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What Does this Mean for Minority Workers?

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The Covid-19 Pandemic Spurred Growth in Automation: What Does this Mean for Minority Workers?

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Abstract

The Covid-19 pandemic has accelerated trends in automation as many employers seek to save on labor costs amid widespread illness, increased worker leverage, and market pressures to onshore supply chains. While existing research has explored how automation may displace non-specialized jobs, there is typically less attention paid to how this displacement may interact with preexisting structural issues around racial inequality. This analysis updates that of a 2021 Brookings paper by the authors, finding that Black and Hispanic workers continue to be overrepresented in the 30 occupations with the highest estimated risk of automation and underrepresented in the 30 occupations with the lowest estimated risk of automation. The updated analysis also includes new attention to automation's impact on wage structures, consideration of the broader implications of automation for global economics, and a discussion of the potential interplay of automation with recent developments in artificial intelligence.

JEL Classification Numbers: D63, E24, I24, J21, J24, J31, O33

Keywords: Race, Automation, Covid-19

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Introduction: Covid-19 Affected Labor Markets and Accelerated Automation

Saturday, January 21, 2023, marked the third anniversary of the first confirmed case of Covid-19 in the U.S. Now in the fourth year of the pandemic, the World Health Organization reported on February 21, 2023, that there had been 757 million confirmed cases of Covid-19 and 6.8 million deaths. More than 1.1 million people, in the U.S. alone have died from Covid-19 related causes (WHO, 2023).

The contagious nature of the virus necessitated physical distancing and remote work for millions of workers. According to the April 2020 Jobs Report from the US Bureau of Labor Statistics, employment fell by 20.5 million jobs between March and April 2020, by far the largest one-month decline in BLS data collection history, and the corresponding unemployment rate increased from 4.4 percent to 14.7 percent (BLS, 2020). More than twice as many jobs were lost between March and April 2020 as were lost during the entire 2007-09 period (BLS, 2020). The pandemic has influenced a variety of intersecting trends around consumer behavior, labor markets, and the degree of automation.

First, the Covid-19 pandemic drove increased e-commerce activity. This was noted most significantly at the onset of the pandemic. Based on the volume of "card not present" CNP transactions, e-commerce boomed during Covid-19. The shift to online shopping increased revenues in online marketplaces. Revenues rose in the first half of 2020 for Amazon (34% year on year), Alibaba (27%), JD (28%), Shopify (74%), Rakuten (16%) and Mercado Libre (50%) (Bloomberg, April, 2020). Large e-commerce companies such as Alibaba, JD.com, and Amazon have used automated technologies, such as autonomous cars, robots, and drones to provide "contactless" deliveries safely to customers (Lin (2020).

During the pandemic, e-commerce growth has been faster where containment measures were stricter, as measured by the Oxford Covid-19 Government Response Tracker stringency index. Additionally, e-commerce increases were higher in low innovative countries prior to the pandemic; however, during the pandemic, e-commerce increases were higher in countries with stronger containment measures. Additionally, e-commerce increases were higher where e-commerce was less developed prior to the pandemic. The lower the level of e-commerce for a country in 2019, the higher the growth rate of e-commerce during the Covid-19 pandemic. This implies that Covid-19 provided an incentive for less developed countries to increase their e-commerce automation. (Alfonso, et al. 2020)

Second, the pandemic served as the impetus for the adoption and increased digitalization of workplaces, with increased use of online meeting platforms, cloud computing, online contracting, and digital payments systems as examples (EBRD, 2021). The pandemic presented a societal necessity for millions of workers to complete their assignments from home. During the height of the pandemic, nearly 38 percent of U.S. workers reported working from home (Bankrate, 2021), with the U.S. Bureau of Labor Statistics reporting that a total of 43.6% of

workers had the ability to work from home in the early months of the pandemic.[5] Nevertheless the early impact of the pandemic did not hit all groups equally as some demographics were more able to work from home than others, including those with a bachelor's degree (67.5%) versus those with a high school diploma (24.5%) or no diploma at all (10.7%); workers age 55+ (48%) versus workers age 15-24 (23.7%), and white workers (48.7%) versus Black (39.4%) and Hispanic (28.9%) workers.

