



Digitization is set to transform manufacturing, including the chemical sector. Producers are exploring digital strategies that can operate at the intersection of manufacturing, product development, R&D, supply chains, and other parts of enterprise. The efforts hold the promise of increased flexibility in manufacturing, increased speed, better quality, and improved productivity. Some key elements are already in place, including OT, in manufacturing, with hardware and software to measure, monitor, and control processes. The next steps, in the early stages, is integrating OT with broader commercial information

technology and enterprise resource planning (ERP) systems. To do this, companies will need to invest in equipment, information and communication technologies, as well as data analysis, to integrate now disparate and often disconnected data flows across the industry value chain.

One analyst estimates digitization could create a trillion dollars in value for chemical makers.

Early efforts

Industry 4.0, in chemicals at least, has taken strongest root in Germany thanks in part to encouragement from the country's economic

affairs ministry. "We are convinced it will take operational excellence to the next level," BASF executive vice president (vp) Martin Brudermüller said at the European Petrochemical Association in September. BASF is operating a number of pilot projects and plans to roll out a digitization program across its plants and sites to improve performance, he adds.

Evonik in October became the first chemical company to join the Industrial Internet Consortium (IIC), a public-private organization formed to accelerate adoption and enablement of the Industrial Internet of Things (IIOT). "We want to exploit

INTEGRATION: Manufacturing OT and commercial information technology (IT) capabilities are converging.



digitalization to develop new, innovative solutions for our customers,” says Henrik Hahn, director for digitalization strategy at Evonik. “Our membership of the IIC will provide valuable stimuli in this direction.”

Some producers are tentative, noting continuous optimization, efficiency, safety, and costs are already deeply embedded in industry’s operating culture. Broad adoption of Industry 4.0 tools needs to be weighed against the costs relative to the additional benefit it can provide. “We’ve invested a lot of time and resources in systems and

processes to ensure we operate our manufacturing network and supply chain efficiently, effectively, and safely,” says Barry Crawford, FMC vp/operations. “There’s a lot of talk about the digital transformation, the use of massive data to improve operations, and cutting-edge tools. We’re certainly monitoring these developments and always keep an open mind for better ways to do things, but we believe many Industry 4.0 methods still have to evolve and mature before they can bring real impact to our operations at a cost that makes sense compared to current technology.” Crawford cites bar coding as a widespread technology used on everything from boxes to product labels. Bar codes are far from cutting edge, but they are highly effective, widely used around the world, and inexpensive. “Like any new technology or operating concept, we think it will take time for many Industry 4.0 principles to develop and mature to a point where it makes sense for the kind of business and operations we run at FMC,” says Dave Kotch, FMC vp and chief innovation officer (CIO).

Mitsubishi Chemical Holdings has expanded efforts to use measured data to operate its plants. The company has developed and is now using Real-time DB, a remote monitoring system across its chemical plants. “By using this system, Mitsubishi Chemical can analyze operating conditions when there are technical problems and also improve day-to-day plant operations,” says Masanori Karatsu, senior managing corporate executive officer at Mitsubishi Chemical Holdings. The company is evaluating digital technologies and IIOT in other areas, including working with customers on product and new businesses development. “The strength, flexibility, and texture of materials can be modified by how two or more materials are mixed, and this is often not quantified and largely depends on the know-how of skilled

workers,” Karatsu says. “If it is possible to quantify and digitally express the production process of materials that the customers demand, the marketing process would change and trial production and product development would speed up. Features that are difficult to quantify, such as texture, might be quantified by obtaining and analyzing data collected from sensors.”

This would require the cooperation of customers and standardization of data exchange through external partnerships, Karatsu notes. Mitsubishi Chemical Holdings is pursuing this path, although there are issues pertaining to how much of the company’s data can be disclosed, he adds. The company is considering adding new positions and organizations within the company to explore the use of digital.

