AUTOMATION:

Challenges and Opportunities for Low-Skill, Low-Wage Workers

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Automation in the 21st Century

Automation is the process of replacing work typically done by humans with work done by machines. In the 21st century, the process of automation is driven by emerging technologies such as the internet, robotics, and artificial intelligence. JFF's research into automation shows that, despite a predictable trend toward increased automation across the entire economy, the process of automation is uneven in both its growth rate and its impacts on populations, industries, and occupations, posing a disproportionate risk to low-wage workers. The effects of COVID-19 are intensifying these risks.

JFF identifies four misperceptions about automation, analyzes what they mean for the education and training ecosystem, and proposes an integrated three-pronged approach to help individuals **evolve, transition,** and **prepare** for the effects of automation. This approach relies on a novel

methodology for evaluating **skill distance**—a new approach to identifying barriers that can power job-to-job transition strategies in a way that was not possible in the past.

What Is Automation?

Automation is when technology replaces human work with work done by machines.[1] The contemporary debate on automation is centered on the effects of information technology, robotics, and artificial intelligence, which are enabling the pervasive and rapid automation of job tasks throughout the global economy.

A common perception about automation is that it will result in decreased employment overall. Yet the history of automation has shown that work may change but it does not decrease.[2] Automation primarily creates changes at the job task level, reconfiguring the work activities of occupations and thus changing their skill requirements.[3] Decreases in specific occupations result, and for those unable to adapt, **displacement** occurs, forcing workers to respond to the shifting skills marketplace by finding new opportunities that are a better fit for their skills.

According to a 2017 McKinsey report, the need to rapidly upskill displaced workers is the core challenge that automation poses.[4] For example, after World War II, automation simultaneously enabled labor-saving advances in agriculture and powered new, more complex industries. Agricultural jobs shrank as clerical, sales, managerial, and professional occupations grew. Shifting from manual agricultural work to process work in an office is not an easy transition, since both domain knowledge and psychosocial barriers need to be overcome. By the late 20th century and early 21st century, higher-skilled occupations—managerial, professional, and technical—continued to grow as other, lower-skilled occupations declined.[5]
Currently, about half of all work activities can be automated with technology that is available now.[6] For 60 percent of all occupations, that means almost a third of work activities will shift to automation. This means that by 2030, less than 10 years from now, 30 percent of the global workforce may be displaced, and another 14 percent will need to shift or change occupations. These two groups represent almost 1.2 billion workers. However, this same scenario estimates that 890 million workers will be needed to meet new labor demands as a result of current trends (such as an aging population in need of health care, the transition to new sources of energy, the marketization of unpaid work, etc.), and another 2.7 billion will be in completely new jobs that don't currently exist.[7]

Workers today may not be in danger of complete replacement in the workforce by automation and emerging technology, but they confront rapid displacement, depression of their skills, and declines in wages.[8]

Who Is Standing on the Automation Cliff?

The current wave of automation coincides with other long-term trends in the U.S. economy that are disproportionately affecting low-wage workers. Globalization and other forces have been driving employment polarization—growth in jobs at the low and high ends of the skills spectrum at the expense of middle-skill jobs. At the same time, the geography of opportunity throughout the nation has been shifting. Both of these trends also intersect with race and gender in complex ways, and both trends are also creating larger and larger gaps for displaced workers to bridge in order to earn a living wage.

Long before the COVID-19 pandemic, the share of middle-wage jobs in the U.S. economy had been shrinking.[9] Low-wage jobs such as home health aides and cleaners, dominated by women of color, have been growing throughout the last 30 years.[10] At the other end, high-wage, maledominated tech jobs such as cybersecurity analysts and software developers are also on the rise but require substantially different skills than the middle-wage jobs they are squeezing out.[11] The gap in wages between these groups has been widening.

Automation affects these categories of jobs differently. Higher-skilled workers will benefit from easier jobs and greater productivity, while low-wage workers are at greater threat for displacement as they fail to shift quickly enough to new opportunities.[12]

Meanwhile, the regional divergence of the U.S. economy since the 1980s has resulted in a concentration of high-growth industries in coastal areas and an overrepresentation of a less diverse industry mix in many non-coastal labor markets.[13] This means that, depending on industry mix, different regions will experience automation's effects differently.[14] The example shared by Efrem Bycer and Liz Wilke of LinkedIn is a manufacturing plant that suddenly displaces a huge number of workers, who now need to re-evaluate their skills in a labor market with few other robust options. Not every worker can respond to these geographic realities by relocating, and women, especially older women, are less mobile and less able to follow economic opportunity.[15]

As automation converges with these trends, we can recognize which U.S. workers are standing on the "automation cliff." They are either newly entering a polarized labor market, already displaced, or facing likely displacement from middle-wage, middle-skill roles. These individuals are more likely to live outside of tech economy centers, may be facing additional barriers related to systemic discrimination against women and/or people of color, and must bridge significant skills gaps in order to enjoy the family-sustaining wages that come with emerging tech-driven occupations. It is also important to be aware that 32 million adults in the United States do not have digital literacy skills to comfortably engage in basic activities such as finding a recipe, making a retail purchase, or filing taxes online, and these individuals have lower labor force participation.[16]

COVID-19: An Automation-Forcing Event?

Previous JFF research confirmed that the recession created by COVID-19 has affected lowincome workers most heavily, in particular women and Black, Hispanic, and Asian workers. These are among the groups that had just begun to dig themselves out of the 2008 recession when the pandemic shocked the economy. It is estimated that 40 percent of the jobs lost during the pandemic may never come back.[17] MIT economist David Autor has called the pandemic an "automation forcing event," especially in areas that were already experiencing automation and now find a shortage of workers (such as warehouse fulfillment).[18] COVID-19 is accelerating many of the trends that were already impacting low-wage workers—namely a polarizing labor market enabled by automation.

