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THE BOSTON CONSULTING GROUP

DECEMBER 2015

INSIDE OPS

INCREASING COMPETITIVENESS THROUGH OPERATIONAL EXCELLENCE

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PREFACE

I AM PLEASED TO PRESENT the inaugural edition of *Inside OPS,* a publication that showcases how The Boston Consulting Group's Operations practice puts operations at the core of business. This edition features five articles that span key topics but all focus on a single theme: *Increasing Competitiveness Through Operational Excellence.* These articles show how operations leaders can institute operational excellence in ways that make their business more competitive—and, therefore, more successful.

This is also the first publication put together by our global Operations Centers, which are home to experienced teams of operations experts, many with years of firsthand shop-floor experience. These centers, currently located in ten key business locations worldwide, offer tailored, fully integrated solutions to optimize operations for long-term success. Functional experts and experienced practitioners with cross-industry expertise provide a broad spectrum of advice, methodologies, training, and tools ranging from pragmatic, hands-on operational improvement programs to simulation and enablement capabilities.

That operations expertise is captured in the five articles included in this edition of *Inside OPS.*

As the first article, "Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries," details, we are in the midst of a wave of technological advancement: the rise of digital industrial technology, known as Industry 4.0, that will power faster, more flexible, and more efficient processes; increase manufacturing productivity and industrial growth; and ultimately change the competitiveness of companies and regions. Producers and manufacturing-system suppliers stand to reap tremendous opportunities; those that figure out how to actively shape the coming transformation will be well positioned to compete and win.

Companies can also seize the power of lean engineering as a lever for operational excellence, as suggested in "The Lean Advantage in Engineering: Developing Better Products Faster and More Efficiently." Some companies are emerging as leaders because they are learning how to apply the tried-and-true lean methods for production and administration to product development. This is a challenging undertaking that requires companies to build capabilities across four dimensions, but success confers significant competitive advantage.

Big data presents another opportunity for operational excellence and consequent competitive advantage. "Making Big Data Work: Supply

Chain Management" takes a detailed look at three high-potential opportunities for supply chain innovation. It explains how companies can tap the opportunities afforded by increasing amounts of data and increasingly sophisticated analytical tools—when they use strategic planning and deep understanding of the marketplace to guide their actions.

Today's uncertain and dynamic economic environment presents operational leaders with challenges—but also fresh opportunities to achieve operational excellence. Companies are forced to revisit decisions made years ago under different circumstances and find new solutions.

"Maximizing the Make-or-Buy Advantage: A Scenario-Based Approach to Increasing Resilience and Value" shows how companies can successfully reevaluate a question critical to each of their product parts and manufacturing processes: Should we make it in-house or buy it from a supplier? A scenario-based approach allows companies to simultaneously assess and compare a broad array of sourcing decisions so that they can make choices that will make them most competitive.

Auto suppliers are confronting a similar marketplace challenge, one that is requiring them to increasingly balance inexorable yet conflicting demands to both cut costs and locate facilities in fast-growing emerging markets, which are becoming the engines of global economic growth. As "The Proximity Paradox: Balancing Auto Suppliers' Manufacturing Networks" explains, this is one of the most serious management challenges that the global automotive-supply industry will face over the next few years. The article depicts how companies in this industry can prepare to strike a crucial balance using operational excellence that will bolster their competitiveness.

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,

Bjørn Matre
Senior Partner & Managing Director
Global Leader, Operations Practice

INDUSTRY 4.0

THE FUTURE OF PRODUCTIVITY AND GROWTH IN MANUFACTURING INDUSTRIES

Technological advances have driven dramatic increases in industrial productivity since the dawn of the Industrial Revolution. The steam engine powered factories in the nineteenth century, electrification led to mass production in the early part of the twentieth century, and industry became automated in the 1970s. In the decades that followed, however, industrial technological advancements were only incremental, especially compared with the breakthroughs that transformed IT, mobile communications, and e-commerce.

Now, though, we are in the midst of a fourth wave of technological advancement: the rise of new digital industrial technology known as Industry 4.0, a transformation that is powered by nine foundational technology advances. (See Exhibit 1.) In this transformation, sensors, machines, workpieces, and IT systems will be connected along the value chain beyond a single enterprise. These connected systems can interact with one another using standard Internet-based protocols and analyze data to predict failure, configure themselves, and adapt to changes. Industry 4.0 will make it possible to gather and analyze data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs. This in turn will increase manufacturing productivity, shift economics, foster industrial growth, and modify the profile of the workforce—ultimately changing the competitiveness of companies and regions.

The Nine Technology Trends

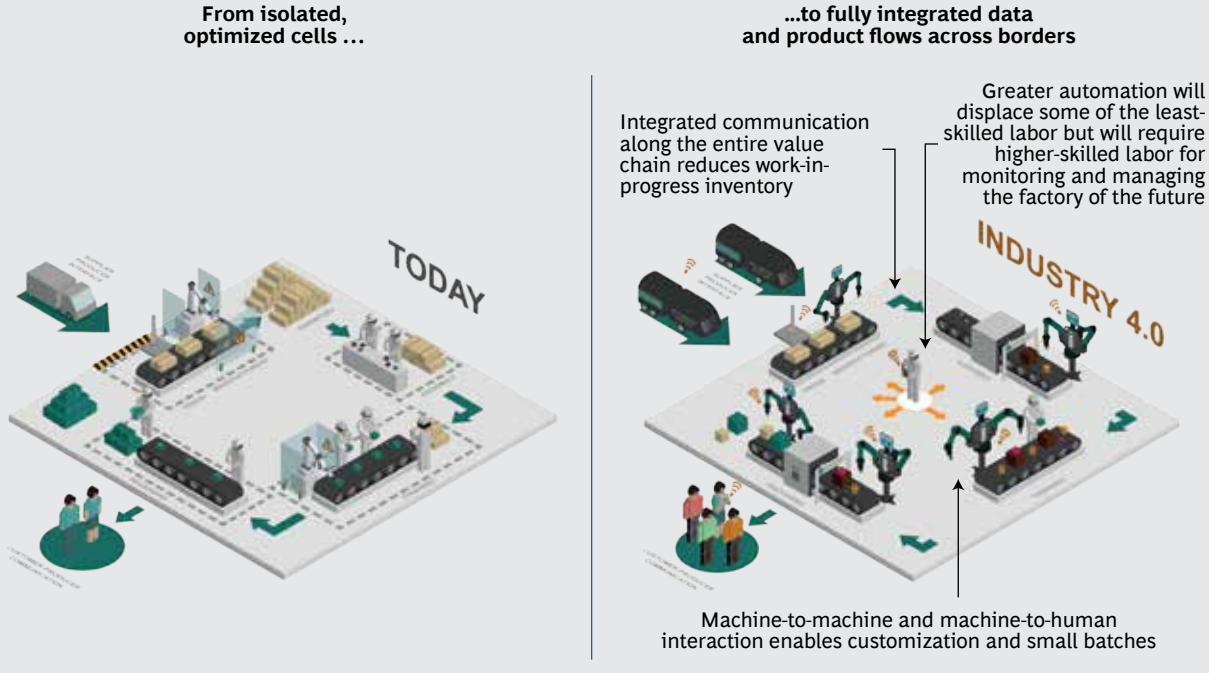
This article describes the nine technology trends that are the building blocks of Industry 4.0 and explores their potential benefits for manufacturers and production equipment suppliers. Many of the nine advances in technology that form the foundation for Industry 4.0 are already used in manufacturing. With Industry 4.0, however, they will transform production: isolated, optimized cells will come together as a fully integrated, automated, and optimized production flow, leading to greater efficiencies and changing traditional production relationships among suppliers, producers, and customers—as well as between human and machine. (See Exhibit 2.)

Big Data and Analytics. Analytics based on large data sets has emerged only recently in the manufacturing world, where it optimizes production quality, saves energy, and improves equipment service. In an Industry 4.0 context, the collection and comprehensive evaluation of data from many different sources—production equipment and systems as well as enterprise- and customer-management systems—will become standard to support real-time decision making.

EXHIBIT 1 | Nine Technologies Are Transforming Industrial Production

Source: BCG.

EXHIBIT 2 | Industry 4.0 Is Changing Traditional Manufacturing Relationships



Source: BCG.

For instance, semiconductor manufacturer Infineon Technologies has decreased product failures by correlating single-chip data captured in the testing phase at the end of the production process with process data collected in the wafer status phase earlier in the process. In this way, Infineon can identify patterns that help discharge faulty chips early in the production process and improve production quality.

Autonomous Robots. Manufacturers in many industries have long used robots to tackle complex assignments, but robots are evolving for even greater utility. They are becoming more autonomous, flexible, and cooperative. Eventually, they will interact with one another and work safely side by side with humans and learn from them. These robots will cost less and have a greater range of capabilities than those used in manufacturing today.

Kuka, a European manufacturer of robotic equipment, offers autonomous robots that interact with one another. These robots are interconnected so that they can work together and automatically adjust their actions to fit the next unfinished product in line. High-end sensors and control units enable close collaboration with humans. Similarly, industrial-robot supplier ABB is launching a two-armed robot called YuMi that is specifically designed to assemble products (such as consumer electronics) alongside humans. Two padded arms and computer vision allow for safe interaction and parts recognition.