There was a significant difference in workers' ability to work at home by occupation. These differences ranged from a high of 86.6% of those in management, business, and finance to very low work at home ability for occupations such as construction (0%), installation and repair (1%), production (0.4%), farming, fishing, and forestry (0%), and service occupations (7.9%) (Bureau of Labor and Statistics, June 2020). Further, the ability to work from home was greater for those with higher incomes than for those in lower paying jobs. Data from a 2021 Bankrate survey noted that of those workers who said they were able to work remotely at any point during the pandemic, over half reported an annual household income of more than $80,000, while only 20 percent of those who worked remotely had an annual household income of less than $40,000 (Johnson & Pilling, 2021). The survey also suggested that telework has had varying financial impacts on American households. For many, it has coincided with increased financial well-being. About 6 in 10 of the workers surveyed, who worked from home at some point due to Covid-19, said it positively affected their finances, while just 10 percent said it hurt their financial status (Johnson & Pilling, 2021).

Another example of technology-enabled changes to work influenced by the pandemic is so-called gig work. The types of gig work are significantly diverse, however there are two defining characteristics: gig work depends on digital platforms or apps and is organized around "gigs," which are short-term arrangements between workers and employers/customers (Kalleberg & Dunn, 2016). The social distancing measures needed to slow transmission of Covid-19 took a staggering economic toll at the beginning of the pandemic. Over 26 million unemployment insurance claims were filed between March 15 and April 18, 2020 (US Dept of Labor, April 2020). As the pandemic fueled this increase in unemployment, gig work may have been more appealing and useful (Reynolds & Kincaid, 2022). Ravenelle et al. (2021) showed that during the pandemic, as conventional work dried up, gig workers in New York City often turned (or returned) to work as rideshare and delivery drivers, dog-walkers, shoppers, and household assistants. In short, when employment opportunities suffered, people seemed to do more gig work. Covid-19 presented a time of increased unemployment and reduced employment opportunities.

In addition to teleworkers and gig workers, millions of other workers were deemed essential and continued to work in police and fire stations, in hospitals and grocery stores, at gas stations and convenience stores, and on garbage trucks and in warehouses, yet under new distancing and hygiene protocols to reduce the spread of Covid-19. According to an April 2020 Kaiser Family

[5] It should be noted that not all workers who had the ability to work from home actually worked from home. This results in a discrepancy between the number of those who had the ability to telework versus the number of those actually teleworking.

Foundation Health Tracking Poll, 34 percent of U.S. adults said they had been deemed an essential worker and were working outside their home. These workers were more likely to be Black, have a household income lower than $40,000, and not have earned a college degree (Kearney and Munana, 2020).

Third, for employers, the Covid-19 pandemic added what Korinek and Stiglitz (2021) refer to as a shadow cost – reflecting the dollar equivalent of all the costs associated with increased risk of disease transmission – on labor that requires proximity. This shadow cost, they explain, accelerated automation during the pandemic. As the pandemic spread in early 2020 and many businesses were forced to close their doors, robot-making companies experienced a surge in orders (Guizzo and Klett, 2020). Orders for robots in North America, mostly in the U.S., increased by 20 percent in the first quarter of 2021 (Lee, 2021). In 2020 approximately 2.25 million industrial robots were in use around the world (Koropenko, 2020).