Automation decisions are driven by predictable factors: the cost of human labor, society's willingness to accept automated services, and the degree to which investment in automated technology is profitable.[19] A number of COVID-19 factors are tipping the economy toward the increased automation of many jobs held by low-wage workers, including the following:

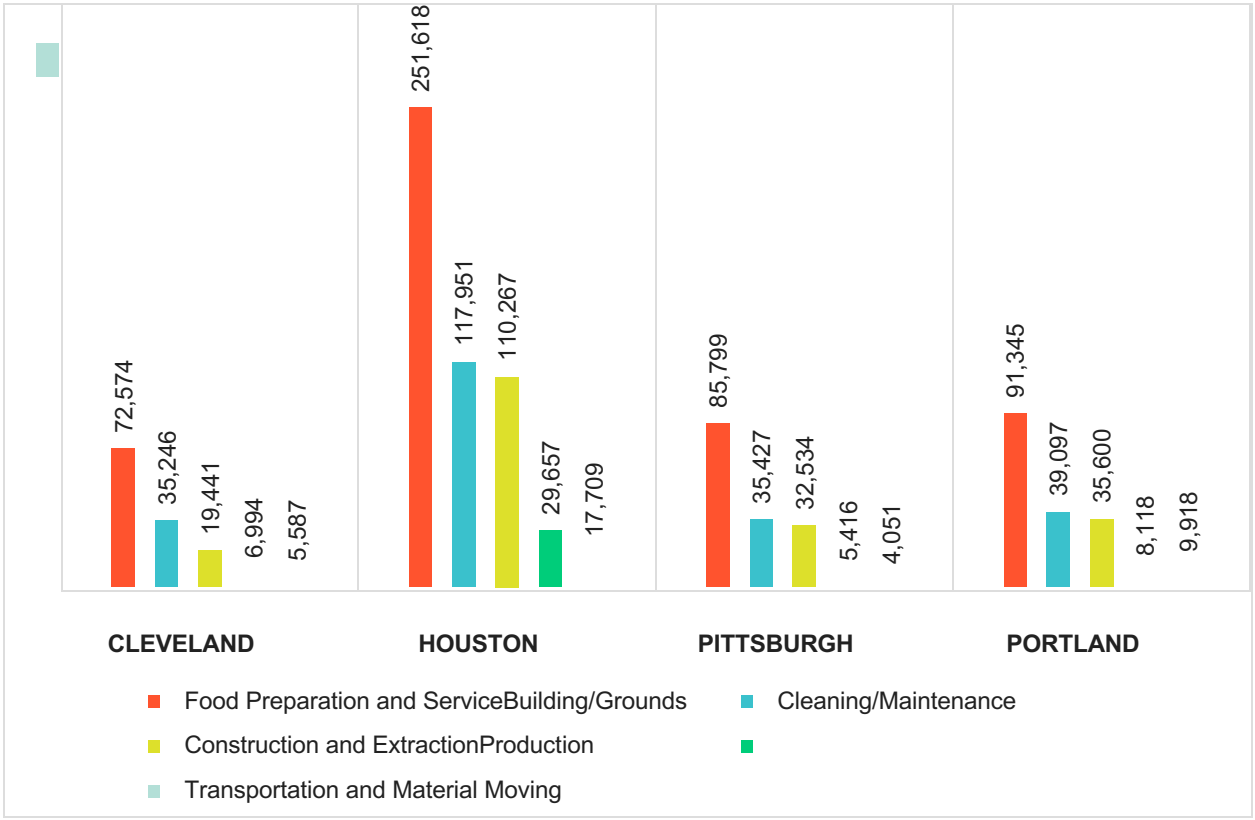
- The pandemic has created human labor shortages and reduced productivity due to workplace restrictions intended to slow the spread of the virus. A recent report from the UC Berkley Labor Center noted that COVID-19 has created an increased use of technology that automates tasks as well as robotics in some industries as a result of labor shortages.
- Human labor costs have increased due to the costs of personal protective equipment, increased sanitation requirements, and the costs of health care for exposed workers. This is especially true for jobs requiring face-to-face transactions that are also at risk for automation (a joint interaction). This includes roles such as medical assistants, customer representatives, and stockers and order fillers.[20]
- Society is more accepting of automated services due to the need to lower risk of exposure to the virus.
- Historically low interest rates in this recessionary economy have drastically lowered the barriers to accessing capital to fund the high up-front costs of automation technology. During the pandemic, chatbots for government services, drones in policing, robots in factories and in retail and cleaning businesses, and autonomous vehicle and drone deliveries have emerged.[21]

While low-skill jobs are being replaced by automation, job growth is happening at the higher end of the skills spectrum. Despite the effects of COVID-19, the first seven months of 2020 saw growth in a wide range of IT positions in industries such as scientific and technical services, finance and insurance, manufacturing, information, and retail trade.[22] The challenge is ensuring that at-risk low-skill and low-wage workers are able to compete for these new opportunities.

Automation and Its Impact on the Verizon Community Initiative

To get a sense of what automation may mean for workers, we analyzed the automation risk index for occupations in the four Verizon Community Initiative pilot metro areas. [23] The occupation families most at risk for automation are those in food preparation and service, building and grounds cleaning and maintenance, construction and extraction, production, transportation, and materials moving (*see Figure 1*). These are occupations such as cooks, bartenders, wait staff, dishwashers, janitors, maids, landscapers and gardeners, carpenters, construction laborers, painters, welders, and packers. The pandemic has additionally affected many of these same occupations.

Figure 1: Number of Sub-Bachelor's Degree Occupations at High Risk for Automation, by Metro Areas and Grouped by Occupation Family[24]

