

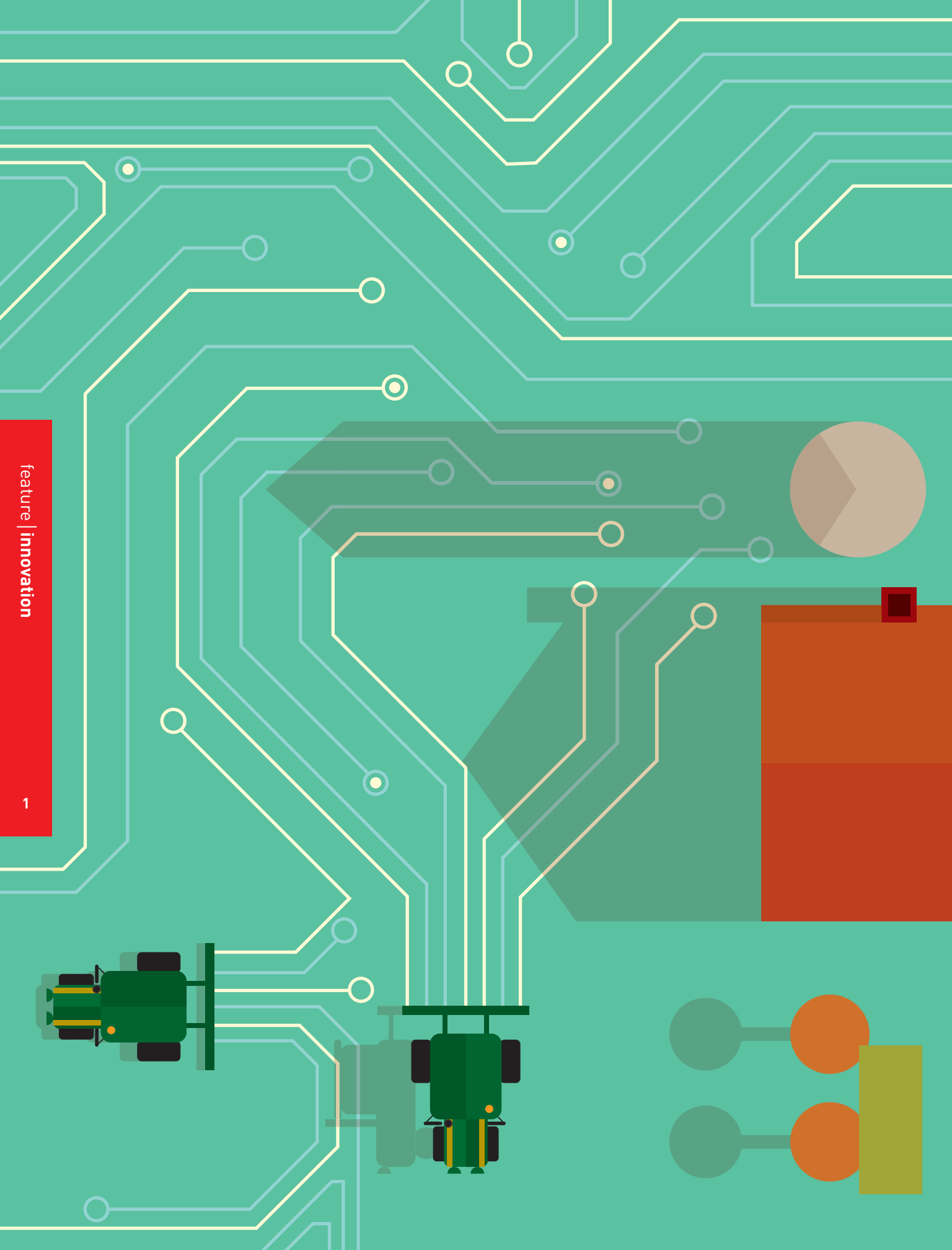
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GLOBAL INNOVATION 1000

## Software-as-a-Catalyst

The world's largest innovators are shifting the focus of their R&D investments from products to programming.

BY BARRY JARUZELSKI, VOLKER STAACK,  
AND ARITOMO SHINOZAKI



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# SOFTWARE-AS-A-CATALYST

**Throughout its nearly 180-year history,** John Deere has been an innovation leader. Its first product was a polished-steel plow that outperformed existing tools. And over the decades, the company's research and development (R&D) efforts were aimed squarely at improving the mechanical and functional performance of its products. Today, Deere's iconic green machinery is recognized the world over for quality and durability. But over the last decade, the focus of the company's R&D has been shifting to software and service offerings.

"Our customers continue to expect the best equipment," says Klaus Hoehn, vice president of advanced technology and engineering. "But on top of that, they want us to provide solutions that address the pain points they're experiencing in their business." Deere's newest generation of corn planters not only run at twice the speed of previous models, but also feature monitors, sensors, and software that optimize the planting process and generate detailed computerized data about how and where seeds are sown.

*by Barry Jaruzelski,  
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Farmers can maximize their productivity during the shorter planting windows that new seed varieties demand, and increase their yields — while gaining a wealth of information to help them manage their operations more productively. To offer these kinds of solutions, Deere needed to significantly alter its mix of R&D resources. Over the last 10 years, Hoehn says, "we have grown software and data analytic resources significantly. It's not hard for me to predict that we'll have more software engineers than mechanical engineers at the company within the next five years."

Most of the world's major innovators are in the midst of the same transformational journey. R&D is shifting more and more toward developing software and services. Software increasingly carries the burden of enabling product differentiation and adaptability, and enhancing customer experiences and outcomes. Services, offered along with or separately from physical products, now focus more on new customer needs, providing enhanced value and improved usability.

