

Industry 4.0: **What's Next**

An SAP Point of View

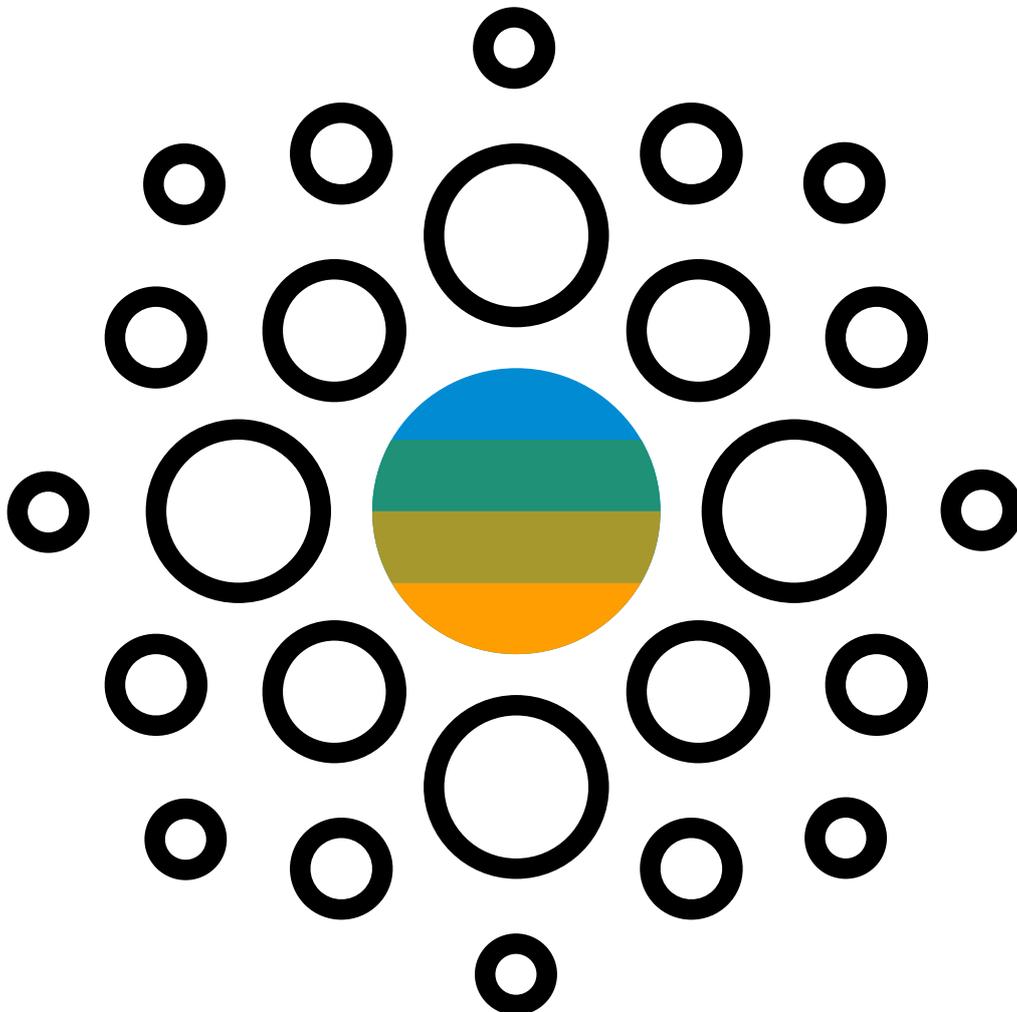


Table of Contents

- 3 The Industry 4.0 Revolution Is Under Way**
 - 4 Taking Industry 4.0 to the Next Level
- 5 A Trifecta Convergence Is Changing the Game**
 - 5 Bringing the Customer into the Product Value Chain
 - 7 Staying Ahead of Digital Disrupters
- 9 Expanding the Definition of Industry 4.0**
 - 10 Level 1: Customer Retention and Catch-Up Innovation
 - 10 Level 2: Customer Empathy and Incremental Innovation
 - 11 Level 3: Customer Intimacy and Disruptive Innovation
- 12 Business Value of Going Beyond Industry 4.0**
 - 13 Level 1: Efficient, Connected Manufacturing
 - 13 Level 2: Better Offerings Based on Product Usage Insights
 - 14 Level 3: End-to-End Solutions and Better Outcomes
- 15 Looking Ahead: Industry 5.0 – Platforms for Value Creation**
 - 16 Getting Started
 - 16 Learn More

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The Industry 4.0 Revolution Is Under Way

Industry 4.0 can solve key challenges facing manufacturers – from extreme supply, demand, and design variability, to emerging markets of one, to the growing need for rapid innovation. Leveraging the principles of Industry 4.0 – and its enabling technologies to automate, integrate, and optimize manufacturing processes – companies can shorten cycle times, improve product quality, and implement efficiency across their operations, as well as grow the manufacturing of highly customized products on a global scale.