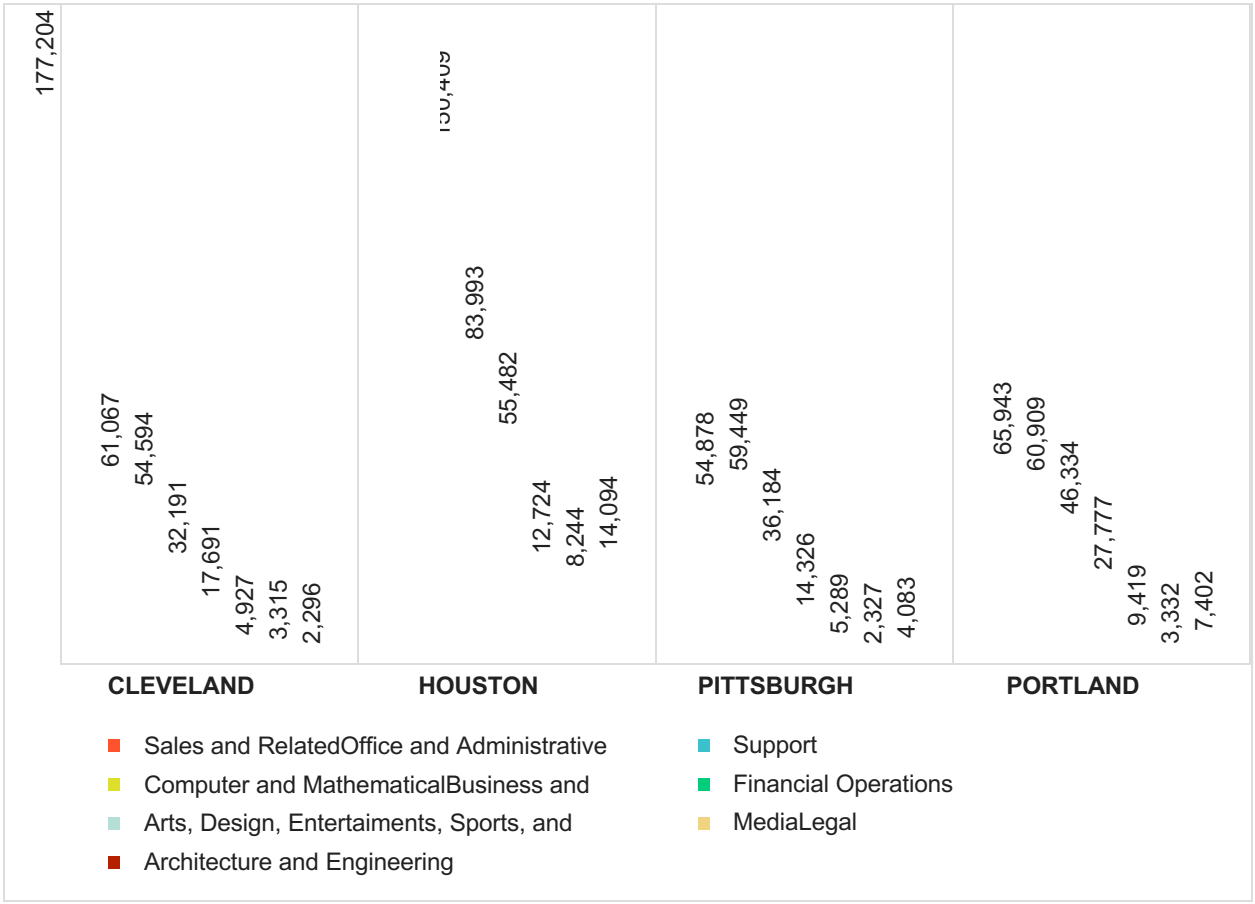


Source: JFF analysis of Emsi quarterly data, Q3 2020

Again, looking to the four Verizon Community Initiative pilot cities as cases in point, we analyzed the automation risk index for occupations, this time looking at occupations with low automation risk, narrowing this list to jobs that have significant employer demand and skills in common with those offered at Verizon Innovation Centers.[25] Based on these criteria, the occupation families that emerged were sales and related, office and administrative support, computer and mathematical, business and financial operations, arts, design, entertainment, sports and media, legal, and architectural and engineering. We chose to keep the list broader than just IT jobs or IT-adjacent jobs to illustrate a stronger point about where automation risks

exist and where they don't, and because IT skills are so broadly in demand. The distribution of these occupations in the pilot cities can be seen in Figure 2.

Figure 2: Number of Select Occupations at Low Risk for Automation, by Metro Area and Grouped by Occupation Family[26]



Source: JFF analysis of Emsi quarterly data, Q3 2020

Table 1 further details the selection of occupations in these larger families, all of which are opportunities in all four Verizon Community Initiative metro areas. In this analysis, over two dozen occupations with low automation risk don't require a bachelor's degree and have median hourly wages of $11 to $36 an hour — averaging just under $25 an hour. Many of these occupations require a foundation in digital skills and digital fluency. Computer-related occupations (those in red) will require additional digital skills, and many will also likely need a bachelor's degree or significant work experience.

Table 1: Selection of Occupations with Low Automation Risk in Verizon Community Initiative Metro Areas, by Degree Required, with Median Hourly Wage

	Median Hourly Wage

Degree Required	Occupation (red = computer related)	Cleveland	Houston	Pittsburgh	Portland
No Formal Education Credential					
Arts, Design, Entertainments, Sports, and Media	Musicians and Singers	$19.97	$32.58	$30.40	$20.89
Sales and Related	Retail Salespersons	$11.32	$11.30	$11.82	$13.89
High School Diploma or Equivalent					
Business and Financial Operations	Claims Adjusters, Examiners, and Investigators	$36.39	$36.17	$28.86	$34.43
Arts, Design, Entertainments, Sports, and Media	Media and Communication Workers, All Other	$15.88	$17.37	$20.14	$23.61
Arts, Design, Entertainments, Sports, and Media	Photographers	$20.42	$18.66	$14.08	$17.59
Sales and Related	Insurance Sales Agents	$25.65	$24.50	$24.74	$29.27
Sales and Related	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	$28.58	$25.54	$28.07	$27.63
Sales and Related	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	$28.33	$32.60	$29.62	$29.89
Office and Administrative Support	Bill and Account Collectors	$15.45	$16.98	$16.49	$19.20
Office and Administrative Support	Customer Service Representatives	$17.60	$16.04	$16.56	$18.61
Office and Administrative Support	Production, Planning, and Expediting Clerks	$22.08	$23.65	$23.65	$24.39
Office and Administrative Support	Legal Secretaries and Administrative Assistants	$24.23	$20.11	$24.19	$25.44
Office and Administrative Support	Medical Secretaries and Administrative Assistants	$18.34	$16.80	$16.80	$21.02
Office and Administrative Support	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	$17.89	$18.09	$17.21	$20.23
Office and Administrative Support	Office and Administrative Support Workers, All Other	$19.84	$18.83	$21.34	$19.50
Some Postsecondary Needed					
Arts, Design, Entertainments, Sports, and Media	Audio and Video Technicians	$22.24	$20.28	$24.61	$23.65
Computer and Mathematical	Computer User Support Specialists	$22.27	$25.68	$22.74	$26.71
Associate's Degree					
Computer and Mathematical	Computer Network Support Specialists	$27.46	$36.26	$28.48	$27.01

