moving up

Promoting workers' economic mobility using network analysis

MARCELA ESCOBARI
IAN SEYAL
CARLOS DABOÍN CONTRERAS

BROOKINGS | Workforce of the Future Initiative

Authors

Marcela Escobari
Senior Fellow

Ian Seyal
Senior Project Manager and Senior Research Analyst

Carlos Daboín Contreras
Consultant at the Workforce of the Future initiative

June 2021

Global Economy and Development
at BROOKINGS

Acknowledgements

Brookings gratefully acknowledges the generous support for this report and the work of the Workforce of the Future initiative from the Bill & Melinda Gates Foundation, Google.org, and the Mastercard Center for Inclusive Growth.

The authors are indebted to colleagues who provided critical insights and contributions. Peter DeWan was instrumental in helping the team develop and execute the network analysis featured in this publication. Eduardo Levy Yeyati and Greg Wright offered thoughtful review and recommendations on methods, findings, and narrative. Dhruv Gandhi, Natalie Geismar, Isha Shah, Jay Garg, Eric Krebs, Zebang Xu, Yumna Naqvi, Sebastian Strauss, Brian Reyes, and Jamal Nimer provided invaluable research, visualization, and analytical help. We extend special thanks to Yashi Wang, whose exceptional data visualization and design skills made the report figures and layout shine.

We owe a debt of gratitude to reviewers who offered guidance on the report, including Ethan Rouen and Douglas Rose, as well as those that provided ongoing advice including Carol Graham, Homi Kharas, Dany Bahar and John McArthur.

Greg Larson provided support throughout the writing process, tirelessly workshopping the report's narrative, flow, and tone with the team. And the authors might still be tinkering with the text if not for the assistance of Bruce Ross-Larson, whose sagacity guided us through the final edit and publication process.

The authors would like to thank our colleagues at Brookings for their support, including David Batcheck, Esther Rosen, Aki Nemoto, Jackie Sharkey, Yvonne Thurman-Dogruer, Drew Badolato, and the Brookings Central Communications team. We thank Brahima Coulibaly for his ongoing leadership.

We gratefully acknowledge our ongoing collaboration with the Texas Higher Education Coordinating Board staff, including Commissioner Harrison Keller and Deputy Commissioner Lori Fey, who helped us make our research applicable to higher education and local leaders. We are grateful to Otis Rolley III from The Rockefeller Foundation and Daniella Ballou-Aares from Leadership Now for their collaboration in developing the ESG metrics described in this report.

Thank you to the researchers at the Bureau of Labor Statistics, the Census Bureau, and IPUMS at the University of Minnesota whose efforts made our work possible. Thank you to Burning Glass Technologies for making their proprietary data available to researchers. In particular, thank you to Bledi Taska and Layla O'Kane for their ongoing thought-partnership on the analyses of job postings data and of worker mobility.

The Brookings Institution is a nonprofit organization devoted to independent research and policy solutions. Its mission is to conduct high-quality, independent research and, based on that research, to provide innovative, practical recommendations for policymakers and the public. The conclusions and recommendations of any Brookings publication are solely those of its authors, and do not reflect the views of the Institution, its management, or its other scholars and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation, Google.org, and the Mastercard Center for Inclusive Growth, or their boards of directors.

Brookings recognizes that the value it provides is in its commitment to quality, independence, and impact. Activities supported by its donors reflect this commitment.

Glossary

Clusters: Groups of occupations within which workers transition frequently but rarely leave. Using a community detection algorithm, we identify 15 distinct occupational clusters in our network model, with stark differences in worker demographics, wages, and mobility prospects.

Low-wage jobs: Occupations with a median wage below $17.26 per hour, or two-thirds of the median hourly earnings for full-time white male workers in 2019.

Mobility: The ability to advance one's career toward increasingly higher-paid work. This report focuses on *intragenerational* mobility (achieved during the course of one's lifetime), as opposed to *intergenerational* mobility (achieved across generations).

Network: Our novel visualization of the labor market as a network using highly granular data on thousands of workers' transitions. Each node in the network represents an occupation; the closer two occupations are in the network, the more frequently workers move between them.

Pathways: A series of transitions. We identify pathways within and between clusters, pinpoint where some workers are getting stuck, and explore ways to widen, accelerate, and create new pathways upward. Steppingstones and skyways (see below) lie along upward pathways.

Sandpits: Clusters with below-average wages and below-average mobility prospects. We identify five sandpit clusters: food and customer service, personal appearance, cleaning services, transportation and production, and assemblers and machine operators.

Share of upward transitions: For a given group of workers, the share of total transitions that results in a higher-than-expected wage increase (compared with the average wage increase for all transitions starting from the same wage level).

Skyways: Occupations into which workers from the five low-wage, low-mobility "sandpit" clusters can feasibly make upward, *cross-cluster* transitions. While fairly rare, skyway occupations typically pay higher wages, are expected to grow, and have low barriers to entry.

Steppingstones: Occupations with a median wage lower than $30 per hour that frequently serve as conduits to occupations with a median wage greater than $30 per hour. We analyze a given occupation's "steppingstone index," which measures how frequently it lies on worker trajectories to high-wage occupations, calculated as a percent of all the pathways that cross it.

Transition: A worker's transition from one occupation to another, without a period of unemployment. We use a monthly Bureau of Labor Statistics (BLS) survey and five-year resume data from Burning Glass Technologies to track workers' movements into and out of 428 occupational categories.

Table of contents

Boxes

Box figures

Figures

Tables

Moving Up

OVERVIEW AND MAIN FINDINGS

The U.S. economy faces a mobility crisis. After decades of rising inequality, stagnating wages, and a shrinking middle class, many American workers find it harder and harder to get ahead. Covid-19 accentuated a stark divide, battering a two-tiered labor force with millions of low-wage workers lacking job security and benefits—as the long-term trends of globalization, digitalization, and automation continue to displace jobs and disrupt career paths.

To address this crisis and create an economy that works for everyone, policymakers and business leaders must act boldly and urgently. But the challenge of low mobility is complex and driven by many factors, with significant heterogeneity across regions, sectors, and demographic groups. When diagnostics fail to disentangle the complexity, our standard policy responses—centered on education, reskilling, and other reemployment services to help workers adapt—fall short.

This report offers a new approach to better understand the contours of mobility: Who is falling behind, where, and by how much. Using data on hundreds of thousands of real workers' occupational transitions, we use network analysis to create a multidimensional map of the labor market, revealing a landscape riddled with mobility gaps and barriers. Workers in low-wage occupations face particular hurdles, and persistent racial and gender disparities hold some workers back more than others.

Even so, many workers travel on pathways to economic mobility. By showing where existing pathways can be expanded and where new ones are needed, this report helps policymakers, community organizations, higher education institutions, and business leaders better understand the challenge of mobility and see where and how to intervene, in order to help more workers move up faster.

The report's major findings:

1 *Mobility gaps exist across wage level, industry, race, and gender*

Low-wage industries offer workers less upward mobility. For example, the sector with the lowest median wage, hospitality, also offers its workers the worst prospects for upward mobility. Of all occupational transitions in hospitality, only 36 percent are upward, far from the 66 percent in utilities or professional services, two of the highest paying and most upwardly mobile sectors.

Race and gender mobility gaps hold some workers back. Across the labor market, Hispanic and Black women face the lowest shares of upward transitions: 37 percent and 43 percent, respectively, well below the 57 percent for white men and 61 percent for Asian men. The gaps persist regardless of education: for Asian men with a bachelor's degree or higher, 75 percent of transitions are upward—compared with only 56 percent for comparably educated Hispanic women.

Industries differ in their mobility gaps. Manufacturing has the largest racial mobility gaps, with Black workers seeing 14 percentage points fewer upward transitions than their white colleagues, and Hispanic workers 18 percentage points fewer. By contrast, mobility gaps are narrower, falling to 6 or fewer percentage points, in government and education, suggesting that public employment may offer more equitable access to mobility.

2 *Many workers in low-wage occupations get trapped*

Low-wage work is sticky. Over 10 years, only 43 percent of workers in low-wage occupations leave low-wage work. Their chances of moving up get smaller and smaller the longer they remain. Every four years, the probability of escaping low-wage work shrinks by half. By their 10th year, the chance of escape is only 1 percent.

Traditional pathways from low- to high-wage work are expected to disappear. Steppingstone occupations—middle-wage jobs that have long served as conduits between low- and high-wage occupations—are shrinking as a share of total employment across the labor market. They made up 16.5 percent of total employment in 2019. According to BLS projections for 2029 employment, the labor market will require an additional 775,000 steppingstone jobs to keep their 2019 share of total employment.

Sections of the labor market are like sandpits. In certain occupational categories, workers spend years churning through low-wage jobs, with few prospects for upward mobility. We identify five distinct "sandpit" clusters of the labor market, comprising 37.5 million workers, for whom only 38 percent of transitions are upward.

3 *While pathways exist, they are narrow and full of hurdles*

Workers move in well-defined patterns. Using network analysis, we identify 15 distinct occupational clusters that have stark differences in wages and mobility. Workers move within these boundaries far more frequently than they cross them: Transitions involving occupations in the same cluster are 3.8 times likelier than cross-cluster transitions.

Some low-wage occupations are especially vulnerable to job displacement and technological disruption. For example, many of the 4.3 million workers in the assemblers and machine operators sandpit cluster will need pathways out. After factoring in the effects of Covid-19, the BLS projects this cluster will lose as many as 301,000 jobs, a 7 percent drop. Moreover, 21 of the cluster's 26 occupations are expected to contract. Whereas these occupations would have been natural landing places for displaced workers, many workers will need to find reemployment outside the cluster, a much more difficult task.

For workers trapped in low-wage sandpits, skyway occupations offer lifelines. To escape occupations with low wages and low mobility prospects, some workers must make a cross-cluster leap to a new, more promising area of the labor market. While this is always challenging, some occupations are like skyways, connecting disparate sections of the labor market. Skyways are as varied as jobs in construction or information technology (IT) support, but they all have low barriers to entry and plentiful opportunities for career development.

Pathways to high-wage work exist, but access is unequal. For example, the health care cluster, which accounts for 34 percent of the labor market's total projected job growth over the next decade, offers notable opportunities for mobility due to existence of both high- and low-wage jobs, with pathways between them. Even so, many upward pathways are marked by gender and racial barriers: white licensed practical nurses (LPNs) are more likely to transition upward into registered nurse (RN) positions, while Black and Hispanic LPNs are more likely to transition downward into lower-wage jobs in home health and personal care.

4 *Refining policy targets can help more workers move up*

Jobs programs, infrastructure investments, targeted training, wage subsidies, portable benefits, and public–private reskilling programs can leverage occupational transitions analysis to identify workers' viable opportunities, feasible pathways, and thus the highly-valued credentials that those transitions require.

Companies, meanwhile, can do more to unlock bottlenecks. They can measure the mobility of their workforce, identify and address any gaps or barriers, create good jobs, and expand mobility opportunities for their employees.

Workers in sandpit clusters need better wages and benefits. Ensuring that employment in low-wage occupations entails adequate compensation—stability, living wages, and minimum benefits—would do much to improve most low-wage workers' mobility prospects by offering a much-needed buffer to workers interested in pursuing new skills training, education, or entrepreneurship. And to the many working people who will not advance, adequate compensation ensures the opportunity to thrive in American society.

Introduction

American workers face a crisis of access, opportunity, and upward mobility. Decades of labor market bifurcation have created a two-tiered workforce with a growing distance between workers in stable high-paid employment and those churning through insecure low-paid jobs with few benefits.[1,2,3] These trends shape our polarized economy, where gains increasingly accrue to the wealthy, the middle class is shrinking, and low-income workers face a steep climb out of poverty.

Only 9 percent of American men in the top income quintile today were born to fathers in the bottom quintile. This is nearly half the average in Organisation for Economic Co-operation and Development (OECD) countries of 17 percent.[4] Being born in Canada rather than the United States nearly doubles a child's chance of moving from the bottom to the top income quintile.[5] And as intergenerational mobility (across generations) has declined, so has intragenerational mobility (within a worker's lifetime). Even for college-educated workers who start their careers in the middle, the probability of retiring at the top has declined by nearly 25 percent since the 1980s. Meanwhile, for workers who start near the bottom, the probability of remaining there throughout their career has increased by more than 27 percent.[6]

For many U.S. workers, the combined effect of these trends is that the American Dream—the idea that anyone can succeed through hard work alone—feels increasingly like a fantasy. A 2019 public opinion poll found that 73 percent of Americans believe the gap between the rich and poor is growing, and 72 percent expect older adults to be less ready for retirement in 2050 than they are today.[7] While Americans still tend to overestimate their own chances of climbing the income ladder, uneven access to opportunity threatens to undermine a core tenet of the national ethos. It is perhaps not surprising, then, that the recent period of declining economic mobility has occurred alongside increasing social discord and alienation, distrust of institutions, and political polarization.

The future may only exacerbate these challenges. Just as globalization and technological change contributed to the decline in U.S. manufacturing and other middle-skill jobs in recent decades, advances in automation and artificial intelligence threaten to cause significant disruption in the decades to come. Concerted effort is needed to ensure that we are ready to face this changing landscape. Furthermore, these changes are expected to increase the proportion of low-wage and low-quality jobs—with as many as 70 percent of new jobs paying less than the median wage by 2029.[8] As millions of workers already struggle to make ends meet in low-wage, low-quality jobs, more must be done to ensure that they have the support to advance throughout their careers—before millions more join their ranks.

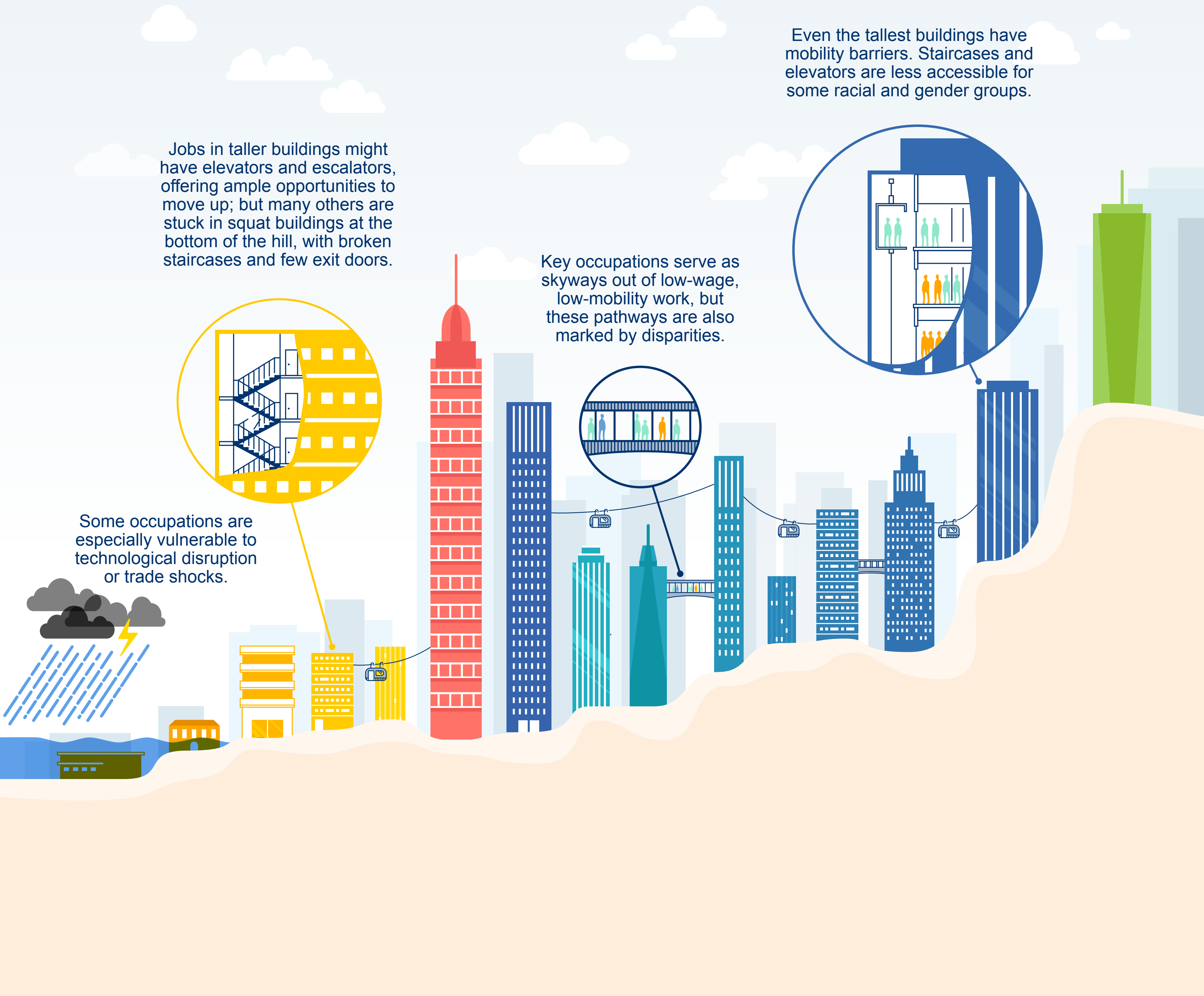
The central challenge of our coming era is to help workers cope with technological disruption while improving mobility, reducing inequality, and advancing equal access to opportunity—so that all American workers can share in the benefits of innovation, rising productivity, and economic growth. To create a future economy that works for everyone, we must focus more on helping workers adapt and transition and ensure that all workers have the chance to move up. To do that, we need better tools for understanding what's required to succeed in our dynamic, rapidly changing labor market.

In particular, we must also acknowledge and address the fact that relatively low-wage work will be a persistent feature of our economy. So, improved job quality and a stronger social safety net are especially essential to those who may spend their entire careers at the bottom of the income ladder.

FIGURE 1

The network model of the labor market as a metaphorical city

If we imagine the labor market as a small city on a hill, where the highest-paid occupations are located on the top floors and the lowest-paid on the bottom, we see that workers' experiences and mobility prospects are determined by where they start.



A new approach for understanding and promoting mobility

Moving Up offers new techniques for assessing and addressing key aspects in this crisis of low mobility. Building on our earlier report, *Realism about Reskilling*, we introduce a novel approach for understanding how workers transition across occupations, pinpointing where (and for whom) obstacles exist, and identifying the most promising pathways for upward movement. Using data on 228,000 real occupation-to-occupation transitions, we trace the most common pathways into and out of 428 occupations across 130 industries. Analyzing labor market data at this granular level—the very site of mobility—offers new insights with actionable implications for policymakers, businesses, workers, and the organizations that support them.

The mainstay of this approach is our network model of the labor market—built to facilitate targeted interventions. By mapping real workers as they move through occupations, we can visualize the complex mix of factors that influence opportunity and mobility. The shape of the network is determined by how frequently workers move between occupations. We find that workers move in well-defined patterns in 15 distinct occupational "clusters," within which workers move frequently but rarely exit.

Imagine the network as a small city where each cluster is a building, the highest-paid occupations are on the highest floors, and the lowest-paid are on the lowest. Workers' experiences and career prospects are powerfully shaped by the buildings where they work. Some jobs, even entry-level, are in skyscrapers built on hilltops, with escalators and elevators offering workers ample opportunities to reach the top floors. Many more, however, are squeezed into squat buildings in deep valleys, with low ceilings, rickety staircases, and few exit doors to more promising opportunities.

Across the labor market, Hispanic and Black women in low-wage occupations face the worst mobility prospects, regardless of education. Some industries and sectors are worse than others: manufacturing has the widest racial mobility gaps, and health care—despite its high potential to offer mobility—is riddled with bottlenecks that hinder the career advancement of workers of color in particular. In our city metaphor, even the tallest buildings have mobility barriers: the staircases, escalators, and elevators are narrower for some racial and gender groups.

While pinpointing gaps and bottlenecks, this approach also identifies channels of upward mobility. Pathways exist throughout the network, and key occupations serve as skyways out of low-wage, low-mobility work. In our imaginary city, some buildings are easier to climb than others, and some occupations offer trapped workers the chance to move to a taller building where they have a better chance at moving up. Yet these paths are also marked by gender and racial barriers. Locating upward pathways and better understanding how and why some workers move seamlessly through them is the first step toward widening them, removing their blockages, and creating the conditions for new mobility opportunities to emerge throughout the labor market.

The report is organized as follows. Chapter 1 presents our analysis of occupational transitions, finding gaps in workers' attainment of upward mobility by industry, race, and gender. Chapter 2 describes our network model of the labor market and highlights its key features, including the concentration of low-wage occupations in certain sections of the network. Chapters 3 and 4 show how workers move in well-defined patterns, and how one's mobility prospects are in many ways shaped by where one starts. Chapter 5 identifies opportunities for mobility—pathways from low- to high-wage work and skyways across clusters. The chapter concludes by reviewing the implications of our findings, as well as recommended strategies for policymakers, business, and worker organizations to help more workers move up.

CHAPTER 1

Addressing the mobility challenge where it happens: Occupational transitions

To address the crisis of low mobility—a complex challenge, driven by diverse factors—we need better diagnostics. This report looks at the challenge of mobility where many workers experience it: Occupational transitions. Analyzing transitions data exposes a labor market riddled with mobility gaps, where some workers move up, but many get stuck. Workers in low-wage sectors see less mobility, and across the economy mobility gaps widen along racial and gender lines. With a better understanding of how and where workers move—or don't—we can design better solutions.

Occupational transitions show how mobility is uneven

Low mobility is shaped by complex factors, and the outlook is challenging

The many drivers of mobility are complex and a long time in the making. At a steady rate over the last two centuries, agglomeration and urbanization continue to shift the geography of jobs and career pathways from rural and suburban areas to cities. Sweeping macroeconomic dynamics like globalization and deindustrialization, which took root in the 1970s and continued over the following decades, damaged longstanding career pathways in production and manufacturing.[9] On top of these dynamics, the quickening pace of technological advancement continues to boost the careers of workers with creative and digital skills.

Moreover, uneven access to institutional and societal drivers of mobility—such as education and reskilling programs that prepare workers for the future, or health insurance and unemployment benefits that protect workers in the present—holds some workers back while vaulting others into the top tiers of the economy. And at the firm level, domestic and international competition, as well as growing business trends like outsourcing or workplace "fissuring"—in which employers increasingly rely on contractors and temp workers rather than hiring employees directly—reduce companies' incentives to invest in their workers or provide upward career paths within the firm. While every worker's self-efficacy also shapes their trajectory, even the most motivated workers face significant headwinds amid these larger structural forces.

Every worker experiences mobility's complexity uniquely. Consider two workers at career crossroads: a recently laid-off retail manager in her mid-50s looking to switch sectors, and a home health aide in his late-20s looking for higher pay and less physically demanding work. Both workers' options will be shaped by shifting economic trends. The late-career retail manager might think her experience makes her a good fit for jobs in human resource management, but she may not realize how digitally intensive the HR field has become. And the early-career home health aide might be good with computers but unaware of the trend of offshoring digital services, which has only accelerated during Covid-19. Both may be willing to learn new skills, but their options may be further constrained by personal and financial realities, such as family obligations or lack of savings, making it impossible to take time from work to prepare for a career pivot. Demographics will also shape each worker's chances: race, ethnicity, and gender all have a strong influence on workers' mobility prospects.

These and other factors can turn a career pivot into a steep uphill climb. Most workers who experience mobility challenges may not recognize the larger forces working against them. But as this report shows, analyzing occupational transition data can help to see the contours of mobility more clearly. With a better view of the hurdles facing workers—where they exist in the labor market, and the potential to overcome them—we can devise more effective solutions to help more workers move up.

For a deeper understanding of how workers move, occupational transitions are a key level of analysis

Occupational transitions are useful for understanding mobility because they reflect how workers advance in the economy (**box 1.1**). Other studies analyze wage data, which is something every worker can understand: wage mobility is a pay

BOX 1.1

Defining occupational transitions and upward mobility

To analyze occupational transitions, we trace worker movements into and out of 428 occupations, using data on 228,000 real occupational transitions. Our dataset of occupation-to-occupation transitions uses the Integrated Public Use Microdata Series (IPUMS) of the Current Population Survey (CPS), conducted by the U.S. Bureau of Labor Statistics (BLS). The CPS is updated monthly and offers higher resolution and stronger fidelity to population demographics than other job-change data sources.[1] We consider only workers who switched occupations without a period of unemployment, reflecting voluntary transitions from positions of relative security and stability, making them better markers of upward mobility. For comparison, workers involuntarily displaced from their job earned an estimated 13 percent less in their next job.[2]

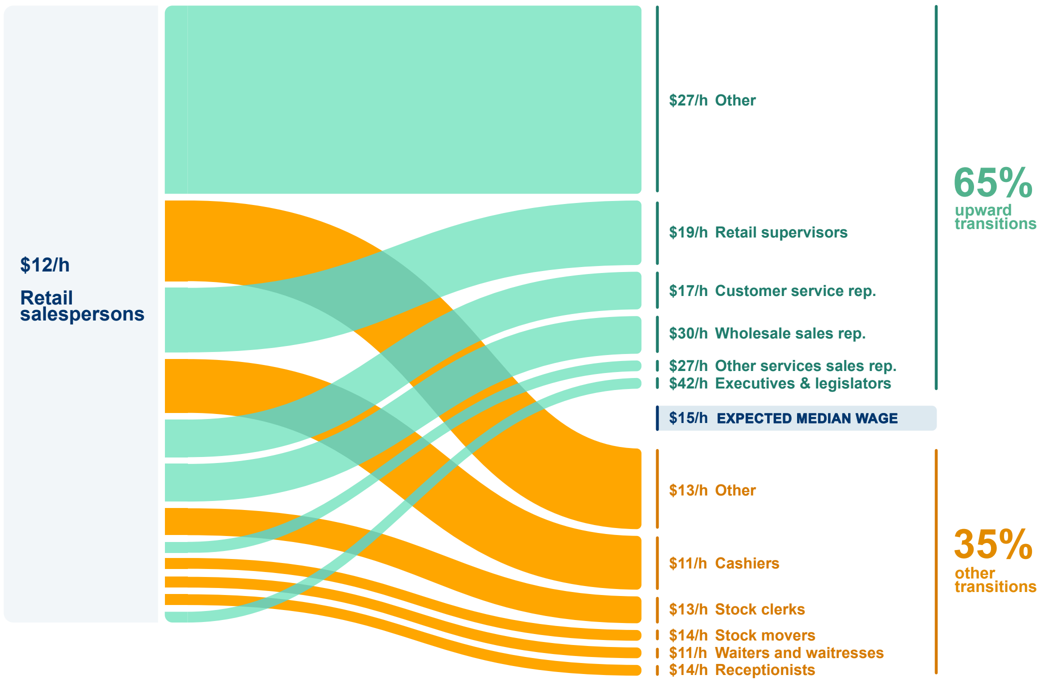
Since linked monthly CPS data do not include transitions' starting and ending wage information, we take the median wage for each occupation from the BLS Occupational Employment and Wage Statistics (OEWS) to build a definition of upwardly mobile transitions. Due to the nature of transitions data, defining an occupational transition as upward simply by the percent increase in median wages would give the misleading impression that lower-wage workers are more upwardly mobile—since workers who start at the lower end of the wage spectrum have more room to advance and are more likely to experience large increases when changing occupations.

Instead, we define an occupational transition as upward if it is likely to yield a higher-than-expected wage increase, based on the starting occupation's median wage. We estimate the expected wage increase as the average wage change across all the transitions starting from that same wage level. For any given occupation, we compute the share of upward transitions as the number of transitions that match or exceed the expected wage increase divided by the occupation's total number of transitions.

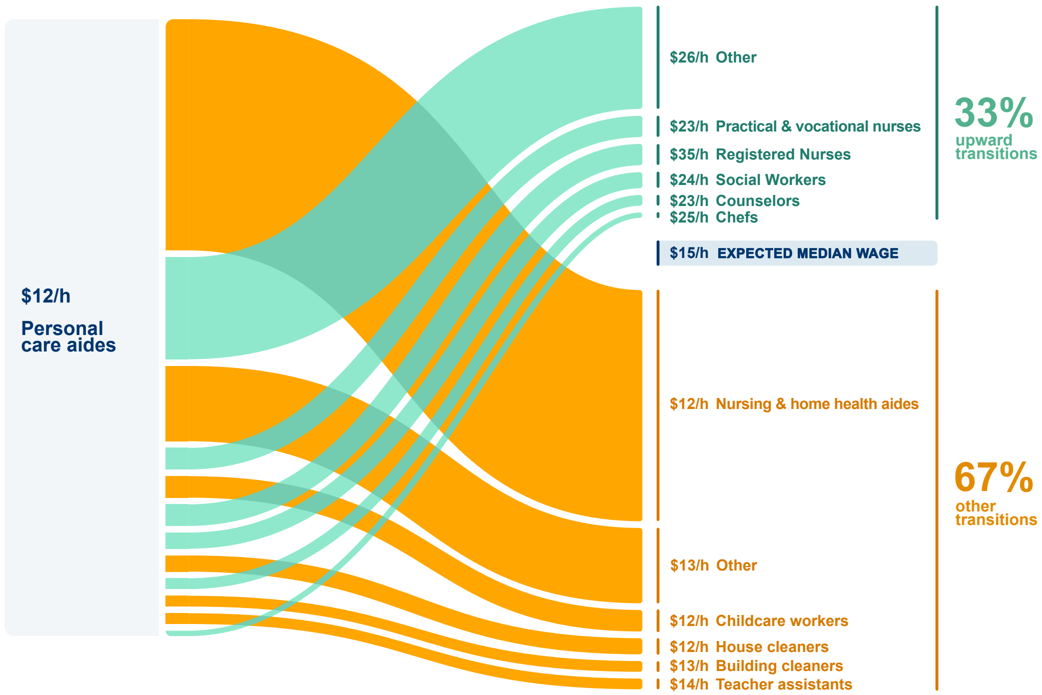
Here, we visualize this analysis by comparing the share of upward transitions for two occupations with similar wages but different upward mobility outcomes: retail salespeople and personal care aides, both of which have a median hourly wage of $12 (**figure B1**). For all occupations with a median wage of $12 an hour, the average wage increase when a worker switches occupations is $3 an hour. Therefore, any transitions out of retail salesperson or personal care aide must end in an occupation with a median wage of at least $15 an hour to be classified as upward. Transitions by personal care aides meet or exceed this threshold only 33 percent of the time, while retail salespeople meet or exceed it 65 percent of the time they switch occupations (**figure B1**).

FIGURE B1

a. Retail salespersons: High upward mobility



b. Personal care aides: Low upward mobility



Source: Authors' analysis of CPS-IPUMS data.

raise, an increase in hours, a bonus, or a promotion. But many low-wage and middle-income workers don't achieve real upward mobility through gradual pay raises alone, since most low-wage occupations have income ceilings. For example, no matter how many wage increases a dishwasher gets, even the highest-paid dishwasher will still have a relatively low income. Including dishwashing, 31 "low-wage ceiling" occupations, employing nearly 20 million workers, pay at least 90 percent of workers within them less than $20 an hour.[10]

Workers' occupations are strongly correlated with their wages and have long been understood as the single most important determinant of their socioeconomic standing.[11] They also correlate with future wages.[12] Some occupations offer transferable skillsets that lead to higher-paid, higher-quality work, and others do not. Of course, many other characteristics affect mobility, which makes untangling its drivers complex. A worker's age, demographics, education level,[13] work experience, and job tenure all play a role, as do employer characteristics like size, location, union status, and industry.[14] Despite the influence of those characteristics, our findings suggest that some occupations offer more mobility than others, even for similar workers. Across all occupations, only about a third of differences in upward mobility can be explained by education, gender, race, tenure, experience, or hours worked. Characteristics about the occupation itself—such as the value and transferability of the skills required and learned on the job—likely account for the remaining two-thirds of the variation in upward mobility (**appendix table A2.1**).[15]

Finally, occupational transitions are a useful level of analysis because job displacement due to trade or offshoring often affects a specific set of occupations.[16] So, a better understanding of how occupations are connected—particularly the ease and frequency for workers to transition between them—can help policymakers and businesses strengthen the resilience of the U.S. workforce by better diagnosing, preparing for, and adapting to future dislocations.

Transitions data expose mobility gaps: Many workers remain in low-wage work over long periods; mobility is uneven across occupations and sectors, as well as race and gender lines

Low-wage work is sticky

Previous research has shown that low-wage workers face big mobility hurdles, and that low-wage work is difficult to escape. During the 1980s and 1990s, 42 percent of households in the lowest income decile remained there for at least a decade.[17] Low-wage work can also persist across generations: In the 2010s, 42 percent of men in the lowest income quartile had been born to fathers in the same bracket.[18]

Our analysis of occupational transitions through Burning Glass Technologies' (BGT) online resume dataset similarly shows that while a majority of workers do manage to achieve some upward mobility, many workers in low-wage occupations spend their entire careers churning through low-paid jobs. The cumulative share of workers in the 31 "low-wage ceiling" occupations who escape low-wage occupations flattens for every additional year spent in the job, showing that low-wage work becomes stickier the longer workers remain in it (**figure 1.1**). The data indicate that workers in these occupations have a 13 percent chance to move to an occupation with a median wage greater than $17.26 an hour in their first year, dropping to a 1 percent chance by their 10th year. Further research could inform the implications of this finding, and whether an intervention earlier during a worker's tenure in low-wage work can have a greater impact.

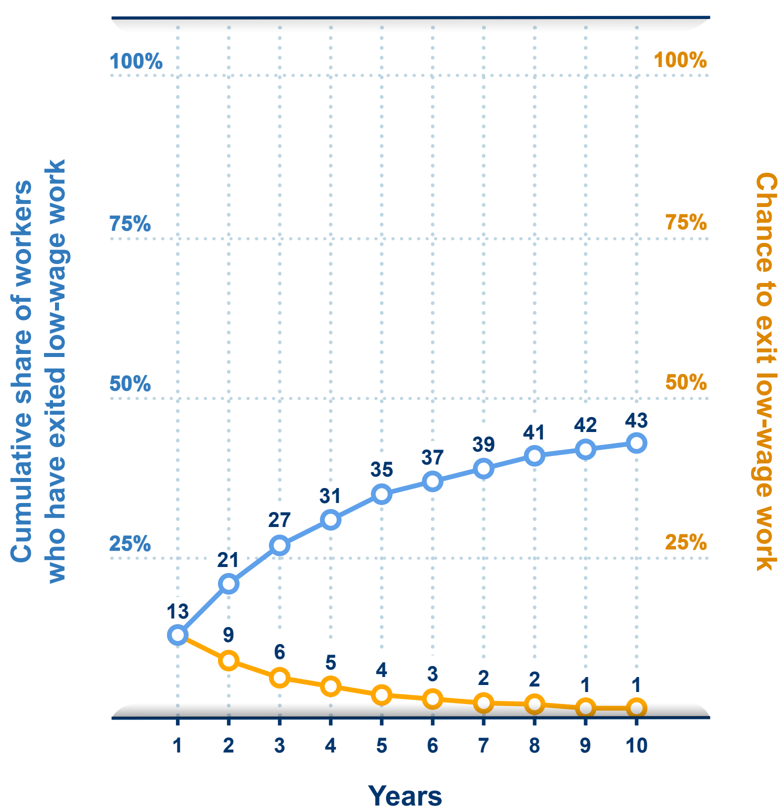
Race and gender mobility gaps

The low-wage workforce in the United States is disproportionately female, Black, and Hispanic, groups that also experience disproportionately low mobility. When transitioning between firms, women achieve roughly 62 percent of the wage growth experienced by their male counterparts.[19] Black workers—controlling for education, marital status, and skills—receive smaller earnings gains from work experience, and their overall earnings disparities widen in higher paying jobs.[20,21] Black and Hispanic women likely receive fewer and lower-paying job offers,[22] and they are also less likely to exit from a low-quality job.[23,24]

Using occupational transitions data, we see that female, Black, and Hispanic workers also face lower rates of upward mobility when they switch occupations. Men experience upward transitions about 54 percent of the time, compared with 46 percent for women. About 52 percent of white workers' transitions tend to be upward, compared with 44 percent for Black workers and 41 percent for Hispanic workers (**appendix table A1.2**). **Figure 1.2a** shows how gender intersects with race or ethnicity to compound mobility gaps. **Figure 1.2b** shows that these mobility gaps are only partly explained by workers' education levels, for the gaps persist even among highly educated workers. Still, all groups with bachelor's degrees do attain above average

FIGURE 1.1

A worker's chances of leaving low-wage work fall dramatically for each additional year on the job



Note: We draw a representative sample of workers' transitions from Burning Glass Technologies online resume data. Still, people who post resumes to job boards are likely to be more upwardly mobile than those who do not, so these figures likely understate the stickiness of low-wage work. See **appendix A1.2** for details. Specifically, this chart follows workers from 31 "low-wage ceiling" occupations, employing nearly 20 million workers, that pay at least 90 percent of workers within them less than $20 an hour.

Source: Authors' analysis of Burning Glass Technologies resume data.

mobility (shares of upward transitions greater than 50 percent).

