How computer automation affects occupations: Technology, jobs, and skills

James Bessen 22 September 2016

A popular notion is that computer automation leads to major job losses. However, this ignores the dynamic economic responses that involve both changing demand and inter-occupation substitution. Using US data, this column explores the effect of automation on employment growth for detailed occupational categories. Computer-using occupations have had greater job growth to date, while those using few computers suffer greater computer-related losses. The real challenge posed by automation is developing a workforce with the skills to use new technologies.

Related

The job race: Machines versus humans
Daron Acemoğlu, Pascual Restrepo

How much we work: The past, the present, and the future
Timo Boppart, Per Krusell

How the digital revolution is reshaping the global workforce
Carl Benedikt Frey, Ebrahim Rahbari

Jobless recoveries and the disappearance of routine occupations
Henry Siu, Nir Jaimovich

Automation has become a concern not just for blue-collar manufacturing workers, but also for white-collar workers and even professionals. New computer programs, some using artificial intelligence, are taking over the tasks of bookkeepers, bank tellers, clerks, and others (Brynjolfsson and McAfee 2014). Some see this replacement causing technological unemployment and a slow recovery from the Great Recession (Ford 2015). Looking forward, Frey and Osborne (2013) project that "47% of total US employment is…potentially automatable over...perhaps a decade or two." While others see a more modest impact (Autor 2015, Arntz et al. 2016), the view that computer automation has been causing and will increasingly generate major unemployment has prompted calls for new policies such as a minimum basic income (Ford 2015).

But has computer automation actually been generating a large net loss of jobs? Unfortunately, much of the popular discussion of automation has not benefited from either rigorous economic analysis or empirical evidence. In a recent paper, I estimate the effects of recent computer automation on employment growth in detailed occupations in the US (Bessen 2016). I use a model that captures basic economic interactions that have largely been ignored in the popular discussion, such as the effect of automation on product demand and on inter-occupation substitution.

Some basic economics of automation

It is important to begin with a clear understanding of what automation is and how it affects jobs. With automation, machines perform part or all of an occupational task, reducing or eliminating the human labour needed to perform that task. But this is not the only way that new technology can disrupt the workforce. New technology can make products obsolete. For example, the automobile eliminated jobs for carriage makers, although it also created jobs for auto-body makers. Technology can also change work organisation. For example, communication technologies facilitate decentralisation, outsourcing, and offshoring, shifting work from one group of workers to another. Self-service technologies (e.g. the airline ticket kiosk) shift work to consumers. Information technology can facilitate new markets (e.g. Airbnb, Uber). Although all of these other sorts of technological change can be disruptive and eliminate jobs for some workers, there is no particular reason to expect them to create large job losses overall; new jobs are created while old ones are eliminated. Automation, on the other hand, might cause net job losses because machines reduce the human labour needed to produce a unit of output.

Also, much of the discussion concerns human jobs being completely taken over by machines (e.g. Frey and Osborne 2013). But in fact, most automation is *partial*—only some tasks are automated. For example, despite extensive automation since 1950, it appears that only one of the 270 detailed

James Bessen
Executive Director, Technology & Policy Research Initiative, Boston University School of Law

Don't Miss

Banking, FinTech, Big Tech: Emerging challenges for financial policymakers
Petralia, Philippon, Rice, Véron

Challenges in the digital age
Labhard, McAdam, Petroulakis, Vivian

The parliamentary Brexit endgame
Tyson

Events

Call for Papers: The Euro Area at 20: Evaluating the Real Side of the Economic and Monetary Union
11 - 12 November 2019 / KOF, ETH Zurich, Switzerland / KOF ETH Zurich

Cross border financial services: Europe's Cinderella?
15 - 15 November 2019 / Brussels, Belgium / SUERF - The European Money and Finance Forum BFF - The Belgian Financial Forum

Autumn School on FinTech
20 - 22 November 2019 / Florence, Italy / Florence School of Banking and Finance, European University Institute

Competition in Digital Markets
20 - 22 November 2019 / Barcelona / Barcelona GRaduate School of Economics

Forecasting for Banking Using Time Series Methods
27 - 29 November 2019 / Florence, Italy / Florence School of Banking and Finance, European University Institute