“Digitalization is all about creating offerings that elevate customer experience, creating, communicating, delivering, and exchanging offerings that have value for customers by the use of digital technologies in our processes and products. This ultimately has an effect on existing business—and will open up new businesses,” Hahn says.

“Predictive maintenance with real-time monitoring might be able to reduce unplanned or shorten planned maintenance even further and thus improve asset utilization. However, so far there is not always enough confidence in these technologies.”

In the early stages, chemical companies are struggling with how to tackle the digital opportunity and where to anchor it. “They

lack the skill set to effectively assess which moves they should make,” says Christoph Schmitz,

Digitization offers the potential to take operational excellence to next level.

Martin Bruder Müller
Executive vp at BASF



senior partner with McKinsey & Co. “Unfortunately, many companies react by delegating their digital strategy and implementation to their IT departments, which is a huge mistake. Advanced analytics (AA) and digital are a business strategy topic and not an IT problem. IT will only be an enabler.”

The vast majority of the value creation will come from how AA and digital can enable companies to reach the next level of functional excellence in commercial, operations, and innovation, Schmitz says. The degree of disruption for chemicals will be an order of magnitude less than disruption in consumer-oriented industries such as media, travel, and financial service given the chemical industry’s business-to-business (B2B) nature and asset-heavy character, Schmitz notes. The impact, however, can still be enormous for chemical makers with the potential to improve EBITDA 8–13 percentage points from contributions across many different levers and functions (*chart*), McKinsey estimates.

“Overall, the opportunity for value creation through digital in the chemical industry is

estimated at more than a trillion dollars,” Schmitz says. “It’s clear, however, that not all companies will be able to capture all the opportunities from the levers. The scope for



HAHN: Digital can transform products and processes.

improvement partly depends on a company’s starting position, and the levers do not apply in the same way to all subsectors in the chemical industry.” Chemicals generally lags relative to other sectors when it comes to digital, says Mehdi Miremadi, partner with McKinsey. “There is visible excitement about the opportunity, but in practice there are not many instances of real end-to-end digitalization,” Miremadi says. Factors that limit interest include the perception of significant investment required, questions about

ultimate value creation, and the lack of existing examples. Many major chemical and ag players are also currently involved in large M&A, which takes away attention and resources from other opportunities, Miremadi adds.