Workers see less mobility in low-wage sectors

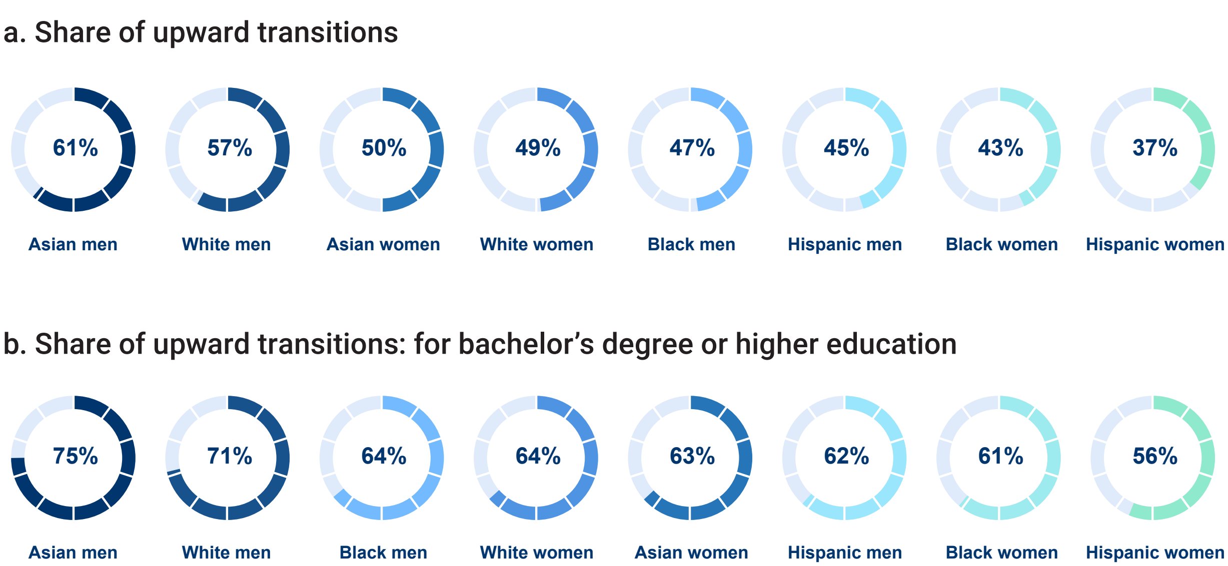
Sectors are segments of the economy that produce similar goods or deliver similar services. We use the North American Industry Classification System (NAICS), which divides the economy into 20 sectors comprising more specific industries.[25] We find that mobility gaps differ dramatically across sectors, implying that sector characteristics such as profit margins, talent composition, and degree of vertical integration play a role in worker mobility (**figures 1.3**, **1.4**, and **1.5**).

The sectors that offer the greatest rates of upward mobility tend to pay higher wages, including professional services, utilities, finance, management, and information. (The information sector contains industries that produce and disseminate copyrighted products.[26]) Given that our definition of upward mobility controls for the fact that high-wage sectors employ more workers in high-wage occupations than low-wage sectors, there are two sources for this association between sector wage and mobility:

- Workers in the same occupation tend to experience higher mobility when they are employed in a higher wage sector. For example, an administrative assistant in the finance sector is more likely to transition upward than one in the hospitality sector.
- Higher wage sectors tend to employ higher mobility occupations across the wage spectrum. For example, the hospitality sector may

FIGURE 1.2

Black and Hispanic workers see lower mobility than their white and Asian counterparts; these gaps hold for workers with a bachelor's degree, so they are not driven by racial or gender differences in educational attainment



Note: The groups of workers appear in descending order by their share of upward transitions.

Source: Authors' analysis of CPS-IPUMS data.

employ more workers in the housekeeping occupation, whereas the finance sector may employ more workers as telemarketers; both occupations pay similar wages, but the latter offers more upward mobility.

See **appendix A2.2** for an exposition of how these two sources drive the association between sector wage and mobility.

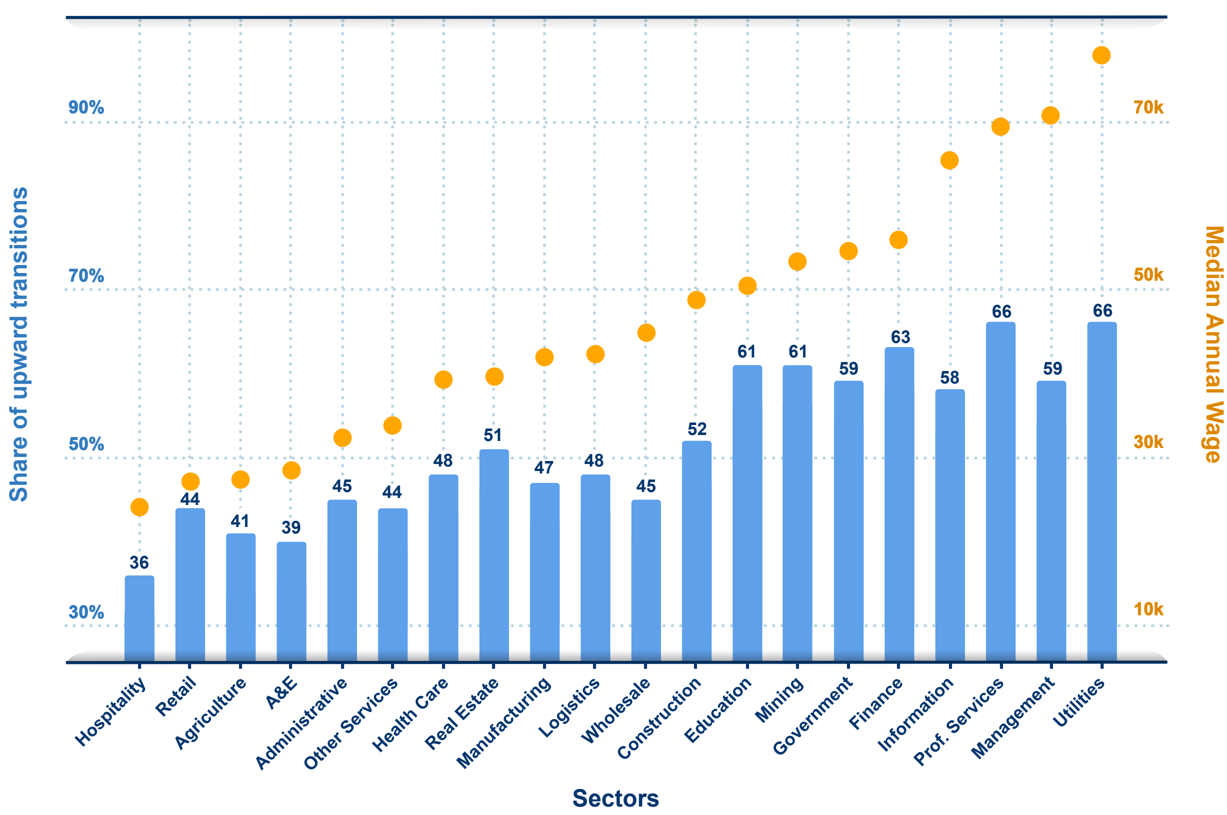
Race and gender mobility gaps differ by sector

Race- and gender-based mobility gaps also vary by sector. In manufacturing, the difference in the rate of upward mobility between Black and white workers is as high as 14 percentage points. In several other sectors, this gap is close to 10 percentage points: arts and entertainment, administrative services, logistics, and utilities (**figure 1.4**). Notably, in the education and government sectors, upward mobility of Black and white workers is somewhat similar, suggesting public employment may offer more equitable access to mobility. While this gap is even smaller in hospitality and retail, overall wage levels and mobility prospects in these sectors are low.

Hispanic workers also see lower upward mobility rates than their white counterparts in nearly every sector: mobility gaps between Hispanic and white

FIGURE 1.3

Workers see less mobility in lower wage sectors

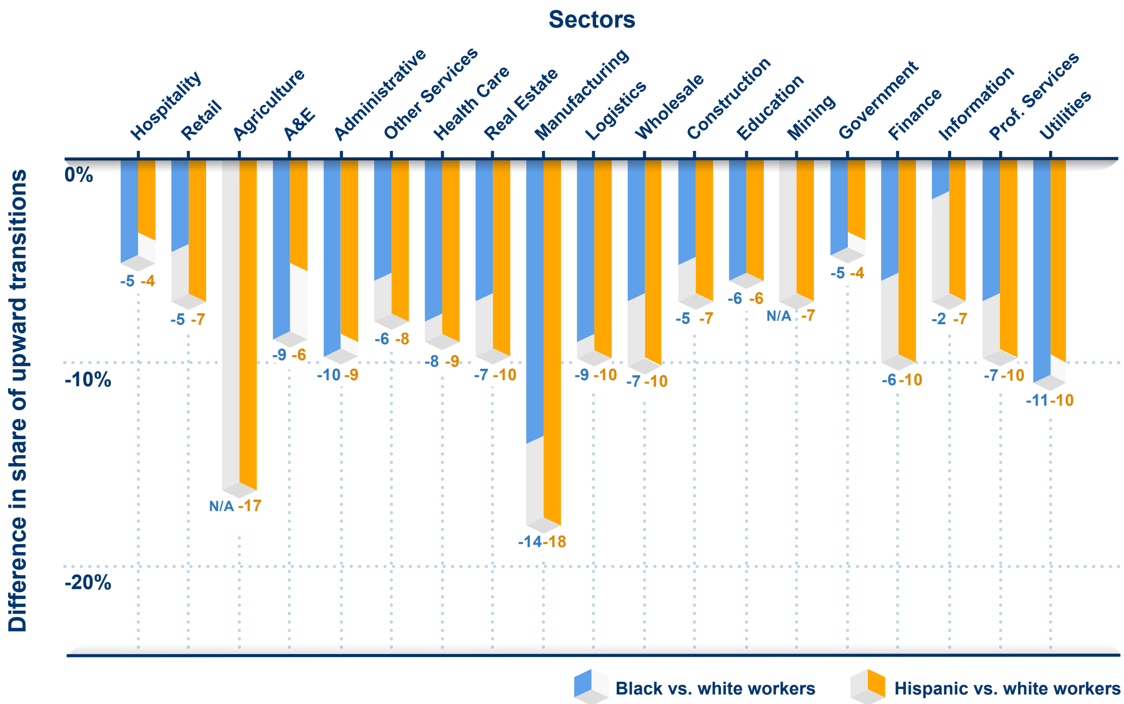


Note: For example, the share of upward transitions for workers in the hospitality sector is 36 percent. The hospitality sector employs workers in many different occupations. When a worker in the hospitality sector transitions, that transition is counted as upward based on the worker's starting wage, as described in **box 1.1**. The total number of upward transitions by workers in the hospitality sector is divided by the total number of all transitions by workers in the hospitality sector to give the share of upward transitions. A&E stands for arts and entertainment.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019 data.

FIGURE 1.4

Racial and ethnic mobility gaps vary by sector



Note: For "Black vs. white workers," "Black" denotes non-Hispanic Black, and "white" denotes non-Hispanic white. For "Hispanic vs. white workers," "Hispanic" denotes Hispanic of any race, "white" denotes non-Hispanic white. For example, Black workers in the hospitality sector switching occupations are 5 percentage points less likely to transition upward than a white worker in the same sector. The data provide too few observations of Black workers in the mining and agriculture sectors to estimate their upward transition rate. A&E stands for arts and entertainment.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019 data.

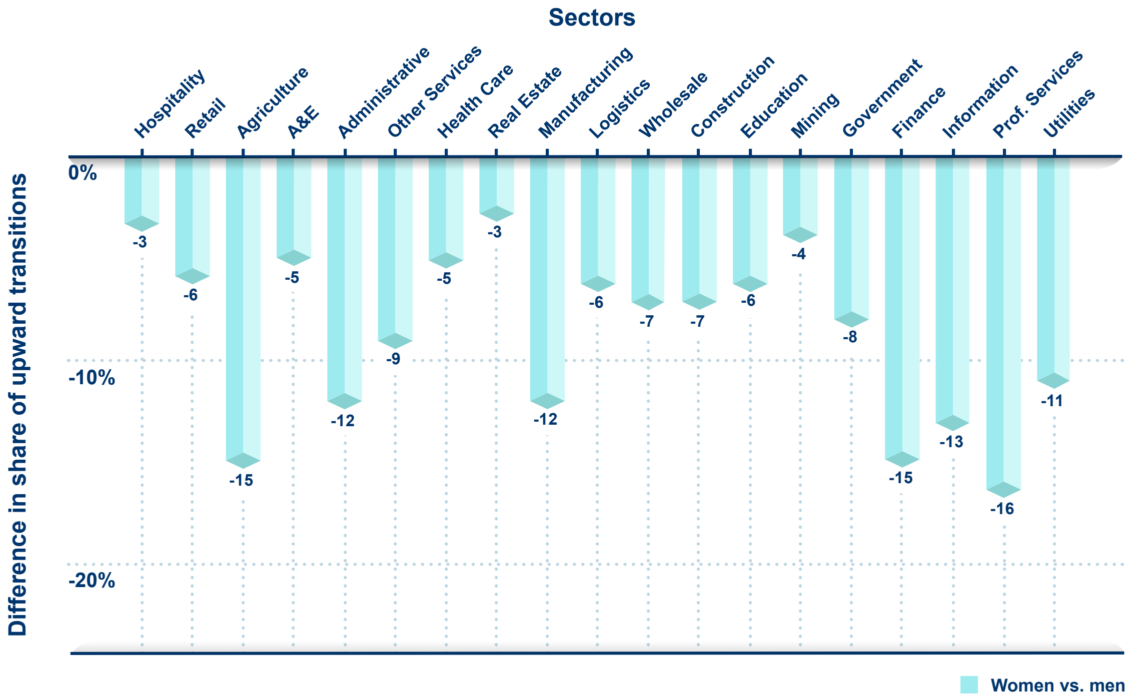
workers meet or exceed 10 percentage points in administrative services, manufacturing, and utilities. The education and government sectors again seem to be bright spots, where upward mobility rates for Hispanic workers are closer to those of white workers. Hispanic workers also have lower mobility disparities in the low-paid, low-mobility hospitality sector.

Similarly, women tend to face lower rates of upward mobility than men across all sectors. In high-wage sectors (as in information, professional services, and finance), middle-wage sectors (as in administrative services and manufacturing), and low-wage sectors (as in agriculture), women's upward mobility rates are more than 10 percentage points worse than their male counterparts (**figure 1.5**).

Clearly, workers face a complex array of mobility challenges, and some face a far steeper climb than others. Occupational transitions data offer a stark glimpse of mobility gaps in the U.S. economy, particularly for workers in low-wage occupations, and show how mobility is uneven across race, ethnic, and gender lines.

FIGURE 1.5

Gender mobility gaps vary by sector



Note: A&E stands for arts and entertainment.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019 data.

CHAPTER 2

The network approach: Identifying how and where workers get stuck to design more targeted solutions

Our network approach provides a granular and multidimensional view of worker trajectories, showing how and where workers get stuck and identifying the most common pathways out of low-wage, low-mobility work. This novel view of the labor market has three key features that can guide policy and business decisions: occupational adjacency, occupational clusters, and pathways to higher-wage work.

Better tools for the challenges ahead

Decades of globalization, digitalization, and automation have led to rapid employment growth in certain occupations (such as high-wage digital services) and to a gradual decline in others (such as middle-wage production jobs, which were more easily offshored or automated), resulting in large-scale occupational shifts and dislocations with far-reaching social and economic consequences. Not only were millions of mid-wage workers displaced, the pathways from low- to mid- to high-wage work were disrupted.[1]

Without bold efforts, these challenges will only grow in the coming years. But the current toolbox for helping workers adjust and adapt to evolving labor dynamics has clearly fallen short. It rests on two primary pillars, both having proved insufficient: first are programs for adult education, reskilling, and vocational training, and second are efforts to help vulnerable or displaced workers adjust to economic shocks, most prominently the Trade Adjustment Assistance (TAA) program.

The current labor education, reskilling, and vocational training architecture

It's easy to understand why education is often seen as the most useful tool to address flagging mobility, stagnant wages, and technological disruption. The value of bachelor's and advanced degrees has grown continuously since 1977,[2] and throughout the labor market and across the wage spectrum employers lament "skill shortages." The remedy seems simple: take the workers who are stuck or who have lost their jobs, teach them the skills of tomorrow, and fill the country's skills gaps.

But the evidence suggests that education and skilling do not, on their own, increase wages or improve mobility.[3] As far back as 1999, a meta-study found that government efforts to educate and train low-wage workers were on average only modestly effective.[4] More recently, another meta-study found that programs to retrain workers were more effective at increasing wages and leading to employment when they were supplemented with coaching and job placement support.[5]

Why are the returns to these types of education and skilling so low? Perhaps because an increasingly large majority of workers are overqualified for the jobs they hold.[6] Other factors restrict mobility. For example, social and professional networks powerfully mediate the value of formal skills, degrees, and credentials.[7] And as chapter 1 showed, racial and gender mobility gaps persist even among highly educated workers (**figure 1.2b**).

As these studies suggest, the challenge of low mobility is complex and driven by heterogeneous factors—including each worker's unique skills and talents, occupation-specific experiences, and pervasive mobility gaps that hold back some workers more than others. Moreover, the skills that employers demand are moving targets that fluctuate with the business cycle; "skill gaps" widen when it's harder for workers to find a job and employers can be more selective.[8] This insight isn't new. As Martin Luther King, Jr. said of the federal government's jobs policy in the late 1960s: "'Training' becomes a way of avoiding the issue of employment, for it does not ask the employer to change his policies and job structures."[9]

On its own, education is bound to fall short. To be more effective, the current architecture for adult education, reskilling, and vocational training needs to be much more tailored and responsive to the unique needs of workers, the nature of occupations and their linkages with other opportunities in the labor market, the dynamics of the local economy where people work, and the mobility pathways available to them.

Current efforts to help workers adjust

The second pillar of the toolbox also makes sense on first glance. When workers are affected by forces beyond their control, they can benefit from various forms of support—such as wage subsidies, assistance in the job search process, or financial support for micro-entrepreneurship.

However, the shortcomings of current efforts are well illustrated by the Trade Adjustment Assistance (TAA) program, the U.S. government's central policy response to mitigating the negative economic effects of trade and globalization. First authorized in 1962 and bolstered in 1974, TAA has enormous potential to support workers, firms, farmers, and communities adversely affected by increased imports. Eligible workers can receive training, a job search allowance, a relocation allowance, extended unemployment benefits, and a variety of other reemployment services.

Despite its potential, TAA fails to reach all workers who qualify for benefits. In its first 10 years, only half of all eligible workers participated in TAA programs, with participation rates as low as 30 percent in some states. Of TAA-eligible workers who didn't participate, 38 percent cited lack of information as a reason for not applying.[10] And beyond the trouble in reaching eligible workers, far too few workers benefit from the program due to overly narrow eligibility criteria that focus only on workers directly affected by international competition or outsourcing. This ignores the secondary effects of trade and globalization on local labor markets, such as downstream unemployment when local supply chains break down. And by not considering which occupations beneficiaries might transition into, TAA fails to foresee the potential negative impacts of its support through increased job competition on incumbent workers.

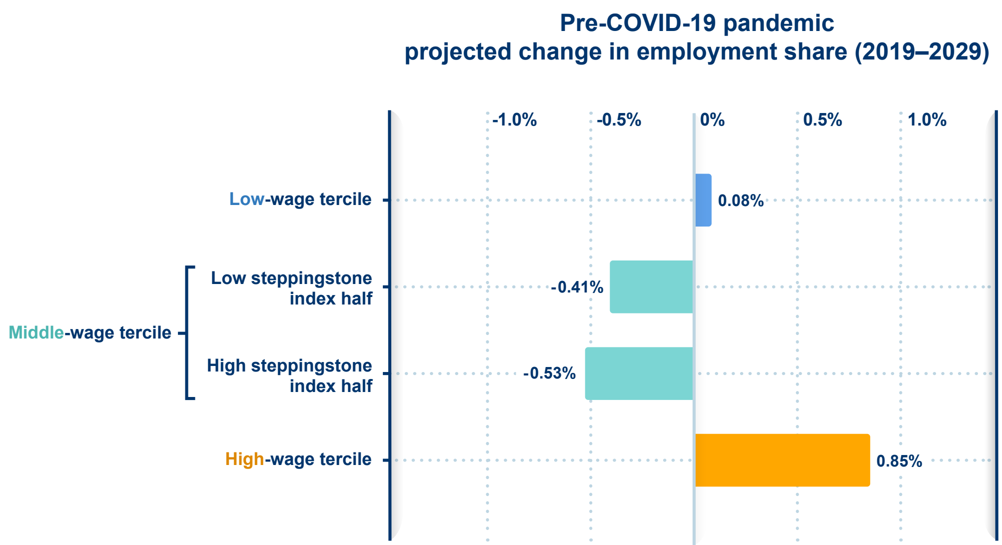
Perhaps most crucially, TAA and programs like it are not designed to consider or address a broader trend: the hollowing out of the labor market, a consequence of labor market polarization in recent decades and the subject of a growing body of empirical work. Driven by increased globalization—in particular the accession of China to the World Trade Organization in 2001—along with recent technological advances such as automation, artificial intelligence, and machine learning, polarization has had a side effect that is far less researched but critical to low mobility: the gradual erosion of mid-wage jobs, especially those traditionally serving as "steppingstones" from low-wage to high-wage occupations. TAA's narrow focus on trade overlooks this broader tearing of the labor market's overall structure, which increasingly affects workers across the wage and occupational spectrum. As these processes persist, more and more mid-wage occupations that previously served as steppingstones to higher-wage work are employing a declining share of the workforce. According to BLS projections, steppingstone occupations are expected to lose significant ground in the coming decade (**figure 2.1**). See **appendix A6** for a complete description of steppingstone occupations.

National and local policymakers are currently under-equipped to help workers and firms navigate these complex challenges. When occupations are disrupted by trade, it makes sense to help workers who lost their jobs get back on their feet. By extension, when steppingstones to higher wages are disrupted, new scaffolding is needed to preserve workers' upward mobility. To adapt TAA and similar programs to this context requires a broader understanding of labor market disruption, particularly the role that affected occupations play in workers' upward mobility. Only then can programs properly target unemployed workers based on their previous experiences and their compatible, adjacent occupations, while also supporting employment in occupations likely to absorb unemployed workers or facilitate workers' mobility.

Here we introduce a novel approach for analyzing and supporting worker mobility: a network view of the U.S. labor market, built on real workers' occupational transitions. Using the network approach, policymakers can identify and support pathways from low-wage, low-quality occupations vulnerable to technological disruption or trade shocks to jobs with livable wages, stability, and real career opportunities.

FIGURE 2.1

The decline of mid-wage work disrupts opportunities for advancement



Note: The middle-wage tercile is divided into two equal size buckets of workers, each accounting for 16.5 percent of jobs in 2019. The high steppingstone index half of the middle-wage tercile includes occupations that bridge low-wage and high-wage jobs more frequently than the rest, as observed in our analysis of workers' resumes.

Source: Authors' analysis of BLS employment projections 2019–29, OEWS 2019, and Burning Glass Technologies resume data.

Visualizing mobility and its challenges

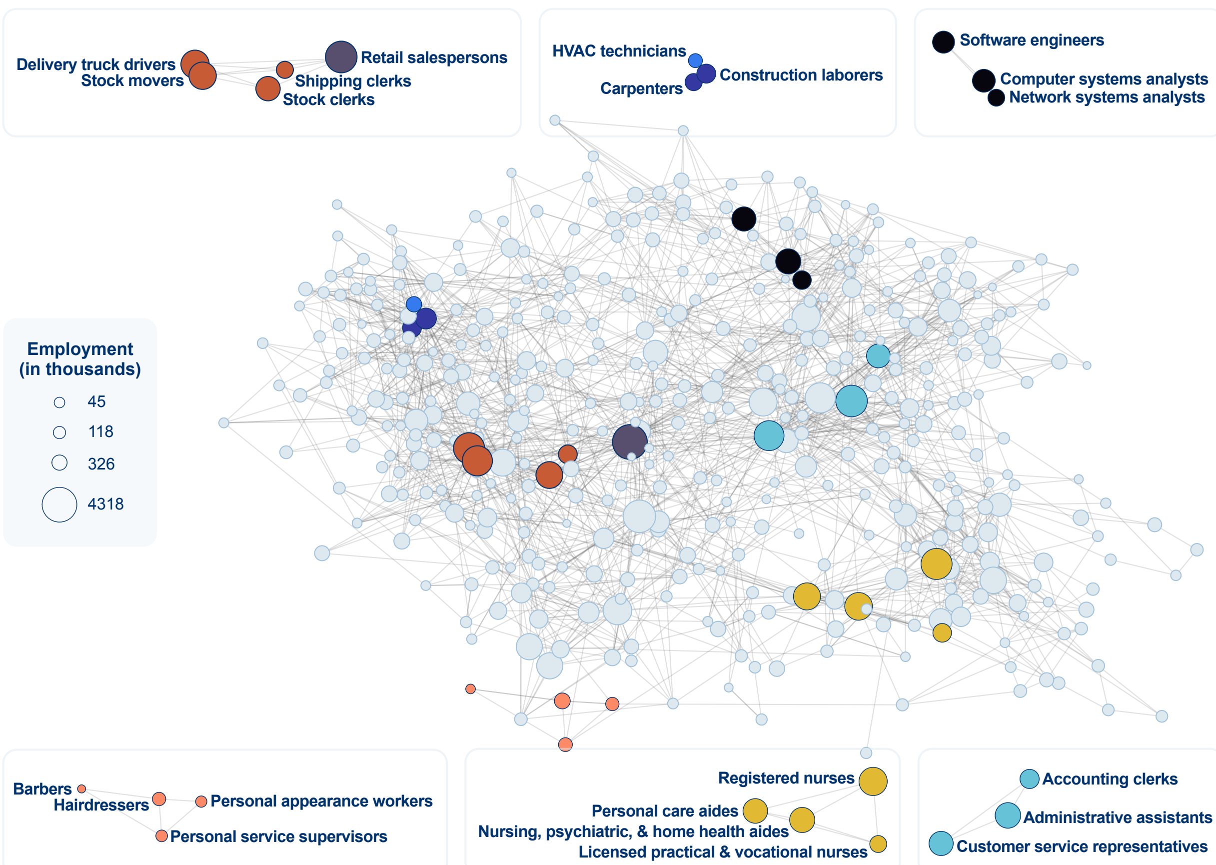
A high-definition view of how workers move

The granularity of occupational transition data—with thousands of new CPS data points each month—makes it possible to visualize the complex mix of factors that determine how workers move. When viewed in aggregate, the data form a dynamic, intricate network of real worker transitions through the labor market—with each node as an occupation, connected by transitions between them.

Our network model's structure is determined by how frequently workers move between occupations: the closer that two occupations are in the network, the more frequently workers move between them (**figure 2.2**). High-density sections reflect high volumes of "traffic" between well-connected occupations, indicating that workers' skills and talents are readily transferable. More remote, lower density sections reflect occupations from which workers have fewer—or harder to reach—opportunities. In the center of the network, where cross-network transitions occur, occupations are bridges between more distant sections of the labor

FIGURE 2.2

Within the network, occupations are closer to one another when workers move frequently between them



Note: Each circle in the figure is an occupation, with size proportional to 2019 employment and the distance between them determined by how frequently workers transition. The colors refer to occupational clusters, which the next chapter explores further.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019 data.

market. (See **boxes 1.1** and **2.1** for more on the methodology.)

A network view of the labor market reflects how and where workers actually move, while also offering hints about why. Unsurprisingly, occupations that require similar skillsets are close to each other in the network, since workers who change occupations are most likely to find work similar to the occupation they are leaving. As a result, the strength of connections between occupations—their proximity in the network, based on the frequency of transitions between them—implicitly captures their overlapping skills, tasks, and duties.[11,12,13] Similar occupations that see a large number of frequent transitions between them are spatially associated throughout the network in denser sections that we call clusters, the subject of chapter 3. By mapping real worker movements, the network implicitly captures the complex set of factors that drive transitions—worker preferences, available jobs, licensing requirements, and the many intangible, hard-to-measure factors that help or hinder mobility (**figure 2.3**).

Visualizing the low-wage, low-mobility trap

By visualizing how workers move, our network model also illustrates where and how some workers are getting stuck. A number of patterns emerge—none more striking than the concentration of low-wage occupations (**figure 2.4**). This reflects the churn that many workers in low-wage occupations experience moving from one low-wage occupation

BOX 2.1

The labor market as a network of occupational transitions reflects how workers move

Modeling the labor market as a network using highly granular transition data complements the existing mobility literature by addressing two limitations. First, we sought to preserve as much specificity as possible, incorporating into our analysis all worker transitions between all 428 occupations from the CPS data. Much existing research, by contrast, classifies occupations into broad categories (such as routine and non-routine; high, mid, and low skill; wage quantiles; or 23 major occupational groups). These traditional approaches trade occupational granularity for a focus on more historical data or individual wage data.

Second, we sought to focus on transitions. While other research also constructs network models using detailed occupation data, it typically classifies occupations based on skill taxonomies, such as O*NET, designed by experts.[1,2] These taxonomies distinguish how different occupations require similar skills, knowledge, and competencies, and are often used effectively to inform or design curricula for training and reskilling programs. While useful for many purposes, this approach has limitations for understanding how workers move from one occupation to the next. Consider nurses and doctors who require many of the same skills but rarely transition between the two occupations.

Other researchers—recognizing the challenge of precisely identifying and measuring diverse skills, knowledge, and competencies—have turned to big data methods that group occupations based on the job requirement categories used in online jobs postings. While these data-driven approaches may be more effective at identifying skills, they encounter the same limitations for understanding how workers move.

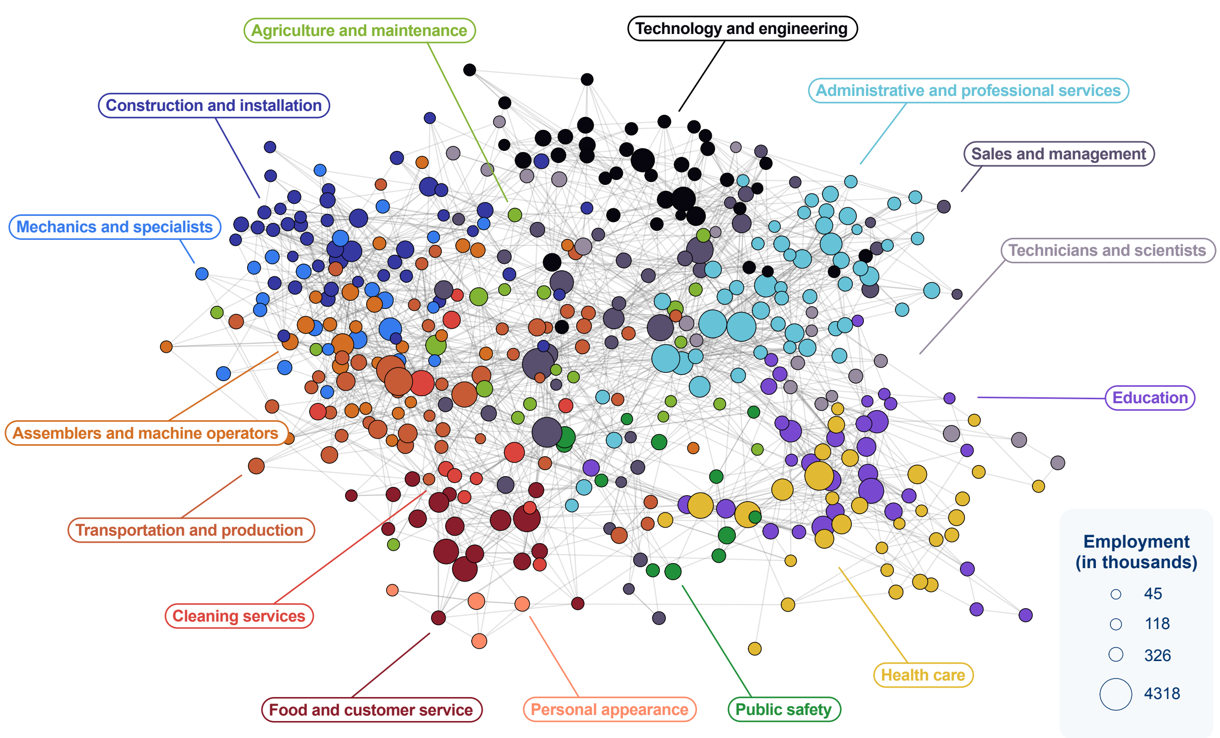
Our network approach models occupational similarity based on real worker movements, using high-frequency CPS transition data (**box 1.1**). Each node in the network is an occupation, and each connection between two nodes reflects actual occupation-to-occupation transitions. The strength of a connection is determined by the frequency of transitions back and forth between any two occupations (**box 3.1**). The model contains 17,000 such pairs of connected occupations. For a bird's-eye view of the network, **figure 2.3** illustrates the most important sections of its structure, including 15 distinct "clusters" of occupations characterized by a large number of frequent transitions between them. While **figure 2.3** shows just 15 percent of the network's total connections, it covers 60 percent of the workers in our sample—reflecting the labor market's most common occupational transitions.

to the next, each with low barriers to entry but few offering pathways to higher-wage work. Just as dishwashers face wage ceilings within their occupation, most workers in low-wage occupations face a broader ceiling blocking their progress out of low-wage work. The low-wage section of the network is like a sandpit, enclosed by steep walls and exhausting to escape, with few insecure pathways to higher-wage, higher-mobility work. In the metaphor from the introduction, the network is a small city where each worker's mobility prospects are determined by the building they work in. Some workers are lucky to have high-wage, high-mobility jobs in skyscrapers on hilltops with escalators and elevators, but many workers spend their careers in squat, low-slung buildings in a valley, with fragile staircases and few exit doors.

Because the network implicitly captures the complex set of factors that drive transitions, the network visualization highlights several other interesting patterns. Its shape can reveal workers' aggregated preferences as well as cultural norms and hiring biases. For instance, male-dominated occupations (such as those in production) are concentrated in the upper left, while caregiving occupations (such as home health aides) in the bottom right of the network are dominated by women (**figure 2.3** and **appendix A3**). Such occupational segregation may pose challenges

FIGURE 2.3

Occupations with frequent transitions between them are spatially in denser sections, which we call clusters

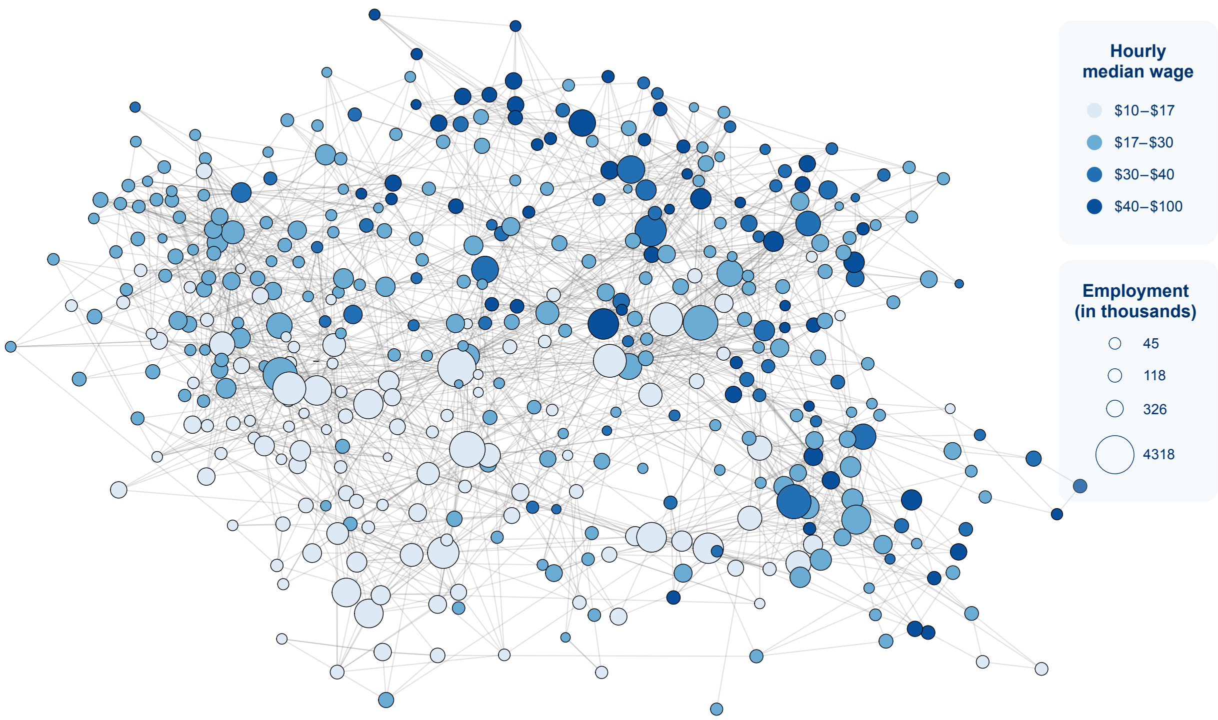


Note: Each circle in the figure is an occupation with size proportional to 2019 employment, and the distance between them is determined by how frequently workers transition. The colors refer to occupational clusters, which the next chapter explores further, including their role in understanding mobility.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019 data.

FIGURE 2.4

Most low-wage occupations are clustered with each other in our network model of the labor market



Note: Each circle in the figure is an occupation with size proportional to 2019 employment, and the distance between them is determined by how frequently workers transition.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019 data.

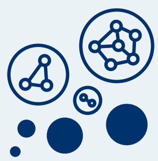
in the coming years, as labor demand declines for production jobs but increases for caregiving work.[14] Occupations that can be performed easily from home are also concentrated in the network, underscoring the divergence of experience during the pandemic between "remotable" workers who continued working in the relative safety of self-isolation while non-remotable, customer-facing workers had to make daily choices between health risks and financial security. (For additional analysis of the patterns that emerge from the network model, see **appendix A3**.)

Using the network approach to unlock targeted, actionable solutions

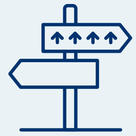
The network has key features that provide actionable insights on mobility: adjacency, clusters, and pathways.

Adjacency: Visualizing which occupations are "nearby" one another (implying frequent transitions and shared skill requirements) helps target policies and programs for supporting worker transitions and mobility, such as retraining and reemployment services. The network can help policymakers and program administrators meet workers where they are, better answering the question: "What's available to workers like me?"

At the regional level, economic planners seeking to attract new industries can use the network approach to identify what occupations those industries will require and whether their geographical region has "nearby" occupations with workers who could be easily trained to make the transition. This proactive approach to building talent could help attract new industries and improve earnings and career prospects for residents, boosting mobility for each distinct region. Former manufacturing cities and towns charting a course toward economic renewal, for example, can use the network approach to explore which industries have the most viable transition potential for their local workforce—such as linkages between steelwork and advanced production work, or between car manufacturing and construction or engineering. For regions transitioning away from extractive industries, the network approach can guide investment in talent to support green economies.