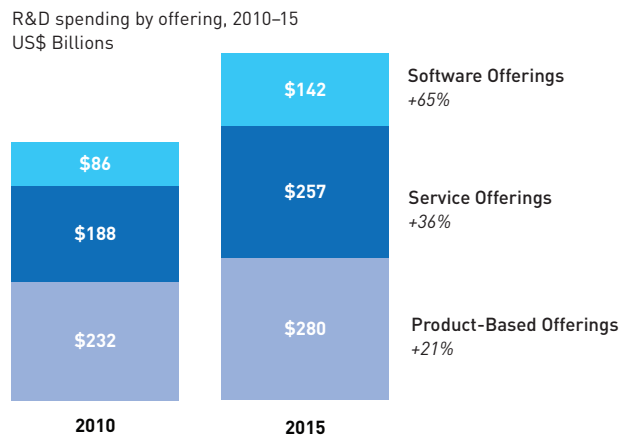
In this year's Global Innovation 1000 study — an examination of the 1,000 public companies that spend the most on researching and developing products for their markets — we focused on the transformation that R&D is undergoing as companies strengthen their software and service offerings (the services themselves also tend to be software-based). The shift is being driven by the supercharged pace of improvement in what software can do, and the growing use of embedded software and sensors in products — as well as the ability to reliably and inexpensively connect and network products, customers, and suppliers via the Internet of Things and the availability of cloud-based data storage. Perhaps most of all, it's being driven by rising customer expectations.

The rapid change is powerfully affecting the mix of R&D spending. Between 2010 and 2015, companies we surveyed for the Global Innovation 1000 study increased their weighted average allocation of R&D in software offerings from 17 percent to 21 percent of their R&D portfolios — a 23 percent rise. Over those five years, total R&D spending for the Global Innovation 1000 grew 34 percent, to US\$680 billion. The result: a 65 percent increase in R&D spending on software offerings, to \$142 billion. In the same time period, R&D spending on service offerings rose 36 percent to \$257 billion. Spending on product offerings, although declining as a percentage of R&D allocation, grew 21 percent, to \$280 billion (*see Exhibit 1*).

This investment shift will continue to intensify. In 2010, more than 40 percent of the companies surveyed

**Exhibit 1: Biggest Leaps in R&D Spending**

Although software remains the smallest of the three main sectors of R&D, it has grown the most rapidly in recent years.



Source: Strategy& analysis

had no allocation in their R&D budgets for developing software offerings. In 2015, that number fell to 30 percent, and by 2020, respondents indicated, it will drop to just 23 percent. R&D spending for service offerings, meanwhile, is becoming more prevalent. Five years ago, 31 percent of the companies surveyed were spending 10 percent or less of their R&D budget on services; by 2020, the respondents indicated only 16 percent will invest such a small amount in development of them.

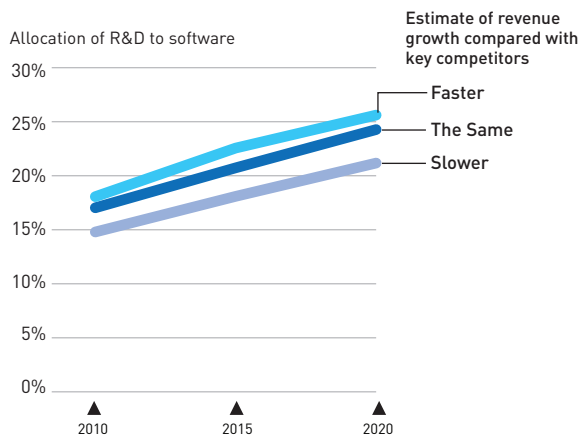
Companies are facing many managerial, organizational, and cultural challenges as the shift of R&D to software and services accelerates. Acknowledging the transition and meeting those challenges is an imperative for companies that want to maintain and enhance their competitive position. In our survey, companies currently allocating 25 percent or more of their R&D

budgets to software offerings reported that their revenues were growing significantly faster than those of key competitors with lower allocations (*see Exhibit 2*).

The shift in types of R&D spending is taking place amid muted overall growth. Total R&D spending rose a scant 0.04 percent from 2015 to 2016 among the Global Innovation 1000 companies, to remain at \$680 billion. The figure was held down in large part by global currency fluctuations — specifically, the significant rise of the U.S. dollar against most other major currencies. (See “Profiling the Global Innovation 1000,” next page, and “Methodology,” page 15.) Given its duration and magnitude, the transition in R&D spending to software and services appears to be independent of these macroeconomic fluctuations, and may in fact accelerate as currencies stabilize and economies improve.

### Exhibit 2: Software Spurs Growth

Companies that committed a higher proportion of R&D to software earlier than competitors are more likely to report their revenues are growing more rapidly.



Source: Strategy& analysis

### Enter the Engineers

In 2010, 50 percent of our survey respondents allocated half or more of their R&D spending to product-based offerings. But in 2015, the product-based share of R&D spending fell to 41 percent from 46 percent in 2010, and is expected to decline to 37 percent by 2020. The share of R&D spending on software offerings has simultaneously been rising. In 2010, 59 percent of respondents said their companies were spending 10 percent or more on software offerings; by 2020, 77 percent expect to be spending at least that much.

The companies represented in our survey were already allocating a higher percentage of their R&D spending to services than to software offerings in 2010. The shift to spending more on services has been less pronounced but is still significant. Overall, on a weighted average basis, our survey shows that spending

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# Profiling the Global Innovation 1000

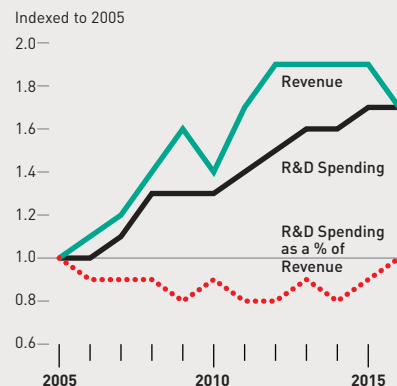
Worldwide R&D spending among the Global Innovation 1000 companies increased 0.04 percent in 2016, to US\$680 billion, essentially unchanged from the previous year. Currency fluctuations played an unusually large role in this year's results: Typically, exchange rate changes cancel each other out,

but in 2016 most key currencies fell against the U.S. dollar. If foreign exchange rates had remained roughly at their 2015 levels, worldwide R&D spending would have increased 6 percent — just above the long-term compound annual growth rate for R&D spending.

Revenue for the Global Innovation 1000 companies fell nearly 12 percent in 2016, dragged down by the chemicals and energy industry, where falling oil prices and the strong dollar resulted in a 31 percent decline. As a result, R&D intensity

## Exhibit A: R&D and Revenue

Flat spending and a decline in revenue led to an increase in R&D intensity.



Source: Bloomberg data, Capital IQ data, Strategy& analysis

## Exhibit B: The Top 20 R&D Spenders

Although some rankings shifted, the 2016 list of the 20 biggest R&D spenders features many of the same names as the previous year's list (and in nine cases, as lists from the last decade). However, there were two notable entrants to the top 20: Bristol-Myers Squibb and Oracle.