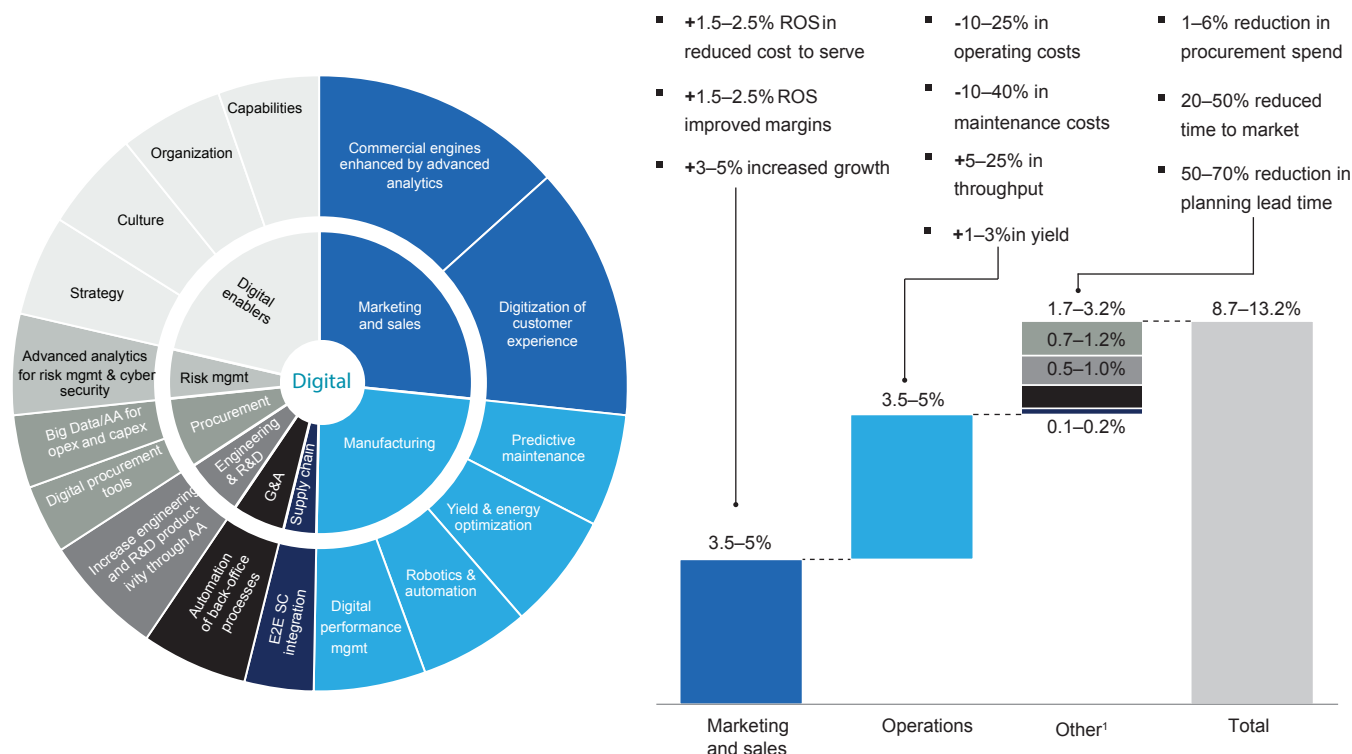
Digitizing the enterprise

Digital offers the opportunity for chemical makers to transform business models, analysts say. “Chemical makers, especially specialty chemical companies, have long struggled to transform themselves from product sellers to solution providers,” says Vijay Sarathy, partner with PriceWaterhouseCoopers (PwC). Digital transformation can provide the impetus and framework to put new models in place, he adds. “Companies talk about solutions all the time, yet examples of true solution providers in the chemical industry are few and far between. Putting *performance materials* or *solutions* on the name of business unit does not change the product-oriented DNA of a company.”

Being a solution provider means solving a

McKinsey: Digital improvement can boost EBITDA by up to 8–13 percentage points

(EBITDA impact by functional lever)



1) Other: Procurement 0.7–1.2, R&D 0.5–1.0, G&A 0.4–0.8, Supply chain 0.1–0.2. Source: McKinsey analysis.

customer's problems, and chemical makers struggle here, Sarathy notes. "Solving problems requires deep insight into customer processes and the role your product plays within a customer's, and often a customer's customer, process," Sarathy says. "Most chemical companies have very limited visibility into, let alone influence over, customer processes."

Digital can change that, Sarathy adds. With costs dropping for sensors and wide-area connectivity, the ability and opportunity to measure and transform processes are expanding dramatically, "For example, a paper chemicals company can deploy sensors in the paper manufacturing process to gather vast amounts of data about various process parameters and therefore be in a position to offer guidance on process improvements to their customer," Sarathy says. "This allows the company to transform itself from a paper chemicals supplier to a solution provider. The fact that the paper industry, especially in North America, has lost a lot of experienced operators creates an opening for the chemical company to fill the void and extract greater value." That value derives from a stickier relationship, greater share of materials spend for the supplier, or outcome-based compensation, Sarathy adds.

PwC finds in a recent survey chemical companies plan to invest 5% of annual revenue in digital operations solutions in the next five years. Nearly a third of chemical companies report they have already reached an advanced level of digitization and integration, and more than three-quarters expect to be at such a level in five years, PwC says. "Indeed, the 75% of chemicals survey participants who expect to have reached advanced levels of digitization in five years' time is one of the highest among the industry sectors covered in our survey," PwC says. "Companies may well feel that the process control and automation that many have put at the heart of their plants gives them an advantage. But one of the challenges will be to resolve interface and architecture challenges and to successfully build outward and beyond the boundaries of individual plants."

