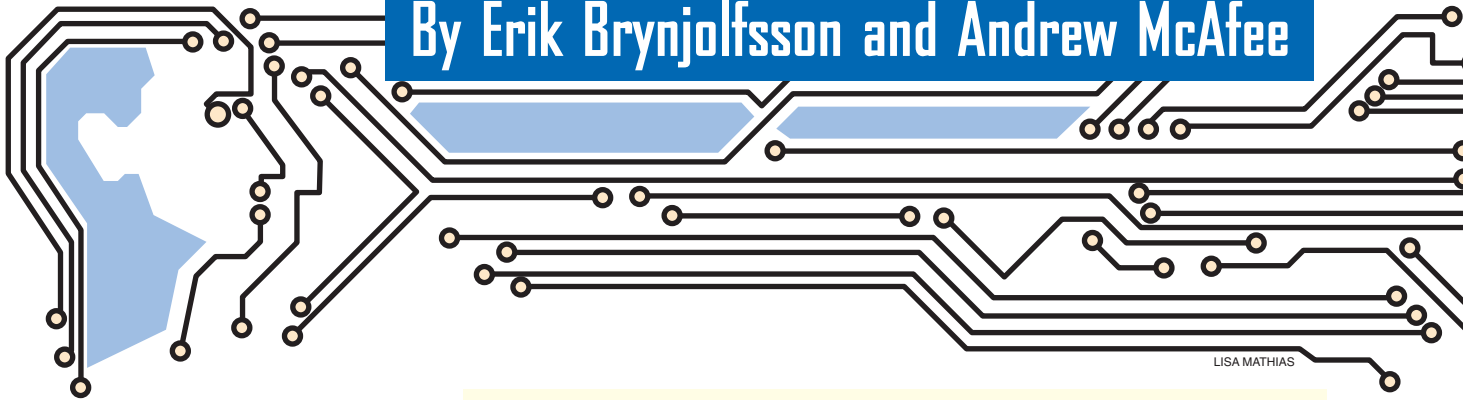


Thriving in the Automated Economy

By Erik Brynjolfsson and Andrew McAfee



The legend of John Henry became popular in the late nineteenth century as the effects of the steam-powered Industrial Revolution were felt in every industry and job that relied heavily on human strength. It's the story of a contest between a steam drill and John Henry, a powerful railroad worker, to see which of the two could bore the longer hole into solid rock. Henry wins this race against the machine but loses his life; his exertions cause his heart to burst. Humans never directly challenged the steam drill again.

This legend reflected popular unease at the time about the potential for technology to make human labor obsolete. But this is not at all what happened as the Industrial Revolution progressed. As steam power advanced and spread throughout industry, more human workers were needed, not fewer. They were needed not for their raw physical strength (as was the case with John Henry), but instead for other human skills: physical ones like locomotion, dexterity, coordination, and perception, and mental ones like communication, pattern matching, and creativity.

Throughout the Industrial Revolution, economists have reassured workers and the public that new jobs would be created even as old ones were eliminated. For more than 200

Two management experts show why labor's race against automation will only be won if we partner with our machines. They advise government regulators not to stand in the way of human-machine innovation.

years, the economists were right. Despite massive automation of millions of jobs, more Americans had jobs at the end of each decade up through the end of the twentieth century. However, this empirical fact conceals a dirty secret. There is no economic law that says that everyone, or even most people, automatically benefit from technological progress.

Around 1811, just as anxiety about the Industrial Revolution was leading to worker uprisings (the Luddite riots), economist David Ricardo—who initially thought that advances in technology would benefit all—developed an abstract model that showed the possibility of technological unemployment. The basic idea was that, at some point, the equilib-

rium wages for workers might fall below the level needed for subsistence. A rational human would see no point in taking a job at a wage that low, so the worker would go unemployed and the work would be done by a machine instead.