CEPR Policy Research

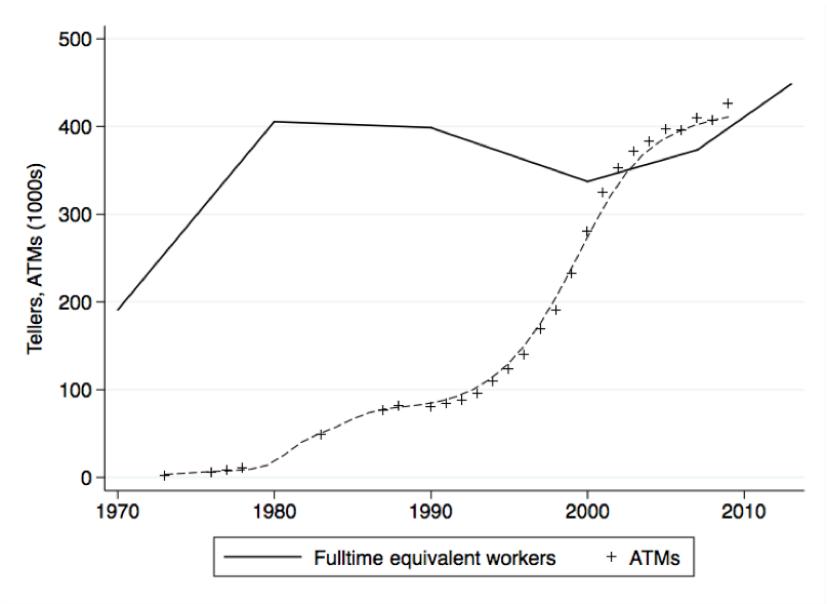
Discussion Papers | Insights

occupations listed in the 1950 Census was eliminated thanks to automation – elevator operators.[1] Many others, however, were partially automated.

This distinction is important because it implies very different economic outcomes. If a job is completely automated, then automation necessarily reduces employment. But if a job is only partially automated, employment might actually increase. This is true even if the job is *mostly* automated. The reason has to do with basic economics. For example, during the 19th century, 98% of the labour required to weave a yard of cloth was automated, yet the number of weaving jobs actually increased (Bessen 2015). Automation drove the price of cloth down, increasing the highly elastic demand, resulting in net job growth despite the labour saving technology.

Similar demand responses are seen with computer automation. Consider, for example, the effect of the automated teller machine (ATM) on bank tellers. The number of fulltime-equivalent bank tellers has grown since ATMs were widely deployed during the late 1990s and early 2000s (see Figure 1). Why didn't employment fall? Because the ATM allowed banks to operate branch offices at lower cost; this prompted them to open many more branches (their demand was elastic), offsetting the erstwhile loss in teller jobs (Bessen 2016).

Figure 1. Fulltime-equivalent bank tellers and installed ATM machines in the US



Of course, partial automation can also decrease employment in an occupation. If demand is inelastic, then growth in demand will not offset job losses. Also, automation can lead to substitution of one occupation for another within firms and industries. For example, there are fewer telephone operators now, but more receptionists; there are fewer typesetters, but more graphic designers, and desktop publishers. Graphic designers using computers became more productive than typesetters, so automation facilitated the shift of work from typesetters to graphic designers.

Estimates of employment demand growth

Taking these considerations into account, I estimate a simple model of occupational demand across industries that allows for changing demand and inter-occupation substitution within industries. As my key independent variable, I measure the extent of computer use by workers in each occupation and industry. These data come from supplements to the Current Population Survey. I assume that occupations that use more computers will have a higher degree of task automation, all else equal. The dependent variable is the relative growth of employment in occupation-industry cells.

The estimates contradict popular assumptions about the impact of computer automation. First, computer-using occupations tend to grow faster, not slower. At the sample mean, computer use is associated with a 1.7% increase in occupational employment per year. In other words, the bank teller example may be typical rather than exceptional.

Second, there is a strong substitution effect between occupations. Occupations tend to have declining growth to the extent that other occupations in the same industry use computers. That is, the story is not about machines replacing humans; rather it is one of humans using machines to replace other humans, as graphic designers with computers replaced typesetters.

> ıstitution effect largely offsets the growth effect. Counting both, at the sample mean,
> ɛr use is associated with positive employment growth but the effect is small, 0.45% per year.

Homeownership of immigrants in France: selection effects related to international migration flows
Gobillon, Solignac

Climate Change and Long-Run Discount Rates: Evidence from Real Estate
Giglio, Maggiori, Stroebel, Weber

The Permanent Effects of Fiscal Consolidations
Summers, Fatás

Demographics and the Secular Stagnation Hypothesis in Europe
Favero, Galasso

QE and the Bank Lending Channel in the United Kingdom
Butt, Churm, McMahon, Morotz, Schanz

