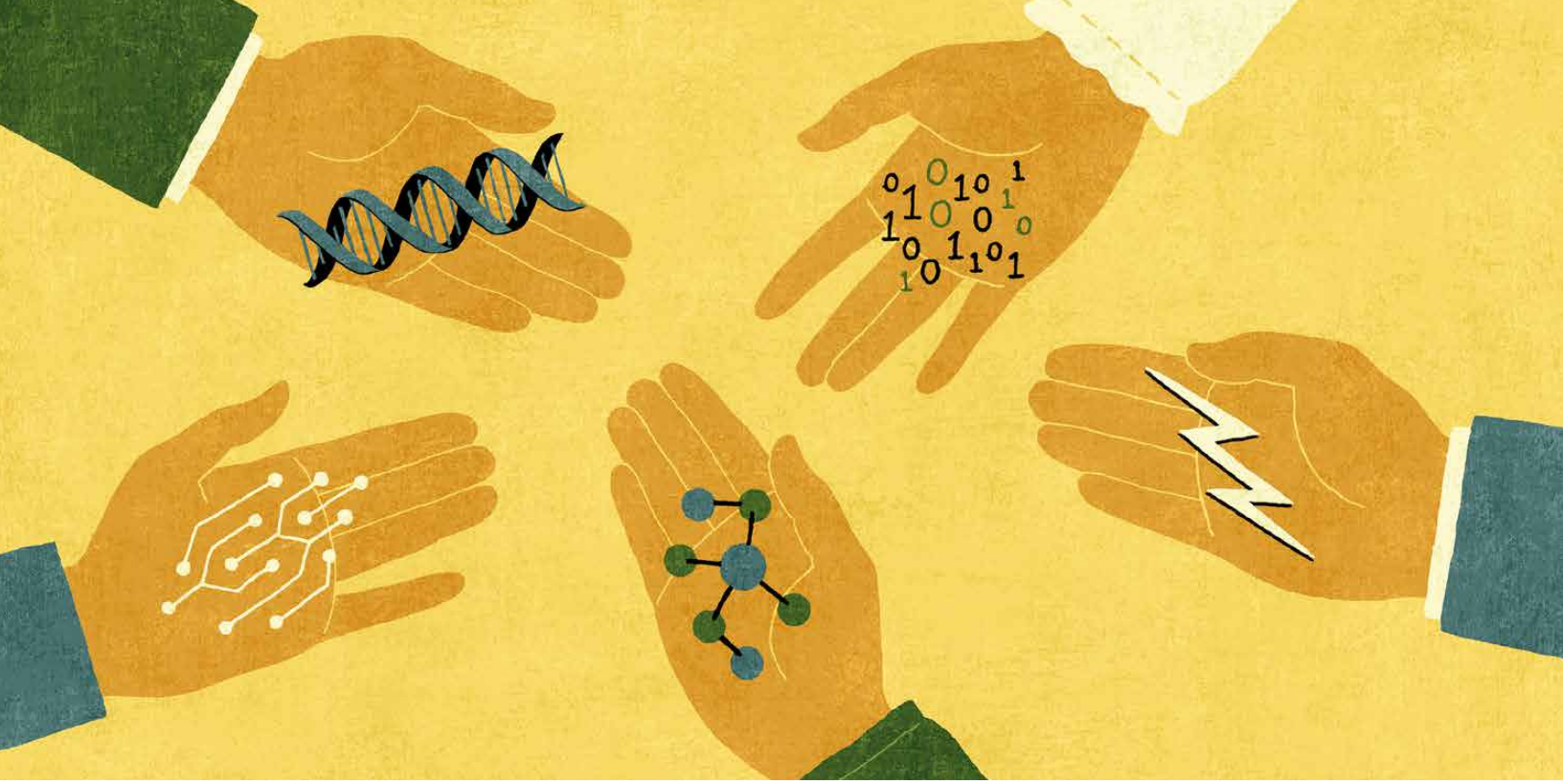


Illustration by James Steinberg

The human factor:
Amassing troops for the 'resource revolution'

Companies on the front lines of the resource revolution need to implement creative talent-management strategies.

Stefan Heck and Matt Rogers

The conventional wisdom is that the world could face a crisis with regard to resource scarcity. In our book, *Resource Revolution: How to Capture the Biggest Business Opportunity in a Century* (New Harvest, April 2014), we argue that this is actually an opportunity to reframe the world economy and create trillions of dollars in value. But doing so will require new organizational models and lots of human capital. In this excerpt from our book, we discuss which skills companies should seek and develop to win.