Simulation. In the engineering phase, 3-D simulations of products, materials, and production processes are already used, but in the future, simulations will be used more extensively in plant operations as well. These simulations will leverage real-time data to mirror the physical world in a virtual model, which can include machines, products, and humans. This allows operators to test and optimize the machine settings for the next product in line in the virtual world before the physical changeover, thereby driving down machine setup times and increasing quality.

Siemens and a German machine-tool vendor developed a virtual machine that can simulate the machining of parts using data from the physical machine. This lowers the setup time for the actual machining process by as much as 80 percent.

Horizontal and Vertical System Integration. Most of today's IT systems are not fully integrated. Companies, suppliers, and customers are rarely closely linked. Nor are departments such as engineering, production, and service. Functions from the enterprise to the shop floor level are not fully integrated. Even engineering itself—from products to plants to automation—lacks complete integration. But with Industry 4.0, companies, departments, functions, and capabilities will become much more cohesive, as cross-company, universal data-integration networks evolve and enable truly automated value chains.

Robots will interact with one another and work safely side by side with humans.

Dassault Systèmes and BoostAeroSpace launched a collaboration platform for the European aerospace and defense industry. The platform, AirDesign, serves as a common workspace for design and manufacturing collaboration and is available as a service on a private cloud. It manages the complex task of exchanging product and production data among multiple partners.

The Industrial Internet of Things. Today, only some of a manufacturer's sensors and machines are networked and make use of embedded computing. They are typically organized in a vertical automation pyramid in which sensors and field devices with limited intelligence and automation controllers feed into an overarching manufacturing-process control system. But with the Industrial Internet of Things, more devices—sometimes including even unfinished products—will be enriched with embedded computing and connected using standard technologies. This allows field devices to communicate and interact both with one another and with more centralized control-

lers, as necessary. It also decentralizes analytics and decision making, enabling real-time responses.

Bosch Rexroth, a drive-and-control-system vendor, outfitted a production facility for valves with a semiautomated, decentralized production process. Products are identified by radio frequency identification codes. Workstations "know" which manufacturing steps must be performed for each product, and they can adapt to perform the specific operation.

Companies have just begun to adopt additive manufacturing, such as 3-D printing.

Cybersecurity. Many companies still rely on management and production systems that are unconnected or closed. With the increased connectivity and use of standard communications protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines from cybersecurity threats increases dramatically. As a result, secure, reliable communications as well as sophisticated identity and access management of machines and users are essential.

During the past year, several industrial-equipment vendors have joined forces with cybersecurity companies through partnerships or acquisitions.

The Cloud. Companies are already using cloud-based software for some enterprise and analytics applications, but with Industry 4.0, more production-related undertakings will require increased data sharing across sites and company boundaries. At the same time, the performance of cloud technologies will improve, achieving reaction times of just several milliseconds. As a result, machine data and functionality will increasingly be deployed to the cloud, enabling more data-driven services for production systems. Even systems that monitor and control processes may become cloud based.

Vendors of manufacturing-execution systems are among the companies that have started to offer cloud-based solutions.

Additive Manufacturing. Companies have just begun to adopt additive manufacturing, such as 3-D printing, which they use mostly to prototype and produce individual components. With Industry 4.0, these additive-manufacturing methods will be widely used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs. High-performance, decentralized additive manufacturing systems will reduce transport distances and stock on hand.

Aerospace companies are already using additive manufacturing to apply new designs that reduce aircraft weight, lowering their expenses for raw materials such as titanium.

Augmented Reality. Augmented-reality-based systems support a variety of services, such as selecting parts in a warehouse and sending repair instructions over mobile devices. These systems are in their infancy, but in the future, companies will make much broader use of augmented reality to provide workers with real-time information to improve decision making and work procedures.

For example, workers may receive repair instructions on how to replace a particular part as they are looking at the actual system needing repair. This information may be displayed directly in workers' field of sight using devices such as augmented-reality glasses. Another application is virtual training. Siemens has developed a virtual plant-operator training module for its Comos software that uses a realistic, data-based 3-D environment with augmented-reality glasses to train plant personnel to handle emergencies.

The Impact of Industry 4.0

The race to adopt elements of Industry 4.0 is already under way.

Producers: Transforming Production Processes and Systems. The next wave of manufacturing will affect producers' entire value chain, from design to after-sales service:

- Along the value chain, production processes will be optimized through integrated IT systems. As a result, today's insular manufacturing cells will be replaced by fully automated, integrated production lines.

- Products, production processes, and production automation will be designed and commissioned virtually in one integrated process and through the collaboration of producers and suppliers. Physical prototypes will be reduced to an absolute minimum.

- Manufacturing processes will increase in flexibility and allow for the economic production of small lot sizes. Robots, smart machines, and smart products that communicate with one another and make certain autonomous decisions will provide this flexibility.

- Manufacturing processes will be enhanced through learning and self-optimizing pieces of equipment that will, for example, adjust their own parameters as they sense certain properties of the unfinished product.

- Automated logistics will adjust automatically to production needs.

Industry 4.0 allows for a faster response to customer needs than is possible today. It improves the flexibility, speed, productivity, and quality of the production process. And it lays the foundation for the adoption of new business models, production processes, and other innovations. This will enable a new level of mass customization as more industrial producers invest in Industry 4.0 technologies to enhance and customize their offerings.

Manufacturing-System Suppliers: Meeting New Demands and Defining New Standards. As manufacturers demand the greater connectivity and interaction of Industry 4.0–capable machines and systems in their factories, manufacturing-system suppliers will have to expand the role of IT in their products. Changes will likely include a greater modularization of functionality with deployments in the cloud and on embedded devices. With increases in the overall functionality and complexity of systems comes the need for a greater distribution of decision making. In addition, online portals for downloading software and collaborative partner relationships may offer more flexible and adaptable equipment configurations.

Industrial-automation vendors and most machine-tool manufacturers have built significant software-development capabilities—but Industry 4.0 will require even more. In addition, these vendors will have to compete with IT players that are moving into the growing market for shop-floor- and production-related applications and data-driven services.

The growing interconnectivity of machines, products, parts, and humans will also require new international standards that define the interaction of these elements in the digital factory of the future. Efforts to develop these standards are in their infancy but are being driven by traditional standardization bodies and emerging consortia. Strategically choosing participation in these and other bodies and actively shaping the standardization agenda will be critical for manufacturing-system suppliers.

The Way Forward

Industries and countries will embrace Industry 4.0 at different rates and in different ways. Industries with a high level of product variants, such as the automotive and food-and-beverage industries, will benefit from a greater degree of flexibility that can generate productivity gains, for example, and industries that demand high quality, such as semiconductors and pharmaceuticals, will benefit from data-analytics-driven improvements that reduce error rates.

Countries with high-cost skilled labor will be able to capitalize on the higher degree of automation combined with the increased demand for more highly skilled labor. However, many emerging markets with a young, technology-savvy workforce might also jump at the opportunity and might even create entirely new manufacturing concepts.

To actively shape the transformation, producers and system suppliers must take decisive

action to embrace the nine pillars of technological advancement. They must also address the need to adapt the appropriate infrastructure and education:

- *Producers* have to set priorities among their production processes and enhance their workforce's competencies. They should identify key areas for improvement—such as flexibility, speed, productivity, and quality—and consider how the nine pillars of technological advancement can drive improvement in the designated areas. Aim for fundamental changes enabled by a combination of the nine technologies. They should also analyze the long-term impact on the workforce and conduct strategic workforce planning. Adapt roles, recruiting, and vocational training to prepare the workforce with the additional IT skills that will be required.

- *Manufacturing-system suppliers* need to understand how they can employ technologies in new use cases to offer the greatest benefits to their customers. These technologies can be leveraged for different offerings, such as the enhancement of networked embedded systems and automation, the development of new software products, and the delivery of new services, such as analytics-driven services. To build these offerings, they must put the right foundations in place: define which business model to leverage for their enhanced or new offers, build the technological foundation, build the right organization structure and capabilities, develop partnerships that are essential in the digital world, and participate in and shape technological standardization.

- Producers as well as suppliers must work to adapt infrastructure and education as they embrace the technologies of Industry 4.0. This is best addressed through a combined effort involving government, industry associations, and businesses to upgrade technological infrastructure, such as fixed- and mobile-broadband services, so that it is fast, secure, and reliable enough for companies to depend on it for near real-time data, and adapt school curricula, training, and university programs to increase the IT-related skills and innovation abilities of the workforce.

Industry 4.0 presents tremendous opportunities for innovative producers, system suppliers, and entire regions. But, as with previous transformational developments, Industry 4.0 also poses a severe threat to laggards. As business models, economics, and skill requirements shift, we could well see major changes in top positions, at both the company and regional levels.

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THE LEAN ADVANTAGE IN ENGINEERING

DEVELOPING BETTER PRODUCTS FASTER AND MORE EFFICIENTLY

Companies in the automotive and engineered-product industries face complex and costly product-development challenges. Last-minute changes and time and cost overruns are common and, in many cases, attributable to poor alignment of product requirements, the development project's time line, and the product's target cost. Some products move forward in the development process despite obvious deficiencies because internal politics frequently trump objective facts. These problems typically stem from inadequate collaboration within and among departments, as well as a failure to capture, utilize, and share knowledge throughout the organization.