What makes all of this possible is the way Industry 4.0 is disrupting – and deepening – the relationships between manufacturing, customers, and suppliers. Industry 4.0 shifts manufacturing from isolated, optimized cells of business processes, systems, and resources to fully integrated data and product flows across corporate borders.

We're already seeing examples of companies reaping the benefits of their Industry 4.0 journey, which is a testament to the fact that executives see its huge potential value.

With an Industry 4.0-enabled factory, Harley-Davidson can build 1,700 bike variations on one production line and ship an individualized bike approximately every 90 seconds. At the same time, the company has brought costs down 7%, increased net margin by 19%, and slashed the locked schedule to build a bike from 21 days to 6 hours.¹

Some drink producers (for example, Coca-Cola with its Freestyle initiative) have created “smart” vending machines that allow consumers to configure their own soda flavor at the time of consumption. With lots of mixture options, consumers can mix together any number of their favorite flavors in seconds.² Sensors monitor levels of flavor syrups in the machines and send alerts to the supply chain, which responds swiftly to replace anything a machine is running low on. Drink producers can also track customer mixes to understand preferences and trends – insights that can be used to develop new canned sodas.

Certain steel and paper companies are building the Internet of Things directly into their production processes to detect or predict deteriorating quality. Their goal is to detect issues early enough for operators to “save” the product by making adjustments in real time. Companies can set up product-specific rules to identify a quality defect (for example, the width or composition of tubes, paper, or steel plates) – and the faster they can recognize a quality problem, the earlier they can adjust manufacturing parameters or trigger maintenance tasks to head off a problem. This improves manufacturing output and speed to market, reduces waste and scrap, and minimizes energy for rework.

1. Richard Howells, “How Harley-Davidson And Other Companies Deliver Individualized Products,” Digitalist Magazine, SAP SE, July 2016, www.digitalistmag.com/digital-supply-networks/2016/07/18/how-harley-davidson-and-other-companies-deliver-individualized-products-04331406.

2. Ibid.

As illustrated by the three real-world examples highlighted in the sidebars, companies are harnessing new technologies to enable unprecedented digitalization horizontally across their functional silos and value chains, as well as vertically from the top floor to the shop floor. For example, sensors and microchips can now be added to almost every tool, machine, and even component, thus making things “smart” and able to receive and share real-time information. The data they generate can be merged with enterprise data and product flows across internal borders, enabling companies to decrease cycle times, improve product quality, and factory efficiency.

For example, companies can:

- **Operationalize mass personalization** by manufacturing individualized products at the efficiency of mass production to give customers what they want, when they want it, while streamlining the supply chain. Using advanced digital technologies on the shop floor, manufacturers can automate production lines in ways that allow them to quickly change configurations, thus adapting to the needs of specific customers.
- **Perform maintenance based on actual operational conditions, usage levels, and predictive insights** rather than preset time intervals. Decisions and investments can be based on real-time asset sensor data reflecting an asset's current state. This data can also be used to predict failures and proactively head them off – or adjust production schedules to meet customer delivery dates. In either case, companies can maintain planned production levels or adjust to meet customer expectations.

- **Improve inline quality control**, for example, to identify deteriorating quality in time to “save” the product and minimize scrap costs by adjusting manufacturing parameters or triggering a maintenance task to solve a problem.
- **Identify patterns and root causes for customer complaints**, such as product color deviations and surface defects, and trace their relationship to process parameters, maintenance, and raw material suppliers.

TAKING INDUSTRY 4.0 TO THE NEXT LEVEL

But from an SAP perspective, this focus on optimizing what happens within the four walls of a manufacturer represents only the first stage of Industry 4.0 – the foundation for even greater transformation and potential. Soon everything will be connected: every asset, material, supplier, worker, warehouse, delivery truck, stakeholder, and customer.

At the same time, products are rapidly becoming more intelligent and even interactive, which is creating more opportunities to apply emerging technologies in ways that we could not imagine before. For example, products are aware of their health and status and communicate this information with the right people and systems at the right time.

As explored in this paper, advanced Industry 4.0 – made possible by an increasingly connected ecosystem, new technologies, and shifts in customer mind-sets – can bring customers of products (and in business-to-business [B2B] contexts, even **their** customers) into the product value chain. And as we'll see, this greatly expands the potential value of Industry 4.0.

A Trifecta Convergence Is Changing the Game

Three developments are pushing Industry 4.0 to the next level.

Digital, intelligent products: Companies can now develop intelligent, connected, and self-aware products capable of sharing information about their health; location; wear and tear; usage level, type, and timing; storage conditions; and more.