Looking for talent far afield

In thinking about the people who will be needed in a new organizational model and its operating system, the first thing to do is to begin to map the new skills that will be needed to pursue opportunities in resource productivity. The list will be long.

All companies will need more software talent, because software increasingly provides the operating instructions for our world. IT no longer is solely the business of managing company desktops and networks; information technology is merging with traditional engineering to create the lifeblood of the modern corporation. Those companies that can build the talent to integrate software and industrial hardware faster and more reliably than the market will win. The operating algorithms that identify which pump needs maintenance and which oil well needs more pressure will become the basis for competitive

advantage, just as Amazon's book-recommendation tools and its rapid checkout-management capabilities defined success in book sales. Many companies we think of as building hardware actually have more software than hardware engineers. Airplanes, automobiles, construction equipment, trains, and industrial machinery all ship with millions of lines of software code and are far more complex than the typical iPhone app.

Many companies will need more systems-integration skills because much of the power of the resource revolution will come from combining bits and pieces of disparate ideas, and most companies simply aren't very good at systems integration at the moment. For companies focused on resource use, the need for specialization is high, but the scarce resources are engineers and innovators who can solve the cross-functional problems that networks of technologies create. Success will come from harnessing rapid innovation in software and semiconductors, biotechnologies and nanotechnologies, and ubiquitous sensors and controls, and then integrating them with industrial processes for the first time. While emerging markets such as Brazil and China have some advantages in resource use because they're able to design networks such as electric grids from scratch, developed countries such as the United States have an advantage with the cross-functional aspects of resource productivity. Developed countries have senior architects with 30 years of experience in designing whole systems—the kind of experience that will be needed to integrate all the technologies available.

Beyond the ability to integrate various functions, new specialty skills will come into play for the first time. For example, automotive companies in Germany have found that while they are long on mechanical engineers, they are short on the software and chemical engineers that will be required to build electric, hybrid, and—perhaps one day—hydrogen cars. Entire components, such as transmission systems, could be eliminated with the advent of electric drivetrains, but carmakers will need people who understand how to weave carbon fiber, integrate 4G communication protocols and security with the car's operating system, and deal with battery issues such as heating and optimizing chemistry. Already, the electronics content in cars has hit 40 to 50 percent of their value, and this is before cars are routinely connected to the Internet. Many other industries will, like carmakers, need to increase their understanding of materials science, chemistry, or biology.

Many companies will need skills at super-low-cost manufacturing, too. For years, the goal in product design was to add features and generally improve capabilities. But the ability to build high quality very inexpensively now offers the key advantage. Wal-Mart pioneered the everyday-low-price promise and developed supply chains that could offer high-end products at very low prices. Huawei did the same for telecommunications technology. The market for high-quality, low-price goods is growing rapidly, and all but a few companies will have to look outside their walls to find the capabilities to tap that market.

The upshot? When looking for new talent, it's no longer enough to try to raid competitors for their best people—those competitors don't have the new skills, either. New talent needs to be found in new places.

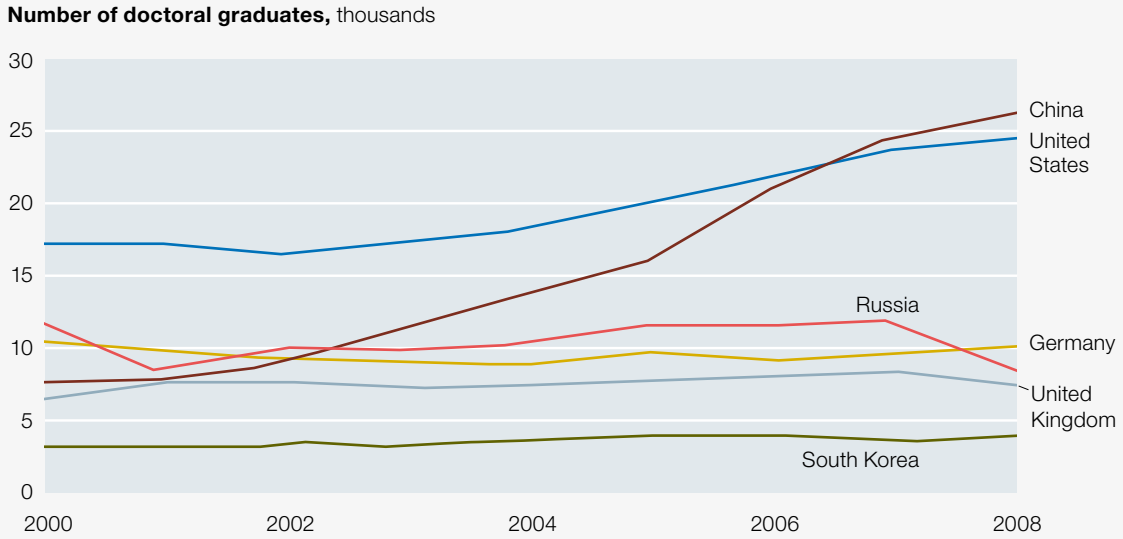
One place to start is in neighboring industries that haven't traditionally overlapped but that have been identified as having capabilities worth borrowing. Consumer electronics will present a big opportunity. So many people have become addicted to their smartphones that they will demand that the rest of the world's interactive devices have a similarly simple, smooth interface, and companies will need to be able to provide one, whatever the industry. Cars, for instance, are already migrating away from levers and buttons and toward iPad-like capabilities—though the switch will have to be negotiated