Automation, in the form of sanitation robots, has been used by airports and airlines to decrease transmission of Covid-19 and help air travelers feel safer. Intelligent Sterilization Robots (ISR), equipped with UV light sterilizers and air sterilizers are being used in Hong Kong International Airport and Milan Malpensa Airport among others (Asaf, 2020; Galvis, 2020). Airlines, including United Airlines, JetBlue, and Qatar Airways are using robotic UV technology to sanitize airplanes (Boon, 2021)

Pandemic-related labor shortages and an increasing demand for contactless delivery have accelerated the utilization of food and retail delivery robots in airports, senior living facilities, and on college campuses, among other places. Food and retail delivery robots are being used in U.S. airports, including Cincinnati Airport and Philadelphia International Airport, to provide passengers with the ability to order online and receive contactless delivery within the airport (Youd, 2021; Youd, 2022).

Grocery stores have deployed robots to process transactions, clean floors, stock store shelves, and deliver groceries to shoppers during the pandemic in an effort to decrease costs, reduce pressure on store workers, and decrease Covid-19 transmission (Meyersohn, 2020). In 2021, 30 percent of grocery store transactions were completed using self-checkout machines (Food Industry Association, 2023).

While the pandemic is still ongoing and it will likely be years before we have a complete picture of the direct impact of the pandemic on the trendlines discussed above, preliminary analysis provides some guidance. In a 2021 version of this paper, we examined 2019 data on estimated risk scores of automation by occupation. In the next section, we update this analysis, providing an admittedly provisional view of dynamic change.

Jobs Most and Least Susceptible to Automation

In a 1930 essay, John Maynard Keynes speculated that advancements in technology and productivity would result in a reduction in the total hours worked to 15 hours per week for most workers, thereby introducing new opportunities for pursuing leisure activities (Keynes, 2010).

Nevertheless, in that same essay, Keynes also warned that in the short-term, innovation leads to "technological unemployment" which results from "our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour."

While we have yet to experience the large reduction in hours worked per week that Keynes forecasted, the rise in automation and artificial intelligence holds plenty of promise for improving workplace safety, including reducing danger and lessening bodily strain in jobs that require routinely strenuous physical motions. But as documented in this section, trends in automation also underscore Keynes' concern regarding "technological unemployment" as a potential structural issue in the near-term, particularly in places where various forms of inequality are already entrenched.

Previous research finds that technological advancements have driven reductions in clerical and administrative jobs across most industries in advanced countries and that while automation of production tasks tends to displace routine jobs more than other low-skilled work, it does not tend to reduce employment overall (Piacentini, et al. 2022). Further Chui, et al. (2015) suggested that few occupations would be eliminated due to automation in the near future, but that certain job tasks were more likely than others to be automated. High-skill and what are often referred to as "low-skill" jobs—but are actually low-wage jobs that require optimizing time trade-offs, quality control, emotional intelligence, and project skills —continue to be less susceptible to automation (Broady, et al. 2021).

Frey and Osborne (2017) used a Gaussian process classifier to examine the expected impacts of future computerization on U.S. labor market outcomes. Drawing from a workshop held at the Oxford University Engineering Sciences Department, they examined the automatability—the ability of a job task to be completed by a computer or computerized technology—of a range of tasks, associated with job descriptions for occupations and answering the question, "Can the tasks of this job be sufficiently specified, conditional on the availability of big data, to be performed by state-of-the art computer-controlled equipment?" They ranked occupations according to their probability of computerization from lowest to highest.

In their study, Frey and Osborne (2017) considered occupations with an automation probability of 70 to 99 percent at high risk of being automated. Automation probabilities are organized with a version of the Standard Occupational Classification, which has an overlapping but a slightly more detailed classification of occupations than the Bureau of Labor Statistics Current Population Survey's occupations racial data. Thus, for some subcategories of occupations we have data by automation risk, but for the larger occupational category we have data only by race. To remedy this issue, we applied the percentages by race of the larger occupational category to the subcategories. Furthermore, the BLS does not provide a racial breakdown for all occupations listed. Hence, our data set includes 220 occupations for which the BLS provides gender and race statistics and for which Frey and Osborne (2017) provide an automation risk score.

