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THE BOSTON CONSULTING GROUP

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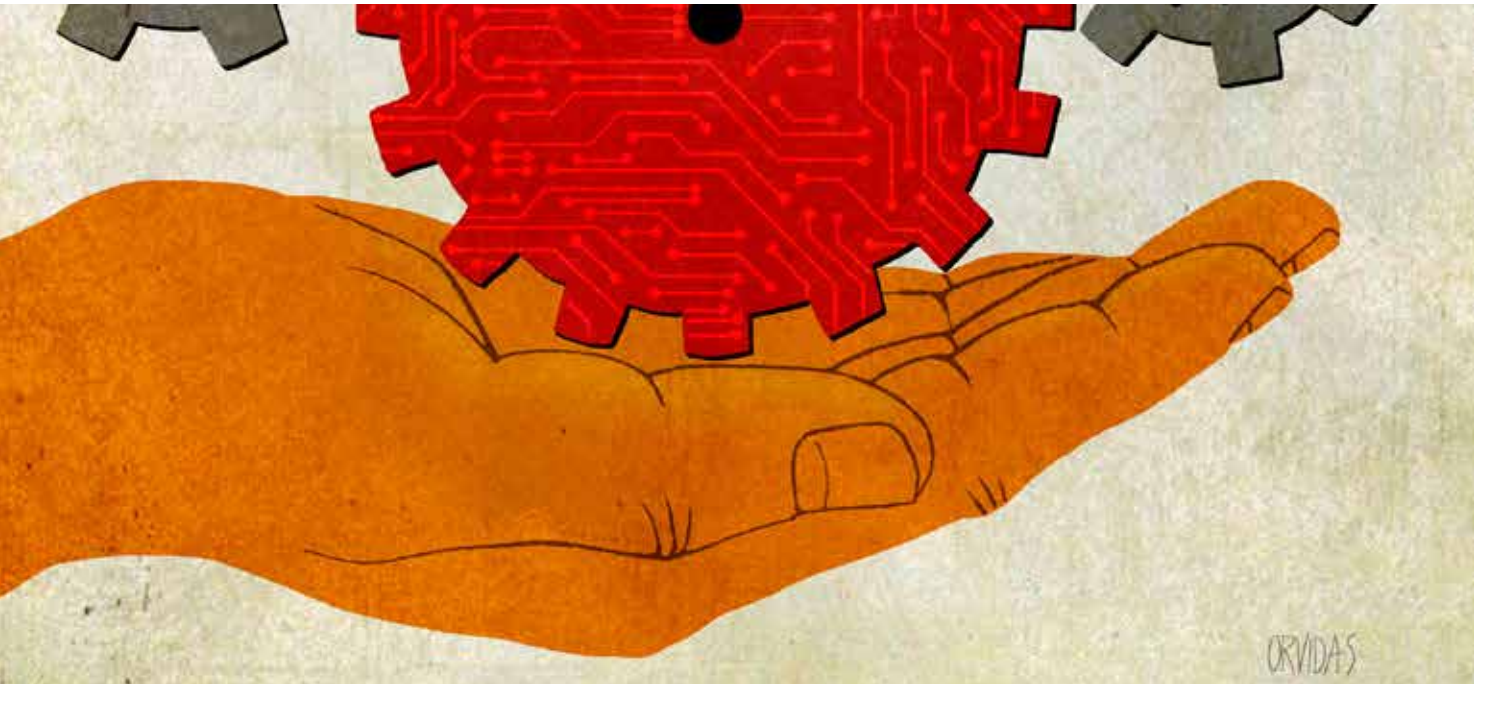
INSIDE OPS

ARE YOUR OPERATIONS READY FOR A DIGITAL REVOLUTION?



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INSIDE OPS

ARE YOUR OPERATIONS READY FOR A DIGITAL REVOLUTION?

July 2016 | The Boston Consulting Group

CONTENTS

PREFACE

Welcome to the second edition of BCG's *Inside OPS,* a publication that showcases how the Operations practice at BCG puts operations at the core of business.

As operations become increasingly globalized and supply chains grow more complex, businesses must become more cost efficient in delivering what their customers need and want. Customer demand for product innovation stretches resources and challenges traditional modes of operation. Leading companies embrace collaboration, pursue integration, and capitalize on Industry 4.0 opportunities to ensure success in any business climate.

With that reality in mind, we recently launched our Innovation Centers for Operations in Germany. (Additional centers will open soon in Paris and the US.) This network of technology immersion model factories helps companies learn how to make the most of Industry 4.0 opportunities. Each factory can be leveraged in BCG projects to foster technology immersion. The model factories include real production lines and visionary technology demonstrators, allowing for a unique experience.

Across industries, technology—particularly digital technology—is changing everything. It's become embedded in products and services and is essential for core processes and service delivery. CEOs and business leaders must ask, How can we manage digital innovation, digitize and support the core business, and reduce complexity and risk? How do we accelerate the digital transformation? How do we create value with our technology function—now and in the future?

Our current edition—whose theme is *Are Your Operations Ready for a Digital Revolution?*—includes five articles that address the above issues and questions.

It is no surprise that efforts to capture the benefits of digital technologies are already under way. In "Time to Accelerate in the Race Toward Industry 4.0," we explore in detail the ways in which German and US companies have been embracing the coming wave of digital technologies. What progress have they made? What ambitions do they have? What lessons do they offer?

Lessons from leaders are showcased in "Three Paths to Advantage in Digital Supply Chains." With powerful digital technologies for supply chain management now available, some companies are generating significant returns on investment. This article details what these lead-

ers are doing and how operations practitioners everywhere can put the leaders' strategies into practice.

In our next article, "The Robotics Revolution," we note that the time is right for a large-scale move toward robotics. Industry has reached an inflexion point at which an attractive return on investment is possible, thus fueling the move away from manual labor and toward robotic alternatives.

Digital offers new opportunities in terms of logistics as well. "Leveraging Big Data to Manage Logistics" acknowledges that logistics has never been more complex. But, it also finds that, given the digital tools and technologies now available, there's never been a better time to optimize logistics.

Another area of opportunity: services. Digitization presents both opportunities and threats here. "Changing the Game in Industrial Goods Through Digital Services" explains how.

I hope you enjoy reading these articles. Please send any comments or thoughts to insideops@bcg.com. We look forward to hearing from you.

Warm regards,

Christian Greiser
Global Leader, Operations Practice
Senior Partner and Managing Director

TIME TO ACCELERATE IN THE RACE TOWARD INDUSTRY 4.0

THROUGHOUT THE WORLD, COMPANIES recognize that their success depends on adopting the new digital industrial technologies collectively known as Industry 4.0. To assess how quickly this fourth wave of technological advances is gaining momentum, BCG studied the status of adoption in Germany and the US.

We surveyed more than 600 managers and senior executives representing 312 German and 315 US companies and found that, so far, companies in the two countries have implemented Industry 4.0 technologies at approximately the same pace. However, German companies appear to be better prepared to implement these advances in the coming years, and they have higher ambitions, which could give them an edge.

Overall, companies see the lack of qualified employees as their biggest challenge in implementing Industry 4.0. Data security and the significant investments required for new digital technologies also ranked as major challenges.

Our study demonstrates that companies in two leading industrial nations have set high ambitions for Industry 4.0 but will need to accelerate their efforts to implement these technological advances and achieve their goals.

We present the survey's key findings and share related insights from BCG's analysis of the effects of Industry 4.0 on the manufacturing workforce. We also discuss how BCG supports companies' efforts to implement Industry 4.0 through its Innovation Center for Operations (ICO), which includes model factories that allow companies' executives and staff to experience and test new technologies.

The Status of Adoption

Companies on both sides of the Atlantic understand that the adoption of Industry 4.0 brings important benefits. Three-quarters of German respondents and two-thirds of US respondents associate Industry 4.0 with increased productivity and cost reduction. In addition, many respondents (48% in Germany and 43% in the US) associate it with revenue growth.

The pace of Industry 4.0 implementation is similar in the two countries. Nineteen percent of German companies have implemented either a full Industry 4.0 concept (such as a smart factory) or first measures toward a concept (such as the introduction of autonomous robots), compared with 16% of US companies.

Furthermore, German companies appear to be better prepared to adopt Industry 4.0. Almost half (47%) of the German companies have developed their first full Industry 4.0 concepts, and only 18% of German respon-

dents say that their company is not yet prepared to introduce Industry 4.0 technologies. In contrast, only 29% of US companies have developed their first concepts, and 41% say that their company is not yet prepared.

In terms of manufacturers, German companies appear to have higher ambitions than their US peers with respect to applying, or planning to apply, advanced technologies. For example, approximately 60% of German manufacturers have applied, or plan to apply (within the next one or two years), digital factory logistics or predictive maintenance, compared with approximately 40% of US manufacturers.

Industry 4.0 is having a significant impact on the industrial workforce.

German companies' strong ambitions for Industry 4.0 reflect their need to overcome the challenges of significant factor costs that arise from high wages and a less-flexible labor market. These factor costs encourage companies to strive for greater productivity and, thus, promote faster adoption of new technologies. The fast pace of adoption in Germany is also fueled by companies' advanced industrial-manufacturing capabilities. Companies can apply these capabilities to accelerate the introduction of new digital technologies, thereby reducing costs, increasing flexibility, and accelerating the speed of manufacturing. For example, German manufacturers lead in robotics adoption, enabling a higher level of automation and promoting productivity gains. In 2014, the rate of robotics penetration in Germany was among the highest: 292 industrial robots per 10,000 workers in manufacturing. This level of penetration exceeded the level achieved in the US (164 per 10,000 workers) by 78%.

The Lack of Qualified Employees Is the Top Challenge

Industry 4.0 is having a significant impact on the industrial workforce. Because Industry 4.0 requires fundamentally new skills, jobs have been lost in some work categories and gained in others. Reflecting this transition, data management, data security, software development, programming, data science, and analytics are among the most desirable Industry 4.0 skills in Germany and the US.