Computer and Mathematical	Web Developers and Digital Interface Designers	$29.08	$29.42	$32.97	$35.75
Architecture and Engineering	Architectural and Civil Drafters	$28.27	$28.14	$26.03	$28.36
Architecture and Engineering	Electrical and Electronics Drafters	$24.62	$26.70	$31.74	$32.48
Architecture and Engineering	Mechanical Drafters	$27.31	$29.41	$26.71	$29.12
Architecture and Engineering	Drafters, All Other	$29.64	$23.14	$25.75	$28.63
Architecture and Engineering	Civil Engineering Technologists and Technicians	$29.27	$24.27	$27.45	$31.03
Architecture and Engineering	Electrical and Electronic Engineering Technologists and Technicians	$29.27	$33.42	$27.05	$29.30
Architecture and Engineering	Industrial Engineering Technologists and Technicians	$24.24	$33.60	$26.44	$28.66
Legal	Paralegals and Legal Assistants	$22.25	$23.27	$28.13	$28.90
Office and Administrative Support	Desktop Publishers	$26.45	$21.02	$19.85	$22.88
Bachelor's Degree					
Business and Financial Operations	Buyers and Purchasing Agents	$29.15	$31.06	$29.43	$28.96
Business and Financial Operations	Cost Estimators	$28.55	$35.64	$33.16	$33.87
Business and Financial Operations	Logisticians	$31.57	$37.71	$35.54	$34.48
Business and Financial Operations	Project Management Specialists and Business Operations Specialists, All Other	$33.78	$37.72	$36.52	$34.76
Computer and Mathematical	Computer Systems Analysts	$39.10	$51.32	$41.40	$45.62
Computer and Mathematical	Information Security Analysts	$45.04	$50.63	$48.26	$49.58
Computer and Mathematical	Computer Network Architects	$43.38	$56.73	$47.92	$55.81
Computer and Mathematical	Network and Computer Systems Administrators	$38.67	$44.64	$35.20	$41.77
Computer and Mathematical	Database Administrators and Architects	$38.42	$46.97	$38.21	$46.85
Computer and Mathematical	Computer Programmers	$30.87	$46.73	$38.49	$39.10
Computer and Mathematical	Software Developers and Software Quality Assurance Analysts and Testers	$40.58	$50.69	$44.66	$50.79
Computer and Mathematical	Computer Occupations, All Other	$37.94	$37.12	$37.07	$39.53
Arts, Design, Entertainments, Sports, and Media	Special Effects Artists and Animators	$15.12	$18.88	$24.72	$28.15
Arts, Design, Entertainments, Sports, and Media	Graphic Designers	$23.64	$22.77	$24.91	$25.64

Arts, Design, Entertainments, Sports, and Media	Film and Video Editors	$26.53	$20.53	$26.10	$22.34
Sales and Related	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	$40.78	$37.53	$35.05	$43.80

Source: JFF analysis of Emsi quarterly data, Q3 2020

While opportunities exist, it is a challenge to move individuals from occupations with high automation risk to those with much lower risk. It is difficult for educators to understand how to train the individuals they serve for these new opportunities, and for those individuals to understand how to move into them, especially if the opportunities are in completely new occupation families. Even for those workers who are able to stay in occupations with high automation risk, it is unclear what additional skills are needed to adapt to and respond to increased automation. We'll explore the specifics of these dynamics in the next section. That said, it is possible to build job-to-job transition strategies that lead from jobs at high risk of automation to ones at low risk, even jobs that on the surface appear to have little in common. What is important, however, is the degree of difficulty in moving someone from job A to job B.

Four Misconceptions about Skills in an Automating World

Automation is a set of dynamic processes with differential impacts on workers and industries. Existing skill sets, current labor market context, and potential transition occupations all interact to present options and strategies for educators, who seek to mitigate the impacts of automation on workers. We present four misperceptions in addressing these realities.

Misperception 1: Low-wage workers don't have the skills necessary to thrive in the face of automation.

It is easy to think that workers in occupations with high automation risk such as wait staff, carpenters, and janitors have little to offer in a highly automated world. However, looking more closely at the 17 occupations with high automation risk included in our previous analysis (*see Figure 1*), we can see that many workers in these roles possess both technology and important baseline skills (the term Burning Glass Technologies uses to identify essential or foundational skills) that could allow them to transition into new occupations that are more resistant to automation or help them prepare for automation in their own occupation. Drawing on skill inventories from O*Net demonstrates that people in occupations with high automation risk often possess a mix of technology skills (*see Table 2*) and baseline skills that are likely to resist automation (*see Table 3*).

Table 2: Technology Skills Within Specific Occupations at High Risk for Automation

Occupation	MS Office/ Word Processing/ Spreadsheets	Email/ Web	MS Windows	Scheduling/ ERP/SAP	Point of Sale	DB User Interface	Analytical Software	Graphics / Photo-Imaging / CAD	Facilities Mgmt / Inventory Tracking / Supply Chain & Logistics	Planning Logistics & Supply Chaing	Project Management / Time Accounting
Cooks, Fast Food & Restaurant	X	X			X	X					
Food Preparation Workers	X	X			X	X					
Bartenders		X			X	X					
Fast Food and Counter Workers	X	X			X	X					
Waiters and Waitresses		X			X						
Dining Room and Cafeteria Attendants and Bartender Helpers			X		X						
Dishwashers			X								
Janitors and Cleaners, Except Maids and Housekeeping Cleaners	X										
Maids and Housekeeping Cleaners	X	X	X			X			X	X	
Landscaping and Groundskeeping Workers	X	X	X			X					
Carpenters	X		X					X			X
Construction Laborers			X					X			X
Operating Engineers and Other Construction Equipment Operators	X	X	X								X
Painters, Construction and Maintenance	X	X				X	X	X			X