Clusters: Analyzing occupational transitions can also reveal sections of the network where workers move most frequently. In the next chapter, we use a community detection algorithm to identify 15 distinct occupational "clusters" in which workers move frequently but rarely leave. Drilling down to the cluster allows us to see which sections of the labor market have the greatest mobility challenges: where workers are getting stuck, where they are most vulnerable to future disruption, or where the chances for upward mobility are greatest. Firms can use cluster analysis at the city, state, and regional level to better understand the workforce and talent available in local labor markets, to help build more targeted recruitment pipelines. Clusters can inform where to recruit for apprenticeships, help firms target local workers in "nearby" occupations, and work with local community colleges on curricula that facilitate specific transitions. In our city metaphor, each cluster is a building—while there are a few skyscrapers on the hilltops, many workers are stuck in buildings in the valley that have only one or two floors, and few connections to taller buildings.



Pathways: The network approach and cluster analysis can help pinpoint the most promising trajectories from low-wage to high-wage work. Chapter 5 explores the pathways within and between clusters and identifies which occupations serve as skyways from low-wage, low-mobility work to more promising career opportunities. In our small city metaphor, the taller buildings' stairs, elevators, and escalators make it relatively easy for workers to move from the bottom to higher-up floors. Skyways offer workers in sandpit clusters the opportunity to change buildings, escaping a squat building in the valley for a taller one on a hillside. Many pathways are narrow and marked by gender and racial barriers. But this type of analysis can help policymakers, workforce programs, firms, and even workers channel their energies to address mobility gaps, widen opportunities, and build new paths where they are needed most.

In chapters 3, 4, and 5, we use network analysis and the features above to explore the complex challenge of low mobility, and how to bolster workers navigating the U.S. labor market. This approach provides a new perspective on a well-documented economic reality—a labor market segmented by wage, job quality, and education, as well as by gender and race. It also offers a novel method for understanding and addressing pervasive low mobility. By seeing today's labor market as a network riddled with mobility gaps, we can envision a better network and strive to shape it, through ensuring that all workers can find their pathways to living wages, job stability, and a fair shot at success.

CHAPTER 3

Workers' mobility prospects are shaped by occupational clusters

With a network view of mobility, many patterns emerge. In some network sections, workers transition from one high-wage job to the next, enjoying strong prospects for upward mobility. In most of them, however, workers face a more difficult journey. Indeed, millions of workers spend their careers stuck in the low-wage, low-mobility sections of the network—trapped in occupations marked by low pay, poor job quality, and few benefits.

Workers frequently move within clusters but rarely leave them

Measuring the strength of connections between occupations in the network reveals 15 distinct clusters, with stark differences in wages and mobility

Our model of the labor market, built on data from real worker transitions, shows that workers move through the economy in well-defined patterns. Using a community detection algorithm that searches the network for groups of more tightly connected occupation nodes, we identify 15 distinct clusters. Some clusters map onto specific sectors of the economy (such as education or health care) and others include fairly narrow types of jobs (personal appearance). But the majority comprise a broad and diverse group of occupations that nonetheless are tightly connected. Since network density is determined by the frequency of transitions between occupations, clusters implicitly reflect the complex set of difficult-to-measure factors that shape mobility, such as skill sets, worker preferences, and market dynamics. They are also a useful unit of analysis, since they do a better job at modeling how real workers actually move through the economy than other leading classifications, such as BLS occupational groups (**box 3.1**).

In previous chapters, we saw how certain workers face hurdles to upward mobility and how the network's structure reflects our polarized labor market. This chapter focuses on the power of clusters to explain how workers move. While a few clusters offer higher wages and plentiful opportunities for upward mobility, several low-wage clusters resemble mobility sandpits that are difficult to escape. Since workers move frequently within clusters but rarely leave them, a worker's career trajectory is in many ways shaped by the cluster they find themselves employed in.

The clusters differ starkly in demographics, size, and types of occupations they contain. Most strikingly, they differ by wage level and mobility prospects. For analytical clarity, the 15 clusters can be organized in four main categories: high-wage and high-mobility; average-wage and average-mobility; health care, which we treat as its own category given its size and wage/mobility diversity; and low-wage and low-mobility, which we call "sandpit" clusters (**figure 3.1**). A list of the largest occupations in each cluster can be found in **appendix table A9.1**. The accompanying online data file gives cluster membership and other statistics for every occupation.

BOX 3.1

Clusters reflect actual worker transitions better than other classification schemes, such as occupational groups

We identify clusters of occupations based on the adjacencies of occupations in the network. To do so, we use a Louvain community detection algorithm over a nondirected version of the network, filtered to ensure that its structure retains the most important connections.[1] We start by defining each edge value (the strength of a connection between two nodes) as the average of two values: the share of transitions starting from occupation *a* that land in occupation *b* and the share of transitions starting from *b* that land in *a*. By using shares rather than counts, we weight edges by their importance for each occupation, regardless of their volume in relation to all labor market transitions. By taking the average of the two values, we assign a higher importance to pairs of occupations where workers move back and forth.

The algorithm then assigns each occupation into separate communities and proceeds to combine them iteratively across different groupings.[2] After each round, the algorithm keeps only the reassignments that increase the overall modularity score, a value ranging from –1 to 1 to assess the quality of different groupings of a network. A higher quality grouping will receive a positive value, indicating a strong community structure (more connections within groups than across groups), whereas negative values reflect a lower quality grouping. The algorithm repeats these rounds until no modularity increases can be achieved.[3]

The result is a network with 15 clusters that yields a modularity score of 0.39—which represents a substantial modularity improvement over the scores obtained from other leading approaches to occupational grouping, such as wage quintiles or the Standard Occupational Classification (SOC) major groups (**table B1**).[4] By comparison, randomly assigned clusters would yield a modularity score of zero.

An average occupation sends 3.1 percent of its transitions to other occupations in the same cluster, almost four times larger than the fraction of transitions sent to occupations in other clusters (0.8 percent), exemplifying how within-cluster connections are more common than across-cluster ones.

TABLE B1

Comparison of the mobility clusters approach to alternative occupational groupings

STRENGTH OF INTRAGROUP LINKS RELATIVE TO A NULL MODEL				
Type of occupational grouping	**Number of groups**	**Modularity score**	**Average share of transitions within clusters**	**Average share of transitions between clusters**
Mobility clusters	15	0.39	3.1%	0.8%
SOC major groups	22	0.30	2.9%	0.9%
Wage quintiles	5	0.13	1.6%	1.2%
Randomly assigned clusters	15	0.00	1.2%	1.2%

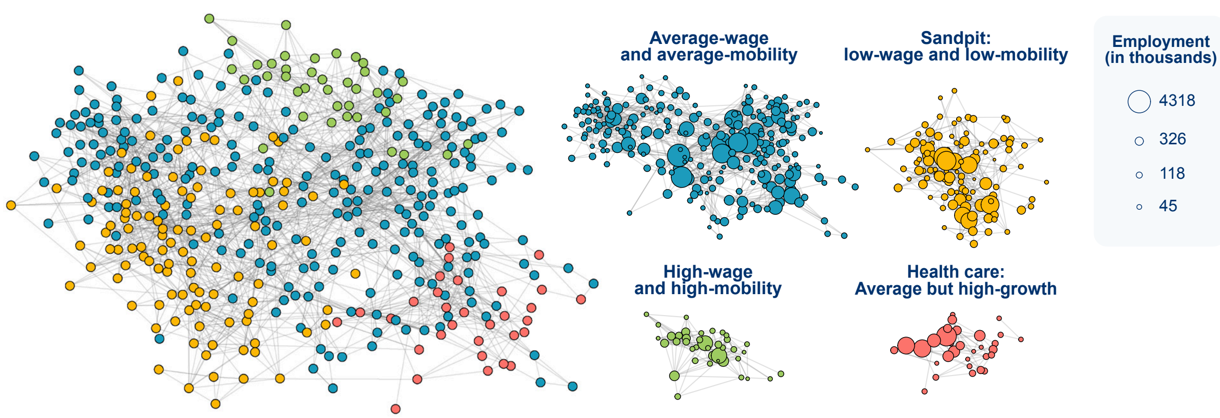
Note: Modularity scores range from –1 to 1. The score is positive when nodes belonging to the same group tend to connect to each other in the network, and negative when they tend to avoid each other. The average share of transitions within a cluster is the average value of every transition share across all connections involving occupations of the same cluster.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019 data.

FIGURE 3.1

Four types of occupational clusters fall into distinct sections of the occupational network

Network regions	Number of workers	Share of U.S. employment	Projected growth (2019-2029)	Median hourly wage	Share of upward transitions	Share of internal upward transitions
High-wage and high-mobility	8.5m	6.0%	8.5%	$43	70.6%	50.7%
Average-wage and average-mobility	81.4m	57.3%	2.2%	$22	51.5%	42.3%
Health care	14.6m	10.3%	12.0%	$23	43.4%	25.2%
Sandpit (low-wage and low-mobility)	37.5m	26.4%	2.2%	$15	38.1%	14.7%



Source: Authors' analysis of CPS-IPUMS, BLS employment projections for 2019–29, and OEWS 2019.

High-wage, high-mobility clusters

Notably, the algorithm detects only one high-wage, high-mobility occupational cluster: technology and engineering, comprising 39 occupations with about 8.5 million workers (6.0 percent of the U.S. workforce) and a median wage of $43 an hour. The cluster is disproportionately male, has the highest share of workers with a bachelor's degree, and has the lowest share of Hispanic and Black workers. Workers in this cluster enjoy the network's largest mobility prospects: 70 percent of their transitions are upward, the majority of which occur within the cluster.

Average-wage, average-mobility clusters

Eight average-wage, average-mobility clusters straddle the network's left and right sides, comprising 245 occupations with about 81 million workers and a median wage of $22 an hour. The category's share of upward transitions is 51 percent, but this reflects a fair degree of heterogeneity among the eight clusters. Three contain manually intensive, disproportionately male occupations that pay relatively lower wages: construction and installation, mechanics and specialists, and public safety. The category also contains a fourth cluster—technicians and scientists cluster—which is also somewhat disproportionately male, but it offers higher wages and its workers are typically better educated. The other clusters in this category—sales and management, administrative and professional services, agriculture and maintenance, and education—are larger, with slightly higher wage ceilings and high proportions of white, female, and college-educated workers. In all, this category represents 57 percent of the U.S. workforce and 44 percent of employment in low-wage occupations.

Health care cluster

Large and distinct enough to constitute its own category, the health care cluster occupies the lower-right of the network, comprising 32 health care occupations with about 8.4 million workers and a share of upward transitions of 43 percent. While the cluster's median wage is only $17.60 an hour, it stands out for high wage variation across the full spectrum of low-, mid-, and high-wage jobs, with a bottom quartile earning less than $13 an hour and a top quartile earning more than $34 an hour. Health care occupations are also growing; according to BLS projections, the cluster is expected to add more than 2.4 million jobs during the next decade.

Although slightly more than half of health care employees work in low-wage occupations, the cluster offers pathways to higher-wage work within it—a feature not seen in any of the low-wage, low-mobility clusters. This suggests that low-wage health care workers can realistically move up without having to make cross-cluster transitions. In practice, however, these mobility pathways are modest and marked by race-related demographic barriers. Thus, health care's projected growth in the coming decade represents an important opportunity to widen the cluster's existing mobility pathways and make them more equitable and accessible than they have been historically. Chapter 5 provides deeper analysis of mobility within health care, along with targeted suggestions for how policymakers and health care companies can increase worker mobility within the cluster.

"Sandpit" clusters: Low-wage and low-mobility

Five low-wage, low-mobility clusters occupy the lower-left of the network, comprising 111 occupations with about 37.6 million workers and a median wage of $15 an hour. With a share of upward transitions of 38 percent—the network's worst mobility prospects—this category offers few pathways to higher-wage work. For many workers within them, these clusters represent career sandpits that make it hard to escape low-wage work. Within this category, the lowest-paying, lowest-mobility clusters are food and customer service, personal appearance, and cleaning services. The others—transportation and production, and assemblers and machine operators—offer higher wages and mobility, comprising mostly manually-intensive occupations that disproportionately employ men without bachelor's degrees.

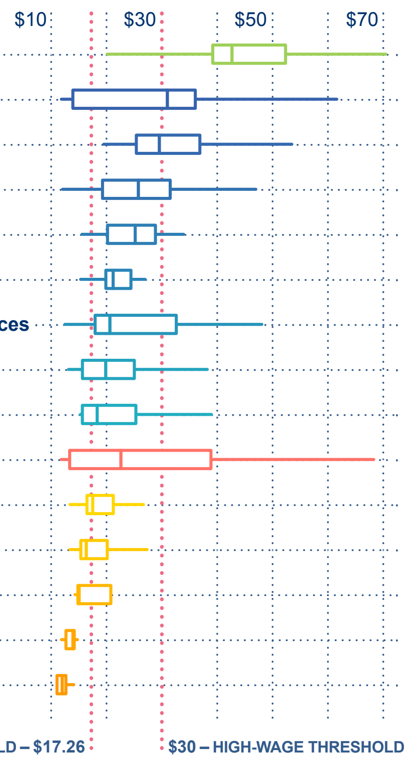
Not all workers employed in these clusters are destined to a lifetime of low-wage work: at any given time, for example, the food services cluster employs many high-school and college students working part-time or seasonally while getting their education. These workers are at the start of their careers and will most likely move up—but their upward mobility will likely occur in a new cluster as the result of their formal education, rather than due to any organic mobility opportunities within food services. But many employees are stuck in sandpit clusters at the middle of their careers—in food services, nearly 40 percent of the workforce (about 4.7 million workers) are over the age of 30. The share of older workers is even higher in the other four sandpit clusters, suggesting that a large number of workers in these clusters may indeed be destined to a lifetime of low-wage work. More than half of cleaning service workers, for example—about 2.4 million workers—are over the age of 45.

Friction within and between clusters reflects low mobility

In general, but not as an artifact of our methods, lower-wage clusters have lower total shares of upward transitions (**figure 3.2**). Not all low-wage occupations are alike, however, and a worker's starting cluster partially shapes their mobility prospects. Despite containing half of all low-wage occupations, for example, the five sandpit clusters account for only 20 percent of the high-mobility low-wage occupations (low-wage occupations with upward transitions accounting for at least 50 percent of total transitions). This underscores how many workers today find themselves locked into

FIGURE 3.2

a. Cluster wage dispersion and internal and overall mobility



Clusters	Median wage	Number of workers	Projected growth	Share of upward transitions	Share of internal upward transitions
Technology and engineering	$43	8.5m	8.5%	71%	50.7%
Sales and management	$31	22.2m	1.7%	49%	18.9%
Technicians and scientists	$29	2.5m	3.4%	59%	23.8%
Education	$26	14.5m	6.6%	54%	33.8%
Construction and installation	$25	7.0m	4.9%	50%	32.3%
Mechanics and specialists	$21	4.7m	3.4%	46%	20.1%
Administrative and professional services	$21	24.6m	-0.9%	53%	29.4%
Agriculture and maintenance	$19	3.1m	1.0%	50%	8.1%
Public safety	$16	3.0m	2.4%	53%	21.9%
Health care	$23	14.6m	12.0%	43%	25.2%
Assemblers and machine operators	$18	4.3m	-6.3%	39%	9.6%
Transportation and production	$16	15.8m	1.3%	40%	11.0%
Personal appearance	$15	0.8m	5.2%	38%	6.6%
Cleaning services	$14	4.7m	3.5%	40%	3.1%
Food and customer service	$12	11.9m	5.8%	34%	14.1%

Note: Upward occupational transitions within a cluster are internal upward transitions.

Source: Authors' analysis of CPS-IPUMS, BLS employment projections 2019–29, and OEWS 2019.

FIGURE 3.2 CON'T

b. Description of cluster occupations

Clusters	Description
Technology and engineering	Technology and engineering is a high-wage, high-mobility cluster including software engineers, computer analysts, and other tech, engineering, media, and IT workers.
Sales and management	Sales and management is an average-wage, average-mobility cluster including retail and wholesale sales representatives, cashiers, business analysts and general managers.
Technicians and scientists	Technicians and scientists is an average-wage, average-mobility cluster including engineering technicians, dental hygienists and assistants, telecom equipment repairiers, and various scientists.
Education	Education is an average-wage, average-mobility cluster, including teachers, teaching assistants, social workers, and counselors.
Construction and installation	Construction and Installation is an average-wage, average-mobility cluster, including construction laborers, carpenters, electricians, and related occupations.
Mechanics and specialists	Mechanics and specialists is an average-wage, average-mobility cluster including vehicle, heavy equipment, and industrial machinery mechanics as well as other technicians, repairers, and specialists.
Administrative and professional services	Administrative and professional services is an average-wage, average-mobility cluster including occupations like administrative assistants, customer service representatives, and office clerks, as well as professional services like lawyers, tax preparers and accountants.
Agriculture and maintenance	Agriculture and maintenance is an average-wage, average-mobility cluster including farmers, groundskeepers, and other production, inspection, science, and compliance workers.
Public safety	Public safety is an average-wage, average-mobility cluster including security guards, correctional officers, firefighters, law enforcement, and other emergency and public safetfy workers.
Health care	Health care is an average-wage, high-growth cluster including doctors, nurses, personal care and home health aides, as well as health support technicians and lab workers.
Assemblers and machine operators	Assemblers and machine operators is a low-wage, low-mobility cluster including general assemblers, machine fabricators and operators, model and patternmakers, and computer control operators.
Transportation and production	Transportation and production is a low-wage, low-mobility cluster including stock movers & clerks, delivery & industrial truck drivers, and railroad workers.
Personal appearance	Personal appearance is a low-wage, low-mobility cluster including hairdressers, personal appearance workers, and barbers.
Cleaning services	Cleaning services is a low-wage, low-mobility cluster including house, building, and equipment cleaners as well as laundry workers, parking lot attendants, and janitorial supervisors.
Food and customer service	Food and customer cervice is a low-wage, low-mobility cluster including waiters and waitresses, other food-service workers, bartenders, dishwashers, and hospitality workers.

Source: Authors' analysis of CPS-IPUMS, BLS employment projections 2019–29, and OEWS 2019.

careers cycling through one low-wage job after another.

Most upward transitions from sandpit clusters involve workers moving to a new cluster: for example, more than 9 of every 10 upward transitions by workers in cleaning services end up in a different cluster. This is the case despite the fact that within-cluster transitions are by definition more feasible and easier to achieve than cross-cluster transitions.

In an ideal labor market, a worker's ability to increase their earnings by transitioning to a related occupation would not be so constrained by their starting point. More clusters would contain a broad range of low-, mid-, and high-wage occupations with feasible pathways between them. Our network model shows that most low-wage occupations are not positioned along well-defined pathways toward higher-wage work—reflecting the realities of today's economy, where low-wage occupations rarely serve as the starting points of ascendant careers.

In our metaphor of a small city, where workers' mobility prospects are determined by where they start, clusters are the buildings. The high-wage, high-mobility cluster—technology and engineering—is the tallest skyscraper on the city's highest hill, where even the lowest floors are higher up than most other buildings, and the top floors tower over the rest of the city. Sandpit clusters, meanwhile, are squat, two- or three-story buildings at the bottom of a valley, where even the highest-paying jobs are low-income. The rest of the buildings are somewhere in between, with varying heights and elevations.

Each cluster's mobility dynamics are the buildings' internal infrastructure, which determine whether, how far, and how fast workers can move up. High-mobility clusters are buildings with escalators and elevators, which allow workers to move up to higher floors with relative ease. Low-mobility clusters, by contrast, are older buildings where the staircases have fragile steps and shaky handrails—the higher floors are harder to reach, and even if workers make it to the top of their building, they may still find themselves at the bottom of a valley.

The next chapter takes a closer look at sandpit clusters to explore how cluster dynamics can shape a worker's chances (or lack thereof) to move up in their career.

CHAPTER 4

Workers trapped in low-wage, low-mobility sandpits need the most support

The network's five low-wage, low-mobility clusters are career sandpits for many workers. With few trajectories toward higher-wage jobs, these workers need more support. At a minimum, they need better wages and financial stability. To advance, however, they need better pathways to upward mobility.

Sandpit clusters are more vulnerable to disruption from automation, digitalization, and shocks like the Covid-19 pandemic

Globalization, digitalization, and automation have led to labor dislocation and lower mobility for millions of American workers in recent decades, disrupting occupational pathways from low-wage to high-wage work. These forces are expected to continue: during the next decade, the BLS projects that 111 occupations (comprising 22 percent of the U.S. workforce) could experience job losses—and in some clusters, the potential long-term economic impacts from the Covid-19 pandemic will exacerbate and accelerate these changes (**figure 4.1**). Although it's natural for certain occupations to grow or recede as economies evolve and innovate, the coming years may force millions of workers to adjust to large-scale disruptions across the labor market. When groups of adjacent occupations are disrupted, employees may be forced to compete for a smaller number of jobs, putting downward pressure on wages, job quality, and employee benefits while threatening local economic stability where these occupations are prevalent.

Specifically, several clusters—like assemblers and machine operators or administrative and professional services—may face net employment contractions in the coming decade (**figure 4.1**). The decline of an entire cluster poses additional challenges for its laid-off workers, who would need to redeploy their skills into the few adjacent occupations that are resilient to these trends. These potential consequences are most dire for workers trapped in sandpit clusters, since their low mobility prospects and low wages make navigating any cross-cluster transition exceedingly difficult.

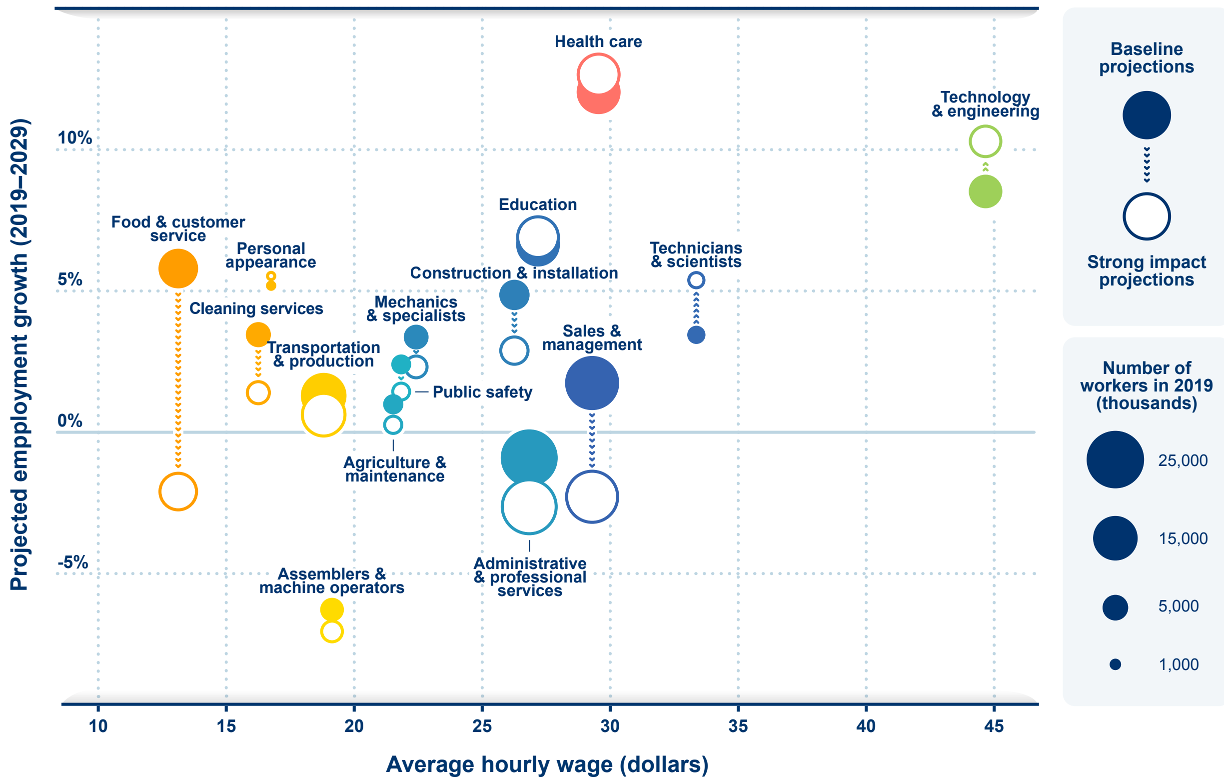
A shrinking sandpit cluster

The assemblers and machine operators cluster has long been expected to shed jobs in the coming years due to long-run labor market trends. Before Covid-19, BLS projections estimated that this cluster would experience a 6 percent job loss between 2019 and 2029, or about 268,000 workers in 21 of the cluster's 26 occupations (**figure 4.2**). But after recently updating the model to simulate the potential long-term economic effects of Covid-19, BLS now forecasts that this cluster could shrink by 7 percent, losing 301,000 jobs in the strongest impact scenario, which assumes that Covid-19 causes long-lasting shifts in consumer demand and firm behavior.

Those in the assemblers and machine operators cluster are especially vulnerable since most of the occupations in the cluster are expected to decline, forcing workers to make more difficult transitions outside the cluster. External transitions require

FIGURE 4.1

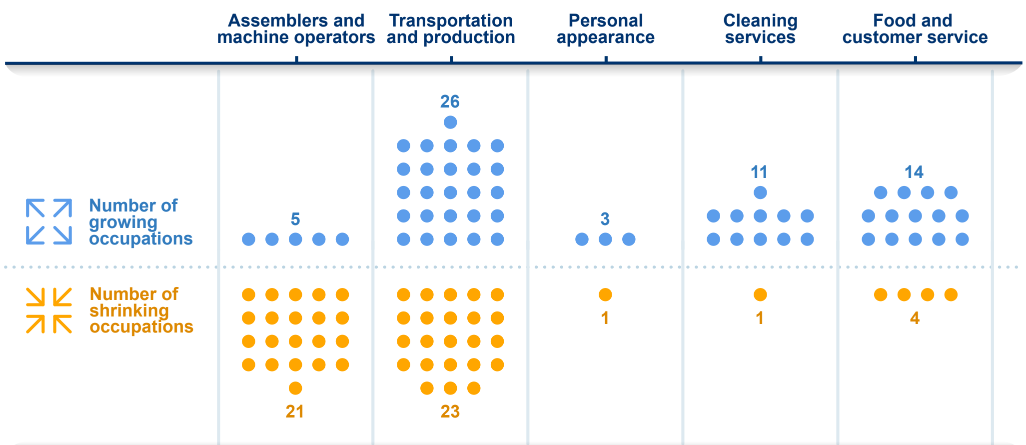
Before Covid-19, occupations in just two clusters were expected to lose jobs in the coming decade, but the pandemic's economic impacts could make things worse, for these and several other clusters



Source: Authors' analysis of BLS employment projections 2019–29 and OEWS 2019.

FIGURE 4.2

Occupations in manually intensive, low-wage clusters are vulnerable to automation



Note: A list of the largest occupations in each cluster is available in **appendix table A9.1**.

Source: Authors' analysis of BLS employment projections 2019–29 and OEWS 2019.

workers to learn new skills while also adapting to different types of employers, perhaps with different workplace cultures and practices. By contrast, though many occupations in the transportation and production cluster are also declining, the growing occupations in the cluster represent more viable opportunities for that cluster's workers (**figure 4.2**).

Recovering sandpit clusters

Prior to Covid-19, the four other sandpit clusters were expected to grow—but each experienced abrupt jobs losses in the early months of the pandemic and now faces an uncertain future. BLS previously estimated that occupations in the clusters of transportation and production, personal appearances, cleaning services, and food and customer service would grow by 3 percent from 2019 to 2029, adding 1.1 million jobs. Job losses from Covid-19 struck these clusters hard, however, especially in customer-facing and non-teleworkable occupations in food services and personal appearance.[1] After factoring in the potential long-term economic impacts of the pandemic, BLS now estimates that the food and customer service cluster could lose up to 264,000 jobs in the most severe scenario of permanent changes in company behavior (such as less business travel, less office space, faster adoption of automation),[2] while cleaning services and transportation and production could add 97,000 and 105,000 fewer jobs, respectively.[3]

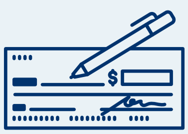
If demand for labor in these historically fast-growing low-wage clusters actually decreases, workers could experience similar challenges as outlined above: heightened competition for too few jobs, leading to even lower wages, worse job quality, and further reduced benefits. Even during the historically tight pre-Covid-19 labor market, low-wage workers already faced precarious futures. For example, only 41 percent of workers in the lowest wage quartile had access to employer-provided health care benefits, compared with 93 percent in the highest wage quartile.[4]

Using network and cluster analysis to better target efforts for low-wage workers

Clearly, workers stuck in low-wage, low-mobility sandpit clusters need support—and indeed, many of these same challenges confront low-wage workers across the labor market. To find upwardly mobile career opportunities, workers in low-wage occupations will increasingly need to look towards unrelated occupations and cross-cluster transitions. And in many cases, they will need additional education, reskilling, retraining, guidance, or career coaching to move up. While most low-wage workers may be willing to learn new skills, many are unlikely to have the time or financial resources to undertake a career pivot on their own. Companies have a role to play as well, widening internal pathways and lifting barriers. Chapter 5 discusses opportunities to strengthen these efforts. Policy responses already exist that, if expanded, could improve low-wage workers' chances of moving up on their own. Three are most prominent: minimum wages, wage subsidies, and portable benefits.

Minimum wages. Calls for minimum wage policies at the state and federal level have increased in recent years amid downward pressure on wages and job quality. Given our finding that about 37.5 million U.S. workers are trapped in sandpit clusters with low wages and low mobility prospects, the need for wage reform is clear. And strengthening workers' financial security would offer a much-needed buffer for those interested in pursuing new skills training, education, or other opportunities. While some argue that minimum wage policies reduce employment, accelerate automation, or encourage firms to relocate, scant empirical evidence supports this view.[5] But there is reasonable disagreement over whether levels and timing should vary by region, city, or even industry.

In addition to accounting for local differences in cost of living, policy tools like wage boards consider the differences between sectors or occupations—such as required education and experience, safety hazards, and job quality—to ensure that workers are fairly compensated. By setting local and targeted standards, wage boards can reduce the potential negative consequences of one-size-fits-all minimum wage increases, and by involving a broad range of stakeholders in the wage reform process, they can also increase workers' bargaining power—a key driver of wage growth and mobility. In 2015, for example, New York State (with a statewide minimum wage of $12.50) approved targeted and gradual wage increases for fast-food workers, up to $15 an hour by 2021, with a faster increase in New York City.[6]



Wage subsidies. Wage subsidies are another active labor market policy that can improve mobility, and which could also benefit from finer targeting with the help of the network approach. As with training, subsidies are often allocated to a target population, but they are seldom conditioned on targeted occupations that are likely to be a productive and lasting match for the worker.

Based on job transitions, wage patterns, and employment spells, we can single out the most promising destination occupations for each individual worker looking for a job (or a better one). Network analysis adds value on two levels: It paves the way for the worker to take on more upwardly mobile pathways, and it reduces the likelihood of a costly failure. In particular, the network of occupational transitions allows us, for a specific worker, to rank occupations based on similarities, mobility upsides, and even job stability. In doing so, the subsidies are more efficiently assigned and possibly even shortened, in a way that incorporates both the worker´s need and the likelihood of a successful match. Thus, as with training policies, the network approach avoids one of the reasons that labor market policies often have limited impact: their lack of targeting.

Portable benefits. Calls have also increased to expand portable benefits, a policy innovation to help more workers acquire benefits and keep them during job transitions or periods of unemployment.[7] Portable benefit systems are common around the world, but not yet widespread in the United States. Considering that only 41 percent of workers in the lowest wage quartile have access to employer-provided health care benefits—a number that is likely to decrease amid the rise of gig work and workplace fissuring—portable benefits are both an important addition to the social safety net and a potential boost to mobility.[8] Going a step further, such schemes could also empower professional and sectoral groups to advocate for gig and contract workers in addition to full-time employees, more so if legislation followed the Nordic model and allowed these professional and sectoral groups to administer the benefits among the groups' members.[9] That way, workers would be incentivized to buy into the sectoral groups by the schemes' offer of more flexibility and support to make transitions, pursue education or training, or search for a new job.

Portable benefits are particularly efficient if hiring and firing costs or seniority premiums inhibit otherwise optimal job transitions. This may be particularly true in clusters that combine a wide wage range with below-average mobility. For example, if a worker receives only retirement benefits after staying with an employer for a year, the worker might be reluctant to seek out another, more upwardly mobile opportunity.[10] Portable benefits could allow workers to retain the benefits they earn when they switch jobs.[11]

While national adoption of the portability scheme is unlikely in the near future, our network analysis could help identify occupations or clusters where workers languish and where the portable option for low- and middle-wage workers could foster upward mobility without sacrificing the worker´s benefits. This links closely with the use of the occupational network to inform training and job matching policies: The pathways highlighted by the network approach may serve as a basis to combine portability of benefits with employer-driven, state-sponsored training programs, since portable benefits usually entail reskilling and job search services.

Other possible policy responses. Even with these efforts, however, workers stuck in low-wage, low-mobility clusters will still face an uphill climb—and for the long-term unemployed or workers who lost their jobs due to the pandemic, these efforts are inadequate. In order to meaningfully improve mobility prospects, more skyways to higher-wage work are needed, and more workers need access to better reskilling or transitioning support services. These needs are most urgent for those affected by the pandemic, but "building back better" after the crisis will require efforts that benefit all workers, including those whose jobs are not yet in jeopardy but whose industry or occupation is on the decline.

Federal infrastructure investment as an immediate and direct option to boost employment and mobility

One of the bold policy ideas being debated that could rapidly reemploy workers and support their upward transitions is a federally supported infrastructure program. Infrastructure investment could increase demand for jobs with low entry-level requirements and provide near-term opportunities for the unemployed and low-wage workers (**box 4.1**).

U.S. employment growth since the initial Covid-19 economic shock has been uneven and slow, especially for low-wage workers. By the end of February 2021, 10 million fewer Americans were working, and job losses in low-wage industries were nearly four times higher than in high-wage industries.[12] Even in a fast recovery, it may take years for employment to return to pre-pandemic levels, risking serious damage to workers' long-term career prospects.

Large-scale federal infrastructure spending could accelerate post-Covid-19 job creation while boosting long-term economic growth prospects. The U.S. spends only 2.3 percent of GDP on infrastructure, compared with 5 percent in Europe and 8 percent in China. To maximize the reemployment benefits of potential infrastructure investments, policymakers can use the methods described in this report to assess which infrastructure projects would best match the current population of unemployed and underemployed workers.

Occupational transitions analysis can help policymakers assess the workforce implication of each project and plan appropriately. For instance, while a project to plug orphan wells to reduce methane leakage may be prioritized for its environmental effects, it could also absorb workers recently displaced from the fossil fuel industry. A national program to plug 50,000 wells annually for 10 years could create 12,000 jobs each year, benefiting workers in oil-producing states like Pennsylvania and Texas. Similarly, broadband expansion would have powerful externalities for rural populations, but could also absorb a large number of currently unemployed workers. Evaluating the regional jobs impact of any potential infrastructure investment can help ensure that the investment both creates good jobs and fosters equity.

BOX 4.1

Broadband expansion, as an example

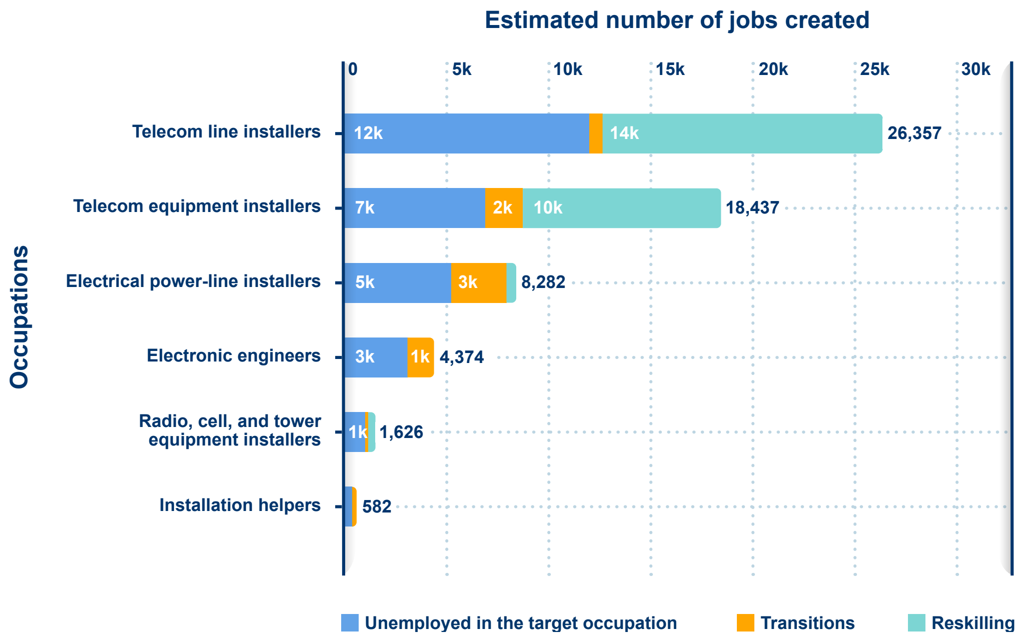
Expanding high-speed broadband across the U.S. and ensuring equitable access to the internet is a long-term priority that Covid-19 has only made more urgent. In 2020, Congress considered legislation to invest $80 billion to close the broadband infrastructure gap—a proposal that informed the infrastructure investment plan introduced by the Biden Administration in early 2021. Our analysis suggests that the potential job creation benefit of this investment would be 200,000 "job years" (equivalent to employing 200,000 workers for one year or 40,000 workers for five years, and so on) across about 130 occupations.[1]

If all of these jobs were created at once, we estimate that about 85 percent—169,000 positions—could be filled by currently unemployed and underemployed workers in the associated occupations (**figure B2**). In the most critical broadband occupations (which would employ a subset of 60,000 workers), there are not enough currently unemployed and underemployed workers to meet the estimated demand surge. These shortages could be partially filled by unemployed or underemployed workers in nearby occupations that could transition with little to no reskilling. But significant gaps would remain, particularly in four critical broadband occupations, for which workers would need to be trained or reskilled. To minimize costs and ramp-up time, the network approach could target workers from occupations with the shortest skill distance.