Today's market environment has intensified these challenges: product lines are proliferating, customers are ever-more demanding, and digitization is changing the way companies operate. To overcome these challenges and remain competitive in this dynamic market, companies need a new approach to product development that simultaneously improves quality, enhances speed, and controls costs. As Martin Winterkorn, CEO of Volkswagen, put it recently, "It's no longer all about bigger, higher, further. Now, it's about being leaner, faster, more efficient."[1]

To address this imperative, many companies have started to explore the opportunities lean engineering offers: they are adapting lean methods that are used in production and administration and applying them to product development.

The companies that were first to master lean engineering have gained significant competitive advantages by developing higher-quality products in up to six months less time, while reducing deviations from product target costs by more than 35 percent.

Although the benefits of lean engineering are clear, capturing them has proved difficult.

Although the benefits of lean engineering are clear, capturing them has proved difficult for many companies. The tried-and-true lean methods applied in production and administration do not correspond neatly to product development, in which processes are not easily analyzed and sequenced and waste is not clearly visible. Unlike traditional target areas for lean, the finished product is unknown at the beginning of the product development process.

Whereas production and administration entail consecutive processes, engineering requires creative loops within processes. This means

that the process itself influences the final product specifications because the knowledge acquired leads to improvements. Moreover, deviations from a planned process are undesirable and costly on the shop floor or in the back office; however, in product development, deviations can provide valuable insights.

To what extent are companies applying lean methods in engineering and what are the success factors for creating value through these efforts? To find the answers, we have combined insights from our experience supporting lean transformations and a recent benchmarking study of 100 leading companies in the automotive and engineered-product industries. Our research partner in the study was the Department of Innovation Management of the Laboratory for Machine Tools and Production Engineering at RWTH Aachen University.

Our conclusions: Companies experience critical gaps between their aspirations for lean engineering and their current performance. To close these gaps, they need to take a broader and deeper approach to transforming the effectiveness and efficiency of their product-development function.

Driving Effectiveness and Efficiency in Four Dimensions

Like traditional lean approaches, lean engineering targets eight types of waste in the product development process. However, the engineering environment has several distinctive characteristics that differentiate it from production and administration—most important, the uncertainty of its output—and this environment therefore has its own sources of waste and non-value-adding activities. (See Exhibit 1.)

A company's objective in seeking to eliminate waste through lean engineering should not be to create a fully predictable streamlined process. This is an unattainable goal. Instead, the objective should extend beyond mere cost cutting to include improvements in quality and time, as well as in customer and employee satisfaction. The company should also look beyond quick wins and pursue improvements that can be sustained over the long term. Success requires both bottom-up solutions created by product development teams and top-down solutions developed higher in the organization.

Furthermore, companies need to consider and adapt complementary techniques be-

EXHIBIT 1 | Lean Engineering Targets Eight Types of Waste

Types of waste		Engineering examples
Overproduction	Producing information or products that are not needed	• Decisions to terminate projects made too late ("riding dead horses") • Redundant parallel development processes (lack of communication)
Overprocessing	Producing more information or products than are needed	• Product overengineering (unnecessary features) • Insufficient utilization of expertise (reinventing the wheel)
Motion	Movement that is not producing value	• Frequent searching for information • Information pushed to the wrong people (excessive e-mail copying)
Transportation	Non-value-adding movement of information or products	• Too many development-process handoffs • Software incompatibility leading to manual information sharing
Inventory	Collection of information that is not yet formally processed	• Half-finished features (works in progress) • Team members using their own information-management or filing systems
Defects	Results of executed processes that do not produce value	• Erroneous calculations or data input • Measurement errors (due, for example, to the wrong testing methodology)
Waiting	Non-value-adding waiting times	• Waiting time during handoffs; cases of incomplete information • Time spent getting multiple approvals
Unused resources or talent	Underutilized intelligence or creativity	• Highly skilled staff performing repetitive work (data input) • Premature freezing of design, curtailing creativity and innovation

Source: Lean engineering benchmarking study, Laboratory for Machine Tools and Production Engineering, RWTH Aachen University, and BCG.

yond the scope of traditional lean. Our analysis shows that automotive and engineered-product companies can successfully apply the "agile" methodology widely used by product development teams in software and IT industries. Agile uses fast, iterative development cycles over the course of the project. The objective is to develop a viable product quickly and then to improve it through reiteration. This objective contrasts with that of traditional development approaches, which aim to define comprehensive and detailed specifications up front in an effort to yield the "perfect" product.

To master lean engineering, a company needs capabilities that drive effectiveness (doing the right things) and efficiency (doing things right). Through our work supporting companies in lean transformations of their engineering functions, we have identified 16 capabilities in four dimensions that are crucial for success: the product itself, development processes, leadership and behavior, and enablement and tools. (See Exhibit 2.)

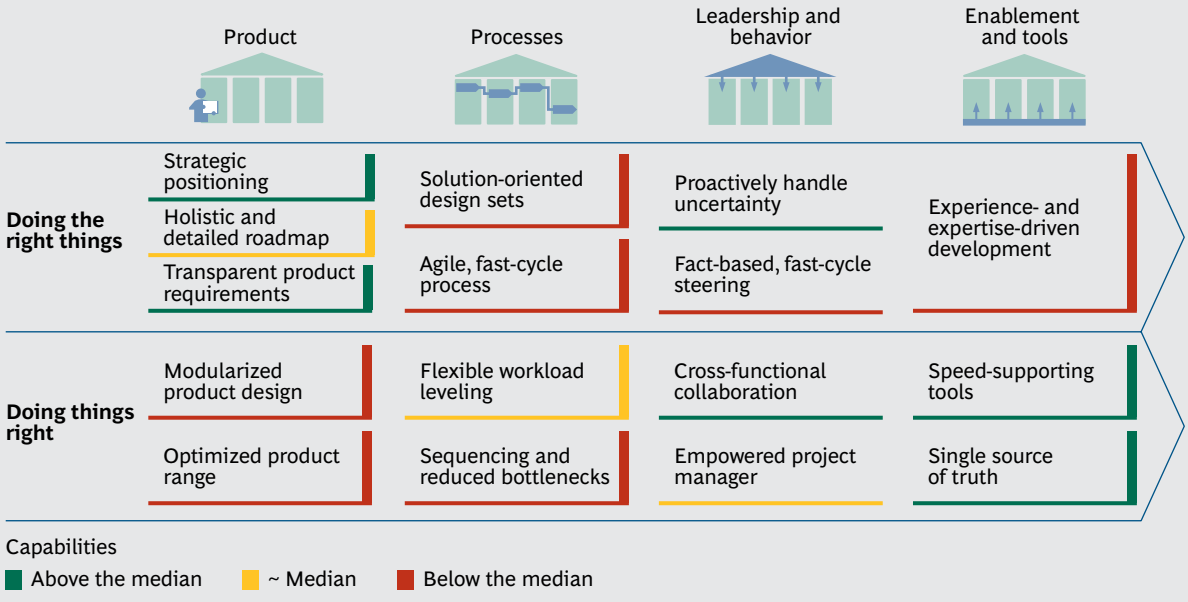
Gauging Performance in the Four Dimensions

Our study assessed the current status of companies' efforts to apply lean methods to engineering, benchmarked participating companies against their top-performing peers, and identified success factors. Our results reveal that most participating companies have at least considered implementing lean methods in engineering. Most of these companies, however, are still at the beginning of this process. Automotive OEMs and machinery manufacturers are the front-runners. Nearly 30 percent of automotive OEMs and 35 percent of machinery manufacturers regularly use lean methods in engineering, compared with approximately 5 percent of automotive suppliers and approximately 15 percent of component manufacturers.

The objective is to develop a product quickly and then improve it through reiteration.

Across industries, our qualitative assessment found that participating companies perform well in some of the 16 lean-engineering capabilities, but there is a clear need for action to improve performance in all four dimensions. Exhibit 2 shows how participating companies perform in each of the 16 capabilities relative to the overall median performance across all capabilities. The results reveal areas of

Exhibit 2 | Lean Engineering Entails 16 Capabilities in Four Dimensions



Source: Lean engineering benchmarking study, Laboratory for Machine Tools and Production Engineering, RWTH Aachen University, and BCG.

strength as well as opportunities for improvement.

On a positive note, we found high levels of maturity in several capabilities. For example, most participating companies already diligently translate customer requirements into a full set of product specifications, and their development teams include representatives from most other functions quite early in the process.

However, the assessment also identified significant improvement opportunities for capabilities within each dimension:

- In many companies, modular product systems are used in only a few product lines. New products are developed with limited reutilization of existing modules.
- The engineering process is typically broken down into five or fewer long phases, some lasting six months or more, with feedback provided at intermediate stages. However, such phases are too long to allow for significant changes to a product that has progressed far into the development process.
- Engineering-specific KPIs—such as person hours or budget—are usually available but are not clear and meaningful enough to enable stringent, fact-based project steering. Design reviews occur too late in the process to allow for effective steering.
- Most companies do not have a cross-functional knowledge-management system, such as a design library. Instead, know-how is managed locally, and lessons learned are shared almost exclusively within a function.

What Sets the Lean Champions Apart?