Welders, Cutters, Solderers, and Brazers	X	X		X		X	X	X			
Cleaners of Vehicles and Equipment		X	X	X		X			X		
Packers and Packagers, Hand	X	X		X		X		X	X		

*Source: JFF analysis of O*NET Online Skills*

Table 3: Baseline Skills Within Specific Occupations at High Risk for Automation

Occupation	Critical Thinking	Judgment / Decision Making	Time Mgmt	Quality Control Analysis	Service Orientation	Social Perceptiveness	Active Listening	Operations and Control
Cooks, Fast Food & Restaurant					X			
Food Preparation Workers					X			
Bartenders					X	X		
Fast Food and Counter Workers					X			
Waiters and Waitresses					X	X		
Dining Room and Cafeteria Attendants and Bartender Helpers					X			
Dishwashers							X	
Janitors and Cleaners, Except Maids and Housekeeping Cleaners							X	
Maids and Housekeeping Cleaners			X		X			
Landscaping and Groundskeeping Workers								X
Carpenters	X	X	X					
Construction Laborers							X	X

Operating Engineers and Other Construction Equipment Operators							X	X
Painters, Construction and Maintenance	X					X		
Welders, Cutters, Solderers, and Brazers	X							X
Cleaners of Vehicles and Equipment				X				X
Packers and Packagers, Hand								

*Source: JFF analysis of O*Net Online data*

Many of the occupations at high risk for automation already incorporate basic productivity technology skills (e.g., word processing, spreadsheet use, email, database interface) coupled with baseline skills (e.g., critical thinking, service orientation). We will discuss later how many of these baseline skills are automation resistant. Additionally, some occupations (e.g., maids, painters, construction workers, and maintenance workers) engage regularly with organizational system platforms or operational technologies (e.g., inventory tracking, project management, scheduling, facilities management, and logistics) that could create a foundation for new career trajectories.

For example, janitors may be using email, spreadsheets, word processing, and web-based platforms to track work activities, communicate to supervisors and peers, and track time. Maids and housekeeping staff may be managing room-cleaning schedules and processes through a facilities management tool and monitoring inventory flows for key hotel room supplies with mobile technology. Construction laborers, carpenters, and those who work in similar environments may be regularly interfacing with project management software, task requests, and reports.

Yet a number of challenges exist for workers, employers, and educators in identifying exactly which skills should be developed and where training investments should be directed. According to Bycer and Wilkes, skills are like an investment portfolio that should be constantly evaluated. What skills does a worker have? What skills are most valuable? How can workers build up their valuable investments before they are dislocated? The ideal point of intervention for obtaining skills in response to automation is not when the job is lost, but rather before—upskilling for the next advanced job in the industry.[27] In this scenario, acquisition or development of new skills should be equally accessible to all workers. This is often true in professionalized occupations, where employers pay for adaptive upskilling for employees when new technology becomes vital.[28] But it's not so for essential workers, who are tasked with adapting to changing digital and technology skill demands on their own, often outside of paid work hours.[29] Too often, the data

that would be most useful in understanding how occupations and tasks are being automated and what training is needed exist within companies and is unavailable to the public.[30]

So, it's not that individuals in occupations with high automation risk lack skills that are relevant in new automation-resistant jobs. The challenge is twofold. First, workers and educators may find it difficult to identify, surface, assess, or document the skills an individual already possesses. Second, it may be difficult to understand what skills are important, or how they might be applied toward future training and job opportunities. Gaining access to relevant and actionable information to navigate employment shocks is a huge problem.[31] It isn't always clear where a worker's skills can be used or what in-demand jobs exist that might be good fits for a worker's skills and experiences.

Misperception 2: It is not possible for high-risk workers to know what a "best bet" transition opportunity is.

Between 2010 and 2020, anywhere from 46 percent to 78 percent of workers in hospitality, food service, transportation, warehousing, retail, and customer service shifted from those occupations to occupations in management, sales, office and administrative support, business analysis and operations, marketing, advertising, public relations, and other fields.[32] These transitions didn't follow perceivable paths, but they demonstrate that transitions do happen. The question is whether transitions would be improved with navigational help. A recent National Bureau of Economic Research paper by Blair and others mapped the "skill distance" between a worker's current occupation and higher-wage opportunities. The distance is calculated based on skills shared by occupations.[33] They further compared these distance scores to actual occupation transitions culled from U.S. Census Bureau data to support the proof of concept. This sort of skill distance analysis is conceptually useful in thinking about current workers at automation risk who possess skills to transition to new work realities through additional training and upskilling. We've attempted to apply the skill distance methodology in this paper to the labor contexts in the four pilot cities. One caveat: skill distance alone doesn't take into account other factors that may impact transition to a new occupation, such as social capital, domain knowledge, and psychological leaps that may be required to move from one industry to another. A bartender may have a short skill distance to become an administrative assistant in a law office, but the two settings and roles are different contextually and psychosocially.

Using the method described in Blair and others, we calculated the skill distance between the occupations with high automation risk listed in Table 2 against the selection of occupations with lower automation risk listed in Table 1.[34] The resulting skill distance score can be used to identify occupations with low automation risk and the easiest skill transition pathway to occupations with high automation risk.[35] For example, as shown in Table 4, wait staff could move into a range of occupations with low automation risk with relatively low skill distance from their current occupation. This likely means they need a few additional skills to transition smoothly into these occupations. There are slightly fewer options for occupations with low

automation risk plausible for construction carpenters that have a relatively low skill distance (lower scores suggest greater skill overlap and potentially less training required). Even so, we see that the occupations close in skill distance are not the same as for wait staff, which suggests the need for more customized skill training options. For janitors and cleaners, the transition to the selected occupations with low automation risk will be a bit more challenging. Their skill distances are higher, and a greater degree of reskilling or upskilling may be needed. The important thing to note about skill distances is that different workers at threat for displacement are not all the same and will need some amount of personalization to address any transition.