Successful examples of service-based models are starting to emerge, says Ulrich Weihe, partner with McKinsey. "These are primarily where chemical suppliers, through their expert knowledge of their customers' processes and the emergence of more widely deployed sensor technology, get access to



MOBILE ADOPTION: Data is increasingly moving into the cloud as advanced analytics take hold.

massive amounts of data that can—in combination with the chemical suppliers' know-how—be leveraged to create distinctive insights that can be monetized." Monetization can be in the form of a paid service, of taking over the customer's process, or by serving the customers' needs with better chemical solutions, including more effective recipes, providing more efficient choice of materials, Weihe says.

There is some talk of more flexible production models or even production on demand, but these depend on the nature of the asset base, analysts say. Advantages of scale are not going away in basic chemicals, for example, but some downstream derivatives may shift. "Concepts like microreactors have been around for decades and have not taken off for good reason," Weihe says. "Economies of scale still determine the profitability of many of the chemical industry's production processes. Exceptions do exist where decentralized, on-demand production can make it possible to avoid transporting large volumes of diluted chemicals in a on-site model similar to what industrial gas companies do. Still, I believe it will not massively alter the landscape of the chemical industry's production assets."

There are opportunities to optimize assets and production footprints, however. "There are areas, such as specialty chemicals, where you could see 25% improvement in output or utilization as you tackle very inefficient processes," says Mark Thompson, director industry solutions group with GE Digital. "The benefits are from using production lines more efficiently, improved switch-overs to different products, inventory management, and other

elements. That improves availability of the most-desired products while reducing the amount of inventory they have to hold on hand. That's a huge win."

Percentages are smaller in commodities, but overall value impact is significant because the volumes involved are much higher, Thompson says. "Being able to monitor plant performance and KPIs across multiple facilities, being able to do more predictive maintenance and better-timed maintenance instead of following a rigid time-based schedule can save anywhere from 2% to 10% of operating costs," Thompson says. "And that impact drops pretty much straight to the bottom line. It allows longer and more efficient runs in commodity businesses where reliable output [and utilization] is the name of the game."

Accenture says a recent survey of 156 C-suite and vp-level chemical industry executives shows digital has permeated the chemicals industry and is gaining C-level support. In the survey, 91% of respondents say digital programs are driving strategic decision making and 94% report the C-level is aggressively setting and supporting the digital agenda, says David Yankovitz, managing director and lead for Accenture's chemical industry practice. About 58% report they are embracing digital to gain an advantage over peers, Yankovitz says. "Investments in digital are expected to increase over the next three years," Accenture says. "Some 85% of respondents report investment in digital overall has increased over the past three years, and 94% expect an increase in the next three years—with 54% expecting a significant increase."

Industry is beginning to scope out the potential, but digital remains in a proof-of-

concept stage, Yankovitz adds. “Companies are asking, ‘Wouldn’t it be great to predict failures ahead of time, adjust operating philosophy, and adjust scheduled downtime so that I could accommodate that repair before there is an unexpected failure?’ No one is really doing that on any wide basis yet. I think a couple things are preventing that. First, there are some foundational issues. You have to be to extract the data and put it a form that provides the right meaning and benefit. The second question is determining where do I start and identifying the value drivers.”

On the specialty side is a desire to increase agility and flexibility to manufacture and turn toward providing a service to customers, Yankovitz says. “A lot of companies on the specialty side are thinking about how to go to a more quick-turn type business, how to speed up transitions between products, and how to do on-the-fly production optimization. That’s a whole different mind-set than long runs, reducing transitions to be able to eke out more product by just being more efficient based on a set sequence of manufacturing products that I can make.” The second part is the shift to a service mind-set, he adds. “Producers want to increase stickiness with customers so there not only providing a particular product, whether a chemical, additive, or a coating, but also a service on top of that so that it ensures that my product is being bought. Because the services and knowledge

around that are equally value-added to the actual compounds that I’m selling.”