We identified lean-engineering "champions" and "followers" among participating companies on the basis of the degree to which they utilize lean methods in product development. Lean champions (19 percent of respondents) routinely apply lean methods in most projects, or they have established lean methods as the new standard in engineering. Lean followers (81 percent) have not yet considered lean methods in engineering, or they have implemented lean methods in only a few engineering projects.

The survey found that lean champions succeed in decreasing development time significantly. For example, among machinery manufacturers, lean champions were able to accelerate their product-development process, moving as much as 25 percent faster, on average, than lean followers—which means that lean champions are developing products up to six months faster.

Furthermore, lean champions have significant advantages in meeting the time and budget constraints of development projects. Lean champions, on average, complete 71 percent of projects within the scheduled time frame and 74 percent of projects within budget. In contrast, lean followers complete only 49 percent of projects on time and 56 percent within budget.

Lean champions succeed in decreasing development time significantly.

As these performance advantages would suggest, lean champions are more advanced in implementing lean-engineering capabilities in each of the four dimensions.

Starting the Journey

A lean transformation of the product development process requires a comprehensive program that builds capabilities in each dimension of lean engineering. Companies starting the journey should seek to emulate the approaches applied by lean champions.

Product. Lean champions design a modular, standard portfolio that spans all product lines. By designing reusable modules, or components, and facilitating their utilization, champions reduce the engineering effort and resources required for each project and product. They adjust their operating model to

smoothly transition their way of working from "custom" to "standard." They apply these adjustments to processes, roles, documentation, and tools relating to products and modules. They also integrate suppliers into their processes early on and collaborate with them to develop modules.

Processes. Lean champions embrace agile processes and a fail-fast mentality rather than waiting for market feedback at the end of a single, long development phase. They regularly visualize the entire engineering process to achieve a comprehensive understanding of the nature, timing, and interdependencies of all process steps. This transparency helps them identify bottlenecks as well as opportunities to reduce time to market. Borrowing from the know-how and methods utilized in the software industry, they then identify process steps that are suitable for an iterative, fast-cycle approach, which allows these companies to rapidly create and recalibrate the product under development.

Leadership and Behavior. Lean champions typically enable teams' cross-functional collaboration by creating standard feedback loops and information flows. By specifying the timing, tasks, and decision rights for each function affected by the engineering process, champions ensure that the representatives of these functions do not need to rely on their own individual initiative to get involved. Visual management tools facilitate collaboration by giving transparency to the activities of work streams and functions.

Enablement and Tools. Lean champions create and implement tools that support their objectives for faster development processes. They recognize that capturing the time and flexibility advantages of development cycles measured in weeks requires abandoning tools that take months to produce—for example, a physical mock-up. To use the right tools for their lean processes, champions adopt new technologies, such as 3-D printing, rapid prototyping, and digital engineering. These tools are selected on the basis of their ability to meet a process step's timing, quality, and precision requirements and, most important, the ease with which they can be integrated with existing tools and process steps.

Automotive and engineered-product companies in the forefront of lean engineering are already capturing significant competitive advantages in terms of quality, speed, and cost. The follower-to-champion transformation will be a multiyear effort, but the rewards are tangible. As our experience and comprehensive benchmarking study have shown, companies that apply the right approach to building their lean-engineering capabilities can expect to develop better products faster and with fewer resources.

NOTE

1. "Cost-cutting VW baffles experts with plans for new Phaeton," *Automotive News,* January 28, 2015, http://www.autonews.com/article/20150128/COPY01/301289974/cost-cutting-vw-baffles-experts-with-plans-for-new-phaeton.

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MAKING BIG DATA WORK

SUPPLY CHAIN MANAGEMENT

In recent decades, companies have looked to technology, lean manufacturing, and global production to increase efficiency and reduce costs. But these tactics are leading to diminishing returns.

Many companies have moved production offshore, for instance. However, the attractiveness of that opportunity is diminishing as differences in global manufacturing costs between countries such as China and the U.S. have narrowed over the past ten years. At the same time, supply chains have grown more complicated—many spanning multiple continents and involving external suppliers—while customer demands have gotten more complex. As a result, companies are bringing production closer to home markets ("nearshoring") and sometimes "reshoring" production all the way back home to high-labor-rate countries.

The combination of large, fast-moving, and varied streams of big data and advanced tools and techniques such as geoanalytics represents the next frontier of supply chain innovation. When they are guided by a clear understanding of the strategic priorities, market context, and competitive needs of a company, these approaches offer major new opportunities to enhance customer responsiveness, reduce inventory, lower costs, and improve agility.

Companies can optimize distribution, logistics, and production networks by using powerful data-processing and -analysis capabilities. They can also improve the accuracy of their demand forecasts, discover new demand patterns, and develop new services by sharing data with partners across the supply chain. In addition, they can increase asset uptime and expand throughput, engage in preventive maintenance of production assets and installed products, and conduct near real-time supply planning using dynamic data feeds.

Three High-Potential Opportunities

With so much available data and so many improvable processes, it can be challenging for executives to determine where they should focus their limited time and resources. We see three opportunities that offer high potential in the near term.

Visualizing Delivery Routes. Logistics management challenges all but the most sophisticated specialists in "last-mile delivery." Traditional routing software at advanced delivery companies can show drivers exactly where and how they should drive in order to reduce fuel costs and maximize efficiency. The most flexible systems can plan a truck's route each day on the basis of historical traffic patterns. But many ordinary systems still leave a lot to be desired, producing significant slack in schedules and, in many

cases, lacking the ability to dynamically visualize and calibrate routes at the street level.

Now, add the difficulty of aligning the deliveries of two or more business units or companies, each of which manages its own delivery system but must work with the others as one. By using big data and advanced analytical techniques to deal with tough supply-chain problems such as these, companies can identify opportunities for savings equal to 15 to 20 percent of transportation costs. Recent advances in geoanalytical mapping techniques, paired with the availability of large amounts of location data and cheap, fast, cloud-based computing power, allow companies to dynamically analyze millions of data points and model hundreds of potential truck-route scenarios. The result is a compelling visualization of delivery routes—route by route and stop by stop.

Advanced analytics can integrate data from systems that speak different languages.

Consider the challenges experienced during the premerger planning for the combination of two large consumer-products companies. To better model the merger of the companies' distribution networks, the two companies layered detailed geographic-location data onto delivery data in a way that made it possible for them to visualize order density and identify pockets of overlap. The companies learned that they shared similar patterns of demand. Vehicle-routing software also enabled rapid scenario testing of dozens of route iterations and the development of individual routes for each truck. Scenario testing helped the companies discover as much as three hours of unused delivery capacity on typical routes after drivers had covered their assigned miles.

Splitting the fleet between two local depots in one major city would reduce the number of miles in each route and allow trucks to deliver greater volume, lowering the effective cost per case. After the merger, trucks would be able to make the same average number of stops while increasing the average drop size by about 50 percent. The savings from a nationwide combination and rationalization of the two networks were estimated at $40 million, or 16 percent of the total costs of the companies combined. All this would come with no significant investment beyond the initial cost of developing better modeling techniques.

The geoanalysis also delivered less quantifiable benefits: the results built confidence that the estimated savings generated as a result of the merger would reflect reality, and they created alignment between the two organizations prior to the often difficult post-merger-integration phase. However, results such as these are only the beginning. New visualization tools, combined with real-time truck monitoring and live traffic feeds from telematics devices, open up even more exciting opportunities, such as dynamic rerouting of trucks to meet real-time changes in demand.

Pinpointing Future Demand. Forecasting demand in a sprawling manufacturing operation can be cumbersome and time consuming. Many managers have to rely on inflexible systems and inaccurate estimates from the sales force to predict the future. And forecasting has grown even more complicated in the current era of greater volatility in demand and increasing complexity in product portfolios.

Now, companies can look at vast quantities of fast-moving data from customers, suppliers, and sensors. They can combine that information with contextual factors such as weather forecasts, competitive behavior, pricing positions, and other external factors to determine which factors have a strong correlation with demand and then quickly adapt to the current reality. Advanced analytical techniques can be used to integrate data from a number of systems that speak different languages—for example, enterprise resource planning, pricing, and competitive-intelligence systems—to allow managers a view of things they couldn't see in the past. Companies can let the forecasting system do the legwork, freeing the

sales force to provide the raw intelligence about changes in the business environment.

Companies that have a better understanding of what they are going to sell tomorrow can ship products whenever customers request them and can also keep less stock on hand We find that companies that do a better job of predicting future demand can often cut 20 to 30 percent out of inventory, depending on the industry, while increasing the average fill rate by 3 to 7 percentage points. Such results can generate margin improvements of as much as 1 to 2 percentage points.

Today's big-data-style capabilities can help solve intricate optimization problems.

For example, a global technology manufacturer faced significant supply shortages and poor on-time delivery of critical components as a result of unreliable forecasts. Salespeople were giving overly optimistic forecasts, whose effects rippled through the supply chain as the manufacturer ordered more than was really needed to ensure adequate supply. Inventories started to increase across the value chain.

To understand the causes of poor forecast performance, the company used advanced tools and techniques to analyze more than 7 million data points, including shipment records, historical forecasting performance, and bill-of-material records. The company also ran simulations comparing forecast accuracy with on-time shipping and inventory requirements to identify the point of diminishing returns for improved accuracy. The underlying pattern of demand proved complex and highly volatile, particularly at the component level. Root cause analysis helped identify the sources of the problem, which included the usual delays and operational breakdowns, as well as more subtle but equally powerful factors such as misaligned incentives and an organization structure with too many silos.

