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Choosing a future

The Second Machine Age

by Erik Brynjolfsson and Andrew McAfee. New York, NY: W. W. Norton, 2014, 320 pp.

Robert D. Atkinson

The past several years have witnessed a lively debate about innovation between techno-pessimists and techno-optimists. The pessimists' view—exemplified by work such as Peter Thiel's *What Happened to the Future*, Robert Gordon's *The Demise of U.S. Economic Growth*, and Tyler Cowen's *The Great Stagnation*—is that the days of robust U.S. innovation and productivity growth are over, in part because most of the low-hanging fruit has already been picked. Gordon, for example, asserts that "there is no need to forecast any slowdown in the pace of future innovation for this gloomy forecast to come true, because that slowdown already occurred four decades ago." For him, "medical research, small robots, 3-D printing, big data, and driverless vehicles" are marginal extensions of past technologies which will do little to drive future growth.

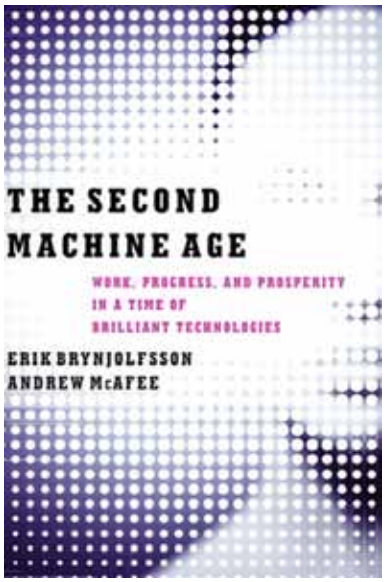
Confronting the innovation pessimists are the innovation optimists, exemplified by, among others, Peter Diamandis and Steven Kotler's *Abundance: The Future is Better Than You Think* and Erik Brynjolfsson and Andrew McAfee's *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. For Diamandis and Kotler, emerging technology is so powerful that "within a generation, we will be able to provide goods and services, once reserved for the wealthy few, to any and all who need them." They don't just mean abundance in the developed world, but in the entire world. There's only one problem with their utopian claim: To reach their projected income levels the world would have to experience productivity growth of 25% a year for the next 25 years, up from the 3.5% average of the past 25 years.

Like Diamandis and Kotler, Brynjolsson and McAfee are similarly utopian, arguing that the "second machine age" (the first one was the Industrial Revolution in Great Britain) is "doing for mental power…what the steam engine and its descendants did for muscle power. They're allowing us to blow past previous limitations and taking us into new territory."

Clearly one (or both) of these camps must be wrong. We can't be simultaneously facing stagnation and surge. What this points to is the difficulty in accurately describing the "innovation elephant." Optimists see the parts that are accelerating and driving change (e.g., our smart phones) and extend them to the entire economy while extrapolating current trends forward. Pessimists see parts of the innovation system that are "stuck" (e.g., much of the personal and knowledge services economy) and assume that this not only describes the entire economy but will not change going forward. The reality is that neither view is right, because some parts of the innovation system are driving rapid change, whereas others are relatively stagnant.

Brynjolfsson and McAfee (B&M) in particular assume that virtually all parts of the innovation system are vibrant and accelerating. They assert that innovation will accelerate at an exponential rate because of three factors: continued exponential advances in computing power, pervasive digitization, and the combinatory nature of innovation. For them, these three factors are enabling transformative tools that will replace large amounts of work currently done by humans, including knowledge work, and this transformation will be on the scale of the first Industrial Revolution.

There are however, major flaws in their framework. First, it's not clear that Moore's law will continue to be true. Gordon Moore's revolutionary prediction in 1965 that the number of transistors on a chip would double every 12 to 18 months (and thus would computer processing speeds) has proven prescient. Indeed, over the past 40 years, processing speeds have increased over 1 million-fold, unleashing a wave of innovation across industries. But possibly as soon as 2020, the dominant silicon-based CMOS semiconductor architecture will probably hit physical limits (particularly pertaining to heat dissipation) that threaten to compromise Moore's law unless a leap can be made to radically new chip architectures. But B&M devote no attention to this critical issue, blithely assuming that semiconductor past is prologue.



Second, after asserting that Moore's law will continue—not just in semiconductors, but in all areas of digital technology—they argue that we are experiencing "the digitization of just

about everything." In other words, not only are digital technologies improving exponentially, but more and more areas of the economy are becoming digital. For them this matters because "when things are digitized…they acquire some weird and wonderful properties. They're subject to different economies, where abundance is the norm, rather than scarcity."

Although it is true that digital technologies are reshaping traditional industries, including transportation, manufacturing, education, and health care, this does not mean that bits will replace all atoms or genes. Food won't be digitized. Manufactured goods, although increasingly sold online and made with digitally enabled technologies, will still be made of atoms. What B&M are really referring to is digitized information, where abundance is real because digital goods are nonrivalrous, meaning I can enjoy them without that coming at your expense. This counterintuitive property, however, applies to probably less than 5% of the economy, and certainly not to activities such as making cars or waiting on tables, where scarcity and rivalry are the rule.

