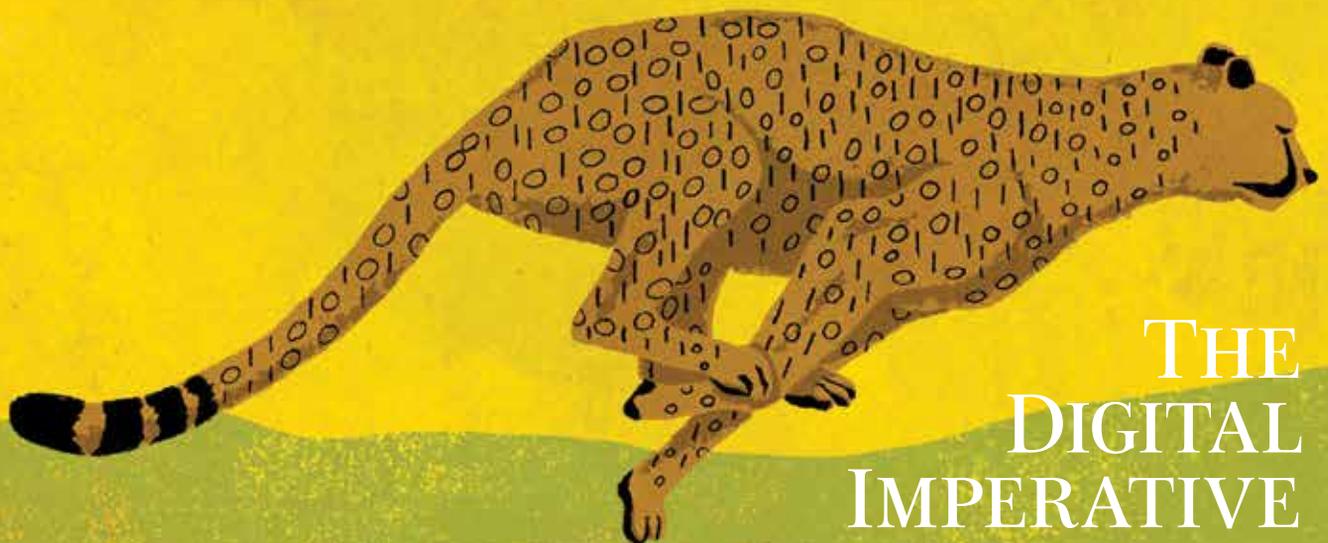


BCG TECHNOLOGY ADVANTAGE

- FOUR DIGITAL ENABLERS: BRINGING TECHNOLOGY INTO THE RETAIL STORE
- RAFFAELLO D'ANDREA ON THE FUTURE OF ROBOTICS
- DIGITIZATION AND SIMPLIFICATION: GETTING THE BEST OF BOTH
- TAPPING NEW EFFICIENCIES: HOW MINING COMPANIES CAN RUN LIKE MANUFACTURERS
- MAKING BIG DATA WORK: SUPPLY CHAIN MANAGEMENT
- OVERCOMING THE DIGITAL DILEMMA IN WEALTH MANAGEMENT



THE
DIGITAL
IMPERATIVE

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Preface



Digitization continues to dominate our discussions with clients. But the focus has shifted in many cases from *what* digitization means for organizations to *how* companies can transform themselves into digital businesses. Many companies struggle to scale up their digital pilot projects and to deploy agile methods and principles across the organization (rather than just in a few software-development projects). Others fail to demonstrate the strong leadership from the top of the organization that is necessary to drive digital transformation.

The April 2015 issue of *BCG Technology Advantage* looks at digitization and its challenges from a number of angles. Our featured article defines a mandate for leaders in the digital realm. Success in the digital economy demands more than simply adopting the latest technologies and “letting a thousand flowers bloom.” Rather, it requires concrete action on several fronts, including digitizing the company’s core business, creating value from data, and mastering the digital ecosystem in which the company operates.

Robotics has moved quickly from the realm of futurists to the C-suites of many businesses. We discuss what lies ahead with Raffaello D’Andrea, a professor of dynamic systems and control at ETH Zurich.

Digitization can transform businesses—but is not the sole sine qua non of a successful technology strategy. A simplified IT environment remains a crucial enabler for many companies. There is a common perception, however, that dedicated efforts toward simplification are unnecessary in the digital era—that the problem of excessive complexity resolves itself once a company starts down the digital path. We argue against this view.

This issue of *BCG Technology Advantage* also includes perspectives on the implementation of digital strategies at the function and industry levels. One article discusses how the combination of big data and advanced tools and techniques is ushering in the next frontier of supply chain innovation. A second describes the vast gains in efficiency that mining companies can achieve by leveraging automation. A third piece identifies four thrusts for retailers seeking to implement digital strategies. A fourth argues that to keep up with client expectations, wealth managers must accelerate their digital agenda.

I hope you will enjoy these articles. Please send any feedback to TechnologyAdvantage@bcg.com.

Ralf Dreischmeier
Global Leader, Technology Advantage Practice

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THE DIGITAL IMPERATIVE

by Ralf Dreischmeier, Karalee Close, and Philippe Trichet

AS ENTIRE INDUSTRIES ARE disrupted by bold digital entrants and business models, more and more companies are at risk of extinction. Music, retailing, media, and travel are far along on this path, but we are also seeing similar patterns in more traditional industries, such as banking, agriculture, energy, health care, industrial goods, and manufacturing.

Digital strategy and transformation must therefore be a top priority of the CEO and the senior management team. Companies can't just dabble at the edges by appointing a charismatic chief digital officer or CIO, adopting the latest shiny technologies, or "letting a thousand flowers bloom." The digital imperative calls for more fundamental action in five areas.

Prototype Your Strategy

When consumer needs and competitive landscapes are rapidly evolving, it's no longer possible to craft a long-term strategy, assign responsibility and performance targets, and execute a three- to five-year plan. "Agile" methods successfully pioneered in software development at companies such as Google, Amazon, Facebook, and Twitter have shown real advantages through learning by doing, rapidly and frequently delivering working products inspired by real consumer needs, developing innovative delivery methods and

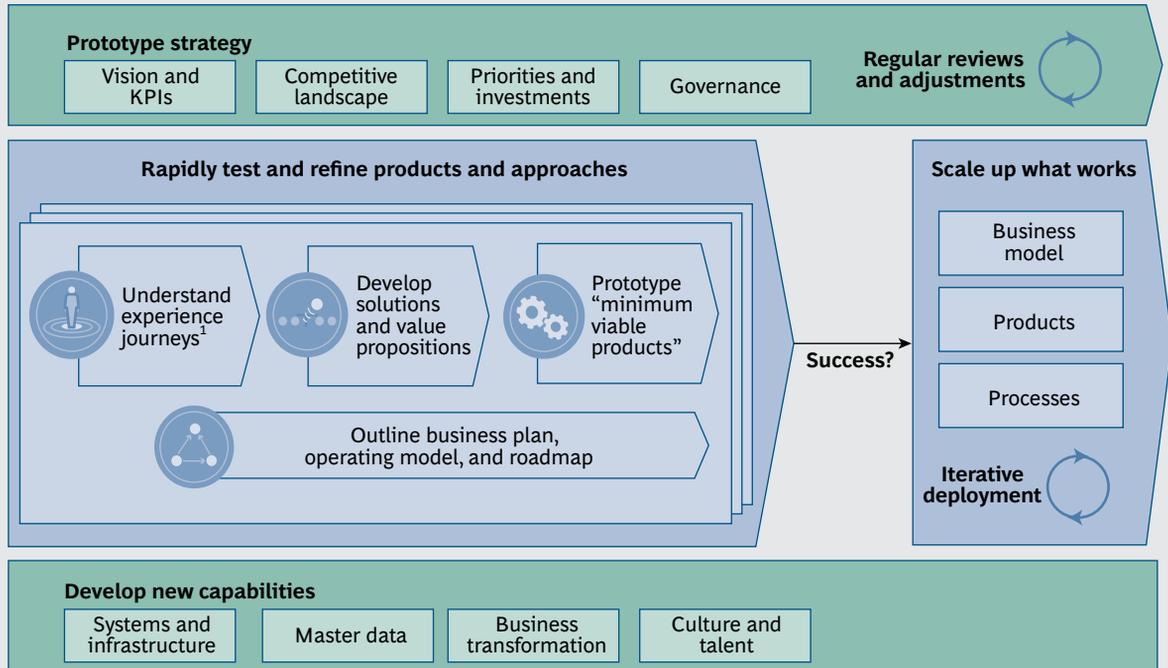
value propositions, and adapting to changing requirements.

Leading digital companies test and refine, or prototype, products and strategies in close cooperation with customers and at a dizzying pace. For example, Amazon has introduced e-readers, tablets, smartphones, cloud services, delivery services, and online marketplaces—all within the past ten years. We have found that this test-and-refine approach can greatly inform the world of strategy. (See Exhibit 1.)

A company's organization and culture must also support digital transformation, with structures, governance, and incentives that promote speed, risk taking, and experimentation—rather than kill disruptive projects before they bear fruit. (See "A Breakthrough Innovation Culture and Organization," BCG article, October 2014.)

Consider how European automaker Renault is prototyping a multichannel strategy. The company's goal is to digitize and strengthen customer relationships across channels to develop a simpler and more personal relationship with the brand. In order to achieve that goal, Renault is simultaneously piloting several strategic approaches: developing digital services to connect cars to Internet-based offerings in areas such as navigation, entertainment, and insurance; testing new business

EXHIBIT 1 | Digital Transformation Requires an Agile Approach



Source: BCG analysis.

¹Experience journeys can include experiences with a company, product, or service by customers, suppliers, partners, employees, users on connected devices, and others.

and operating models such as the optimization of the total cost of ownership across a vehicle fleet; and adapting its marketing and sales processes in Renault Stores and company call centers.

In just seven months, Renault also built the foundation of a 360-degree view of customer data from models of the customer journey that spotlight “moments of truth” in which the company has an opportunity to influence a decision, convert customers to a sale, or build loyalty. The company can then integrate that foundation with a tool to manage customer leads that unites disparate data from internal and external sources. Renault is now implementing these IT approaches as a pilot project in France for 32 million customer accounts, with a plan to deploy them across 25 countries after learning what works.