Of course, this was only an abstract model. But in his book *A Farewell to Alms* (Princeton University Press, 2007), economist Gregory Clark gives an eerie real-world example of this phenomenon in action:

There was a type of employee at the beginning of the Industrial Revolution whose job and livelihood largely vanished in the early twentieth century. This was the horse. The population of working horses actually

peaked in England long after the Industrial Revolution, in 1901, when 3.25 million were at work. Though they had been replaced by rail for long-distance haulage and by steam engines for driving machinery, they still plowed fields, hauled wagons and carriages short distances, pulled boats on the canals, toiled in the pits, and carried armies into battle. But the arrival of the internal combustion engine in the late nineteenth century rapidly displaced these workers, so that by 1924 there were fewer than two million. There was always a wage at which all these horses could have remained employed. But that wage was so low that it did not pay for their feed.

As technology continues to take on jobs and tasks that used to belong only to human workers, one can imagine a time in the future when more and more jobs are more cheaply done by machines than humans. And indeed, the wages of unskilled workers have trended downward for more than 30 years, at least in the United States.

We also now understand that technological unemployment can occur even when wages are still well above subsistence if there are downward rigidities that prevent them from falling as quickly as advances in technology reduce the costs of automation. Minimum wage laws, unemployment insurance, health benefits, prevailing wage laws, and long-term contracts—not to mention custom and psychology—make it difficult to rapidly reduce wages. Furthermore, employers will often find wage cuts damaging to morale. As the efficiency wage literature notes, such cuts can make employees unmotivated and cause companies to lose their best people.

But complete wage flexibility would be no panacea, either. Ever-falling wages for significant shares of the workforce is not exactly an appealing solution to the threat of technological employment. Aside from the damage it does to the living standards of the affected workers, lower pay only postpones the day of reckoning. Moore's law is not a one-time blip but an accelerating exponential trend. Either way, technological un-

employment is emerging as a real and persistent threat to middle-class employment.

When significant numbers of people see their standards of living fall despite an ever-growing economic pie, it threatens the social contract of the economy and even the social fabric of society. One instinctual response is to simply redistribute income to those who have been hurt. While redistribution ameliorates the material costs of inequality, and that's not a bad thing, it doesn't address the root of the problems the economy is facing. By itself, redistribution does nothing to make unemployed workers productive again. Furthermore, the value of gainful work is far more than the money earned. There is also the psychological value that almost all people place on doing something useful. Forced idleness is not the same as voluntary leisure. Franklin D. Roosevelt put this most eloquently:

No country, however rich, can afford the waste of its human resources. Demoralization caused by vast unemployment is our greatest extravagance. Morally, it is the greatest menace to our social order.

Fortunately, if we make the right decisions today, we can still secure the gains that come from technological progress without sacrificing broad prosperity or the social contract. Here are some ideas.

Racing with the Machine

The John Henry legend shows us that, in many contexts, humans will eventually lose the head-to-head race against the machine. But the broader lesson of the first Industrial Revolution is more like the Indy 500 than John Henry: Economic progress comes from constant innovation in which people race *with* machines. Human and machine collaborate together in a race to produce more, to capture markets, and to beat other teams of humans and machines.

This lesson remains valid and instructive today as machines are winning head-to-head mental contests, not just physical ones. We observe that things get really interesting once

this contest is over and people start racing with machines instead of against them.

The game of chess provides a great example. In 1997, Garry Kasparov, humanity's most brilliant chess master, lost to Deep Blue, a \$10 million specialized supercomputer programmed by a team from IBM. That was big news when it happened, but then developments in the world of chess went back to being reported on and read mainly by chess geeks. As a result, it's not well known that the best chess player on the planet today is not a computer. Nor is it a human. The best chess player is *a team of humans using computers*.