Companies in **RED** have been among the top 20 R&D spenders every year since 2005.

RANK		R&D Spending					
2016	2015	Company	2016 US\$ Billions	Change from 2015	% of Revenue	Headquarters	Industry
1	1	<b>Volkswagen</b>	\$13.2	2.7%	5.6%	Europe	Auto
2	2	<b>Samsung</b>	\$12.7	-3.0%	7.2%	South Korea	Computing and Electronics
3	7	<b>Amazon</b>	\$12.5	35.2%	11.7%	North America	Software and Internet
4	6	<b>Alphabet</b>	\$12.3	24.9%	16.4%	North America	Software and Internet
5	3	<b>Intel</b>	\$12.1	5.1%	21.9%	North America	Computing and Electronics
6	4	<b>Microsoft</b>	\$12.0	5.8%	12.9%	North America	Software and Internet
7	5	<b>Roche Holding</b>	\$10.0	-3.2%	19.9%	Europe	Healthcare
8	9	<b>Novartis</b>	\$9.5	-1.6%	19.2%	Europe	Healthcare
9	10	<b>Johnson &amp; Johnson</b>	\$9.0	6.5%	12.9%	North America	Healthcare
10	8	<b>Toyota</b>	\$8.8	5.1%	3.7%	Japan	Auto
11	18	<b>Apple</b>	\$8.1	33.5%	3.5%	North America	Computing and Electronics
12	11	<b>Pfizer</b>	\$7.7	-8.4%	15.7%	North America	Healthcare
13	13	<b>General Motors</b>	\$7.5	1.4%	4.9%	North America	Auto
14	14	<b>Merck</b>	\$6.7	-6.6%	17.0%	North America	Healthcare
15	15	<b>Ford</b>	\$6.7	0.0%	4.5%	North America	Auto
16	12	<b>Daimler</b>	\$6.6	4.5%	4.0%	Europe	Auto
17	17	<b>Cisco</b>	\$6.2	-1.4%	12.6%	North America	Computing and Electronics
18	20	<b>AstraZeneca</b>	\$6.0	7.5%	24.3%	Europe	Healthcare
19	32	<b>Bristol-Myers Squibb</b>	\$5.9	30.6%	35.7%	North America	Healthcare
20	22	<b>Oracle</b>	\$5.8	4.8%	15.6%	North America	Software and Internet
TOP 20 TOTAL			\$179.4	6.3%	8.7%		

Source: Bloomberg data, Capital IQ data, Strategy& analysis

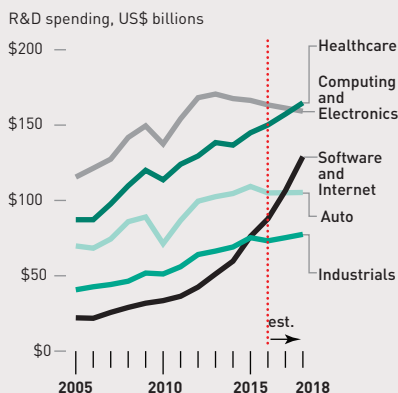
(innovation spending as a percentage of revenues) returned to its all-time high of 4.2

percent (see *Exhibit A*).

Volkswagen and Samsung retained their positions as the number one and number two R&D spenders in 2016, with totals of \$13.2 billion and \$12.7 billion, respectively (see *Exhibit B*). Just over \$1 billion, however, separated the top five companies. Amazon continued its ascent of the top 20 R&D spenders list, moving to third place from seventh. Alphabet, the parent company of Google, moved from sixth position in 2015 to fourth in 2016. Apple made the biggest jump in position — from number 18 to number 11 — as it significantly increased R&D spending. But Apple also stands out for having the lowest R&D intensity of any of the top 20 companies — at 3.5 percent, it is about half the average intensity of the computing and electronics industry. Apple is extremely efficient in translating its R&D spending into popular products and continues to be voted the world's most innova-

### Exhibit C: Leading Industries

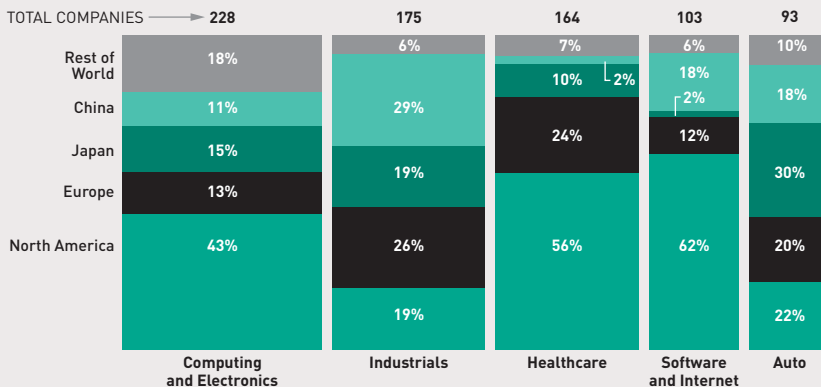
By 2018, healthcare will spend more on R&D than any other industry.



Source: Bloomberg data, Capital IQ data, Strategy& analysis

### Exhibit D: The Geography of R&D

The two sectors in which R&D spending is growing most rapidly — healthcare and software and Internet — are heavily weighted to companies headquartered in North America.



Source: Bloomberg data, Capital IQ data, Strategy& analysis

tive company (see “The 10 Most Innovative Companies,” page 9). Bristol-Myers Squibb (BMS) and Oracle joined the top 20 this year in the 19th and 20th slots. The largest company on the top 20 spender list is Volkswagen, with \$236.9 billion in sales, and the smallest is BMS, with just \$16.6 billion.

Only three of the nine industries we track — software and Internet, healthcare, and consumer — increased their R&D spending in 2016. Software and Internet had the biggest gain by far; R&D spending was up 15.4 percent, compared with 2.6 percent for healthcare and 0.7 percent for consumer. The continued rapid expansion of R&D investment by the software industry does not even reflect the increasing investments in this technology made by other industries, such as auto, computing and electronics, and healthcare. The sharpest declines in R&D spending were in chemicals and energy (11.5 percent) and telecom (12.2 percent).

