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Automation and Technological Change: The Outlook for Workers and Economies

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Since the advent of mechanization, predictions regarding the demise of jobs have accompanied each labor-altering technological advance. In 1930, John Maynard Keynes coined the phrase "technological unemployment" to express the idea that technological change may lead to gross and potentially permanent declines in employment (Keynes 2010). In recent decades, the rise of big data, machine learning and robotics promised a dramatic reorganization of industrialized economies, which always seems to be just around the corner. While past episodes of technological progress did not lead to permanent unemployment, many fear this time is different. Dire predictions have been made, such as a report by Frey and Osborne (2017) arguing that, with current and emerging technology, over 47% of all jobs stand to be automated in the coming decades.

UNDERSTANDING TECHNOLOGICAL CHANGE

To understand how technology changes jobs, it is useful to first divide jobs into component tasks. An economy can be envisioned as a large number of tasks to be performed, groups of which are bundled into jobs, which are then further bundled into firms. A new technology can change the task distribution in two ways: first, it can replace tasks that were previously performed by individuals; for instance, mechanical looms developed in the eighteenth century directly replaced artisanal weavers. Second, a technology can require the development of new tasks, typically in order to operate, maintain and improve technology; in the case of the weavers, mechanical looms were operated by individuals untrained in weaving and maintained by mechanics and technicians. The mechanization of textiles thus led to a massive reallocation of labor, creating new jobs for women and children, but destroying those for the artisanal weavers who could not compete with mass-produced textiles. Similar patterns play out today with modern industrial robots, which directly replace factory workers, but create new jobs for developing, assembling, programming and maintaining the robots.

For other types of technological change, the effect on workers is more nuanced. Consider the case of secretaries and office support workers. Until the 1980s, the majority of secretarial tasks consisted of typing and re-typing documents, as well as filing and maintaining physical databases. Several rounds of innovation, beginning with the widespread adoption of personal computers in the 1980s, have moved secretarial jobs away from these routine tasks. Job ads for office support workers now request a variety of skills related to software and technology, and list a broad array of required tasks, ranging from accounting, customer service, writing and beyond. Evidence suggests that technological change did not cleave tasks from secretarial jobs, but rather broadened the scope of tasks involved in the job through having secretaries operate newer technologies. We can refer to such cases as "worker-augmenting" technology, as opposed to the "worker-replacing" technology in the aforementioned cases of textiles and industrial manufacturing.

For many white-collar and skilled jobs, emerging technologies are best described as worker-augmenting. For instance, radiologists can be assisted by AI that evaluates films and flags patterns the radiologist may have missed, making a radiologist more accurate and perhaps increasing the volume of scans a single radiologist can oversee. Nonetheless, AI is unlikely to replace other aspects of a radiologist's job, which include synthesizing information from scans with the rest of the patient's medical history to make a diagnosis and treatment plan, and communicating with other physicians and patients. Thus, radiologists may increasingly be asked to have technical skills to operate the AI. Further, like office support workers, the adoption of radiology in AI is likely to allow radiologists to specialize in the aspects of the job that are much harder to replace with technology.

This occurs because of the comparatively narrow range of tasks that modern technology can perform. To use terminology popularized by Autor et al. (2003), computers, AI and robots excel at *routine tasks*, that is, narrow and well-defined tasks performed repeatedly. When such tasks are combined with human intellect, individuals can harness the power of the technology to improve their own productivity and performance. However, this is very different from replacing a radiologist with AI.

Jobs that primarily consist of performing routine tasks, such as assembly line workers, switchboard operators or travel agents, are more likely to be at risk from technology. Most jobs, however, are more broadly based, encompassing routine, interpersonal and cognitive tasks. In these jobs a facility with work-

er-augmenting technology can provide great dividends to individuals and their employers.

UNDERSTANDING THE ADOPTION OF TECHNOLOGY

A search of current job postings finds a handful of firms advertising for switchboard operators. This may seem surprising, as automated options for telephone switching have existed for decades. A large gap exists between what futurists predict for jobs, what technology is currently available, and what technology has been actually implemented in a widespread way.

Adopting new technology often requires large costs, both upfront and recurring. The machine or technology must be installed and customized, after which it must be maintained by skilled technicians, who are often harder to come by than the workers that usually perform the tasks that the technology is replacing. If the technology is to be used by the current workers, they must be trained and convinced to "buy in" to the new technology, as many businesses discover after purchasing an expensive software product only to find that none of their employees make use of it. Adopting a new technology hence relies on a cost-benefit equation, such that many firms will appear to lag in adoption due to the cost barrier.