Disrupt Your Business (Before Others Do)

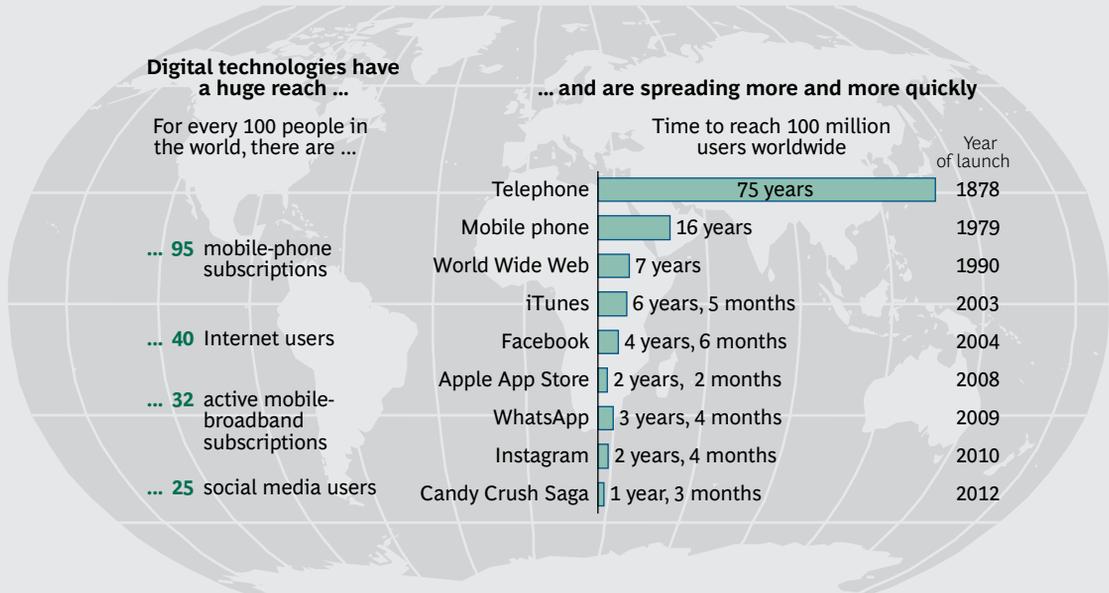
Executives need to create their own “digital attacker” businesses. Long-dominant companies are increasingly under attack from a host

of digital start-ups that are out to reinvent businesses and industries by addressing consumer needs in completely new ways. Examples are emerging in every industry: just look at Uber in the taxi business and Airbnb in travel. And the pace of disruption is rapidly increasing. Digital disrupters are themselves constantly under attack, as witnessed by the start-ups targeting established companies such as Facebook, itself once a disrupter. (See Exhibit 2.)

Incumbents should be more disruptive in their approach and not leave the playing field open. Large companies hold a lot of cards—including resources, assets, relationships, and data—that smaller competitors frequently do not have enough of. But they often do not fundamentally rethink their business model. Only rarely do they launch anything that might attack the current business.

CEOs must think broadly and holistically about how to innovate around the unmet needs and pain points of their customers. Digital transformation is not only about a website and a sexy marketing campaign;

EXHIBIT 2 | The Pace of Disruption Has Increased Exponentially



Sources: ITU; Statista; BCG research. Telephone: ITU; mobile phone: ITU (the base year is considered the start of the first cellular network), mobilephonehistory.co.uk; World Wide Web: *Scientific American*, Internet Live Stats; iTunes: number of accounts, *Fortune*; Facebook: active monthly users, Facebook; Apple App Store: number of accounts, *OS X Daily*, *VentureBeat*; WhatsApp: active users, *Wired*, *Digital Quarterly*; Instagram: monthly users, *TechCrunch*; Candy Crush Saga: Facebook users only, AppMtr.com.

more important, it’s about entirely new business opportunities.

For example, BBVA is beginning to act like a venture capital firm that seeds start-ups and enables innovation. BBVA’s venture-capital arm, BBVA Ventures, invests in start-ups and incubators working on disruptive technologies for the financial industry. BBVA is also launching digital bank initiatives with a focus on creating an innovative customer experience, including a promise of no minimum balances and none of the usual fees. Its peer-to-peer money app, Wizzo, allows users to transfer money to others as easily as sending a text message, without requiring an account. The product joins BBVA Wallet, which is already the biggest mobile-payment app in Spain, and BBVA Link, the first money-transfer app on Facebook in Latin America.

Digitize the Core Business

Top management must take advantage of digital capabilities to transform the current business. This isn’t just about rolling out new IT projects but also about fundamentally transforming the company’s business to en-

sure leanness, agility, and lower cost. Best-in-class companies think “end to end” about where digital efforts can produce a step change in performance and value for their customers—not only in marketing but also in operations and the back office. And they tackle many efforts in parallel, using standardized processes and agile techniques to accelerate execution and inject more flexibility into strategy.

To deliver an integrated, lean customer experience, global energy-management specialist Schneider Electric fundamentally transformed several core processes. One transformation covered marketing, sales efficiency, and customer care through a dedicated effort led by the executive team. Redesigning processes to focus on the customer experience, standardizing front-office processes, and moving processes to the cloud delivered a strong foundation for a more integrated customer experience, consolidated more than 300 legacy customer-relationship-management systems, and integrated numerous enterprise-resource-planning systems.

A test-and-learn approach across 90 countries, four lines of business, and 30,000 employees

delivered results every quarter. Performance significantly improved. For example, Schneider increased revenues by cross-selling energy solutions, improved customer satisfaction by routing customer service online, and increased call center efficiency by consolidating call centers from 145 to 45.

Create Value from Data

Agile leaders try to find ways to better use internal and external data. BCG research shows that leaders in the use of big data generate 12 percent higher revenues than companies that don't experiment with big data. They are three times more likely than weak innovators to mine big data for new-project ideas and to actively target innovation toward digital design, mobile products and capabilities, speed of adopting new technologies, and big-data analytics. (See "A Digital Disconnect in Innovation?" BCG article, October 2014.)

Digital transformation offers companies new opportunities to gain sustainable competitive advantage from data and to generate entirely new revenue streams, business units, and stand-alone businesses by capitalizing on the data they hold. (See "Seven Ways to Profit from Big Data as a Business," BCG article, March 2014.) For example, Verizon's Precision Market Insights service offers access to anonymized data about shopping habits, interests, travel, and mobile browsing derived from a sample of the company's more than 86 million wireless customers. A leading European cruise line developed pricing in a highly segmented and targeted way on the basis of a customer's profile, the timing of the price being offered, and the product offering, thanks to the use of advanced analytical tools and technologies.

Position Your Business in the Broader Ecosystem

Companies must secure their place in the broader ecosystem—the network of companies, individual contributors, institutions, and customers that interact to create mutual value. Digital ecosystems are disrupting businesses in nearly every consumer-centric industry through close collaboration among partners, institutions, and customers. Ecosys-

tem players join forces with external companies working toward a common goal and achieve complete alignment of the value chain.

Collaboration across a broader ecosystem creates new opportunities to address consumer needs. Technical foundations, or platforms, that allow devices, applications, data, products, and services to work together in new ways become core to strategy. Current owners of the customer relationship risk potential disruption from platform owners and marketplaces that allow the components of the ecosystem to easily collaborate and interconnect. (See "The Age of Digital Ecosystems: Thriving in a World of Big Data," BCG article, July 2013.)

Digital ecosystems disrupt businesses in nearly every consumer-centric industry.

Philips, founded in 1891, is innovating as an ecosystem player in health care by collaborating with telecommunications, health-services, and logistics providers to create a new "service ecosystem" to support seniors at home. The Lifeline service consists of a pendant with a button that, when pressed, sends a radio signal to a hub device in the person's home, which places a call to an emergency response center by means of a landline or AT&T's cellular network.

Ecosystems also play a role in sourcing key talent. Digital talent thrives best in open, collaborative, experimental cultures where team members can learn and grow and be around a critical mass of similar talent, rather than in top-down, micromanaging bureaucracies that spread digital talent thin and stifle innovation. Leading players collaborate with incubators, universities, and other institutions to gain access to critical talent. We also see leaders experimenting with "digital factories"—functions that are set up differently from the core business, providing an ecosystem of talent to support internal digital initiatives.

LEADERS in the digital age are different from leaders in the past. They prototype an agile strategy and learn from their experiences. They attack their own businesses before disrupters do. At the same time, they digitize their core business and get the most value from both their existing and external data, all the while mastering the digital ecosystems they operate in.

To be sure, companies that embrace the digital imperative take on a fundamental transformation of their business, including some strategic and execution risk and disruption. But to do otherwise risks a fate worse than disruption: extinction.

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FOUR DIGITAL ENABLERS

BRINGING TECHNOLOGY INTO THE RETAIL STORE

by Peter Burggraaff, Marc Schuurin, and Bill Urda

THE RETAIL INDUSTRY IS rife with digital innovation and organizational change. Consumers—drawn to the ease and convenience of always being just a click away from user reviews, comparison pricing, and endless aisles—have come to rely on online and mobile shopping. It is no surprise that traditional retailers are bringing digital channels into stores to tap those consumer preferences. At the same time, historically pure-play online retailers are increasingly opening brick-and-mortar shops in high-profile locations, seeking to capitalize on the tangible experiences that cannot be delivered through a device. Both traditional stores and pure-play online retailers are working toward the same goal: to create a highly personalized, consistent, and integrated shopping experience across all points of contact between retailers and customers.