At current growth rates, healthcare remains on track to surpass computing and electronics as the largest industry in terms of R&D

spending in 2018. The industry with the fastest R&D spending growth trajectory, however, continues to be software and Internet: R&D spending has grown faster in that category than in any other since 2011. At current growth rates, the software and Internet sector will outpace auto to become the third-largest R&D spending industry by 2017 (see *Exhibit C*).

Regionally, companies headquartered in North America — the vast majority in the U.S. — had the second-fastest growth in R&D spending among all regions, and accounted for nearly 44 percent of total Global Innovation 1000 R&D spending. These results were influenced by the dollar's increased strength. But there are other indications that North American companies are flourishing in the current innovation environment. U.S. firms are dominant in the two industries where R&D is growing the fastest: 62 percent of all software and Internet companies are headquartered in North America, as are 56 percent of all healthcare companies (see *Exhibit D*).

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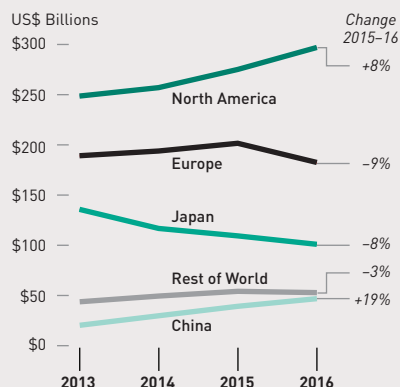
Additionally, in 2016, for the first time in the study's history, the number of Global Innovation 1000 companies headquartered in the U.S. rose, by 8.5 percent.

Although R&D spending by companies headquartered in China rose in 2016 (by 19 percent), the pace of their R&D spending growth has slowed. In 2014, for example, the R&D growth rate at China-based companies was more than 15 times the rate at North American companies; in 2016, it was only twice the rate (see *Exhibit E*). As we noted in

last year's study, however, China has become a magnet for R&D investment from companies headquartered in other regions, which is one of the reasons Asia is now the number one region for innovation spending, when measured by where R&D dollars are spent. (See "Innovation's New World Order," by Barry Jaruzelski, Kevin Schwartz, and Volker Staack, *s+b*, Oct. 27, 2015.) R&D spending was down for companies headquartered in Europe and Japan in 2016, and flat for those in the rest of the world.

### Exhibit E: R&D Spending by Region

Companies based in the world's most developed economies are retaining their significant lead in investment.



Source: Bloomberg data, Capital IQ data, Strategy& analysis

(continued from page 4)

on service offerings will surpass spending on product offerings by 2020 (see *Exhibit 3*).

To support the transition to software and service offerings, fewer companies are focusing the bulk of their R&D spending on electrical and mechanical engineering, according to our survey. From 2010 to 2020, our survey indicates that among companies that employ electrical engineers, the number reporting that electrical engineers are the top engineering specialty will fall by 35 percent. In 2010, just 8 percent of companies said data engineers represented their largest group of engi-

neers. By 2020, that proportion should double, to 16 percent (see *Exhibit 4*).

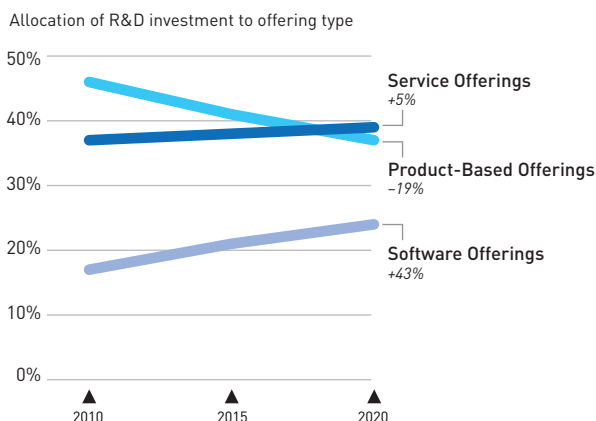
Global technology and industrial company Siemens has been at the forefront of the redirection of R&D from physical products to software and services. "Everything we make now — all our products and all our services — is software driven," says Eric Spiegel, president and chief executive officer of Siemens USA. "And in addition to the software associated with our products, we are developing software platforms like Sinalytics that collect and analyze the data from our products. At the highest level, what's happening in our company — and, I think, in the economy — is a huge shift toward people and skills needed in software development and software upgrading." Siemens currently employs some 17,000 software engineers, a force of comparable scale to that of Microsoft or Google, and expects to hire an additional 5,000 by 2020, as well as growing numbers of specialists in data analytics and related fields.

General Electric, which competes in many of the same industries as Siemens, is moving in a similar direction. CEO Jeffrey Immelt announced in 2015 that GE aims to be "a top 10 software company" by 2020, and that the transformation would determine the company's success or failure over the next decade.

Pitney Bowes, best known in the 20th century for its ubiquitous postage meters, has transformed itself over the past decade into an increasingly digital company, says Roger Pilc, executive vice president and chief

### Exhibit 3: Shifting Priorities

Companies are allocating higher proportions of their R&D budgets to software and service offerings.



Source: Strategy& analysis



## FEWER COMPANIES ARE FOCUSING THE BULK OF THEIR R&D SPENDING ON ELECTRICAL AND MECHANICAL ENGINEERING, ACCORDING TO OUR SURVEY.

innovation officer. “Today, roughly 80 percent of our R&D spend is on software, data, e-commerce services, analytics, and design — across all our business units,” he says. One of the company’s major recent offerings is a cloud-based set of software and data services for managing shipping, including payments, address validation, postage, and fulfillment. “It enables customers to see and analyze their usage in real time, comparing their performance to peers,” says Pilc. “And they can do it from any device, including a desktop PC, tablet, postage meter, or mobile phone.”

### Model Behavior

For the past nine years, the Global Innovation 1000 study has assessed the distinct ways companies man-

age the innovation process, as well as their culture, corporate strategy, and relationship to customers. We have identified three fundamental models. *Need Seekers* make a point of engaging customers directly to generate new ideas and develop products and services based on superior end-user understanding, aiming to fill unarticulated needs. *Market Readers* monitor customers and competitors closely and create value by making incremental changes and by capitalizing on market trends as fast followers to meet customers’ articulated needs. *Technology Drivers* rely on their internal technological capabilities to develop new products and services and seek to push these technologies out into the market in search of desirable applications.