carefully, both because of familiarity with the old ways and because drivers have to keep their eyes on the road.

The Nest Labs thermostat provides another example. Until Nest came along, thermostat interfaces hadn't changed much since the shift in the early 1970s from the mercury-based mechanical switch to the box with a small liquid-crystal display and a bunch of buttons. Nest now has taken on the attributes of an iPod: the thermostat, which is round again, with an interface like a track wheel, learns users' preferences and communicates with their iPhones and other equipment in their houses over Wi-Fi. Nest, which can adjust to the weather and sense whether anyone is at home, takes another page from Apple in that the company sees the thermostat as just the first app for household-wide automation and convenience. Nest has already announced a smoke detector that gently warns users when it detects small amounts of smoke or when its battery is fading. Because the thermostat and smoke detector can already tell when someone is home, security is a natural extension. The plan is that new applications, software features, and more sensors and controls will one day allow Nest to do everything but deliver breakfast in bed.

Even though companies will need expertise on technologies such as the chips, apps, and batteries that go into consumer electronics, it won't always make sense to hire people from other industries. In some cases, it will make more sense to form partnerships with businesses in those industries that provide access to specialized expertise. For instance, rather than hire all its own experts on materials science, Apple is working with Corning on glass and coatings and with Liquidmetal Technologies on casting and ductility for casing materials. To differentiate its products from competitors with similar inventions, Apple has signed extensive agreements that guarantee exclusivity and supply from its partners.

Exhibit 1 **Finding qualified graduates will require a global search.**



Beyond looking at new industries for talent, it will be important to look in new countries, too. Building the leading workforce in the world requires developing a global talent-sourcing pipeline (Exhibit 1). Where companies might have traditionally recruited from the industrial-engineering core in the United States's Midwest and South—the Big Ten and Southeastern Conference engineering axis that powered the industrial innovations in the United States during the 20th century—the leading companies today need to be winning on the campus of Tsinghua University in Beijing, for example. Companies need to go to Russia to find experts in algorithms, to Israel for electro-optics and water technology, to Finland for leaders in wireless technology, and so on.

Less developed countries will be important sources of talent for low-cost manufacturing because "low cost" has a very different meaning to a street vendor in Delhi than it does to a citizen of the European Union. The lack of an infrastructure such as the one taken for granted in the United States requires that we look at technology and design options that would never even be considered in the United States. An American-made refrigerator needs to make ice cubes, fit in with kitchen decor, and have enough storage space to hold a weekly SUV run of groceries. For a person in the 80 percent of India's population that has no access to ice or refrigeration, there are no such expectations.

That difference is why Godrej's Chotukool, a $70 refrigerator, was developed in India and not the United States. The refrigerator, which looks like an oversize cooler and uses a battery-powered heat exchanger for its cooling technology rather than traditional compressors, comes at a price that wouldn't have even been considered possible in the developed world. Hitting that price may unlock a market for cooling in the developing world that is $108 billion today and is set to increase to $185 billion or more by 2018. Similarly, a low-cost sonogram machine was developed in India and is now being marketed worldwide by General Electric.

It isn't enough to just go looking for new talent, of course. Companies have to be able to win the competition for it. To do so, companies must first realize that they aren't just competing against traditional rivals. Companies have to win against, say, consumer-electronics firms and software companies, too. Likewise, competing for talent in China, India, and Russia requires competing against local national champions and their privileged local networks.