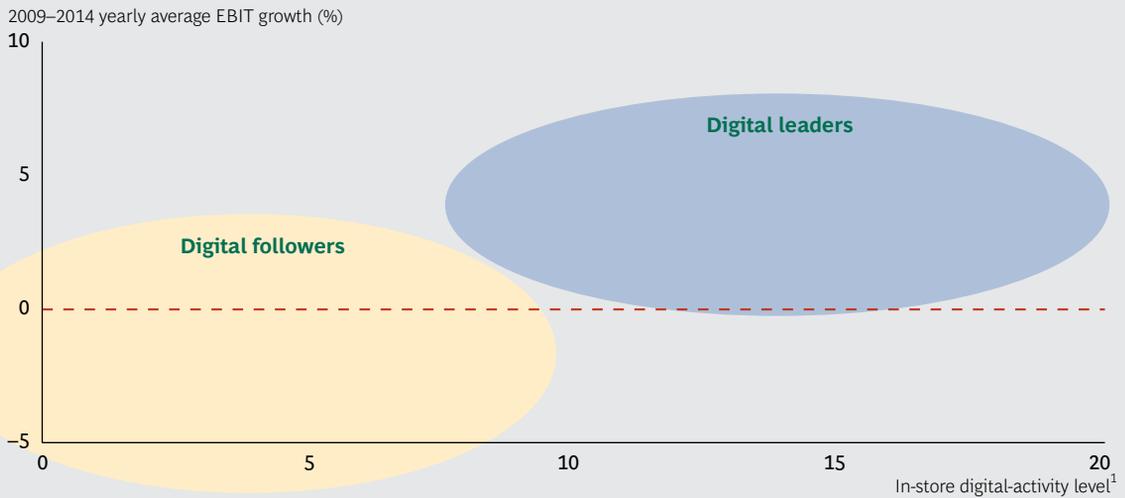
Because so many traditional retailers have begun to experiment with digital technologies in stores, The Boston Consulting Group examined how companies with advanced digital strategies are performing relative to their peers. BCG's analysis indicates that brick-and-mortar retailers that implement digital technologies in stores—both to enhance the customer experience and to improve employee performance—tend to outperform retailers that have not yet implemented a digital strategy. In our survey of

25 fashion retailers based in Europe and North America, companies that are leaders of digital implementation in stores showed stronger EBIT growth than digital followers. (See Exhibit 1.) We define leaders as those that have fully integrated digital technologies into their daily activities, pursued a multichannel strategy, developed a data analytics capability, and integrated digital into the in-store experience.

Affordable solutions are now available to retailers of all sizes.

As the pace of innovation accelerates and as digital technologies influence the buying decisions of a growing percentage of customers, retailers need to act. Our research shows that even a modest investment can deliver rewards, particularly as digital solutions—often powered by third-party developers—become increasingly available and financially accessible. The truly cutting-edge innovations may be most appropriate for companies with the resources, customers, and culture to support the required investment, but affordable solutions are now available to retailers of all sizes that seek to launch an in-store digital strategy.

EXHIBIT 1 | In-Store Digital Activity Is Correlated with EBIT Growth



Sources: Press search; annual reports; BvD's Orbis; BCG analysis.

¹Activity level is based on six criteria: buy online, return in store; buy online, pick up in store; in-store navigation or movement tracking; radiofrequency identification tags on items sold; using augmented reality in store; and using interactive displays in store. Each of the criteria is scored on a scale from not available (0) to leading the pack (3).

The Rise of In-Store Digital Strategies

Just a few years ago, the leading technologies in stores were point-of-sale systems and bar code scanners; now, new digital solutions are popping up everywhere. In-store technologies can increase employees' effectiveness by providing data at the moment it is needed to execute a task (whether that is interacting with a customer on the sales floor or managing inventory in the back). Employees of companies such as The Container Store and Tesco are carrying or wearing in-store solutions to assist with work flow management, merchandising, and day-to-day tactical management of the sales floor.

For the customer, digital technologies can integrate online and off-line sales channels and drive a seamless shopping experience. In-store touch screens that provide customers with "endless aisles" (that is, the full range of available products); "magic mirrors" that offer product information, recommendations, and virtual fittings; "clienteling" (an approach by which well-informed store staff using data on individual customers' preferences and buying habits create a customized in-store experience)—all of these in-store digital solutions are transforming customers' omnichannel-shopping experiences. (See Exhibit 2.)

Four Enablers of In-Store Digital Success

Although many companies have established a digital presence—a website, some digital advertising, a presence in social media—only a small percentage are truly tapping the potential of an omnichannel strategy. To enable maximum digital impact in stores, retailers must first drive organizational change in four key dimensions.

R&D needs to be taken seriously to drive digital innovation. To make a significant impact with in-store digital strategies, retailers need to budget for digital innovation. Devoting funds to digital ventures signals that the company sanctifies initiatives that might otherwise be deemed too risky or tangential. Digital-innovation strategies are typically not prioritized within the overall IT-investment budget. For most retailers, IT funds are limited and spent primarily on maintenance and upgrades of backbone technology systems that support merchandise and supply chain functions. R&D need not be a major investment—even a small R&D budget of \$100,000 annually should be enough to infuse digital experimentation into a retailer's daily operations.

Although pure-play online retailers such as Amazon.com and Zalando have taken calcu-

EXHIBIT 2 | In-Store Digital Solutions Are Used Across the Customer Shopping Journey



Source: BCG analysis.

Note: Phases in the customer journey are derived from BCG's omnichannel-shopping-experience audit methodology.

lated risks and embraced the notion of “failing fast,” physical retailers are accustomed to a much more conservative culture. But competing in digital requires a new mind-set. Some of the major players, such as Nordstrom and John Lewis, are leading the way through bold experimentation. For example, Nordstrom announced in 2014 that 30 percent of its capital expenditures would be in technology. It has established an innovation lab in Seattle to develop and test new products on a weekly basis; invested in e-commerce companies such as Bonobos, Trunk Club, and HauteLook to merge the online and in-store shopping experiences; and implemented interactive touch screens in fitting rooms, to name just a few initiatives.

Set up new organizational models to manage innovation. Developing digital solutions in stores to enhance the customer experience should not be viewed as an IT responsibility. The most successful models of innovation merge IT teams, which should understand the digital-technology landscape, with retail teams that know the operational challenges and customer base. (See the sidebar “Digital Innovation in Action.”) Some successful models of collaboration are as follows:

- **Store Employee Teams.** In-store associates, supported by IT, are given the responsibility

to explore new technologies that can enhance the retail experience. These experiments may focus on behind-the-scenes operational efficiency or customer-facing digital initiatives.

- **Business and IT Teams.** Lean start-up-like teams inside the company are formed to develop close-to-customer innovations. These teams can focus on quick wins by staying highly responsive to customer needs.
- **Innovation Labs.** On-site or off-site innovation labs can help companies discover and explore digital strategies that will shape the future of retail. Some companies looking to lead the digital revolution—such as Walmart, Target, and Kohls—have set up off-site innovation labs in the epicenter of global technology innovation: Silicon Valley. Others—such as Staples, Nordstrom, and Sears—stay closer to home, at headquarters or in nearby urban environments with access to creative talent.
- **A Portfolio of Start-Up Companies.** To get in on the ground floor with the latest technologies, retailers need to think creatively about partnering with start-ups. Some retailers are funding start-ups (much as private equity firms do). Others

DIGITAL INNOVATION IN ACTION

These five retailers are among those that have pioneered successful models of digital innovation in stores.

Sonae's Store-Employee Teams. Portugal's largest retailer, Sonae, invests more than €70 million annually in R&D and innovation. More than 500 employees participate in innovation activities such as ShineOn, through which employees from various otherwise-siloed functions address real-world problems and propose solutions to the executive board. The company's best-practice forums, held every two months, also help employees to share knowledge and streamline processes. In addition, teams of employees are recognized with innovation awards each year.

Nordstrom's Business and IT Teams. Nordstrom has created lean, start-up-like teams that work on close-to-customer innovations. The team selects a one-week pilot project, creates a prototype, tests it on users in stores, and makes changes on the fly. The team can adapt technologies to consumers' needs in real time, benefiting from immediate feedback.

The Home Depot's Off-Site Innovation Lab. The Home Depot opened a 6,500-square-foot innovation center on the campus of the Georgia Institute of Technology, enabling the company to tap into nearby engineering talent. The university-

based lab focuses on home automation technologies, as well as in-store technologies such as self-service kiosks and point-of-sale devices.

John Lewis's Portfolio of Start-Up Companies. UK retailer John Lewis launched a technology incubator called JLAB that encourages businesses to develop new products and services in four categories: enhancing the company's knowledge of its customers (and vice versa), improving the retail experience, simplifying customers' lives, and a category called "surprise us," where anything goes. At the end of JLAB, one winning business receives an investment of up to £100,000 and the opportunity to supply its solution to John Lewis.

Walgreens' Ecosystem of Solution and Content Providers. Walgreens has partnered with Google's Project Tango and the indoor-mapping start-up Aisle411 to pioneer an in-store 3-D navigation app that helps customers find products on the shelves. Employees can also use the app to see which products are in demand or difficult to locate, helping retailers to better manage inventory, restocking, and product placement.

are allowing start-ups to run pilot projects in the store. Kroger, for instance, recently announced a pilot program with start-up Strap that brings wearable analytics technology into the store. Some retailers are bringing start-ups in-house (serving, in effect, as incubators), providing a base of operations for innovation.

- **An Ecosystem of Solution and Content Providers.** Retailers that want to ramp up their digital environments quickly and efficiently have partnered with third-

party players including retail-technology start-ups, established technology giants (such as eBay and Google), and universities. This option is especially beneficial for retailers lacking a core strength in digital capabilities and smaller players with a highly digital-aware customer base.

Develop an information architecture that provides meaningful insights into customer behavior. Retailers, as they delve more deeply into digital commerce, have the potential to unlock a wealth of data on customer behavior, transactions, and consumption patterns.

By providing valuable information on the end-to-end customer journey (acquired from physical stores, supply chain vendors, and banks), this data can yield insights that enable retailers to improve the customer experience, build loyalty, and enhance operational efficiency.

Basic principles for information architecture include the following:

- *Build nimble digital frameworks.* Legacy systems contain immensely valuable data, but they cannot be upgraded easily. Where possible, decouple new digital services related to customers and vendors from historical back-office systems. Software as a service and unified communication tools can be used for this purpose.
- *Invest in master data.* High-value, core information on customers and products is essential to delivering a personalized shopping experience. The IT team must invest time and resources to mine high-quality master data that can help guide critical business decisions.
- *Create a “data lake.”* Structured and unstructured data can be hosted in a single repository—the data lake. This solution makes all data available to everyone within an organization, whether the data resides in a front-end platform or in the back offices.
- *Integrate data to leverage its value.* To capitalize on the value of data, companies must analyze performance in marketing, sales, and service, then use this combined information to support engagement with the customer (through cross-selling, up-selling, and more).