Table 1 shows the subset of the 30 jobs with the highest automation risk scores that employ the highest number of U.S. workers. Black and Hispanic workers are overrepresented in these

occupations. For example, Black workers were overrepresented in 17 of the 30 occupations and represent 13.7 percent of the employment in the 30 highly automatable occupations, compared to 12.3 percent of the civilian labor force. Hispanic workers are overrepresented in 22 of the occupations, accounting for 25.1 percent of the top 30 automatable occupations, compared to 18.7 percent of the civilian labor force. In addition, women accounted for 50.6 percent of the employment in the 30 highly automatable jobs in this subset, while accounting for 47 percent of the total workforce.

It is expected that automation will have a significant effect on Black and Latino workers. Black workers are overrepresented in particular jobs with a high risk of being eliminated or fundamentally changed by automation. Broady (2017) found that compared to White workers, Black workers were over one-and-a-half times more likely to be cashiers, cooks, combined food preparation and serving workers (including fast food), production workers, and laborers and freight/stock/material movers; and over three times more likely to be security guards, bus drivers, and taxi drivers/chauffeurs.

Table 1. The Subset of 30 Occupations with the Highest Automation Risk Scores
Sorted by Number of U.S. Workers. 2021

Occupation	Total Employed	Automation Risk Score	Average Hourly Wage	Total % Employed	% of Female Workforce	% of White Workforce	% of Black Workforce	% of Asian Workforce	% of Hispanic Workforce	% Female	% White	% Black	% Asian	% Hispanic
1 Retail salespersons	2,750,000	92.00	$18.61	1.80	1.86	1.82	1.90	1.31	2.08	48.5	78.3	13.0	4.8	20.8
2 Cashiers	2,601,000	97.00	$13.38	1.70	2.63	1.56	2.36	1.78	2.17	72.5	71.1	17.0	6.9	22.9
3 Construction laborers	2,165,000	88.00	$20.99	1.42	0.14	1.55	0.93	0.56	3.85	4.5	84.8	8.1	2.6	48.9
4 Laborers and freight, stock, and material movers	2,161,000	85.00	$16.67	1.42	0.69	1.30	2.31	0.75	1.90	22.9	71.4	20.1	3.5	24.1
5 Secretaries and administrative assistants	2,009,000	96.00	$20.08	1.32	2.59	1.42	1.04	0.64	1.02	92.5	83.8	9.7	3.2	14.0
6 Cooks	1,905,000	81.00	$14.73	1.25	1.07	1.17	1.60	1.14	2.49	40.2	72.9	15.8	6.0	35.9
7 Waiters and waitresses	1,631,000	94.00	$13.89	1.07	1.55	1.08	0.77	1.07	1.47	68.2	78.4	8.9	6.6	24.7
8 Accountants and auditors	1,630,000	94.00	$39.24	1.07	1.41	1.05	0.85	1.91	0.58	62.0	76.3	9.8	11.8	9.8
9 Office clerks, general	1,249,000	96.00	$19.39	0.82	1.46	0.80	0.95	0.79	0.86	83.6	75.7	14.3	6.4	19.0
10 Sales, wholesale and manufacturing	1,216,000	85.00	$48.32	0.80	0.51	0.91	0.40	0.40	0.53	30.1	88.1	6.2	3.3	12.0
11 Receptionists and information clerks	1,215,000	96.00	$16.30	0.80	1.52	0.78	0.98	0.54	0.93	90.0	75.8	15.2	4.5	21.0
12 Landscaping and groundskeeping workers	1,211,000	95.00	$16.79	0.79	0.10	0.87	0.59	0.22	2.08	6.2	84.9	9.2	1.8	47.1
13 Bookkeeping, accounting, and auditing clerks	1,097,000	98.00	$21.99	0.72	1.30	0.79	0.39	0.59	0.52	84.7	85.3	6.6	5.4	13.1