Emerging technologies: New technologies, such as cognitive computing, 3D printing, augmented reality, blockchain, machine learning, artificial intelligence, voice-controlled user interfaces, and robotics, are reaching a tipping point in terms of readiness and availability. These technologies are making it possible to translate futuristic digital business concepts into business realities for the very first time. Imagine using augmented reality on the factory floor to get job information, access raw material information, process instruction sheets, and even do physical inventory by detecting where workers look.

Shifts in customer attitudes, behaviors, and expectations: From wearables, connected cars, and networked running shoes to hyperconnected industrial products, the Internet of Things is positioned to give companies and organizations even more opportunities to collect data and use it to their advantage. Customers are clearly changing their attitudes about sharing previously “private” information with trusted companies

they do business with – especially if they get something valuable in return – and this is enabling a heightened level of customer empathy that can transform product value chains.

BRINGING THE CUSTOMER INTO THE PRODUCT VALUE CHAIN

These developments are making it possible to bring the customer into the product value chain as an indispensable “user contributor.” When customers – both B2B and business-to-consumer (B2C) – purchase and use connected, self-aware products, they can send product and usage data passively in the course of daily activities and work (for example, usage levels, wear-and-tear rates, maintenance information, and functionality used and not used).

This data can be used to inform every aspect of the product value chain, as shown in Figure 1. Upon the purchase of a smart refrigerator, for example, a customer agrees to passively stream product and usage data from that refrigerator on a continuous basis. Sensors that have been built into the refrigerator capture and send performance and operations data useful to every player in the product value chain. As a smart product, the refrigerator can send data or alerts when compressors are overheating, vibrations or temperatures are exceeding desired maximums, or refrigerant levels are low.

Looking ahead, we anticipate that traditional manufacturers of B2B and B2C products will no longer be able to **compete without employing** the philosophy and methods of Industry 4.0.

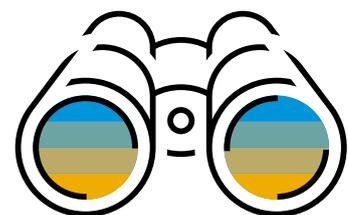
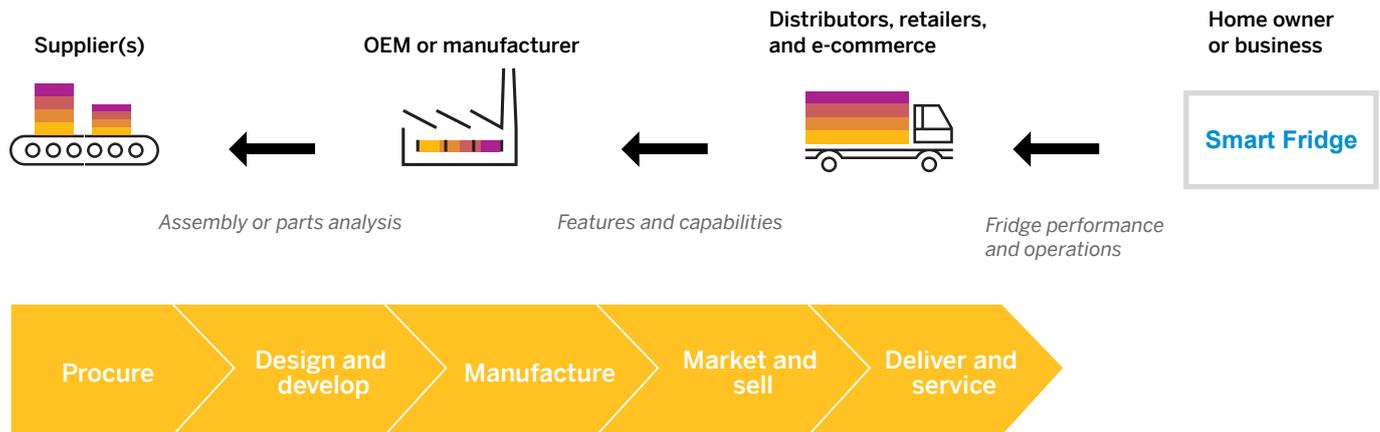


Figure 1: The Value Chain Focused on Customer-Centered Product Development



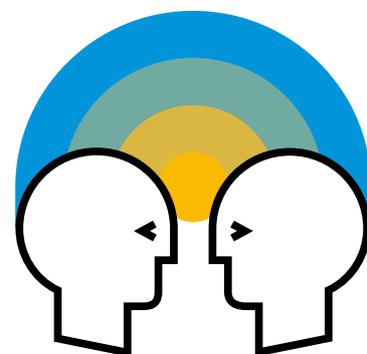
The implications of bringing customers into the product value chain through connected products are huge. Let's take a closer look.

Gain Meaningful, Actionable Insights for Deeper Customer Empathy

Most companies pay lip service to the concept of putting customers first, but they miss out on key opportunities as a result. Others do not grow,

because they fail to put themselves in their customers' shoes – to truly understand and address customer concerns. As a result, their product value chains repeat the same product, delivery, and service issues over time – or create new ones – and customers feel increasingly alienated.