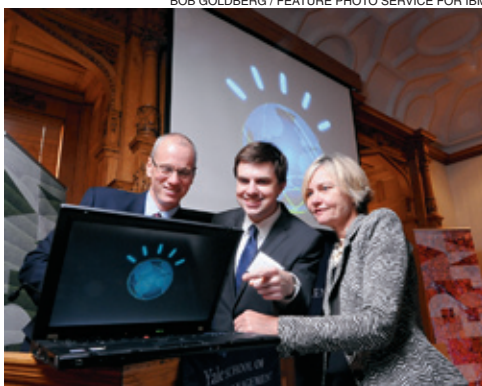
After head-to-head matches between humans and computers became uninteresting (because the computers always won), the action moved to "freestyle" competitions, allowing any combination of people and machines. The overall winner in a recent freestyle tournament had neither the best human players nor the most powerful computers. As Kasparov writes, it instead consisted of

a pair of amateur American chess players using three computers at the same time. Their skill at manipulating and "coaching" their computers to look very deeply into positions effectively counteracted the superior chess understanding of their grandmaster opponents and the greater computational power of other participants. ... Weak human + machine + better process was superior to a strong computer alone and, more remarkably, superior to a strong human + machine + inferior process.

This pattern is true not only in chess but throughout the economy. In medicine, law, finance, retailing, manufacturing, and even scientific discovery, the key to winning the race is not to compete *against* machines but to compete *with* machines. While computers win at routine processing, repetitive arithmetic, and error-free consistency and are quickly getting better at complex communication and pattern matching, they lack intuition and creativity and are lost when asked to work even a little outside a predefined do-



Fans watch as World Chess Champion Garry Kasparov plays IBM's Deep Blue in 1998.



From competitor to partner: IBM business analysts marvel over Watson.

main. Fortunately, humans are strongest exactly where computers are weak, creating a potentially beautiful partnership.

As this partnership advances, we're not too worried about computers holding up their end of the bargain. Technologists are doing an amazing job of making them ever faster, smaller, more energy efficient, and cheaper over time. We are confident that these trends will continue even as we move deeper into the twenty-first century.

Digital progress, in fact, is so rapid and relentless that people and organizations are having a hard time keeping up. We want to focus on recommendations in two areas: improving the rate and quality of organizational innovation, and increasing human capital—ensuring that people have the skills they need to participate in today's economy, and tomorrow's. Making progress in these two areas will be the best way to allow human workers and institutions to race with machines, not against them.

Fostering Organizational Innovation

How can we implement a "race with machines" strategy? The solution is organizational innovation: co-inventing new organizational structures, processes, and business models that leverage ever-advancing technology and human skills. Economist Joseph Schumpeter described this as a process of "creative destruc-

tion" and gave entrepreneurs the central role in the development and propagation of the necessary innovations. Entrepreneurs reap rich rewards because what they do, when they do it well, is both incredibly valuable and far too rare.

To put it another way, the stagnation of median wages and polarization of job growth is an *opportunity* for creative entrepreneurs. They can develop new business models that combine the swelling numbers of mid-skilled workers with ever-cheaper technology to create value. There has never been a worse time to be competing against machines, but there has never been a better time to be a talented entrepreneur.

Entrepreneurial energy in America's tech sector drove the most visible reinvention of the economy. Google, Facebook, Apple, and Amazon, among others, have created hundreds of billions of dollars of shareholder value by creating whole new product categories, ecosystems,

and even industries. New platforms leverage technology to create marketplaces that address the employment crisis by bringing together machines and human skills in new and unexpected ways:

- eBay and Amazon Marketplace spurred more than 600,000 people to earn their livings by dreaming up new, improved, or simply different or cheaper products for a worldwide customer base. The "long tail" of new products offered enormous consumer value and is a rapidly growing segment of the economy.

- Apple's App Store and Google's Android Marketplace make it easy for people with ideas for mobile applications to create and distribute them.

- Threadless lets people create and sell designs for T-shirts. Amazon's Mechanical Turk makes it easy to find cheap labor to do a breathtaking array of simple, well-defined tasks. Kickstarter flips this model on its head and helps designers and creative artists find sponsors for their projects.

- Heartland Robotics plans to provide cheap robots-in-a-box that make it possible for small-business



Threadless designer Brock Davis, with art for sale.