14 Food preparation workers	872,000	87.00	$14.98	0.57	0.71	0.55	0.65	0.48	0.93	58.3	74.2	14.0	5.6	29.3
15 Couriers and messengers	837,000	94.00	$16.50	0.55	0.29	0.51	0.87	0.23	0.71	24.9	72.1	19.4	2.8	23.3
16 Miscellaneous agricultural workers	835,000	87.00	$14.27	0.55	0.27	0.63	0.17	0.17	1.42	23.3	89.3	3.8	2.0	46.7
17 Inspectors, testers, sorters, samplers, and weighers	829,000	98.00	$21.47	0.54	0.45	0.55	0.51	0.58	0.66	39.3	78.6	11.6	7.1	21.7
18 Property, real estate, community association managers	780,000	81.00	$36.61	0.51	0.55	0.55	0.43	0.31	0.32	50.7	83.2	10.3	4.0	11.4
19 Industrial truck and tractor operators	623,000	93.00	$18.88	0.41	0.08	0.36	0.83	0.09	0.76	9.1	69.2	24.9	1.5	33.3
20 Billing and posting clerks	483,000	96.00	$20.30	0.32	0.58	0.31	0.43	0.18	0.31	86.7	76.7	16.9	3.8	17.6
21 Paralegals and legal assistants	431,000	94.00	$27.55	0.28	0.51	0.28	0.26	0.22	0.32	84.8	78.1	11.2	5.1	20.6
22 Construction equipment operators	360,000	95.00	$26.51	0.24	0.02	0.27	0.15	0.00	0.29	3.0	89.0	8.0	0.1	21.8
23 First-line housekeeping supervisors, janitorial workers	338,000	94.00	$22.20	0.22	0.18	0.23	0.24	0.11	0.37	38.9	81.2	13.1	3.4	30.0
24 Claims adjusters, appraisers, examiners, investigators	330,000	98.00	$33.24	0.22	0.27	0.21	0.29	0.14	0.18	58.2	74.4	16.7	4.3	14.6
25 Hosts and hostesses, restaurant, lounge, and coffee shop	282,000	97.00	$15.39	0.18	0.33	0.18	0.15	0.16	0.23	84.3	77.1	9.7	5.8	22.4
26 Bus drivers, school	276,000	89.00	$18.63	0.18	0.21	0.17	0.34	0.08	0.10	55.3	72.4	23.2	3.0	10.0
27 Insurance claims and policy processing clerks	257,000	98.00	$21.23	0.17	0.28	0.15	0.35	0.05	0.18	78.2	69.1	25.3	1.9	19.5
28 Packaging and filling machine operators and tenders	253,000	98.00	$17.09	0.17	0.18	0.15	0.28	0.18	0.40	51.5	67.8	21.0	7.3	43.9
29 Butchers and other meat, poultry, fish processing workers	246,000	93.00	$17.33	0.16	0.07	0.16	0.20	0.11	0.36	19.4	75.3	15.4	4.6	39.7
30 Dining room & cafeteria attendants & bartender helpers	243,000	91.00	$13.75	0.16	0.16	0.16	0.18	0.10	0.29	46.8	76.6	14.0	4.1	33.0
Total/*Average*	**31,115,000**	*92.67*	*$21.21*	**20.39**	**21.97**	**20.54**	**21.42**	**14.91**	**28.31**	*50.6*	*77.7*	*13.7*	*4.4*	*25.1*

Source: U.S. Bureau pf Labor Statistics (BLS), 2022 authors' calculations; Frey and Osborne (2017)

Note: This table reflects data for a subset of the 220 occupations for which the BLS provides gender and race statistics and for which Frey and Osborne (2017) provide an automation risk score

In contrast, Table 2 lists the 30 occupations at the least risk of being automated in 2021, again according to Frey and Osborne (2017). White and Asian workers were overrepresented in occupations at low risk of being automated, while Black and Hispanic workers were underrepresented. Moreover, of the occupations least likely to be automated, White workers were overrepresented in 21, while Asian and Black workers were overrepresented in 12 and 11, respectively, and Hispanic workers were overrepresented in none.