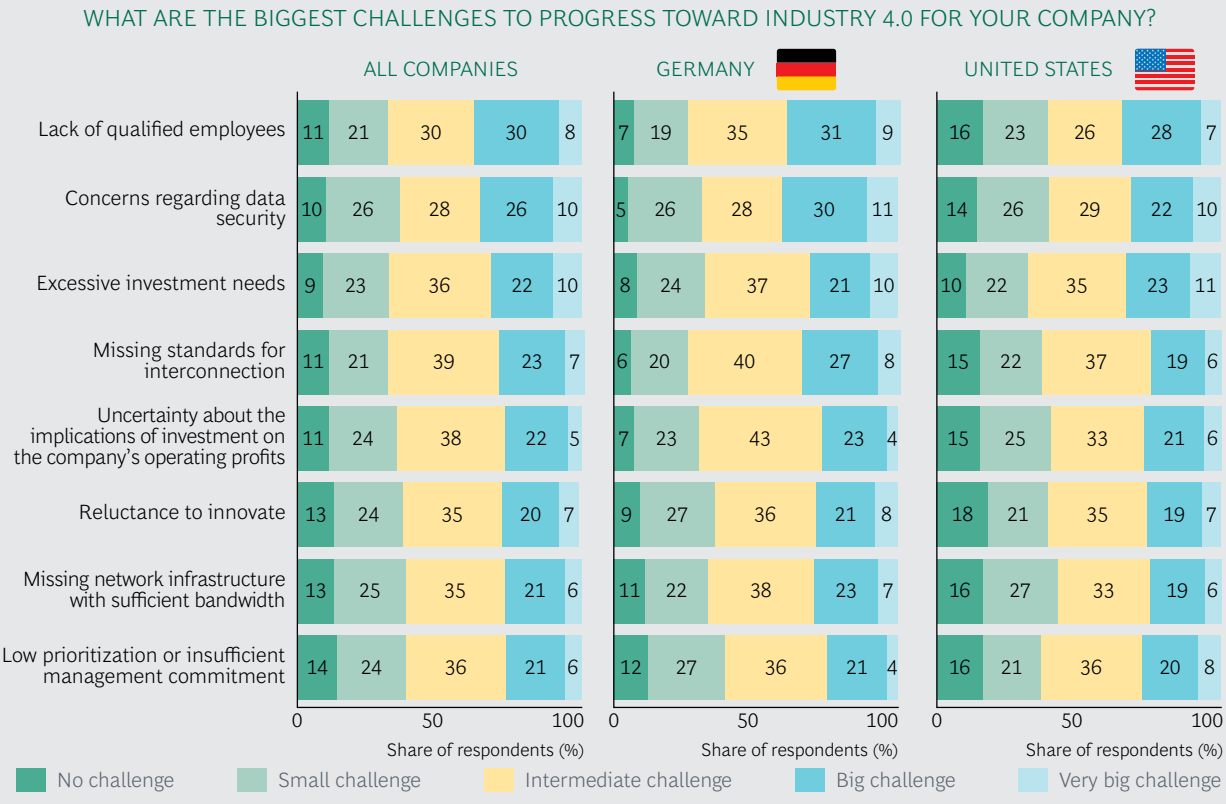
The extent to which companies benefit from Industry 4.0 will depend on how successfully they build and manage newly skilled talent pools. Respondents recognize the challenge: 40% of German companies and 35% of US companies regard the lack of qualified employees as a major ("big" or "very big") challenge. (See the exhibit on the next page.)

To close the Industry 4.0 qualifications gap, German companies appear to be considering an approach that is less aggressive than that of US companies. Consistent with the constraints imposed by Germany's strict labor regulations, almost two-thirds (64%) of German respondents say that they will focus on continuing education to ensure that their current employees are qualified for Industry 4.0. They place much less emphasis on occupational retraining (15%) and recruitment of new talent (20%). In contrast, approximately half (48%) of US respondents say that they will focus on continuing education, while about one-quarter will focus on occupational retraining (27%) and hiring new talent (25%).

By broadening and intensifying their efforts to educate employees internally and train them on the job, companies can facilitate their workforce's transition to Industry 4.0. However, while German companies' focus on internal education may help maintain the employment of the current workforce, it will not be sufficient to meet the skill requirements of Industry 4.0. The critical Industry 4.0 jobs—for example, data managers and scientists, software developers, and analytics experts—require skills that are fundamentally different from those that most industrial workers possess today. To close such skill gaps, German companies need to place a greater emphasis on tapping into the global pool of digital talent.

BCG's detailed modeling forecasts a net increase of approximately 400,000 jobs in Ger-

Finding Qualified Employees Is the Major Challenge



Source: BCG online survey of 312 German companies and 315 US companies, March 2016.
Note: Because of rounding, not all percentages add up to 100.

many from 2015 through 2025. This analysis indicates that approximately 600,000 German manufacturing jobs will be lost during the next ten years. But the decline will be more than offset by the need for approximately 1 million new Industry 4.0 jobs in areas such as software development, advanced analytics, human-machine interaction, IT solution architecture, and user interface design. There will be demand for approximately 200,000 new highly skilled workers in IT, analytics, and R&D roles, as well as the creation of approximately 800,000 new jobs resulting from revenue growth opportunities. Design tasks, data analytics, and management of network processes will replace operating machines and moving objects as the most important aspects of industrial job profiles.

The survey found that IT and software development skills ranked as the most desirable skills for Industry 4.0. BCG's modeling found that the number of IT and data integration jobs in Germany will nearly double: 110,000 jobs will be added. Within this job category, growth in demand for industrial data scientists—one of the roles created by Industry 4.0—will be the highest: approximately 70,000 new jobs will be added. Industrial data scientists extract and prepare data, conduct advanced analytics, and apply the findings to improve products or production. Industry 4.0 will also require workers with programming skills, including the ability to use both statistical and general-purpose programming languages. The modeling estimated that 40,000 new jobs will be created in Germany for such Industry 4.0 roles as IT solution architect, user interface designer, and robot coordinator.

Data Security and Investment Needs Are Also Major Challenges

Survey respondents overall cited data security and investment needs as the next-most-difficult challenges to successful implementation of Industry 4.0. However, we found

notable differences in how companies rated the magnitude of these challenges.

Of the German companies, 41% rated data security as a major challenge, compared with only 32% of the US companies. German respondents' greater concern about data security no doubt reflects the strong sensitivity about data privacy in Germany and points to the need to develop a clear legal framework for data security and data privacy for the digital market. It also reinforces the importance of making further progress toward a long-term data-privacy and data-protection agreement between the US and the European Union.

Companies in both countries said that they will need to make significant investments in order to adopt Industry 4.0, and they estimate the level of investment at, on average, 7% to 9% of total revenues. About one-third of both US and German companies consider excessive investment needs to be a major challenge, although German companies rated this slightly lower than several other challenges. Notably, for manufacturing companies alone, excessive need for investment is the number one concern of US manufacturers: 37% rate it a major challenge. This issue is further down the list of concerns for German manufacturers: only 27% rate it a major challenge.

Because the investment requirements for new digital technologies are significant, companies must develop clear plans for their Industry 4.0 expenditures early in the implementation process. Careful planning is especially important for companies—large US companies as well as small companies in both countries—that are most concerned about their ability to cover the necessary investment costs.

Mastering the Challenges

To master the challenges of implementation, a company needs to define a tailored Industry 4.0 strategy. BCG's ICO supports companies' efforts by using model factories to facilitate a four-step approach.

Understanding Pain Points and Assessing the Industry 4.0 Maturity Level. To understand where Industry 4.0 solutions can be deployed, we identify the key challenges to a company's operations. We use a health check to help the company assess its current state of Industry 4.0 progress. To better comprehend how the identified pain points can be addressed, company executives and staff participate in exploratory demonstrations of Industry 4.0 technologies at the ICO's model factories.

Companies said that they will need to make significant investments in order to adopt Industry 4.0.

Developing a Long List of Specific Opportunities. Drawing on BCG's database of more than 150 examples of Industry 4.0 applications, companies can identify specific use cases for further examination. Workshops at the ICO's model factories can help companies detail those opportunities.

Assessing Impact and Selecting Priority Use Cases. At the ICO's model factories, workshops support companies as they quantify all related implementation costs and required investments for the long list of use cases. The assessment of expected financial and nonfinancial benefits helps companies select the priority use cases for implementation.

Starting Implementation. Companies should identify technology suppliers, perform application engineering as required at the ICO's model factories, and prepare for implementing a pilot program and a full rollout. Companies should also assess the qualifications gap of their workforce and determine the best ways to respond, hiring new talent as well as retraining the existing workforce.

THIS study demonstrates that companies do recognize both the significant value of Industry 4.0 and the formidable challenges they must overcome to implement the new technologies. To build and sustain a lead in the race to full implementation, companies

need to broaden and deepen their practical knowledge about digital technologies and the related use cases. This knowledge will provide the basis for developing and implementing the right digital manufacturing strategies. The early adopters have set a fast pace for implementation and are building capabilities that will enable them to increase their lead. To maintain their competitiveness, all companies will need to accelerate their efforts along the Industry 4.0 journey.

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THREE PATHS TO ADVANTAGE WITH DIGITAL SUPPLY CHAINS

FOR YEARS, COMPANIES HAVE used digital supply chain technologies to improve service levels and reduce costs. But the inability to connect disparate systems, provide end-to-end visibility into the supply chain, and crunch massive amounts of data, among other issues, has prevented many companies from achieving the full potential of their supply chains.

Now, thanks to the wide availability and adoption of much more powerful digital technologies, companies are generating dramatically better returns on their investments.

Companies use digital supply chain technologies to improve service levels and reduce costs.

A BCG study shows that the leaders in digital supply chain management are enjoying increases in product availability of up to 10 percentage points, more than 25% faster response times to changes in market demand, and 30% better realization of working-capital reductions, on average, than the laggards. They have 40% to 110% higher operating margins and 17% to 64% fewer cash conversion days. With the help of three key strategies, these agile companies are quickly leaving behind their less nimble competitors.

What the Leaders Are Doing

With so many buzzwords out there, it can be hard for executives to discern the most strategic areas for investment in supply chain technologies. We have drawn on our work in this area with dozens of companies to distill the three key strategies that leading companies are using to achieve results today.