Members of the band Halloween Alaska won funding for their production work thanks to Kickstarter.



owners to quickly set up their own highly automated factory, dramatically reducing the costs and increasing the flexibility of manufacturing.

Collectively, these new businesses directly create millions of new jobs. Some of them also create platforms for thousands of other entrepreneurs. None of them may ever create billion-dollar businesses themselves, but collectively they can do more to create jobs and wealth than even the most successful single venture.

As technology makes it possible for more people to start enterprises on a national or even

"There is no automatic ceiling to the number of different markets that can be created."

global scale, more people will be in the position to earn superstar compensation. While winner-take-all economics can lead to vastly disproportionate rewards to the top performer in each market, the key is that

there is no automatic ceiling to the number of different markets that can be created. In principle, tens of millions of people could each be a leading performer—even the top expert—in tens of millions of distinct, value-creating fields. Think of them as micro-experts for macro-markets. Technology scholar Thomas Malone calls this the age of hyperspecialization. Digital technologies make it possible to scale that expertise so that we all benefit from those talents and creativity.

The Limits to Organizational Innovation and Human Capital Investment

We're encouraged by the emerging opportunities to combine digital, organizational, and human capital to create wealth: Technology, entrepreneurship, and education are an extraordinarily powerful combination. But we want to stress that even this combination cannot solve all our problems.

First, not everyone can or should be an entrepreneur, and not everyone can or should spend 16 or more years in school. Second, there are limits to the power of American entrepreneurship for job creation. A 2011 research report for the Kauffman Foundation by E. J. Reddy and Robert Litan found that, even though the total number of new businesses founded annually in the United States has remained largely steady, the total number of people employed by them at start-up has been declining in recent years. This could be because modern business technology lets a company start leaner and stay leaner as it grows.

Third, and most importantly, even when humans are racing using machines instead of against them, there are still winners and losers. Some people, perhaps even a lot, can continue to see their incomes stagnate or shrink and their jobs vanish while overall growth continues.

We focus our recommendations on creating ways for everyone to contribute productively to the economy. As technology continues to race ahead, it can widen the gaps between the swift and the slow on many dimensions. Organizational and institutional innovations can recombine human capital with machines to create broad-based productivity growth. That's where we focus our recommendations.

Toward an Agenda for Action

The following solutions involve accelerating organizational innovation and human capital creation to keep pace with technology. There are at least 19 specific steps we can take to these ends in the United States.

Education

1. Invest in education. Start by simply paying teachers more so that more of the best and the brightest sign up for this profession, as they do in many other nations. American teachers make 40% less than the average college graduate. Teachers are some of America's most important wealth creators. Increasing the quantity and quality of skilled labor provides a double win by boosting eco-

nomics growth and reducing income inequality.

2. Hold teachers accountable for performance by, for example, eliminating tenure. This should be part of the bargain for higher pay.

3. Separate student instruction from testing and certification. Focus schooling more on verifiable outcomes and measurable performance and less on signaling time, effort, or prestige.

4. Keep K-12 students in classrooms for more hours. One reason American students lag behind international competitors is that they simply receive about one month less instruction per year.

5. Increase the number of skilled workers in the United States by encouraging skilled immigrants. Offer green cards to foreign students when they complete advanced degrees, especially in science and engineering subjects at approved universities. Expand the H-1B visa program. Skilled workers in America often create more value when working with other skilled workers. Bringing them together can increase worldwide innovation and growth.

Entrepreneurship

6. Teach entrepreneurship as a skill not just in elite business schools but throughout higher education. Foster a broader class of mid-tech, middle-class entrepreneurs by training them in the fundamentals of business creation and management.

7. Boost entrepreneurship in America by creating a category of founders' visas for entrepreneurs, like those in Canada and other countries.

8. Create clearinghouses and databases to facilitate the creation and dissemination of templates for new businesses. A set of standardized packages for start-ups can smooth the path for new entrepreneurs in many industries. These can range from franchise opportunities to digital "cookbooks" that provide the skeleton structure for an operation. Job training should be supplemented with entrepreneurship guidance as the nature of work evolves.