Table 4: Possible Occupations with Low Automation Risk and a Low Skill Distance for Wait Staff, Construction Carpenters, and Janitors and Clean

High Automation Risk Occupation	Low Automation Risk Occupation	Skill Distance
Waiters and Waitresses	Singers	2.636
	Musicians, Instrumental	1.976
	Film and Video Editors	2.933
	Retail Salespersons	2.306
	Bill and Account Collectors	2.671
	Customer Service Representatives	1.930
	Production, Planning, and Expediting Clerks	1.977
	Medical Secretaries and Administrative Assistants	2.389
	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	2.838
Carpenters, Construction	Computer Network Support Specialists	2.692
	Electronic Engineering Technicians	2.815
	Electrical Engineering Technicians	2.716
	Audio and Video Technicians	2.597
Janitors and Cleaners, Except Maids and Housekeeping Cleaners	Paralegals and Legal Assistants	4.477
	Singers	2.757
	Musicians, Instrumental	3.610

	Photographers	4.098
	Film and Video Editors	4.294
	Customer Service Representatives	4.237
	Production, Planning, and Expediting Clerks	4.222
	Medical Secretaries and Administrative Assistants	3.991

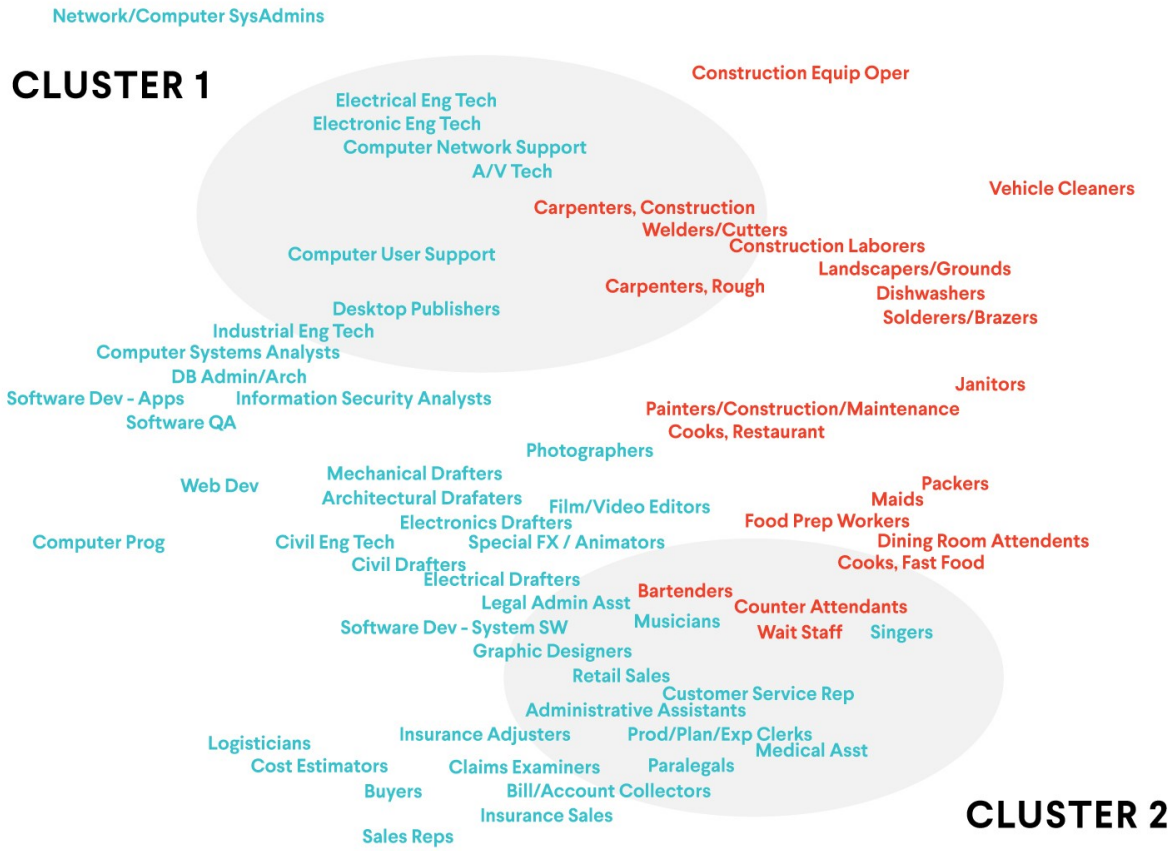
*Source: JFF analysis of O*Net skills requirement data*

Keep in mind that moving from a score of 2 to a score of 3 does not necessarily require the same effort as moving from a score of 3 to a score of 4 in terms of skill distance. It is likely more helpful to think about distances generally. For example, moving from a 2 to a 3 is likely easier than moving from a 2 to a 4. (A full skill distance matrix for the occupations discussed in this memo can be obtained upon request.) As a metric, skill distance can help identify which occupations, even those in very different occupation families, are candidates for a possible transition. With potential transition occupations in view, workers and those looking to reskill or upskill them can more easily understand the gap between current and needed skills. Using resources such as the O*Net occupation search could support more structured career exploration and navigation and inform training design.[36]

We can also visualize skill distance (*see Figure 3*) to provide hints at what the nearest occupations with low automation risk (in blue) might be for specific occupations with high automation risk (in orange). Cluster 1 shows that carpenters and welders/cutters might more easily transition to computer user support or computer network support occupations than to, say, to information security analyst or web developer. Cluster 2 highlights that a bartender, wait staffer, or counter attendant might look to graphic design or customer representative occupations rather than, say, web development or computer support roles. This isn't to say that bartenders can't set their eyes on one of these further skill-distant roles, but they may need more training, time, or support to transition to these roles.

This visualization can also suggest potential pathways for those working to train and upskill. Consider a bartender who wants to be a web developer. It may be a good first step for the bartender to focus on graphic design or film- and video-editing occupations or to explore a drafting occupation, which are closer in terms of skills. Or if a carpenter wants to eventually be a network computer systems administrator, they would be better off to choose the computer network support path over the computer user support path. Skill distance and visualizations of skill distance should be used to suggest and explore, not necessarily prescribe, career transition paths.

Figure 3: Visualization of Skill Distance Between Occupations at High-Risk (Orange) and Low-Risk (Blue) for Automation



*Source: JFF skill distance analysis of O*Net skills requirement data*

Misperception 3: You can't skill up for jobs that don't exist.