Subscribe

@VoxEU

RSS Feeds

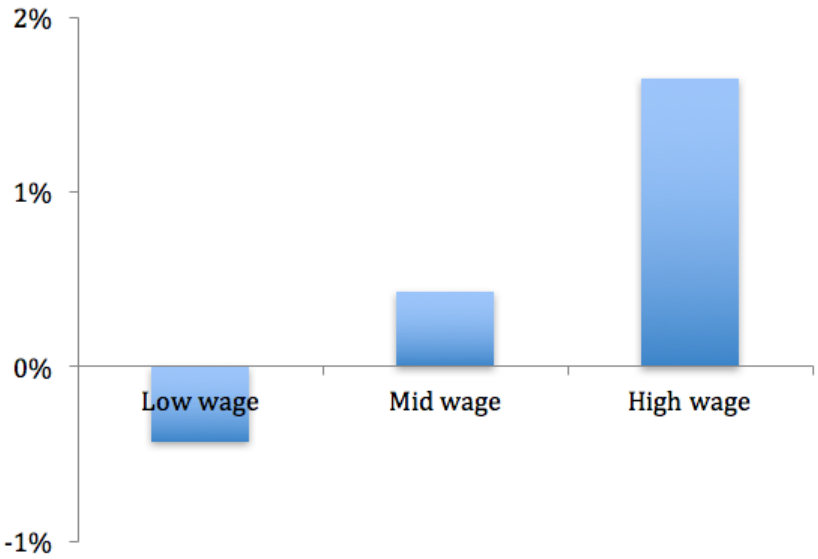
Weekly Digest

This association is not necessarily causal—perhaps some other factor caused computer-using occupations to grow. But this finding does show that computer automation is not associated with major job losses.

Computer automation and inequality

Nevertheless, computer automation is associated with major workforce dislocation. While automation does not appear to have a major effect on overall employment, automation is associated with substantial job losses for some groups of occupations and job gains for other occupations. In particular, low-wage occupations tend to lose jobs while high-wage occupations gain (see Figure 2). High-wage occupations use computers more intensively, allowing them to substitute for work done by low-wage occupations.

Figure 2. Net effect of computer automation on occupation job growth, grouped by 1980 mean occupational wage



This disparity could contribute substantially to economic inequality if workers in low wage occupations cannot easily transfer to high wage occupations. Low-wage workers, for instance, might not get opportunities to work with computers or might not have the necessary skills. My data provide some evidence that this might be the case. Occupations that use computers more heavily have had growing dispersion of within-occupation wages—workers who acquire new skills earn more, but not all workers have the opportunity or ability to learn. Also, computer-using occupations tend to employ increasing shares of college educated workers, even in occupations such as bank teller that do not require college degrees.

Conclusion

Computers automating tasks doesn't imply that occupations that use computers will necessarily suffer job losses. In fact, computer-using occupations have had greater job growth to date. Instead, it is the occupations that use few computers that appear to suffer computer-related job losses.

The notion that computer automation necessarily leads to major job losses ignores the dynamic economic response to automation, a response that involves both changing demand and inter-occupation substitution. Of course, the recent experience does not necessarily predict the future and new artificial intelligence technologies might have a different effect. Indeed, even though past technologies, such as automated weaving, initially created many jobs, demand elasticity eventually declined, and then further technological gains led to job losses. Computer automation may create job losses in the future.

But focusing on that future problem is a poor guide for today's policy. The evidence suggests that while computers are not causing net job losses now, low wage occupations are losing jobs, likely contributing to economic inequality. These workers need new skills in order to transition to new, well-paying jobs. Developing a workforce with the skills to use new technologies is the real challenge posed by computer automation.

References

l, T Gregory and U Zierahn (2016) "The risk of automation for jobs in OECD countries: A ative analysis", OECD Social, Employment and Migration Working Papers, No 189, OECD

Publishing, Paris.

Autor, D H (2015) "Why are there still so many jobs? The history and future of workplace automation", *The Journal of Economic Perspectives,* 29(3): 3-30.

Bessen, J (2015) *Learning by Doing: The Real Connection Between Innovation, Wages, and Wealth,* Yale University Press.

Bessen, J (2016) "How computer automation affects occupations: Technology, jobs, and skills", Boston University School of Law, Law and Economics Research Paper 15-49.

Brynjolfsson, E and A McAfee (2014) *The Second Machine Age: Work, Progress, And Prosperity In A Time Of Brilliant Technologies*, New York: WW Norton & Company.

Ford, M (2015) *Rise of the Robots: Technology and the Threat of a Jobless Future,* New York: Basic Books.

Frey, C B and M A Osborne (2013) "The future of employment: How susceptible are jobs to computerisation", Working Paper.

Endnotes

[1] Others were eliminated for a variety of reasons including changing demand for the service (boardinghouse keepers) and technological obsolescence (telegraph operators).

Topics: Frontiers of economic research Labour markets Productivity and Innovation

Tags: automation, computer automation, technology, innovation, employment growth, occupations, workforce dislocation, substitution, Inequality, skills

Related

The job race: Machines versus humans
Daron Acemoğlu, Pascual Restrepo

How much we work: The past, the present, and the future
Timo Boppart, Per Krusell

How the digital revolution is reshaping the global workforce
Carl Benedikt Frey, Ebrahim Rahbari

Jobless recoveries and the disappearance of routine occupations
Henry Siu, Nir Jaimovich

Printer-friendly version