This approach has its own complexities: the potential for an infrastructure project to absorb unemployed workers and the extent to which reskilling would be required depends on how and where job creation is distributed over time. The number of unemployed or underemployed workers can shift rapidly, depending on the business cycle, and the geographic distribution of unemployed and underemployed workers may not match where the project is located. Even so, this approach can help policymakers maximize the total job creation potential of any planned infrastructure investment, while addressing the challenges and frictions.

FIGURE B2

Estimated jobs created in mission-critical broadband occupations, by labor source



Source: Brookings policy brief, "How federal infrastructure investment can put America to work."

Leveraging adjacency to staff infrastructure projects and target reskilling

Any given infrastructure project will have unique staffing needs depending on the occupational mix required. Given how many occupations were hit hard by Covid-19, some projects could be staffed entirely by unemployed workers who already possess the necessary job qualifications. For projects with larger staffing needs, the network feature of adjacency—which measures the distance between occupations in our network model, implying frequent transitions and shared skill requirements—is a useful tool. By identifying nearby occupations that have a large number of currently unemployed or underemployed workers, planners could staff projects with little to no reskilling costs while helping get Americans back to work. If the hiring pool is still not large enough, assessing the proximity of other occupations can help maximize the efficiency of any needed reskilling efforts. While training unemployed and underemployed workers from less adjacent occupations would not be easy or free, targeting the closest candidates would save time and money.

Targeting training and reskilling

More targeted and demand-driven training and reskilling programs could help workers better deploy their skills for new opportunities. Tailoring programs to the needs of displaced workers and targeting the skills needed for locally in-demand jobs can increase effectiveness while also saving taxpayer dollars. The network approach offers state and local governments a useful tool in this effort, as in our work with the Texas Higher Education Coordinating Board (THECB) to allocate resources for credentialing programs (**box 4.2**). These efforts target unemployed workers across the state, with a focus on placing graduates in growing occupations that are resilient to the Covid-19 crisis. The network approach helped THECB identify viable opportunities, find feasible pathways to the target

BOX 4.2

Targeting reskilling and reemployment efforts in Texas, as another example

As Covid-19 hit Texas, the state grappled with a 12 percent unemployment rate, and the higher education system faced a steep 8 percent decline in two-year college enrollment. Texas Governor Greg Abbott authorized more than $118 million in emergency funding for Texas's higher education institutions in 2020, received as part of the CARES Act relief package passed in response to the Covid-19 economic crisis. The Texas Higher Education Coordinating Board (THECB) saw the funds as an opportunity to increase the number of Texans with a post-secondary degree or credential that offered students, displaced workers, and particularly stop-outs—workers who have left a post-secondary degree program before completion—the highest value for their time and money.

Stop-outs have already demonstrated the self-efficacy and gumption to pursue a degree, so it makes sense that targeting the population could pay dividends. However, a reskilling program that targets stop-outs needs to assure these potential students that reenrolling will be worth the time, cost, and risks; most have moved on from their education and now have jobs, family responsibilities, and limited savings. To address these challenges, THECB wanted to ensure funding reached credential programs that offered high value—both for potential students (by offering the promise of well-paid, in-demand, and upwardly mobile jobs) and for Texas (by leading to occupations that could build a talent pool to drive future growth), all while targeting occupations accessible to this target population. Using Texas-specific unemployment data and occupational transitions data, Brookings Workforce of the Future (WoF) and THECB worked together to build an online data visualization tool that allowed higher education decisionmakers to identify the high-value credentials that best matched these features in their local area.

Using network metrics to help reskilling students chart the right course

The THECB swiftly organized a request for application process that required colleges and universities to clearly make the case for how the credential programs it planned to fund would deliver promising, high-quality, and resilient employment for stop-out students in their region—but many applicants had limited resources to conduct this analysis on their own. Most used labor market information to some extent. But that was typically limited to assessments of current (short-term) demand or relied on college administrators' existing interactions with local industry leaders who solicited educational institutions. With a sudden infusion of relief funding with a short fuse and multiple issues to address, colleges and universities needed to prioritize how to use these newly available funds for maximum impact.

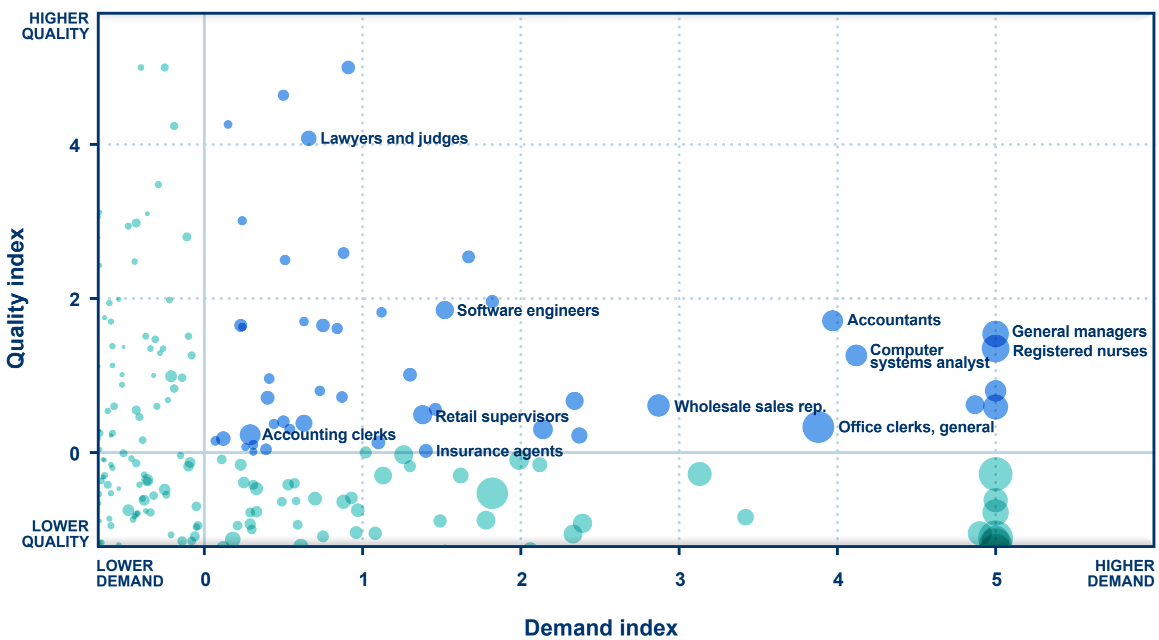
To help colleges and universities respond quickly, THECB leveraged WoF analysis to disseminate the Texas Workforce Development Toolkit— a source for region-specific information on job quality, resilience, and mobility. The toolkit has two components.* First, it provides an index of occupational quality based on local wages and WoF's mobility index, which uses a dataset containing two decades of occupational

* (The Brookings Workforce of the Future initiative's Texas Workforce Development Toolkit is available online at https://brookingswof.shinyapps.io/TX_workforce_dev_app/.)

FIGURE B3

Regional differences in occupational demand and job quality can drive funding for higher education

Occupational demand and job quality in the Gulf Coast Workforce Development Area (WDA)



Note: Circle size is proportional to the number of workers in the occupation in the Gulf Coast workforce development area, conformed by 13 counties in the Houston-Galveston region. Thresholds show the Quality Index and Demand Index of the average occupation in the region. Dark blue circles represent occupations that are above both the average Quality Index and Demand Index for the region.

Source: Authors' analysis of Texas Workforce Commission data on wages and employment projections by workforce development area; Emsi occupational employment data; Burning Glass data on job postings and online resumes.

transitions data to estimate the likelihood that a given occupation will lead to a higher-paying one within five years (see **figure B3** and **appendix A5** for details). Second, it provides an absorption index, which uses the same transitions data to estimate how applicable the prior experience of recently laid-off workers are to a given occupation—that is, how well a given occupation could absorb a region's unemployed workers, based on the origins and frequencies of transitions into that occupation in the past. Together, the indices provided a helpful proxy to assess whether a credential program would be worth students' time, money, and other risks of enrollment.

Importantly, the toolkit accommodated the unique labor compositions and Covid-19 impacts in each of Texas's 28 distinct workforce development regions. In the economically diversified region around San Antonio, for instance, most unemployed workers had lost jobs in food services or sales—experience that the toolkit indicated would be well-suited to higher-quality and more upwardly mobile jobs in customer support or logistical clerking. In less-diversified regions, such as those around the cities of Sherman or Denison, most unemployed workers came from working in production jobs such as those in assembling, machine operating, and textiles—skills and experience that the toolkit indicated could be leveraged for higher-quality and more upwardly mobile jobs in construction or logistics management.

occupations based on the profile of the state's current unemployed population, and determine which credential programs could deliver the highest value for graduates.

The next chapter explores more broadly how the network approach can target and tailor efforts to support worker transitions. Opportunities for upward mobility do exist in our network view of the labor market, both within and across clusters. Most pathways and skyways are narrow, however, and race- and gender-based barriers prevent many workers from accessing them. To help more workers move up, we need to widen mobility opportunities where they exist and create new ones where they don't.

Place-specific, forward-looking, and worker-centered insights can guide organizations like THECB in prioritizing program funding. But they can also help students, workers, and the unemployed or underemployed—in Texas and beyond—make well-informed decisions about which credentials will readily translate into reemployment and upward mobility.

CHAPTER 5

Mobility pathways and skyways

Throughout the labor market, certain occupations offer workers better prospects for mobility. Chapter 3 showed how workers tend to move within clusters of occupations, and how certain clusters give workers a better or worse chance at upward mobility. Chapter 4 described how sandpit clusters offer both low wages and low mobility prospects, confining many workers to spend their entire careers churning through one low-wage job after another. Of course, many workers—including some low-wage workers—do move up. Opportunities for mobility exist throughout the network, both within clusters and between them. This chapter highlights the specific routes that ascendant workers most commonly take—illuminating some of the most viable and well-trodden routes from low-wage to high-wage work.

Some clusters have high rates of internal upward mobility, while others support upward transitions across clusters. That distinction leads to two types of mobility opportunities. Upward pathways within clusters offer workers a real opportunity to move up by transitioning between closely related occupations. And skyway occupations offer workers the chance to make the more challenging leap to a new, more promising cluster. To continue with our small city metaphor, we now turn to assess the internal infrastructure within buildings—the staircases, escalators, and elevators—and the special occupations that allow workers, otherwise trapped in squat, run-down buildings, to access taller buildings through skyways.

Although pathways within clusters (and even within firms) are by nature more viable than external transitions since they mitigate the loss of firm- and cluster-specific human capital, they are often blocked with gendered, racial, financial, educational, and social barriers. Skyways across clusters, meanwhile, are relatively rare, and made more difficult by shortcomings in today's labor education, reskilling, retraining, and transition support architecture.

To widen existing pathways and skyways, remove obstacles, accelerate workers' journeys, and help new mobility opportunities emerge, coordination between the government, private sector, and worker organizations will be critical. The network approach—by offering a zoomed-in, high-definition view on these issues, challenges, and opportunities—gives policymakers, businesses, and their partners new tools for designing targeted, fit-for-purpose solutions.

Pathways within clusters and firms

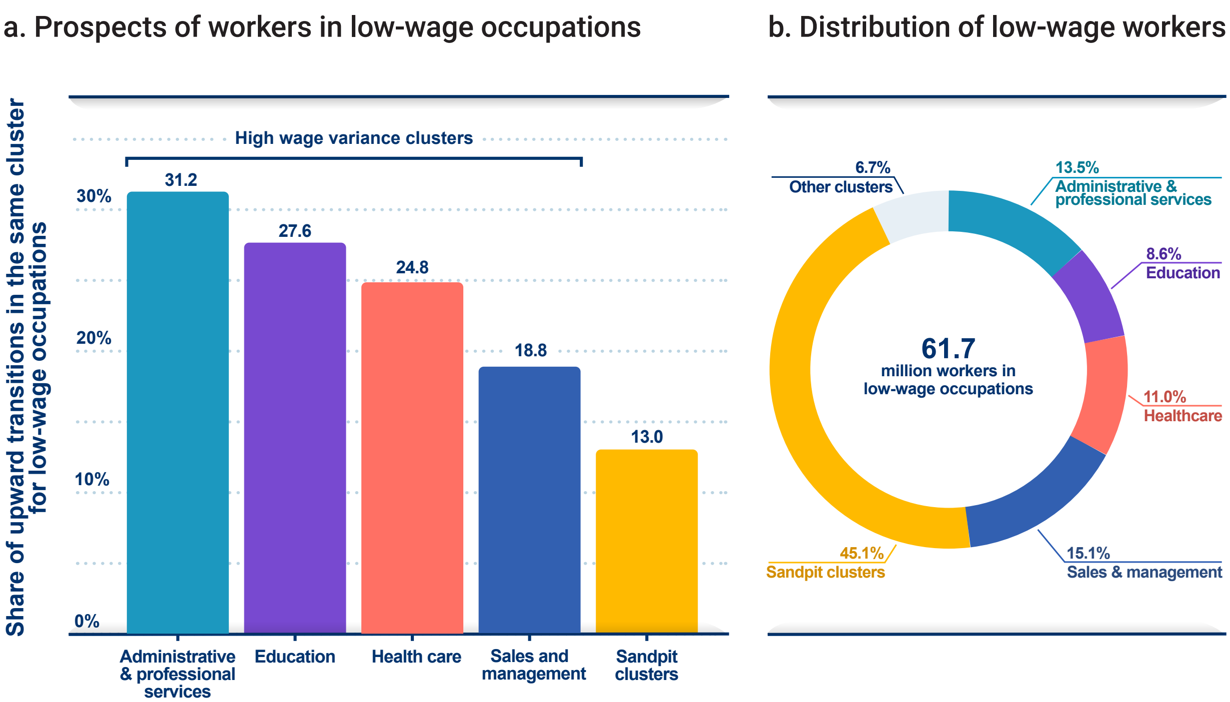
Pathways within clusters exist, but are limited and often blocked by racial, ethnic, and gender barriers

Mobility pathways within clusters are relatively common. By nature, clusters are groups of occupations that see frequent occupational transitions within them, reflecting a degree of shared characteristics between occupations. As **chapter 3** noted, achieving upward mobility within a worker's own cluster ought to be easier and more feasible than pursuing cross-cluster transitions, since experience and expertise in a current occupation makes transitioning to related occupations more viable. Research has shown that specialization in an occupation (or even within a firm) is a significant contributor to a worker's seniority and career path, suggesting that human capital is specific to occupations,[1] tasks,[2] and industries.[3] Thus, pathways within clusters offer workers a better chance to move up without needing to undertake significant retraining, reskilling, or other education. As seen, however, workers' actual experience of mobility is often not so easy. In certain sections of the labor market, promising pathways simply do not exist—particularly in sandpit clusters. But in other sections, within-cluster pathways are indeed a key opportunity for upward mobility, particularly for low-wage workers. This is especially true in clusters with high wage dispersion (a wide range of occupations spanning the low-, middle-, and high-wage spectrum with ample linkages between them), which ought to provide realistic and viable pathways from low- to high-wage work.

Four clusters—health care, administrative and professional services, education, and sales and management—share this feature of high wage dispersion prominently. Moreover, these clusters employ nearly 50 percent of all workers in low-wage occupations, but in contrast to the sandpit clusters, offer higher rates of upward mobility for

FIGURE 5.1

Workers in low-wage occupations in high wage variance clusters attain higher rates of within-cluster upward mobility



Note: Low-wage occupations are those with a median wage below $17.26 per hour, and group 61.7 million jobs, or 43 percent of total wage and salary employment. The figure shows that the within-cluster rate of upward transitions for low-wage workers in the four clusters with highest wage variance is greater than what they face in the five sandpit clusters. In total, these nine clusters account for 93 percent of employment in low-wage occupations.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019.

low-wage workers. Most of the low-wage upward mobility in the first three clusters is internal, or within the same cluster (**figure 5.1**). By contrast, the sales and management cluster, because of its central location in the network, comprises occupations with highly transferable skills that make cross-cluster transitions easier. As a result, it has relatively low within-cluster mobility but high mobility overall.

While occupational transitions data suggest that each of these three clusters contains well-traveled pathways from low- to mid- and high-wage work, not all workers enjoy equal access. Here, we explore how these pathways are marked by sharp racial, ethnic, and gender discrepancies. Research into "occupational segregation" has long shown that women, Black, and Hispanic workers are often disproportionately represented in lower-paying occupations.[4] With network analysis, however, we can pinpoint exactly where and how these disparities play out.

In particular, health care, though it contains viable pathways from low- to high-wage work, has large pay disparities between occupations that are disproportionately filled by white versus Black workers (**figure 5.2**). In turn, while the administrative and professional services cluster similarly offers promising pathways, Hispanic workers access them at lower rates than their white counterparts.[5] And the technology and engineering cluster, while not a high wage variance cluster with many opportunities for low-wage workers, is notable for its gender mobility gaps in computer jobs, which drive its occupational gender segregation.

FIGURE 5.2

Women, Black, and Hispanic workers are often disproportionately represented in lower-paying occupations

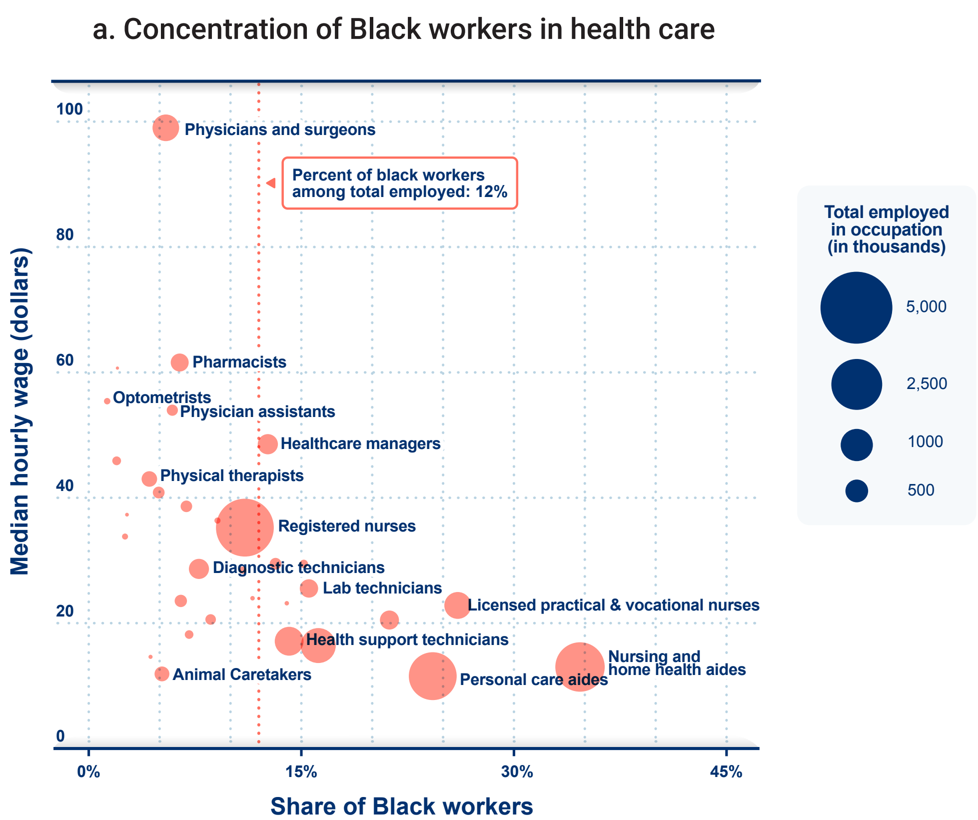
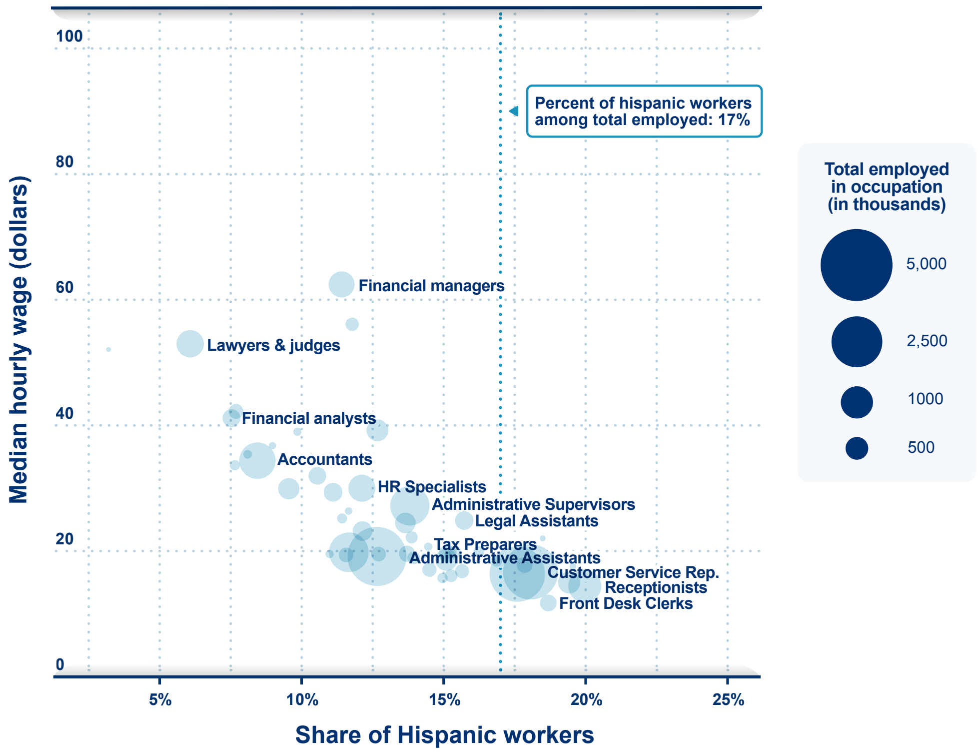
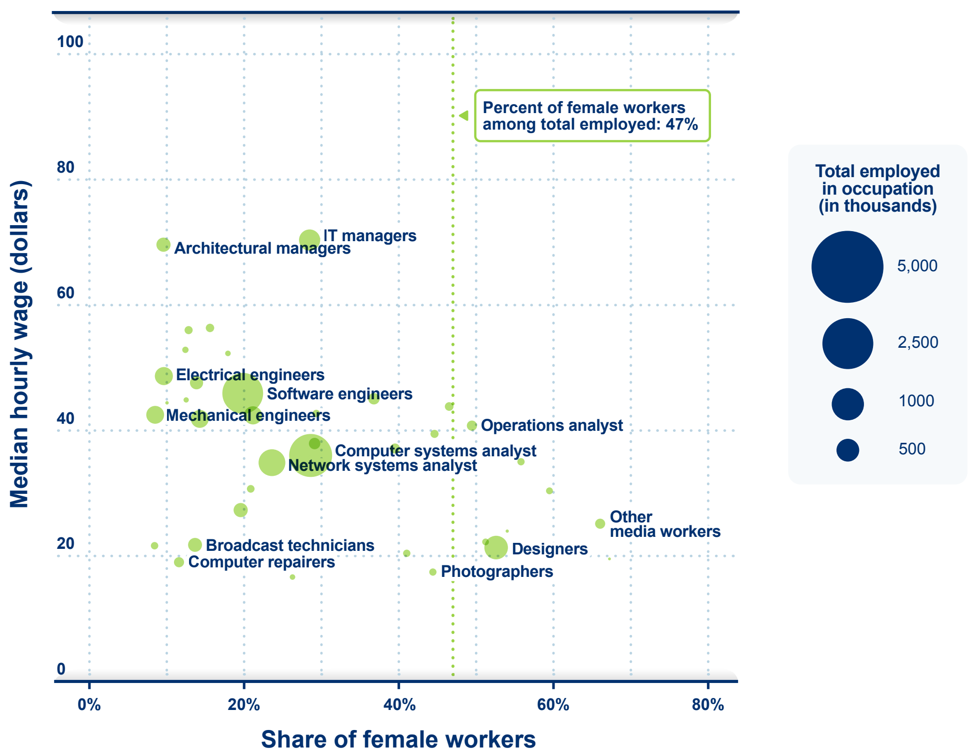


FIGURE 5.2 CON'T

b. Concentration of Hispanic workers in administrative and professional services



c. Concentration of female workers in technology and engineering



Note: The figure shows the shares of Black, Hispanic, and female workers in the health care, administrative and professional services, and technology and engineering clusters. Compare the share in each occupation with the occupation's wage and to the dashed line, which is the share of each group in the national employed population.

Source: Authors' analysis of ACS-IPUMS and OEWS 2019.

Racial discrepancies in nursing

As the U.S. population ages, demand for home health aides and personal care aides is growing rapidly. Over the next decade, the BLS predicts that the workforce in this sector will grow by 34 percent. Jobs in nursing, psychiatric, and home health aides (collectively referred to as home health aides) and personal care aides are both low-paying, with median hourly wages of $13.01 and $11.55 respectively. But each occupation is a common step on the path toward two higher-skilled, higher-paying positions: licensed practical and vocational nurses (LPNs), with a median hourly wage of $22.83, and registered nurses (RN), with a median hourly wage of $35.24. Since those jobs are also projected to grow during the coming decade, these linkages present a promising pathway.[6]

However, Black and Hispanic workers access these pathways at significantly lower rates than their white counterparts. While workers of color account for 45 percent to 50 percent of home health and personal care aide occupations, they have 37 percent of LPN jobs and just 18 percent of RN jobs. White workers transition from home health aides to RN positions at a rate 3.5 percentage points higher than Black workers and 9 percentage points higher than Hispanic workers (**figure 5.3**). While transition rates are more equitable into LPN jobs, which often serve as a middle step, white workers make the transition from LPN to RN jobs at rates 20 percentage points higher than Black workers and 17 percentage points higher than Hispanic workers.

Conversely, Black and Hispanic workers are far more likely to transition downward from LPN jobs into home health aide jobs. Rather than serving as a pathway for all workers, the data suggest that Black and Hispanic workers in health care transition between the cluster's lower-paying jobs more frequently than white workers. It is revealing that Black and Hispanic workers significantly outpace their white colleagues in only two occupational transitions: from LPN to home health aide jobs, and from home health aide to personal care aide jobs, which represent wage *declines* of $9.82 an hour and $1.46 an hour, respectively. By contrast, transitions into RN jobs offer median wage boosts of more than $12 an hour.

Educational and sociological factors may play a significant role in these divergences between health care workers of color and their white colleagues, especially at the LPN juncture. While most LPNs have about one year of training and a certificate, RNs typically have a two-year degree or three-year diploma. And while LPNs and RNs must both pass a National Council Licensure Examination (NCLEX), the RN version of the exam has more in-depth knowledge requirements.[7] These higher educational requirements can entail significant investments of time and money, which may pose barriers for some Black and Hispanic workers. In addition, research has documented an entrenched history of racism in health care professions, including discrimination in educational settings and RN pay disparities, which may alienate Black and Hispanic workers or impact their self-efficacy. Workers of color may also be discouraged by a lack of observed role models in the field.[8,9,10]

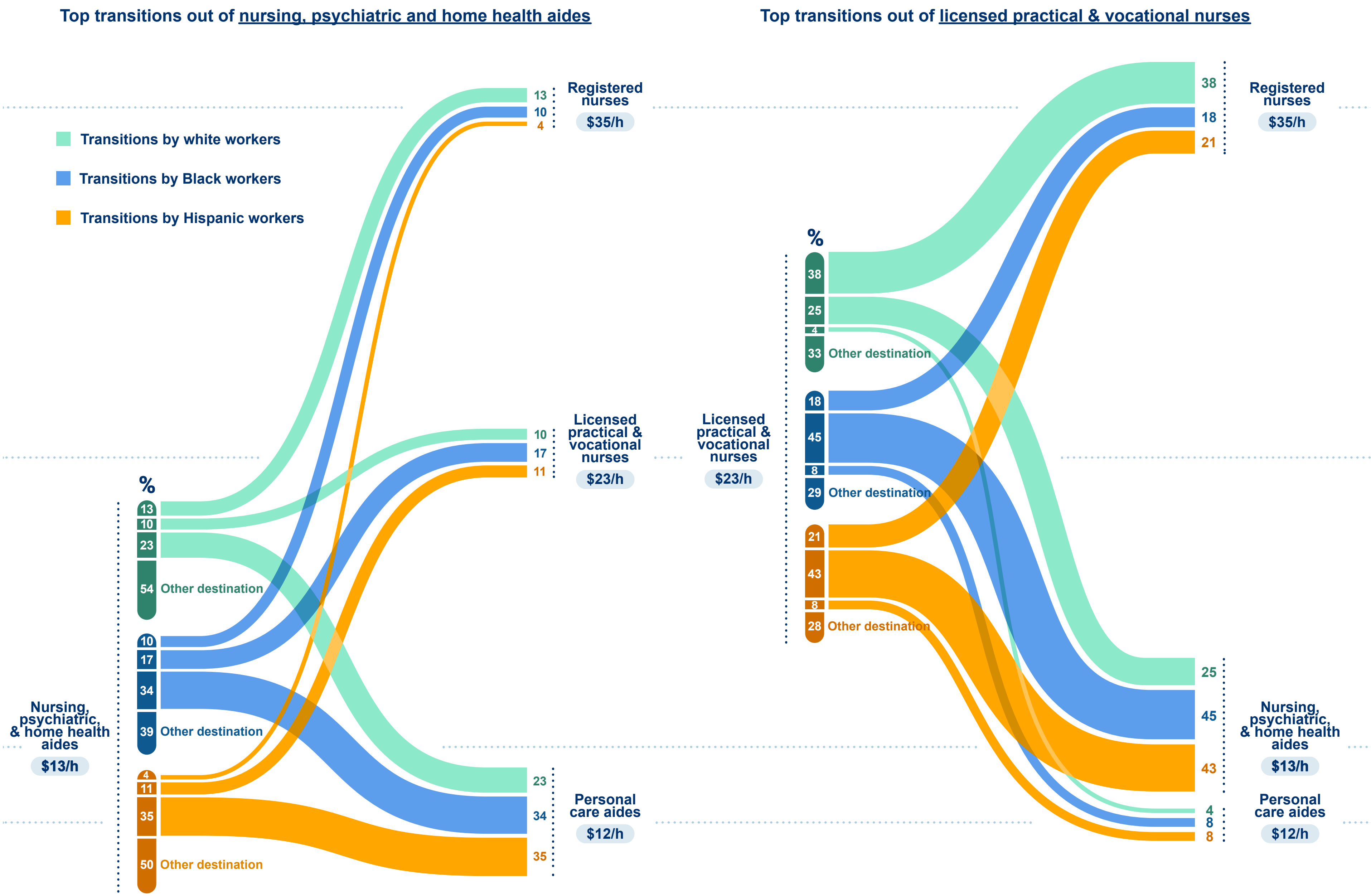
Ethnic disparities in accounting

Similar barriers block mobility pathways in the administrative and professional services cluster—particularly in financial services, a field long known for its lack of diversity.[11] The pathways into and out of the accounting and auditing profession is a particularly significant example. Tax preparation is the lowest-wage occupation on this pathway, and a common upward transition (about 25 percent of all tax preparers' transitions) is into accounting and auditing, with a nearly $14 an hour wage boost. And the most common upward transition for accountants and auditors (about 12.5 percent of their transitions) is to financial manager jobs, with a $28 an hour wage increase.

But significant ethnic disparities exist along this pathway (**figure 5.4**). For instance, white tax

FIGURE 5.3

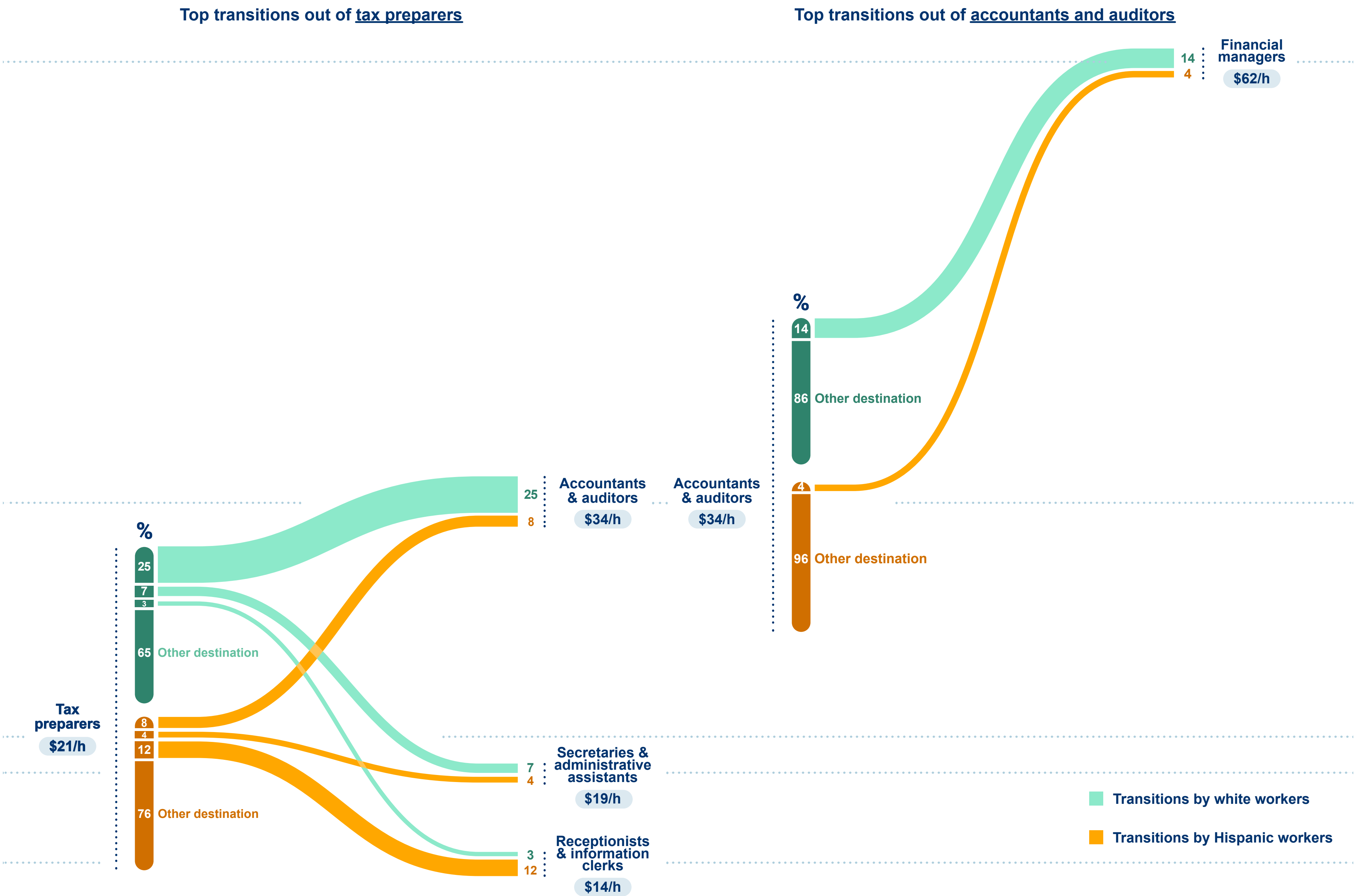
Uneven access to mobility within the health care cluster



Source: Authors' analysis of CPS-IPUMS and OEWS 2019.

FIGURE 5.4

Uneven access to mobility within the administrative and professional services cluster



Source: Authors' analysis of CPS-IPUMS and OEWS 2019.

preparers make the upward transition into accounting and auditing at a rate 18 percentage points higher than their Hispanic colleagues—who in fact are more likely to transition *downward* into receptionist and information clerk jobs, a median wage drop of $6.26 an hour. Likewise, white accountants transition into financial manager positions at a rate 9 percentage points higher than Hispanic accountants.

These findings are puzzling considering recent advances by Hispanic workers in the accounting and auditing profession. Between 2006 and 2018, the Hispanic share of graduates from bachelor's and master's degree programs in accounting swelled from 5 percent to 16 percent. Despite this trend, the Hispanic share of employment in accounting and finance functions at U.S. Certified Public Accountant (CPA) firms are just 6 percent of professional staff and 4 percent of CPAs.[12] In the critical time after obtaining their accounting degrees, a substantial number of Hispanic workers are getting stuck.

Gender-based drop-offs in the technology and engineering cluster

Technology and engineering is the network's highest paid, highest mobility, and second-fastest growing cluster. Accordingly, efforts to widen the pathways into and within it offer an opportunity to drastically improve workers' mobility in aggregate. However, technology and engineering also has significant racial and gender disparities: across the entire network, it has the lowest share of Black workers (6 percent), the lowest share of Hispanic workers (8 percent), and the third-lowest share of female workers (25 percent).