Analytics improve

Automation and use of data are already very high on the shop floor level, Hahn says. “We capture data from hundreds of sensors and use advanced process control and even real-time optimization.” The degree of

Additional **3.1%**
revenue *per annum*

Cost **4.2%**
reduction *per annum*

Expected benefits from digitization over the next five years
Source: PwC

automation and data use varies significantly, he adds. “Big assets are typically designed to run for at least 30 years, so that leads to mishmash of capabilities,” Hahn says.

Asset condition monitoring is not new for big assets in the chemical industry, although in the past there were no real-time cloud services available for that. “What is new for

most chemical companies is the inclusion of unstructured data from outside of the process itself and the smart combination with existing process data,” Hahn says. Companies are starting to navigate here. “Evonik has built up a Big Data lab for this purpose,” Hahn says. “The lab and the businesses are closely cooperating on the identification of use cases for any business process imaginable, starting with examples such as sales forecasts, production planning, and utilization of the information flow within the supply chain network.”

Chemical makers do collect a lot of data, although the quality and comparability of the data needs improvement. “The data that they’re collecting off of that as well as the comparability of that data is all over the map,” Thompson says. “There is a job to do in terms of bringing it up to a common standard.” The process today tends to be manual, where experts and engineers rationalize the data and make it comparable. “That means it happens on an infrequent basis because the time and effort required is just too high,” Thompson says. “So they don’t get all of the value that they could out of it if they put in more automated systems.”

Industry process controls and approaches vary, creating some barriers to standardization. “You have a heterogeneous environment in the chemical industry with a lot of older protocols still in use, including some that pretty eccentric,” Thompson says. “You have things that have worked on an asset for 20–25 years, and there’s understandable reluctance to change. So that becomes a challenge to what I think that commonality can introduce.”

Projects under way

“We see clear opportunities for digitization, concerning both new business models and process optimization,” says Altana CEO Martin Babilas. Altana has formed a digital transformation department. The head of digital transformation reports directly to the CEO at Altana. “One focus is on the evaluation of data from the value chain in order, for example, to control manufacturing processes more intelligently,” Babilas says. “Digitization and process automation can help us use machines more effectively, making products more readily available. We attach particular importance to the integrated analysis and evaluation of possible consequences and potential. A decisive yardstick remains the consistently high quality of our often



PROCESS CONTROL: Remote monitoring can bring big benefits.

individualized specialty chemical solutions for customers.”

Ag is one area where FMC, a maker crop protection chemicals, monitors developments in digital commercially. “Analytics that are currently driven by Big Data in agriculture are primarily focused on seed- and fertilizer-related decisions,” says Diane Allemang, director of portfolio strategy and director North American business development for FMC Agricultural Solutions. “This enhanced decision making can help farmers by reducing the cost of inputs and improving return on investment. FMC is not in the seed or fertilizer business, and so we are not actively engaged. However, we are assessing it closely to determine how and when FMC will incorporate Big Data in future product and technology offerings.”

BASF, meanwhile, has several projects under way. In smart manufacturing, BASF is implementing digital technologies and applications in its plants to make production safer and more efficient. “The first predictive maintenance applications, for example, were installed in the steam cracker in Ludwigshafen, Germany, and forecast the condition of technical components, such as pumps or motors,” says a BASF spokesperson. “Sensors are used to collect live data about operating conditions, which are then evaluated with special analysis software, taking into consideration historical process data such as maintenance history.” The objective here is to predict the best timing for maintenance. “This will help reduce unplanned repairs and downtime and optimize the coordination of maintenance and production processes,” BASF says.

The OT/IT interface comes together

The integration of OT and IT is starting to happen, producers and suppliers say. “Most companies are realizing that despite the history of [OT] and IT being very separate ... the future involves a degree of interrelationship that wasn’t there before,” Thompson says. “I think the companies that are doing it well are really thinking about, that while OT is separate function, with needs for separate protection in particular, there is a lot of value to being able to visualize that data across the network in a secure way.”