Empathy **unlocks the power** in people – and companies – to improve the world.



Connected, interactive products can help companies break this cycle by exposing how customers use products day to day, which is different from traditional customer satisfaction data or information captured through surveys and customer support. The customer usage data from connected products gives decision makers a unique window into the customer experience, enabling a heightened level of customer empathy that's essential to building successful, profitable, long-term customer relationships. For example, when combined with social media data, manufacturing and supplier data, and traditional customer feedback from surveys and service desks, this "voice of the customer" data enables companies to establish a truly customer-centered product value chain that continually listens, understands, and adapts to meet customer needs and desires.

Act Swiftly on Insights in a Scalable, Cost-Effective Way

To fulfill customer expectations – and meet business expectations – companies will need a seamless, connected, and interactive business that can:

- Harness customer usage and other data to predict customer needs through live, dynamic profiling
- Respond instantly with the right products

- Deliver a consistent, omnichannel experience
- Share usage data to deliver more value to customers over time – for example, by building better products or providing more value through them

This is the entry point to what SAP refers to as Live Business, which is when companies have a true picture of their business and customers and act on what they understand, right in the moment. This ability is central to fulfilling the implicit agreement with customers willing to share product usage data: they must see meaningful value in exchange for their contribution to the value chain.

STAYING AHEAD OF DIGITAL DISRUPTERS

All of this is redefining customer relationships and how value is defined and created – thus creating opportunities for everyone from upstarts to forward-thinking industry leaders willing to boldly harness new technologies and data. These companies can quickly disrupt traditional manufacturing segments by "listening" to customer data and quickly developing customer-centered, data-focused solutions – not just quality, well-priced products.

"We have cars with sensors, we have homes with sensors, and we are starting to have bodies with sensors. Any organization that is not thinking about how this **digitized world impacts** or disrupts will wake up one day and wonder what happened."

Geoff Scott, CEO, Americas' SAP Users' Group³

3. Source: Paul Taylor, "Customers First: Feel the Empathy," Digitalist Magazine, SAP SE, January 2017, www.digitalistmag.com/customer-experience/2017/01/20/customers-first-feel-empathy-04846291.

Consider, for example, how **General Electric (GE)** anticipates a clear disruption in the energy value chain – and it is responding by harnessing its domain expertise and knowledge of how its customers use GE products to provide value in new areas to their customers.⁴ Management realized that in the not-too-distant future, data streaming from sensors built in to GE's products would eventually be worth more than the products themselves. This data could be harnessed to provide solutions that improve the performance of the machines, predict when they will break, extend and improve their functionality and uptime, reduce costs, and maximize return on assets. Eventually, machines will be able to regulate themselves without human operators, and even function differently based on changes in software. In this world, who owns an asset becomes less important when assets are delivered as part of a suite of services. And who owns and harnesses the data will ultimately own the market.

Similarly, **Siemens** is responding to the increasing role of digitalization in manufacturing industries by making it easier for customers to capture and analyze the enormous volume of data being generated by assets in real time and turn it into insights.⁵ These data and insights can be used to deliver totally new services that improve asset management, energy efficiency, resource optimization, and more.

And then there's **Local Motors**, which manufactures vehicles for the automotive market. Its digitally driven strategy is breaking all the rules –

and has the potential to disrupt the vast global automotive market. It manufactures custom vehicles that meet customer requirements by 3D-printing vehicle bodies and other components using composite polymers and fitting them with electric drive trains. The entire manufacturing process takes place in microfactories that can be set up in a matter of weeks. Local Motors has even reinvented the product design process: new products are developed through a global community of designers from inside and outside the company.

Local Motors' manufacturing and business model has already shortened the development time for a new vehicle from four to five years (the industry average) to one or two years, while doing so to a customer's market-of-one specifications. And it is able to make cars in drastically less time, with less capital and investment, and in smaller production facilities. The company is constantly innovating new materials, design methods, and advanced manufacturing processes to create new products that inspire, empower, and nurture people.⁶

These examples illustrate how, as everything gets more intelligent and communicative, companies will differentiate, in part, based on how they harness the latest technologies in combination with deep customer insight to innovate new products and services. For most companies, this will require venturing into the brave new world of connected, interactive products that collect customer usage data. Because if they don't, either a traditional or nontraditional competitor will.