Fix performance gaps. Some companies apply digital technologies to relatively straightforward supply chain problems that are too cumbersome to address with conventional approaches. For example, advanced analytics help managers dynamically calculate optimal inventory allocations and forecast demand more accurately—two areas that have always been difficult with traditional processes based on static, monolithic enterprise resource planning (ERP) systems. Often, newer digital technologies ride on top of legacy systems, making them more flexible and easier to operate. That avoids the workarounds that often plague new-technology rollouts and encourages employees to use the integrated system rather than dispersed spreadsheets. Ultimately, companies can create a single version of the truth, thus improving decision making, customer service, and asset and working-capital utilization.

Consider the goal of transparency in the supply chain. Real-time visibility into which goods are in the warehouse, which trucks are on the road, and which machines are running is difficult to achieve with traditional ERP systems. A global supply chain network generates a huge amount of data per minute, and it requires a massive amount of machine intelligence to filter the information and then to present it in a way that is easy to understand. Digital technologies can perform those tasks automatically, giving employees the insight that they need to optimally steer the global network.

After years of showing more promise than results, radio-frequency identification (RFID) is also generating value as a result of focused applications—if companies exploit the big data streams in a meaningful way. For example, a European fashion retailer with $1 billion in revenue has installed RFID gates in every store to track and manage in-store replenishment. The result: drastically increased on-shelf availability of products. Thanks to insights from the massive amounts of data that RFID sensors produce, the retailer can better understand in-store replenishment cycles and thereby improve the efficiency of replenishment from back rooms and warehouses or enable direct delivery to stores. As a result, sales are rising by 2% to 3% and store delivery costs are falling by 3% to 5%.

Innovate business processes. Digital supply chain technologies are helping some companies achieve a step change in performance in more complex areas. Consider the potential of automated replenishment to transform manual processes. Amazon, for example, offers the Dash Button, an Internet-enabled device that consumers press—without having to log into an account—to reorder items.

Cross-functional teams whose members are colocated in hubs known as supply chain control towers are another innovative example. The teams monitor and direct activities across the supply chain, taking advantage of real-time data about demand, inventory, capacity, and other factors to fine-tune the global network in a way that was not possible before. Advanced analytics help the team get at the root of performance issues, develop strategies to deal with supply chain disruptions, and improve delivery service and speed.

In the past, a company gave a customer a delivery date based on outdated calculations of the time it would take to get components from suppliers, assemble products in the factory, and perform other steps in a heavily siloed supply chain. It was often impossible to unify, analyze, and interpret all the information needed from different computer systems and to construct a reasonable end-to-end representation of the supply chain.

Some customers will pay more for up-to-the-minute supply chain information.

Now, increasingly sophisticated and integrated control-tower technologies can automatically track components down to the individual unit in real time, enabling teams to predict delivery times much more accurately, reroute parts around disruptions quickly, and communicate solutions proactively to customers when things go wrong. Some customers will even pay more for up-to-the-minute supply chain information and reliable delivery of mission-critical components found in everything from mobile phones to jet engines. As a result of control towers, revenues and profits improve as companies speed up supply chain activities, increase efficiency, and uncover new revenue streams.

In addition to establishing control towers, companies can find more intelligent and integrated ways to balance supply and demand in asset-intensive, inflexible production systems. A global chemical company, for instance, introduced an advanced allocation algorithm to decide which customers should receive goods that are in limited supply. On the basis of information the system provided about the cost to serve a customer and expected margins, managers could determine the optimal allocation. The new asset-utilization system allowed the company to switch to a customer-centered approach

based on supply and demand. As a result, margins rose by an average of 0.5 percentage points.

Disrupt the supply chain. Leading companies are using digital supply chain technologies to redesign their operating models and their go-to-market approaches in order to generate significant growth in revenues and margins. In this way, companies can find new routes to customers, decentralize activities, and substantially speed up delivery, among other tactics.

For example, a company can eliminate a distribution channel by developing direct-to-customer capabilities in-house, powered by digital technologies, thereby saving on third-party distribution costs and capturing the margin that distributors previously controlled. It can fully automate filling and packing with advanced robotics to enable small-scale distribution, at a tenth of the cost a decade ago. More readily available advanced technologies make it possible to move final assembly or processing closer to end customers and thus improve service. Cloud-based solutions also let centralized expert teams oversee increasingly complex networks.

Building products closer to the customer in mobile manufacturing units can speed delivery substantially.

Building products radically closer to the customer in mobile manufacturing units can speed delivery substantially. Amazon has filed a patent for a mobile 3-D-printing delivery truck that would make it possible to print out a customer's order from a data file sent to the nearest vehicle. This innovation would let the company get items to shoppers much more quickly and reduce its warehouse space.

How to Begin

To put these strategies into practice, operations leaders move through the following stages.

Immerse yourself in the possibilities. Companies should put their best people to work scanning the landscape of digital supply chain management. This "digital immersion team" can collect innovative ideas from outside the company about ways to innovate and disrupt their business rather than simply improve existing processes. Team members must know how to tap into the expertise of new people, find applications from other industries, and improve on promising ideas. Visits to leading technology companies in digital hotbeds such as Silicon Valley and to road shows in which vendors display the latest digital technologies can jump-start the process.

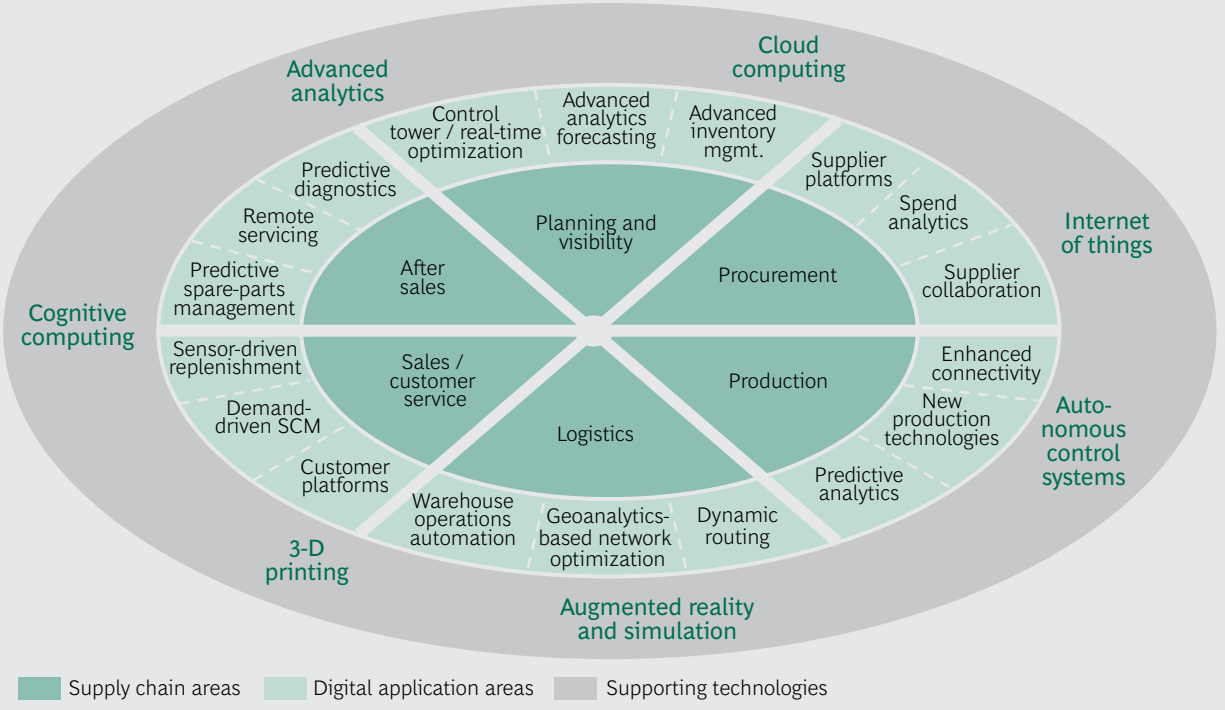
To organize this exploration of the landscape of digital supply chain management, we have developed a map of the major areas of activity to use as a starting point. (See the exhibit on the next page.)

Prioritize the opportunities. Out of the hundreds of ideas that may result from this research, companies should select the ones that could be relevant and useful—the digital applications that have the potential to create significant value for the business and address gaps in performance. Managers can then map those ideas against current business challenges in order to identify areas of alignment. Finally, they should develop a business case—based on the potential uplift in sales and decrease in costs or inventory, for instance—for the opportunities that seem the most relevant, realistic, and financially rewarding.

Launch pilots. Following the immersion and prioritization phases, companies should design a handful of pilots that can help them learn what works before they scale initiatives throughout the company. For example, the design phase of the pilot could look at elements of the supply chain that might be candidates for a new performance management dashboard.

As they roll out pilots, leading companies are testing ideas on a small scale in a high-priority area of the business, selectively refining the approach, and identifying new opportunities that emerge. To get the best re-

The Landscape of Digital Supply Chain Management



Source: BCG analysis.
Note: SCM = supply chain management.

sults, they assemble a group of people who can constructively challenge and develop ideas to lead the project. If a pilot proves successful and applicable to other areas of the business, companies develop an implementation plan that includes the high-level business case and the resources required. Securing senior-level buy-in and developing a change management process are often essential before companies can take pilots to scale.

Build the infrastructure for success at scale. Even the best-designed pilots will fail if the organization is not ready for them. Companies often need to build capabilities, systems, structures, and processes unique to their industry and business context in order to succeed.

Digital technologies often require a substantially different skill set than traditional supply chain tools do. Take the role of the demand planner. Whereas the planner used to simply collect sales information, today the role calls for highly developed analytical skills. Statistical forecasting engines, for example, require constant maintenance from data scientists, who adjust parameters and blend statistical methods.

Going digital also has major implications for organization structures. Companies must adapt to increasing decentralization, develop new governance models, and centralize the right activities to achieve economies of scale. Other changes involve transitioning from monolithic systems to "app style" solutions on the cloud and more automated process handling that focuses on exception management rather than on repetitive tasks.

DIGITAL supply chain management has matured and is generating substantial value. Organizations need to move quickly to apply the highest-priority opportunities to their business and industry context. They must find the right mix of fixing performance gaps, innovating business processes, and disrupting the supply chain.

Companies cannot afford to wait. The competition is already making moves, and the lead-

ers in digital supply chain management are building a financial advantage that will be more difficult to overcome with each passing year.