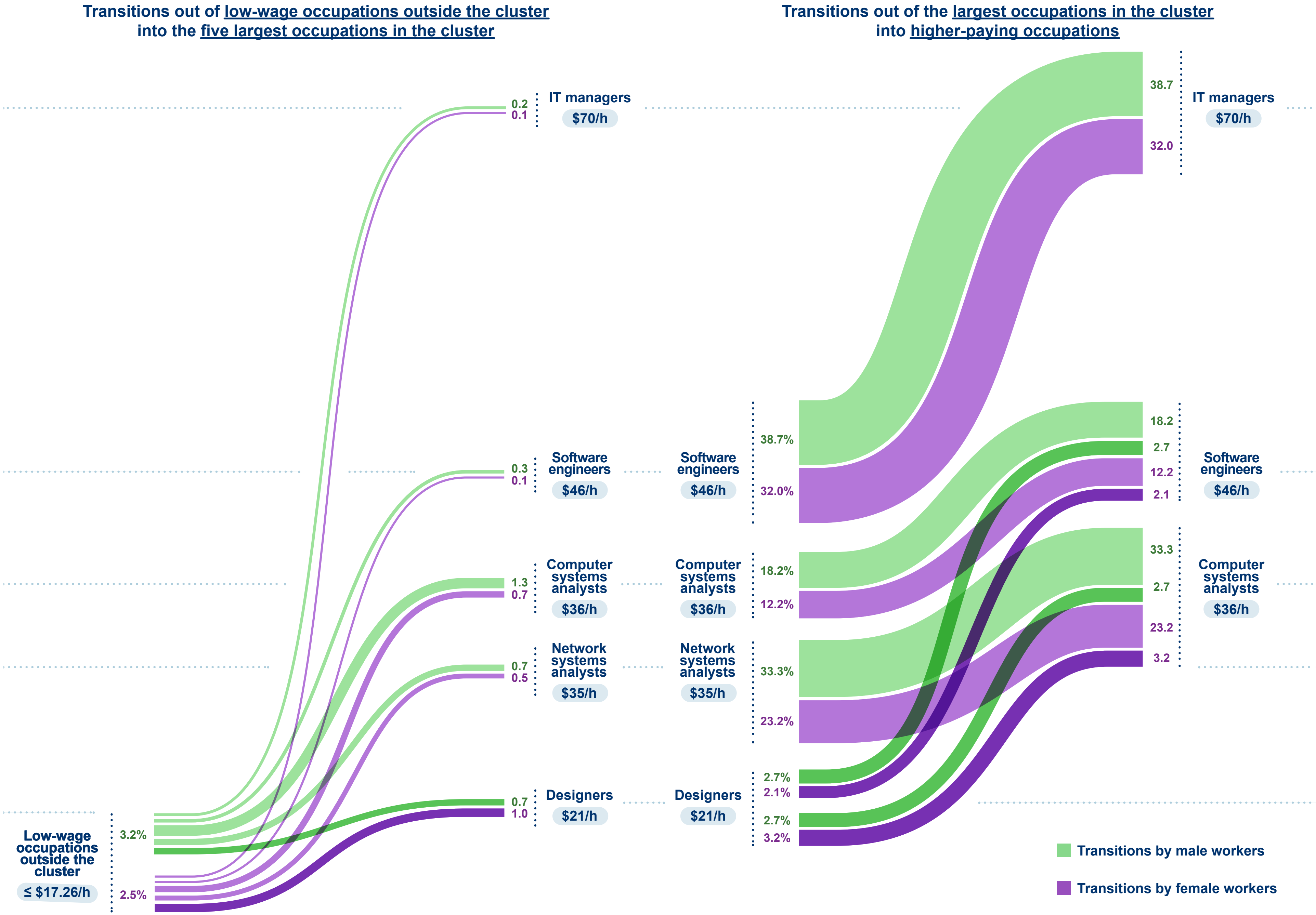
Transition data can shed light on some of the factors driving these disparities. First, technology and engineering is the network's most insular cluster, with 57 percent of its occupation-to-occupation transitions occurring from within rather than from outside (see appendix **figure A4.2**). These high barriers to entry pose particular obstacles for low-income workers from other clusters, who transition into technology and engineering jobs at very low rates (see the left side of **figure 5.5**). Moreover, those who do transition into the cluster are disproportionately white and male: white workers make this transition 24 percent more often than Black workers and 77 percent more often than Hispanic workers, while men make it 45 percent more often than women.

The cluster's gender disparities are illustrated with more granularity in **figure 5.5**, which shows that female workers in low-wage occupations outside the cluster transition into four of the cluster's five largest occupations at lower rates than their male counterparts. The one exception is design, the lowest-paying occupation of the five. Thus, while it is clear that efforts are needed to increase access into the technology and engineering cluster, simply widening pathways without addressing the underlying causes of these disparities runs the risk of amplifying them. Instead, efforts should focus specifically on creating more entry points for women across the cluster, including (and particularly) into its male-dominated occupations. This will likely require efforts to address broader educational factors, such as the well-documented links between gender roles, norms, and expectations and lower female participation in STEM education.[13,14,15]

Within the technology and engineering cluster, female workers face similar disparities for achieving upward mobility (see **figure 5.5**). Again, however, the design occupation offers women more opportunity. Not only does design draw female workers into the cluster, it also serves as a steppingstone for women to transition into higher-paying jobs within the cluster, such as computer systems analysis and computer software engineering. That said, the transition rates from design into the cluster's higher-paid occupations are low. This suggests ample room to widen pathways for upward mobility—such as through targeted training programs that teach designers

FIGURE 5.5

Pathways into and within the technology and engineering cluster are marked by gender disparity



Source: Authors' analysis of CPS-IPUMS and OEWS 2019.

the skills required for computer systems analyst and software engineer jobs.

While not shown in **figure 5.5**, designers in the technology and engineering cluster also frequently transition into higher-paying occupations throughout the network, such as managers, executives, business operations specialists, artists, and sales representatives. As a steppingstone, the design occupation ranks 57th of 317 mid- and low-wage occupations across the network, implying that many workers pass through it on their route to high-wage work. However, design is also among the steppingstone occupations that the BLS projects will shed jobs over the next 10 years. Regardless of the Covid-19 impact scenario, the occupation is forecast to remain sizable—with around half a million workers—but to contract by at least 30,000 jobs.

Efforts to improve mobility into and within technology and engineering, one of the network's most attractive clusters, could pay large dividends for workers. But given current disparities, more efforts are needed to widen pathways and create new ones. The design occupation, in particular, despite the fact that it is expected to shrink slightly in the coming decade, offers a promising target for efforts to reduce gender disparities within the cluster.

Policy implications: increase access to pathways within clusters

Within-cluster transitions are an important mobility pathway for workers, and reducing disparities in occupational transitions rates would go a long way toward addressing occupational segregation in the labor market. In addition to diagnosing the issue, the network approach can identify potential ways to overcome mobility barriers. By pinpointing where and how some workers are getting stuck, we can target our interventions to promote increased mobility for all. In our metaphor: We can help workers find the best staircases, elevators, and escalators—and repair or install new ones where they are broken or lacking.

In the accounting and auditing profession, for instance, identifying additional pathways could help more Hispanic workers move up. As noted, accountant and auditing jobs are a key steppingstone in the cluster to higher-wage opportunities like financial manager jobs. While Hispanic tax preparers face barriers moving into accounting and auditing jobs, the top feeder occupation for accounting and auditing is actually bookkeeping and accounting clerks—a middle-wage ($19.82 an hour) financial services job that does not require advanced credentials. As it happens, Hispanic workers make up the second largest racial demographic among bookkeeping and accounting clerks, accounting for 11.6 percent of workers in the occupation, and are 4.4 percentage points *more* likely to transition into accounting and auditing jobs from bookkeeping and accounting clerk jobs than white workers.[16] So, bookkeeping and accounting clerk jobs present potentially promising steppingstones for Hispanic workers in financial services, offering a well-trodden pathway to higher-wage work.

Career pathway programs

One existing approach, career pathway programs, could be particularly effective at removing mobility barriers, especially in combination with network diagnostics and targeting. Workers often face a wide range of personal, professional, and financial hurdles in their efforts to move up in their careers. Recognizing these challenges, career pathway programs seek to help workers thrive by providing a more holistic support system tailored to local context and needs. They typically offer several services targeted to low-income and disadvantaged populations, ranging from in-classroom instruction, workforce training, job readiness curricula, and job placement services to financial assistance, childcare support, and support for multiyear associate degree programs.

The programs are facilitated by community colleges, nonprofits, and private companies. While expanding them would do much to support worker mobility across the labor market, network analysis could help guide and target their implementation at the federal, state, and local levels to the sectors, subsectors, occupations, and demographics that need the most help. Intentionally targeting home health aides, designers, and bookkeepers could pay large dividends for the overall mobility rates in health care, technology and engineering, and administrative and professional services.

The Department of Health and Human Services is currently sponsoring the first-ever randomized trial of career pathways programs through its Pathways for Advancing Careers and Education (PACE) Evaluation, comprising nine programs in 18 sites across the country.[17] Intermediate results show the potential for career pathways programs to increase enrollment, credential attainment, and earnings.[18]

Nursing diversity programs

A relevant example is the federal Nursing Workforce Diversity (NWD) program, which aims to increase diversity in the nursing workforce by supporting nursing students of color. It specifically seeks to address “social determinants” and other mobility obstacles, including financial barriers, burnout risk, and lack of access to mentoring and support services. NWD grants enhance student retention in nursing programs, increase local workforce diversity, and generate a multiplier effect by inspiring participants’ friends and family members.[19,20]

Network tools could target NWD programming to, say, help workers of color overcome the barriers currently preventing home health aides, personal care aides, and LPNs from becoming RNs. Our finding that Hispanic and Black workers often transition downward from LPN jobs could be used to tailor an NWD program specifically to the needs of LPN workers of color. Similar applications could be designed to address ethnic disparities in accounting jobs, gender-based disparities into and within the technology and engineering cluster, and other mobility gaps and barriers identified in a given city, state, region, or at the national level.

Pathways within firms have narrowed

Since the 1950s, and particularly in large companies, career pathways have narrowed.[21] Across the labor market, workers now increasingly look outside their firm when seeking to move up in their career, in large part due to changes in business models, firm-level practices and industry structures.[22]

While data on how companies currently invest in their workers are scant, they suggest that the state of human capital investment is bleak—especially for female, Black, and Hispanic workers.[23] Companies, under pressure to cut costs and worried that their investments in workers will be unrealized if those workers leave, have slashed training programs, professional development opportunities, and benefits.[24,25] Simultaneously, firms are increasingly shifting their workforce from core employees to part-time workers, temporary workers, and contractors.[26] These trends combine in a downward spiral toward a new status quo where low-skilled jobs with low mobility prospects are becoming the norm, offering most workers limited opportunities to improve their skills and achieve more seniority, responsibility, or job complexity within the same company.

These processes of labor market externalization—more transitions between firms, fewer within them—and workplace fissuring may be a significant contributor to broader declining mobility trends. As **chapter 1** noted, sector characteristics and firm behavior shape labor markets and the career pathways available to workers: a low-wage worker’s mobility prospects are significantly higher in the information industry than in hospitality. So, interventions seeking to support worker mobility must not only try to understand the dynamics that influence stagnant roles—to be effective, they must also work with and influence firm- and sector-level practices.

Persuading companies to support their own workers’ mobility (including their upward mobility to other companies when few internal opportunities exist) will require more than changing the narrative.

It will require pressure from investors and consumers who are willing to reward companies that invest in human capital, more evidence of the potential returns to human capital investment, and policies that level the playing field and require minimum worker conditions when human capital investment may not be in companies' immediate self-interest.

A growing field of research empirically demonstrates that investing in job quality and workers' mobility could align with firms' best interests by fostering employee retention and performance. Turnover is expensive for firms, costing an average of 16 and 20 percent of an employee's annual salary for workers earning less than $30,000 and $75,000, respectively.[27] Research also shows that benefits like employer-sponsored health insurance can reduce turnover by up to 25 percent, and that offering better wages and tangible opportunities for intrafirm mobility can improve retention.[28] And internal hires have been shown to yield better performance evaluations after two years on the job—in addition to typically being less expensive than external hires and more able to quickly hit the ground running, even if they require extra training or support.[29,30,31]

That said, our understanding of the link between human capital investment and firm productivity remains tenuous. Much of the literature is limited to specific sectors or based on case studies from a small number of firms, and returns to human capital investment can vary greatly by industry, occupation, work structure, and type of investment. Indeed, a key finding is that human capital investment will generate firm benefits only under certain conditions, or when operational changes to improve efficiency and productivity are made in tandem.[32] Until further research and firm experience build a more compelling and conclusive fact base, many companies will likely continue to operate under the status quo assumption that enhancing job quality for their workers (raising wages and expanding benefits) and improving mobility prospects (investing in training and career development opportunities within the firm) will ultimately hurt their bottom line. In fact, current accounting standards further reinforce this status quo assumption by treating investment in workers only as a cost, not as an investment in an asset.[33]

Given the tremendous impact companies exert on society through their employment practices—most directly from wages and career advancement, but also on less tangible aspects such as increased workers' self-esteem, positive health outcomes, and stronger communities—it is clear that more needs to be done to nudge firms to improve job quality and investments in workers, and to strengthen mobility as a key channel for workers to move up.[34]

Policy implications: Initiatives to improve human capital investments and widen pathways within firms

Improving job quality and intrafirm mobility could have major impacts, and there are a number of promising efforts, though more data and research are needed across the board. Here we discuss three examples:

- The global environmental, social, governance (ESG) movement to increase corporate transparency, including metrics on human capital investment.
- New outcome-based metrics for companies to improve their own firm-level tracking.
- Government efforts to incentivize firms to invest in their workers.

Public ESG metrics for human capital investment

As part of its goals to improve corporate sustainability and social impact, the ESG movement has long championed the importance of greater corporate transparency, including the disclosure of information about investments in human capital. Requiring or incentivizing companies to disclose this type of information can improve the information landscape around human capital investment. And more important, it can help promote worker mobility and the creation of better jobs by attracting socially minded investors and enabling managers to better understand the connection between human capital investment and firm value.

Such efforts are gaining momentum. In recent months, more than 60 global business leaders at the World Economic Forum announced their commitment to recording what they call “stakeholder capitalism” metrics.[35] NASDAQ proposed a rule change that would require listed companies to disclose the gender diversity of their boards, which can have a positive impact on human capital investments. And the Securities and Exchange Commission made the first significant change to its disclosure requirements in 30 years, including the addition of a section on human capital resources. Influential organizations such as the Sustainability Accounting Standards Board and the Global Reporting Initiative have also developed disclosure standards across the ESG spectrum, with the goals of increasing transparency and demonstrating how sustainability can drive corporate value.

Disclosure policies in these areas have risks, however. While the goal is to help the market identify which human capital investments also benefit firms, poorly constructed metrics may leave loopholes that companies could exploit to appear better without enacting meaningful changes. Or investors could use greater transparency to pressure companies into cutting back on human capital investments, potentially worsening outcomes for workers. Overly complex and burdensome disclosure requirements could even turn employers away from reporting at all, while metrics used to “name and shame” could reduce reporting incentives and create unfair comparisons between different types of companies. A food service company will likely always have lower wages than a tech company, for example. And much like earnings numbers, any accounting number that requires estimates—such as human capital investments—also provides management with the opportunity to manipulate the numbers to appear rosier than workers’ reality.

The field of ESG metrics is accelerating and making progress on these thorny issues. Initiatives like the Impact Weighted Accounts Program at Harvard Business School seek to monetize a firm’s human capital contributions into a single dollar value so that investors or elected officials can make financial decisions based on less tangible aspects of firm impact.[36] More firms are engaging in voluntary disclosures, and investors are demanding it. As momentum builds toward a standard, accurate, and useful set of metrics that are uniformly required in disclosures, companies can do a lot more on their own.

Internal metrics and experimentation within firms

While not contributing to greater corporate transparency, better internal measurement by companies can also help drive the operational changes needed to improve job quality and mobility. Controlled by management and less susceptible to public scrutiny, the right internal metrics are also more likely to prompt creative experimentation around more meaningful targets (for example, the percentage of frontline workers making a living wage versus employee engagement scores), and they capture which investments have strong value-for-money in the long term. Moreover, internal metrics have potential to drive broader impact given that public firms, the focus of public ESG metrics, employ less than a fifth of the U.S. workforce.

In conjunction with The Rockefeller Foundation and the Leadership Now Project, Brookings Workforce of the Future (WoF) has developed a set of internal metrics that companies can use to measure their own contributions to improving job quality for low-wage workers. While based on several metrics that are already widely tracked, our approach leans toward action and narrowly focuses on the twin goals of job quality and worker mobility. Designed for firms of any size, the metrics compare wages, benefits, training expenditures, internal promotion rates, turnover, and other measures *across wage quintiles and demographics*. They can thus help managers see which opportunities are accessed equally throughout the workforce, identify racial or gender gaps, and ensure that their investments in frontline workers translate to improved opportunity inside and outside their firms.

The set of metrics also seeks to capture more nuanced indicators of job quality and mobility. For instance, measuring what percentage of workers make a living wage based on their region's cost of living can guide productivity improvements that allow workers to earn more while firms benefit from greater worker stability. Measuring the percentage of job openings that don't require a bachelor's degree can help firms avoid "degree inflation," which locks many qualified workers out of entry-level roles. Likewise, measuring how many jobs that don't require bachelor's degrees are actually filled by non-degree-holding workers can show whether firms are adapting their interview procedures, confronting bias, and investing in broadening the pipeline of applicants in ways that will help firms expand opportunity while acquiring diverse talent. Measuring the extent to which companies offer paid internships, career development, or cross-training (to teach employees skills for other job functions) can show whether workers have opportunities to improve their career prospects within the firm, without having to pursue time-intensive and costly education or reskilling outside work. And since internal promotions are not always possible due to the limited number of managerial roles, determining whether investment in workers translates into workers' increased opportunity for upward moves outside the company can make the employer more attractive to prospective workers.

By internally measuring the factors that drive job quality and mobility, companies can benchmark how they fare compared to industry averages while tracking their own progress. For example, the executives of a manufacturing company might compare the upward mobility rate of its workers to the industry-wide rate of 47 percent (see **figure 1.3**). To benchmark equitable mobility in the company against the industry norm, they could aim to improve on the industry-wide upward mobility gap between Black and white workers, a staggering 14 percentage points (see **figure 1.4**).

As the debate around ESG disclosures continues, and as pressure mounts for firms to treat workers fairly and equitably, internal metrics offer firms the chance to practice bolder introspection. Managers can use such metrics—and the tools introduced in this report—to isolate bottlenecks to mobility within their operations and experiment with interventions that improve job quality and mobility. If an accounting firm sees a dramatic drop in Hispanic women being promoted from entry-level positions to more senior roles, providing specific support for that pathway might be more effective than enacting company-wide gender or race quotas. Or if a tech company needs to hire more computer scientists and systems analysts, job-to-job transition data (either national data as depicted in the Mobility Pathways Tool, or internal company data) can help identify potential internal candidates within the company for whom this would be a feasible upgrade. For example, occupational transition data show that office machine repairers have historically transitioned successfully into computer analyst jobs. With some upskilling, the tech company's own office machine repairers could achieve real mobility, and the firm may end up with a less expensive, higher-performing hire who is able to hit the ground running quickly.

Ultimately, firms can use internal metrics to identify which human capital investments improve productivity and profitability—a feature that will be critical if pro-worker practices are going to scale. Measures that inform action and changes in practices can have a powerful impact on the social challenges described in this report, while also providing much-needed evidence on what works and what doesn't, as well as what's material and what's not, in order to accelerate changes across industries. A richer information landscape can help managers pick up best practices from competitors and create feedback loops in which more experimentation and evidence spark broader adoption, in turn sparking more experimentation, and lowering frictions for increased human capital investment across the labor market. Returning to our metaphor: Fixing staircases or installing elevators can help workers achieve real progress within their own firms, and as more firms take up these approaches, whole clusters and the entire network will benefit.

Public policies to promote human capital investment

As noted, one of the risks in obtaining greater awareness about which human capital investments *don't* lead to financial performance improvements for companies is that managers, executives, and investors could use that information to cut back on investments that help workers. This is precisely why greater transparency is essential: by identifying the gaps where private investment may not fill the gap, the public sector can step up to the challenge. Effective policy to promote human capital investment should both reward firms that invest in their workers' futures and incentivize behaviors that provide these public goods (such as training, mobility, stability), even when they come at a short-term cost. With more data and analysis to pinpoint where public policy is most needed to nudge firms in the right direction, governments can design smarter regulations and incentives in the form of wage subsidies, tax credits, public procurement requirements, or skilling subsidies.

For example, offering government subsidies or tax credits for firms to make targeted human capital investments has been shown to be effective, especially if tied to regional job opportunities.[37] The Michigan Job Opportunity Bank provided companies with one-time grants to train their workers; participating firms dramatically increased training opportunities for their employees, which increased both worker productivity and output quality.[38] In Massachusetts, subsidies from the Workforce Training Fund have trained more than 200,000 workers, leading to increased wages, higher firm productivity and profitability, and increased tax receipts for the state.[39] Adopting similar programs at the national level could help millions of workers, nudging companies to invest in their employees and reinvigorating upward mobility across the labor market.

The network analysis tools introduced in this report could also be used to target training subsidies more effectively. For instance, an evaluation of a UK government training subsidy found that low take-up may have been driven by a perceived low return on investment for the credentials supported by the program, and suggested that encouraging training for higher-valued credentials may have increased the program's success.[40] In cases like these, tools such as the Texas Workforce Development Toolkit described in **box 4.2**, or the Mobility Pathways online data visualization described in **box 5.2**, could help policymakers identify targeted training to fill specific gaps between low-paying occupations and in-demand, higher-paying ones. In other cases, internal promotions may simply not be viable for every worker due to a company's employment structure—there are always fewer supervisory than frontline roles—so portable benefits, described in chapter 4, are key to ensuring that external channels to mobility are also open.

Skyways out of sandpit clusters

While less common and more difficult to traverse than pathways within clusters or firms, skyways also exist between clusters. As seen, moving between clusters is by nature atypical and generally

BOX 5.1

Skyway occupations offer paths to mobility

While the journey out of low-wage work is never easy, some paths are more promising than others. Skyway occupations satisfy two criteria: they absorb workers from low-wage, low-mobility sandpit clusters (see **chapter 4**) at higher-than-average rates; and they are in growing clusters that offer decent wages and good prospects for upward mobility. Some occupations, while promising, don't satisfy both criteria. Full-stack developer jobs, for instance, offer excellent wages and strong growth, but rarely (if ever) absorb workers from sandpit clusters. Cashier jobs, meanwhile, frequently absorb workers from one sandpit cluster (food services) but have relatively low wages and are not projected to grow.

In contrast, construction labor is a prime example of a skyway occupation. It is among the most common skyways out of all five sandpit clusters and is the most common for food and customer service, transportation and production, and assemblers and machine operators. The occupation's high absorption rate is largely due its low barriers to entry. The vast majority (94 percent) of construction laborers (also referred to as general laborers or construction workers) don't have a college degree, and a third don't have a high school diploma. Workers with minimal related experience can obtain basic certification online from the Occupational Safety and Health Administration (OSHA) with a relatively small time and financial commitment (10 hours and $79).[1] The occupation has a disproportionate share of Hispanic workers (42 percent), as do several of the most common occupations that feed into construction labor.

Construction labor also offers a good median wage ($36,860) and myriad opportunities for career growth. After initial certification, there are many opportunities for advancement and specialization—from advanced OSHA credentials to licenses for specific environments, machinery, and techniques. Unions offer many construction laborers access to special trainings, apprenticeships, and other skill-building opportunities.[2] The most common occupational transition for construction laborers is to carpentry, which on average offers an $11,000 salary increase. Another common transition is to construction management, which offers an average salary of $105,000 and has low barriers to entry (two thirds of construction managers have less than a bachelor's degree). In addition, construction labor is in demand: the occupation is projected to grow by 8.5 percent in the coming decade, well above average.

While rare, other skyway occupations also offer workers a shot at higher-wage, higher-mobility opportunities. One notable example is the computer systems analyst (or computer user support specialist*) occupation, which serves as a promising skyway into the tech sector. The occupation is one of the most common skyways out of two sandpit clusters (food and customer service, and assemblers and machine operators) and has relatively low barriers to entry. While job postings commonly list a bachelor's college degree as a prerequisite, 39 percent of computer systems analysts have less than a bachelor's degree. Moreover, the occupation is expected to grow by 10 percent over the next decade and offers an above-average median salary ($74,900). Computer systems analysts also commonly transition into higher-wage positions in software engineering, data communications analysis, and computer and systems information management.

As demand for technology-competent workers has increased, retraining and certificate programs have seen rapid growth. The Computing Technology Industry Association offers a wide array of online certifications, covering everything from the basic software and hardware skills to high-level certifications in risk assessment, cloud computing, and computer maintenance.[3] Microsoft, Apple, and the Information Technology Infrastructure Library all offer their own online certifications as well.[4] Google finds that 80 percent of users experience upward mobility after completing its new six-month online IT certification program, which is delivered on the web-based learning platform Coursera and costs less than $300.[5] During the Covid-19 pandemic, demand for online learning courses exploded; Coursera's yearly enrollments grew by 444 percent.[6] In March 2021, Google launched additional certification programs in project management, UX design, and data analytics.

* By our custom occupational scheme, the computer systems analyst occupation contains the computer user support specialist entry-level occupation. See **appendix A.1.3.1**.

more challenging for workers—possibly requiring significant financial and time investments in education, credentialing, reskilling, and training. For many workers, especially those in certain low-wage, low-mobility sandpit clusters, making that leap is often the only way for workers to get ahead. Chapter 4 noted how basic social safety net improvements—like minimum wage policies, wage subsidies, and portable benefits—can indirectly support cross-cluster mobility by boosting workers' financial security and helping enable those investments. On their own, though, minimum wages and portable benefits do not directly address low mobility.

Indeed, there are occupations outside each sandpit cluster that combine stable prospects of job growth (based on the BLS projections for 2019–29, revised to account for Covid-19's impact), above-average upward mobility, pay in excess of the cluster's median, and a large inflow of workers from the cluster. In other words, they work both as a strong attractor and as a skyway for workers otherwise confined to low wages and lateral moves.

Box 5.1 describes the nature of skyway occupations within our network model of the labor market, and **figure 5.6** shows the most promising cross-cluster skyways from the low-wage, low-mobility sandpit clusters identified in chapter 4. Since they are rare, occupational transitions between clusters typically involve unique circumstances: individuals who have special skills, talents, or motivation, or who receive some type of external support that makes cross-cluster transitions more accessible.

The network approach is particularly useful to identify skyway occupations. As **box 4.1** outlined, it can also help assess the labor market impact of public investment projects in a more dynamic way, namely by considering not only the number of (often transitory) jobs created, but also their value added, in terms of enhancing the career paths of the workers involved. If we apply our city metaphor, by identifying special occupations that serve as entry points for workers who are otherwise trapped in squat buildings, we can help more workers make the jump from the valley to taller buildings on the hillside. In this way, the policy tools listed below can better serve workers by leveraging the natural contours of the labor market:

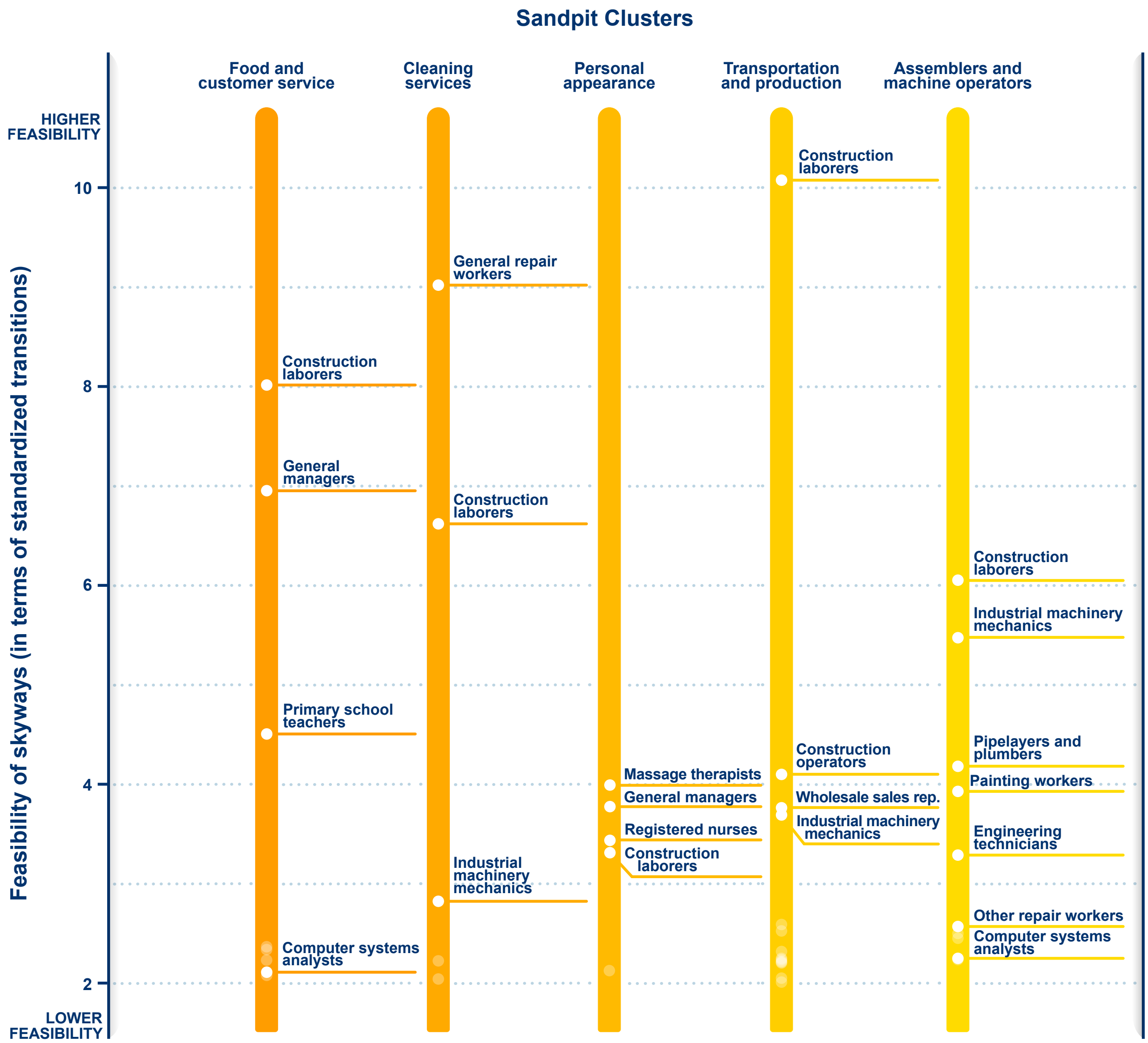
- **Jobs programs.** To quickly provide cross-cluster skyways for the unemployed or workers stuck in sandpit clusters, jobs programs can be one of the most direct and immediate policy options. The government can create new jobs through increased public spending in priority sectors—for instance, through public investment in infrastructure. The network approach can be particularly useful in these efforts by helping government identify which groups of workers would be best-suited for training and employment in the chosen sector or project, based on historical rates of occupational transitions. For a more detailed example of how a specific infrastructure program could utilize the network approach, **box 4.1** identifies which occupations would be best-suited for—and benefit the most from—federal investment in broadband expansion.

- **Targeted training.** Many unemployed people, and most workers in shrinking occupations, will be forced to redeploy their skills or learn new ones in order to transition. Today's reskilling architecture, however, is poorly equipped to serve many workers, partly due to insufficient funding. From 1985 to 2018, federal funding for training declined from 0.14 percent of GDP to 0.01 percent. Jobseekers would also benefit from more reliable guidance about which occupations are currently in demand and which offer the best prospects for upward mobility. Unsurprisingly, such guidance is more effective when tailored to each jobseeker's prior work experience, since transitions into occupations with similar tasks and responsibilities are typically more successful. The network approach offers tools that could strengthen and better target reskilling efforts, helping unlock skyways for even the lowest-wage, lowest-mobility occupations.

- **Public-private reskilling programs.** The World Bank estimates that only 25 percent of at-risk workers in the United States could be viably and profitably reskilled through the private sector.[41] As discussed in our report *Realism about Reskilling*, supporting workers as they navigate opportunities in the labor market requires an integrated, systems-level approach. So, partnerships between

FIGURE 5.6

Some occupations tend to serve as skyways out of sandpit clusters



Note: The figure shows skyway occupations out of the five sandpit clusters. Skyway occupations are those that the BLS expects to add jobs between 2019 and 2029 (accounting for Covid-19's impact) and that offer workers above-average mobility, pay more than the origin cluster's median occupation, and recive more transitions from the origin cluster than the average occupation. "Feasibility" reflects the number of transitions from a cluster to a skyway occupation expressed in standard deviations from the mean of the distribution.

Source: Authors' analysis of CPS-IPUMS, OEWS 2019, and BLS employment projections.

policymakers, educational institutions, workforce development practitioners, and firms will be essential to widening the skyways to a larger and more diverse population of low-wage workers. Recently, municipal government collaborations with reskilling and upskilling organizations and businesses have proven to be effective. In Louisville, Kentucky, a partnership between the mayor's office, the University of Louisville, Microsoft, Humana, and General Assembly organized a public "30-Day Upskilling Challenge," offering free courses in data analytics, coding, digital marketing, and other tech skills.[42] In Houston, Texas, the Greater Houston Partnership—which works with hundreds of employers, public agencies, and education providers—launched UpSkill Houston, an initiative to help reskill and upskill workers into high-demand industries and occupations.[43] By working together with businesses and local organizations on reskilling programs, officials and policymakers can create opportunities for workers while bolstering local economic growth.

Network analysis can help ensure that programs and efforts like these are well targeted to address mobility gaps and bottlenecks occurring in local labor markets. Policymakers, firms, and organizations that support workers can also use these tools to better understand the potential impact of future trends on workers—to anticipate the challenges ahead, identify vulnerable occupations, and craft policy responses to help workers adjust.

Conclusion

Some workers have a steeper climb to quality employment than others. For many, the climb is impossible. While the drivers of low mobility are complex and heterogeneous, this report identifies some troubling patterns holding millions of American workers back: occupational sandpits with low wages, minimal benefits, and low mobility prospects; race and gender disparities that pose additional barriers to career advancement; and how the looming forces of automation, digitalization, and the possibility of protracted economic impacts from Covid-19 expose large swaths of the U.S. labor market to further vulnerability.

The report also makes clear that our current tools, policies, and efforts to support workers are falling short. At the very least, workers stuck in low-wage, low-mobility sandpits are in dire need of a more robust safety net; targeted wage subsidies and portable benefits would go a long way to help these workers get by. But to build a more resilient workforce across the labor market, we need bolder efforts and more creative solutions. Local, state, and federal governments need dynamic strategies that integrate workforce development with economic planning. Better diagnostic tools are a start. The network approach, by mapping labor market dynamics using data on real workers' transitions, offers a high-resolution view of which workers are getting stuck where and the proximity between occupations—helping policymakers and firms identify opportunities for mobility and better tailor and target their efforts.

While mobility opportunities exist, they are narrow and full of hurdles. By pinpointing mobility gaps, barriers, and bottlenecks, policymakers and firms can help expand existing opportunities while enabling new ones to emerge. In our city metaphor, a better understanding of the architecture, internal infrastructure, and layout of the labor market's 15 cluster-buildings can help us determine where workers need better staircases, escalators, and elevators—or where they just need help escaping the sandy valley and moving to a taller building on the hillside.

As shown, the network approach reveals three types of promising mobility opportunities:

- **Upward pathways within occupational clusters** offer workers a real chance to move from low- to high-wage work within their section of the labor market. But these opportunity channels are often blocked by gendered, racial, financial, educational, and social barriers. Coordination and partnership between government, the private sector, worker organizations, and community groups can unblock and widen these pathways, helping more workers access more opportunities.

- **Skyways across clusters**, while less common, offer critical lifelines to help workers escape low-wage, low-mobility occupations—they're the occupations that offer entry points for workers trying to escape squat buildings in the valley to taller buildings on the hill. But these too are marked by gender and racial barriers. The most promising skyway occupations have relatively low barriers to entry, promising opportunities for career growth, and a track record of absorbing workers from low-wage occupations; construction labor and computer system analysts are prime examples. A robust, modernized social safety net that boosts workers' financial security would enable more workers to pursue skyway transitions, which often require time and resources to obtain training, degrees, or certification. A federal job program (in infrastructure, for example) would provide a labor demand shock that could absorb a large number of low-wage low-mobility workers (and the unemployed) into skyway occupations like construction labor. If carefully targeted using the network analysis tools in this report (see **table 5.1**), current and future Covid-19 stimulus programs could be optimized to maximize mobility, absorption, and diversity benefits. Bolstering skyway opportunities in the long term will require a revitalization of the U.S. reskilling architecture, including more robust funding, better targeting toward in-demand, high-mobility jobs, and better coordination with the private sector on tailored reskilling programs.

- **Pathways within firms** have long been key opportunities for workers to move up, particularly women and underrepresented groups—but these have narrowed in recent years amid declining firm-sponsored training and career development programs, increased automation, and labor market externalization. To widen these pathways, business leaders should rethink professional development, identify and dismantle racial and gender inequities, and use tools to identify mobility bottlenecks and help more workers move up. Worker training subsidies for firms, targeted upskilling within firms, and ESG standards that measure and promote firm investments in human capital can also help.

Table 5.1 lists the report's key findings and broad recommendations. While there is no "one size fits all" solution to low mobility and we do not prescribe a specific menu of policy responses, the table identifies some promising ideas for supporting workers' mobility. Given the high degree of complexity and heterogeneity involved, different approaches will be more effective in different regions and contexts—requiring bespoke analysis, tailored interventions, and broad collaboration across multiple levels of government, the private sector, and organizations that support workers.

Declining mobility is a long-term challenge driven by complex factors and broad, structural forces. But far too many workers are vulnerable and lack meaningful opportunities to move up.

There is no magic bullet, but inaction today will leave more workers stranded. This report offers new methods and tools, but the future of mobility lies with policymakers and business leaders who must decide whether to build meaningful and sustainable ladders of mobility for workers everywhere.