4. "G.E., the 124-Year-Old Software Start-Up," The New York Times, August 2016, www.nytimes.com/2016/08/28/technology/ge-the-124-year-old-software-start-up.html?_r=0

5. "MindSphere – Siemens Cloud for Industry," The Magazine, Siemens AG, November 2015, www.siemens.com/customer-magazine/en/home/industry/digitalization-in-machine-building/mindsphere-siemens-cloud-for-industry.html

6. Dick Slansky, "Digital Transformation Changing the Face of Manufacturing," ARC Advisory Group, March 2017.

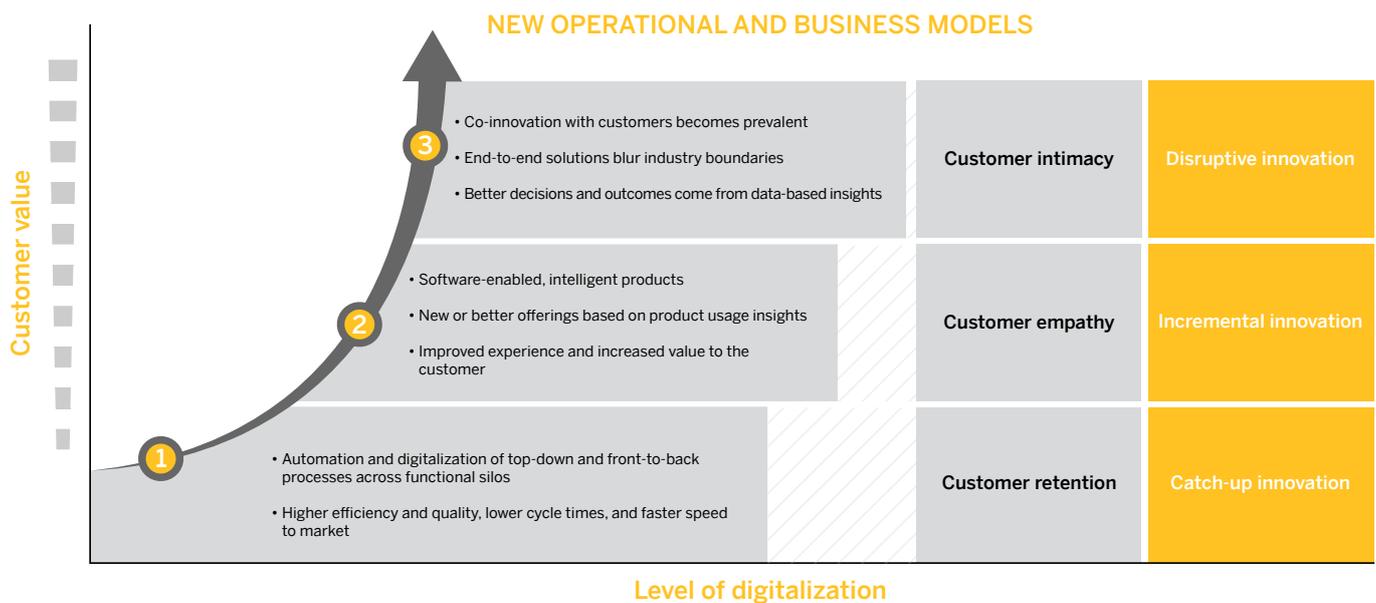
Expanding the Definition of Industry 4.0

Industry 4.0 is a transformational journey during which technology merges physical and digital worlds throughout the manufacturer's entire value chain – from the customer to R&D and the ecosystem of suppliers.

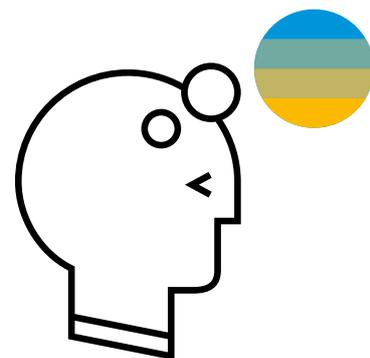
As shown in Figure 2, bringing the customer in to the product value chain extends the value of Industry 4.0 beyond the flexibility to make customized products as efficiently as mass-

produced items. As customer intimacy increases at each level of maturity, companies can innovate new operational and business models that deliver ever-greater value to customers. And through connected products, customers become key contributors of continuous insights, which companies can use to continuously transform products and the value chain that produces and services them.

Figure 2: A Model For Going Beyond Industry 4.0



Customer intimacy increases with maturity, and each **customer becomes a vital contributor** of continuous insights.



LEVEL 1: CUSTOMER RETENTION AND CATCH-UP INNOVATION

As shown in Figure 2, level 1 on the maturity curve generally aligns with what is commonly associated with Industry 4.0: automating, integrating, and digitalizing top-down and front-to-back processes across functional silos. This allows companies to decrease cycle times and improve product quality, efficiency, and speed to market – and, ultimately, increase customer retention.

In addition, at this foundational, essential maturity level, a forklift manufacturer, for instance, can invest in catch-up innovations that allow the business to produce products more quickly, more efficiently, and with consistent quality by digitalizing horizontally and vertically.