Table 2. The Subset of 30 Occupations with the Lowest Automation Risk Scores

Sorted by Number of U.S. Workers. 2021

	Occupation	Total Employed	Automation Risk Score	Average Hourly Wage	Total % Employed	% of Female Workforce	% of White Workforce	% of Black Workforce	% of Asian Workforce	% of Hispanic Workforce	% Female	% White	% Black	% Asian	% Hispanic
1	Elementary and middle school teachers*	3,260,000	0.44	$29.48	2.14	3.60	2.31	1.74	1.10	1.27	79.2	83.8	10.0	3.4	10.7
2	Registered nurses	3,201,000	0.90	$37.24	2.10	3.87	2.03	2.27	2.73	1.03	86.7	74.9	13.3	8.6	8.8
3	Chief executives	1,664,000	1.50	$98.14	1.09	0.68	1.21	0.52	1.12	0.45	29.1	85.7	5.9	6.8	7.4
4	Education and childcare administrators	956,000	1.32	$27.31	0.63	0.87	0.65	0.71	0.31	0.34	65.5	79.8	14.0	3.3	9.7
5	Secondary school teachers*	940,000	0.78	$29.72	0.62	0.78	0.69	0.36	0.34	0.28	59.5	86.4	7.2	3.6	8.3
6	Other physicians	921,000	0.42	$101.60	0.60	0.51	0.51	0.40	2.09	0.19	39.7	66.1	8.1	22.9	5.8
7	Medical and health services managers	791,000	0.73	$57.01	0.52	0.83	0.51	0.59	0.55	0.30	75.0	76.1	14.1	7.0	10.5
8	First-line production & operating supervisors	767,000	1.60	$32.13	0.50	0.21	0.52	0.52	0.24	0.49	19.5	80.7	12.8	3.2	17.6
9	Other teachers and instructors	737,000	0.95	$29.90	0.48	0.67	0.49	0.52	0.31	0.30	65.3	79.1	13.3	4.3	11.0
10	Engineers, all other	666,000	1.40	$50.23	0.44	0.15	0.40	0.18	1.32	0.23	16.3	71.9	5.1	19.9	9.6
11	Preschool and kindergarten teachers	613,000	0.74	$18.02	0.40	0.83	0.42	0.41	0.22	0.30	96.8	81.0	12.7	3.6	13.4
12	Marketing managers	576,000	1.30	$74.49	0.38	0.49	0.41	0.19	0.42	0.17	61.4	83.5	6.2	7.3	8.3
13	Computer systems analysts	464,000	0.65	$47.94	0.30	0.24	0.27	0.28	0.74	0.19	37.5	70.0	11.3	16.0	11.0
14	Clergy	404,000	0.81	$28.14	0.26	0.09	0.29	0.19	0.19	0.12	16.2	84.4	8.7	4.7	8.0
15	Social and community service managers	391,000	0.67	$36.72	0.26	0.37	0.25	0.37	0.16	0.20	68.6	74.6	17.9	4.0	13.7
16	Mechanical engineers	354,000	1.10	$45.90	0.23	0.05	0.23	0.09	0.48	0.11	9.4	78.0	4.6	13.7	8.9
17	Pharmacists	352,000	1.20	$60.86	0.23	0.28	0.21	0.15	0.69	0.08	57.8	70.3	7.9	19.8	6.0
18	Human resources managers	273,000	0.55	$65.01	0.18	0.31	0.18	0.18	0.17	0.12	80.8	78.9	12.3	6.4	12.5
19	Securities, commodities, & financial services sales agents	243,000	1.60	$30.25	0.16	0.10	0.16	0.09	0.28	0.09	29.3	79.9	6.6	11.7	10.2
20	Coaches and Scouts*	235,000	1.30	$18.73	0.15	0.15	0.17	0.14	0.08	0.10	44.3	84.4	10.9	3.5	11.7
21	First-line supervisors of mechanics, installers, and repairers	222,000	0.30	$35.07	0.15	0.02	0.17	0.07	0.02	0.10	6.0	89.1	5.8	0.7	12.3
22	Speech-language pathologists	187,000	0.64	$39.53	0.12	0.25	0.15	0.04	0.02	0.03	95.1	93.7	4.3	1.3	5.1
23	Training and development specialists	166,000	1.40	$33.03	0.11	0.12	0.11	0.12	0.07	0.07	52.9	77.4	14.1	4.2	10.9
24	Occupational therapists	135,000	0.35	$40.77	0.09	0.16	0.10	0.03	0.09	0.02	84.9	87.9	4.1	6.8	4.2
25	Logisticians	132,000	1.20	$37.78	0.09	0.07	0.09	0.09	0.06	0.05	39.3	80.3	13.4	4.9	10.2
26	Dietitians and nutritionists	117,000	0.39	$30.88	0.08	0.15	0.08	0.08	0.04	0.06	89.6	83.0	13.3	3.1	14.1
27	Lodging managers	116,000	0.39	$32.58	0.08	0.08	0.07	0.06	0.14	0.06	47.6	75.1	10.3	12.5	14.1
28	Public relations and fundraising managers	100,000	1.50	$65.16	0.07	0.09	0.08	0.02	0.04	0.03	68.0	89.3	3.5	4.4	7.2
29	First-line supervisors of police and detectives	92,000	0.44	$45.88	0.06	0.02	0.06	0.07	0.01	0.03	15.8	82.1	13.4	0.7	8.9
30	Surgeons	59,000	0.42	$123.20	0.04	0.02	0.04	0.01	0.03	0.02	27.7	89.4	4.6	5.6	8.6
	Total/*Average*	**19,134,000**	*0.90*	*$46.76*	**12.54**	**16.06**	**12.87**	**10.51**	**14.08**	**6.82**	*52.2*	*80.6*	*9.7*	*7.3*	*10.0*