What if you aren't certain where to transition to because the occupations and skills a worker will face in the future aren't clear? After all, Dell predicts that 85 percent of the jobs that will be needed by 2030 don't yet exist.[37] While we don't know what these jobs will be exactly, we know digital skills will be needed across nearly all occupations. Baseline digital skills (such as the ability to use word processing and spreadsheets, write an email, or look up things online) are required for even low digital content jobs (e.g., janitor) and for things such as looking at the work schedule, filling out time cards, looking for jobs, participating in online education, banking, and shopping.[38] Additionally, these foundational digital skills will need to be integrated with baseline skills that skew toward higher-order cognitive, social, and emotional capacities.[39]

In terms of increased technology skills and industry trends, there is an increasing need for skills related to internet provision and everything that takes place in the cloud: the internet of things (IoT), 5G, logistics, the enabling technologies of remote work, AI, and augmented and virtual reality.[40] Programming robots for tasks and working with them and using collaboration

platforms (e.g., work-based social media, instant messaging) are other emerging skills.[41] These technological advances also increase the need to understand data flows and strategically communicate important data and information to various audiences as intelligent monitoring, wearable tech, and computing that monitors complex environments take further hold.[42]

Technology skills have a short shelf life, since new tools and systems constantly emerge and develop.[43] To complement in-demand tech skills, workers will also need a set of skills that persist over time or are more durable.[44] Employers may talk about these in a number of ways: soft skills, employability skills, human skills, essential skills, resilient skills, or baseline skills, as referred to in this paper. These are the skills that will allow workers to interpret reality, frame a complex problem, and then use digital tools to solve the problem that they have framed.[45] The literature and our interviews with thought leaders suggest that skills such as learning agility, problem-solving, critical thinking, inductive reasoning, communication, situational adaptability, visual and language recognition, interpersonal acuity, adaptability, resilience, reliability, and accountability will remain important.[46] According to Nitzan Perlman at ClimbHire, a winning strategy for developing and acquiring skills encompasses technical skills but focuses holistically on preparing the individual to thrive in a middle-class job. The ability to "use statistics, do experiments, weigh evidence, reach conclusions, defend . . . thinking, and communicate effectively" will also increasingly be part of automation-supported occupations.[47]

While it is hard to predict exactly what jobs may emerge due to automation, current job postings provide us with insights on skills that are projected to grow.[48] A review of the literature and our interviews with thought leaders further suggest that skills such as troubleshooting technical issues, data analysis, inductive logic, IT strategy, self-motivation, and self-starting, as well as customer service orientation, will be critical.[49] We were able to identify these and other related skills projected for growth (*see Table 5*).

Table 5: Skills that Align with an Automating Workforce and that Are Projected to Grow

Skills	Median Salary	Number of Job Postings	Projected Growth
Data Analysis & Related Skills			
Data Analysis	$74K	538,396	30.5%
Data Visualization	$86K	102,991	26.9%
Statistics	$77K	117,985	2.2%
Data Management	$79K	295,860	2.0%
Inductive Logic & Related Skills			
Architectural Problems	$87K	645	31.8%

Pneumatic Schematics	$43K	2,289	20.9%
Computer Problem Resolution	$39K	4,022	9.3%
Electronic Schematics	$41K	3,724	5.2%
Inductive Logic	$41K	3,588	2.0%
Ability to Communicate Medical Terminology	$32K	16,293	1.9%
IT Strategy Skills			
Cybersecurity Strategy	$114K	5,271	46.9%
Solution Architecture	$112K	51,347	7.6%
Growth Strategies	$78K	23,482	3.3%
Business Strategy	$90K	194,622	1.7%
Self-Starter & Self-Motivation Skills			
Detail-Oriented	$36K	4,614,285	2.2%
Time Management	$41K	1,928,166	1.3%
Self-Starter / Self-Motivation	$46K	1,308,430	2.6%
Financial Acumen	$75K	56,886	1.6%
Troubleshooting & Related Skills			
Software Issue Resolution	$65K	19,381	6.3%
Troubleshooting Technical Issues	$64K	174,224	3.7%
Initiative	$38K	329,573	2.8%
Root Cause Analysis	$78K	189,823	1.5%
Troubleshooting	$51K	2,026,730	0.9%
Hardware and Software Problem Diagnosis	$54K	21,903	0.2%
Problem Solving	$51K	4,276,942	0.2%
Customer Service Skills			
Basic Customer Service	$32K	8,534,243	0.50%
Advanced Customer Service	$43K	726,500	1.60%

Source: JFF analysis of Labor Insights from Burning Glass Technologies

According to a recent Emsi report on resilient skills, data analysis and cybersecurity skills are currently in high demand, with significant gaps in that demand being met.[50] Labor market information culled from nationwide job postings provides insights on what skills these employers are looking for in terms of specialized, baseline, and software skills.[51] While workers might not be completely prepared to take on these roles, these related skills can help inform training design and educational choices to get closer to these occupational destinations. Being transparent about these skills can help workers see where they might have existing skill assets or near competency.

Table 6: Skills Co-Occurring with High-Growth, In-Demand Skills

DATA ANALYSIS		
Median Salary	$74K	
Education Level	High school or Associate's (10% of job postings)	
	Bachelor's Degree (80% of job postings)	
Experience Level	0 to 2 years (27% of job postings)	
	3 to 5 (50% of job postings)	
Other Skills Present in Job Postings		
Specialized	**Baseline**	**Software**
Data Analysis	Communication Skills	Microsoft Excel
SQL	Microsoft Excel	SQL
Project Management	Teamwork / Collaboration	Microsoft Office
Python	Research	Microsoft Powerpoint
Budgeting	Problem Solving	Python
Tableau	Planning	Tableau
Quality Assurance and Control	Writing	Microsoft Word
Scheduling	Detail-Oriented	SAS
Customer Service	Microsoft Office	Oracle
Business Process	Organizational Skills	Software Development
CYBERSECURITY STRATEGY		
Median Salary	$114K	
Education Level	High school or Associate's (3% of job postings)	
	Bachelor's Degree (91% of job postings)	
Experience Level	0 to 2 years (8% of job postings)	
	3 to 5 years (35% of job postings)	
Other Skills Present in Job Postings		
Specialized	**Baseline**	**Software**
Cybersecurity Strategy	Communication Skills	Microsoft Office
Information Security	Teamwork / Collaboration	Software Development
Information Systems	Planning	Python
NIST Cybersecurity Framework	Research	Microsoft Excel
Project Management	Problem Solving	COBIT
Cyber Security Knowledge	Writing	Linux
Risk Management	Building Effective Relationships	Vulnerability assessment