To win, companies not only have to compete on the usual measures of compensation and responsibility but also have to be willing to go where the talent is, whether geographically or virtually. Companies may even need to be willing to set up multiple development centers around the world to tap into those algorithm experts in Russia and the electro-optics geniuses in Israel.

Developing talent

In some cases, people with the skills to help companies thrive throughout the resource revolution simply don't exist, at least not in the numbers that will be needed, so companies will have to develop their own talent.

Much of the need will occur at the top of organizations, among the leaders. The leadership skills required to deliver 10 to 15 percent annual productivity gains for a decade or more are a far cry from the incremental-improvement skills that marked the generation of leaders after World War II. When technologies are largely mature in an industry, the focus on generating incremental improvement is the whole game, and we have developed a group of managers who are great at squeezing the last drop out of the radish. We developed a whole series of tools—lean, Six Sigma, business-process redesign, dispatch linear programs—all with the goal of

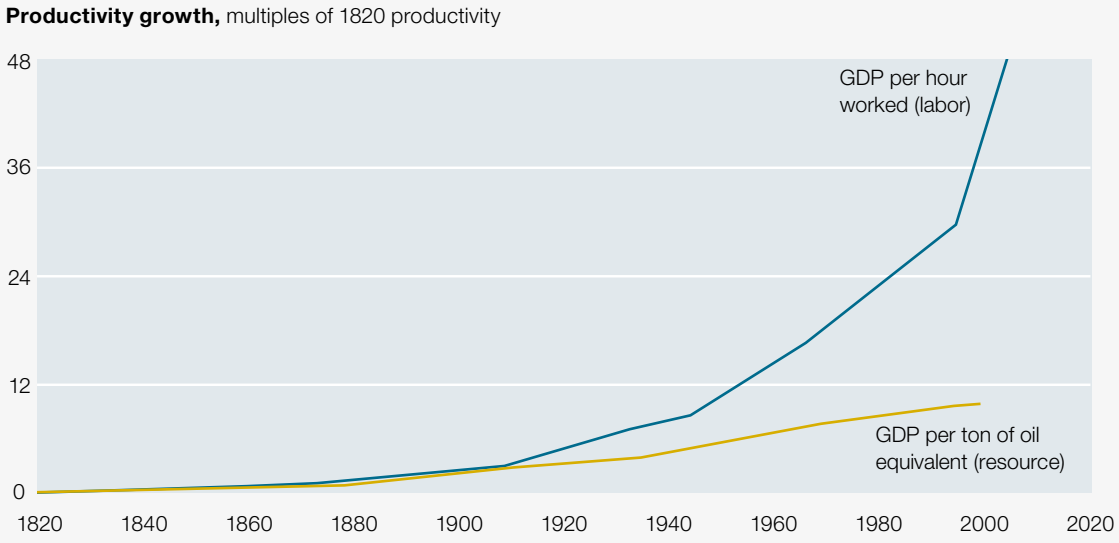
improving productivity by 1 to 2 percent annually. The idea was: keep the process in control, squeeze the next drop out, and the company will win. But not anymore.

Leaders' technology-management skills will also have to improve radically. When technology is changing at a rapid pace, the ability to identify and integrate new tools to improve performance is critical (Exhibit 2).

Everyone is familiar with the difficulties of upgrading their computers to handle new software—performance is always supposed to get better, but most of the time the upgrade takes forever, and there is a great deal of lost productivity in the transition. The same can happen when a business makes a fundamental upgrade in its operating system and supporting technology. So, imagine the pressure when a manager needs to upgrade the base business-technology portfolio every six to nine months and can't afford any downtime.

Even tougher, the challenge won't be just to upgrade a known form of technology; the world of resource revolutions is too cross-functional to be that simple and requires different departments, multiple suppliers, and often a customer willing to try something new. To take a simple example: it might make sense to shift from making trucks that use diesel to making trucks that use natural gas, to take advantage of low-priced, clean-burning methane. That single shift requires changes to the fuel tanks, the engine, pollution-control equipment, driver-information systems, cooling systems, network fueling infrastructure, and maintenance protocols. The results can deliver 37 percent savings in fuel costs and 9 percent savings in the total cost of ownership for the truck, but success requires taking an integrated view of the network problem. Making these integrated decisions in a world where the future differential between natural gas and diesel is highly uncertain makes the decision making even more difficult. Even within the car or truck platform, automotive companies will have to make trade-offs

Exhibit 2 **Factory-productivity growth will continue to improve.**



The good news is that, while the search for new organizational models and new talent in new places will be extraordinarily taxing, just about all the competition will face the same problems.

that cut across software, mechanical engineering, electronics, and chemistry.

