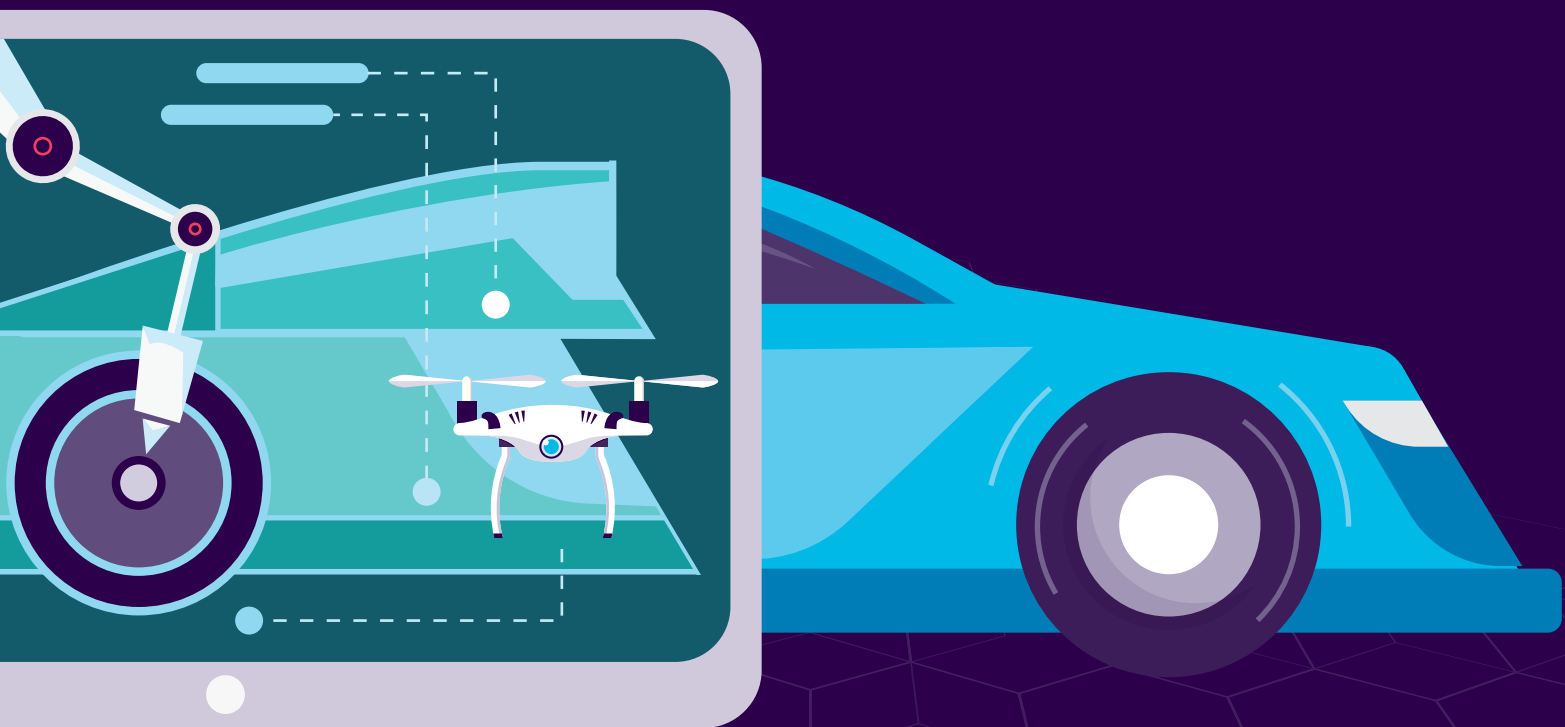


# How automotive organizations can maximize the **smart factory potential**



# Introduction

With the Fourth Industrial Revolution accelerating, manufacturing is focused on the factory of the future. Our 2019 research on smart factories in the sector found that nearly 70% of manufacturers as a whole have ongoing smart factory initiatives, up from 43% in 2017.<sup>1</sup> And, our 2018 research into the automotive sector in particular also found significant appetite.<sup>2</sup> Today, auto OEMs and suppliers are committing significant investment. Audi's Mexican factory was constructed with an investment of USD1.3 billion, while Great Wall Motor's smart facility in China cost USD629 million.<sup>3</sup>

While these are notable examples, we wanted to understand how auto firms are turning appetite for smart factories into reality. To understand whether they have been able to scale their smart factory initiatives, we surveyed a hundred auto firms, 98 of which have smart factory initiatives underway. We also spoke to executives overseeing smart factory initiatives across the world.