LEVEL 2: CUSTOMER EMPATHY AND INCREMENTAL INNOVATION

At maturity level 2, companies create software-enabled, intelligent products that help the customer become an active contributor to the value chain. Through sensors built in to products, customers can passively stream data about

when and how much the products are used, rates of wear and tear, when products need to be repaired or replaced, and so on. In this way, the user of products acts as a passive “user contributor” of information that cultivates customer empathy across the rest of the product value chain. As a result, companies can develop new and better products that customers want and need – and deliver meaningful value.

To return to our forklift manufacturer example, management can understand, for example, how and when a given product is actually being used (and if it is different than expected or originally designed for), how often and under what physical conditions, the rate of deterioration of key components of the product given this rate and type of use, and more. The manufacturer may learn that many customers are using their midlevel model in harsher conditions and for longer periods of time each day than this model was designed and built for, resulting in a shorter lifespan and frequent and costly breakdowns that are hurting customer satisfaction and sales and increasing warranty costs.

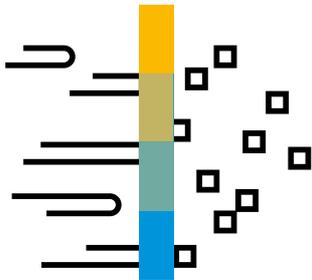
INDUSTRY 4.0 ELIMINATED A CLASSIC, PAPER-BASED MANUFACTURING ORDER PROCESS – AND THE RISK OF INCORRECT ORDERS AND DELIVERIES.

At its factory in Gerlingen, Germany, TRUMPF Werkzeugmaschinen GmbH + Co.KG used an Industry 4.0 approach to transform production of punching tools, of which there are approximately 31 million potential variations.⁷ Because 45% of the customer-individual tools are needed on the day of the order or the following day, speed and agility are essential.

Now each customer order automatically starts the production of the order, and the work piece has the detailed order information bar-coded onto it. This information triggers the instructions for the machines that make the tool and that deliver it correctly.

7. “TRUMPF: Intelligent Networking of Human, Machine and Component,” Plattform Industrie 4.0, Federal Ministry for Economic Affairs and Energy (Germany), 2017, www.plattform-i40.de/I40/Redaktion/FN/Use-Cases/127-trumpf-intelligent-networking-of-human-machine-and-component/article-trumpf-intelligent-networking-of-human-machine-and-component.html#trumpf.

Insights on product usage can be fed back into processes at any point in the value chain. For example, R&D can use such insights to make a more-robust midtier product or expand the company's product lines to meet newly identified requirements at different price points. At this level of the Industry 4.0 maturity curve, companies can invest with confidence in features and capabilities that customers really want, and truly differentiate themselves from competitors.



The new market leaders will “listen” continuously to their customers through streaming **product usage data** and respond swiftly with customer-driven products.

LEVEL 3: CUSTOMER INTIMACY AND DISRUPTIVE INNOVATION

At level 3 of the maturity curve, manufacturers use customer usage data to not only understand how customers are using, storing, and maintaining products, but also to co-innovate with them and even build digital, value-added services around physical products. These end-to-end services can broaden and redefine product value for entire markets, empowering companies to differentiate even the most commoditized products in new ways, just as Local Motors and GE are redefining their business models and value to customers. Instead of providing commoditized cars and industrial products, they now provide differentiated, digitally enabled mass customization and data-driven services, respectively.