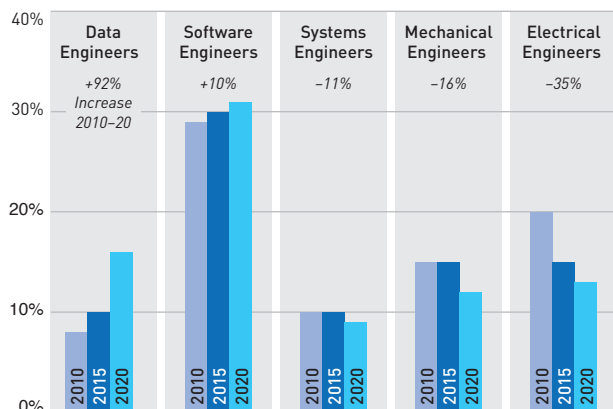
Companies of all three types have reduced their allocation of R&D spending on physical product offerings since 2010, and plan to continue to do so over the coming five years. Technology Drivers are shifting the most toward service offerings, in an effort to become more customer-centric. They are also raising their spending the least on software offerings — probably because they were already strong in that area. Market Readers, the most product-centric of the three, are boosting their R&D allocation to software and services only modestly. Need Seekers, which by definition are the most driven by customer insights, have the highest proportion of R&D resources in service offerings and are increasing their allocation to software offerings most aggressively — from 20 percent in 2010 to 29 percent in 2020.

On a regional basis, companies in North America are making the strongest move to software offerings, from 15 percent of total R&D spending in 2010 to 24 percent in 2020. Asia remains the most product-centric

### Exhibit 4: Allocating Talent

Companies are focusing less on traditional disciplines like mechanical and electrical engineering and more on data and software engineering.

Percent of companies where the largest engineer employee group is...



Source: Strategy& analysis

# The 10 Most Innovative Companies

For the seventh year running, Apple and Alphabet (formerly Google) were voted the two most innovative companies in the Global Innovation 1000 by the study participants. Apple's once substantial margin, however, has narrowed, and it edged out Alphabet this year by only a handful of votes. Alphabet's Google continues to make waves with initiatives such as its self-driving car project, while Apple focuses on its capabilities in gaining customer insights to improve popular, profitable products such as the iPhone. Interestingly, the two companies are now competing directly in one of the hot new software markets — connectivity platforms for cars — with the Apple CarPlay and Android Auto offerings going head-to-head.

3M moved up from sixth position

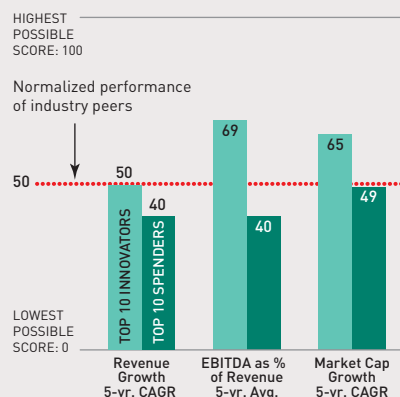
last year to third in 2016, proving that the innovation executives who vote in our survey value the steady, long-term approach to innovation that the Minnesota-based company has long exemplified (see *Exhibit F*).

Tesla joined the most innovative companies list in 2013 in ninth place, and has ascended to the number four position in 2016. It is the only auto company voted onto this year's list, and that seems appropriate given the focus of this year's Global Innovation 1000 study: the increasing shift of R&D investment to software and service offerings. Tesla has been an innovator in both areas, with such offerings as its Autopilot self-driving feature, which was delivered overnight — over the Internet — as a software update to 60,000 customers in October 2015.

Amazon has also moved quickly up the list, first appearing in the 10th position in 2012 and now residing at number five. Amazon, of course, first made its name by developing the most successful B2C software offer-

## Exhibit G: Innovating vs. Spending

Companies ranked by their peers as most innovative show better financial performance than the top R&D spenders.



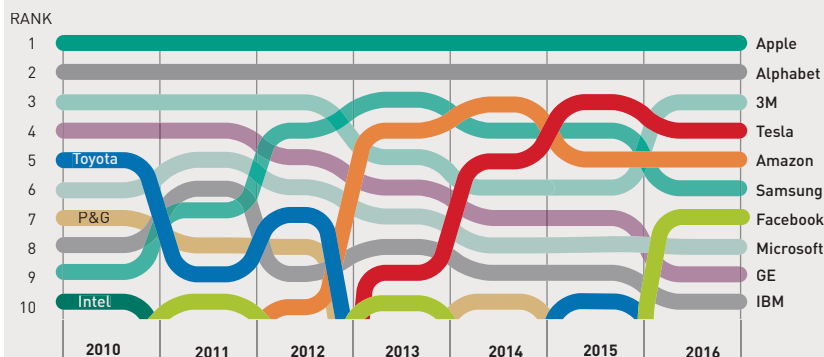
Source: Bloomberg data, Capital IQ data, Strategy& analysis

ing in retail — however, B2B is likely its larger future. While the company's efforts to develop drone delivery for packages make headlines, its Amazon Web Services cloud computing platform for businesses makes money: The subsidiary is on track to hit \$10 billion in revenues for 2016, and it currently accounts for more than half of Amazon's profits.

As has been the case for each of the past seven years, the 10 most innovative companies continue to outperform the top 10 R&D spenders on key performance metrics. They surpassed their competitors on five-year revenue growth and did far better on EBITDA as a percentage of revenue and market capitalization growth — once again proving one of our key findings of the Global Innovation 1000 study: *How* you spend on innovation is more important than *how much* you spend (see *Exhibit G*).

## Exhibit F: The 10 Most Innovative Companies

In recent years, 3M and Tesla have risen in the ranks of the most innovative companies, while GE has fallen.



Source: Strategy& analysis

region — due in part to China’s focus over the last 15 years on becoming the world’s manufacturing center (see *Exhibit 5*). Forty-four percent of its R&D investment was allocated to product offerings in 2010, a proportion expected to fall to 40 percent in 2020.