Budgeting	Verbal / Oral Communication	Systems Development Life Cycle (SDLC)
Cybersecurity Assessment	Presentation Skills	Microsoft Powerpoint
Security Operations	Organizational Skills	Splunk

Source: Labor Insights, Burning Glass Technologies

We can't know what the skills will be for in-demand jobs that haven't yet been created. But we do know that the skills we've listed above—human-centric skills—will be in high demand and are unlikely to be automated. Essential workers in the future will be those who master these skills, regardless of what futuristic job they may hold. People who are best at doing the things that robots can't do will be successful in the future economy. And we can teach those skills today.

Misperception 4: Training, communicating, and certifying automation-resistant skills are too complicated to do effectively.

Identifying, validating, and teaching automation-resistant skills for otherwise at-risk workers is tremendously complicated work that is beyond the capabilities of many education and training providers today. Workers have lots of skills that they don't recognize, and too often, it is incumbent on these individuals to understand and communicate what skills they have. Organizations and programs working with these workers can support this surfacing of skills and identifying specific skills needed to meet changing work contexts. One way of doing this could be a digital portfolio built on blockchain as a way for workers to understand, own, and control their skill development and accomplishment data via learning and employment records (LERs).[52] Another key challenge of addressing occupational shifts for workers is the lack of access to relevant and actionable information to navigate employment shocks.[53] Here too, workers need road maps and guides that help them explore and identify options. Finally, workers being pressured by automation likely possess a number of durable or baseline skills. However, these skills are the most difficult to assess, recognize, and signal.[54] Their certification is often dependent on social capital and signaled through social structures such as work experience, referrals, and artifacts such as college degrees.[55] This is another place where educators and those supporting workers affected by automation can leverage intentional interventions, institutional leadership, and policy in support.

Confronting Automation: A Three-Pronged Approach

For those designing and delivering training to workers dislocated or potentially at risk for automation, our research and analysis suggest three approaches to mitigate automation impact. Rather than picking one approach, the strongest programs will likely employ all three, personalized for specific workers and populations. These approaches are as follows:

1. ***Evolve***. Plan for the evolution of current automation-impacted occupations in a manner that allows workers to adapt to and integrate new technologies, rather than being replaced by them.

2. ***Transition***. Help workers move from existing automation-impacted occupations into options with lower automation risk by identifying transferrable skills and matching them to in-demand jobs via customized training and skill development to meet the new opportunity.
3. ***Prepare***. Make sure workers are ready for unknown occupations by monitoring trends, seeing opportunities, and positioning workers for occupations that don't yet exist by building up a set of foundational technology skills and the more durable baseline skills.

What's an Educator to Do?

Based on the research analysis, we believe the top features of a promising skills-based response to the impacts of automation would empower people to:

1. understand and own their current portfolio of skills—which ones are valuable now, which ones are susceptible to automation, and which ones are likely to be durable into the future;
2. decide how they want to translate their current skills to new opportunities, including:
    a. **distance:** how different the skill requirements of new opportunities are from their current work;
    b. **ROI:** what labor market demand in their region looks like if they were to invest their time and resources in a transition, including advancement opportunities; and
    c. **lived reality**: how people who have had similar work and educational experiences get these desirable jobs, what it's like to occupy that job, and what besides skills they need to know to be successful;
3. test and build the human baseline skills that we know are less automatable, such as problem-solving, critical thinking, planning, and digital communication, in addition to the most valuable digital skills according to data on in-demand jobs;
4. validate and communicate their prior and new/evolving competencies through credentials that are intelligible to employers; and
5. focus on building social capital in industries that matter to their advancement plans as they also improve their skills.

Because the most effective point of intervention is often ***before*** displacement by automation, an approach that serves both jobseekers and skill seekers would make sense. Ensure that incumbent workers in at-risk occupations (retail, food service, transportation, etc.) can weather the changes in automation and that those already displaced are being served as well.

Methodology

This memo is a descriptive analysis informed by both quantitative and qualitative data. Our data collection included:

- a review of current literature related to automation found through academic search databases and supplemented by Google Scholar, general web search, and peer network shares;
- semi-structured interviews conducted with six thought leaders in the automation and future of work arena: Chandra Childers (Institute for Women's Policy Research), Efrem Bycer (LinkedIn), Nathan Martin (formerly of Pearson), Nitzan Pelman (ClimbHire), Bledi Taska (Burning Glass Technologies), and Liz Wilke (LinkedIn);
- labor market information extracted from Emsi, including analysis of automation risk for occupations in Cleveland, Houston, Pittsburgh, and Portland, Oregon;
- nationwide metrics for high-growth, automation-resilient skills obtained from Burning Glass Technologies' Labor Insights report of job postings; and
- O*Net data on skills and occupations used to conduct skill distance analysis.

Our analysis was primarily focused on synthesizing key themes and interpreting data with a lens that is rooted in a pragmatic orientation, with particular attention to issues of diversity, equity, and inclusion.

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[25] For an explanation of how Emsi calculates the automation risk index, visit https://kb.emsidata.com/glossary/automation-index/.

The calculation of automation risk is more deeply explored in Frey and Osbourne's 2013 paper, "The Future of Employment: How Susceptible are Jobs to Computerisation?"

[26] Occupations included were those with an automation risk index of 100 or less and where the typical educational requirement was a bachelor's degree or less. Occupations selected were included to represent a range of occupations that had many job openings and were likely to have skills that could be built upon through work experience or training by Verizon Innovation Centers. High-growth occupations such as nurse, health care worker, and K-12 educator were not included given the specialized training required.

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