Construct IT systems with a stable back end and flexible front end for agile development. To maximize the impact of digital technologies, retailers need to provide a stable back end, with solid support for supply chain, merchandise, and financial transactions. On that back end, disparate platforms, applications, and information architectures—covering a range of technologies, from operations to supply chain—should be brought together

in a consolidated IT architecture. Most retailers turn to enterprise-resource-planning systems, such as those offered by Oracle, JDA Software Group, Microsoft, and SAP, to aggregate and consolidate data sources and facilitate meaningful insights.

Retailers must also build or buy a flexible front-end technology platform to allow for the following:

- *Agile Development.* Retailers should be prepared to deliver the minimal viable product to market quickly, adapt, and iterate on the fly in response to customer feedback.
- *A/B Testing.* Retailers should implement A/B testing where possible; that is, test different versions of products side by side, analyze customers’ responses, and use the findings to increase sales.
- *Trial and Error.* Retailers that test and refine products continuously create rich opportunities to discover what does and doesn’t work with customers. Walmart discovered this with its Scan & Go app, which was implemented in 200 stores and then scrapped; along the way, the retailer discovered applications for electronic receipts, leading to the development of its Savings Catcher price-comparison app, which has been rolled out nationally.
- *Scaling Up.* New concepts can be tested in select stores. If those concepts are poorly received by customers, companies absorb the lessons learned and move on. If, however, pilots prove successful, companies can transfer these new concepts to the IT team and scale up rapidly.

Setting a Course

Retailers can strengthen their connection with customers by creating unique in-store and omnichannel digital experiences and improving operational efficiency for employees, but these initiatives have to be rock solid in terms of features. The digital-retail journey is already littered with canceled programs, pared-down features, scrapped pilots and pro-

totypes, and lessons learned. Failed experiments are not necessarily a bad thing—companies that are given the freedom to fail are likely taking the kinds of risks that will ultimately lead to success. But retailers must beware of simply rushing at the next me-too product or overwhelming customers with too many digital options, rather than building an in-store digital strategy that speaks directly to their customers' needs.

Failed experiments are not necessarily a bad thing.

As traditional retailers push deeper into digital territory and reinvent in-store models, they must cultivate innovation at the core of their enterprise. The bar is being raised every year by pure-play online retailers, technology companies, and start-ups that have blazed the trail in e-commerce. Traditional retailers must innovate to stay relevant—not for the sake of bells and whistles but to improve internal operations and help customers shop faster and smarter.

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RAFFAELLO D'ANDREA ON THE FUTURE OF ROBOTICS

AN INTERVIEW WITH THE PROFESSOR OF DYNAMIC SYSTEMS AND CONTROL, ETH ZURICH

Raffaello D'Andrea's robots can do amazing things: play soccer and ping-pong, perform complex choreographed acrobatics in the air, build towers brick by brick, and move pallets around warehouses. (You can see the video at his website, <http://raffaello.name/>, and check out his TED Talk at https://www.ted.com/speakers/raffaello_d_andrea.)

He also cofounded Kiva Systems, which was acquired by Amazon.com in May 2012 for \$775 million with the hope of using the company's orange robots to move items around warehouses, get products to consumers faster, and lower costs. Robots have reportedly been deployed in Amazon warehouses around the country.

Massimo Russo, a senior partner and managing director in the Boston office of The Boston Consulting Group and the regional leader of the Technology Advantage practice in North America, recently spoke with D'Andrea about the future of robotics. Edited excerpts from their conversation follow.

You've developed some amazing robots that play soccer and ping-pong. What novel potential uses for business and society do you see for robots in the future, and where are we liable to see robots next?

In the short term, the biggest impact is going to be from how we make things—how we extract things from the ground (mining, agriculture), how we make things (manufacturing), and how we distribute them. We're going to see a lot of that innovation find its way into these sorts of realms in the next three to five years.

I still think we're a ways away from the general-purpose robot in your home that's going to do your bed, do the dishes, and so on. But I think we will also see in the medium-to-long term an infiltration of automation and robotics in the home.

A lot of your research has been around learning systems and learning robots. Do you see applications of learning algorithms for products such as the driverless car?

One of the biggest advantages of learning and adaptation is that it

RAFFAELLO D'ANDREA

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allows you to create powerful systems that are inexpensive to make. If you try to make a very precise robot, it costs a lot of money. If, however, you relax that requirement to make a machine that right off the bat is high performance, and let it learn and adapt to become high performance, it becomes economically viable to deploy such a machine. I think learning and adaptation will have a huge impact on how we make machines.

What has changed over the past few decades, either in terms of the underlying technology or in the economics of robotics, and how do you see robotics changing forward?

A lot of it is probably best thought of as reaching tipping points. Let's say you make a robot that could do something and that it costs \$1.25 for it to do that, and a person could do the same thing for \$1. You're not going to use that robot. But next year, let's say it takes 5 cents less to do it, so it becomes \$1.20, and then \$1.15, and then \$1.10. From an outside perspective, you may say there's no progress being made in this technology. Yet when that tipping point comes, when this robot can do the job for \$1 or less, all of a sudden it becomes economically viable and everybody jumps in to adopt it. I think that there has been steady progress in the development of robotics and automation, but I think we've just reached various tipping points that will make them, all of a sudden, economically viable to deploy.

What kinds of systems innovations are you seeing? And if you think about this from a company perspective, are there interesting startups or maybe lessons even for the more established robotics players?

One of the neat things that big companies are doing is using robots in a cooperative fashion. A lot of people think that's been going on for a long time, but actually that's not true. For example, having multiple robot arms work together to manipulate objects for manufacturing, for installations, and so on—that's a pretty new development. A lot of the big robotics companies are exploring these ideas—also integrating different types of automation technologies together. I think that's an exciting development that big companies are mainly undertaking.

One of the neat things that big companies are doing is using robots in a cooperative fashion.

With startups, what really gets me excited are the folks who are looking at new ways to think about location and navigation. If we really want robots or autonomous systems to be pervasive, they need to know where they are—not just outdoors but also indoors. A lot of startups are trying to solve this problem by using advances in computer vision—and advances in inexpensive sensors, accelerometers, gyros, magnetometers, you name it—and in the algorithms to fuse all that information together and provide a local awareness for autonomous systems that just doesn't exist right now.

Your startup, Kiva, was acquired by Amazon. What's the long-term potential you see for warehouse logistics and management, distribution, and operations going forward?

What's interesting about Kiva was that in the original business model, the key value that we thought Kiva was bringing to the space

was cost. We thought, "Here's a system that will allow us to reduce the cost of filling orders." But it turns out that it was many of our secondary value-adds that were really exciting to customers: flexibility, adaptability, and a reduction in human errors. There was the fact that you could set up a warehouse in six weeks instead of two years, and the fact that if you wanted to reconfigure the warehouse, it was easy to do—which you couldn't do with existing automation. The lesson was that businesses really want flexibility and adaptability.

Do you see applications of Kiva's technology outside of warehouses, perhaps in more of a manufacturing environment?

Absolutely. We always thought about manufacturing when we were growing the company, but we were really focused on distribution. There was just so much opportunity in distribution that we said, well, manufacturing will come later—maybe we will spin off another company, maybe we will start another division. That still may happen. The underlying ideas can certainly be brought to manufacturing.

There's been a lot of discussion about big data and companies hiring decision scientists. Are the underlying skill sets very similar, or should companies be thinking about hiring control engineers as well?

The right answer is somewhere in between. You can try to model absolutely everything and never look

at data, and try to predict. This is what the Greek philosophers used to do—sit around and try to think of how the world works and forget about observations: “There should be a way to think things through.” That’s one extreme. The other extreme is, “Forget about trying to have any understanding of the physical world, we’re just going to look at data, and the data is going to tell us what causal relationship should take place and how the world works.”

We like to do things in between. We like to have physical models. We like to sit on the shoulders of the giants who have developed all of this understanding about how the world works. But we also like to use real physical data to augment our models, to refine our models, to tell us where our models have deficiencies. The more data you have, the better you can do that. I think there’s a lot to be gained by combining those two approaches. Folks who are only focused on big data—I think that’s limiting. Folks who can only do modeling—I think that’s limiting. You need people who can do modeling and who can work with big data.

Systems are inherently unpredictable and complex when you start connecting them. Do you have any cautionary tales for business leaders about how behaviors could be unpredictable around business systems?

There are many examples of when feedback or interactions with the environments can cause things to go wrong. One example that comes to mind is the Tacoma Narrows Bridge. When this bridge was designed, people didn’t really take into account the interaction of the bridge with a constant flow across the bridge. That caused the bridge to become unstable, and it collapsed. There was Chernobyl, which was basically a system that ran wild and became unstable because of various feedbacks that caused a positive runaway cycle.

Feedback is very powerful, but it’s also very dangerous. You have to be very careful when you start feeding things back without some sort of supervision, because you get unpredictability. It’s a two-edged sword: you want to harness the power, but at the same time you don’t want things to go wrong.

How do you get around that? One, try to understand things before you connect them together and try to predict what could go wrong. You can do that by simply trying to understand the system and trying to reason through it, but also you can make simulation models, agent-based models, you name it. I think that’s the first point. Second, just be cautious. Try things out, and see how it works. For really complicated things, it’s very difficult to prove that something is going to work when interconnected. A lot of times you just have to try it out.

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DIGITIZATION AND SIMPLIFICATION

GETTING THE BEST OF BOTH

by Michael Grebe, Olivier Morb , and Sabine D schl

IN THE DIGITAL AGE, companies are expected to connect with customers and run IT in simpler, more agile ways. In addition, companies need to provide accessible new channels for customers and suppliers, develop applications quickly, and optimize their use of the cloud and their data. Although IT complexity can hinder these efforts, there’s a common perception that the problem resolves itself once a company starts down the digital path. Companies look at digital start-ups and see that they have managed to be nimble without simplifying. For many businesses, this begs a question: Is simplification still necessary in the digital era?

The short answer is yes. Indeed, in our experience, companies put themselves in the best position to reap the rewards of their digitization efforts when they undertake IT simplification in tandem. For example, consider the three main opportunities of digitization:

- *Stimulating growth* in and around the core business by enhancing product offerings, gaining actionable insights

(such as those that can be garnered from analyzing big data and monitoring social media), and improving the customer experience

- *Spurring efficiency* by streamlining processes (for example, by automating the supply chain) and reducing costs
- *Transforming the core* by optimizing the IT landscape and building up digital capabilities throughout the organization to better compete—and succeed—in the digital age

These opportunities hold great promise. But to take advantage of them, businesses will have to answer the following questions:

- How can we make the multitude of data sets accessible for more than their original purposes, unlocking the value for the benefit of the entire enterprise?
- How can we adjust our product portfolio and application architecture to support the digitization of business processes?