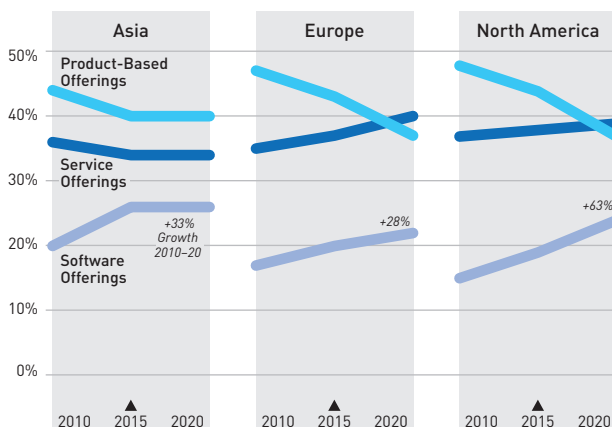
### Factors Driving the Shift

The three most commonly cited explanations for why companies are shifting R&D budgets toward software were staying competitive (57 percent of survey respondents), driving revenue growth (54 percent), and meeting changing customer expectations (48 percent) (see *Exhibit 6*). The next most frequently cited reasons were the need for higher margins, the desire to access untapped markets, the need to reduce operating costs,

### Exhibit 5: Regional Variations

While declining in both Europe and North America, product-based R&D continues to dominate in Asia.

Estimated allocation of R&D investment by type of offering

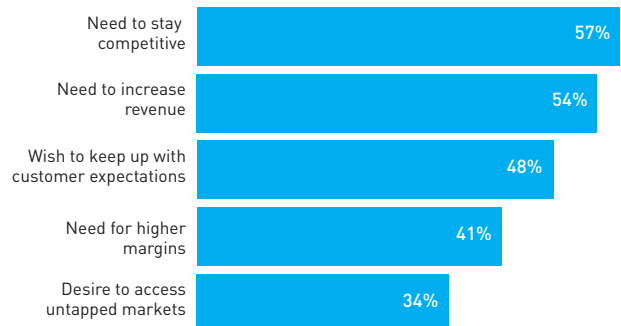


Source: Strategy& analysis

### Exhibit 6: Explaining the Investment Shift

Companies are most likely to cite competition factors as they account for changing R&D priorities.

What is driving the change in your company's R&D mix?



Source: Strategy& analysis

and the desire to better incorporate digitization into the business.

Need Seekers most frequently cited the need to keep pace with customer expectations (53 percent), which tracks with their propensity to be tightly aligned with customer needs and market trends. For Technology Drivers and Market Readers, the leading reason was staying competitive (60 percent and 58 percent, respectively), which indicates they are playing catch-up to Need Seekers, who are driving this trend.

Companies are adapting to rapidly shifting standards and expectations. “The hardware itself is becoming fairly commoditized in many of the businesses we’re in,” says Michael Maiello, senior vice president for home and business networks at Schneider Electric, which manufactures equipment for industrial, energy, and IT customers. “To really differentiate yourself and create lasting offers, you need to move from not only

best-in-class hardware products to a customer solution that includes different product components and software, with services wrapped around it. We've realized that software and services are going to be a large part of our needed competencies as we move forward."

German automaker Daimler is focused on bringing the best products to the market, with the best fuel economy. "But today much of what you do to improve fuel economy is in the software," says Heiko Noessler, director of manufacturing at Daimler. "And software is having more of an impact not only in the products themselves, but through what connectivity enables, such as service diagnostics." In the past, when a delivery truck broke down, a driver would take it to a service station. "Today, if the truck is breaking down, the driver can get in contact with a service representative who guides him through how to keep it running or what kind of a repair will be needed," Noessler notes. "This saves a lot of time and keeps the product on the road, and that's how the customer makes his money."

In many cases, companies are facing competition from new market participants, or from different sectors. "We have competitors we never thought we would have," says John Deere's Hoehn. "They are coming from a 180-degree different perspective, but they are also trying to provide solutions that address our customers' pain points. We have seen this new variety of competition coming from all directions in the last five to eight years." Seed companies, for example, have service offerings that aim to deliver some of the same analytical features that Deere is providing with its farm machinery. "They might see our equipment as a commodity, and we might see their seed material as a commodity," Hoehn says. "But they are trying to occupy

the same space we are, and in a broader sense, we're now in the same business."

Companies seeking higher revenues are increasing their R&D spending on software and services because that's where they see their growth opportunities. The need to generate revenue and growth was the second most important reason companies gave for their changing R&D portfolios. The pattern is especially pronounced in the auto business. "What's happening in the automotive industry is as significant as the invention of the internal combustion engine over 100 years ago," says Martin O'Brien, general manager of the integrated electrical systems division of Mentor Graphics, which supplies software and software tools to automotive, aerospace, and other industries. "The car has gone from being a largely mechanical device a decade ago to having the most embedded software of almost any platform in the world today. A modern car may have 80 different computers controlling the different functions in the vehicle, and perhaps 100 million lines of software code to implement many of those functions. Function growth is driven mostly by safety, consumerization, and connectivity needs in this new era."

### **Building Capabilities, Finding Opportunities**

More than half of the companies surveyed are changing their mix of talent because their changing customer offerings require a different mix of engineering resources; that was the case for Technology Drivers, Market Readers, and Need Seekers alike. Other reasons frequently cited were that companies had acquired a new set of capabilities that required R&D support (28 percent) or that there were changes in their industry (26 percent). A quarter of respondents said they were relying on third-

## ROUGHLY ONE-THIRD OF THE COMPANIES SURVEYED SAID THEY HAD INVESTED CORPORATE FUNDS DIRECTLY IN EXTERNAL STARTUPS WITHIN THE LAST FIVE YEARS.

party providers for software and service engineering.

Attracting and retaining R&D personnel with the right talents is a challenge in most industries. “We are recruiting for data analytics and digitalization-based roles at the senior levels of the organization. We are looking for leaders who can identify opportunities and create business models to expand, optimize, and transform the business deploying analytics platforms and tools,” says Siemens’s Spiegel. The shift is already changing the way business schools think about their course offerings, and will have profound effects both on education and, more generally, on the future of employment. (See “Jobs in the Age of Digital Innovation,” next page.)

Companies that made an acquisition during the past five years reported that 71 percent of the deals were done to augment capabilities in software (33 percent) or services (38 percent). Forty-one percent of the companies we surveyed either have acquired a services firm or plan to do so in the next five years, and 38 percent have acquired or plan to acquire a software firm. Need Seekers and Market Readers said they were the most likely to acquire a software firm over the next five years, and Technology Drivers said they were the most likely to acquire a services firm. And roughly one-third of the companies surveyed said they had invested corporate funds directly in external startups within the last five years. These companies also anticipate making the biggest change in the proportion of R&D spending to software offerings. Between 2010 and 2020, they expect that their allocation of R&D to software offerings will grow 57 percent — nearly twice the rate of companies that have not invested in a startup.