Third, B&M assert that innovation is speeding up because the possible combinations of innovations are increasing, as is our ability to combine the ingredients. For them, innovation is easier in the digital era because of the possibility to recombine "recipes" and test them, what they call "recombinant innovation." They claim that the "number of potentially valuable building blocks is exploding around the world." Growth is being held back only by our inability to process all the new ideas fast enough. In short, they argue that the "second machine age will be characterized by countless instances of machine intelligence and billions of interconnected brains working together to better understand and improve our world."

But this is a simplistic view of the process of innovation that likens it to random recombinations of elements, akin to having a million monkeys on typewriters, hoping that one will write a Shakespeare play. If this were true, the rate of innovation should have sped up over the past 100 years as more building blocks were created and more people were at work combining ingredients. But innovation is no faster today than it was in the late 1800s. In fact, it appears that innovation is getting much harder, because the problems to solve are so much tougher, and the only thing keeping us from suffering an innovation drought is the increased global resources going to R&D.

This leads them to perhaps their largest misreading of the future, one that is shared by many futurists speaking at corporate confabs, TED-talk

pundits, and pretty much everyone who works at Silicon Valley's Singularity University: the notion that technical progress is improving "exponentially." If innovation is actually improving exponentially every few years, this would suggest that a decade from now, the U.S. Patent Office should be issuing 4.4 million patents a year, up from the 542,000 in 2013 (the exponential rate of increase). I can't wait.

Finally, they overstate the extent to which digital innovation is transforming occupations. For them, virtually all jobs will be disrupted by smart machines. A closer look suggests otherwise. In a back-of-the-envelope analysis of U.S. occupations, the Information and Technology Innovation Foundation came up with a roughly 20-50-30 split among jobs that are moderately difficult to automate, difficult to automate, and very difficult to automate. In other words, only about 20% of total U.S. jobs are likely to be easily automated over the next decade or two.

Despite the utopian future that B&M suggest is waiting for us, at least in terms of innovation, they are surprisingly pessimistic about the effects, warning of all sorts of dystopian results, the principal one being massive unemployment and income inequality. They have backed off somewhat from their more extreme claims made in their e-book *The Race Against the Machine*, in which they claimed that the second machine age would cause massive unemployment. But they still raise the fear flag, arguing that "as computers get more powerful, companies have less need for some kinds of workers."

But their logic is fundamentally flawed. For example, after pointing out that since the year 2000, productivity and employment are no longer growing apace, they assert that this disjuncture is evidence that productivity kills jobs. But not only has productivity not accelerated after 2000, there is simply no logical reason why growth in the labor force and growth in productivity would be related.

And although they acknowledge that technologically driven productivity would reduce prices, which should enable consumers to purchase more of other goods and services, thereby employing more workers, they dismiss this possibility. Without any evidence or logic, they claim that consumers will be satiated and not want to consume more even if their disposable incomes go up. I don't know about MIT professors, but the average U.S. family with a household income of around $50,000 would be ecstatic if higher productivity doubled or even tripped their real incomes and would easily find things to spend it on.

The most disturbing aspect of B&M's argument is that it might lead policymakers to conclude that their job should be to slow down innovation-driven productivity growth. B&M argue that "we can do more to invent technologies and business models that augment and amplify the unique capabilities of humans to create new sources of value, instead of automating the ones that already exist." They advocate that government award prizes for technologies that don't replace labor. They want to start a "made by humans" labeling movement. And since technology will destroy jobs and create a massive new lumpenproletariat sitting at home with nothing to do, they advocate for a slew of redistributionist, rather than growth, solutions, including a negative income tax, an expanded Earned Income Tax Credit, and a national mutual fund that provides dividends for everyone.

The excesses of the techno-optimists do not mean, however, that the techno-pessimists are correct in asserting that we can no longer expect much benefit from innovation. Given the slow growth in U.S. productivity over the past decade and the large expected rise in retirees over the next quarter century, the most important thing policymakers can do is support innovations that "automate the jobs that already exist." Stoking neo-Luddite fears of technology-induced joblessness is a step in the wrong direction.

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Steal this book

Open Access

by Peter Suber. Cambridge, MA: MIT Press, 230 pp.

Paul F. Uhlir

In 1971, Abbie Hoffman mischievously named his first book-length screed *Steal This Book*, and founded a publishing company, Pirate Press, because no existing publisher would touch it. It was a countercultural manifesto against the "pig" establishment. The networks—CBS, NBC, and ABC, plus the upstart Fox—were "evil corporate conglomerates" spewing capitalist lies.

Flash forward four decades, and the inmates are running the asylums. Establishment journals, including *Issues in Science and Technology*, publish their content freely and openly online, inviting readers to "steal" their articles. The old TV networks still exist, but the one that really matters is the global Internet, where free information rules. The born-digital generation regularly pirates copyrighted content or at least expects information to be free and instantaneous. And there are even political "Pi-