In response, the company redesigned its planning process, dedicating more time to component planning and eliminating bottlenecks. Furthermore, by improving the quality of the data for the component planners, the company was able to reduce the time wasted chasing data and fixing errors. And it developed more sophisticated analytical tools for measuring the accuracy of forecasts.

The company expects to improve forecast accuracy by up to 10 percentage points for components and 5 percentage points for systems, resulting in improved availability of parts and on-time delivery to customers. The changes are expected to yield an increase in revenues, while lowering inventory levels, improving customer service, and reducing premium freight costs.

Simplifying Distribution Networks. Many manufacturers' distribution networks have evolved into dense webs of warehouses, factories, and distribution centers sprawling across huge territories. Many such fixed networks have trouble adapting to the shifting flows of supplies to factories and of finished goods to market. Some networks are also too broad, pushing up distribution costs. The tangled interrelationships among internal and external networks can defy the traditional network-optimization models that supply chain managers have used for years.

But today's big-data-style capabilities can help companies solve much more intricate optimization problems than in the past. Leaders can study more variables and more scenarios, and they can integrate their analyses with many other interconnected business systems. Companies that use big data and advanced analytics to simplify distribution networks typically produce savings that range from 10 to 20 percent of freight and warehousing costs, in addition to large savings in inventories.

A major European fast-moving-consumer-goods company faced these issues when it attempted to shift from a country-based distribution system to a more efficient network spanning the continent. An explosion in the volume and distribution of data across different systems had outstripped the company's existing capacity, and poor data quality further limited its ability to plan.

The company used advanced analytical tools and techniques to design a new distribution network that addressed these rising complexities. It modeled multiple long-term growth scenarios, simulating production configurations for 30 brands spread across more than ten plants, each with different patterns of demand and material flows. It crunched data on 50,000 to 100,000 delivery points per key country and looked at inventory factors across multiple stages. Planners examined numerous scenarios for delivery and transport-rate structures.

Unlocking insights from this diverse data will help the company consolidate its warehouses from more than 80 to about 20. (See the exhibit, "Advanced Analytics Reduced Complexity in a Distribution Network.") As a result, the company expects to reduce operating expenses by as much as 8 percent. Each remaining warehouse will grow bigger and more efficient. And by pooling customer demand across a smaller network of bigger warehouses, the company can decrease the variability of demand and can, therefore, hold lower levels of inventory.

How to Begin

Operations leaders who want to explore these opportunities should begin with the following steps:

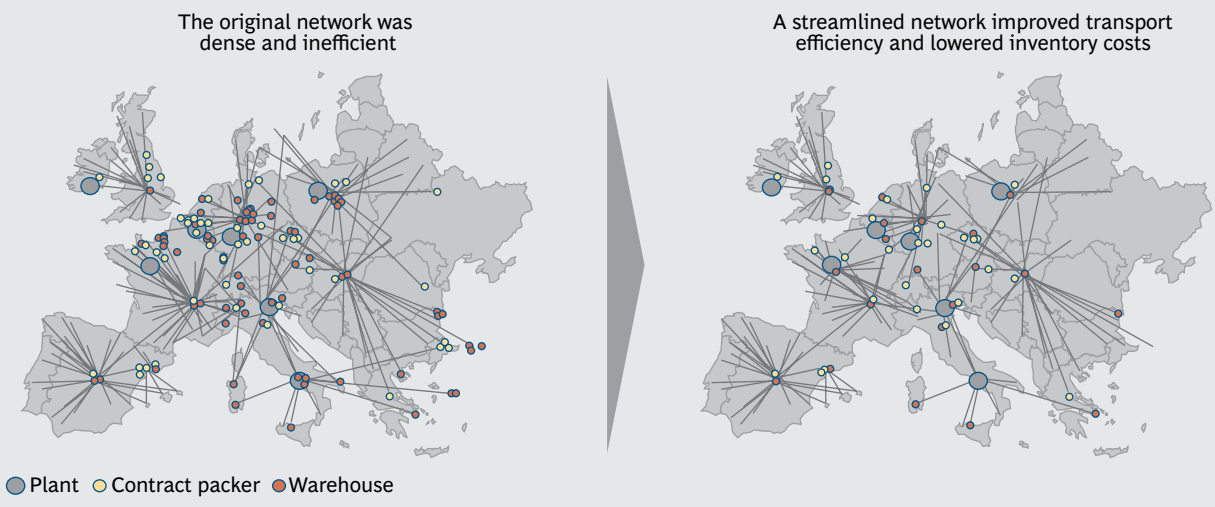
- *Connect the supply chain from end to end.* In order to have big data to analyze in the first place, companies must invest in the latest technologies, including state-of-the-art sensors and radio-frequency identification tags, that can build transparency and connections into the supply chain.

- *Reward data consistency.* While big-data systems do not require absolutely perfect data quality and completeness, a solid consistency is necessary. The problem is that in many companies, management doesn't assign a high priority to the collection of consistent data. That can change when leaders make the impact of poor data clear and measure and reward consistent standards.

- *Build cross-functional data transparency.* Data about production reliability, adherence to schedules, and equipment breakdowns should be visible across functions. To encourage people to be more transparent, management might assemble personnel from different functions to discuss the data they need to do their jobs better.

- *Invest in the right capabilities.* Companies need to both partner with others and develop their own internal, diverse set of capabilities in order to put big data into a strategic business context. Only then will

Advanced Analytics Reduced Complexity in a Distribution Network



Source: BCG analysis.

they be able to focus on the right opportunities and get the maximum value from their investments.

COMPANIES that excel at big data and advanced analytics can unravel forecasting, logistics, distribution, and other problems that have long plagued operations.

Those that do not will miss out on huge efficiency gains. They will forfeit the chance to seize a major source of competitive advantage.

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MAXIMIZING THE MAKE-OR-BUY ADVANTAGE

A SCENARIO-BASED APPROACH TO INCREASING RESILIENCE AND VALUE

Management teams at manufacturers of both industrial and consumer goods face a critical question for each of their products' parts and manufacturing processes: Should we *make* it in-house or *buy* it from a supplier?

Although the make-or-buy decision has been on management agendas for decades, the complexity and relative weight of the factors to optimize have changed in recent years. In the global economy's prevailing atmosphere of uncertainty, the need for resilience to quickly recover from economic adversity—caused by, for example, currency shifts, energy costs, rising wages, and advanced manufacturing technologies—has gained importance relative to shorter-term financial considerations. Manufacturers recognize the benefits of being able to respond rapidly to fluctuations in demand from other manufacturers throughout the value chain and from end customers.

Manufacturers seeking to use make-or-buy decisions to enhance their ability to cope with today's uncertain and dynamic economic environment must often revisit decisions made years ago under different circumstances. For example, consider the experience of a European automotive manufacturer that we will call AutoCo. A decade ago, after determining that it could not capture significant cost savings through outsourcing, the company decided to keep the stamping and parts-processing functions in-house. In reviewing today's market landscape, however, AutoCo considered outsourcing arrangements from the perspective of resilience in the face of economic adversity as well as total cost. The company found that by outsourcing to new suppliers in nearby countries, such as Poland and the Czech Republic, it could achieve only small reductions in total cost. More important, however, AutoCo determined that it could increase its resilience during economic downturns. The company recognized that it would benefit from replacing the fixed costs of in-house production with variable costs made possible through outsourcing. Reducing the share of fixed costs in the total cost base decreases a company's break-even point, allowing it to maintain profitability even if demand should drop significantly. To capture this advantage, AutoCo decided to outsource stamping and parts processing even though the reduction in total cost would be negligible.

In assessing make-or-buy decisions, manufacturers need also to consider the potential for rapid and dramatic changes in the cost structures of their production locations around the world. Companies are producing goods in more locations than ever before, and these locations' cost competitiveness is continually changing.

In this dynamic environment, leading manufacturers are taking a longer-term perspective that assesses how each region's cost structure

(including labor, logistics, energy, overhead, and taxation) will evolve over the next five to ten years.

The Scenario-Based Approach

To establish the basis for make-or-buy decisions, manufacturers need to systematically assess each product, part, and process along two dimensions: strategic value and the cost of in-house manufacturing versus that of outsourcing. However, it is also important to take a holistic perspective by considering the full range of implications of all make-or-buy decisions across product lines and manufacturing locations. These decisions can affect, for example, sourcing and logistics costs, capacity utilization, workforce requirements, and investment requirements, as well as entail one-time costs, such as severance payments.

To maximize their advantages, leading manufacturers use a scenario-based approach to simultaneously assess and compare value creation and cost structures for a broad array of sourcing decisions. (See Exhibit 1.) This approach enables manufacturers to develop a comprehensive set of guidelines for make-or-buy decisions.