- How can we transform our IT infrastructure to support our digitization efforts?
- How can we turn IT into a “digital organization,” with more of a start-up mindset and a digital-ready workforce?

The answers to these questions lie in IT simplification. To realize the full potential of digitization, companies need to reduce unnecessary complexity in their IT systems, processes, and workforce. Only by doing so will businesses be able to develop applications nimbly and scale IT resources up and down as needed. Less complexity will also lead to improved IT efficiency, which will help companies maintain an IT cost structure that supports competitiveness and that allows for ongoing digital innovation.

To be sure, many start-ups are flexible, agile, and efficient. But their situations are different from those of established companies. Start-ups don’t have to deal with legacy systems. For example, they can design IT systems from the ground up to use cloud services and big data analytics, facilitating, among other

things, a 360-degree view of the customer. Established companies, by contrast, often find that their existing IT infrastructure is a major impediment to becoming more flexible, agile, and efficient. Cloud services don't always integrate into the infrastructure seamlessly, and customer views often have to be pieced together from multiple data sources with various tools. To implement their goals, established companies must develop more than a digitization strategy. They must also create a roadmap for simplifying their IT environment in a way that helps them achieve their digital objectives.

A Roadmap for Simplifying IT

Reducing unnecessary IT complexity isn't easy, but some companies have already seen significant success by following a multipronged approach. (See the sidebar "How to Rein in Excessive Complexity.") Simplifying IT to support a digital transformation, however, calls for tweaking the traditional approach. Here, we answer the questions posed earlier, outlining four ways that companies can substantially reduce complexity that does not create value.

Organize and manage data differently. In many companies today, data is scattered among an array of systems; there is no clearly defined master data repository and no synchronization among the systems. Often, companies attempt to organize and manage their data by building a data warehouse on top of this structure and using data marts to give various business units access to the information they need. But this approach rarely provides the results that companies need; namely, the ability to view data in real time and to access consistent data company-wide.

HOW TO REIN IN EXCESSIVE COMPLEXITY

The traditional approach to IT simplification is based on the following six levers. (See *Simplify IT: Six Ways to Reduce Complexity*, BCG Focus, March 2013.) These levers can be applied in unison or selectively, depending on a company's needs.

- *Intelligent Demand Management.* Help business units develop a clear understanding of the available IT resources and their costs, so managers can make informed decisions about how to consume them.
- *Scenario-Based Application and Data Simplification.* Look for ways to consolidate and decommission applications—or replace them with better, less complex alternatives—and to simplify the data landscape.
- *Infrastructure Technology-Pattern Reduction.* Embrace

opportunities (for example, through standardization) to minimize the number of unique configurations of hardware and software.

- *A Simplified IT Organization and an Enabled IT Workforce.* Remove bottlenecks by trimming management layers and optimizing spans of controls. Also, ensure an appropriately sized and skilled IT staff.
- *Effective Governance and Simplified Processes.* Create a governance model that positions IT as a strategic partner of the business units, while streamlining IT processes.
- *A Shared-Services Model and Optimized Sourcing.* Pool demand and adopt a shared-services model for both external and internal resources.

To unlock the value of the information a company possesses, leaders should implement an architecture built around data clusters that are shared by all processes.

A European bank, for example, helped its digitization efforts by designing an IT application architecture around data clusters and three main application domains that correspond to client relationship functions, client-servicing functions, and transaction processing. Having organized the application architecture in this way, the bank could develop applications for each domain using the most appropriate methodology, instead of using one approach for all ini-

tiatives. For some projects, agile software-development methodologies might make the most sense; for others, the traditional waterfall model might be more appropriate. Indeed, the bank reduced the cost of developing applications by a third and shortened the development schedule. This design also gave all systems—including those of data providers and other corporate partners—easy access to the data they require. Legacy systems could then be refocused on providing transactional services—such as those that let a bank's customers manage their accounts and pay bills—the types of services such systems were designed to handle. In addition, this approach enabled

the company to develop new digital applications that could easily tap the necessary data.

Simplify the product portfolio and the application architecture. In a typical product portfolio, 20 percent of a company's products generate 80 percent or more of its revenue. Eliminating the offerings that do not add value lets a business streamline the corresponding business processes and decrease the number of supporting applications, thus reducing IT complexity.

The problem is that existing complexity is carried over to the new system, not eliminated.

Identifying which products to eliminate requires the joint effort of business and IT stakeholders. Their first step should be to group the products into three categories: “differentiating products” that generate substantial profit and for which customization is economically reasonable; more “standard products,” whose differentiation comes not from features but from the company's brand, delivery speed, or the additional information provided; and third-party products, whose underlying complexity is irrelevant as long as they can be technically integrated into the company's own digital platform. The stakeholders' second step should be to determine the value that each product group contributes to the business.

A major financial-services company divided its capital markets products into groups. It then calculated each group's contribution margin, analyzing the associated business, operations, and IT costs. This calculation enabled the company to identify the products generating the least value—and to

simplify its product offering and underlying IT systems without negatively affecting its bottom line.

It is also important to simplify the application architecture by implementing strong business-IT governance. Many companies take what seem to be the right steps toward IT simplification—such as replacing an ever-growing and fragmented array of applications with a single state-of-the-art system—yet they fail to achieve their goals for improving flexibility and agility.

The problem is that existing complexity is carried over to the new system, not eliminated. To avoid this, IT and business stakeholders have to work closely together to ensure that business requirements are challenged when necessary and that simplification is achieved by carefully weighing additional functionality against IT complexity.

The collaboration between IT and business stakeholders should not end there, however. IT should work with the business side to reduce current costs so that a higher percentage of the IT budget can be allocated to digital initiatives. Traditionally, business units do not know their IT costs or how to contribute to IT's cost-reduction efforts. On a regular basis, IT and the individual business units should discuss a cost breakdown that details the IT resources that can be influenced by the business unit. Typically, the business side can influence the number and types of critical applications, the transaction and storage volumes, the number of IT employees serving the business unit, and the number of

desktops supported. During this regular “performance dialogue,” participants can discuss the sources of significant cost increases (for example, rising storage requirements) and agree on measures to address them (such as reducing the level of service or decommissioning rarely used applications).

Standardize the IT infrastructure and transform the sourcing model. Standardizing a company's IT infrastructure will boost flexibility and agility by simplifying the provisioning and administration processes. Standardization lets companies take advantage of automated infrastructure provisioning and on-demand scalability and, thereby, launch new applications much more quickly.

An international services company is taking this step and building a simplified and standardized private-cloud infrastructure platform. This platform will enable the company to develop a self-service provisioning function that lets application teams log on to a portal to choose standard infrastructure components (for example, a logical server with predefined specifications, including the CPU performance, operating system, middleware, and database). By giving teams this flexibility, the company expects to reduce the time required for server provisioning and deployment from what had typically been several weeks (but on one occasion stretched to more than 150 days) to a few days.

It's also worth taking a close look at the company's sourcing model and asking how it could be simplified to more effectively seize digital opportunities. For example, if a company needs to replace a legacy platform, it could turn to transformational outsourcing and rely on a vendor to not only manage the ex-

isting system but also to lead the migration to the new platform. Such an approach is particularly valuable for companies that have limited experience with IT transformations. In general, companies should structure their sourcing relationships similar to partnerships in which the goals of each party are complementary and the value achieved is shared. An increasingly common practice is to link a vendor's financial compensation to business KPIs, such as the savings generated or the level of customer satisfaction achieved.

Adopt new tools and a collaborative approach. Agile software-development frameworks, such as Scrum, and lean development methods reduce IT development cycles to weeks or months. But companies should not completely eliminate traditional methodologies, such as the waterfall model. For many businesses, it makes sense to have the so-called two-speed IT, which employs traditional development processes for legacy systems and agile and lean methods for digital platforms.

Collaboration, too, is crucial. For this to happen, however, the workforce increasingly needs to speak both languages. The IT staff needs to understand the business experts' lingo, and the business side needs to understand technical terms and concepts. Only then will both sides be able to cooperate and make the right decisions, such as when it makes sense to use agile development methods.

Taking steps such as these will significantly help simplify the way many companies work. A European bank, for example, was able to implement a new customer experience in less than four months—cutting the cost of the project by more than 50 percent—by creating

a joint IT-business team and applying agile methodologies. The team was comprised of IT and business process specialists who had a good understanding of the existing setup and an ability to think creatively and see the other side's perspective. During development sprints, the team used special tools that let it collaboratively describe the new business process, translate it into an "application skeleton," and then fine-tune the skeleton. Together, the new tools and the new way of working spurred creativity and improved productivity.

Managing a Digital Transformation

No matter which industry a company is in, creating a digitization strategy has to be a team effort, developed jointly by the business and IT leadership. Executives need to agree on which digitization opportunities should be pursued and in what sequence, prioritize the IT-simplification levers, and develop a transformation plan.

Implementing best practices can help ensure the plan's success. The transformation should be governed jointly by business and IT stakeholders and should receive the commitment and support of top

Contrary to what many leaders think, digitization does not make IT simplification obsolete.

management. These actions will create company-wide momentum. It's also important that the company stay firmly in control of the transformation; although the company may outsource some tasks, it should ensure that it has sufficient project-delivery and technical capabilities to be the key decision maker on all design, implementa-

tion, and delivery issues, including selecting and managing vendors.

The rollout plan shouldn't be set in stone. As with everything else in the digital world, flexibility is important. For example, a major financial-services company is detailing only the first six months of a three-year transformation plan and defining only critical milestones for the remaining two-and-a-half years. The plan will be re-evaluated and updated every six months. Even critical milestones can change, so long as the completion date remains firm.

So how does a company start developing a digitization strategy? Executives should examine the digital trends that are relevant to their industry and perform an assessment of the company's capabilities. It's also important to assess customers' needs and competitors' activities. Finally, executives should identify the areas in IT that are ripe for simplification.