In light of Covid-19, such calculations may be altered dramatically. Disease mitigation requires humans to keep a certain distance from other humans, giving an edge to automated processes. Technology that completely replaces humans or allows businesses to operate with fewer in-person staff gains significant value in this context. Businesses previously undecided on adopting such technology will be more likely to move ahead with it. However, as the accompanying recession will likely curtail capital investments, I do not expect this effect to be widespread.

Adopting worker-assisting technology is likely to be curtailed during the pandemic. In addition to economic limitations on new capital investment, the necessary worker retraining and buy-in for new technologies are difficult to accomplish under distanced or other extraordinary pandemic conditions. As economies recover, however, businesses may take advantage of the opportunity to invest and hire new workers skilled in new technologies (see Hershbein and Kahn 2018), accelerating adoption at that point.

The overall effect of technological change on wages and employment is, therefore, quite mixed. Both worker-replacing and worker-augmenting technologies may reduce the employment demand for workers in the affected job. In the former case, workers are directly replaced, while in the latter case, broadening the job to encompass additional tasks may offset the drop in demand directly due to technology replacing aspects of the job.

As for overall employment, predictions are ambiguous. Why? Although less worker time is spent performing the automated task, new tasks may be created (such as operating or building the technology), and the productivity gains may spread throughout the economy. Depending on the magnitude of these spillover effects, growth can be either positive or negative and overall wages can fall or rise. What is undeniable is that the impacts are unequal, as some workers will lose their jobs at the same time as new opportunities open up for others. Policy regarding technological change should be crafted to mitigate these inequalities.

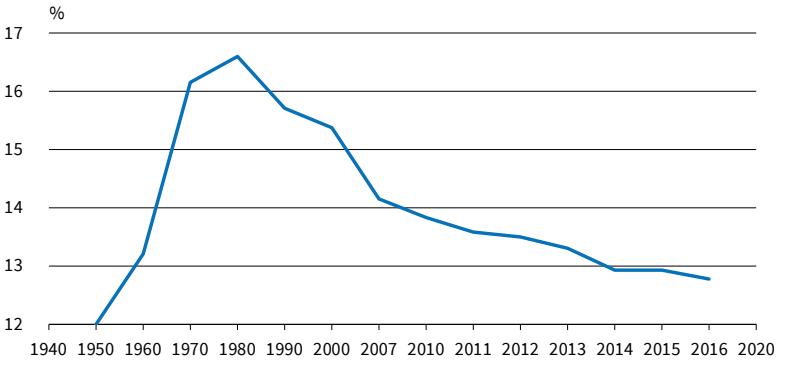
CASE STUDY: OFFICE SUPPORT WORKERS

We can examine the direct and spillover effects of technological adoption more closely by focusing on one field. In Dillender and Forsythe (2020), we investigate recent changes for office and administrative support (OAS) workers due to technological adoption. Figure 1 shows the trajectory of employment of OAS workers in the United States, peaking in the 1980s and falling dramatically thereafter. Although OAS employment has fallen from a peak of 16% of all US employment, at 13% it still represents a greater share of workers than manufacturing. Predictions by Frey and Osborne (2017) suggest that OAS workers could be almost wholly replaced by technology, making this an important focal group.

We drew from over 8 million online job postings for office support workers between 2007 and 2016 to investigate the changing task content of jobs. Figure 2 shows the increase in the appearance of particular phrases as employers list new technologies and software packages in the postings. Over time, the jobs require more skills, with employers asking for additional higher-skill tasks such as writing, accounting and finance and cognitive tasks. We do not find evidence that more-basic office support tasks are disappearing; on the contrary, employers still mention copying, filing, and answering phones in their descriptions. This is indicative that these jobs are becoming more skill intensive and broader, with office support workers being asked to perform a wider variety of tasks.

Figure 1

Office and Administrative Support: Share of Employment



Source: Dillender and Forsythe (2019). © ifo Institute

Why might these jobs become more skilled? One possibility is that, in order to employ individuals who are adroit in handling modern technology, employers are hiring individuals who are skilled in other ways. This allows employers to include a wider variety of office tasks in the job description. Importantly, the addition of new tasks and skills makes OAS jobs less similar to the routine jobs that are most at risk for replacement by automation. The additional tasks are more likely to rely on judgment, interpersonal skills, and higher-level thinking—exactly the types of tasks that humans excel at and that machines perform poorly. Thus, while technology has dramatically reshaped these jobs, it appears to have insulated these jobs from elimination due to future technological change.

Tasks shifted to OAS jobs include many that used to be in the domain of higher-skilled office jobs such as accountants, human resources managers and other specialists. This suggests that employers are shifting tasks between job titles as skilled and technologically augmented OAS workers are able to take on more tasks. All these facts point toward a far more optimistic view of the future of OAS jobs than a static view of jobs would suggest.