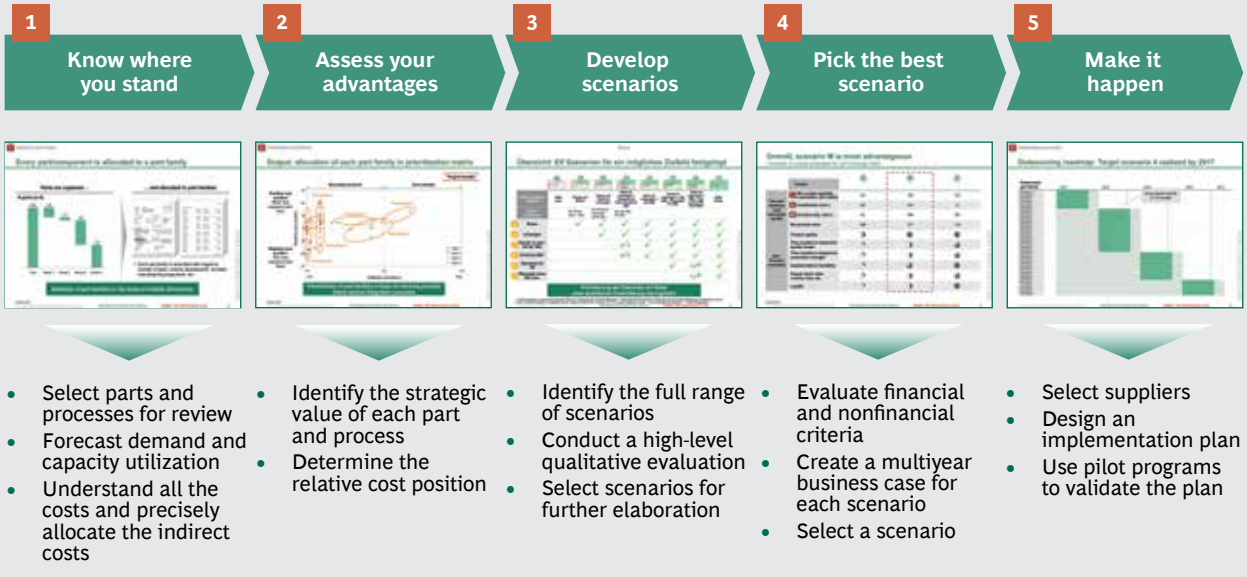
1. KNOW WHERE YOU STAND

The first task is to identify the products, parts, and processes—which we'll call parts—that will be included within the scope of the analysis. The manufacturer needs to thoroughly assess each part selected to learn where it stands in terms of demand, capacity utilization, and costs.

To determine its future production requirements, the manufacturer should forecast demand for each part on the basis of the company's current strategic plan. Manufacturers typically have a strategic plan that forecasts how many end products (such as cars) they expect to sell during the subsequent ten years. To precisely quantify production requirements, the manufacturer needs to break down this end-product forecast to the level of parts.

To determine future capacity requirements and utilization levels for its equipment at the forecast demand levels, the manufacturer should identify the equipment used in each part's production process and record production times for each machine. In performing such an assessment, AutoCo found that to meet the forecast demand levels during the subsequent ten years, the company would be required to increase its production capacity by 20 percent more than it had previously estimated. This finding had a significant impact on make-or-buy decisions, as the need for

EXHIBIT 1 | A Scenario-Based Approach to Holistic Make-or-Buy Decisions



Source: BCG analysis.

larger-than-anticipated investments in capacity made outsourcing a more attractive option in some cases.

Such assessments allow the manufacturer to determine the full cost of internal production for each part. This detailed understanding is particularly valuable because it allows for the precise allocation of indirect costs to each part, ensuring the manufacturer's ability to compare the full and accurate cost of producing a part in-house with offers from suppliers.

2. ASSESS STRATEGIC VALUE AND COST ADVANTAGES

The manufacturer should use the fact base to assess the strategic value of owning and operating each part's manufacturing process and controlling the related technology and intellectual property, as well as to determine the company's relative cost position for each part.

To assess strategic value, the manufacturer should first determine the relevant dimensions to evaluate. These dimensions may include flexibility, structural advantages, innovation potential, interdependencies, customer expectations, and supplier availability.

The flexibility to rapidly ramp production levels up or down allows manufacturers to capture revenue opportunities without risking underutilization of capacity. Flexibility also allows for variable costs, which can preserve profit margins. These benefits should be weighed against the risks related to intellectual-property protection and supply continuity that can arise in outsourcing arrangements. Assessing strategic issues also requires the comparison of the manufacturer's structural advantages (such as scale in production and procurement) with those of potential suppliers. Furthermore, manufacturers should consider whether a product platform might be valuable for future development of product or process innovations before deciding to hand over control to a supplier.

Operational issues also have implications for strategic value. Products and processes that strongly depend on close internal coordination are typically more valuable kept in-house. In addition, customer expectations for consistently high quality and short supply chains argue in favor of creating value through in-house production. The strategic value of in-house production is also higher if there are only a few qualified suppliers.

Flexibility allows for variable costs, which can preserve profit margins.

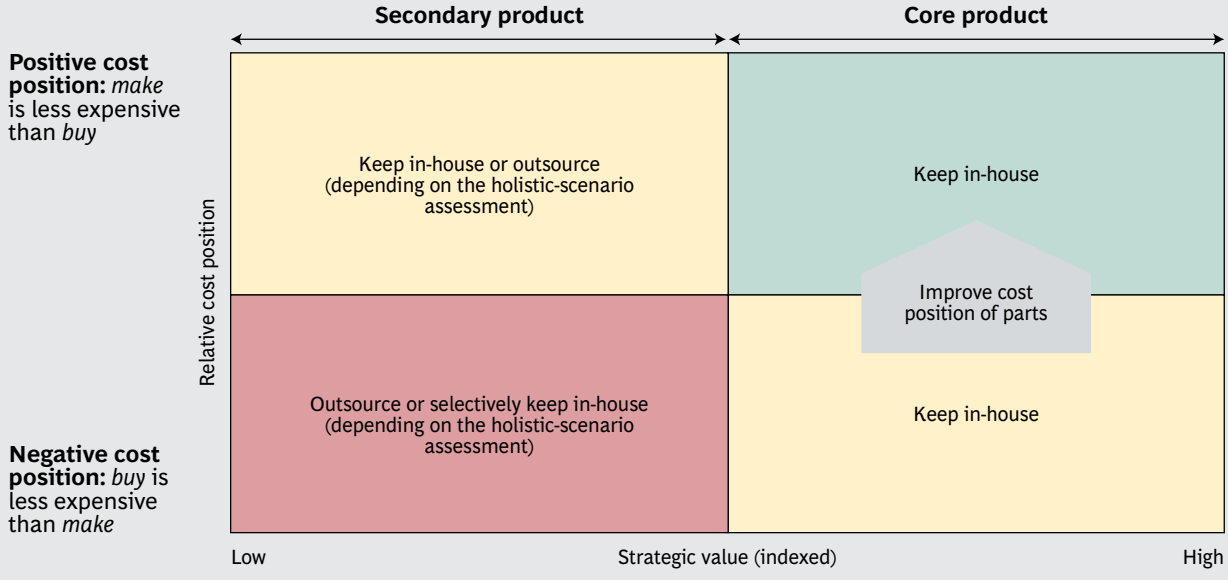
To determine their relative cost position for each part, manufacturers should first identify potential supplier sites for the comparison, considering the most feasible regions or countries. It is essential to assess the most up-to-date information on suppliers' capabilities and capacity. For example, in Eastern Europe, suppliers offer advanced technologies today that were not available in that region a decade ago.

3. DEVELOP SCENARIOS FOR SOURCING COMBINATIONS

Combining the results of the assessments of strategic value and relative cost position in a four-field matrix allows manufacturers to identify those parts that should be prioritized for in-house production rather than outsourcing. (See Exhibit 2.) The production of parts represented in the exhibit's upper-right quadrant should be kept in-house: they have high strategic value, and making them is less expensive than buying them. For parts in the lower-right quadrant, the goal should be to improve the relative cost position so as to create more value from in-house production. These items have high strategic value, but buying them is less expensive than making them. Because of their low strategic value, parts in the two left-hand quadrants are strong candidates for outsourcing. Although in-house production of parts in the upper-left quadrant is less expensive, manufacturers should choose in-house production only if they have difficulty accessing suppliers or can realize significant savings without diminishing their ability to focus on core strategic products.

The allocation of parts to specific quadrants of the matrix provides the basis for deriving

EXHIBIT 2 | Assessments of Strategic Value and Relative Cost Position Are the Basis for Make-or-Buy Scenarios



Source: BCG analysis.

scenarios for different combinations of in-house production and outsourcing. The scenarios under consideration should cover a wide spectrum that ranges from in-house production of all parts to outsourced production of as many parts as possible.

Holistic scenarios that group parts on the basis of the equipment utilized are crucial for understanding the optimal make-or-buy decision. In some cases, such scenarios may reveal that it is financially optimal to keep production of parts with a negative cost position in-house or to outsource parts with a positive cost position.

4. PICK THE BEST SCENARIO

To evaluate and rank the scenarios according to their potential for value creation, the manufacturer should consider both financial and nonfinancial criteria. Financial criteria include annual cost-savings potential, additional costs relating to equipment and employees, requirements for future investments, and restructuring and onetime implementation expenses. Nonfinancial criteria include the ability to maintain product quality, availability of suppliers, feasibility of implementation, opportunities for innovation, and supply chain and country risks.