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THE ROBOTICS REVOLUTION

THE NEXT GREAT LEAP IN MANUFACTURING

It has been roughly four decades since industrial robots—with mechanical arms that can be programmed to weld, paint, and pick up and place objects with monotonous regularity—first began to transform assembly lines. Yet walk the floor of any manufacturer, from metal shops to electronics factories, and you might be surprised by how many tasks are still performed by human hands—even some that could be done by machines. The reasons are simple: economics and capabilities. It is still less expensive to use manual labor than it is to own, operate, and maintain a robotics system, given the tasks that robots can perform. But this is about to change.

The real robotics revolution is ready to begin. Many industries are reaching an inflection point at which, for the first time, an attractive return on investment is possible for replacing manual labor with machines on a wide scale. We project that growth in the global installed base of advanced robotics will accelerate from about 2% to 3% annually today to some 10% percent annually during the next decade as companies begin to see the economic benefits of robotics. In some industries, more than 40% of manufacturing tasks will be done by robots. This development will power dramatic gains in labor productivity in many industries around the world and lead to shifts in competitiveness among manufacturing economies as fast adopters reap significant gains.

A confluence of forces will power the robotics takeoff. The prices of hardware and enabling software are projected to drop by more than 20% over the next decade. At the same time, the performance of robotics systems will improve by about 5% each year. As robots become more affordable and easier to program, a greater number of small manufacturers will be able to deploy them and integrate them more deeply into industrial supply chains. Advances in vision sensors, gripping systems, and information technology, meanwhile, are making robots smarter, more highly networked, and immensely more useful for a wider range of applications. All of these trends are occurring at a time when manufacturers in developed and developing nations alike are under mounting pressure to improve productivity in the face of rising labor costs and aging workforces.

To assess the potential impact of the coming robotics revolution on industries and national competitiveness, BCG conducted an extensive analysis of 21 industries in the world's 25 leading manufacturing export economies, which account for more than 90% of global trade in goods. We analyzed five common robot setups to understand the investment, cost, and performance of each. We examined every task in each of those industries to determine whether it could be replaced or augmented by advanced robotics or whether it would likely remain unchanged. After ac-

counting for differences in labor costs, productivity, and mix by industry in each country, we developed a robust view of more than 2,600 robot-industry-country combinations and the likely rate of adoption in each.

Industries and Economies Leading the Robotics Revolution

For the past few decades, the scramble for competitive advantage in manufacturing has largely revolved around finding new and abundant sources of low-cost labor. Rapidly rising wages in most big emerging markets are bringing the era of easy gains from labor cost arbitrage to a close. A little more than a decade ago, for example, Chinese labor costs were about one-twentieth of those in the US. Today the manufacturing cost gap between China and the US has nearly disappeared for many products that are sold in the US.

As a result, manufacturers worldwide are under intensifying pressure to gain advantage the old-fashioned way: by improving their productivity. This imperative came through loud and clear in our 2014 BCG Global Manufacturing Cost-Competitiveness Index, which revealed changes in the direct manufacturing costs of the world's 25 leading manufacturing export economies from 2004 to 2014. In the economies where cost competitiveness improved or held steady during that period—such as Mexico, the Netherlands, the UK, and the US—productivity growth largely offset increases in such direct costs as wages and energy. Economies whose productivity did not keep pace with rising costs—including Australia, Brazil, China, and most countries of Western Europe—either lost ground in manufacturing cost competitiveness or faced increasing pressure.

Even though the shift toward automation has been a driver of productivity improvement for decades, advanced robots will help to accelerate this trend and will boost productivity even further in a number of ways. Robots can complete many manufacturing tasks more efficiently, effectively, and consistently than human workers, leading to higher output with the same number of workers, better quality, and less waste. Robots will free up skilled workers to focus more of their time on higher-value tasks. Because advanced robots often can perform many tasks autonomously, moreover, they can keep working through the night as human workers sleep, in effect serving as a third production shift.

To estimate the potential productivity gains from wider adoption of robots, we calculated the savings in total manufacturing labor costs over the next decade under the conservative assumption that machines will perform at least one-quarter of the manufacturing tasks that can be automated, compared with a global average of about 11% today. We adjusted our model for differences in robotics adoption rates by economies and industries, as well as projected increases in factory wages.

> Manufacturers are under pressure to gain advantage the old-fashioned way: by improving their productivity.

We estimate that, as a direct result of installing advanced robots, and depending on the location, output per worker in manufacturing industries will be 10% to 30% higher in 2025 than it is today. The impact on cost is likely to be just as dramatic: the total cost of manufacturing labor in 2025 could be 16% lower, on average, in the world's 25 largest goods-exporting economies than they would be otherwise.

All manufacturers and economies will not share these benefits equally, however, because the adoption rates of advanced robotics will vary sharply. The basic economic trade-off between the cost of labor and the cost of automation will continue to be a primary consideration. So will the technical capabilities of machines to replace manual labor. Labor laws, cultural barriers to substituting machines for humans, the availability of capital, the foreign-investment-policy environment, and the age and skill levels of workers are also important considerations.

To get a fuller picture of advanced robotics' potential to boost productivity, therefore, it is important to assess the opportunities and

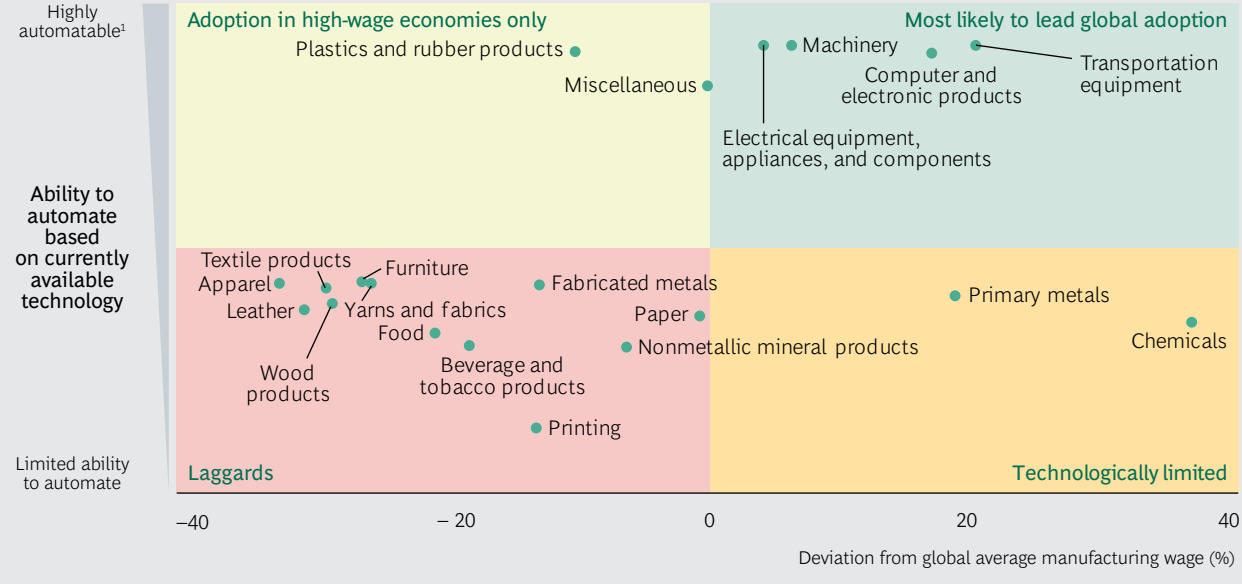
challenges industry by industry and economy by economy.

The Impact on Industries. Two key considerations will heavily influence how widely robots are deployed in industries. How cost-effective is it to substitute machines for human labor? And how easy is it to automate production tasks? (See Exhibit 1.)

Manufacturing industries in which labor accounts for the highest portion of costs are generally the most likely candidates for automation, although it will be more challenging for some industries than others. Labor costs range from about 15% of production costs in typical chemical, food-product, and steel plants to approximately 30% in apparel, furniture, fabricated-metals, electronics, and printing facilities. Location is also important, of course. Industries concentrated in a low-cost economy will be less likely to adopt automation than those based in a high-cost economy. But there are also major cost differences among industries. Whether manufacturing for the petroleum and coal production industries takes place in a high-cost economy or a low-cost one, for example, the median wage is about double that for all manufacturing industries. In the apparel industry, wages are 32% lower, on average.

The technical limits of wider robotics use will also vary by industry. Each industry has its own set of job roles and each role has its own set of tasks. Some of these tasks are potentially automatable; others are not. Furthermore, different production tasks call for different robotics functions—some of which will require more expensive robotics systems than others. A machine that simply lifts materials of the same shape and size from one place and moves them to another may be far less costly than one able to visualize and feel non-uniform materials. What's more, some industries have tasks, such as picking up pieces of cloth to be sewn into apparel, that simply are not robot friendly and therefore will likely be done, for the most part, by workers in low-cost locations for at least the near to medium term. The growth potential of robots in these industries is more limited. If a way could be found to automate such processes, however, robotics could transform the clothing industry from one in which manufacturing is done globally to one that is more local.

Exhibit 1 | Some Industries Are More Likely to Benefit from Robotics Because of High Wages and Automatable Tasks



Sources: US Bureau of Labor Statistics, "International Labor Comparison of Hourly Compensation Costs in Manufacturing Industries, 2012"; BCG analysis.
Note: Petroleum and coal manufacturing are not depicted because of a high and variable wage premium, consistent with immovable, resource-intensive industries.
[1]These are defined as occupational tasks that have the potential to be replaced with advanced robotics.

We calculated the costs of robotics for 21 industries by aggregating all of the production tasks and types of robots required by those industries. We then adjusted those costs for expected improvements in performance and projected them over ten years. Finally, we amortized the investment in robotics systems over five years to arrive at a cost per hour in US dollars and compared that amount with the projected labor costs in each economy. On the basis of these cost-performance projections and automatable tasks, we developed estimates for robot adoption for the next decade in each of the 21 industries.

The four industry groups that currently account for the vast majority of global robot use will remain in the vanguard.