THE EFFECT OF OFFICE SUPPORT TECHNOLOGY ON THE BROADER LABOR MARKET

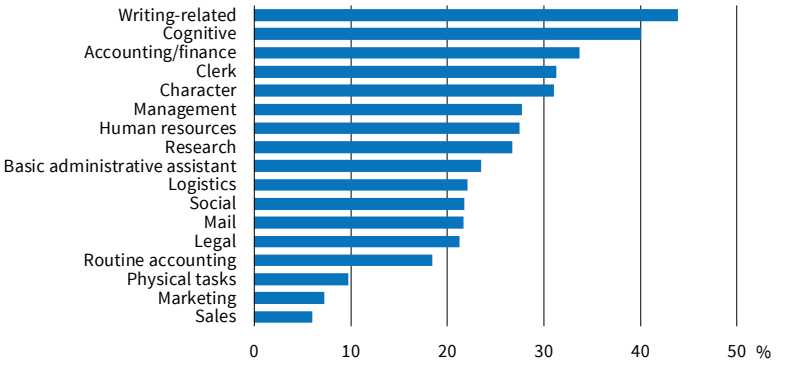
Although a broader skill portfolio insulates OAS jobs from elimination, we saw in Figure 1 that the share of OAS employment continues to fall. To investigate the effects of technological adoption in a specific field on the broader labor market, we look (Dillender and Forsythe 2020) at labor market outcomes for the surrounding geographic area. By comparing locations where employers have adopted more technology to those whose employers have adopted less and by using nationwide industrial trends, we can isolate the *effect* of technological adoption on labor market outcomes. (In the paper we describe this methodology in detail.)

We find that more OAS technology usage results in less employment in these jobs, which is consistent with the evidence suggesting that fewer individuals are increasingly able to perform more work, and with the general downsizing (but not-elimination) of secretarial workers in the modern office. However, despite these job losses, the local areas in which more technology was adopted show *higher* overall employment. Thus, rather than killing jobs overall, this type of technological change leads to job growth. As discussed above, this may be due to increased productivity, which can grow the local labor market.

It is important to note that this is not a general result about technological adoption. For instance, Acemoglu and Restrepo (2020) find that adopting industrial robots *reduces* overall employment. The key difference seems to be that industrial robots represent job-replacing technology, whereas OAS technology is operated by OAS workers and hence is job-augmenting. Nonetheless, since much white-collar automation is more likely to share similarities with the adoption of OAS technology, our results suggest that such technological change may increase overall employment.

Figure 2

Job Ads: Percentage Increase in Frequency



Source: Dillender and Forsythe (2019). © ifo Institute

Although total employment rises, the gains do not benefit all workers. We find that employment growth is concentrated among women with college degrees, while wage losses are largest for women without a college degree. This suggests two simultaneous processes: less-educated and predominantly-female workers are pushed out of OAS employment (or are never hired to begin with), leading to increased competition for jobs that do not require a college degree, leading to decreased wages for these workers. Meanwhile, the increased productivity of office support workers increases productivity for all white-collar workers, as they work hand-in-hand. This expands employment in white-collar jobs, opening up opportunities for women with college degrees. Adopting technology thus pushes the labor market to favor more highly educated workers, while leading to worse outcomes for the less educated.

We do not find a discernible effect on average wages, as less-educated workers experience losses whereas other workers see gains. However, since employment increases, total earnings in the local area rise.

CONCLUSION FOR POLICY MAKERS

There are several conclusions one can draw from our research. First, jobs are not written in stone. Instead, employers can adjust job duties and requirements, often without even changing the job title. This means that, while technology may replace *tasks*, this occurs in conjunction with new tasks being added to jobs (not the least of which is using the technology). In the case of office support *jobs*, the modern support worker is asked to perform a wider variety of tasks, resulting in such jobs persisting with fewer, higher-skilled workers. This will be the case in any job

requiring employees to operate or interact with new technologies. The vast majority of automation technologies now available or on the horizon will cause jobs to change, but not disappear.

Second, the overall effect of such technologies on the labor market is mixed. If history is a guide, in the longer term we should expect employment to continue to grow. In the case of OAS technology, we find overall growth in local employment accompanies adopting ongoing technological innovation. While automation and technological change require active labor market policies to manage transitions, this progress should be welcomed.

Third, as with many economic disruptions, gains and losses are unevenly distributed. In particular, losses appear greatest for those without college degrees. Policy-makers should be aware that the continued march of technological change is likely to lead to disruptions in individuals' careers. Individuals who experience such technological displacement need support to find employment in suitable alternative careers. Such support should include income support and access to training.

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