The evaluation of financial criteria allows the manufacturer to create a detailed business case for each scenario. Such a business case should cover a multiyear period.

By giving appropriate weight to nonfinancial criteria, AutoCo ultimately was able to select a scenario that had a slightly weaker business case than another scenario under consideration. The selected scenario required fewer layoffs and rated more favorably with respect to implementation feasibility, product quality, risks, and time required for responding to production changes.

5. GET READY TO MAKE IT HAPPEN

If the chosen scenario entails outsourcing, the manufacturer needs to select suppliers with the required production technologies and available capacity. In some cases, this can be done within a few months. In other situations, shifting volumes to suppliers is a complex process that can take several years. The process requires close collaboration and innovative ideas, such as the formation of a joint venture in which the manufacturer and another party coinvest in production equipment.

Regional differences are also critical considerations when planning for implementation.

Many European countries impose restrictions on shutting down plants, and they require companies to redeploy workers or pay severance when jobs are shifted to suppliers.

Mastering make-or-buy decisions confers significant competitive advantage.

After it selected a supplier, AutoCo prepared a detailed implementation plan to help manage the complex process of shifting volumes. The plan defined the outsourcing sequence for parts, established pilot programs on the basis of the negotiated prices, and specified how the parties would coordinate and train employees involved in the outsourcing arrangement. The pilot programs produced the first outsourced parts and served to validate the proposed arrangement and to spotlight any potential problems.

Making the Case for Action

For manufacturers that master make-or-buy decisions across their product lines, the competitive advantage can be significant. In addition to achieving near- and long-term cost savings, companies will be able to align their sourcing strategies with their core capabilities and strategic objectives. Developing and evaluating scenarios as the basis for a holistic decision-making process will be essential for maximizing the benefits of resilience and increasing the breadth of value creation.

To make the case for action, manufacturers should consider the current status of their make-or-buy decisions. The evaluation should consider a number of questions:

- How frequently do we reassess our make-or-buy decisions?
- Have we assessed the strategic value of all products, parts, and processes?
- Do we prioritize parts and processes for in-house production on the basis of their strategic value and relative cost position?
- Do we consider the full range of implications for make-or-buy decisions in developing a business case and assessing nonfinancial criteria, including equipment utilization, workforce development, and space requirements?
- Do we systemically create a short list of suppliers for implementing our outsourcing decisions and develop well-designed plans for piloting and launching the arrangement?

For many manufacturers, the answers to these questions will point to opportunities to capture significant benefits by adopting a more rigorous and comprehensive approach to their make-or-buy decisions.

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THE PROXIMITY PARADOX

BALANCING AUTO SUPPLIERS' MANUFACTURING NETWORKS

THE PAST FEW YEARS have been relatively good ones for the world's leading automotive suppliers. Thanks to an industry recovery from the global financial crisis of 2008 and 2009 and successful cost-cutting initiatives, earnings and return on capital for the ten largest automotive suppliers are approaching their highs of about a decade ago. Global auto sales remain strong, powered by robust growth in emerging markets.

A new financial squeeze is on the way, however. Suppliers' key customers—the world's biggest automakers—are preparing to demand some of the deepest cost reductions in years. At the same time, automakers are increasingly pressuring their suppliers to locate more production facilities and R&D in fast-growing emerging markets so that they will be closer to their assembly plants. For most suppliers, expanding their manufacturing footprints in emerging markets—where wages are rising fast and skilled talent is becoming scarce—will add both cost and complexity to global operations.

We call the dilemma over how to balance these conflicting demands—for both cost reduction and manufacturing close to the customer—the *proximity paradox*. It is one of the most serious management challenges that the global automotive-supply industry will face over the next few years. Pressure to cut prices is unlikely to relent, and avoiding emerging markets is not an option because they are critical to growth. Indeed, China surpassed the U.S. in 2009 as the world's biggest automotive market and is emerging as the engine of global growth for the industry.

To understand the challenges that companies are facing and to assess how well they are prepared to confront them, The Boston Consulting Group in partnership with the Fraunhofer Institute for Manufacturing Engineering and Automation surveyed 42 automotive suppliers from around the world. This sample comprised one-quarter of the world's 100 biggest players and a selection of midsize companies. We also interviewed dozens of auto supply executives and industry experts.

Our research confirmed that suppliers are struggling with the twin burdens of lowering costs and locating production closer to their customers and are taking action to find an optimal balance between these two demands. But we also found evidence that most companies can better prepare to succeed in the increasingly difficult environment.

The Auto Supplier's Dilemma

Meeting perennial demands by automakers to cut costs has long been an uncomfortable fact of life for the world's roughly $750 billion global automotive-parts-and-components industry. In a typical year, suppliers are asked

to shave 2 to 3 percent off their prices. But after several years of relative price stability, the coming round of cost reductions is likely to cut much deeper. Some of the largest automakers have adopted programs to cut $2 billion to $6 billion in annual costs, constituting about 4 to 6 percent of total spending, according to press reports. Suppliers will bear some 55 to 65 percent of these cutbacks.

Meeting these cost targets will be especially difficult because they come at a time when auto suppliers' production networks have been growing more globally dispersed and more complex. Complexity costs are more difficult to manage than ever.

So far, shifts in production have not kept pace with shifts in demand.

Regardless of the practical difficulties of lowering costs and expanding locations, suppliers are being pulled in both directions by their customers. Asked to rate the most important reasons for adjusting their global production networks on a scale of one to six, respondents assigned increasing cost pressure a five, the highest mark given. The second-most-important driver was proximity to end customers. Typically, that means having manufacturing sites close to the assembly plants of automakers, wherever those assembly plants are located. Other considerations, such as the desire to shorten product lead times or reduce the risk of disrupting extended supply chains, ranked relatively low.

The essential problem is that production decisions that are intended to cut costs and those made to be close to the customer are based on fundamentally different business rationales.

If cost is the primary consideration, most production decisions rest mainly on the basis of total landed cost, which takes into account such factors as labor, logistics, and energy. Economies of scale and the expertise and process capabilities needed to build a plant are also important considerations.

The logic behind localization is entirely different. The primary factor is the customer's requirement that parts and components arrive at the automotive assembly line at the precise time and in the precise sequence needed.

The Auto Supply Industry's Shifting Center of Gravity

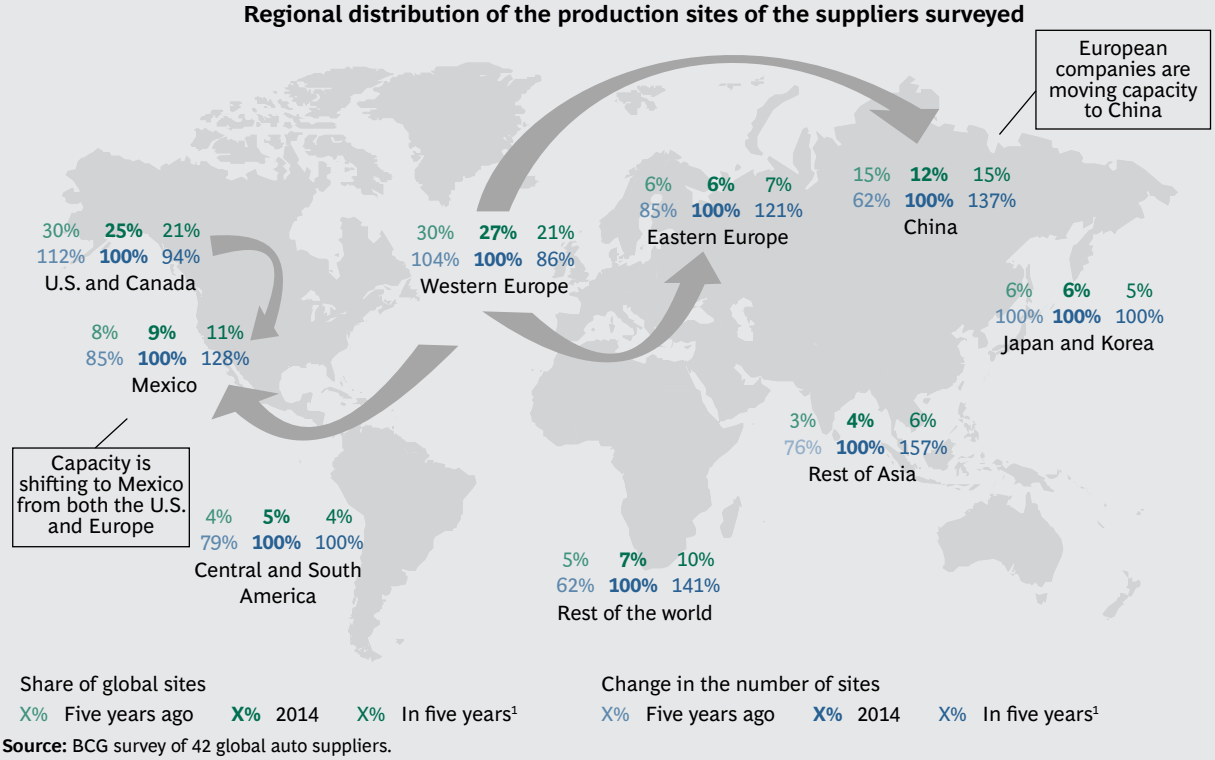
These days, the main driver of localization programs is a dramatic shift in global demand for cars and light vehicles. In 2009, 53 percent of global auto sales and 56 percent of global production were in the group of developed nations that are known as the triad economies and include Western Europe, the U.S., and Japan. By 2014, the share of sales in the triad countries had dropped to 46 percent. The triad economies are projected to account for only 40 percent of sales by 2019.