Contrary to what many leaders think, digitization does not make IT simplification obsolete. Indeed, digitization and simplification should be executed in parallel: simplifying IT makes a digital transformation more likely to suc-

ceed, and a digital transformation creates a wealth of opportunities to simplify IT. Undertaking them in tandem also lets CIOs take advantage of a significant investment budget for digitization—along with a strong buy-in from the business side and a commitment from top management—to simplify. As to the question of whether IT

simplification is necessary in the digital age, the answer is a resounding yes. If the benefits aren't reason enough to embrace it, however, consider this: companies that simplify IT can operate more like start-ups—and can come closer to replicating their digital success.

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TAPPING NEW EFFICIENCIES

HOW MINING COMPANIES CAN RUN LIKE MANUFACTURERS

by Nigel Bailey, Richard Helm, and Grant McCabe

MINING, THOSE IN THE business will tell you, is not like other industries. Companies operate across geographically dispersed and remote locations, and working conditions can be severe and unpredictable. Indeed, there is an extraordinary amount of variability, from the weather to the quality of the ore. And little of it can be controlled. Mining teams, often far-flung, have a hard time working together in a system, much less an optimized one.

For a long time, miners have simply accepted this lack of efficiency as a fact of life. But does that really have to be the case? No doubt, mining companies could better coordinate their operations if they more resembled manufacturing companies. Manufacturers can integrate their assembly processes under one roof and more easily target, control, and reduce variability—such as by improving the way they manage suppliers and train their employees. For miners, it’s not so simple. How does one control the weather? Or know for sure what is in the ground?

Not surprisingly, no one has yet figured out how to make mining more like manufacturing. But we think that prospect is no longer out of reach. Certainly, mining operations aren’t going to take place under one roof, but processes could be integrated end to end, and variability could be managed better. So while a mining company may never look like a

manufacturer, it could nonetheless run like one. The key to this approach lies in something mining companies have already started to embrace: automation.

To date, the industry has utilized automation mainly to optimize discrete subsystems within the mining value chain. In Australia and South America, for example, companies are starting to move to autonomous operations, piloting driverless trucks and drills and studying the use of driverless trains. But these discrete improvements, while welcome, only hint at the possibilities. If more machines across the value chain were connected via the Internet, for example, data on performance and conditions could be collected and sent to a central control center. (See “The Rise of Robotics,” BCG article, August 2014.) If this information were then fed into software with an optimizing algorithm, decision making could be transformed, because software can process far more variables than humans—and far faster, too. So the variability in mining could be better accounted for, resulting in more informed, and ultimately more successful, responses.

That such end-to-end optimization is now a realistic aspiration is due to five key technology trends:

- Low-cost, network-connected sensors and actuators

- Increasingly powerful on-board control systems in machines
- Ubiquitous high-speed network connectivity across mining operations
- Scalable, low-cost computer processing and data storage
- The advanced algorithms and off-line analytics of big data

Together, these trends empower the so-called Industrial Internet, through which different machines in different locations can interact with each other, allowing companies in the mining industry to better link and coordinate their operations. Given recent developments in the market, this ability has not come a moment too soon. Declining ore grades, lower commodity prices, and rising labor costs have squeezed margins over the past several years. Total shareholder return, meanwhile, has dropped markedly for the top ten producers, and even more for companies outside that tier. (See *Value Creation in Mining 2013: The Productivity Imperative*, BCG report, May 2014.) For producers large and small, improving productivity is essential.

But if mining companies are to create a manufacturing-like system where processes are coordinated, linked, and optimized end to end, then they need to change the way they approach automation. Deployments shouldn't be ad hoc, implemented in projects that focus solely on specific steps in the value chain. What is needed, instead, is a holistic strategy for integrated automation: a clearly articulated vision for the role, extent, and purpose of automation across the entire value chain.

Developing this strategy is no simple thing. But by concentrating on several key areas—the scope of automation, the implications of more data, the role of vendors and standards, the protection of intellectual property (IP) and cybersecurity, and the challenges of implementation—mining companies can put themselves in the best position to craft an integrated automation strategy that fits their needs and circumstances. Keep in mind, too, that this is not a short-term effort. The transformation of mining that we propose is still

at least five—perhaps even ten—years out. But that's all the more reason to start planning and take the steps today that could lead to leaps tomorrow.

The Scope of Automation

Integrated systems can help mining companies coordinate far-flung operations, anticipate and avoid potential problems, and respond faster to disruptions. That's powerful stuff. But it can also seem overwhelming. What tools and processes—in what places, in what order, in what time frame—are needed?

Eat the elephant one bite at a time. End-to-end integration isn't going to happen overnight; it will need to be developed piece by piece. So companies will want to start with the pieces that offer the greatest rewards—the parts of the value chain in which automation will have the biggest impact, such as by increasing utilization at bottlenecks.

End-to-end integration isn't going to happen overnight.

At the same time, it's crucial to think about how these initial projects will interact with what's coming down the road. This is what makes the holistic approach to automation different from the ad hoc approach: You're always thinking about how any given project fits into the big picture. To this end, a roadmap is essential. So, too, is an awareness of technical standards. You want to be sure that the technology you're putting in the field will be able to integrate with the technology you're putting on the agenda.

Laying the technical groundwork, however, is just the beginning. Companies also must champion integrated automation to break through any cultural and organizational resistance. This means clearly defining and articulating outcomes and potential benefits. And while a long-term goal, such as a fundamental reset of the cost base, may be the real prize, companies will need to identify short-

term benefits, too, such as more localized asset productivity. Early tangible benefits will be instrumental in sparking the funding that the overall effort will require.

The Implications of More Data

Automated equipment with on-board sensors will generate a great deal of data. Thanks to increasingly fast networks and less-expensive storage, this information can be readily transmitted to, and retained by, a mining company. Big-data tools and analytics provide powerful new ways to make use of this data; for example, by identifying patterns in a machine's performance that signal an impending catastrophic failure. (See "The Industrial Internet: Six Critical Questions for Equipment Suppliers," BCG article, October 2014.)

But analyzing data and drawing insights can be complex tasks that often call for new skills. In many cases, these skills will be unfamiliar to mining companies, and the required talent will have to be actively developed internally or attracted from outside. Either way, mining companies must determine how to support and nurture these professionals, and that can be trickier than they might expect.

The opportunities that big data presents to mining companies will be extensive.

Experts brought in from outside, particularly from the digital-savvy startups that excel in data science and analytics, may be used to working in a faster-paced, more entrepreneurial environment. They may also be accustomed to having leeway to experiment and to do things in new and unproven ways. Mining companies will need to minimize culture clash and spur innovation. One way to do both is to embrace more of the agile ways of software development, which is built around experimentation, an acceptance of failure—because it happens early, doesn't cost much, and offers lessons to draw on—and short, iterative cycles.

The opportunities that big data presents to mining companies will be extensive. But realizing them will require investments in time, effort, and resources, as well as a willingness to try novel and untested approaches. Companies will have to decide just how big an investment they should make. They'll have to weigh the potential benefits of using data against the costs of doing so. And they'll have to assess the price of not using data, too.

The Role of Vendors and Standards

To date, mining companies have largely let vendors take the leading role on automation, allowing them to develop and position products instead of setting priorities and goals themselves. While there are benefits to this approach—such as productivity improvements, even if just modest ones, without much management effort—there are risks, as well.

Equipment vendors naturally tend to take a vertical view. Their goal is to "own" a complete process, such as autonomous haulage, by providing the entire IT stack: everything from sensors and actuators through control systems and human-machine interfaces to data-historian and business-intelligence solutions. Accordingly, vendors tend to focus far less on horizontal integration with adjacent steps in the value chain. But that horizontal integration is crucial for mining companies, which prefer open standards that allow them to combine the offerings of multiple vendors and link together all the discrete elements of production. In this respect, the goals of vendor and miner often conflict.

Moreover, ceding too much control to vendors may mean ceding too much of the value that is ultimately created. The data generated by sensor-laden equipment, for example, has potential value for vendor and mining company alike. If vendors control the access to this data, not only could they utilize it on their own—and perhaps create lucrative new revenue streams that they will not share with the mining companies—but miners may have a harder time obtaining and using that data for their own improvements to safety and production.

Still, mining companies are not technology companies, and they have little interest in acting as such. So when they need to partner with vendors, they should make sure that the relationships are balanced. Applying technical standards can be extremely helpful here, enabling miners to benefit from a vendor's expertise without ceding too much control of the resulting innovations or getting locked into vendor monopolies. But standards raise some difficult questions. What role should mining companies play in the standard-setting process? When in the innovation process should standards be introduced? Setting them too early, before the full business potential of a technology has been identified, could discourage further experimentation and stifle innovation. But setting them too late could allow for wasteful investments in solutions that do not fit the standards that the rest of the industry will ultimately accept. The key, we've found, is to pursue standardization once best practices have emerged.

Protecting Intellectual Property and Cybersecurity

Whether developed entirely in-house or in collaboration with vendors, innovations can create competitive advantages that will need to be protected. This can be accomplished through establishing intellectual property rights. For mining companies, the question is no longer whether to invest in those rights, but *how much* to invest in them.

Yet companies—in all industries—often miss a crucial consequence of securing IP rights: just as your IP rights can keep competitors at bay, so can their IP rights bar you from potential routes to growth. We already see mining companies partnering with leading automation vendors and developing patents together. A holistic automation strategy, then, doesn't just look to protect IP, but to keep a close watch on the competition. It needs to identify lock-out risks and to steer efforts and resources accordingly. No one wants to follow in the footsteps of one international oil producer that learned this lesson the hard way: the company was suddenly forced to halt development on a valuable new production technique—and write off a very significant investment—when a competitor obtained a patent

after independently developing the same technology.

A holistic automation strategy needs to identify lock-out risks.

Cybersecurity can be another source of concern, particularly when automated systems—running over networks and storing data, perhaps in the cloud—are used in business-critical operations. (See *Cybersecurity Meets IT Risk Management: A Corporate Immune and Defense System*, BCG Focus, October 2014.) Utilities, for example, have realized new efficiencies and opportunities for value creation since they began deploying smart meters on their electricity grids. But at the same time, they've had to address security risks brought by the convergence of information technology and operational technology. For example, IT security chiefs are increasingly reporting to CIOs at utilities. Mining companies that embrace automation will reap rewards, too, but just like utilities, they will have to identify and reduce risks. This means more than deploying appropriate software and hardware. It requires changes to the organization.

