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Smart machines and the future U.S. workforce

The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. By Erik Brynjolfsson and Andrew McAfee, New York: Norton, 2014, 306 pp., $26.95.

In *The Second Machine Age*, coauthors Erik Brynjolfsson and Andrew McAfee examine the possible effects on the American workforce of the rapid improvements in technology in the last decade and those expected in the near future. The book is easy to read and aimed at a broad audience. Much of its evidence is familiar, but all readers should find something new and interesting in its pages. Many other books and articles have examined similar themes, so the broad topic is already in the social consciousness.

The authors argue that daily work will go through major changes as it adapts to exponentially improving digital electronic technologies. To meet the challenge, they recommend several new government policies, including revamping education.

The first sections of the volume examine the rapid and sustained rate of technological progress in computers, software, and communications. Brynjolfsson and McAfee describe the sources of this progress as *digital*, *exponential*, and *recombinant*. Because computerized information is organized and processed *digitally*, in bits and bytes, it can be shared among computers and other machines rapidly and reliably. The capabilities of these machines have improved *exponentially* over time. As Moore's law states, the number of transistors that can be put on a chip, and hence chip speed and capability, has doubled about every 2 years. The inventive human role in such progress is labeled "brilliant tinkering," and discoveries and inventions at the nanoscale level are rapidly turned into

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reproducible designs with a broad impact. Sustained over many years, Moore's law has a large cumulative effect.

Each technology improves in ways that augment the capabilities of related technologies. For example, sensors, data transmission, and processing have improved to the extent that facial and x-ray images can now be precisely recorded, transmitted, and analyzed by a computer in a matter of seconds. The book highlights Waze, which detects and analyzes traffic conditions and rapidly transmits them to travelers. This capacity for *recombination* results partly from the digital property of the technologies, which allows them to work together effectively, and partly from the layering of many technologies to develop and produce modern products. High-tech products combine software with chips, sensors, memory, and other elements. Rapid advances in each of these areas open up vast new opportunities. Beyond the layering of functions in a particular product, different systems can "talk" to one another (be networked) to benefit from their separate capabilities and the information that each possesses.

The resulting improvements are qualitative as well as quantitative. The book discusses some of the things that computers are now capable of. For example, it is now possible for a computer to translate from one language to another much faster and more cheaply than a person can, and almost as well. Computers can also translate a language even when no one who knows that language is around. In addition, it is possible for a person to have a conversation with a computer.

Many experts have assumed that mass-produced computers and robots can perform only routine, repetitive work, but waves of improvement have undermined that view. With additive manufacturing (i.e., 3-D printing), mechanical design changes can be prototyped and tested immediately. Computers can write essays. Robots can fly aircraft and respond to what they "see" or to new instructions from a remote human operator. Cars will be able to detect traffic problems through networks and adapt without human intervention.

The book's discussion of the effects of these new technologies on the workforce is less illuminating. The authors argue that the new technological "wizardry" will intensify inequality, leading to large incomes for a fortunate few and eliminating jobs for large numbers of people. They present some persuasive examples: if trucks can drive themselves, there will be fewer truckers. But the book does not offer a systematic empirical view of the effect of computerization on different occupations, as, for example, is presented by Carl Frey and Michael Osborne in their paper "The Future of Employment: How Susceptible Are Jobs to Computerisation" (Oxford, U.K.: University of Oxford, 2013). Many readers would have appreciated some explicit guidance about which occupations or industries are most in danger of being displaced. It is difficult to predict, but the long-term technical advances documented by Brynjolfsson and McAfee may not directly affect workers in most jobs and industries over the next 25 years. For example, about 15 million Americans work in retail stores or restaurants. As more goods are delivered by robots, autonomous trucks, or aircraft, how many of these workers could be displaced? The book does not tell us.

Other countries are adjusting to new technical capabilities as well. If new generations of Chinese and Indian workers become more productive through using smart machines, the effects on American workers, consumers, and taxpayers may appear in trade flows rather than in American manufacturing. Computer support and other services are increasingly being transmitted internationally, and smart machines have expanded the scope of offshoring. Americans who have to compete with billions of people in the world, many of whom are supported by

smart technology, do not have an easy road. *The Second Machine Age* does not address employment questions with enough of an international perspective.

American teenagers' exposure to technology is helping to prepare them for the future. By learning to use computers, collaborating online, and participating in social media, they are developing some of the skills required to work effectively with smart machines. These trends are sure to propel many American workers into useful jobs designing and implementing the technology that represents all of this remarkable technical progress. But what about less capable or less scientifically inclined students or poorer, less plugged-in groups that lack access to the new tools? How will they fit into an age of smart machines?

The authors offer some policy advice, mostly standard prescriptions for economic growth, such as paying teachers more, expanding online courses, reducing regulatory burdens on businesses, sustaining research funding, improving transportation infrastructure, and encouraging the immigration of foreign technical workers to the United States.

There are any number of new ways people will engage with smart machines. For example, a past age invented courses in "driver's ed," and future schools could likewise provide training in "robotics ed." If families and schools could cultivate creativity and flexibility more strongly in young people, future generations would probably be better prepared to work in ways that are complementary to smart machines, and those generations would then have to compete with machines less directly. Unfortunately, Brynjolfsson and McAfee do not directly discuss any of these or other, similar developments.

No one book can resolve all these matters, but we would like to have seen conclusions more firmly grounded in quantitative analysis. Still, overall, *The Second Machine Age* clearly illustrates important technical trends and how the authors expect smart machines to affect technology and the workforce in the future.