Standardizing and digitizing OT can help industry address demographic challenges. “One of the things I hear in the chemical industry a lot is that a lot of our expertise is getting older and starting to move towards

retirement,” Thompson says. “And the question is how do we spread that knowledge and spread expertise from perhaps a centralized location or a semicentralized few facilities across a network of facilities to enable better learning and lower overall cost.”

The convergence of IT and OT has broad implications for how the chemical enterprise is managed, says Pete Frandina, director with Accenture. “The CIO is starting to take a more prominent role in improving capability at the OT layer. There is this pent-up demand [for changes] at the site level, and unless the CIO can control that, the sites are often running out and doing rogue projects and losing all the standardization and the strict conformity that the CIOs want to have at the OT level,” Frandina says.

The first frontier in implementation is around mobility and making operating resources more productive at the plant by providing information to them, enabling two-way communication and collaboration, and allowing them to not have to move away from the operations or the repair or the piece of equipment and go back to a control room, where they’re often making sort of decisions or take action,” Frandina says. “The question is what level of wireless infrastructure do I need to put in. Is it just a couple of hot spots? Is it a mesh-network, or is it all the way to pervasive wireless that then allows me to do physical tracking of resources and people?” Frandina asks. Frontier number two is analytics. “People are saying, What can I do with the data I have available to me now? Are there immediate benefits that I could take with that data first? And then I could look expanding that either of two ways.” One expansion is enabling capability to monitor multiple assets from one location and do more remote monitoring of lighter assets. The other involves collecting more data, more sensors, and more equipment at a single site.

There are customers in the chemical sector that have been doing IOT for a long time, says Andrew Hird, director/digital with Honeywell. “They haven’t called it that; they’ve called it standard things like KPI management, visualization, [and] enterprise intelligence. We’ve done a lot of this for a while, but we haven’t ever really called it IOT. But now,

however, the technology’s completely evolved, so you can now collect huge amounts of data, you can securely move it inside your organization and even to the cloud, and the applications to solve those problems have been around for a long time.”

Adoption may be hastened by economics, he adds. “Lower oil, volatility, and concerns about growth drives a lot of people back into optimizing their plants rather than building other plants,” Hird says. “The money shifts from to capital expenditures to operating expenditures. The ability to get that last 1% out of your production facility offers a huge potential benefit.”

Process modelling in the cloud and remote process troubleshooting can provide great benefit, Hird adds. “Imagine the ability to monitor a dozen ethylene plants around the world constantly at all times through exception-based surveillance. Imagine the value we could create for customers. And that’s here and now. We’re doing that with refineries where we’ve got their models in the cloud.

The major integrated oil companies with chemical business inside are probably at the top end of the adoption curve, but that could change, he adds. “The larger integrated firms have been at it for a while. But the smaller guys have a different problem. They’ve got smaller plants. They don’t have the same knowledge on-site. They don’t have the big engineering departments and pervasive sensors to help them solve these problems,” Hird says. “The good side, however, is they’re smaller and more agile. They’re more willing to put data in the cloud because there’s more benefit.”

Cybersecurity risks also must be mitigated. “The chemical industry operates a quite strictly controlled and enclosed OT to avoid security issues, especially in safety critical plants and environments,” Hahn says. “Any new industrial IOT technology and cloud service will only have a chance to be used in the chemical industry if the cyber risks are appropriately mitigated. From a technology perspective, this can be achieved.”

Cybersecurity is evolving, Frandina says. “Two years ago, it was about building bigger or stronger wall to keep attackers from getting in and hardening protection for assets. That has not addressed all vulnerabilities. The shift now has been to the mentality of *I know they’re going to get in, so while I still*



BABILAS: Business models will change.

have my big walls, I also need to have security analytics that detect anomalies in my traffic. You need to be able to detect a penetration, contain it, and isolate that from doing any damage. Our clients now are taking the perspective of I know I'm going to be attacked; the issue is how quickly can I identify threats and address them to minimize the impact."

