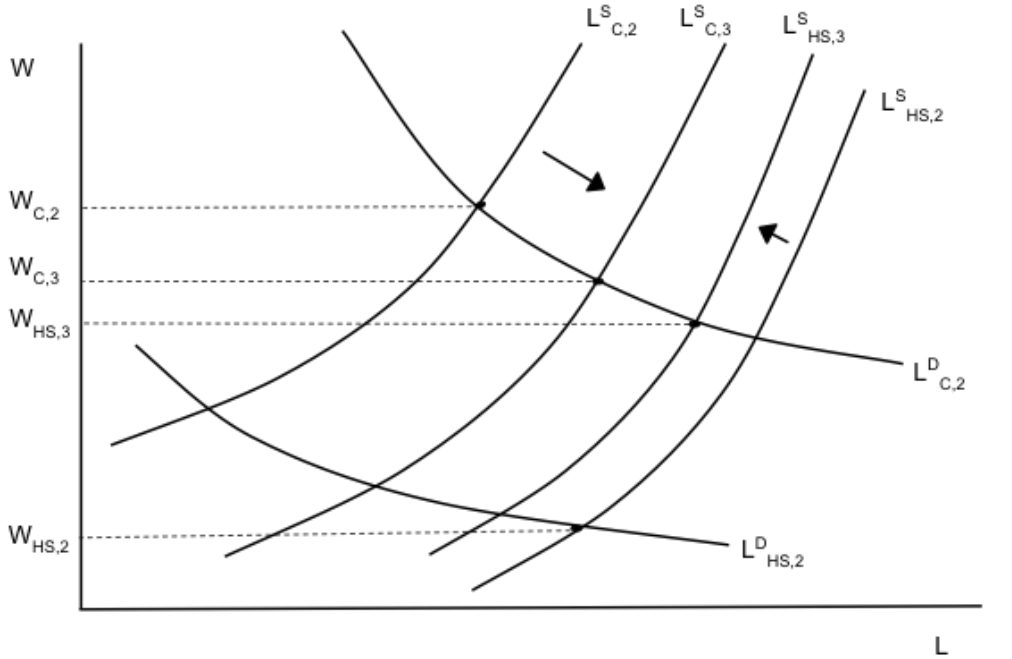
Source: Nedelkoska and Quintini (2018), Table 4.1.

Figure 5. Labor Demand Shifts and Supply Responses for College and High School Graduates