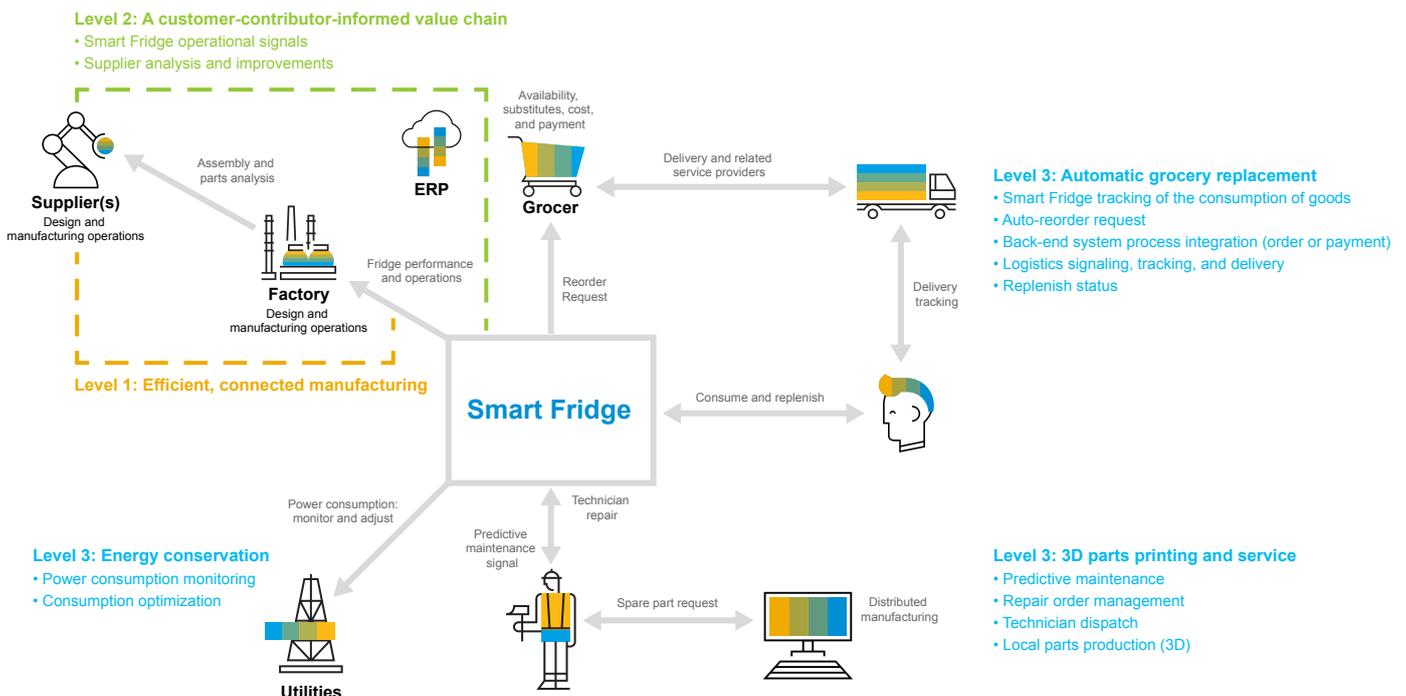
In a B2B context, redefined product value is tied directly to a customer's key performance indicators and bottom line. For example, a forklift manufacturer creates a data-based service that analyzes forklift movements within a warehouse and recommends the optimal deployment and routing of these assets to improve warehouse operations and reduce costs. It could share best practices with the customer on the optimal use of the product, given the design parameters; advise on how to achieve better outcomes and maximize return on investment; or implement predictive maintenance to maximize longevity and minimize downtime. As these examples illustrate, a manufacturer can help customers can make better, data-driven decisions that improve its business.

Business Value of Going Beyond Industry 4.0

By expanding the definition of Industry 4.0 to include levels 2 and 3, companies have a clearer path to become a market leader and even innovator, enabled by a customer-driven, extended, product value chain. Customers are incentivized to become active participants in product development and innovation by sharing their data, because they have been offered an extraordinary value proposition: the promise of highly personalized products and value-added, data-based services that meet their specific needs and are continuously improved based on what their data reveals. And because of investments at level 1 of the maturity curve, manufacturers can make these customized products quickly and in ways that keep prices affordable, even as innovation and personalization increases.

To illustrate how this concept can play out in the real world, consider the following example of a hypothetical manufacturer of commercial and residential refrigeration product lines. In this case, the company's Industry 4.0 journey has progressed to not only include B2B traditional suppliers that enable the manufacturer to make better products (refrigerators), but it also goes beyond this by involving other providers of data-based services around the product to expand the customer value proposition.

Figure 3: Transformation of the Refrigeration Product Value Chain



LEVEL 1: EFFICIENT, CONNECTED MANUFACTURING

At level 1 of the Industry 4.0 maturity curve, the refrigerator manufacturer invests in connected systems and processes so that:

- Manufacturing and supply chain processes can be organized to take advantage of intelligent interaction between machines, work pieces, processes, and people.
- Cost structures can be fundamentally transformed to cost-effectively serve new markets in underserved segments.
- Personalized product configurations can be manufactured and delivered to each customer in a scalable, profitable way.

LEVEL 2: BETTER OFFERINGS BASED ON PRODUCT USAGE INSIGHTS

At level 2 of the maturity curve, the refrigerator manufacturer can now capture live customer usage data. The company builds connected, interactive products that send a continuous stream of customer usage data, which it can use to power a customer-driven approach to product design. For example, designers of commercial refrigeration systems can use product usage data to know exactly what features and capabilities are being used and eliminate or redesign what's not used, which can lower overall cost per item. They

can also take segment-of-one personalization to a whole new level. The manufacturer can now advise corporate customers on what features of their product weren't used much and what functions they can eliminate to lower the cost of their next segment-of-one item, and suggest new options that may be of more value to them. This demonstrates a higher level of customer empathy, resulting in greater customer satisfaction and trust in the manufacturer.

The refrigerator manufacturer can also use this customer-contributor usage data to adjust the procure-manufacture aspects of the value chain to ensure that the right parts or replacement products are ready just in time. Uptime of refrigeration systems is mission critical for many organizations. Viewed from this perspective, product usage data is used all the way up the value chain to drive customer-centered maintenance and even demand planning. If manufacturers know when products in use will fail or are due for replacement, they can make better decisions about when to place raw material orders and plan production of replacement parts and entire products so goods are ready to meet customer needs. In addition, sales and marketing can proactively reach out to customers, or even have customers sign up for automatic replacements based on usage data.