For Polaris Industries, which designs, develops, and manufactures power sports vehicles such as snow-

mobiles and motorcycles, the competition is mainly focused on vehicle performance, says Ken Pucel, executive vice president of operations, engineering, and lean manufacturing. Most of the company’s software R&D involves improving performance, such as computerized engine controls that can switch from “work” to “performance” mode at the push of a button, and most of the software for doing that work is available from third-party vendors. In 2013, however, Polaris acquired a software development company to build its RiderX platform, which connects the vehicle to the driver’s mobile phone. “It’s a navigation system for the off-road enthusiast,” says Pucel. “You can see the turns on the trail ahead. You don’t get lost. You can find a gas station or a restaurant, and it connects you with your friends. It enhances the whole riding experience, and I see our platform as the industry standard.”

### Culture and Management

The shift toward software and service offerings is presenting new cultural and managerial challenges to companies. Some companies with product-centered roots are moving more of their R&D operations away from their home base — which is often in an industrial region unattractive to young software engineers and data specialists — toward Silicon Valley or to emerging tech clusters such as Phoenix; Austin, Tex.; and North Carolina’s Research Triangle. Ford, for example, opened a new research facility in Palo Alto, Calif., in 2015, close to Stanford University (and Tesla’s headquarters), with 125 employees. Most were locally hired, and the facility is managed by a former Apple executive. In August 2016, Ford CEO Mark Fields said the workforce there was doubling — at the same time he announced

## Jobs in the Age of Digital Innovation

The rising trend line of R&D investment in software and service offerings suggests there will be major changes in the kinds of jobs that will be created — and in the opportunities for those jobs that will continue to exist — over the next decade and beyond.

Companies are already feeling the effects of the shift within their R&D operations as they compete to increase their ranks of software engineers and other specialists. “It’s very hard today to make a distinction between an engineer and a software engineer,” says Soumitra Dutta, dean of the Samuel Curtis Johnson Graduate School of Management at Cornell University. “Almost every product you create either has software embed-

ded in it or requires using a software product to create it in the first place. Software has become a kind of basic language, like mathematics, which you need to know just to work successfully as an engineer.”

Familiarity with software is becoming a necessary skill for managers as well. At Cornell’s Johnson School, more MBA students are signing up for programming courses in the engineering department. “They’re not necessarily interested in programming — though most of them do program things themselves; they’re taking these courses so they are able to understand the language and interact with professional software engineers,” says Dutta. “We are also seeing increasing interest in courses focused on the service economy and on technology.”

The shift toward software and service offerings is also changing the skill sets needed for other jobs in a wide range of industries. For ex-

ample, in today’s advanced manufacturing workplaces, a factory worker is more likely to be carrying a tablet computer than a wrench, and may have the skills to configure software for new situations, or understand how to program CNC (computer numerical control) machines. To prepare people for these jobs, companies and governments at the federal, state, and local levels in the U.S. have launched dozens of initiatives to improve skills in science, technology, engineering, and math (STEM) subjects over the last decade, at both secondary schools and community colleges.

The rise of software and services can be viewed as just the latest effect of the computer age, which has radically changed the nature of employment in many industries over the last 30 years. Welders have been replaced by robots, bank tellers by ATMs, and phone operators by automated switchboards. The phe-

that Ford would be manufacturing fully autonomous cars by 2021.

General Electric opened a software center in San Ramon, Calif. (not far from Silicon Valley), in 2011, and has been expanding it as the central hub of GE Digital, a new unit that combines the company’s software and technology efforts. The company is also running a national TV advertising campaign in the U.S. in which a young software developer tries to explain to uncomprehending friends and family members why he’s taking a job at GE. The tagline is: “The digital company. That’s also an industrial company.”

Companies are also finding they must adapt their

innovation models to allow for the different cadences at which hardware innovation, software innovation, and service innovation run. “Another challenge is applying and coordinating management processes and systems to the right types of innovation at different stages of the product and technology life cycle, rather than having a one-size-fits-all approach,” says Pitney Bowes’s Pilc. For new, transformative, or disruptive innovation, the company employs lean startup, design thinking, and highly agile data methodologies in cloud-based, software-as-a-service distribution models. “A large portion of our global development budget is what we would describe as continuous innovation —

nomenon was foretold — even given a name — by the British economist John Maynard Keynes in 1930: *technological unemployment*.

But as an increasing number of the world's leading innovators accelerate the shift away from purely physical products to software and service offerings, the employment effects will become much more dramatic and far-reaching. Several books and a welter of scholarly papers and articles have argued the pros and cons of the shift over the last few years. In "The Future of Employment: How Susceptible Are Jobs to Computerisation?" Oxford University professors Carl Benedikt Frey and Michael A. Osborne review this literature and employ a novel methodology for quantifying the effects of digitization. They come to a stark conclusion: "According to our estimates," they write, "about 47 percent of total U.S. employment is at risk."

Frey and Osborne list the

probability that computerization will eliminate jobs for 702 detailed occupations, including most workers in office and administrative support, production, and transportation and logistics. Some of the job classifications with the highest degree of risk are drivers, sales workers, loan officers, and insurance underwriters. Repetitive white-collar and service vocations are most vulnerable to digitization today.

Where will new jobs come from to replace the many that will disappear? The answer is not clear. Modern society has experienced employment shifts of this magnitude before. In 1900, for example, more than 40 percent of the U.S. workforce was employed in agriculture. Today the number is just 1.4 percent, thanks to technological advances. Manufacturing jobs took up some of the slack for many decades, but their numbers, too, have been falling since the late 1940s, and they account for

only 9 percent of the workforce today. As the first industrial robots were being developed in the 1960s, U.S. president John F. Kennedy warned that preventing massive unemployment in an age of automation would be the major economic issue of the decade. Nearly all the net new job growth in the country since the mid-20th century has been in services, and between 1950 and 2016, the U.S. workforce increased from 62 million to more than 160 million.