A. Effects of Labor Demand Shifts towards College Graduates



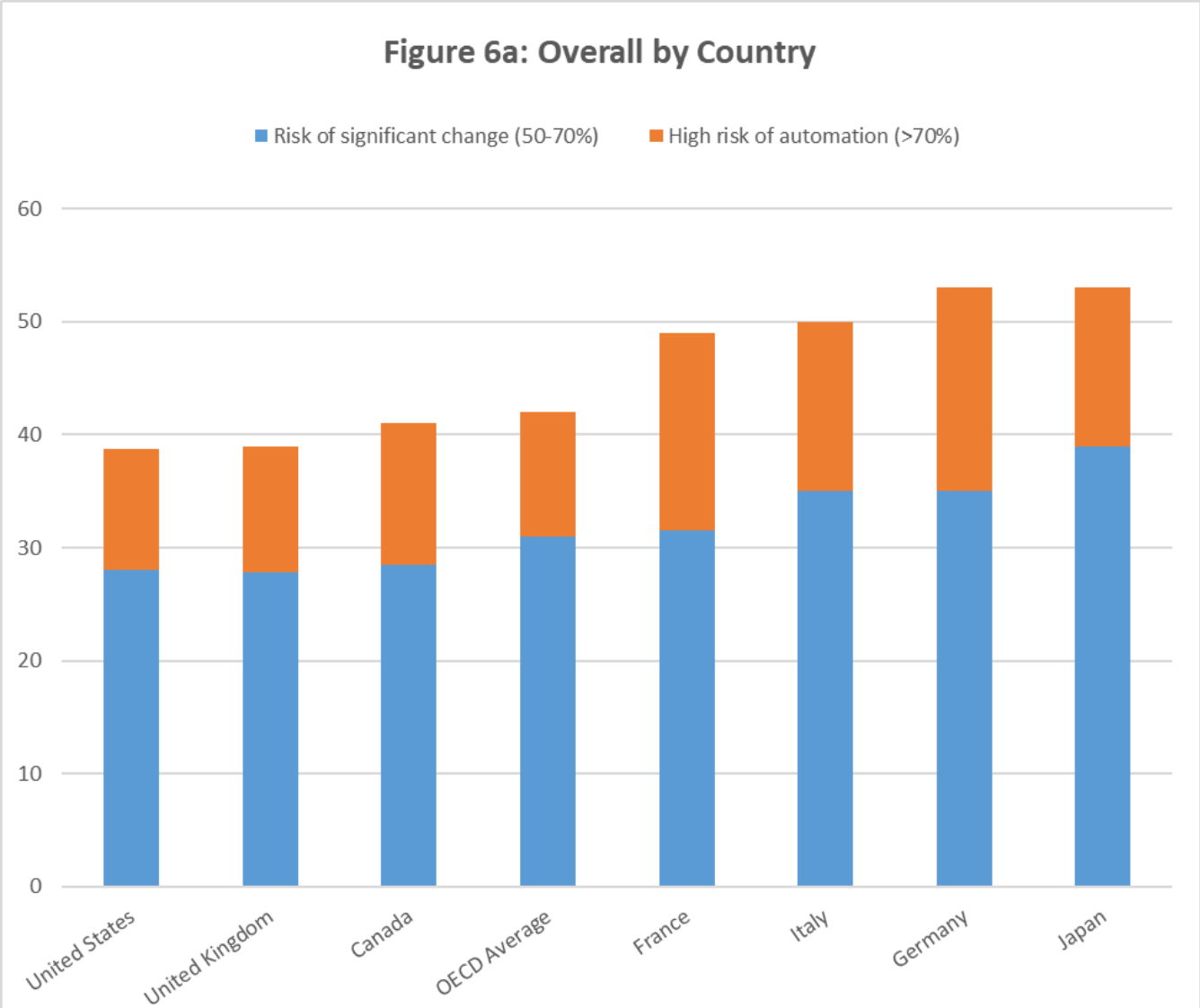
B. Labor Supply Responses



Note: To simplify these diagrams, we assume a joint labor supply curve between high school and college graduates in Part A, but separate ones in Part B.

Figures 6: Tasks and Probabilities of Automation Displacement

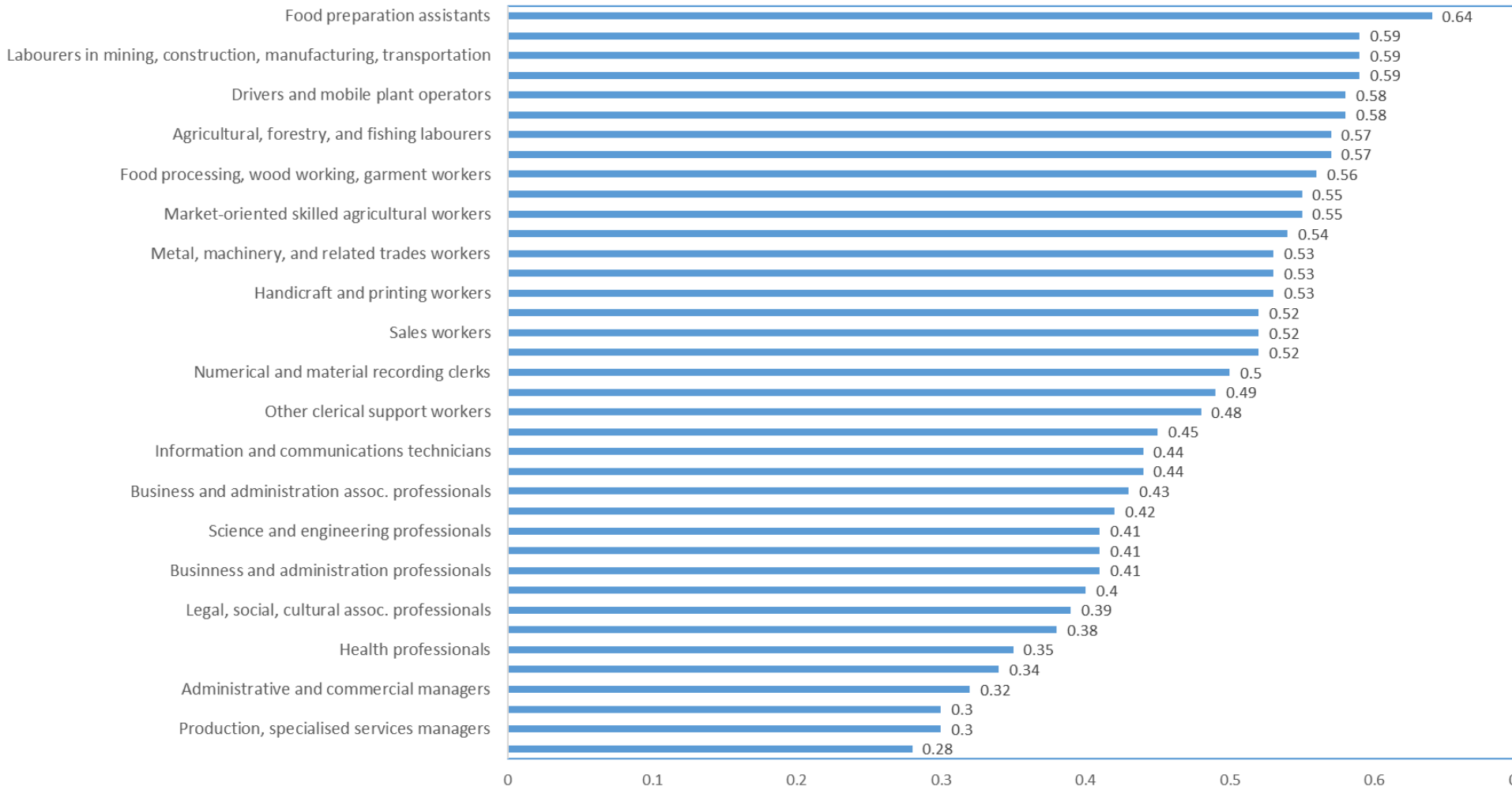
(by total and by occupation)



Note: High risk - more than 70% probability of automation;
Risk of significant change - between 50 and 70% probability.

Source: Nedelkoska and Quintini (2018), Figure 4.2.

Figure 6b: Automation and Work Displacement by Occupation



Source: Nedelkoska and Quintini (2018), Figure 4.3.