Because most manufacturers don't make everything that goes into their products, they depend on an ecosystem of suppliers and partners. A supplier in this ecosystem can embed its own sensors into the materials, parts, and assemblies it provides to its OEMs, such as synthetic tubing used in refrigerators. In this case, the supplier can use these sensors to better understand how the tubing is being stored, when it fails at end-customer locations, the environmental conditions when in use, and more. By using this data, the supplier can improve its tubing product and recommend design changes to the OEM that could minimize failure rates of its refrigerators.

LEVEL 3: END-TO-END SOLUTIONS AND BETTER OUTCOMES

At level 3 of the Industry 4.0 maturity curve, the refrigerator manufacturer can redefine the value of the physical product by co-innovating with customers that have new needs or by developing or partnering in data-driven services around it.

For example, as shown in Figure 3, they can establish:

- **Automatic grocery replacement:** The refrigerator manufacturer can build sensors into its products to monitor the consumption of goods and autotrigger the reordering of items, as determined by the customer, through partnerships with grocery and related delivery service providers.
- **Energy conservation service:** The refrigerator manufacturer can resell customer usage data to energy providers who can then provide services to help customers – both commercial and residential – monitor their energy usage, and find ways to optimize power usage and costs.
- **Just-in-time, 3D printing of replacement parts:** Armed with predictive insights, the manufacturer can ensure timely parts dispatch in all locations and ensure immediate access to parts. For example, it can partner with third-party providers of maintenance services and equip them with 3D printers to generate the right parts, just in time for field service staff to bring them to customer sites.

As these examples illustrate, there's huge potential to expand and even reinvent a product's value proposition when companies capture and harness customer usage data and share it with a broader network of service providers and partners.

The big questions for manufacturers will be:

- What do they want to own, and what do they want to partner in?
- How will they monetize data when sharing it with service provider partners?
- How can they build trust both within the network and with customers?
- How can they safely share customer insights with suppliers to continuously improve materials and components built in to their products?

Looking Ahead: Industry 5.0 – Platforms for Value Creation

Looking ahead to Industry 5.0, we anticipate the further restructuring of product development and production in ways that will redefine not only manufacturing processes but also what a product is and the value it provides to customers. As more products incorporate digital technologies, they will move from being a bundle of functionality and become **platforms for value creation** – both for the user and the maker of products.

With each new product platform, new opportunities will be created for platform players to align with a platform and innovate on it. Success will require more than just the loose ecosystems of partners and suppliers. We envision tightly integrated ecosystems, or “industry mashups,” of companies in different industries working together to provide distinctive, significant value to customers through the creation and delivery of more-complete offerings.

Expect rapid evolution of these mashups, thanks to:

- The pervasiveness and exponential growth of data and the software that uses it
- Increased standardization of application interfaces, integration points, and automation technologies, which reduce friction and simplify the creation of mashups

Looking ahead, we expect Industry 5.0 mashups will create new and more agile offerings centered around customers’ demands, likes, needs, and preferences. As more products become platforms for innovation and value creation, opportunities will open up for companies to be platform adopters and innovate on the platforms of the players. And as we’ve witnessed time and again, no single company can own innovation on platforms.

GETTING STARTED

Clearly, the opportunities are great. And for many manufacturers, embracing Industry 5.0 will require stepping out of the familiar and into the unfamiliar – the world of software and everything digital. But the risks of not doing so are even greater, and we believe that they will impact companies much faster and more significantly than executives anticipate.

So how can companies get moving along the maturity curve? SAP recommends jump-starting the process by:

- **Reviewing and assessing your organization's current maturity level.** Determine current levels of automation and digitalization within top-down and front-to-back processes across functional silos. The goal is to identify opportunities for improvement in areas such as operational efficiency, product quality, cycle times, and speed to market.
- **Evaluating existing products.** Look for opportunities in which to embed software, intelligence, and connectivity to gain additional insights on product usage. The end-user data you collect from connected products can help you identify new customer needs, develop new or better offerings, improve customer experiences, and deliver increased – and even totally new – value to customers.
- **Investigating the potential of new technologies such as artificial intelligence, machine learning, and 3D printing.** Competitors are likely already doing so – so don't fall behind. By studying examples of other companies and thought leaders and partnering with solution providers driving innovation, you can learn how these technologies can help you change business models, strategies, and business operations in a whole new way.
- **Brainstorming about potentials for disruptive innovation and new business models.** They are the key to outpacing competitors and entering new markets. Brainstorming should include discussions with selected customers and analysis of how customers are using your products.

LEARN MORE

To learn how emerging technologies and innovation platforms can accelerate your transformation journey with Industry 4.0, see www.sap.com/leonardo.

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