The four industry groups that currently account for the vast majority of global robot use will remain in the vanguard: computers and electronic products; electrical equipment, appliances, and components; transportation equipment; and machinery. According to our projections, these four industry groups will account for around 75% of robot installations globally through 2025. Currently, at least 85% of the production tasks in these industries are automatable. Most tasks involving assembly and the tending of machines, for example, are highly repetitive and involve rigid materials, so they can be performed by relatively basic robots. Wages in these industries are also relatively high because many tasks require highly skilled workers. Global wages in the transportation and computer industries, for example, are roughly 20% higher than average global manufacturing wages.

In another cluster of industry groups, robots will most likely be adopted in high-wage economies in the near term, and wider adoption will occur as the costs and performance of systems improve. These groups include plastics and rubber products, petroleum and coal products, and primary metals. We project that robots will perform 10% to 20% of tasks in these industries globally by 2025. Economics will be the main limitation. Although about 86% of tasks in plastics and rubber-products plants can be automated, manufacturing wages are expected to remain relatively lower. This will limit the financial benefits of automation, especially in low-wage emerging markets.

A number of industries will remain a poor fit for robots in the near term. Chemicals, wood products, paper, fabricated metals, food processing, and textile products are prominent examples. We project that robots will perform only about 1% to 5% of tasks in these industries a decade from now. Global manufacturing wages in these industries are low because they tend to have a smaller portion of automatable jobs and because the economic trade-offs don't justify broad robotics adoption, at least for now.

Technical impediments to widespread robot use also exist in certain industries. As mentioned previously, the biggest hurdles for machines in apparel manufacturing are the abilities to pick up single pieces of cloth and then align them so that they can be cut and fed through a sewing machine—tasks that are still better done by humans. As a result, the hourly cost of owning and operating a robot in a US apparel, textile, chemical, or paper plant ranges from about $40 to $47. By 2025, that cost is projected to drop to about $20 to $25 per hour, which would still not be competitive with labor in apparel factories in many countries.

The Impact on Economies. Robotics will penetrate the manufacturing sector to different degrees in different economies as well. The mix of industries in each economy will be one of the variables in assessing robot penetration. Another will be regulations that make it difficult and very expensive for companies to replace workers; economies with such regulations will probably adopt robotics at lower rates. Other variables include the cost, supply, and flexibility of labor and the availability of investment capital.

On the basis of these factors and current trends, our projections show that five countries—China, the US, Japan, Germany, and South Korea—will account for about 80% of

robot shipments over the next decade; China and the US alone will account for around half of those shipments.

We found that industries in certain economies are embracing robots much more energetically than we anticipated, given the underlying economic factors. In other economies, robotics adoption is lagging even though the economic rationale for automation seems compelling.

To get a sense of who is in the vanguard, we analyzed the world's 25 biggest manufacturing export economies, which account for some 90% of goods exports. We grouped these economies into four categories of robotics adopters: aggressive, fast, moderate, and slow. (See Exhibit 2.)

These differences in robotics adoption may seem small and less noticeable now. But over time they are likely to lead to significant gaps in productivity gains and manufacturing costs among leading export economies—especially as more and more industries reach the inflection point and investment in robots accelerates. Indeed, we believe that as wage gaps between low-cost and high-cost economies continue to narrow, robot adoption could emerge as an important new factor that will contribute to redrawing the competitive balance among economies in global manufacturing.

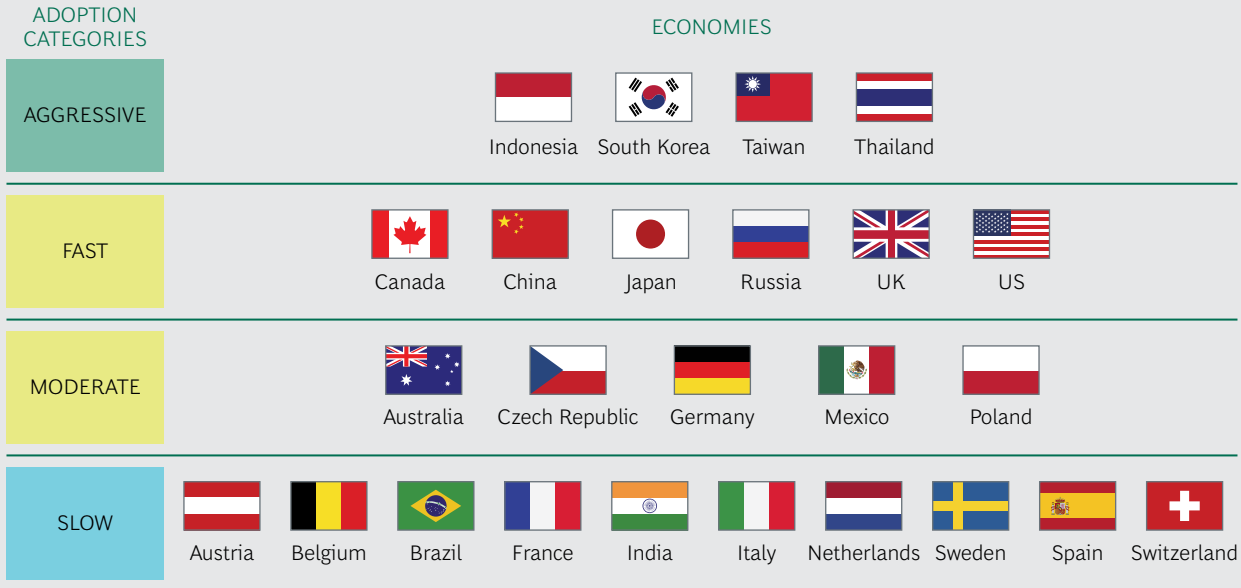
How Robots Will Redefine Competitiveness

To understand the likely winners and losers in the robotics revolution, we estimated the impact that projected robotics-adoption rates would have on both productivity and labor costs in each of the 25 leading manufacturing export economies, given their mix of industries.

In many cases, the impact on cost competitiveness will be dramatic. According to our projections, the biggest beneficiaries will be manufacturers in South Korea, where the combined cost of human labor and robotics in 2025 will be an estimated 33% lower than it would be without greater robotics adoption. That is double the average cost reduction estimated across all 25 economies—and it should give South Korea a real advantage.

We estimate that labor costs will be about 25% lower in Japan, 24% lower in Canada, 22% lower in the US, 21% lower in Germany

Exhibit 2 | Major Goods-Exporting Economies Follow Four General Patterns of Robotics Adoption



Sources: The Economist Intelligence Unit; Organisation for Economic Co-operation and Development; The Fraser Institute; ETUI's website www.worker-participation.eu; Ius Laboris; L&E Global; Thomson Reuters Practical Law; BCG analysis.

and the UK, 20% lower in Australia, and 18% lower in China and the Czech Republic.

Economies that are expected to adopt robotics relatively slowly will see far less impressive cost reductions. We project that robots will lower costs by just 3% in Mexico and will have negligible influence on labor costs in India and Indonesia, where manufacturing wages are expected to remain very low through 2025.

The savings from advanced robots will be modest in some developed economies.

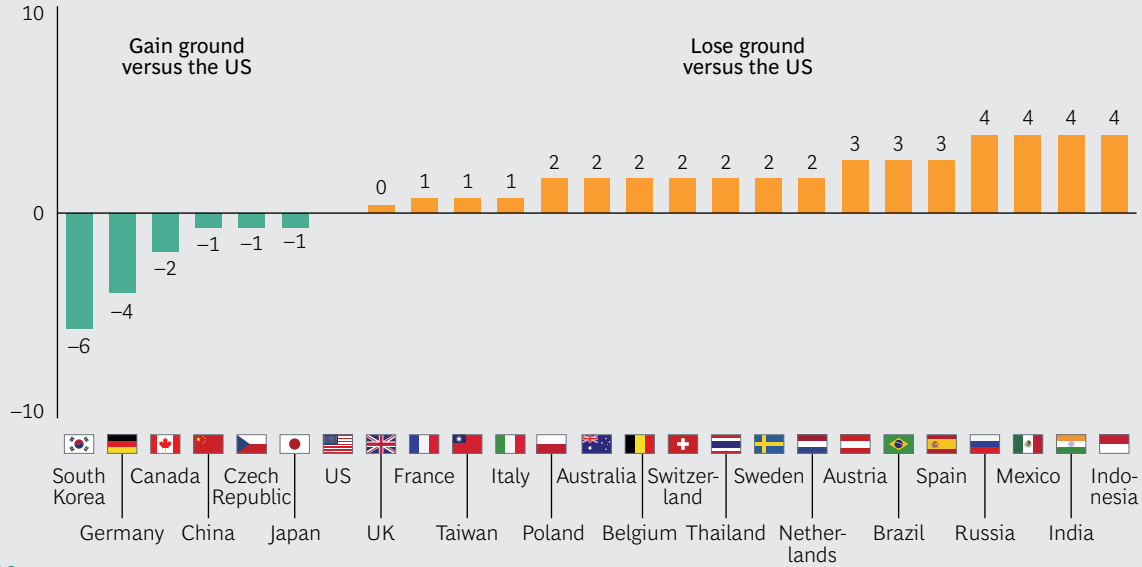
The savings from advanced robots will also be modest in a number of developed economies that already suffer from a combination of relatively high wages, low productivity, tight labor markets, and labor restrictions. In France, Switzerland, Belgium, Italy, Russia, Sweden, Austria, the Netherlands, Brazil, and Spain, labor cost reductions will range from about 9% to 6%. This translates into losses in competitiveness of as much as 4 points for a host of economies, when indexed against the US. (See Exhibit 3.)

In economies such as India and Mexico, losing ground will have little tangible impact. Because labor rates are projected to remain low in those economies for the next ten years, they will still likely have very competitive cost structures a decade from now—and will, therefore, remain attractive locations for the many industries in which automation is difficult.