So far, shifts in production have not kept pace with shifts in demand: the triad economies still produced 51 percent of the world's cars and light vehicles as of 2014. But this will change. By 2019, China is projected to account for 29 percent of automotive output, nearly as much as Europe, the U.S., and Canada combined that year. The contribution of production by all triad economies is expected to drop to 44 percent.

In 2009, the suppliers in our study had 66 percent of their manufacturing sites in triad economies. That share is now down to 58 percent—and is expected to decline to 47 percent in 2019. The share of manufacturing sites in Canada and the U.S. is expected to drop to 21 percent in 2019, from 30 percent in 2009. The share of sites in Western Europe will also drop to 21 percent. China, not surprisingly, will see significant gains in share, as will Mexico. (See Exhibit 1.)

One challenge posed by this additional offshore production is that suppliers' manufacturing networks are becoming more spread out and difficult to coordinate. Over the past five years, the average respondent to our survey added two plants—many of them through acquisition—and entered one new region. That translates into a 9 percent overall increase in manufacturing sites for the 42 suppliers surveyed.

EXHIBIT 1 | Auto Suppliers Are Shifting More Plants from Europe and the U.S. to Emerging Markets



Source: BCG survey of 42 global auto suppliers.
Note: "Relative per region" shows the number of sites as a percentage of 2014 figures.
[1]Based on survey participants' planned site locations and subject to change.

More triad-country-based suppliers are becoming truly global players. One telling sign is that they are locating more lead plants in more markets around the world. Lead plants are the core manufacturing operations of every supplier. They pioneer the most-advanced production processes and are staffed with the company's top design and engineering talent.

The number of companies in our study with lead plants in China is expected to double to 16 in five to ten years, and the overall number of lead plants located there is projected to jump by 150 percent over that period. The number of lead plants is expected to rise by 29 percent in Mexico, by 50 percent in Eastern Europe, and by 50 percent in the rest of developing Asia. Emerging markets will not be the only ones to gain. Our survey respondents also expect to increase their number of lead plants in the U.S. and Canada by 25 percent over the next five to ten years.

Most of these lead plants will assume global responsibility for manufacturing new products and developing new manufacturing technologies and processes. But several will replace current lead plants in Western Europe.

For each supplier, transferring such core operations offshore presents both opportunities and risks. It can put suppliers in a stronger position to capitalize on growth in emerging markets and strengthen their relationships with both international automakers and rising local players. The downside is that once the home R&D and skill base has been dismantled, there is little turning back if the offshore operations underperform. Such transfers also typically require significant changes in organization structure and the ways in which an organization operates, given that lead plants typically focus on one region as a "home market." If not well managed, localization can add cost at a time when customers are demanding major cost reductions.

Balancing Cost and Proximity

There is little doubt that finding the right balance in their global manufacturing networks

is an urgent priority for automotive suppliers. A full 97 percent of executives we interviewed agreed with the statement, "The relevance of manufacturing-network design will increase in the next five to ten years." Ninety-six percent reported that their companies review their manufacturing networks either once or twice a year.

It is also clear, however, that automotive-supply executives have not been satisfied with the cost savings they have attained through previous manufacturing-optimization projects in emerging markets. Although 79 percent of respondents stated that they are satisfied overall with the performance of their localized production facilities in emerging markets, 68 percent reported that the cost savings were lower than expected.

In part, this is because cost-efficiency was not the top priority when automotive suppliers opened their first factories in emerging markets. Many entered because their customers needed to meet local-content requirements. The chief concern was meeting quality standards.

Optimization programs can improve these manufacturing networks. A well-executed program lowers costs in most industries by 15 percent—and in some cases by up to 25 percent—over a three- to eight-year period. But in our experience, we have found that auto suppliers have generally struggled more than manufacturers in other industries with efforts to optimize their global production networks.

One major reason for the disappointing savings is the difficulty in gauging total costs. Huge fluctuations in labor, energy, and other direct costs are rapidly changing the economics of auto parts manufacturing in emerging markets. A host of other factors can also decrease an emerging market's cost advantage.

Another huge challenge facing auto suppliers is that they have limited flexibility to manufacture where costs are lowest, owing to commitments to locate plants close to customers. Indeed, our research found that auto suppliers that focus most on proximity to their customers' assembly plants realize lower cost savings than those that do not. Eighty percent of suppliers with less than €1 billion ($1.13 billion) in annual revenues that focus on customer proximity when locating plants reported that their cost savings from related production-network-optimization efforts amounted to less than 5 percent. By contrast, more than 60 percent of these small companies that do not focus on proximity achieve cost savings of 5 to 25 percent.

All of the challenges of emerging markets and complex supply chains, however, are not diminishing the imperative to manufacture close to customers' assembly plants. What options do auto suppliers have if they must both manufacture close to customers and slash costs? One approach to resolving the proximity paradox is to gently push back against customer demands that are uneconomic. Suppliers can be firmer, essentially asking customers, "What is more important—low cost or proximity? If cost is paramount, then let us do our job." There is reason to believe that, in some cases, the localization requirements of customers are not as rigid as they are perceived to be.

In some cases, localization requirements are not as rigid as they are perceived to be.

The biggest opportunities for cutting costs come from improving the efficiency of current production networks. We estimate that savings from optimization programs can be doubled if the programs address organizational inefficiencies, supply chain issues such as local sourcing and logistics, and production processes through such measures as lean initiatives or improved utilization of capital equipment. To achieve the best results, suppliers need a comprehensive understanding of the economic factors influencing costs in their far-flung global production networks so that they can accurately compare one site with another and allocate production efficiently.

Suppliers could significantly improve profitability by adopting a more comprehensive

approach to adjusting their manufacturing networks, one that balances the necessity to have certain production close to customers with a cost analysis that goes beyond direct factors such as labor rates, materials, and shipping. A manufacturing-network optimization program should encompass improvements to the global supply chain, organization structure, and manufacturing processes.

Developing an Optimal Production Network

In today's swiftly changing global economy, maintaining an optimal global manufacturing footprint calls for far more than periodic tactical adjustments. It requires an ongoing commitment with a time horizon of at least a decade and a high level of management focus so that the organization can continually adapt its manufacturing network with speed and vigor.

More than anything, this increasingly complex global environment requires that automotive suppliers make production decisions on the basis of a good, holistic view of their own global networks, their key markets, and their competitive challenges. Our empirical analysis suggests that many suppliers still lack such a holistic view. We believe that this largely explains why most executives we interviewed are not satisfied with the cost savings their companies are realizing from their network-optimization efforts.

Suppliers should conduct a thorough "health check" of their optimization programs.

Suppliers have significant opportunities to improve their performance, starting with a full understanding of the strengths and weaknesses of their current manufacturing network and their ability to make adjustments. Suppliers should conduct a thorough "health check" of their optimization programs that assesses the past performance of the network and whether current capacity in a region can meet projected demand. With this preparation, suppliers will be in a stronger position to optimize their global manufacturing networks in a holistic way. The process should be driven by several fundamental considerations, as shown in Exhibit 2.

EXHIBIT 2 | Suppliers Should Consider Several Fundamental Topics when Optimizing Their Global Manufacturing Networks

Current footprint

What, where, and how much is produced today?
- What is the rationale of today's manufacturing footprint?
- What drives manufacturing-volume allocation?

Current cost base

What does today's cost structure look like?
- What drives manufacturing costs?
- How are cost drivers and costs related?
- What is the relationship between best-cost-country sourcing and logistics?

Future playground

What, where, and how much should we produce in the future?
- What will the market look like in the future?
- What will demand look like in ten years?
- Which disruptive trends might affect manufacturing networks?
- Which customers require focus?
- What do customers require?

Opportunity for change

What, where, and how much is produced today?
- What would the ideal manufacturing network look like?
- Which options go beyond the obvious?
- How can we balance risk aversion and appetite for change and risk?
- What are core competencies and what should be outsourced?
- What is nonnegotiable?

Opportunity valuation

What will influence network scenarios?
- What will total landed costs be in the future?
- How will converging wages among countries affect manufacturing networks?
- How robust are landed costs in the face of volatility in transportation costs?
- Is the supply chain flexible enough?
- What is the relationship between financial upside and downside risk?

Making change happen

How should network changes be managed and implemented?
- What is the best approach for closing and ramping up production sites?
- What are the most effective tools and methods for managing talent?
- What is an effective way to avoid supply chain disruptions?
- What is an effective way to maintain customer service levels?

Because each piece is unique, a tailored network approach is needed.

Source: BCG analysis.

The answers to resolving the proximity paradox by striking the best balance between localization and cost reduction will vary from one auto supplier to the next and should be tailored to each competitor's needs. But getting those answers right will be critical. The ability to optimally balance conflicting customer demands is likely to spell the difference between suppliers that seize the advantage in the rapidly evolving automotive industry—and those that are overwhelmed by its complexity.

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NOTE TO THE READER

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