TABLE 5.1

Report findings and recommendations

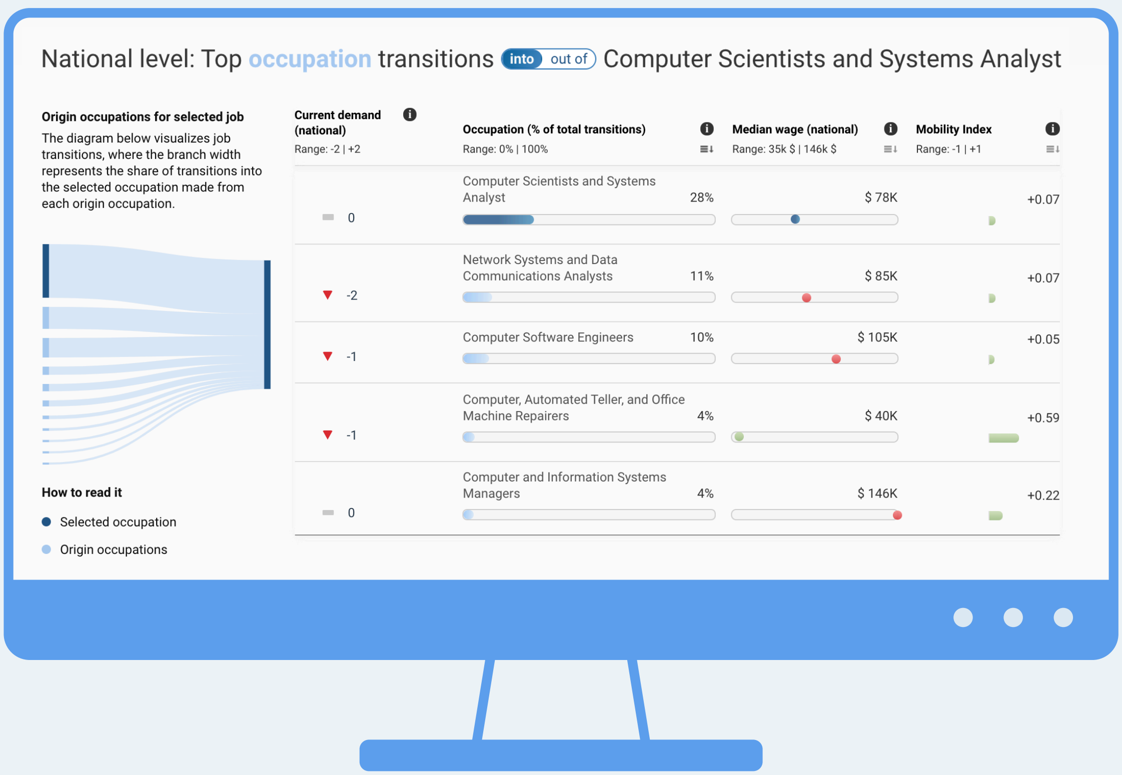
FINDING	RECOMMENDATIONS AND POLICY OPTIONS
Many workers get stuck, especially in low-wage, low-mobility “sandpit” clusters	Modernize the social safety net to meet workers’ needs in ways that bolster dynamic economic growth • Minimum wages • Wage subsidies • Portable benefits
Upward pathways within clusters and firms are blocked for many workers	Widen pathways, establish new ones, and expand access for the workers most in need • Career pathway programs • Worker training subsidies for firms • Targeted upskilling within firms • ESG metrics to measure and promote firm investment in human capital and mobility • Enhanced coordination between private sector, government agencies, education institutions, and worker organizations
Skyways across clusters are promising but rare	Enable more workers to pursue career transitions • A modernized social safety net that boosts workers’ financial security (as with wage floors and portable benefits) Optimize stimulus programs to maximize mobility and absorption • Jobs programs (as for infrastructure) Revitalize reskilling • Upgrade the reskilling architecture • Target training for in-demand, high-mobility jobs • Public-private reskilling programs
The current policy toolbox is inadequate for today’s complex mobility challenges	Use granular analysis to assess mobility dynamics, pinpoint gaps and vulnerabilities, and design targeted and tailored responses that seek to help the workers, demographic groups, regions, occupations, and sectors most in need • Mobility Pathways Toolkit • Texas Workforce Development Toolkit • Smart Growth Strategies Toolkit (forthcoming)

BOX 5.2

A resource to support mobility: The *Mobility Pathways* online data visualization tool points to upward job transitions in 382 cities

The Workforce of the Future initiative developed an interactive tool to help employers and skill-building organizations better understand low-wage workers and connect them to higher paying jobs. *Mobility Pathways* visualizes data on over 228,000 real job-to-job transitions, tracing the common pathways into and out of 441 occupations and 130 industries at the national level and across 382 metropolitan areas. It is the first element of a toolkit to support job mobility and smart growth.

Workers and firms can use the tool to identify realistic pathways back into the labor market and through alternate occupations and industries. For example, the tool shows that a retail salesperson might seek a job as a stock clerk—a top transition for retail sales workers and a position in high demand. An employer seeking to fill computer analyst roles would find that office machine repairers are a top “origin” occupation and then work to reskill or recruit these workers. In addition to helping identify short-term opportunities to reenter the labor market, the tool ranks occupations on their ability to offer wage gains over a five-year span using WoF’s “mobility index.”



With millions of workers seeking reemployment, *Mobility Pathways* can target promising transitions into resilient occupations that offer good wages and opportunities for upward mobility, tailored to workers’ experiences and locations. Companies can use it to widen their pools for talent acquisition and make career paths available to more workers. Organizations that support workers can encourage workers to enter occupations that are both in demand locally and offer long-term upward mobility prospects. *Mobility Pathways* offers a map and compass for navigating labor market shifts—during and after the pandemic.

Access *Mobility Pathways* at https://www.brookings.edu/interactives/wof-mobility-pathways/

APPENDIX 1

Data

1.1. The CPS transitions dataset

We construct a dataset of occupation-to-occupation transitions using the Integrated Public Use Microdata Series (IPUMS) of the Current Population Survey (CPS) between 2003 and 2019.[1] We choose the CPS over other sources for its fidelity in representing the population and its high resolution in terms of monthly observations.

The CPS basic survey is administered monthly to nearly 70,000 households in the United States, collecting labor force and demographic information from its respondents once a month for four consecutive months, followed by an eight-month break, after which they are surveyed again for four final months. We use CPS person-level identifiers (CPSIDP)[2] to match answers from working age individuals across consecutive samples, allowing us to identify month-to-month changes in workers' occupation, industry, employment status, educational attainment, and other measures. Each monthly sample in the CPS comprises eight equally sized cohorts that rotate through sequentially, with two rotation groups being retired each month (one temporally and the other permanently), such that approximately 75 percent of the subjects coincide across two consecutive samples.

We exclude unemployed individuals from this matching process in order to restrict our sample to employed workers who change occupations from positions of relative job security and stability, as these transitions are more likely to reflect workers' preferences and skills. We also exclude spurious matches in which an individual presents changes in race, gender, or age information across samples, as well as observations with imputed occupation or industry codes due to non-response or refusal to answer.

The probability of being dropped from the sample in these steps correlates with demographic information. To correct for this, we reweight the new sample using inverse probability weighting to reobtain a representative sample.[3]

This matching process results in a dataset with 8.1 million observations and more than 228,000 occupational transitions (equivalent to a transition rate of 2.8 percent). We define occupational transitions as month-to-month changes in occupational codes, excluding transitions made by self-employed workers, active members of the armed forces, students in higher education, or transitions with unverifiable information. **Table A1.1** shows the overall characteristics of the resulting dataset.

TABLE A1.1

Broad characteristics of the CPS transitions sample

CHARACTERISTICS OF EMPLOYED INDIVIDUALS IN CONSECUTIVE MONTHLY SAMPLES							
Years	Monthly samples	Respondents	Transitions	Transition rate	Share of upward transitions	Number of occupations	Number of industries
2003–2019	204	8,183,389	228,366	2.8%	50.0%	428	135

Source: Authors' analysis of CPS-IPUMS.

Table A1.2 breaks down this sample by race, gender, age, and education level, highlighting each group's average workforce participation rate, transition rate, and share of transitions that are upward (see **appendix 2** for a definition of upward transitions).

A breakdown of the transitions dataset by gender shows that its composition broadly follows the structure of the labor market, with each gender's share of respondents comparable to their average share in the workforce. Both groups also transition at the same rate (2.8 percent), though men are more likely to transition upward than women.

While the CPS monthly samples between 2003 and 2019 register as many as 24 race groups, as well as whether respondents have Hispanic origin, small sample sizes prevent us from studying transitions separately for each of these groups. We instead divide the sample into five large groups, the largest of which is white (74 percent of respondents), followed by Hispanic (11.3 percent), Black (7.9 percent), Asian (4.5 percent) and Multiracial/Other (2.4 percent). While the Hispanic, Multiracial/Other, and Black groups show the highest transition rates, they also have the lowest shares of upward transitions. The white group, by contrast, has a transition rate below the sample's average but above-average

TABLE A1.2

CPS transitions sample, by demographic characteristics

CHARACTERISTICS OF EMPLOYED INDIVIDUALS IN CONSECUTIVE MONTHLY SAMPLES BETWEEN 2003 AND 2019								
Variable	Value	Employed respondents	Share of respondents	Transitions	Transition rate	Share of upward transitions	Avg. share in workforce	Share in transitioning population
Gender	Female	3,914,961	47.8%	109,646	2.8%	46.0%	46.8%	46.5%
	Male	4,268,428	52.2%	118,720	2.8%	54.0%	53.2%	53.5%
Race	Asian	365,518	4.5%	11,227	3.1%	55.3%	5.1%	5.6%
	Black	645,659	7.9%	20,746	3.2%	44.7%	10.4%	11.7%
	Hispanic	920,941	11.3%	35,058	3.8%	41.1%	14.5%	19.3%
	Multiracial/Other	199,331	2.4%	6,375	3.2%	46.1%	2.0%	2.2%
	White	6,051,940	74.0%	154,960	2.6%	52.7%	68.0%	61.1%
Age	18-19	280,120	3.4%	14,518	5.2%	27.6%	3.3%	5.6%
	20-29	1,423,553	17.4%	58,585	4.1%	45.7%	19.4%	27.8%
	30-39	1,753,962	21.4%	48,032	2.7%	54.3%	22.0%	21.6%
	40-49	1,959,661	23.9%	47,352	2.4%	54.3%	23.6%	20.3%
	50-59	1,805,930	22.1%	40,901	2.3%	54.0%	21.0%	17.0%
	60-69	780,295	9.5%	15,708	2.0%	52.4%	8.8%	6.4%
	70+	179,868	2.2%	3,270	1.8%	47.9%	2.0%	1.3%
Education	Less than HS	707,332	8.6%	24,146	3.4%	32.2%	9.3%	11.2%
	High school diploma	3,786,441	46.3%	112,860	3.0%	43.2%	46.2%	49.1%
	Associate degree	871,645	10.7%	21,161	2.4%	52.0%	10.2%	8.9%
	Bachelor's degree	1,803,813	22.0%	49,336	2.7%	63.7%	22.1%	21.9%
	More than Bachelor's	1,014,158	12.4%	20,863	2.1%	74.4%	12.1%	9.0%
All		8,183,389	100.0%	228,366	2.8%	50.1%	100.0%	100.0%

Source: Authors' analysis of CPS-IPUMS.

rate of upward transitions. The Asian group has an above the average transition rate and above-average rate of upward transitions.

In terms of education levels, 46.3 percent of the respondents hold a high school diploma as their highest education certificate, while 22.0 percent have a bachelor's degree, and 8.6 percent have less than a high school diploma. Groups with lower education levels tend to exhibit above-average transition rates but below-average shares of upward transitions. Certain age groups exhibit a similar pattern, with those aged 18 to 29 years old also showing above-average transition rates but below-average shares of upward transitions.

We divide the 428 occupations included in the dataset into major occupational groups using the hybrid SOC (see **appendix 1.3.1**). **Table A1.3** presents the breakdown of major occupational groups. The

TABLE A1.3

CPS transitions sample, by occupational group

CHARACTERISTICS OF EMPLOYED INDIVIDUALS IN CONSECUTIVE MONTHLY SAMPLES BETWEEN 2003 AND 2019							
Occupational major group	Employed respondents	Share of respondents	Transitions	Transition rate	Share of upward transitions	Avg. share in workforce	Share in transitioning population
Architecture and engineering	168,564	2.1%	5,608	3.3%	72.0%	2.1%	2.5%
Arts, design, entertainment, sports, and media	161,762	2.0%	3,644	2.3%	53.9%	2.0%	1.6%
Building and grounds cleaning and maintenance	297,584	3.6%	7,861	2.6%	42.6%	3.7%	3.4%
Business and financial operations	368,083	4.5%	10,357	2.8%	57.9%	4.5%	4.6%
Community and social service	144,199	1.8%	3,708	2.6%	62.7%	1.7%	1.5%
Computer and mathematical	214,303	2.6%	6,647	3.1%	74.1%	2.8%	3.0%
Construction and extraction	437,451	5.3%	13,664	3.1%	50.0%	5.4%	6.2%
Education, training, and library	518,607	6.3%	11,418	2.2%	57.8%	6.1%	4.7%
Farming, fishing, and forestry	59,931	0.7%	1,834	3.1%	47.9%	0.7%	0.7%
Food preparation and serving related	420,765	5.1%	15,689	3.7%	34.8%	5.3%	6.7%
Healthcare practitioners and technical	473,700	5.8%	7,290	1.5%	40.6%	5.7%	3.2%
Healthcare support	185,202	2.3%	5,160	2.8%	51.8%	2.3%	2.3%
Installation, maintenance, & repair	289,793	3.5%	8,629	3.0%	52.1%	3.5%	3.8%
Legal	105,917	1.3%	1,247	1.2%	48.4%	1.2%	0.5%
Life, physical, and social science	88,148	1.1%	2,685	3.0%	67.2%	1.0%	1.1%
Management	966,839	11.8%	20,907	2.2%	46.0%	11.4%	9.0%
Office and administrative support	1,050,137	12.8%	37,276	3.5%	53.8%	12.7%	16.2%
Personal care and service	280,436	3.4%	7,060	2.5%	40.9%	3.5%	3.1%
Production	483,750	5.9%	17,024	3.5%	41.2%	6.0%	7.6%
Protective service	165,840	2.0%	3,222	1.9%	54.4%	2.1%	1.4%
Sales and related	827,655	10.1%	23,383	2.8%	53.6%	10.3%	10.3%
Transportation and material moving	474,723	5.8%	14,053	3.0%	41.0%	6.0%	6.3%
All	8,106,838	100.0%	228,366	2.8%	50.1%	100.0%	100.0%

Source: Authors' analysis of CPS-IPUMS.

occupational groups with the highest transition rates include office and administrative support (also the largest in the sample); management; and sales and related. Those with the lowest transition rates include legal; life, physical, and social sciences; and farming, fishing, and forestry.

The occupational groups with the highest shares of upward transitions are architecture and engineering; computer and mathematical; and life, physical, and social sciences. Those with the lowest shares of upward transitions include food preparation and building; healthcare practitioners and technical; and personal care and services.

One can also categorize CPS month-to-month data by NAICS industry codes. **Table A1.4** presents an overview by sector, showing that healthcare, retail, and manufacturing are the three largest employers in our dataset, while arts/entertainment, mining,

TABLE A1.4

CPS transitions sample, by sector

CHARACTERISTICS OF EMPLOYED INDIVIDUALS IN CONSECUTIVE MONTHLY SAMPLES BETWEEN 2003 AND 2019							
Sector	Employed respondents	Share of respondents	Transitions	Transition rate	Share of upward transitions	Avg. share in workforce	Share in transitioning population
Administrative	317,837	3.90%	11,088	3.5%	45%	4.2%	5.1%
Agriculture	163,135	2.00%	2,607	1.6%	41%	1.5%	1.0%
Arts/Entertainment	159,242	1.90%	5,058	3.2%	39%	1.9%	2.1%
Construction	567,578	6.90%	15,721	2.8%	52%	7.0%	7.3%
Education	784,805	9.60%	17,794	2.3%	61%	9.3%	7.3%
Finance	384,083	4.70%	11,592	3.0%	63%	4.7%	5.2%
Health Care	1,106,635	13.50%	27,159	2.5%	48%	13.3%	11.9%
Hospitality	532,604	6.50%	19,154	3.6%	36%	6.7%	8.3%
Information	175,801	2.10%	5,170	2.9%	58%	2.2%	2.3%
Logistics	346,353	4.20%	7,925	2.3%	48%	4.4%	3.7%
Management	4,522	0.10%	137	3.0%	59%	0.1%	0.1%
Manufacturing	854,733	10.40%	27,743	3.2%	47%	10.8%	12.5%
Mining	59,592	0.70%	2,190	3.7%	61%	0.6%	0.7%
Other Services	387,422	4.70%	8,899	2.3%	44%	4.8%	3.9%
Professional	560,057	6.80%	15,841	2.8%	66%	7.0%	7.3%
Public Administration	425,003	5.20%	10,843	2.6%	59%	4.9%	4.1%
Real Estate	166,938	2.00%	3,735	2.2%	51%	2.1%	1.7%
Retail	892,934	10.90%	27,267	3.1%	45%	10.9%	11.8%
Utilities	75,808	0.90%	2,274	3.0%	66%	0.9%	0.9%
Wholesale	218,307	2.70%	6,169	2.8%	45%	2.7%	2.8%
All	8,106,838	100.0%	228,366	2.8%	50.0%	100.0%	100.0%

Source: Authors' analysis of CPS-IPUMS.

and utilities are the smallest. The sectors with the highest shares of upward transitions are professional services, utilities, and finance (each with a median wage above $27 per hour, according to the OEWS 2019). The sectors with the lowest shares of upward transitions are agriculture, arts and entertainment, and hospitality (each with a median wage below $14 per hour).

1.2. The Burning Glass Technologies resume dataset

BGT is a job market analytics company that has gathered over 16.5 million individual resumes from recruiting agencies, workforce agencies, and job boards, coding and categorizing resume information to facilitate analysis along dimensions such as skills, training and occupational transitions.

We use BGT's resume data to extend our analysis of occupation-to-occupation transitions. While the CPS survey offers high-resolution data on respondents' occupational transitions during the 16 months of their participation in the survey, BGT enables viewing workers' occupational transitions over time, often throughout the entire trajectory of a career. For each transition in the data, BGT imputes the O*NET codes for the origin and destination occupations. We exclude resumes without at least one job transition between consecutive jobs, where consecutive means that there is no substantial time of unemployment. In addition, we exclude transitions that are missing occupational codes and job start or end dates. The full dataset includes nearly 50 million occupational transitions. We use a crosswalk from O*NET codes to a hybrid version of the Standard Occupational Codes (SOC) 2010 (SOCXX) to make the data compatible with CPS transitions and other data sources (see **appendix 1.3.1**).

A key concern with resume data is that it is unrepresentative of the population, given that workers in some occupations, particularly low-wage ones, are less likely to submit resumes to recruiting agencies, workforce agencies, and job boards.[4] Indeed, the median wage for origin occupations in the BGT data is $62,000, compared with $49,000 in the CPS data, indicating that the BGT data skews toward higher-wage occupational transitions. Even when resumes include low-wage jobs, upward transitions may be overrepresented in the BGT data, given that workers who ultimately end up in higher-wage positions are more likely to submit resumes to recruiting agencies, workforce agencies, and job boards.

To account for these issues, we sample and weight the BGT data to match the more representative CPS dataset, essentially by ensuring that the distribution of transitions between occupations is similar in both. The resulting BGT sample includes 10 percent of the full dataset, or approximately 5 million transitions. While this method improves representativeness, it does not achieve perfect fidelity. An intractable problem is that individuals who prepare resumes may be fundamentally different on unobserved confounders from those who do not. Further, the data is more useful if we capture entire job histories for each individual in the sample. By preserving this property, we do not fully control the distribution of transitions. An individual's resume might include transitions that are both underrepresented and overrepresented with respect to the actual population. Nonetheless, the CPS and BGT datasets and resulting analyses are complementary, as the CPS data gives us information that is largely representative of the US population, while the BGT data gives us longer job histories and a different set of covariates.

1.3. Complementary data sources

Worker characteristics, their occupation, wages, the nature of their work, and their long-term employment prospects are fundamental pieces of our network analysis. Below, we describe the datasets used in combination with CPS and BGT transitions data to complement our study.

1.3.1. *Making the CPS transitions dataset compatible with other datasets*

Our complementary datasets can be broken down into three groups, each with its own occupational classification scheme:

- Information about workers' demographics, education, and work types comes from the IPUMS American Community Survey (ACS). We use the ACS 2018 five-year sample, in which jobs are categorized into Occupational Census Codes 2010 (OCC 2010), the same occupational classification system in our initial CPS transitions dataset.

- Median wage and employment projections are pulled from BLS Occupational Employment and Wage Statistics (OEWS) and its employment projections database. We use the 2019 edition of both datasets, in which occupations are delineated by Hybrid SOC 2019, a provisional scheme used to transition from SOC 2010 (available in the OEWS 2018 for the last time) to SOC 2018 (to be released in the 2021 OEWS).

- Other skill, task, and activity-related variables are pulled from the Occupational Information Network (O*NET). We use the 24.2 release, which delineates occupations by O*NET-SOC codes. These codes are more granular versions of typical SOC 2010, with up to eight digits of detail instead of six.

We aggregate information from all the sources listed above into a custom occupational scheme called SOCXX. This final occupational classification is a hybrid between the detailed 6-digit, broad 5-digit, minor 4-digit, and major 2-digit levels of the SOC 2010, reducing the total number of occupations in the dataset from 837 to 437. This aggregation makes our dataset compatible with OCC 2010 (those in the CPS and the ACS) as well as SOC 2010 and Hybrid SOC 2019 (those in the BLS, O*NET, and BGT datasets).

Ultimately, 428 of these SOCXX codes were successfully integrated into the CPS transitions data, representing the set of occupations we use to create our network model of the labor market. This final set, as presented across the report, accounts for 96 percent of total employment according to estimates from the OEWS 2019.

1.3.2. *Occupational Employment and Wage Statistics (OEWS) 2019*

We use OEWS 2019 for wage and total employment estimates by occupation and industry.[5]

These datasets initially follow the Hybrid SOC 2019, which is compatible with our hybrid SOCXX, aside from a few exceptions. To ensure that we have a balanced estimate of the wages within our new occupational categories, we average each wage variable after joining the SOCXX codes to the OEWS 2019, weighted by total employment estimates.

Thirteen occupations from our transitions dataset lack employment and wage estimates from the OEWS 2019. For seven of these occupations, we use employment and wage estimates from OEWS 2018.[6] For the remaining six, we impute wages based on the average of each minor 4-digits occupational group.[7]

1.3.3. *IPUMS American Community Survey (ACS) 2018 5-year estimates*

We use the 2018 IPUMS 5-year ACS,[8] which provides recent and precise estimates of occupations' demographic, educational, and ethnic profiles (the same variables as the CPS). For the purposes of this report, we focus on the following variables: race, age, gender, and education. Similarly, ACS-IPUMS presents occupations in OCC 2010, a system compatible with the hybrid SOCXX we attached to the CPS.

Finally, we use ACS person-level weights to measure whether any particular demographic group is overrepresented or underrepresented in a particular occupation, given their overall participation in the labor force. To do this, we calculate the share of workers by occupation across races, age groups, gender, educational attainment, and part-time/full-time positions, and create a representation index by dividing each of the resulting shares by the groups' share of total employment:

$$Workers_{ag} = \sum_i Person\ weigths_{iag}$$

$$RepresentationQuotient_{ag} = \frac{\frac{Workers_{ag}}{\sum_g Workers_{ag}}}{\frac{\sum_a Workers_{ag}}{\sum_a \sum_g Workers_{ag}}}$$

where *a* represents any occupation, *g* represents any demographic group, and *i* is a single employed respondent of the survey. When the representation quotient is larger than one, we say the group is overrepresented in a given occupation.

1.3.4. *BLS employment projections 2019–29*

We use the BLS 2019-29 employment projections as estimates of the growth prospects of each occupation over the next decade.

The BLS model uses several indicators for its employment projections. After projecting population size and demographic composition by race, gender, age, and ethnicity over the decade, it plugs this demographic model into a macroeconomic model licensed from IHS Markit. Their labor force predictions are imposed as exogenous constraints on economic growth, and the IHS Markit model also makes assumptions about variables like energy prices and public policy. BLS incorporates an input-output model to project intermediate good production and demand, then extrapolates the required employment across industries to meet the projected demand for a given commodity. Finally, historical data on employment and wages by industry are used to calculate the expected growth of individual occupations.

In the BLS data, occupations are listed at the Hybrid SOC 2019 level. We apply a crosswalk from Hybrid SOC 2019 to our hybrid SOCXX, and then recalculate the projected change of employment during 2019-2029 at this level.

In response to the Covid-19 pandemic, BLS released two alternate scenario projections to estimate the potential long-term impacts of the crisis on firm and consumer behavior: a moderate impact scenario and a strong impact scenario. In practice, these scenarios were constructed by directly changing certain projections of demand categories as well as the expected industries' staffing patterns in response to structural changes from the pandemic.[9]

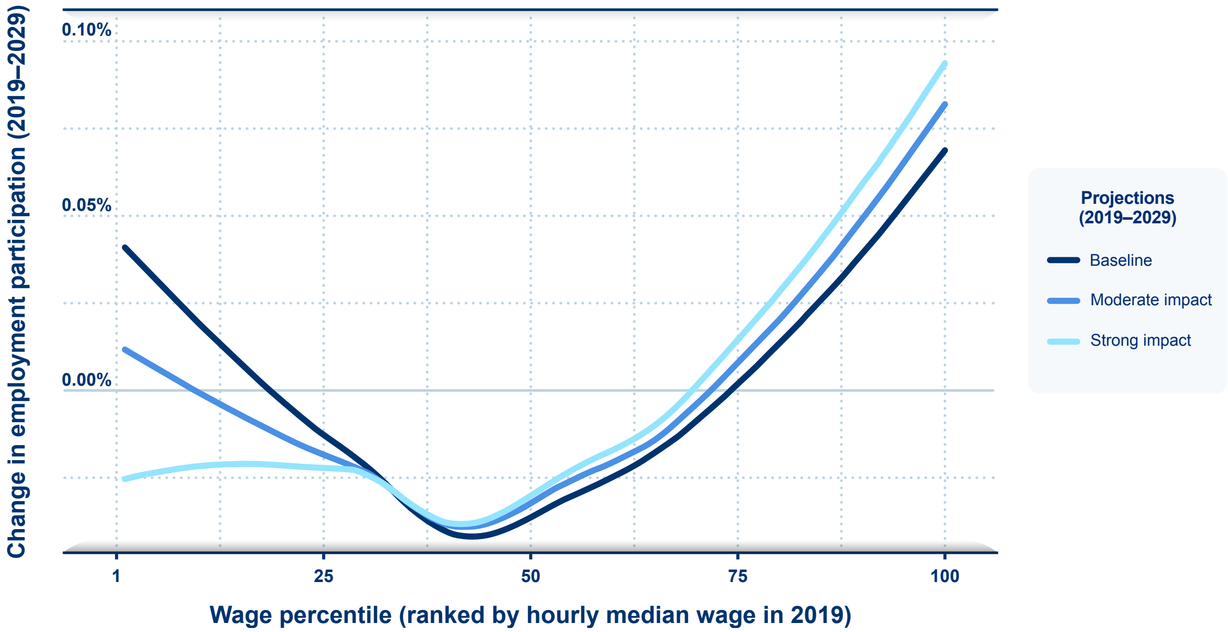
Figure A1.1 compares the baseline BLS 2019-2029 employment projections and their alternate scenario projections by wage percentile. While the baseline scenario anticipated a bifurcation of the labor market (an increase in the lowest-wage and highest-wage terciles at the expense of middle wage one), the alternate scenarios suggest that long-lasting effects from Covid-19 on consumption and production patterns could decrease demand for the lowest-wage occupations, placing even more workers at risk of dislocation.

1.3.5. *O*NET 24.2 Tasks, Work Activities, and Work context components*

We use several qualitative occupation descriptions from the O*NET database to tag occupations along different dimensions in our network analysis. Specifically, we use the O*NET Tasks, Work Activities, and Work Context descriptors. The Tasks descriptor lists each occupation's core functions; Work Activities is more general, describing an occupation's overarching responsibilities; and Work Context describes the physical, relational, and intellectual environment in which an occupation is performed. For each occupation, these qualitative descriptors are then numerically scored to indicate how essential they are to the occupation.

FIGURE A1.1

Employment projections 2019-29 by wage percentile, baseline and alternate scenarios



Note: Curves show the change in employment participation by percentiles, ordered from lower to higher wage.

Source: Authors' analysis of BLS employment projections 2019-29 and OEWS 2019.

For example, registered nurses' key Work Activity descriptors in the O*NET database are maintaining accurate records, administering medicine to patients, and recording patients' vital signs. Their central task descriptors are assisting and caring for others, documenting/recording information, and getting information. Their main Work Context descriptors involve using the telephone, contact with others, and working indoors.

We adapt O*NET descriptors to create two custom variables.10 First, we approximate whether a job requires routine manual work using the O*NET descriptors for jobs where the pace is determined by the speed of equipment, key functions include controlling machines and processes, and the work involves spending time making repetitive motions. In a similar fashion, we approximate whether a job constitutes analytical work by using the descriptors for jobs that involve analyzing data or information, thinking creatively, and interpreting the meaning of information for others. In order to create binary indicators for these custom variables, we aggregate the importance score of each variable's components, and then split the results at the middle of its distribution.

To estimate the effects of Covid-19 on different occupations, we also adapt O*NET descriptors to approximate whether an occupation can be performed remotely. This approach identifies jobs that involve working outside, using protective equipment, physical movement, or operating machinery, along with similar tasks and contexts.[11] We classify all occupations as either "remotable" or "not-remotable" based on how relevant these descriptors are in the O*NET database.

All O*NET variables in our analysis were originally computed at the O*NET SOC level. In a final step, we apply a crosswalk to aggregate these variables by our hybrid SOCXX codes. A given SOCXX occupation would be remotable, manual, or cognitive depending on the characteristics of the majority of the O*NET SOC occupations that conform it.

APPENDIX 2

Defining the mobility index and upward transitions

Identifying upward transitions in the data is challenging, given the absence of individual wages reported before and after an occupational transition.[1] To overcome this lack of data, we complement our datasets with each occupation's median wage from the OEWS 2019. However, simply measuring the difference in median wages before and after an occupational transition presents an additional challenge. Formulated this way, transitions from lower wage occupations are very likely to result in a median wage increase; this is especially true for occupations at the federal minimum wage or other wage floor, from which workers' wages can only stagnate or increase. By contrast, transitions from higher wage occupations can often result in median wage decreases, given the wider wage bands at higher wage levels. This approach would give the misleading impression that workers at the lower end of the labor market are far more likely to achieve upward mobility than those at the higher end. For a more balanced approach, we define mobility in a relative way that helps us identify the most and least mobile occupations across the wage spectrum. To do this, we assign each occupation a unique "mobility index," on a scale from -1 to 1.

2.1. Mobility index

We calculate the mobility index of an occupation based on the expected wage of its workers after a transition, compared with the expected wage of workers transitioning from any occupation with the same starting wage. For instance, to determine the mobility index of an occupation *a* with a median wage of $15 per hour, we calculate the median wage of occupation *a*'s actual destination occupations in the dataset, (weighted by frequency of transitions), and then compare it with the weighted median wage of the destinations of those occupations with a starting wage of $15 per hour. If the median wage of *a*'s actual destinations is higher than the median wage of its peer occupations' destinations, we say that occupation *a* offers above-average mobility.

We operationalize these comparisons for each occupation *a* with the following linear model:

$$\log\left(\text{median}(\overline{wage}_b|a)\right)_a = \beta_1 \log(\overline{wage}_a) + \mu_a$$

where $\text{median}(\overline{wage}_b|a)_a$ is occupation *a*'s final wage after transitioning, measured as the median of its destinations' median wages $\overline{wage}_a$, β_1 is the relationship between initial median wage and final median wage, and μ_a is the error term.

In the above example, the mobility index between -1 and 1 is stated formally as the error term, μ_a. This error term will be larger than zero when an occupation's median destination wage is higher than expected given their starting median wage and vice versa. When applying this model on top of the CPS dataset's month-to-month transitions, we refer to this error term as the short-term mobility index, and when we apply it on top of BGT dataset's 5-year transitions, we call it the mid-term mobility index. Since these metrics are uncorrelated with median wage, they become a useful indicator of short-term and mid-term upward wage mobility.

Table A2.1 shows that only about a third of the variability in both versions of the mobility index can be explained by workers' characteristics like education, gender, race, tenure, experience, or hours worked. The remaining two thirds is likely explained by role or sector-specific factors.

TABLE A2.1

Variability in mobility captured by workers' characteristics

Characteristic	CPS MOBILITY INDEX Beta	CPS MOBILITY INDEX 95% CI	CPS MOBILITY INDEX p-value	BG MOBILITY INDEX Beta	BG MOBILITY INDEX 95% CI	BG MOBILITY INDEX p-value
(*Intercept*)	0.13	-0.68, 0.93	0.8	-0.05	-0.83, 0.74	>0.9
Hourly median wage (logs)	-6.1	-7.7, -4.5	<0.001	-8.7	-10, -7.1	<0.001
Wage dispersion	-0.8	-1.8, 0.20	0.12	-1.1	-2.1, -0.15	0.024
Median tenure	-4.7	-8.5, -1.0	0.013	6.9	3.3, 11	<0.001
Squared median tenure	3.2	-0.37, 6.8	0.079	-5.2	-8.7, -1.7	0.003
Share of workers with at least a bachelor's degree	21	17, 26	<0.001	19	15, 23	<0.001
Squared share of workers with at least a bachelor's degree	-14	-18, -10	<0.001	-11	-15, -7.4	<0.001
Share of female workers	-3.1	-4.3, -1.9	<0.001	-1.2	-2.4, -0.08	0.037
Share of Black workers	-0.59	-1.5, 0.36	0.2	-2.5	-3.4, -1.6	<0.001
Share of full-time workers	4.1	3.0, 5.2	<0.001	3	1.9, 4.1	<0.001
R-squared		0.3			0.335	

Note: CI stands for confidence interval.

2.2. Upward transitions

The same model is used to estimate the expected median wage of all potential destination occupations for a given starting occupation. These predictions can be used to identify cases where a transition's actual destination occupation has a median wage that exceed the model's expectation, which we refer to as "upward transitions." We can then calculate the share of upward transitions for a given occupation (denoted by *a*) by dividing the sum of all upward transitions from occupation *a* by the total number of transitions from occupation *a*. Similarly, we can calculate the share of upward transitions for individuals (denoted by *i*) of a given demographic group (denoted by *g*) by dividing the sum of all upward transitions by individuals *i* in demographic group *g* by that groups' total number of transitions:

$$Share\ of\ occupation\ upward\ transitions_a = \frac{\sum_b t_{ab} * 1\left[wage_b > median\left(\widehat{dest\ wage}|a\right)\right]}{\sum_b t_{ab}}$$

$$Share\ of\ group\ upward\ transitions_g = \frac{\sum_i t_{iab} * 1\left[wage_{ib} > median\left(\widehat{dest\ wage_i}|a\right)\right]}{\sum_i t_{iab}}$$

where t_{ab} is the total number of transitions from occupation *a* to *b*.

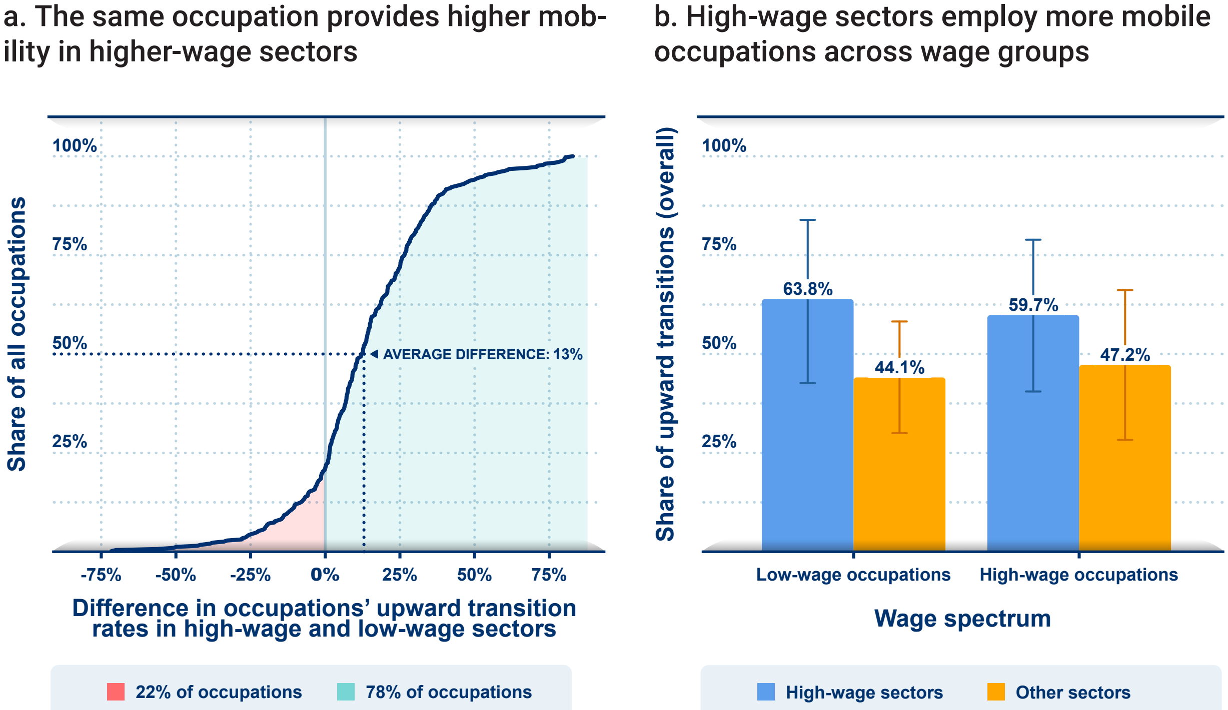
Although correlated by construction, the share of upward transitions complements the mobility index by enabling easier comparisons across gender, race, sector, and occupational groups. For instance, analyzing upward transitions across sectors can help us explore the drivers behind our finding that workers in low-wage sectors see lower mobility, mentioned in the first chapter of the report.

To do this analysis, we first classify each sector as either "higher-wage" or "other," classifying "higher-wage" as any sector with a median wage equal to or higher than $49,000 per year.[2] Then, we look at whether workers in the same occupation tend to experience higher mobility when they work in a higher-wage sector. We find that, on average, workers in the same occupation will move upwards 13 percentage points more often when they are employed in a high-wage sector. Moreover, 78 percent of occupations have a higher share of upward transitions within high-wage sectors. (**Figure A2.1a**). We attribute these differences to sector-specific factors.