The sunniest outlook going forward will be for employees who have the skills and knowledge to manage or orchestrate automation, and for those who have the people skills and experience to bridge the gap between technology and the human needs of customers. A key skill for innovative companies in the future will be to channel that creativity in ways that create both business value and new kinds of employment.

version five of a very, very good product, for example, where there's a certain requirement for predictability of delivery because we've got hundreds of customers who already use it and hundreds of salespeople and channel partners who are counting on the next version," Pilc continues. "The final category is our long-term technology strategy, where we're responding to our CEO's direction about what technologies we need to be great at over the next five years. Like other companies, we have to be ambidextrous and have those three types of activities coexist and complement and work with each other, but not stifle the inherent natural cadence of each of them."

### The Path Forward

No matter what industry they are in, company leaders need to know where they stand with respect to the shift of the R&D portfolio to software and service offerings. Are you discussing the changes you see at the highest levels of the company, and are you prepared to invest in new capabilities if you find you are out of step with the times? As we noted earlier, the companies that are transitioning the fastest are also the companies that believe they are outperforming their competitors. Companies that are reporting faster revenue growth are allocating 25 percent more of their R&D portfolio to software offerings than their slower-



growing peers, and they are also investing more in service offerings. Companies that report slower revenue growth than key competitors are those that have made the smallest shift away from product-based offerings and are allocating less of their R&D investment to service offerings. Among the innovation models we study, Need Seekers made the most aggressive move to software offerings between 2010 and 2015, and they were also significantly more likely to report that their companies were outperforming competitors in both revenue and profit growth.

Company leaders need to ensure that their innovation operating models are tightly aligned with new software and service offerings. Traditional research and development approaches, such as stage-gate development for products and technology, remain valid, but more innovative approaches such as open innovation models, design thinking, agile methodologies, co-creation, and in-company incubators are becoming more important as portfolios change. These advanced innovation approaches can help in bridging the development time and time-to-market of software and software-enabled

## Methodology

As it has in each of the past 11 editions of the Global Innovation 1000, this year Strategy&PwC's strategy consulting business, identified the 1,000 public companies around the world that spent the most on R&D during the last fiscal year, as of June 30, 2016. To be included, companies had to make their R&D spending numbers public. Subsidiaries that were more than 50 percent owned by a single corporate parent during the period were excluded if their financial results were included in the parent company's financials. The Global Innovation 1000 companies collectively account for 40 percent of the world's R&D spending, from all sources, including corporate and government sources.

In 2013, Strategy& made some adjustments to the data collection process in order to gain a more accurate and complete picture of

innovation spending. In prior years, both capitalized and amortized R&D expenditures were excluded. Starting in 2013, we included the most recent fiscal year's amortization of capitalized R&D expenditures for relevant companies in calculating the total R&D investment, while continuing to exclude any non-amortized capitalized costs. We have now applied this methodology to all previous years' data; as a result, historical data referenced in the studies from 2014 onward will not always align with previously published figures for the 2005 through 2012 studies.

For each of the top 1,000 companies, we obtained from Bloomberg and Capital IQ the key financial metrics for 2011 through 2016, including sales, gross profit, operating profit, net profit, historical R&D expenditures, and market capitalization. All sales and R&D expenditure figures in foreign currencies were converted into U.S. dollars according to an average of the exchange rate over

the relevant period; for data on share prices, we used the exchange rate on the last day of the period.

All companies were coded into one of nine industry sectors (or "other") according to Bloomberg's industry designations, and into one of five regional designations, as determined by their reported headquarters locations. To enable meaningful comparisons across industries, the R&D spending levels and financial performance metrics of each company were indexed against the average values in its own industry.

Finally, to understand the ways in which global R&D is and will be conducted at companies across multiple industries, Strategy& conducted an online survey of 466 innovation leaders around the world. The companies participating represented more than US\$91 billion in R&D spending, or 13.5 percent of this year's total Global Innovation 1000 R&D spending, all nine of the industry sectors, and all five geographic regions.



service offerings, which turn around much more quickly than traditional products.

Leaders also need to monitor a broader competitive environment closely to assess the ways the rise of software and services is affecting their core businesses and their industry. Are any of your product or service offerings at risk as software becomes more powerful and pervasive, and as it enables new kinds of service offerings that better meet changing customer expectations? One useful exercise is to think through how a software startup might go about disrupting your business. Is one of your offerings, your company, or even your entire industry a potential victim of disruption from a new entrant with an innovative software- or services-driven business model?

On the positive side, software and services offer fertile ground for reimagining your value proposition and the business model that supports it in creative ways. As in the case of many of the companies cited in this article, increasing R&D in software and services can enable you to meet or anticipate your customers' needs (and add new streams of revenue) in ways that weren't imaginable just a few years ago, as well as creating greater stickiness with established customers.

The reason that the fastest adopters of software and service offerings are outperforming others is simple: They are simultaneously embracing the massive changes that digitization is enabling in product capabilities and usability and responding to rising customer expectations. The embrace and the response are symbiotic, each creating opportunities and pressures that drive the other. Offering excellent physical products has become table stakes for competing in today's economy. More

and more, features that depend on software and the services it provides are the factors that differentiate companies, create competitive advantage, and launch new revenue streams. +

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## Resources

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Carl Benedikt Frey and Michael A. Osborne, "The Future of Employment: How Susceptible Are Jobs to Computerisation?" Oxford Martin School Working Paper, Sept. 17, 2013: Describes which jobs are most likely to be made obsolete by digitization.

Reinhard Giessbauer, Jesper Vedsø, and Stefan Schauf, "A Strategist's Guide to Industry 4.0," *s+b*, May 9, 2016: The next step in the evolution of industry will be for companies to integrate operations into a seamless digital whole.

Daniel Gross, "Siemens CEO Joe Kaeser on the Next Industrial Revolution," *s+b*, Feb. 9, 2016: The head of the German industrial giant describes how it is using software, sensors, and savvy to create a 21st-century digital manufacturer.

Links to all previous Global Innovation 1000 studies from 2005 to 2015, as well as videos, infographics, and other articles: [strategyand.pwc.com/innovation1000](http://strategyand.pwc.com/innovation1000).

Strategy&'s Innovation Strategy Profiler allows you to evaluate your company's R&D strategy and the capabilities it requires: [strategyand.pwc.com/global/home/what\\_we\\_do/services/innovation/thought-leadership/innovation-strategy-profiler](http://strategyand.pwc.com/global/home/what_we_do/services/innovation/thought-leadership/innovation-strategy-profiler).

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