Supply chain impacts

Digitization is also likely to have broader impacts on the supply chain. BASF says it already working on networked logistics chains. "The entire supply chain—including all internal and selected external partners—will be made transparent," BASF says. "Big data analytics will enable more precise forecasting and provide better support for tactical and strategic decisions. This will serve to make planning faster, more reliable, and more efficient." For a pilot project under way in North America, BASF has implemented a cloud-based platform that enables the company to exchange important planning data in almost real time with a customer and simulate various scenarios. "This eliminates long planning cycles and means BASF is able, for example, to react to adjustments in the customer's production planning without any delay," BASF says. In another pilot, in the nutrition and health business, selected overseas freight shipments are being digitized. A sensor installed in the shipping container records factors such as temperature, humidity, impacts, and location and transmits this information in real time via satellite. "This is especially useful for temperature-sensitive freight, such as products for the pharmaceutical industry," BASF says. "Among other things, the data can be used to prove that the products were transported appropriately throughout the entire shipment. And the company can proactively react to any issues that may arise."

Who owns it?

An initial question is who should best to manage implementation. Analysts generally say it is best to avoid placing solely on IT. Digital needs to be embraced at the board level. "We believe that the topic of digital and advanced analytics strategy needs to be anchored and driven from the management board level," Schmitz says. "And it needs to be owned by one person—but not by the head of IT." Digital strategy needs to be owned by businesses or by center-of-excellence functions, Schmitz adds. "This leader of digital strategy needs to orchestrate the

"Digitization can speed trial runs and product development."

Masanori Karatsu
Mitsubishi Chemical

development of all the required skill sets. The first step should be a comprehensive screening of the company to identify business model and functional excellence opportunities. These should be prioritized based on the potential impact, and the skill sets should be developed or brought in to make it possible to pilot AA/digital initiatives in these high priority areas."

The traditional chemical industry CIO has focused on infrastructure- or back-bone-type activities, including ERP, email, and maybe manufacturing systems, Sarathy says. "But as chemical companies progress in their digital journeys, they will realize, like in other industries, digital affords them the opportunity to fundamentally transform their business both externally and internally." To work, it needs to move from the traditional IT and CIO orientation of supporting the enterprise to a more strategic role of transforming the enterprise," Sarathy says. "We are seeing the emergence of the chief digital officer in many industries. This is a recognition perhaps of the fact that the two roles require different skill sets."

Workforce impacts

The increasing use of digital technologies will influence skills required, producers say. "We have experienced changes in required skills with increasing automation of our processes for decades," Hahn says. "What we do know is that with increasing complexity of information, the demand for pattern recognition abilities and methods to identify irregularities in data will rise."

Digital technologies can also help address industry's demographic challenges. "In the years to come, many experienced staff will go into retirement and will not always be able to pass on their knowledge and experience to succeeding colleagues," Hahn says. "Digital technologies give us the means to preserve knowledge and deliver it directly to where it might be needed."

Technical skills are not the only things that have to change; how companies



operate will need to as well. "We expect that the way we organize projects and our work will have to change," Hahn says. "Lean start-up methods are seen as key success factors, and we aim to foster these working styles to ultimately alter the mind-set of the organization at large."

The German chemical industry employers association BAVC and the union IG BCE apparently have addressed workforce issues with Germany's federal employment minister.

"We have to take the challenges of digitization seriously but also recognize and use the enormous opportunities," says BAVC president Margret Suckale. "That's the better way to go than one of increasing political regulation of work, which frequently overlooks the needs of employers and causes additional burdens for companies in terms of international competition."

"Digitization is an opportunity but also a threat," says Evonik chairman Klaus Engel. "Transparency is increasing along the whole value chain. This is much different, say, than 10 years ago. B2B was more or less like clothes shopping, essentially a product off the rack. The advantage now is you can see through to the end market, the consumer market, so you would have to really keep aware of these trends. You have to develop solutions for the end customer. You have to take solutions one step forward. Otherwise, you'll lose touch."