Source: U.S. Bureau pf Labor Statistics (BLS), 2022 authors' calculations; Frey and Osborne (2017)

Note: This table reflects data for a subset of the 220 occupations for which the BLS provides gender and race statistics and for which Frey and Osborne (2017) provide an automation risk score.

Importantly, it is not clear whether the disparate impact of automation would translate to higher unemployment rates for various groups, or whether it would simply mean displacement into other occupations or other jobs within the same occupations. However, it is likely that automation will both eliminate and create jobs. New technologies may both displace workers and generate new employment opportunities. For example, while sales from ecommerce companies like Amazon, particularly considering the growth in ecommerce during the pandemic, reduce the number of sales and employees at traditional retail stores, Amazon also creates new jobs by hiring workers at fulfillment centers and in other parts of its distribution network. Mandel (2017) found that from 2007 to 2016, the general retail sector lost 51,000 jobs while the ecommerce sector added 355,000 jobs.

Artificial Intelligence and the Future of Automation

The previous section focused mostly on the risk that automation poses to jobs that involve routine, non-specialized tasks, but recent innovations in artificial intelligence indicate that an even broader range of jobs may be impacted by technology than was previously projected. For example, the recently debuted model Chat GPT has already been used to debug broken code, generate emails with improved grammar, and even produce a published academic paper on the legal implications of this technology (Jain, 2022; Harwell et al. 2022; & Perlman, 2022). Chat GPT joins a growing number of innovative AI programs including Google's AlphaCode that can generate programmer-quality coding, Meta's Cicero which recently beat humans in the strategy game Diplomacy, as well as the AI art creator Midjourney which has already produced award-

winning artwork (Li, et al., 2022; Hutson, 2022; & CBS Colorado, 2022). While it is still unclear how commercialization will drive usage, prior Brookings' analysis suggests that AI innovations may soon affect nearly every current occupation and may fundamentally alter a wide range of industries (Muro, et al., 2019).