9. Aggressively lower the governmental barriers to business cre-

ation. In too many industries, elaborate regulatory approvals are needed from multiple agencies at multiple levels of government. These too often have the implicit goal of preserving rents of existing business owners at the expense of new businesses and their employees.

Investment

10. Invest to upgrade the country's communications and transportation infrastructure. The American Society of Civil Engineers gives a grade of D to the overall infrastructure in the United States at present. Improving it will bring productivity benefits by facilitating flow and mixing ideas, people, and technologies. It will also put many people to work directly. You don't have to be an ardent Keynesian to believe that the best time to make these investments is when there is plenty of slack in the labor market.

11. Increase funding for basic research and for preeminent government R&D institutions, including the National Science Foundation, the National Institutes of Health, and the Defense Advanced Research Projects Agency (DARPA), with a renewed focus on intangible assets and business innovation. Like other forms of basic research, these investments are often underfunded by private investors because of spillover, a benefit that accrues to someone or some company that's far away from the original innovator.

Laws, Regulations, and Taxes

12. Preserve the relative flexibility of American labor markets by resisting efforts to regulate hiring and firing. Banning layoffs paradoxically can lower employment by making it riskier for firms to hire in the first place, especially if they are experimenting with new products or business models.

13. Make it comparatively more attractive to hire a person than to buy more technology through incentives, rather than regulation. This can be done by, among other things, decreasing employer payroll taxes and providing subsidies or tax breaks for employing people who

have been out of work for a long time. Taxes on congestion and pollution can more than make up for the reduced labor taxes.

14. Decouple benefits from jobs to increase flexibility and dynamism. Tying health care and other mandated benefits to jobs makes it harder for people to move to new jobs or to quit and start new businesses. For instance, many a potential entrepreneur has been blocked by the need to maintain health insurance. Denmark and the Netherlands have led the way here.

15. Don't rush to regulate new network businesses. Some observers feel that "crowdsourcing" businesses like Amazon's Mechanical Turk, which allows a global pool of workers to bid online for temporary jobs or tasks, exploit their members, who should therefore be better protected. However, especially in this early, experimental period, the developers of these innovative platforms should be given maximum freedom to innovate and experiment, and their members' freely made decisions to participate should be honored, not overturned.

16. Eliminate or reduce the massive home mortgage subsidy. This costs more than \$130 billion per year, which would do much more for growth if allocated to research or education. While home ownership has many laudable benefits, it likely reduces labor mobility and economic flexibility, which conflicts with the economy's increased need for flexibility.

17. Reduce the large implicit and explicit subsidies to financial services. This sector attracts a disproportionate number of the best and the brightest minds and technologies, in part because the government effectively guarantees "too big to fail" institutions.

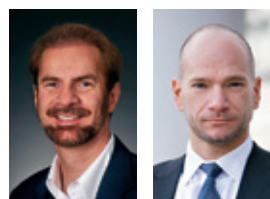
18. Reform the patent system. Not only does it take years to issue good patents due to the backlog and shortage of qualified examiners, but too many low-quality patents are issued, clogging our courts. As a result, patent trolls are chilling innovation rather than encouraging it.

19. Shorten, rather than lengthen, copyright periods and increase the flexibility of fair use. Copyright cov-

ers too much digital content. Rather than encouraging innovation, as specified in the Constitution, excessive restrictions like the Sonny Bono Copyright Term Extension Act inhibit mixing and matching of content and using it creatively in new ways.

These suggestions are only the tip of the iceberg of a broader transformation that we need to support, not only to mitigate technological unemployment and inequality, but also to fulfill the potential for new technologies to grow the economy and create broad-based value. We are not putting forth a complete blueprint for the next economy—that task is inherently impossible. Instead, we seek to initiate a conversation. That conversation will be successful if we accurately diagnose the mismatch between accelerating technologies and stagnant organizations and skills.

Successful economies in the twenty-first century will be those that develop the best ways to foster organizational innovation and skill development, and we invite our readers to contribute to that agenda. □



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