On the other hand, differences in the occupational composition between sectors play a role too. If we calculate each occupation's average share of upward transitions, then consider the set of occupations required by each sector, we see that high-wage sectors tend to employ higher-mobility occupations across the wage spectrum. Indeed, the high-wage sectors' average low-wage occupation (defined as an occupation paying less than $17.20 per hour) has a total share of upward transitions that is 19 percentage points higher than the average low-wage occupation in other sectors, while the average difference for mid and high-wage occupations is 12 percentage points (**Figure A2.1b**).

FIGURE A2.1

Why do workers see lower mobility in low-wage sectors?



Note: Error bars in panel b show the standard deviations in the average share of upward transitions across each group.

Source: Authors' analysis of CPS-IPUMS and OEWS 2019.

APPENDIX 3

Visualizing the network of occupational transitions

The CPS transitions dataset comprises approximately 34,000 occupation-to-occupation transitions or "links"[1] from a universe of 182,000 possible links (482 occupations times 427 destinations). Most potential links between occupations are either nonexistent or extremely rare (e.g., it is highly uncommon for a metalworker to become a doctor). Instead, the average occupation is connected to approximately 40 other occupations.

A key feature of our analysis is using this data to visualize the labor market as a network of occupational transitions. Given the levels of complexity and intricacy in our data, we need to make a number of choices in order to construct a visual network model in a simplified but useful way.

The first is choosing how to represent the strength of links (also known as edges or ties). There are many possible ways to define the strength of the relationship between occupations. Throughout this report, we are primarily concerned about how common each given destination is to a particular starting occupation. Hence, we define a link as the proportion of all transitions from occupation *a* that terminate in occupation *b*.[2]

$$Share_{ab} = \frac{t_{ab}}{\sum_b t_{ab}}$$

where t_{ab} is the number of transitions from occupation *a* to *b*.

Second, we need to decide whether to preserve directionality of occupational transitions in our final representation of the network. Even though we use directionality when creating the mobility index, steppingstone index, and other metrics, directionality is not an essential attribute when conveying the importance of a link for two connected occupations. Thus, we create an undirected network using both the incoming and outgoing transitions. Removing directionality is useful both for visualization and other mathematical operations that function best on an undirected network.

Turning a directed network into an undirected one consists of unifying the link *ab* and the link *ba* so the resulting tie still conveys meaningful information about the relationship between occupations *a* and *b*. We choose to define this undirected tie as the average between both transition shares. The relative size of the directional tie is thus lost, but we retain information about the frequency of movement along each link. By using share rather than count, we keep the links that are important for each occupation, whether they are large or small relative to the total transitions within the labor market.

$$Tie_{ab} = \frac{Share_{ab} + Share_{ba}}{2}$$

$$Tie_{ab} = Tie_{ba}$$

Lastly, we need to select the set of relationships that best represent the network's structure. While the undirected network has half as many links as the directed version, it is still difficult to construct visualizations of a network with 17,000 links across 428 occupations without applying a filter. There are two kinds of methods in the literature to filter a network's linkages: global and multi-scale. The global filter method consists of applying a threshold for link strength over the whole network. In our network, this would leave out the links with lower overall transition rates while overrepresenting those with high transition rates. Instead, a multi-scale filter method accounts for each node's connections and attempts to maintain the core structure of the network by keeping the most important ones.

For our network's final representation, we choose to apply a multi-scale filtering method known as the 'disparity filter,'[3] which preserves 60 percent of all transitions in just 15 percent of the links (for a detailed description, see **appendix 4**).

Figure A3.1 presents a series of network visualizations to highlight the agglomeration patterns of occupations by wage level, educational requirements, reliance on routine/manual work, reliance on analytical work, remotability, and gender concentration. The disparity filtering method provides an adequate representation of how transitions between occupations with similar properties tend to cluster along multiple covariates.

FIGURE A3.1

Areas in the network of occupational transitions

Notes: We define low-wage occupations as those with a median wage below $17.26 per hour and high-wage as those with a median wage of at least $30 per hour. We define as male (female) dominated to those occupations where male (female) participation exceeds their share in total employment across the network by at least 50 percent. We define "routine/manual" or "analytical" as those occupations where the respective scores are above the average value across the network. We define "remotable" and "requiring at least a BA for entry" as those occupations that are flagged as such in the raw data.

Source: Authors' analysis of CPS-IPUMS, IPUMS USA, O*NET 24.2, OEWS 2019, and measures of education and training from the BLS employment projections.

APPENDIX 4

Community detection: Finding mobility clusters

Our community detection process has two steps: choosing a community detection algorithm, and selecting the most representative links (also known as edges or ties) of the network to maximize the effectiveness of the algorithm.

4.1 The community detection algorithm

We use Louvain community detection algorithm,[1] which attempts to find the best way to partition a network into mutually exclusive communities while maximizing an objective function known as ”modularity.” There is no computationally tractable and deterministic way to partition networks into communities based on maximizing modularity; in principle, it would depend on testing every possible number of communities with every possible distribution of nodes within them. The Louvain algorithm provides a reasonable solution by iteratively testing community assignments until a point where no improvements are reached. Mechanically, the algorithm works by assigning each occupation into a separate community (what we call “cluster”) and iteratively shuffling occupations across different potential cluster groupings. Reassignments are only kept if they increase the partition's modularity score, and the algorithm stops when no increases can be achieved. Because not every possible cluster assignment is tested, this does not necessarily achieve the best possible partition, but it has been shown to work well in most cases.

We define each link value (the strength of a connection between two nodes) as the average of two values: the share of transitions starting from occupation *a* that land in occupation *b*, and the share of transitions starting from *b* that land in *a*. By using shares rather than counts, we weight links by how important they are for each occupation, regardless of their volume compared to all labor market transitions. By taking the average of the two values, we assign a higher importance to those pairs of occupations where workers move back and forth. We tried several other specifications, including using the minimum of the two, the maximum of the two, and functions that included information about the average wage in each occupation. Although all of these performed similarly and gave similar results, the two shares' average was best at creating higher modularity clusters.

The modularity score is a value ranging from -1 to 1.[2] Positive modularity values reflect a strong community structure (more connections within groups than across groups) and negative values reflect the opposite. It is calculated as the fraction of links with starting and ending nodes in the same cluster, minus the same fraction in a counterfactual scenario where nodes are distributed randomly while preserving the same number of connections (or degree).

Modularity can be calculated for any undirected network using the following formula:

$$Q = \frac{1}{2m}\sum_{ab}(E_{ab} - \frac{k_a k_b}{2m}) x\ 1[C_a = C_b])$$

where E_{ab} is the binary or weighted link between occupations *a* and *b*, C_a is the cluster of occupation *a*, k_a is the sum of all the links connected to occupation *a*, and *m* is the sum of all the links in the graph, defined by:

$$m = \frac{1}{2}\sum_{ab} E_{ab}$$

4.2 Filtering the network to maximize effectiveness of the algorithm

In our dataset, as in many real-world networks of observed data, some nodes have many more connections than others, often by multiple orders of magnitude. This natural structure can make it extremely difficult to analyze the lower frequency nodes and links. In our community detection process, a consequence is that the highly-connected nodes tend to pull the least-connected nodes into clusters where they don't necessarily belong. A very broad occupation like general management, for example, can pull on less broader occupations that involve a lot of management, such as construction, hospitality, or office support. If these less broader occupations have a relatively low number of their own links, the overlap with general management could pull them into a manager-heavy cluster.

We address this challenge through the "disparity filter" method. As noted in **appendix 3**, this is a multi-scale filtering method for weighted networks that characterizes each link by how important it is for a node, rather than how important it is for the network overall. The disparity filter reduces the total number of links in the network by progressively removing the least essential links for each node. The overall structure of the network remains, but it becomes substantially easier to analyze effectively, including for the calculation of community detection and centrality measures.[3]

Mechanically, the method consists of comparing the weight of each link in the network with a null model in which weights are randomly assigned, keeping nodes' degree distributions constant. Links with weights substantially higher than the null model are retained. The likelihood of a link of such weight existing in the null model is characterized as a measure alpha, such that lower values of alpha are assigned to the real-world links, which are less likely to have been generated by a random or pseudo-random process. Formally, the alpha value of the link between occupations *a* and *b* corresponds from the perspective of *a* is defined as:

$$\alpha_{ab} = 1 - (k-1)\int_0^{P_{ab}} (1-x)^{k-2}\partial x$$

where k corresponds to the degree of a, and P_{ab} is the normalized weight of the link ab.

As the alpha threshold decreases, the size of the resulting potential network (or 'backbone') decreases while maintaining an overall structure similar to its original. **Table A4.1** shows several

TABLE A4.1

Progressive improvement of clusters and comparison with SOC groups

DISPARITY FILTER RESULTS ON CPS TRANSITIONS													
Alpha	Links	Links kept	Share of links kept	Pairs	Pairs kept	Share of pairs kept	Share of transitions kept	Nodes isolated	Number clusters	Median cluster size	Number of small clusters	Clusters modularity	SOC group modularity
1%	34,522	1,968	5.70%	17,390	1,332	7.7%	45.4%	0	25	10	6	79.6%	61.4%
5%	34,522	3,454	10.01%	17,390	1,909	11.0%	55.0%	0	18	12	3	71.0%	50.4%
10%	34,522	4,725	13.69%	17,390	2,535	14.6%	60.7%	0	16	23	3	66.0%	46.8%
20%	34,522	7,010	20.31%	17,390	3,702	21.3%	68.2%	0	15	17.5	4	60.7%	43.7%
40%	34,522	11,882	34.42%	17,390	6,271	36.1%	78.7%	0	12	32	1	54.7%	39.8%
50%	34,522	14,747	42.72%	17,390	7,813	44.9%	83.2%	0	11	31	2	52.3%	38.2%
100%	34,522	34,522	100.0%	17,390	17,390	100.0%	100.0%	0	10	43	1	43.2%	29.6%

Note: The highlighted row shows the selected alpha threshold and the characteristics of its backbone and clustering outcomes.

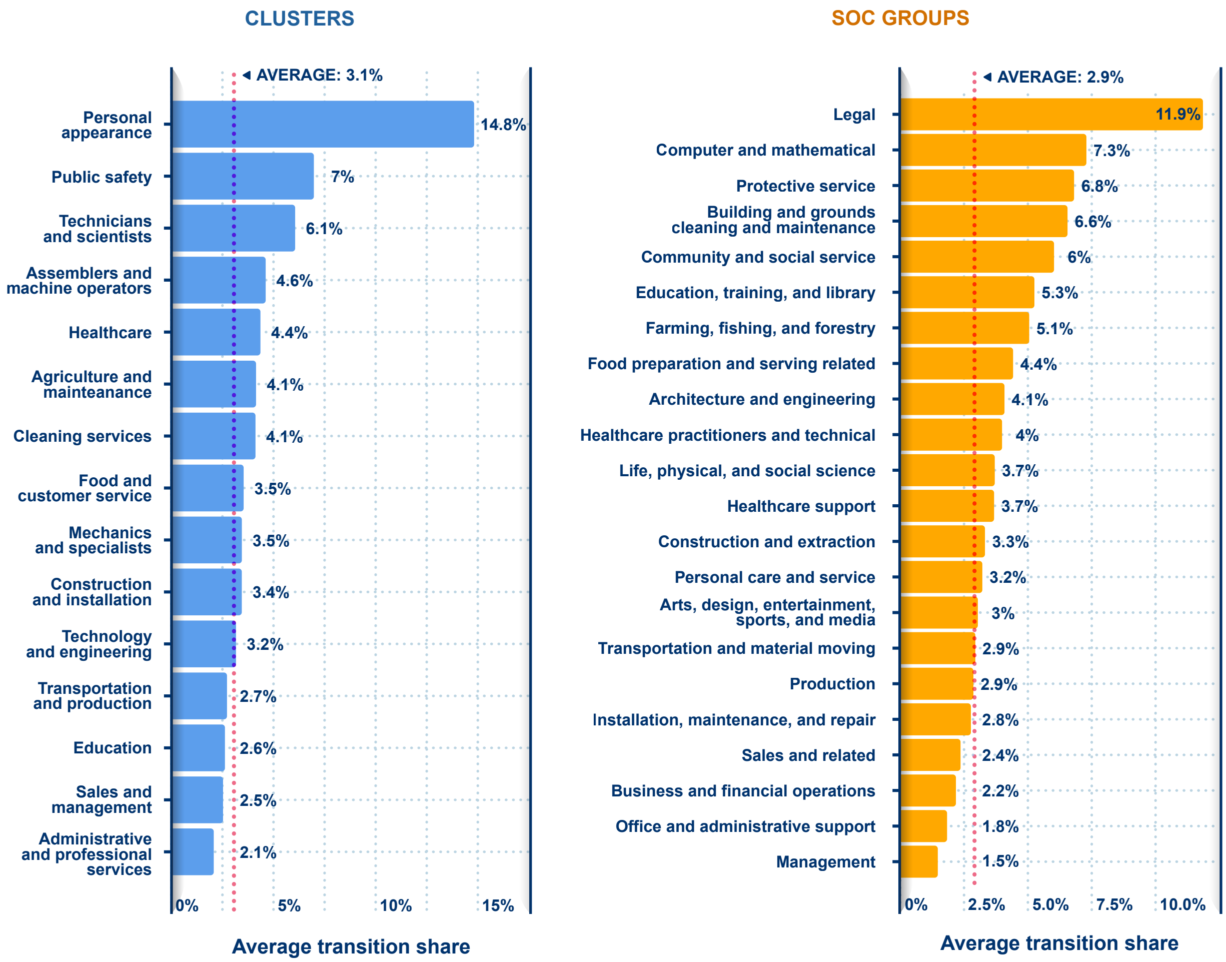
backbones and clustering outcomes resulting from applying different alpha thresholds. Each alpha threshold results in different backbone characteristics, in terms of the fraction of links and pairs kept, the number and size of clusters detected, and a comparison between the clusters' modularity and SOC major groups' modularity.

Ultimately, we chose to filter the network at an alpha of 1 percent, preserving a backbone with 7.7 percent of all pairs that reflect 45.4 percent of all transitions in the dataset. The Louvain algorithm detects a set of 25 clusters in this backbone, half of which contain more than 10 occupations. In a final step, we merge those small adjacent clusters with very similar occupational compositions. The resulting network has 15 clusters as a consequence.

These specifications create cluster structures with a substantially higher modularity score than the SOC code structure at every value of alpha. Consequently, we find that clusters in our network model are more tightly connected than in SOC groups (**Figure A4.1**). In the average cluster, occupations send 3.1 percent of their transitions to another occupation within that cluster (with a range from

FIGURE A4.1

Average share of transition within clusters and comparison with SOC groups



Source: Authors' analysis of CPS-IPUMS.

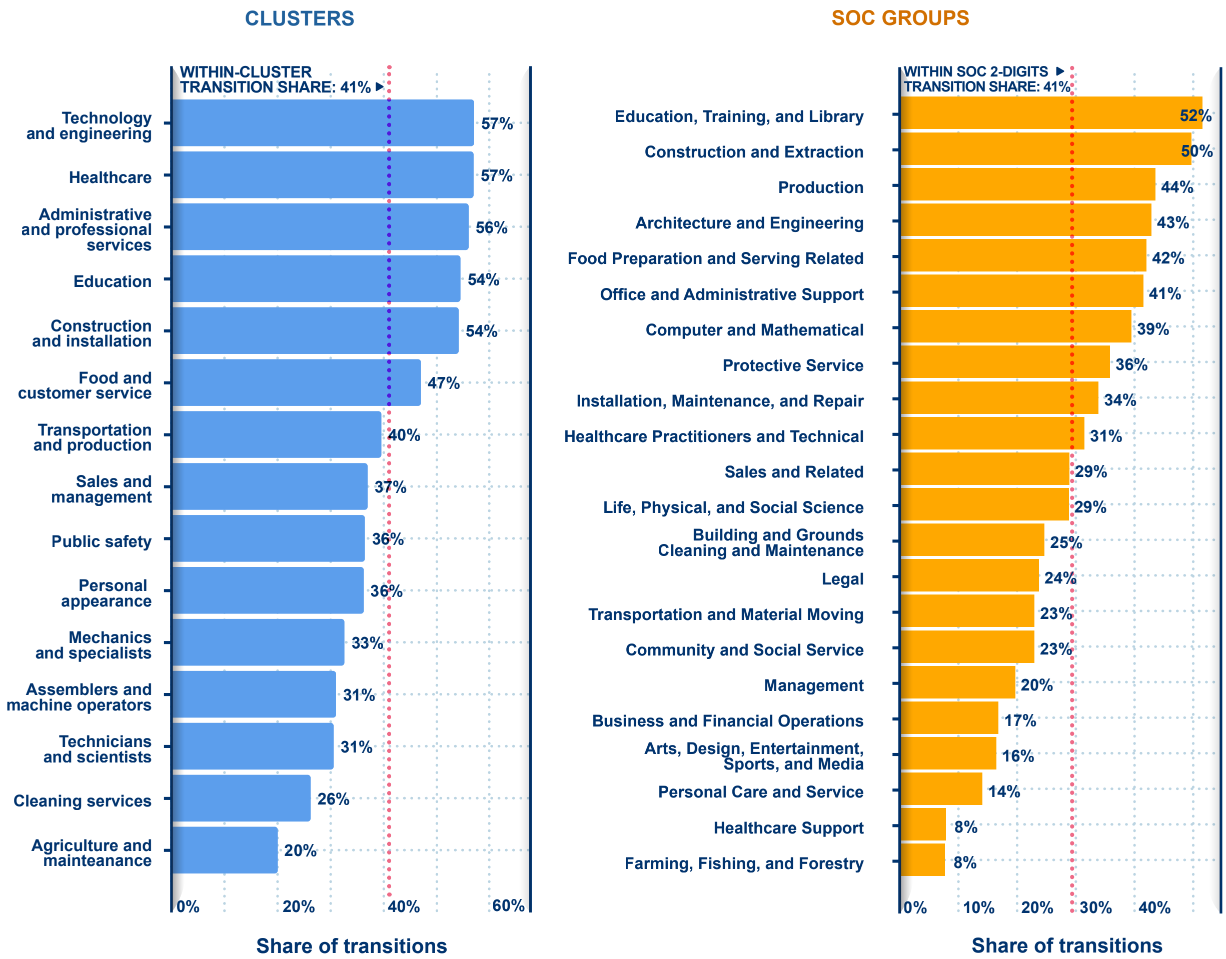
2.1 percent to almost 14.8 percent).[4] By contrast, occupations in the average SOC major group send 2.9 percent of their transitions to another occupation within that SOC group (with a range from 1.5 percent to 11.9 percent).

Similarly, the average cluster receives 41 percent of its total transitions from within the cluster[5], with a range from 20 percent to 57 percent. By contrast, the average SOC group receives 29 percent of its total transitions from within the group, with a range from 8 percent to 52 percent (**Figure A4.2**).

This approach has advantages for labor mobility research. By grouping occupations based on observed transitions, we are looking at how individuals actually move in the labor market. This results in a different categorization of occupations than the SOC code structure, which is based instead on similarities in job skills and other traits. We argue that the clustering method achieves a more representative and useful categorization.

FIGURE A4.2

Overall share of transition within clusters and comparison with SOC groups



Source: Authors' analysis of CPS-IPUMS.

APPENDIX 5

Metrics presented in the Texas Mobility app

We created different metrics to aid the reskilling efforts of the Texas Higher Education Coordinating Board throughout its *Texas Reskilling Support Fund Grant Program* (TRSF) initiative. These metrics were an absorption index, demand index, and quality index, available online for 428 occupations in *The Brookings Workforce of the Future initiative's Texas Workforce Development Toolkit*.

The absorption index is a proxy for how smoothly an occupation could reemploy workers from occupations that shrank between April and August 2020 in each of the 28 Texas Workforce Development Areas (WDA)[1]. The absorption index uses two sources of information: the number of unemployment insurance (UI) claims for each WDA (tagged by 2-digit SOC group) and the CPS occupation-to-occupation transitions matrix. By combining both datasets, we're able to identify the most plausible destinations of workers who applied for UI in a given region, according to the SOC group of their last occupation.

We first find the share of transitions from each origin occupation *a* (at the 2-digit SOC level) to each destination occupation *b* (at the SOCXX level) using the transitions dataset:

$$Reallocation\ Share_{ab} = \frac{t_{ab}}{\sum_b t_{ab}}$$

We then weight this indicator by the number of local UI claims by occupational group, and aggregate it for each destination occupation *b*. The resulting indicator is an estimation of the share of all jobs lost in region *c* that could hypothetically be reallocated into each destination occupation, assuming that every new unemployed worker was able and willing to change occupations, and that the receiving occupation had enough demand to absorb these workers. The final absorption index is the normalized version of this metric, which allows for comparisons across regions and destination occupations:

$$Absorption_{\ bc} = \sum_a \left(\frac{t_{ab}}{\sum_b t_{ab}} x Employment\ loss_{ac} \right)$$

$$Absorption\ Index_{\ bc} = \frac{Absorption_{\ bc} - E(Absorption_{\ bc})}{\sigma(Absorption_{\ bc})}$$

Figure A5.1 illustrates one application of the absorption index metric. The diagrams organize each occupation according to its absorption index in Texas's Gulf Coast and North Central WDAs and its share of workers with at least an associate's degree according to the BLS. Occupations with a high absorption index (the top-left corners of the diagrams) have historically been common destinations for the currently unemployed workers that were displaced by Covid-19 in these two regions. Many of these occupations are also accessible through certifications, apprenticeship, or on the job training.

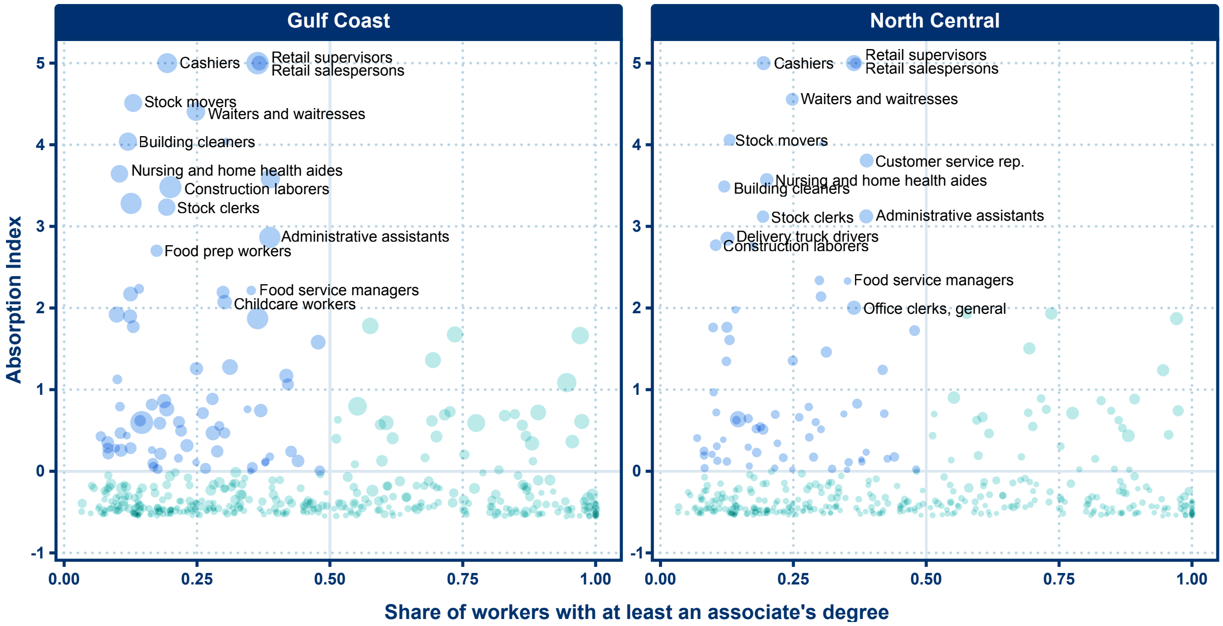
The demand index is a metric reflecting each occupation's historic and estimated future demand by region. It corresponds to the aggregation of two standardized variables: the occupation's contribution to employment growth between 2004 and 2018 and its projected contribution to employment growth between 2018 and 2028, both at the WDA level:

$$Growth\ contribution_{ac,\Delta t} = \frac{Jobs_{ac,t} - Jobs_{ac,t-1}}{\sum_c (Jobs_{ac,t} - Jobs_{ac,t-1})}$$

$$Demand\ Index_{ac} = SC\ Growth\ contribution_{ac,04,18} + SC\ Growth\ contribution_{ac,18,28}$$

FIGURE A5.1

Absorption capacity and educational requirements by occupation

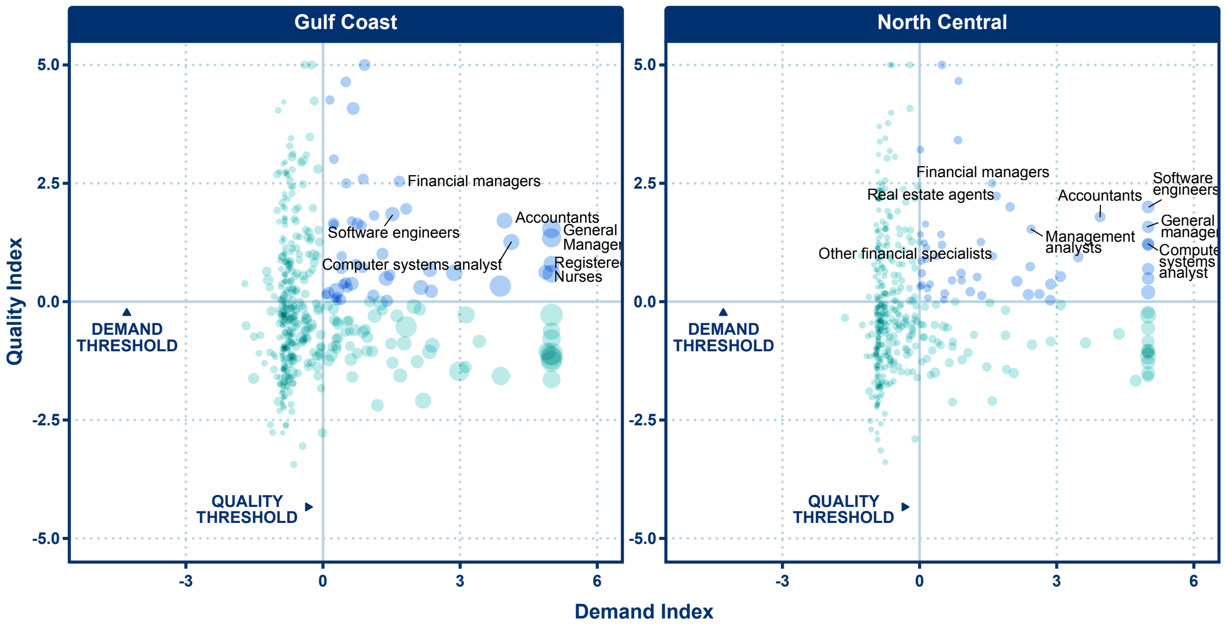


Note: The size of points is proportional to each occupation's number of workers in the respective WDA in 2018.

Source: Authors' analysis of Texas Workforce Commision's data on UI claimants by occupational group and WDA, BLS educational requirements by occupation 2018, CPS-IPUMS, and Emsi occupational employment data.

FIGURE A5.2

Demand and quality diagram



Note: The size of points is proportional to each occupation's number of workers in the respective WDA in 2018. Thresholds show the quality index and demand index of the average occupation.

Source: Authors' analysis of Texas Workforce Commission's data on wages and employment projections by WDA; Emsi occupational employment data.

where the prefix *SC* stands for the standardized value of each score by WDA.

The quality index is a metric reflecting each occupation's local wage level and overall mobility prospects. It is calculated using the occupation's mid-term mobility index (see **Appendix 2**) and its local hourly median wage by WDA. Both metrics are standardized and added together for the construction of the final index:

$$Quality\ Index_{ac} = SC\ Median\ wage_{ac} + SC\ Mobility\ index_{ac}$$

Figure A5.2 reflects occupation's quality and demand indices for Texas's Gulf Coast and North Central WDAs. Occupations appearing in the top right quadrant of the diagrams are both high quality and in high demand, suggesting that they are promising occupations that could offer high wages and mobility to local workers with a good degree of jobs stability over the next decade.

APPENDIX 6

Steppingstone occupations

Network methods offer a toolbox of analytic techniques which must then be matched to substantive concepts in the field of study. Some of its most useful tools characterize the importance of particular nodes or groups of nodes in the overall system and are typically termed centrality measures. There are three main ideas that animate centrality measures in network science. One type (degree, eigenvector) relies on counts of connections. A second (closeness) measures how distant other nodes in the network are. A third (betweenness) looks at whether paths through the network flow through particular ties or nodes. We use BGT resume data and follow workers' careers up to their fifth occupational switch, to focus on this third definition of centrality.

In its standard implementation, betweenness measures the shortest path between every pair of nodes in a network and identifies those nodes appearing in between; nodes with high levels of betweenness appear on many of these shortest paths. Since we're not interested in pathways that lead to bad jobs (or even pathways from good jobs to other good jobs), this definition is too broad for our purposes. Specifically, we are interested in identifying pathways from low-paying to high-paying jobs. Thus, using \$30 per hour as a threshold for high-paying jobs, we construct our "steppingstone" index: a betweenness measure showing the probability that an occupation paying less than \$30 per hour connects even lower-paying occupations with those that pay more than \$30 per hour.

Simply put, the steppingstone index is the share of pathways passing through an occupation that start in an occupation with a median wage less than \$30 per hour and end in an occupation with a median wage greater than \$30 per hour. It is only calculated for occupations with a median wage of less than \$30 per hour; for occupations with higher median wages, the measure is undefined. Occupations that frequently connect the low-middle wage and the high-wage regions of the labor market have a higher steppingstone index. We derive the index as follows:

$$Target_b = \begin{cases} 1\ if\ median\ wage_b \geq \$30/hr \\ 0\ if\ median\ wage_b < \$30/hr \end{cases}$$

$$Steppingstone\ index_c = \frac{\sum_a \sum_b (t_{abc} * Target_b)}{\sum_a \sum_b t_{abc}}$$

where t_{abc} stands for the number of multi-step pathways between occupation *a* and *b* that pass through a third occupation *c*. Occupations *a* and *c* have an hourly median wage below $30 per hour, while *b* could take a median hourly wage above or below $30 per hour.

Tables A6.1 and **A6.2** show the occupations with the highest and lowest steppingstone indexes in our dataset, which range from 3 percent to 37 percent. The occupation with the lowest steppingstone index is Pressers, Textile, and Garment workers; the highest is Biological Technicians. On average, occupations at the higher end of the steppingstone index distribution tend to pay higher median wages and require higher levels of education.

As the formulas above suggest, this metric is flexible to changes in the value of the high-wage threshold. This is important since stakeholders could have different priors on what occupations could be more convenient for low-wage workers across different regions.

TABLE A6.1

Occupations with the highest steppingstone index

Title	Steppingstone index	Total employment	Median wage
Biological technicians	36.50%	79,530	$22
Computer, automated teller, and office machine repairers	35.90%	98,260	$19
New account clerks	34.10%	43,420	$18
Statistical assistants	34.00%	9,810	$24
Other education, training, and library workers	32.70%	314,450	$25
Summary	33.97%	545,470	$23

Source: Authors' analysis of BGT resumes dataset and OEWS 2019.

TABLE A6.2

Occupations with the lowest steppingstone index

Title	Steppingstone index	Total employment	Median wage
Laundry and dry-cleaning workers	4.40%	209,330	$12
Furniture finishers	4.30%	16,220	$16
Packers and packagers, hand	3.50%	633,640	$12
Dishwashers	3.50%	514,330	$12
Pressers, textile, garment, and related materials	3.30%	38,070	$12
Summary	9.41%	1,411,590	$13

Source: Authors' analysis of BGT resumes dataset and OEWS 2019.

APPENDIX 7

Skyway occupations

The central motivation of several elements of our analysis, particularly our assessment of pathways and steppingstones, is to identify upward mobility opportunities for low-wage workers. However, there are no universal pathways to escape from low-wage work. Indeed, a key feature of our cluster analysis is the identification of five clusters marked both by low wages and low mobility prospects ("sandpit" clusters). For workers in these clusters, our analysis of pathways and steppingstones does not offer many realistic opportunities for upward mobility.

To help address the mobility challenges faced by workers in sandpit clusters, we sought to identify "skyway" occupations throughout the network. We categorize skyways as occupations into which workers from low-wage, low-mobility sandpit clusters can feasibly make upward, cross-cluster transitions. Specifically, we define skyways as occupations that offer workers above-average mobility, pay above the origin sandpit cluster's median occupation, frequently receive workers from that cluster, and are expected to add jobs in the coming decade (based on BLS projections under the most disruptive Covid-19 scenario). We measure the feasibility of skyway occupations as a numerical value based on the frequency of standardized transitions. Formally:

$$Target_{cb} = \begin{cases} 1 \; if \; median\ wage_b \geq median\ wage_c \;\; AND \; mobility_b > \; mean\ mobility_c \; AND \; \Delta jobs_{b,19,29} > 0 \\ else \\ 0 \end{cases}$$

$$Skyway\ Score_{cb} = \sum_a t_{ab} \;\; x\, Target_{cb}$$

where sandpit clusters are represented by *c*, *a* represents any occupation in the cluster *c*, and *b* stands for any occupation outside cluster *c*.

APPENDIX 8

Summary statistics of clusters

Tables A8.1 and **A8.2** show summary labor market and demographic information for clusters and meta-clusters, including metrics on total employment, wage levels, occupational mobility, gender and racial composition, and projected growth.

APPENDIX 9

Clusters' membership

Table A9.1 presents the twenty largest occupations of each cluster according to the OEWS 2019. The online data file gives cluster membership and other statistics for every occupation.

TABLE A8.1

Composition of occupational clusters

Meta cluster	Cluster	Number of workers	Share of U.S employ-ment	Median hourly wage	Mean hourly wage	Share of internal transitions	Share of upward transitions	Share of internal upward transitions	Projected growth (2019-2029)	Share of part time workers	Share of workers w/ Bachelor's degree or more	Share of female workers	Share of Black workers	Share of Hispanic workers	Share of workers in low-wage occupations
High-wages + high-mobility	Technology and engineering	8,520,710	6.00%	$43	$45	57%	71%	51%	8.50%	6.70%	69.10%	25.70%	6.40%	8.30%	0.30%
Average-wage + average-mobility	Sales and management	22,168,510	15.60%	$31	$29	37%	49%	19%	1.70%	22.70%	38.40%	48.60%	10.10%	14.40%	42.00%
	Technicians and scientists	2,507,700	1.80%	$29	$33	31%	59%	24%	3.40%	16.00%	38.40%	44.00%	7.80%	13.30%	0.00%
	Education	14,492,190	10.20%	$26	$27	55%	54%	34%	6.60%	24.00%	68.50%	69.40%	12.00%	12.00%	36.60%
	Construction and installation	6,966,090	4.90%	$25	$26	54%	50%	32%	4.90%	9.60%	8.40%	4.00%	6.70%	30.70%	7.40%
	Mechanics and specialists	4,675,910	3.30%	$21	$22	33%	46%	20%	3.40%	7.00%	6.50%	3.50%	7.80%	19.90%	6.10%
	Administrative and professional services	24,578,680	17.30%	$21	$27	56%	53%	29%	−0.9%	16.40%	37.30%	72.60%	11.70%	14.10%	33.90%
	Agriculture and mainteanance	3,090,620	2.20%	$19	$22	20%	50%	8%	1.00%	14.00%	24.50%	24.30%	8.40%	29.70%	51.20%
	Public safety	2,990,050	2.10%	$16	$22	36%	53%	22%	2.40%	14.40%	24.80%	24.50%	19.80%	14.50%	58.40%
Health care	Health care	14,612,720	10.30%	$23	$30	57%	43%	25%	12.00%	21.90%	39.00%	80.20%	17.20%	12.80%	46.40%
Sandpit: Low-wage + low-mobility	Assemblers and machine operators	4,277,160	3.00%	$18	$19	31%	39%	10%	−6.3%	7.90%	6.10%	25.70%	12.40%	20.20%	57.30%
	Transportation and production	15,823,790	11.10%	$16	$19	40%	40%	11%	1.30%	17.60%	10.60%	24.00%	16.80%	22.50%	58.70%
	Personal appearance	807,640	0.60%	$15	$17	36%	38%	7%	5.20%	29.60%	13.70%	80.10%	8.80%	16.00%	73.00%
	Cleaning services	4,773,390	3.40%	$14	$16	26%	40%	3%	3.50%	25.50%	7.70%	39.30%	16.70%	30.90%	84.00%
	Food and customer	11,851,050	8.30%	$12	$13	47%	34%	14%	5.80%	52.20%	12.70%	60.30%	11.40%	21.60%	96.90%
Total		142,136,210	100.00%	$20	$25	45.90%	48.60%	23.40%	3.90%	20.80%	32.30%	50.00%	12.50%	17.10%	44.30%

Source: Authors' analysis of CPS-IPUMS, IPUMS USA, and OEWS 2019.