Workers will need to be developed, too, whether by schools, by the government, or by employers. The reason is that the nature of work is changing and, in many cases, becoming much more technical. Workers on a solar-panel assembly line, for instance, need to learn how to handle equipment that operates within a tolerance of a fraction of a millimeter. That doesn't require a four-year college degree but does require a great deal of training with digital process-control technologies.

Quality-control supervisors in manufacturing will have to be able to understand advanced statistical techniques and need to be able to make adjustments to process-control technology to deliver extremely tight tolerances.

Resource productivity requires frontline labor such as the delivery-truck drivers employed by UPS to make much more sophisticated decisions based on big data and advanced analytics. They obviously don't have the data-analysis capabilities that UPS does centrally, so UPS pushes as much information out to the drivers as possible. UPS integrates data both on actual traffic and on anticipated traffic to instruct drivers to adjust routes. Now, as drivers make their morning deliveries, UPS dynamically pulls together routes for the pickups they'll make that afternoon.[1]

Developing new talent requires a new education model, much more technically focused than the one the developed world built around German liberal-education principles at the end of the 19th century to help people move from the farm to the city and be able to read, vote, and conduct business. The focus has been driving 90 percent of the population to have at least a high-school degree. The challenge now is that a high-school degree is not enough. Most countries in the developed world show 40 to 50 percent of the population having some college education, but countries will need to reach 80 to 90 percent to remain competitive with the likes of Korea, as "knowledge worker" skills such as communicating, problem solving, analyzing data, setting parameters on machines and algorithms, and collaborating globally become much more important. The German model continued to evolve after World War II to incorporate technical apprenticeships in trades like machining, carpentry, and programming, but much more is needed.

Learning will need to continue postcollege, too, largely through online course work—basically, higher education will undergo its own resource revolution, delivering learning virtually rather than in classrooms and lecture halls, even though the face-to-face model has worked well for millennia. Universities such as Stanford are already experimenting with a "flipped classroom" model enabled by computing technology: students read the book and watch the video of the lectures on their own time

on an iPad or laptop, and come to class (physically or virtually) to discuss, ask questions, and get a deeper understanding of the material. Once physical constraints are removed, the student can even be in a remote part of Western China and have access to the world's best professors on any topic. (A 15-year-old in Mongolia became 1 of 340 students to earn a perfect score in 2012 in MIT's Circuits and Electronics, a sophomore-level class that was the first massive open online course, that MIT offered. More than 150,000 students had enrolled in the course. The boy was accepted as a freshman at MIT at 16.)

The flipped classroom is the brainchild of companies such as Coursera and Udacity, which are trying to make the best courses in the world available to the masses, without requiring students to pay $50,000 a year to go to Harvard.

There also needs to be a stronger alignment between business and education, setting ever-increasing technical standards for each graduate. Students will need at least four years of mathematics plus specific technical training in statistics and data management to remain competitive during the resource revolution. Some companies are working with schools to set up feeder programs. Microsoft, for one, recently began sending engineers to high schools both to teach math skills and to generate enthusiasm that could bring more talent into software design and coding.

Businesses will need to do even more of their own training, too. There will need to be hands-on learning combined with simulations, often using the best graphics to allow hundreds of repeats on major tasks and key decisions. Businesses may want to work with universities to bring some of their experts and proven techniques to the corporate campus.

The good news is that, while the search for new organizational models and new talent in new places will be extraordinarily taxing, just about all the competition will face the same problems. That fact gives each company a bit of a grace period, but the sooner management starts confronting the gaps a company is facing, the sooner it is likely to close them—and gain a big edge on the ones who don't. ■

[1] UPS is on the cutting edge in other ways, too. It is experimenting with trucks that run on natural gas, which now costs a fraction of the price of gasoline because of shale-gas breakthroughs. Liquefied natural gas (LNG) is also much denser than gasoline with respect to the energy it contains. UPS trucks could travel from Texas to Chicago on three tanks of LNG. Eventually, when enough LNG fuel stations get built, the trucks will also be able to cross east to west.

This article is excerpted from *Resource Revolution: How to Capture the Biggest Business Opportunity in a Century,* first edition, New York, NY: New Harvest, April 2014.

Stefan Heck is a consulting professor at Stanford University's Precourt Institute for Energy and an alumnus of McKinsey's Stamford office; **Matt Rogers** is a director in the San Francisco office.