The Challenges of Implementation

We believe that automation, integrated across the value chain, can unlock significant benefits for mining companies, such as improved asset productivity and reduced waste. But it will also change the way the business and its people work. That raises important considerations. For one thing, software would be making decisions instead of humans in many situations. Initially, these individuals will likely feel that they are giving up the parts of their work they value most—and that's a potential problem.

But companies can quickly dispel those concerns. Instead of making reactive decisions based on situations that have already occurred, mining personnel could be looking to where problems might appear in the future

and take steps to prevent them. So in the long term, their responsibilities would actually increase—as would their value to the company's operations.

Another issue to consider as automation becomes more widespread is the impact on industrial relations. Here the automotive industry highlights both sides of the coin: overall, the industry has been a case study for the benefits of wide-scale automation, but for decades, labor disputes constrained automation's expansion, particularly in the United States.

Mining companies can aspire to the levels of discipline and efficiency of manufacturers.

Certainly for some workers, automation means short-term pain. But in the long run, it creates different types of jobs into which people may transition. Companies need to do a certain amount of balancing, weighing the impact of automation on some workers against the improved productivity and competitiveness it ultimately will bring to the broader organization.

That automation has a place in mining is indisputable. The question is how pervasive its role will be. The holistic approach to automation is based on the idea that mining companies can aspire to the levels of discipline and efficiency maintained by manufacturers. Miners can now better understand, anticipate, and react to all the uncontrollable variation in the business. And they can do it because technology has begun to enable end-to-end integration of scattered operations and faster, better-informed decision making. The ultimate vision of mining may not yet be a reality, but it is no longer a fantasy, either. Mining companies should start taking the steps to realize that vision now.

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MAKING BIG DATA WORK

SUPPLY CHAIN MANAGEMENT

by Libor Kotlik, Christian Greiser, and Michele Brocca

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. (See *How Global Manufacturing Cost Competitiveness Has Shifted over the Past Decade*, BCG Data Point, May 2014.) 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. (See *The U.S. as One of the Developed World’s Lowest-Cost Manufacturers: Behind the American Export Surge*, BCG Focus, August 2013.)

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 from production sensors and the Internet of Things.

Three High-Potential Opportunities

But 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. In our work with supply chain operations across a range of industries, we see three opportunities that offer high potential in the near term. Companies that exploit them can generate significant revenues and profits, as well as reduce costs markedly, lower cash requirements, and boost agility.

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.

Forecasting demand in a sprawling manufacturing operation can be cumbersome.

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. We frequently find that 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.

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. (See Exhibit 1.) Vehicle-routing soft-

ware 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.

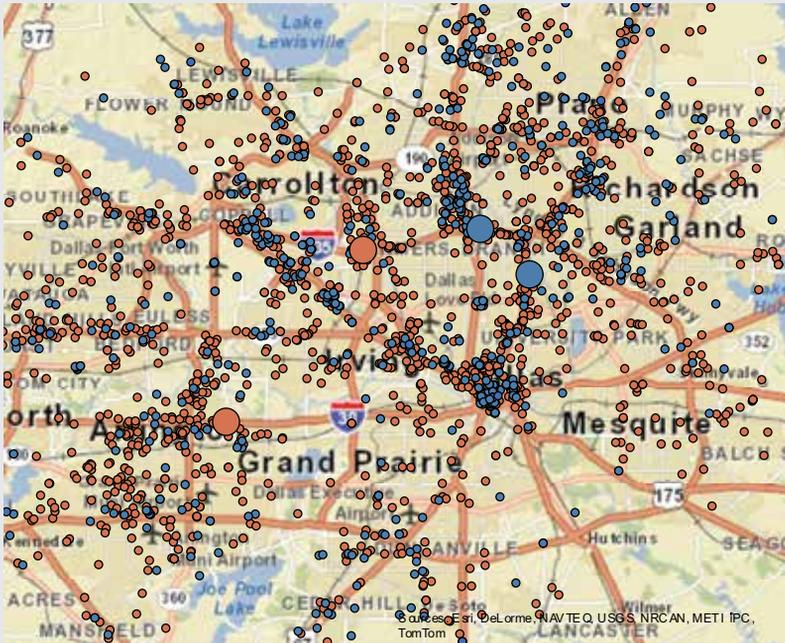
By establishing a common picture of the present and a view of the future, the geoanalysis also delivered less quantifiable benefits: the results built confidence that the estimated savings generated as a result of the merger would reflect reality when the rubber met the road and would also create alignment between the two organizations prior to the often difficult postmerger-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.

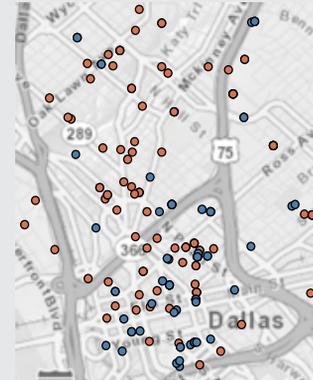
Now, companies can look at vast quantities of fast-moving data from customers, suppliers,

EXHIBIT 1 | Geoanalytics Helped Plan the Merger of Two Complex Delivery Networks

A hypothetical distribution of one day's customer orders in a major metropolitan area for two major companies seeking to merge indicated similar patterns



Overlapping dense pockets of orders signaled the potential for postmerger network efficiencies



- Company A's distribution center
- Company A's orders
- Company B's distribution center
- Company B's orders

Source: BCG analysis.

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—two important levers for improving operational performance and reducing costs. Essentially, with better demand forecasting, companies can replace inventory with information and meet customers' demands in a

much more agile way. 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.

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. In addition, the company's suppliers ordered too much from their own component suppliers. As a result, 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 from data flows and IT processing. 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.

On the basis of these and other organizational and process improvements, 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, delivering better customer service, and reducing premium freight costs.

Simplifying Distribution Networks. Many manufacturers' distribution networks have evolved over time into dense webs of warehouses, factories, and distribution centers sprawling across huge territories. Over time, 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. Lead-

ers can study more variables and more scenarios than ever before, 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.

Today's big-data capabilities can help companies solve more intricate problems.

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, including full truck loads, direct-to-store delivery, and two-tier warehousing, as well as different transport-rate structures that were based on load size and delivery direction.

Unlocking insights from this diverse data will help the company consolidate its warehouses from more than 80 to about 20. (See Exhibit 2.) As a result, the company expects to reduce operating expenses by as much as 8 percent. As the number of warehouses gets smaller, each remaining warehouse will grow bigger and more efficient. And by pooling customer demand across a smaller network of bigger

EXHIBIT 2 | Advanced Analytics Reduced Complexity in a Distribution Network

The original network was dense and inefficient



A streamlined network improved transport efficiency and lowered inventory costs



● Plant ● Contract packer ● Warehouse

Source: BCG analysis.

warehouses, the company can decrease the variability of demand and can, therefore, hold lower levels of inventory: it is volatile demand that causes manufacturers to hold more safety stock.

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. Many companies lack the ability to track details on materials in the supply chain, manufacturing equipment and process control reliability, and individual items being transported to customers. They fail to identify and proactively respond to problems in ways that increase efficiency and address customers' needs. 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. At the same time, companies should be careful to invest in areas that add the highest business value.

Reward data consistency. Many companies struggle to optimize inventory levels because lot sizes, lead times, product SKUs, and measurement units are entered differently

into the various systems across the organization. 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. The supply chain function depends on up-to-date manufacturing data, but the manufacturing function may tightly guard valuable reliability data so that mistakes will be less visible. The data could also help customer service, which might inform customers proactively of delayed orders when, for example, equipment breaks down. 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. Many operations leaders still don't understand how this new discipline can provide a competitive advantage or how to convert big data into the best strategic actions. Hiring a team of top-shelf data scientists to do analytics for analytics sake is not the answer, however.

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 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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OVERCOMING THE DIGITAL DILEMMA IN WEALTH MANAGEMENT

by Brent Beardsley, Daniel Kessler, Matthias Naumann, Neil Pardasani, and Jürgen Rogg

WEALTH MANAGEMENT CLIENTS ARE increasingly accustomed to using mobile, social, cloud, and Web technologies in their personal and professional lives. Thus it's no surprise that they expect the institutions and experts managing their wealth to progressively employ digital tools and practices as well, to improve service, efficiency, and the overall client experience. The problem is that most wealth management entities are not yet able to do so.

For wealth managers, the benefits of embracing digitization are huge. Mobile banking now allows clients to interact with their wealth managers anytime, anywhere. Cloud computing provides access to unprecedented computer power and storage, permitting complex transaction processing. Big data applications help wealth managers capture, analyze, and interpret vast amounts of data and leverage that knowledge to create highly customized solutions. And social media platforms, along with closed communities, allow clients and others to connect and discuss market developments, investment options, and other financial matters instantly.

These advances can reshape the way products, services, and information are provided to clients. A wealth manager could increase client activity, for instance, by delivering tailored investment ideas to the client's mobile device—factoring in actual market movements,

the client's financial situation, and insights that reflect the company's research-house view. Greater self-service provisioning across devices will help generate higher share of wallet through optimized up-selling and cross-selling as well as through a lower cost to serve. Although the traditional wealth manager-client relationship will continue to emphasize face-to-face contact and the sense of trust that such contact engenders, digital communication will radically redefine and enhance the relationship, effectively changing the dynamics of competitive advantage.

Digital communication will change the dynamics of competitive advantage.

Yet despite its potential, digitization is occurring more slowly in wealth management than in other industries. Scale and complexity are part of the issue: many players are reluctant to disrupt the traditional client-service approach, and they can have a hard time figuring out where to start because of the heterogeneity of wealth management activities. As a consequence, wealth managers have been holding back. At the same time, “robo-advisors” and new players entering the market with a digital-first model are raising

the competitive stakes, increasing both client expectations and the sense of urgency to act. Combined, these factors mean that wealth managers are facing a digital dilemma.