Several high-cost economies, however, stand to fall further behind. Cost increases that have exceeded productivity growth have eroded the competitiveness of, for example, Belgium, Brazil, France, and Italy over the past decade. We expect these economies to be slow to invest in automation, despite the strong economic case for doing so and the urgent need to accelerate productivity, because of a host of

EXHIBIT 3 | Robots Could Shift the Economics of Global Manufacturing

THE POTENTIAL CHANGE IN BCG'S MANUFACTURING COST-COMPETITIVENESS INDEX AS A RESULT OF ROBOTICS, 2014–2025[1]



SCENARIOS																								
Aggressive	–11	–12	–3	–5	–4	–2	0	0	–6	1	–5	1	1	–2	–2	2	–0	0	0	1	2	6	6	7	7
Conservative	–4	–0	–1	–0	0	–1	0	–0	–0	–0	–0	1	1	0	0	1	0	0	1	1	1	1	1	2	2

Sources: OECD STAN Bilateral Trade Database; US Bureau of Labor Statistics; BCG analysis.
Note: Each economy is measured relative to the US; thus, a one-point gain versus the U.S. means that the direct manufacturing costs of the economy in question will become 1 percentage point cheaper relative to the US by 2025.
[1]BCG's Global Manufacturing Cost-Competitiveness Index tracks changes in direct manufacturing costs in the world's top 25 export economies.
For further information, see *The Shifting Economics of Global Manufacturing: How Cost Competitiveness Is Changing Worldwide,* BCG report, August 2014.

economic, cultural, and social barriers. Such tardiness will likely lead to further deterioration of these economies' competitiveness.

Preparing for the Robotics Revolution

Few manufacturing companies will be left untouched by the robotics revolution. But getting the timing, cost, and location right will be critical. Investing in expensive robotics systems too early, too late, or in the wrong location could put manufacturers at a serious cost disadvantage against global competitors. To gain competitive advantage, companies need to adopt a holistic approach to the robotics transition. We recommend that companies take the following actions.

Understand the global landscape. Companies need a clear picture of the trends in robot adoption around the world and in their industries. They need to know how the price and performance of robots are likely to change in comparison with the total cost of labor in each economy where they manufacture—and how this comparison is likely to change in the years ahead. They must factor in other considerations that support or hinder wider robotics adoption in a given economy. It is important to keep in mind that these are moving targets.

Benchmark the competition. Companies need to be well aware of what their competitors are currently doing and understand what they will do in the future. If robotics adoption is expected to rapidly increase in their industry, they should assume that the total cost of systems will fall. This knowledge will help companies more accurately estimate the cost and timing of investments as well as make decisions about where to locate new capacity.

Stay technologically current. Companies must stay abreast of the evolving capabilities of advanced robotics systems. They should have a clear view of whether and how quickly innovation is resolving technical barriers that so far have inhibited the use of robots, such as the ability to manipulate flexible or oddly shaped materials or to operate safely alongside workers. Just as important, when will these new applications be cost-effective? Many companies—even small and midsize manufacturers—may discover that installing robotics is more cost-effective than they once thought. In some cases, having a view on the evolution of robotics and automation can help a company determine whether it is better to wait for a better technology to emerge or to implement a new process that allows them to upgrade technology without having to duplicate what they have already done. In many ways, timing is crucial.

Prepare the workforce. As more factories convert to robotics, the availability of skilled labor will become a more important factor in the decision about where to locate production. Tasks that still require manual labor will become more complex, and the ability of local workforces to master new skills will become more critical. The availability of programming and automation talent will grow in importance. Companies and economies must prepare their workforces for the robotics revolution and should work with schools and governments to expand training in such high-compensation professions as mechanical engineering and computer programming.

Few manufacturing companies will be left untouched by the robotics revolution.

Prepare the organization. Even if the economics don't yet favor major capital investment, companies should start preparing their global manufacturing operations now for the age of robotics. They should make sure that their networks are flexible enough to realize the benefits of robotics as installations become economically justified in different economies and as suppliers automate. They should get themselves up to speed on new advanced-manufacturing technologies and think about how they will transform their current production processes so that these technologies can achieve their potential. For many manufacturers, adapting to the age of robotics will require a transformation of their operations.

MANUFACTURERS do not have the luxury of waiting to act until the economic conditions for robotics adoption are ripe. Our projections show that when the cost inflection point arrives, robotics installation rates are likely to accelerate rapidly. This will provide the opportunity to create a substantial competitive advantage. Companies and economies that are ready to capitalize on the opportunity will be in a position to seize global advantage in manufacturing.

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LEVERAGING BIG DATA TO MANAGE LOGISTICS

For many major B2B enterprises, logistics networks have never been more complex. The increasing prevalence of operations that are global—with growing numbers of production sites and clients that could be anywhere—has introduced challenges that didn't exist to the same degree previously. The good news is that there has also never before been a moment when there were more tools and more opportunities to optimize logistics costs.

Most B2B players have already improved their ability to minimize logistics costs on a route-by-route level. They know how to find the least expensive route for shipping products from a given production facility to an individual client location.

However, few have a holistic view of their logistics network or of the associated costs. Such a view considers all supplier and customer flows simultaneously. It tracks not only transportation and handling but also warehousing and inventory working-capital costs, specifically by end customer. Without such a picture, companies might miss opportunities to capture greater value from their network.

The incomplete view that most companies have of their transportation costs is the result of a siloed organization structure that has each part of the business focusing on a single aspect of logistics. For example, one part of the business might be responsible for shipping from plants to warehouses. Another might manage allocation of customers to specific production facilities. A third might be in charge of negotiating rates with carriers.

Some organizations segment supply chain management by customer or channel and duplicate network structures. And in many cases, inbound-logistics management is separate from outbound—or simply not directly managed—creating major backhaul inefficiencies, particularly in remote areas. Managers in each part of the business strive (understandably) to optimize logistics costs for their own silos but might not factor in the interdependencies. They might not even be aware that their decisions could result in higher costs for other parts of the business.

Five Levers for Optimizing Logistics Routes

Instead of taking a piecemeal approach, companies need to manage their logistics networks holistically. This means looking at all product volumes and all possible routes flowing from suppliers to production facilities and customers, considering the impact of each decision on total logistics costs, and making trade-offs as needed to optimize costs throughout the chain. To achieve all this, supply chain leaders can activate the following set of five levers.

Mode and Route Mix. Managers must determine which configuration of modes (such as truck, rail, and boat) over which routes and junction points will optimize the flow of goods in terms of cost and lead time. They must assess the trade-offs and implications for inbound and outbound logistics, including potential synergies with supplier and customer networks through backhaul optimization. For instance, on the surface, one-way shipping by truck along a particular route might be more expensive than shipping by rail. However, if there are backhaul loads, it might be less expensive. Shipping small loads is not optimally efficient, but it can speed delivery time, decrease in-transit inventory, and make the most of working capital. Finally, adding transloads at junction points might increase handling, but it can also help reduce overall costs if the company can build scale or access a lower-cost transport mode (for example, ship instead of rail). All these factors merit careful consideration.

Warehouse and Distribution Center Network. Managers should carefully consider the number of warehouses and distribution centers (DCs) their company needs, where those DCs should be located, what products they should host, and which suppliers and clients they should serve. It's useful to determine whether serving different customers from particular warehouses or having one DC host multiple products could help optimize asset utilization for the company's carriers, thereby enabling managers to negotiate lower shipping rates.

Production Origin and Destination Swaps. Companies might create arbitrage opportunities by reallocating products and clients to specific production facilities in ways that reduce overall distances and costs. Clearly, the business will need to weigh the relative benefits of the change against capital implications and operational constraints. In many cases, it's possible to make small production tweaks at reasonable cost, and such changes can lead to material logistics savings.

Shipment Consolidation. A close examination of a company's production schedule could reveal ways to consolidate shipments in order to maximize the utilization of the business's own equipment as well as that of its carriers. For instance, a company with enough rail-shipment volume might be allowed blocks of railcars or unit trains.

Knowing which levers to pull, when, and how isn't easy.

Ways of building bigger shipments include holding inventory, establishing a hub, and clustering volumes with other companies. The result could be increased leverage with carriers and avoidance of switching costs, enabling the company to ink better deals on shipping rates.

Shipping Rates. Companies need transparency into pricing and cost structures (including base rates, fuel surcharges, handling fees, and third-party equipment and lane fees) across modes and routes. They can achieve this transparency through broad market tenders and "should cost" modeling. Such knowledge, which is critical for optimizing mode and route mix, helps managers identify specific routes for which the business might be overpaying.

To have any leverage, companies must generate competition among shippers by exploring routes with alternate modes or carriers. It's important to assess and understand where the business might have this kind of leverage and, using a carrot-and-stick approach, be able to apply it strategically. For instance, managers might explore opportunities to increase a carrier's volume for some routes in exchange for more competitive rates on routes lacking alternatives (carrots). Or they could threaten to reduce volume in situations that offer no alternatives if a carrier doesn't agree to the target rates (sticks).

Deploying Big-Data Analytics

Knowing which levers to pull, when, and how isn't easy. The levers are interdependent, and a change in one generally triggers trade-offs in others. Companies must make these trade-offs with an eye to the impact on overall logistics costs. To optimize costs holistically

across its supply chain, a company needs to consider all levers simultaneously.

The number of parameters and possibilities is mind-boggling. Consider a company that ships metal products in North America. To determine the best way to manage the outbound distribution of products throughout the continent, the business might have to consider a network that includes more than 500 nodes—plants, clients, transload locations, and warehouses. Furthermore, the company might also have to take into account as many as 100,000 arcs: the arcs represent the various modes of transitioning from one node to another and comprise millions of miles of roads, hundreds of thousands of miles of rail, and a waterway network. (See the exhibit below.)

To optimize such a network, a company would have to analyze as many as 100 billion possible combinations. Moreover, external cost drivers—such as demand for particular commodities, locations and number of suppliers and clients, fuel and commodity prices, and foreign-exchange rates—are continually changing. A solution that optimizes logistics costs under a single set of conditions could backfire should one or more of those conditions shift.

Many supply-chain leaders know that evaluating all of these factors is the right way to solve the problem, but doing so is not always practical. Because the range of variables is so wide and the volume of data that companies need to access is so huge, few companies have enough talent or time to arrive at actionable conclusions in today's fast-changing environment. But thanks to advances in big-data analytics tools and approaches, optimization has become far more feasible.

Getting Started

To begin optimizing total logistics costs using data analysis, supply chain leaders should first gather stakeholders from different parts of the organization to build a clear picture of the business's current logistics network. Together, group members should map the loca-

Picking the Right Route Is a Complex Process

MULTIPLE NODES AND MODE-ACCESSIBILITY OPTIONS....