These developments suggest that while the harms of automation may be disproportionately concentrated or most severely felt among a small subset of workers, a much larger swath of workers may be impacted by artificial intelligence than previously forecasted even as college degrees lose some of their ability to insulate workers. Indeed, these trends suggest that technological innovations in automation and AI could soon produce broad structural impacts, like previous inventions such as electricity, the steam engine, or the world wide web.

Seen this way, just as with deindustrialization in the 70s and onward, initial technologically-driven job displacement for Black and Hispanic workers may function as a canary in the coal mine, signaling subsequent macroeconomic shifts (Kolesnikova and Liu, 2010). Alternatively, if advancements in and commercialization of automation and AI happen concurrently, the micro and macro impacts may be felt simultaneously.

Automation Disproportionately Increases Inequality in Less Developed Nations

Thus far, this paper has considered the disparate risks of automation borne by specific groups within the United States. But automation will likely also produce disparate impacts globally, both within and between nations.

Automation may increase global within-country automation through structural effects on labor markets that provide wage premiums to high-skill occupations while displacing workers in low-skill occupations (Prettner and Strulik, 2019). Within-country inequality may also be increased by automation compounding the growing gap between capital shares and labor shares in income (Dao, et al., 2017). At the level of political economy, automation may intersect with preexisting incentives to invest in capital rather than labor since the former is often taxed at a lower rate. (Acemoglu, 2021).

In addition to within-country inequality, automation may increase between-nation inequality. Specifically, less developed nations may face several additional interconnected harms from automation. First, developing nations may experience widespread job displacement because employment in these nations is often highly concentrated in industries susceptible to automation. For example, agriculture currently accounts for nearly a third of all total employment in low- and middle-income nations (The World Bank, 2021). Regarding this risk, a 2016 analysis by the World Bank estimates that as many as two-thirds of all jobs in developing countries are at risk of automation (World Bank, 2016). Even if displacement is more limited, automation may reduce labor's share of income and freeze or diminish wages for low or middle-skill workers (Autor, 2018; and Acemoglu and Restrepo, 2017).

Second, automation may diminish developing nations' current comparative advantages derived from cheap labor costs, leading to diminished exports and subsequent declines to GDP (Kenny, 2019). This concern is amplified given that global supply chain disruptions have led to increased pressure for onshoring in the United States and Europe, even as automation allows employers to avoid increased labor costs associated with that onshoring. (Studley, 2021).

Third, preexisting global disparities in access to capital may inhibit the ability of emerging economies to finance technological adoption that will be required to compete in global markets (Arias and Wen, 2015). This concern is consistent with prior research which finds that previous periods of concentrated innovation such as the Industrial Revolution resulted in widened global inequality. Adding to this concern, the pandemic has increased the financial woes of developing nations through increased indebtedness, even as rising interest rates may increase borrowing costs and negatively affect capital inflows and outflows (World Bank, 2021; Rappeport, 2022; & Gill, 2022).

Conclusion

The pandemic has accelerated preexisting trends toward growing automation of jobs due to both micro and macroeconomic factors. Our analysis finds that Black and Hispanic workers are overrepresented in jobs at high-risk of automation and underrepresented in jobs with low risk of automation. In addition to risk of displacement, our analysis also indicates that automation may also directly affect wage structures.

Our findings suggest that various structural inequalities around race and class may be exacerbated by technological innovations if left unaddressed. Policymakers will need to consider what implications may be drawn from this research in a broad range of domains including higher education, unemployment insurance, and workforce development. Additionally, our brief discussion of international trends suggests similar concerns regarding growing global inequality, which should be considered in decisions about foreign policy issues including trade and foreign direct investment.

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