The Mismatch Between Digital Readiness and Client Expectations

What do clients expect from wealth managers? A survey of approximately 140 wealth managers around the world, released in conjunction with BCG’s Global Wealth report last year, found that approximately 75 percent of wealth management clients indicated that they would like more interactive multi-channel offerings. (See *Riding a Wave of Growth*, BCG report, June 2014.) Few organizations, however, currently have such offerings, and only 25 percent of wealth managers provide customized advice online. Sophisticated functionalities that make use of big data and advanced portfolio analytics—such as personalized monitoring of investment preferences, simulations, and tailored invest-

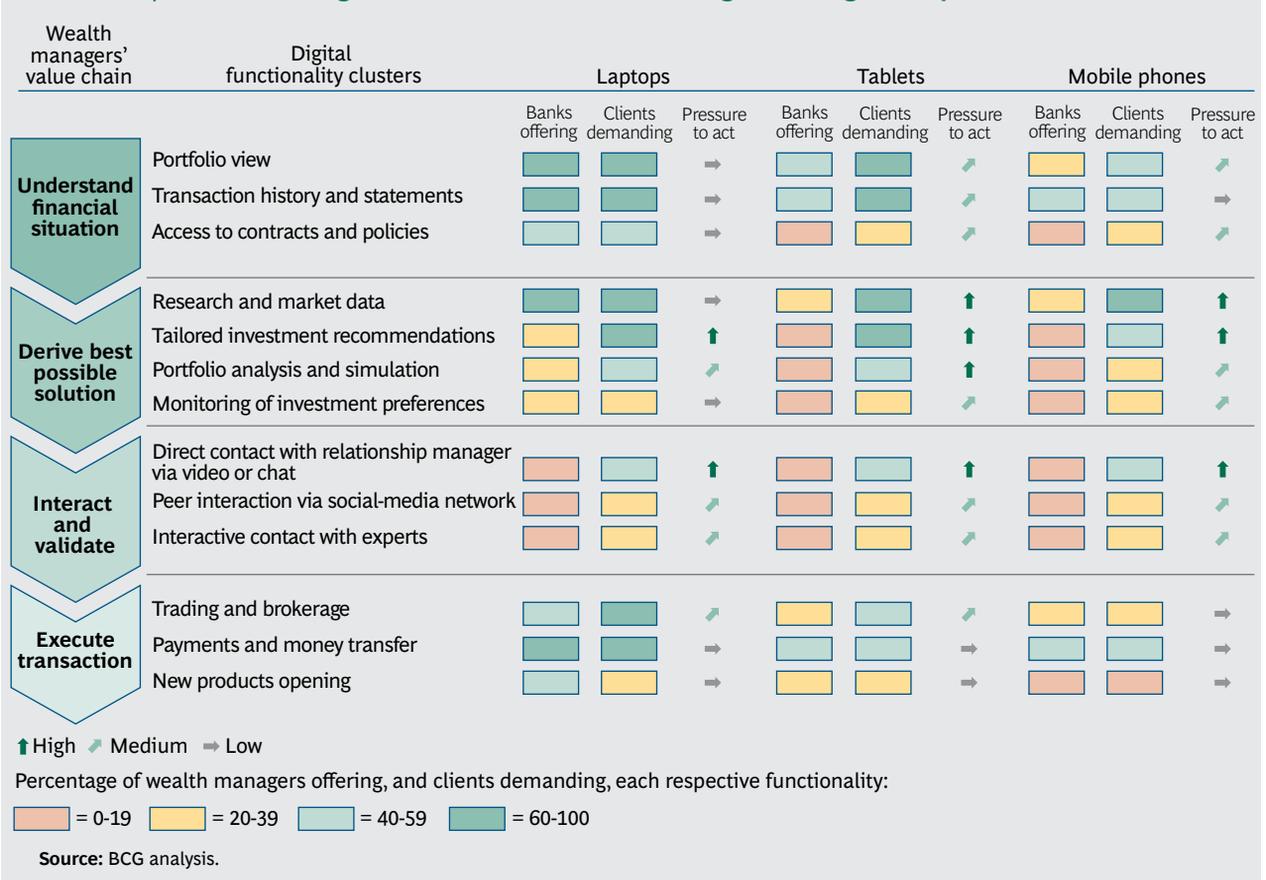
ment recommendations—remain largely nascent. Digital collaboration is the least developed. Only 13 percent of participating banks enable video or chat interactions with relationship managers (RMs), despite the fact that clients highly value such communication. (See Exhibit 1.)

Efforts are slowly picking up in the broader social-media arena. According to our study, 30 percent of respondents offer at least one form of social-media functionality that is specific to wealth management. But most of those offerings tend to be static—RM profiles on professional networks such as LinkedIn, for example, and basic company information on platforms such as Facebook and YouTube. Only 4 percent of wealth managers provide higher-value services, such as advice-sharing forums or portfolio-modeling simulators.

Time to Capture the Opportunity

Early movers that best balance traditional, relationship-led wealth management with

EXHIBIT 1 | Wealth Management Clients Are Demanding More Digital Capabilities



intuitive, simple-to-use, and integrated digital features, products and services, have a real opportunity to gain competitive advantage. Providing a compelling digital proposition can spark revenue growth while increasing efficiency. (See Exhibit 2.) According to our study, up to 40 percent of participants prefer receiving tailored digital outreach via RM phone calls; more than 60 percent would like to exchange investment ideas with like-minded peers; and more than half consider customized research information and instant simulation delivered over digital channels to be a critical competency.

Even modest improvements can yield significant benefits. For instance, wealth managers with an advanced—yet not leading—digital offering reduced attrition by as much as 5 percent, increased revenue from cross-selling by 2 to 5 percent, and realized efficiency gains from greater automation and more streamlined processes by 10 to 15 percent. For organizations that go further in delivering a rich, integrated cross-channel experience, the potential is significantly higher. Considering the value at stake, wealth managers must start now or risk being left behind as competitors accelerate their digitization.

Our experience shows that instead of diluting the traditional wealth manager–client relationship, as many fear, digital transformations enrich the quality of client service by improving the end-to-end experience. Through superior service, a greater range of offerings, and enhanced interactivity, digitization can effectively transform the client relationship, generating richer forms of engagement and providing RMs with the ability to offer more pertinent, targeted, and timely advice—qualities that can be competitively differentiating. (See Exhibit 3.)

Building a Leading Digital Proposition

Wealth management practices seeking to go digital should begin by articulating their strategic objectives relative to their desired value proposition, client experience, channel management, delivery platform, and product design. Executing against that strategy then requires a multidisciplinary engagement model, strong delivery focus, and rigorous change management. Wealth managers should take the following steps:

- *Define a clear ambition.* Develop a truly differentiating value proposition and ensure that the vision is integrated into

EXHIBIT 2 | Digitization Confers Material Benefits for Wealth Managers

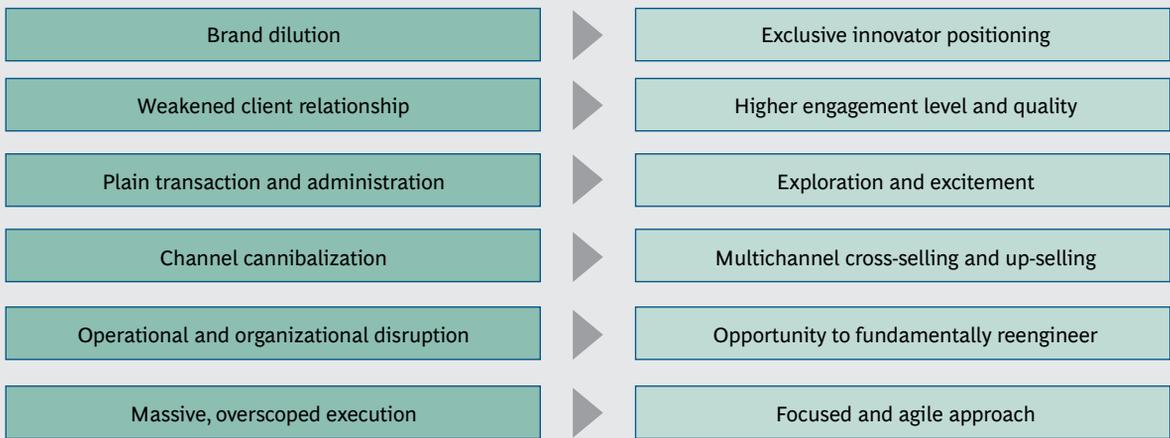
Benefit	Driver	Enabler
Revenue uplift	Share of wallet and retention	<ul style="list-style-type: none"> • Higher client activity with instant, individualized news and alerts • Deeper engagement in personal finance and greater “stickiness”
	Cross-selling and up-selling	<ul style="list-style-type: none"> • Proactive, tailored advice and recommendations • Segment-based pricing for new, premium digital offering
	New clients	<ul style="list-style-type: none"> • Broader, innovative client value proposition • Access to untapped client segments
Efficiency gains	Front office	<ul style="list-style-type: none"> • Investment ideas captured and simulated by clients digitally • Possible RM substitution for lower wealth segments¹
	Processing and administration	<ul style="list-style-type: none"> • Process simplification across the entire value chain • Intuitive, guided self-administration
	Products and services	<ul style="list-style-type: none"> • Configuration performed by clients digitally² • Early client testing and feedback

Source: BCG project experience.
¹RM = relationship manager.
²Within regulatory limits.

EXHIBIT 3 | Misperceptions Delay Digital Advancement

Wealth managers see digitization as high risk...

...but BCG data shows that digitization provides high value



Source: BCG project experience.

the overall bank strategy. Gaining early alignment with top management, cascading it through the front office and project teams, and including external stakeholders—such as regulators—in the discussion are critical to success.

- *Identify a primary focus.* Prioritize a handful of high-value “client journeys” across channels. Three to five such pathways are recommended to start with; providing too many, especially at the outset, increases complexity and costs.
- *Build a simple—but compelling—client experience.* Using the set of identified client journeys as the driver, develop intuitive functionalities to enable a unique user experience, such as tailored alerts or personalized portfolio recommendations offering instant collaboration with the RM. Keep things simple and actionable to drive adoption and advocacy. Resist the temptation to bring the full breadth of sophisticated, professional RM tools and processes to all digital channels.
- *Test and refine continuously.* Commit to rapid prototyping and continuous iteration in both the front office and with clients. This approach will help refine and shape digital offerings more quickly and maximize overall effectiveness.

- *Establish operational readiness.* Ensure a clear perspective on the operational and policy implications of digital banking. This will help improve efficiency and address time-consuming and complex fine-tuning ahead of your launch date.
- *Drive rigorous change management.* Ensure strong commitment from senior management and governance, including rigid prioritization, agile solution development, and proactive alignment with all parts of the company.

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NOTE TO THE READER

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