Network nodes (client example)

X current production facilities	
X customer demand locations	
Warehouses	X existing locations 225 potential locations • All junction points • Rail-truck transition nodes
15 ports	West Coast • Origin: X, Y, Z • Destination: Seattle, Vancouver, Long Beach East Coast • Origin: X, Y, Z • Destination: Baltimore, Veracruz, Charleston, Savannah, Mobile, Oswego, Toledo, Detroit, Chicago

+ ... AUGMENTED WITH 3 MILLION MILES OF ROADS, NEARLY 200,000 MILES OF RAIL, AND A WATERWAY NETWORK

Source: BCG analysis.

tions of the business's suppliers, clients, plants, warehouses, DCs, and modes.

The next step is to identify the company's biggest cost drivers, including particular modes of transportation, inventory in transit, and specific types of equipment. Management should also determine the company's current constraints, such as lead time obligations to clients and production capacities of various plants.

Supply chain leaders will need a team of logistics and modeling experts.

It is important to determine whether these constraints are truly etched in stone. For instance, management might assume that a particular customer requires daily shipping, but the customer might, in fact, be happy with a more flexible shipping schedule. At this stage, it's also critical to understand the value of all the potential alternatives by, for example, executing a broad tender process to gain a full picture of true market rates.

Supply chain leaders will need a team of logistics and modeling experts to build a network optimization tool that accounts for all of this information. Armed with this powerful tool, they will be able to tune the company's logistics network across a number of variables, experimenting with changes in assumptions and current constraints in the network. They will also be able to test each scenario's potential impact on the business's overall logistics costs and to generate alternative logistics strategies across modes to strengthen the company's negotiating position with suppliers.

With such a capability, the business will be able to create a detailed picture of its options for manipulating the five levers to optimize logistics costs across its entire supply chain. Although it's just the beginning, gaining this picture is a vital first step in surmounting the complex logistics challenges that face companies today.

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CHANGING THE GAME IN INDUSTRIAL GOODS THROUGH DIGITAL SERVICES

Services have long been an attractive area of growth for industrial goods companies. Spare-parts, modernization, and maintenance services typically have higher margins and growth rates than do sales of new equipment. These services also promote customer loyalty and lead to future equipment sales.

Digitization is now enabling service providers to reach a new level of performance and efficiency. Yet many OEMs and other service providers have been slow to make the transition to digital services. They doubt their ability to monetize digital services and recoup the investment. Digitization has two important benefits that are often underappreciated, however. It greatly reduces the cost of delivering services, and it facilitates closer, longer-term customer relationships that offer a variety of new service possibilities. We believe that taking these factors into account will change the calculation.

For OEMs, digitization poses a threat as well as an opportunity. By shifting the locus of value creation from servicing equipment to managing information and equipment, digitization expands the universe of potential competitors. Digitally savvy companies could take over parts of the service business despite having little expertise in industrial goods—and perhaps eventually commoditize the hardware elements of the value chain. To maintain a competitive position and boost prospects for growth, manufacturers need to move quickly.

Digital Technology and the Service Business

Digitization has been going on for a while, but new service and sales opportunities are arising from several recent technological developments. For example, the cheap sensors and pervasive wireless communication that underpin the Internet of Things are enabling companies to receive massive amounts of data and manage equipment operations remotely, and mobile and augmented-reality devices are making service field personnel more efficient.

Almost every kind of service-related information can be digitized, which means that existing services can be transformed and new services and new business models can be created. This shift's potential value to customers is so great that many companies in adjacent industries are either pursuing or actively considering the opportunity. Digitization depends on implementing systems that capture, transmit, and process information. So, large software companies are using their expertise with these systems to carve out segments of the service business.

The size of the opportunity will appeal to companies inside and outside industrial

goods. OEMs that hope to maintain or increase their service business should be entering the field of digital services with conviction—and soon.

Digitizing Existing Services

Even though many OEMs are convinced of the value to be gained by digitizing existing services, they are moving cautiously. They see digitization as something they'll have to embrace eventually. But they are concerned about the complexity of the shift and about recouping the investment, since customers might resist paying for digital upgrades.

There's some truth in that perspective, but it overlooks the cost side of the equation. Digitizing existing services can eliminate some on-site visits, speed up others, and enable companies to handle the same number of customers with fewer technicians. So, digitizing existing services can reduce labor costs substantially.

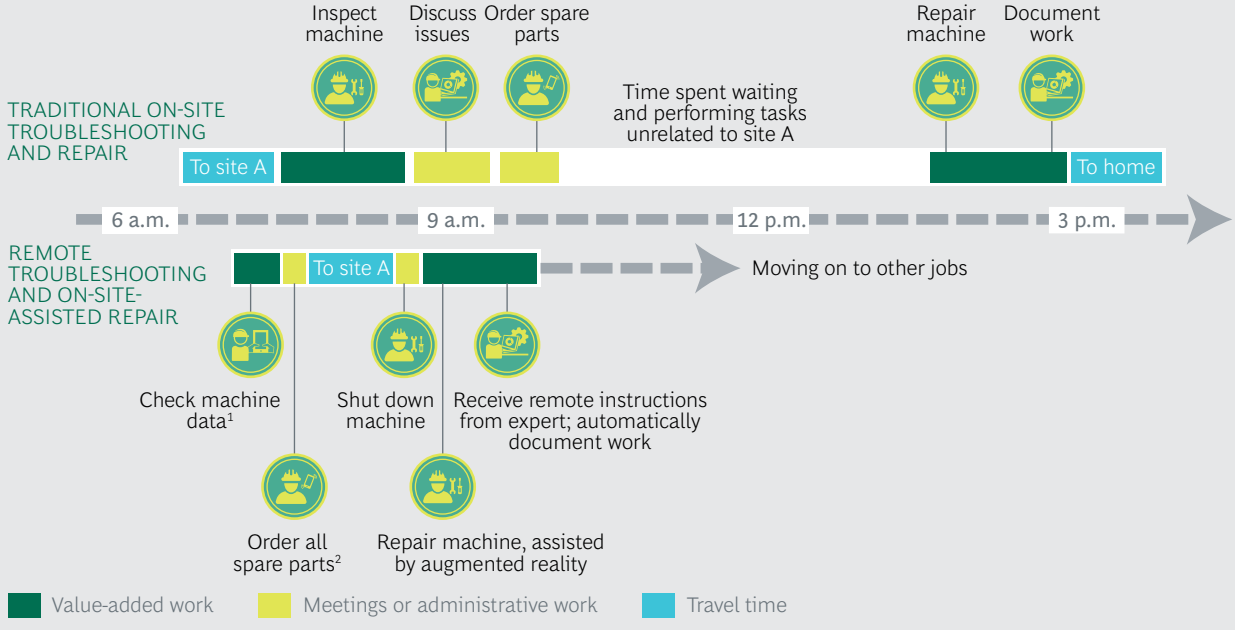
Instead of having a technician travel to a customer's site, for example, a service company can have the equipment send vital statistics to its technicians on a set schedule. And if the equipment malfunctions, technicians can run diagnostics remotely. Because software is increasingly being built into equipment, some problems can be fixed immediately simply by adjusting or updating the software—with little or no human involvement.

OEMs should be entering the field of digital services with conviction—and soon.

Digitization speeds up the submission of reports, because it can be done right on-site. And 3-D printing enables service offices to quickly print spare parts on demand, rather than store costly inventory or wait for delivery from warehouses. Meanwhile, workflow management software can optimize service calls both to minimize idle time and to ensure service consistency.

For example, a wind turbine OEM found that digitization cut its technicians' time by more than half. (See Exhibit 1.) Remote diagnostics allowed the technicians to arrive with spare

EXHIBIT 1 | Technology Transforms a Service Technician's Daily Work



Sources: Expert interviews; BCG analysis.
[1]Review real-time data from machines' sensors for abnormalities.
[2]Order spare parts for all machines with abnormalities or damaged parts.

parts in hand, rather than first diagnose the issue on site, place the order for spare parts, and wait for them to arrive.

Whether done remotely or in person, digitized service interventions are not only cheaper but also faster and better. That means less unplanned downtime for customers' expensive equipment and greater safety for technicians. The customers are delighted, and the savings from higher productivity cover the payoff on the digital investment, without raising prices.

Offering digital services does require some staff training, but the costs here are outweighed by the lesser need for specialized knowledge. In many cases, service providers will be able to send technicians with only general training, rather than specialists, because technology will enable technicians to communicate in a richer way with specialized support or will fill in the gaps.

New Digital Offerings

Customers may resist paying higher prices for digital versions of existing offerings, but a package of new digital services can offer a provider a clean slate and new pricing opportunities. More important, new services give providers the opportunity to change their relationship with their customers. Rather than offering services on a one-off or as-needed basis, providers can introduce services that are performed on a continual basis, improving customers' operations and becoming an integral part of customers' businesses.

Condition Monitoring and Predictive Maintenance. Repairing machines quickly is one thing, but it is even better to prevent a breakdown in the first place. By using sensors and a monitoring system to continually track a machine's performance, a service company can learn how equipment functions in a customer's operation. Sophisticated analytics can isolate the main operating variables and find correlating events that lead to deteriorating performance or a breakdown. Armed with these insights, the monitoring system can anticipate when failures are likely to occur and schedule maintenance, assign technicians, and ensure that the workers will have the needed tools and spare parts in time.

Performance Improvement. Service companies can perform analytics on equipment not only to watch for breakdowns but also to optimize its use. By combining this analysis with a deep knowledge of the equipment, service providers can propose improvements in customer practices that reduce the operating costs or maximize the output for both current machines and future purchases.