TABLE A8.2

Composition of occupational meta-clusters

Meta cluster	Number of workers	Share of U.S employ-ment	Median hourly wage	Mean hourly wage	Share of internal transitions	Share of upward transitions	Share of internal upward transitions	Projected growth (2019-2029)	Share of part time workers	Share of workers w/ Bachelor's degree or more	Share of female workers	Share of Black workers	Share of Hispanic workers	Share of workers in low-wage occupations
High-wages + high-mobility	8,520,710	6.00%	$43	$45	57%	71%	51%	8.50%	6.70%	69.10%	25.70%	6.40%	8.30%	0.30%
Average-wage + average-mobility	81,469,750	57.30%	$22	$27	76%	52%	42%	2.20%	18.20%	38.00%	51.20%	10.70%	16.10%	33.30%
Health care	14,612,720	10.30%	$23	$30	57%	43%	25%	12.00%	21.90%	39.00%	80.20%	17.20%	12.80%	46.40%
Sandpit: Low-wage + low-mobility	37,533,030	26.40%	$15	$17	58%	38%	15%	2.20%	28.80%	10.60%	38.80%	14.40%	22.90%	74.00%
Total	142,136,210	100.00%	$20	$25	45.90%	48.60%	23.40%	3.90%	20.80%	32.30%	50.00%	12.50%	17.10%	44.30%

Source: Authors' analysis of CPS-IPUMS, IPUMS USA, and OEWS 2019.

TABLE A9.1

Top largest occupations by cluster

CLUSTER	OCCUPATIONS			
	Top 5	6th to 10th	11th to 15th	16th to 20th
Technology and engineering	Computer systems analyst	Industrial engineers	Drafters	Operations analyst
	Software engineers	Electrical engineers	Broadcast technicians	Other media workers
	Network systems analyst	Civil engineers	Other engineers	Computer repairers
	Designers	Mechanical engineers	Architects	Artists
	It managers	Architectural managers	Database administrators	Other mathematical science workers
Sales and management	Retail salespersons	Retail supervisors	Goods buyers	Property managers
	Cashiers	Other service sales rep.	Counter clerks	Real estate agents
	Business operations specialist	Management analysts	Executives & legislators	Production managers
	General managers	Production worker supervisors	Parts salespersons	Transportation technicians
	Wholesale sales rep.	Other managers	Pr specialists	Telemarketers
Technicians and scientists	Engineering technicians	Other life scientists	Materials scientists	Electronic technicians
	Dental assistants	Dentists	Biological technicians	Astronomers and physicists
	Telecom equipment repairers	Telecom line installers	Medical device technicians	Radiation therapists
	Dental hygienists	Power-line installers	Instrumentation technicians	Other physical scientists
	Other science technicians	Biological scientists	Chemical technicians	Space scientists
Education	Primary school teachers	Counselors	Preschool teachers	Administrative managers
	Postsecondary teachers	Social service specialists	Education administrators	Athletes
	Teacher assistants	Fitness workers	Special education teachers	Community managers
	Other teachers	Social workers	Other entertainment workers	Speech language pathologists
	Secondary school teachers	Childcare workers	Other education workers	Govt. Program interviewers
Construction and installation	Construction laborers	Construction operators	Cement masons	Masons
	Carpenters	Construction managers	Highway maintenance workers	Electronics repairers
	Electricians	Construction helpers	Roofers	Flooring installers
	Construction supervisors	Painters	Drywall & ceiling tile installers	Extraction machinery laborers
	Pipelayers & plumbers	Cost estimators	Cabinetmakers	Other extraction workers

Note: Shortened versions of occupation names are used in this table. Each occupation has its own SOCXX code.

TABLE A9.1 CON'T

CLUSTER	OCCUPATIONS			
	Top 5	6th to 10th	11th to 15th	16th to 20th
Mechanics and specialists	General repair workers	Heavy equipment mechanics	Sheet metal workers	Small engine mechanics
	Vehicle mechanics	Other repair workers	Other maintenance helpers	Power plant workers
	Industrial machinery mechanics	Painting workers	Other plant operators	Millwrights
	Hvac technicians	Vehicle body repairers	Metal fabricators	Plant utilities engineers
	Diesel engine specialists	Other vehicle mechanics	Machinery maintenance workers	Home appliance repairers
Administrative and professional services	Administrative assistants	Accountants	Financial clerks	Production clerks
	Office clerks, general	Receptionists	Billing clerks	Loan officers
	Customer service rep.	Lawyers & judges	Other financial specialists	Legal assistants
	Accounting clerks	Hr specialists	Financial services agents	Financial analysts
	Administrative supervisors	Financial managers	Insurance agents	Claims adjusters
Agriculture and mainteanance	Groundskeeping workers	Building inspectors	Sawing machine workers	Transportation inspectors
	Product inspectors	Groundskeeping supervisors	Logging workers	Agricultural supervisors
	Other agricultural workers	Other practitioners & technicians	Agricultural sorters	Food science technicians
	Compliance officers	Funeral service workers	Conservation scientists	Agricultural inspectors
	Environmental scientists	Material recordkeepers	Food scientists	Forest conservation workers
Public safety	Security guards	Police supervisors	Private investigators	
	Correctional officers	Criminal investigators	Fire inspectors	
	Other public safety workers	Other public safety supervisors		
	Firefighters	Fire department supervisors		
	Paramedics	Correctional supervisors		
Healthcare	Registered nurses	Practical and vocational nurses	Lab technicians	Occupational therapists
	Nursing and home health aides	Physicians and surgeons	Pharmacists	Respiratory therapists
	Personal care aides	Healthcare managers	Physical therapists	Psychologists
	Other healthcare support workers	Diagnostic technicians	Animal caretakers	Physician assistants
	Health support technicians	Other health technicians	Physical therapy aides	Massage therapists

Note: Shortened versions of occupation names are used in this table. Each occupation has its own SOCXX code.

TABLE A9.1 CON'T

CLUSTER	OCCUPATIONS			
	Top 5	6th to 10th	11th to 15th	16th to 20th
Assemblers and machine operators	Other assemblers	Electronics assemblers	Extruding machine operators	Other textile workers
	Machine fabricators	Computer operators	Tool & die makers	Rolling machine operators
	Machinists	Sewing machine operators	Engine assemblers	Textile winding operators
	Model & patternmakers	Aircraft mechanics	Molders	Tailors
	Machine tool operators	Metal & plastic workers	Aircraft assemblers	Metal furnance workers
Transportation and production	Delivery truck drivers	Packagers	Mail carriers	Logisticians
	Stock movers	Industrial truck operators	Production helpers	Transportation attendants
	Stock clerks	Transportation supervisors	Production workers	Order clerks
	Shipping clerks	Packaging operators	Prepress operators	Chemical equipment operators
	Taxi drivers	Meat processors	Preparation operators	Shipping managers
Personal appearance	Hairdressers			
	Personal service supervisors			
	Personal appearance workers			
	Barbers			
Cleaning services	Building cleaners	Janitorial supervisors	Hazardous waste removers	
	House cleaners	Parking lot attendants	Textile pressers	
	Mechanic supervisors	Porters & concierges		
	Equipment cleaners	Pest control workers		
	Laundry workers	Other personal care workers		
Food and customer service	Waiters and waitresses	Bartenders	Food service managers	Cooking equipment operators
	Food service workers	Other hospitality workers	Bakers	Travel guides
	Counter attendants	Dishwashers	Food batchmakers	Roaster operators
	Food service supervisors	Hosts and hostesses	Ticket takers	
	Food prep workers	Food servers, nonrestaurant	Chefs	

Note: Shortened versions of occupation names are used in this table. Each occupation has its own SOCXX code.

References

Chapter 1

1 Lesley Williams Reid and Beth A. Rubin, "Integrating Economic Dualism and Labor Market Segmentation: The Effects of Race, Gender, and Structural Location on Earnings, 1974–2000," *The Sociological Quarterly* 44, no. 3 (June 1, 2003): 405–32, https://doi.org/10.1111/j.1533-8525.2003.tb00539.x.

2 Kenneth Hudson, "The New Labor Market Segmentation: Labor Market Dualism in the New Economy," *Social Science Research* 36, no. 1 (March 2007): 286–312, https://doi.org/10.1016/j.ssresearch.2005.11.005.

3 William T. Dickens and Kevin Lang, "A Test of Dual Labor Market Theory," *The American Economic Review* 75, no. 4 (1985): 792–805.

4 Anjali Bhatt, Melina Kolb, and Olivier Ward, "How to Fix Economic Inequality? An Overview of Policies for the United States and Other High-Income Economies" (Washington, D.C.: Peterson Institute for International Economics, 2020), https://www.piie.com/sites/default/files/documents/how-to-fix-economic-inequality.pdf.

5 Ibid.

6 Michael D. Carr and Emily E. Wiemers, "The Decline in Lifetime Earnings Mobility in the U.S.: Evidence from Survey-Linked Administrative Data" (Washington, D.C.: Washington Center for Equitable Growth, 2016), https://equitablegrowth.org/working-papers/the-decline-in-lifetime-earnings-mobility-in-the-u-s-evidence-from-survey-linked-administrative-data/.

7 Juliana Menasce Horowitz, Rich Morin, and Kim Parker, "Looking to the Future, Public Sees an America in Decline on Many Fronts," (Washington D.C.: Pew Research Center, March 2019), https://www.pewresearch.org/social-trends/2019/03/21/public-sees-an-america-in-decline-on-many-fronts/.

8 David Autor, David Mindell, and Elisabeth Reynolds, "The Work of the Future: Building Better Jobs in an Age of Intelligent Machines," (Cambridge, MA: MIT Task Force on the Work of the Future, 2020), https://workofthefuture.mit.edu/wp-content/uploads/2021/01/2020-Final-Report4.pdf.

9 Pablo Chauvin et al., "What is Different about Urbanization in Rich and Poor Countries? Cities in Brazil, China, India and the United States," NBER Working Paper 22002, (Cambridge, MA: National Bureau of Economic Research, February 2016), https://www.nber.org/system/files/working_papers/w22002/w22002.pdf.

10 Authors' analysis of OEWS data (appendix A1.3.1 and A1.3.2).

11 Roxanne Connelly, Vernon Gayle, and Paul S. Lambert, "A Review of Occupation-Based Social Classifications for Social Survey Research," *Methodological Innovations* 9 (January 1, 2016):205979911663800, https://doi.org/10.1177/2059799116638003.

12 William E. Even and David A. Macpherson, "The Wage and Employment Dynamics of Minimum Wage Workers," *Southern Economic Journal* 69, no. 3 (2003): 676–90, https://doi.org/10.2307/1061701.

13 Helen Connelly and Peter Gottschalk, "Differences in Wage Growth by Education Level: Do Less-educated Workers Gain Less from Work Experience?," IZA Discussion Papers, No. 2331, (Bonn, Germany: IZA – Institute of Labor Economics, September 2006), http://ftp.iza.org/dp2331.pdf.

14 Stephen G. Broners and Melissa Famulari, "Wage, Tenure, and Wage Growth Variation within and across Establishments," *Journal of Labor Economics* 15, no. 2 (April 1997): 285-317.

15 See appendix A2.

16 Sharon Traiberman, "Occupations and Import Competition: Evidence from Denmark," *American Economic Review* 109, no. 12 (December 2019): 4260-4301.

17 Thomas L. Hungerford, "How Income Mobility Affects Income Inequality: US Evidence in the 1980s and the 1990s," *Journal of Income Distribution* 20, no. 1, (March 2011): 117-126

18 OECD, "A Broken Social Elevator? How to Promote Social Mobility," (Paris, France: OECD, June 2018), https://doi.org/10.1787/9789264301085-en.

19 Jessica Pearlman, " Gender Differences in the Impact of Job Mobility on Earnings: The Role of Occupational Segregation," *Social Science Research* 74, (August 2018): 30-44, page 28, Table 2, Model 1a.

20 Kenneth I. Wolpin, "The Determinants of Black-White Differences in Early Employment Careers: Search, Layoffs, Quits, and Endogenous Wage Growth," *Journal of Political Economy* 100, no. 3 (June 1992): 535-60

21 Eric Grodsky and Devah Pager, "The Structure of Disadvantage: Individual and Occupational Determinants of the Black-White Wage Gap," *American Sociological Review* 66, no. 4 (August 2001): 542-567.

22 Sigal Alon and Marta Tienda, "Job Mobility and Early Career Wage Growth of White, African-American, and Hispanic Women," *Social Science Quarterly* 86, no. s1 (2005): 1196–1217, https://doi.org/10.1111/j.0038-4941.2005.00342.x.

23 Julia Beckhusen and Liana Christin Landivar, "Racial Disparities in Women's Mobility out of Retail and Service Occupations," (Washington, D.C.: U.S. Census Bureau, February 2019), https://www.census.gov/library/working-papers/2019/demo/SESHD-WP2019-03.html.

24 Chunhui Ren, " Fluctuating Courses and Constant Challenges: The Two Trajectories of Black-white Earnings Inequality, 1968–2015," *Social Science Research* 77, (January 2019): 30-44.

25 Office of Management and Budget, "North American Industry Classification System," (United States: 2017), https://www.census.gov/naics/reference_files_tools/2017_NAICS_Manual.pdf.

26 Ibid.

Box 1.1

1 Sarah Flood, Miriam King, Renae Rodgers, Steven Ruggles and J. Robert Warren. Integrated Public Use Microdata Series, Current Population Survey: Version 8.0 [dataset]. Minneapolis, MN: IPUMS, 2020. https://doi.org/10.18128/D030.V8.0

2 Henry S. Farber, "The Changing Face of Job Loss in the United States, 1981-1995," (Washington, D.C.: The Brookings Institution, 1997), https://www.brookings.edu/bpea-articles/the-changing-face-of-job-loss-in-the-united-states-1981-1995/.

Chapter 2

1 Craig Holmes and Gerbrand Tholen, "Occupational Mobility and Career Paths in the 'Hourglass' Labour Market," (Oxford, U.K.: University of Oxford, 2013), https://www.semanticscholar.org/paper/Occupational-Mobility-and-Career-Paths-in-the-Holmes-Tholen/9f7632f0d4eaf8c6adb5260b6036d03b5b98e6d6#paper-header.

2 Jonathan James, "The College Wage Premium," (Ohio, U.S.: Federal Reserve Bank of Cleveland, August 2012), https://www.clevelandfed.org/en/newsroom-and-events/publications/economic-commentary/economic-commentary-archives/2012-economic-commentaries/ec-201210-the-college-wage-premium.aspx.

3 Josh Bivens et al., "Raising America's Pay: Why It's Our Central Economic Policy Challenge" (Washington, D.C.: Economic Policy Institute, June 2014), epi.org/publication/raising-americas-pay/.

4 James J. Heckman, Robert J. Lalonde, and Jeffrey A. Smith, "The Economics and Econometrics of Active Labor Market Programs," in *Handbook of Labor Economics*, vol. 3 (Elsevier, 1999), 1865–2097, https://doi.org/10.1016/S1573-4463(99)03012-6.

5 Eduardo Levy Yeyati, Martín Montané, and Luca Sartorio, "What Works for Active Labor Market Policies?," (Massachusetts, U.S.: Center for International Development at Harvard University, July 2019),https://growthlab.cid.harvard.edu/files/growthlab/files/2019-07-cid-wp-358-labor-market-policies.pdf.

6 Stephen Vaisey, "Education and Its Discontents: Overqualification in America, 1972–2002," *Social Forces* 85, no. 2 (December 1, 2006): 835–64, https://doi.org/10.1353/sof.2007.0028.

7 Camille Busette et al., "How We Rise: How Social Networks Impact Economic Mobility in Racine, WI, San Francisco, CA, and Washington, D.C.," (Washington, D.C.: The Brookings Institution, January 2021).

8 Alicia Sasser Modestino, "Downskilling: Changes in Employer Skill Requirements over the Business Cycle," (Boston, MA: Federal Reserve Bank of Boston, December 2014) https://www.econstor.eu/bitstream/10419/171763/1/868653179.pdf.

9 Martin Luther King, *Where Do We Go from Here: Chaos or Community?* (Boston: Beacon Press, 1967).

10 Ronald D'Amico and Peter Z. Schochet, "The Evaluation of the Trade Adjustment Assistance Program: A Synthesis of Major Findings," (California, U.S.: Mathematica Policy Research, December 2012), https://mathematica.org/publications/the-evaluation-of-the-trade-adjustment-assistance-program-a-synthesis-of-major-findings.

11 Martín Montané and Eduardo Levy Yeyati, "Specificity of Human Capital: An Occupation Space Based on Job-to-Job Transitions," (Massachusetts, U.S.: Center for International Development at Harvard University, May 2020), https://growthlab.cid.harvard.edu/files/growthlab/files/2020-04-cid-wp-379-specificity-human-cap-revised.pdf.

12 Christina Gathmann et al., "How General is Human Capital? A Task-Based Approach," (Bonn, Germany: IZA – Institute of Labor Economics, September 2007), http://ftp.iza.org/dp3067.pdf.

13 Kyle DeMaria, Kyle Fee, and Keith Wardrip, "Exploring a Skills-Based Approach to Occupational Mobility," (Philadelphia, PA: Federal Reserve Bank of Philadelphia, June 2020), https://www.philadelphiafed.org/community-development/workforce-and-economic-development/exploring-a-skills-based-approach-to-occupational-mobility.

14 Francine D. Blau, Peter Brummund, and Albert Yung-Hsu Liu, "Trends in Occupational Segregation by Gender 1970-2009: Adjusting for the Impact of Changes in the Occupational Coding System," NBER Working Paper 17993, (Cambridge, MA: National Bureau of Economic Research, April 2012), https://www.nber.org/system/files/working_papers/w17993/w17993.pdf.

Box 2.1

1 Edward J. Feser, "What Regions Do Rather than Make: A Proposed Set of Knowledge-based Occupation Clusters," Urban Studies 40, no. 10 (September 2003): 1937-1958

2 Ahmad Alabdulkareem et al., "Unpacking the Polarization of Workplace Skills," *Science Advances* 4, no. 7 (July 2018).

Chapter 3

Box 3.1

1 We use Serrano and Vespignani et al. (2009) filtering method of weighted networks to minimize the chances that high-centrality occupations (some attached to more than half of the occupations in the network) bias the clustering outcomes. See Appendix A4 for more details.

2 See Vincent D. Blondel et al., "Fast Unfolding of Communities in Large Networks," *Journal of Statistical Mechanics: Theory and Experiment* 2008, no. 10 (October 9, 2008): P10008, https://doi.org/10.1088/1742-5468/2008/10/P10008.

3 See Aaron Clauset, "Finding Community Structure in Very Large Networks," *Physical Review* E 70, no. 4, (August 2004) for a detail discussion of modularity, and appendix A4 for more details on how we applied in the search of occupational clusters.

4 "Standard Occupational Classification (SOC) System," U.S. Bureau of Labor Statistics, accessed June 9, 2021, https://www.bls.gov/soc/.

Chapter 4

1 Simon Mongey, Laura Pilossoph, and Alex Weinberg, "Which Workers Bear the Burden of Social Distancing?," NBER Working Paper 27085, (Cambridge, MA: National Bureau of Economic Research, March 2021), http://www.nber.org/papers/w27085.

2 David Autor and Elisabet Reynolds, "The Nature of Work after the COVID Crisis: Too Few Low-Wage Jobs" (Washington, D.C.: The Brookings Institution, July 2020), https://www.brookings.edu/wp-content/uploads/2020/08/AutorReynolds_LO_FINAL.pdf.

3 "Effects of the COVID-19 Pandemic : U.S. Bureau of Labor Statistics," U.S. Bureau of Labor Statistics, accessed June 10, 2021, https://www.bls.gov/emp/notices/2020/pandemic-effects-soon.htm.

4 "Employee Benefits in the United States" (Washington D.C.: Bureau of Labor Statistics, March 2020), https://www.bls.gov/news.release/pdf/ebs2.pdf.

5 "A $15 Minimum Wage for New York's Fast-Food Workers" (National Employment Law Project, July 2015), https://www.nelp.org/wp-content/uploads/Fact-Sheet-15-Minimum-Wage-for-New-York-Fast-Food-Workers.pdf.

6 Ibid.

7 "Non-Traditional Work" (The Aspen Institute), https://www.aspeninstitute.org/programs/future-of-work/nontraditional-work/.

8 "Employee Benefits in the United States" (Washington D.C.: Bureau of Labor Statistics, March 2020), https://www.bls.gov/news.release/pdf/ebs2.pdf.

9 David Rolf, Shelby Clark, and Watterson Bryant, "Portable Benefits in the 21st Century: Shaping a New System of Benefits for Independent Workers," (Washington, D.C.: The Aspen Institute, 2016), https://www.aspeninstitute.org/publications/portable-benefits-21st-century/.

10 Olivia S. Mitchell, "Fringe Benefits and Labor Mobility," *The Journal of Human Resources* 17, no. 2 (1982): 286, https://doi.org/10.2307/145474.

11 Libby Reder, Shelly Steward, and Natalie Foster, "Designing Portable Benefits: A Resource Guide for Policymakers" (Washington, D.C.: Aspen Institute, June 2019), https://assets.aspeninstitute.org/wp-content/uploads/2019/06/Designing-Portable-Benefits_June-2019_Aspen-Institute-Future-of-Work-Initiative.pdf?_ga=2.183053029.2143180557.1623252145-1072458967.1623252145.

12 Chad Stone and Matt Staenz, "Labor Market Weaker Than Headline Numbers Suggest" (Washington D.C.: Center on Budget and Policy Priorities, March 1, 2021), https://www.cbpp.org/research/economy/labor-market-weaker-than-headline-numbers-suggest.

Box 4.1

1 Marcela Escobari, Dhruv Gandhi, and Sebastian Strauss, "How Federal Infrastructure Investment Can Put America to Work" (Washington, D.C.: The Brookings Institution, March 17, 2021), https://www.brookings.edu/research/how-federal-infrastructure-investment-can-put-america-to-work/.

Chapter 5

1 Gueorgui Kambourov and Iourii Manovskii, "Occupational Specificity of Human Capital," *International Economic Review* 50, no. 1 (February 2009): 63–115, https://doi.org/10.1111/j.1468-2354.2008.00524.x; Alexandros Zangelidis, "Occupational and Industry Specificity of Human Capital in the British Labour Market," *Scottish Journal of Political Economy* 55, no. 4 (September 2008): 420–43, https://doi.org/10.1111/j.1467-9485.2008.00460.x.

2 Christina Gathmann and Uta Schönberg, "How General Is Human Capital? A Task-Based Approach," *Journal of Labor Economics* 28, no. 1 (January 2010): 1–49, https://doi.org/10.1086/649786.

3 Paul Sullivan, "A Dynamic Analysis of Educational Attainment, Occupational Choices, and Job Search," *International Economic Review* 51, no. 1 (February 2010): 289–317, https://doi.org/10.1111/j.1468-2354.2009.00580.x.

4 Livia Lam, "A Design for Workforce Equity," (Washington, D.C., U.S.: Center for American Progress, October 2019) https://www.americanprogress.org/issues/economy/reports/2019/10/16/475875/design-workforce-equity/#fn-475875-70

5 While a body of literature also documents racial discrepancies in the financial service sector between white and Black groups, CPS sample sizes were insufficient to allow for meaningful analysis.

6 Home health aides and personal care aides typically work in individuals' homes or at long-term care facilities under the supervision of registered nurses or physicians and assist with basic medical and non-medical tasks. Licensed practical and vocational nurses are required to complete specialized educational programs and pass the NCLEX-PN exam. They perform a broader array of medical tasks than home health and personal care aides, including monitoring tube and IV sites, using nasogastric tubes, and inserting catheters. Registered nurses obtain more advanced education than LPNs, obtaining an Associate or Bachelor's degree in nursing, and must pass the NCLEX-RN exam. They have a much broader scope of practice than LPNs, including administering IV medications, developing care plans, and administering chemotherapy medications or dialysis. They typically report directly to physicians, while LPNs report to RNs.

7 "LPN versus RN | What Are the Differences?," NursingLicensure.Org (blog), November 4, 2020, https://www.nursinglicensure.org/articles/lpn-versus-rn/.

8 Antonia M Villarruel, "Bridges and Barriers: Educational Mobility of Hispanic Nurses," *Journal of Nursing Education* 40, no. 6 (September 2001).

9 Kechi Iheduru-Anderson, "Barriers to Career Advancement in the Nursing Profession: Perceptions of Black Nurses in the United States," *Nursing Forum* 55, no. 4 (November 2020): 664–77, https://doi.org/10.1111/nuf.12483.

10 Jean Moore and Tracey Continelli, "Racial/Ethnic Pay Disparities among Registered Nurses (RNs) in U.S. Hospitals: An Econometric Regression Decomposition," *Health Services Research* 51, no. 2 (April 2016): 511–29, https://doi.org/10.1111/1475-6773.12337

11 Helen G. Gabre, Dale L. Flesher, and Frank Ross, "CPA Credential Perceptions: A Case Study of Hispanic Accountants," *Accounting Education* 26, no. 1 (January 2, 2017): 54–77, https://doi.org/10.1080/09639284.2016.1274910.

12 "2019 Trends in the Supply of Accounting Graduates and the Demand for Public Accounting Recruits" (The Association of International Certified Professional Accountants), https://www.aicpa.org/content/dam/aicpa/interestareas/accountingeducation/newsandpublications/downloadabledocuments/2019-trends-report.pdf.

13 Sapna Cheryan et al., "Double Isolation: Identity Expression Threat Predicts Greater Gender Disparities in Computer Science," *Self and Identity* 19, no. 4 (May 22, 2019): 412–34.

14 Allison Master et al., "Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science," *Journal of Educational Psychology* 108, no. 3 (April 2016): 424-437.

15 Ming-Te Wang et al., "Math achievement is important, but task values are critical, too: examining the intellectual and motivational factors leading to gender disparities in STEM careers," *Front. Psychol.* 6, no. 36 (November 2014).

16 2018 5-year estimates are used from the IPUMS USA dataset: Steven Ruggles, Sarah Flood, Sophia Foster, Ronald Goeken, Jose Pacas, Megan Schouweiler and Matthew Sobek. IPUMS USA: Version 11.0 [dataset]. Minneapolis, MN: IPUMS, 2021. https://doi.org/10.18128/D010.V11.0.

17 "Pathways for Advancing Careers and Education (PACE)," Career Pathways, accessed June 11, 2021, https://career-pathways.org/acf-sponsored-studies/pace/.

18 Karen Gardiner and Randall Juras, "Cross-Program Implementation and Impact Study Findings" (Rockville, MD: Pathways for Advancing Careers and Education, February 2019).

19 Cynthia Degazon and Crystal Mancha, "Changing the Face of Nursing: Reducing Ethnic and Racial Disparities in Health," *Family and Community Health* 35, no. 1 (March 2012): 5–14, https://doi.org/10.1097/FCH.0b013e3182385cf6.

20 Ted Murray et al., "Nursing Workforce Diversity Project: Strategies for Recruitment, Retention, Graduation, and NCLEX-RN Success," *Nursing Education Perspectives* 37, no. 3 (June 2016): 138–43.

21 Arne Kalleberg and Ted Mouw, "Occupations, Organizations, and Intragenerational Career Mobility," *Annual Review of*

Sociology 44 (July 2018): 283–303, https://doi.org/10.1146/annurev-soc-073117-041249.

22 A.-K. Kronberg, "Stay or Leave? Externalization of Job Mobility and the Effect on the U.S. Gender Earnings Gap, 1979-2009," Social Forces 91, no. 4 (June 1, 2013): 1117–46, https://doi.org/10.1093/sf/sot041.

23 Paul Osterman, "Skill Training for Adults" (Cambridge, MA: MIT Work of the Future, October 2020), https://workofthefuture.mit.edu/wp-content/uploads/2020/11/2020-Research-Brief-Osterman3.pdf.

24 Peter H Cappelli, "Skill Gaps, Skill Shortages, and Skill Mismatches: Evidence and Arguments for the United States," *ILR Review* 68, no. 2 (March 2015): 251–90.

25 Daron Acemoglu and Jorn-Steffen Pischke, "Why Do Firms Train? Theory and Evidence," *The Quarterly Journal of Economics* 113, no. 1 (February 1998): 79–119.

26 Lawrence Katz and Alan Krueger, "The Rise and Nature of Alternative Work Arrangements in the United States, 1995-2015," NBER Working Paper 22667, (Cambridge, MA: National Bureau of Economic Research, September 2016), https://www.nber.org/system/files/working_papers/w22667/w22667.pdf.

27 Heather Boushey and Sarah Jane Glynn, "There Are Significant Business Costs to Replacing Employees" (Washington, D.C.: Center for American Progress, November 16, 2012), https://www.americanprogress.org/wp-content/uploads/2012/11/CostofTurnover.pdf.

28 Brigitte C Madrian, "Employment-Based Health Insurance and Job Mobility: Is There Evidence of Job-Lock?," *The Quarterly Journal of Economics* 109, no. 1 (February 1994): 27–54.

29 Youngsang Kim et al., "The Effects of Staffing and Training on Firm Productivity and Profit Growth Before, During, and After the Great Recession," *Journal of Applied Psychology* 99, no. 3 (December 2016)

30 Scott Brum, "What Impact Does Training Have on Employee Commitment and Employee Turnover?," Seminar Research Paper Series (Rhode Island, U.S.: Schmidt Labor Research Center, 2007).

31 Matthew Bidwell, "Paying More to Get Less: The Effects of External Hiring versus Internal Mobility," *Administrative Science Quarterly* 56, no. 3 (December 2011).

32 Zeynep Ton, The Good Jobs Strategy: How the Smartest Companies Invest in Employees to Lower Costs and Boost Profits (Boston: New Harvest, Houghton Mifflin Harcourt, 2014).

33 "The Problem with Accounting for Employees as Costs Instead of Assets," *Harvard Business Review*, October 17, 2019, https://hbr.org/2019/10/the-problem-with-accounting-for-employees-as-costs-instead-of-assets.

34 David Freiberg et al., "Accounting for Organizational Employment Impact" (Cambridge, MA: Harvard Business School, October 2020), https://www.hbs.edu/ris/Publication%20Files/21-050_02b3dec4-b30f-4fd4-aa41-2d6a4933383b.pdf.

35 "Global Business Leaders Support ESG Convergence by Committing to Stakeholder Capitalism Metrics," World Economic Forum, accessed June 10, 2021, https://www.weforum.org/press/2021/01/global-business-leaders-support-esg-convergence-by-committing-to-stakeholder-capitalism-metrics-73b5e9f13d/.

36 "The Opportunity - Impact-Weighted Accounts - Harvard Business School," accessed June 10, 2021, https://www.hbs.edu/impact-weighted-accounts/the-opportunity/Pages/default.aspx.

37 A recent review of training subsidy literature from Dauth (2020) found that job training subsidies generally yield positive effects for unemployed workers, but the effects of programs that target employed, low-wage workers are more mixed. Still, positive, replicable models exist, and expanding on them would be a step in the right direction.

38 Harry J. Holzer et al., "Are Training Subsidies for Firms Effective? The Michigan Experience," *Industrial and Labor Relations Review* 46, no. 4 (February 1993): 625-636

39 Kevin Hollenbeck, "Is There a Role for Public Support of Incumbent Worker On-the-Job Training?," (Michigan, U.S.: W.E. Upjohn Institute for Employment Research, January 2008) https://research.upjohn.org/cgi/viewcontent.cgi?article=1000&context=up_policypapers

40 Laura Abramovsky et al., "Providing Employers with Incentives to Train Low-Skilled Workers: Evidence from the UK Employer Training Pilots," *Journal of Labor Economics* 29, no. 1 (January 2011): 153–93, https://doi.org/10.1086/656372.

41 Børge Brende, "We Need a Reskilling Revolution. Here's How to Make It Happen," *World Bank Blogs* (blog), April 15, 2019, https://blogs.worldbank.org/jobs/we-need-reskilling-revolution-heres-how-make-it-happen.

42 Anand Chopra-McGowan and Srinivas B. Reddy, "What Would It Take to Reskill Entire Industries?," *Harvard Business Review*, July 10, 2020, https://hbr.org/2020/07/what-would-it-take-to-reskill-entire-industries.

43 "UpSkill Houston," Greater Houston Partnership, accessed June 10, 2021, https://www.houston.org/upskillhouston.

Box 5.1

1 "OSHA 10-Hour Training Courses," OSHA Education Center, accessed June 10, 2021, https://www.oshaeducationcenter.com/osha-10-hour-training/.

2 Robert Glover, Paul Goodrum, and Carl Haas, "Construction Industry Craft Training: Experience to Date and the Path Forward" (2nd Specialty Conference on Leadership and Management in Construction, Grand Bahama Island, Bahamas, 2006), 350–56.

3 "CompTIA Certifications," CompTIA, accessed June 10, 2021, https://www.comptia.org/certifications.

4 "Industry Certifications for IT Computer Support Specialist," Milwaukee Area Technical College, https://matcitsupport.org/why-getting-certified-can-help-launch-your-it-computer-support-career/

5 "Google Career Certificates," Grow with Google, https://grow.google/certificates/#?modal_active=none.

6 "2020 Impact Report," (California, U.S.: Coursera, September 2020), https://about.coursera.org/press/wp-content/uploads/2020/09/Coursera-Impact-Report-2020.pdf

Appendix

Appendix 1

1 Sarah Flood, Miriam King, Renae Rodgers, Steven Ruggles and J. Robert Warren. Integrated Public Use Microdata Series, Current Population Survey: Version 8.0 [dataset]. Minneapolis, MN: IPUMS, 2020. https://doi.org/10.18128/D030.V8.0

2 For a discussion of how to prepare the CPS for longitudinal analysis see Julia A. Rivera Drew, Sarah Flood, and John Robert Warren, "Making Full Use of the Longitudinal Design of the Current Population Survey: Methods for Linking Records across 16 Months," *Journal of Economic and Social Measurement* 39, no. 3 (December 29, 2014): 121–44, https://doi.org/10.3233/JEM-140388.

3 For more details on why invalid answers aren't randomly distributed and how to reweight CPS samples accordingly,

Christopher R. Bollinger and Barry T. Hirsch, "Match Bias from Earnings Imputation in the Current Population Survey: The Case of Imperfect Matching," *Journal of Labor Economics* 24, no. 3 (2006): 483–519, https://doi.org/10.1086/504276.

4 For a detailed description of the representativeness of BGT resume data, see Gregor Schubert, Anna Stansbury, and Bledi Taska, "Employer Concentration and Outside Options," Working Paper Series (Washington Center for Equitable Growth, January 26, 2021), https://equitablegrowth.org/working-papers/employer-concentration-and-outside-options/.

5 "Occupational Employment and Wage Statistics Home Page," U.S. Bureau of Labor Statistics, accessed June 11, 2021, https://www.bls.gov/oes/. Wage variables in the OEWS include the mean hourly and annual wages, plus the interquartile range of both (10th percentile, 25th percentile, median, 75th percentile and 90th percentile).

6 From largest to smallest, these occupations are: Nursing, Psychiatric, and Home Health Aides; Personal Care Aides; Financial Analysts; Medical Records and Health Information Technicians; Personal Care and Service Workers, All Other; Computer Operators; and Explosives Workers, Ordnance Handling Experts, and Blasters.

7 These occupations are: Buyers and Purchasing Agents, Farm Products; Purchasing Agents, Except Wholesale, Retail, and Farm Products; Television, Video, and Motion Picture Camera Operators and Editors; Financial Clerks, All Other; Fishing and Hunting workers; and Bus and Ambulance Drivers and Attendants.

8 Steven Ruggles, Sarah Flood, Sophia Foster, Ronald Goeken, Jose Pacas, Megan Schouweiler and Matthew Sobek. IPUMS USA: Version 11.0 [dataset]. Minneapolis, MN: IPUMS, 2021. https://doi.org/10.18128/D010.V11.0

9 For a detailed review of the BLS alternate employment projections methodology see Lindsey Ice, Michael Rieley, and Samuel Rinde, "Employment Projections in a Pandemic Environment," *Monthly Labor Review*, February 16, 2021, https://doi.org/10.21916/mlr.2021.3.

10 Daron Acemoglu and David Autor, "Skills, Tasks and Technologies: Implications for Employment and Earnings,"NBER Working Paper 16082, (Cambridge, MA: National Bureau of Economic Research, 2010), https://doi.org/10.3386/w16082.

11 Jonathan I. Dingel and Brent Neiman, "How Many Jobs Can Be Done at Home?," *Journal of Public Economics* 189 (2020): 104235, https://doi.org/10.1016/j.jpubeco.2020.104235.

Appendix 2

1 Although CPS registers labor market and earnings information of employed respondents during their fourth and eight survey (also known as outgoing rotation groups), the resulting transition samples are too small to provide insights at the intersection of occupations with race, gender, and sectors.

2 Based on this threshold, the high-wage sectors are construction, professional services, education, government, information, finance, mining, utilities, and management.

Appendix 3

1 Links comprise transitions both to and from a given occupation. Therefore, the dataset has a total of 17,000 pairs of connected occupations.

2 We also tried transition probabilities, which was defined as the proportion of all workers in occupation *a* – whether they transitioned or not – which transitioned into occupation *b.* These two measures are highly correlated and lead to very similar results, but the transition share performs better across the entire dataset, especially for large occupations or ones with few or infrequent transitions.

3 M. A. Serrano, M. Boguna, and A. Vespignani, "Extracting the Multiscale Backbone of Complex Weighted Networks," *Proceedings of the National Academy of Sciences* 106, no. 16 (April 21, 2009): 6483–88, https://doi.org/10.1073/pnas.0808904106.

Appendix 4

1 Vincent D Blondel et al., "Fast Unfolding of Communities in Large Networks," Journal of Statistical Mechanics: Theory and Experiment 2008, no. 10 (October 9, 2008): P10008, https://doi.org/10.1088/1742-5468/2008/10/P10008.

2 Aaron Clauset, M. E. J. Newman, and Cristopher Moore, "Finding Community Structure in Very Large Networks," *Physical Review* E 70, no. 6 (December 6, 2004): 066111, https://doi.org/10.1103/PhysRevE.70.066111.

3 Ibid.

4 Before regrouping the 25 communities into 15 clusters, the average share of transitions ending in the same cluster was 3.6 percent.

5 In the 25 clusters' original setting, the average share of transitions ending in the same cluster is 35.6 percent.

Appendix 5

1 WDAs are groups of counties overseen by Workforce Development Boards, which are groups of community leaders appointed by local elected officials responsible for planning and oversight of workforce programs and services.

Global Economy
and Development
at BROOKINGS

1775 Massachusetts Avenue, NW
Washington, D.C. 20036-2188
telephone 202.797.6139
fax 202.797.2965
www.brookings.edu/product/workforce-of-the-future-initiative/