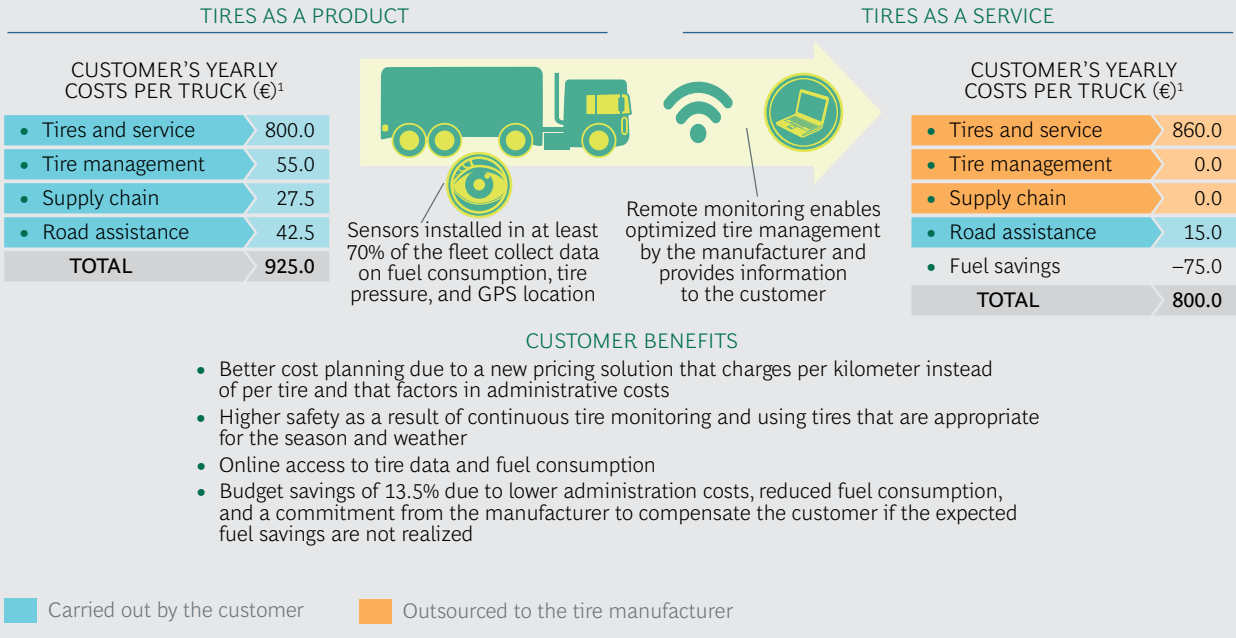
New Business Models

Digitization is eroding the fundamental distinction between products and services. Building on a deep understanding of a machine's life cycle and customers' typical usage patterns, some OEMs are offering their equipment not for sale but as an ongoing service.

Some OEMs are offering their equipment not for sale but as an ongoing service.

A large tire manufacturer offers tires as a service for which customers pay on a per kilometer basis. The customers agree to put telematics and sensors in a large part of their fleets to enable remote management. A customer's immediate costs are higher than if it purchased the tires outright, but the total cost of ownership is lower. That's partly because the customer is no longer responsible for monitoring and replacing its tires. But the management and overall costs are also lower because the manufacturer guarantees the customer's fuel savings. Having tracked tire-deployment data in the past, the OEM has learned the kinds of savings that are likely from optimizing it. Shifting the customer from a product-centric model to a service-centric one gives the OEM full control over how those tires will be deployed. (See Exhibit 2.) The more customers the manufacturer signs up, the richer its accumulated data set becomes, giving it a leg up on any rivals that appear later.

EXHIBIT 2 | Technology Enables a Tire Manufacturer to Add a New Business Model



Source: A leading tire manufacturer's commercial brochure.
Note: GPS = global positioning system.
[1]The example is for illustrative purposes.

We expect that such business models will soon become the "new normal" in many sectors of industrial goods. Failing to deliver such services may well mean losing out not only on service contracts but also on new-equipment sales.

Monetizing Digital Services

Pricing new digital services is often trickier than expected. Which parameters—for example, equipment usage or output—should a service company use to establish a rate schedule? And if the pricing assumes a boost in the equipment's productivity, customers may be skeptical, since they think they know their own equipment better than the manufacturer does. Pricing solutions are still developing. In the meantime, service providers should consider several factors when tackling this task.

The solution to customer skepticism is to make the new services a clear win-win—for the customer and the service provider. Service companies that promise a customer a certain level of savings in order to sell a service should guarantee reimbursement to the customer for any shortfalls. Over time, as the customer starts to trust the service, the service provider may be able to drop those guarantees.

Predictability is essential. Even when pricing is based on a customer's use, cost predictability matters. In the tire example, the manufacturer charged according to the number of kilometers driven. To minimize unprofitable agreements while still attracting new customers, service providers must develop a new set of pricing capabilities.

It's also important to remember that the payoff from investments in digital services will come not only directly through increased revenues but also indirectly through improved customer relationships. Whenever a customer switches from a discretionary, as-needed service to an ongoing service package, the service provider gains in lower sales costs, more efficient service planning, and a lower risk of customer attrition. Service packages also increase the number of services provided, whether in the form of spare parts or maintenance, and protect service companies from losing customers to third parties. Earning that payoff requires a clear strategy that supports the service commitments as well as a long-term view of the market.

Service providers are exposed to significant risk if they get the service business case wrong. Using analytics, they can gain a thorough understanding of the costs involved in the service, both the upfront costs and the recurring ones. In addition, service companies can compare the characteristics of a new customer with those of past customers whose cost savings fit the promised results. Providers should moreover assess the financial and reputational risks of failing to live up to their commitments or of costs generated by unexpected events.

Safety risks may be relevant as well. Service companies should therefore develop the skills and tools for comprehensive risk assessments and, if necessary, have an exit plan.

Finally, service providers should insist on certain commitments from customers, including a minimum duration agreement, in order to recover the often-hefty initial costs. More important are mechanisms to align a provider's interests with those of its customers. Without such mechanisms, customers may change their behavior in response to the shift in responsibility.

Increasing Sales Through Digitization

Although transforming current services and creating new digital services and business models are the main opportunities of digitization, digitization can boost service sales as well. It has already revolutionized the relationship between retailers and their customers in the consumer sphere, and it is poised to alter the dynamic between manufacturers and their customers in industrial goods. By combining data from equipment with new platforms for communicating with customers, service providers can better differentiate themselves from their competition and secure long-term ties.

To boost digital service sales, however, service providers will also need to rethink their digital sales tools, sales channels, and marketing platforms, thus empowering the sales force and extending the company's reach. In some cases, service companies will be pulled along by customers that are technologically better informed and more sophisticated and that seek much greater transparency and collaboration from their providers.

Digital Sales Tools. Service providers can draw on the variety of data gathered from existing customers to determine the most appropriate upgrade or retrofit for a piece of equipment and when to pitch it. Diligent sales-support functions can go a step further and use that data to develop a profile of the most likely new customers. By matching that profile to the companies in the marketplace, the support staff can develop a list of likely prospects for the salespeople to pursue.

Indeed, by using big-data analytics to determine customer-acquisition patterns, management can define new customer and product segments on the basis of more specific, more sophisticated factors, such as equipment age, availability of third-party spare parts, or frequency of part purchases. Greater knowledge can also lead to more finely tuned discounts and other incentives that secure a sale without a lot of persuasion or hard data from the sales representative. In our experience, OEMs have increased their margins by 5% to 10% by implementing these initiatives. Providing data to salespeople raises their productivity without a big investment in training them on how to use it.

Digitization is poised to alter the dynamic between manufacturers and their customers in industrial goods.

As customers and services become more sophisticated, the sales force has to follow suit. Mobile sales tools can greatly improve how a sales force interacts with customers. Tablets and other devices can help salespeople navigate among various service offerings for customers. In addition to enabling customers to visualize the proposed solution, mobile tools help salespeople address customers' concerns in real time with value-based arguments and calculations. The tools should also

simplify any ordering processes, improving productivity and ensuring consistent information.

E-Commerce. Although e-commerce represents a small percentage of total revenues for service providers, online sales may become a major percentage in the future. E-commerce is spreading in business-to-business sales as a whole, and the services sector is likely to be next. Some non-OEM sales platforms are emerging, offering customers greater transparency on prices and service characteristics. Equipment owners may have a long-standing relationship with one OEM or more, but accessible online providers that offer price transparency may win sales for smaller parts that customers can install themselves. Such transactions can foster a relationship that cuts into OEMs' business down the road.

Service providers will need to shift their overall culture toward agility and innovation.

With this in mind, even OEMs with low expectations for online sales might consider launching their own sales portal. A sales portal offers OEMs the opportunity to connect directly with customers, leapfrogging traditional channels such as the distributor channel. Although connecting directly with customers might generate conflicts with channel partners, it also builds customer relationships that ultimately increase customer loyalty and sales.

Social Media. Online forums are flexible, diverse platforms for presenting the values, expertise, products, and services of a company. These sites accommodate news releases, blogs, articles, event announcements, and product launches, with complex imagery and video as needed. Through frequent updates and clever use of celebrities in their videos, a leader in construction machinery has garnered millions of page views. Its Facebook profile is followed by close to half a million people.

Making It Happen

Digitization has the potential to transform services at industrial goods companies. But the learning curve can be steep, and many companies struggle with the change from the beginning. The digital transformation should start with a clear understanding of how digital services can generate value for the target customer and what that customer journey will look like. This knowledge will clarify the service company's ambition and long-term vision. It will also define a digital-services roadmap, including an implementation plan.

Ongoing leadership and management support is essential. A separate business unit or organization that is focused on digitization may be necessary. Whether developed within the existing organization or separately, the initiative should be part of the overall corporate agenda, even at an executive committee level. A high-level manager, or even a chief technology officer or a chief digital officer, may need to spend significant time on the initiative.

Service companies may also need to acquire new kinds of talent, not only technology experts but also senior managers who can act as catalysts within the organization. The need may be so great that a company decides to acquire a digitally savvy firm, as much for the talent as for the products.

Finally, service providers will need to shift their overall culture toward agility and innovation. The new digital world is still in the making. Service providers need to embrace fast-paced, iterative processes and pilots that allow for quick testing and learning in controlled environments, with ongoing adjustments as needed. Each successful project will create momentum in the organization, strengthening the vision for digital services.

Most industrial-goods companies won't have a choice whether to embrace digital services. Companies that hold back will eventually find themselves squeezed out of the marketplace, either by existing rivals or new disruptive entrants. Others may prepare

now but wait to see how peers proceed before moving decisively. Such companies will lower their risk but find themselves playing a catch-up game.

Digitization gives service providers that act now the chance to lower delivery costs, offer new services, create new business models, and boost sales effectiveness. Providers that seize the opportunity will not only move ahead in digitization but also elevate their customer relationships.

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NOTE TO THE READER

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7/16

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