Based on our analysis, this report looks at the following areas:

1. The industry's appetite for smart factories and the progress made over the last 18 to 24 months
2. How smart factories benefit the auto industry
3. What OEMs and suppliers can do to scale their smart factory initiatives and achieve the full potential of this new industrial revolution.



# 1. Automotive firms have hit the accelerator on their smart factory plans

## One in two organizations has made good progress on their journey

Our previous research showed that the automotive industry was a leading adopter of smart factories – one of the top

three sub-sectors across manufacturing.<sup>4</sup> The reasons for this interest are many, from improvements in productivity to significant cost savings.

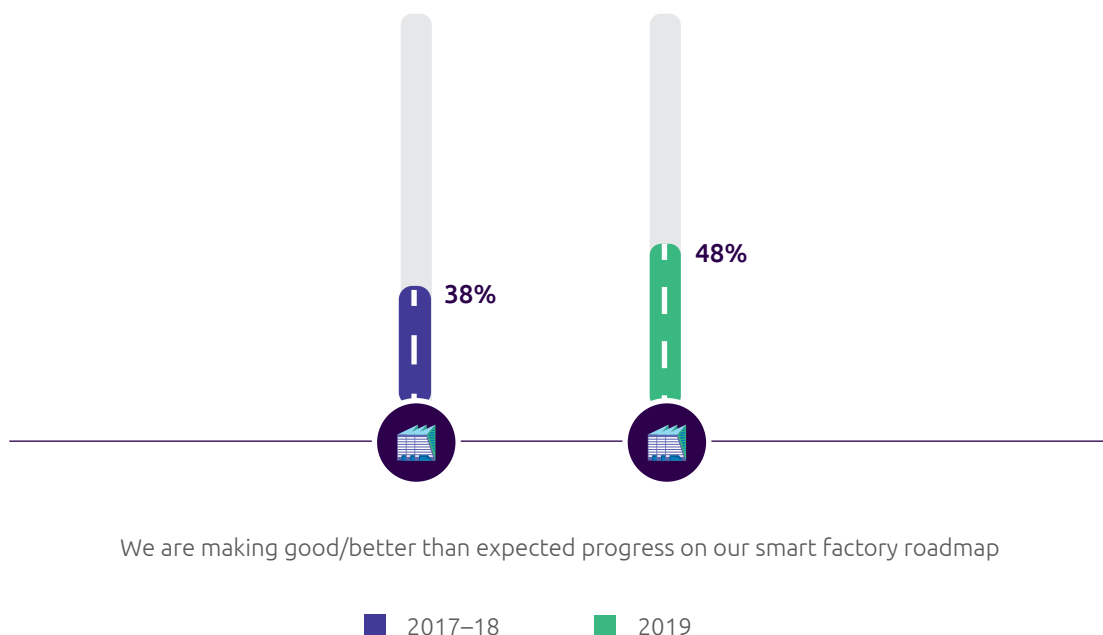
Our latest research confirms that the automotive industry has made significant progress in the past 18 months. And, as Figure 1 shows, nearly half of respondents (48%) say that they are making good progress against their smart factory roadmap. In our earlier study, this number was only 38%.

*“There are three primary reasons why we took up the smart factory initiative. The first is to improve the productivity of our old factories through modernizing and digitizing their operations. The second is to deal with the quality issues that are difficult for human beings to detect. And the third is to incorporate made-to-order or mass-customization capabilities. All these formed part of a massive internal strategic program called Modular Business Program.”<sup>5</sup>*

**Dr. Seshu Bhagavatula**, president, New Technologies and Business Initiatives at Ashok Leyland, one of the largest heavy vehicle manufacturers in India.

Figure 1

More automotive firms are progressing well on their smart factory roadmap compared to 18 months before



We are making good/better than expected progress on our smart factory roadmap

Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=100 automotive manufacturers; Smart factory survey 2017–18.

## What is a smart factory?

“Smart” factories leverage digital technologies to gain significant improvements in productivity, quality, flexibility, and service.

### Three key digital technologies enable the smart factory:

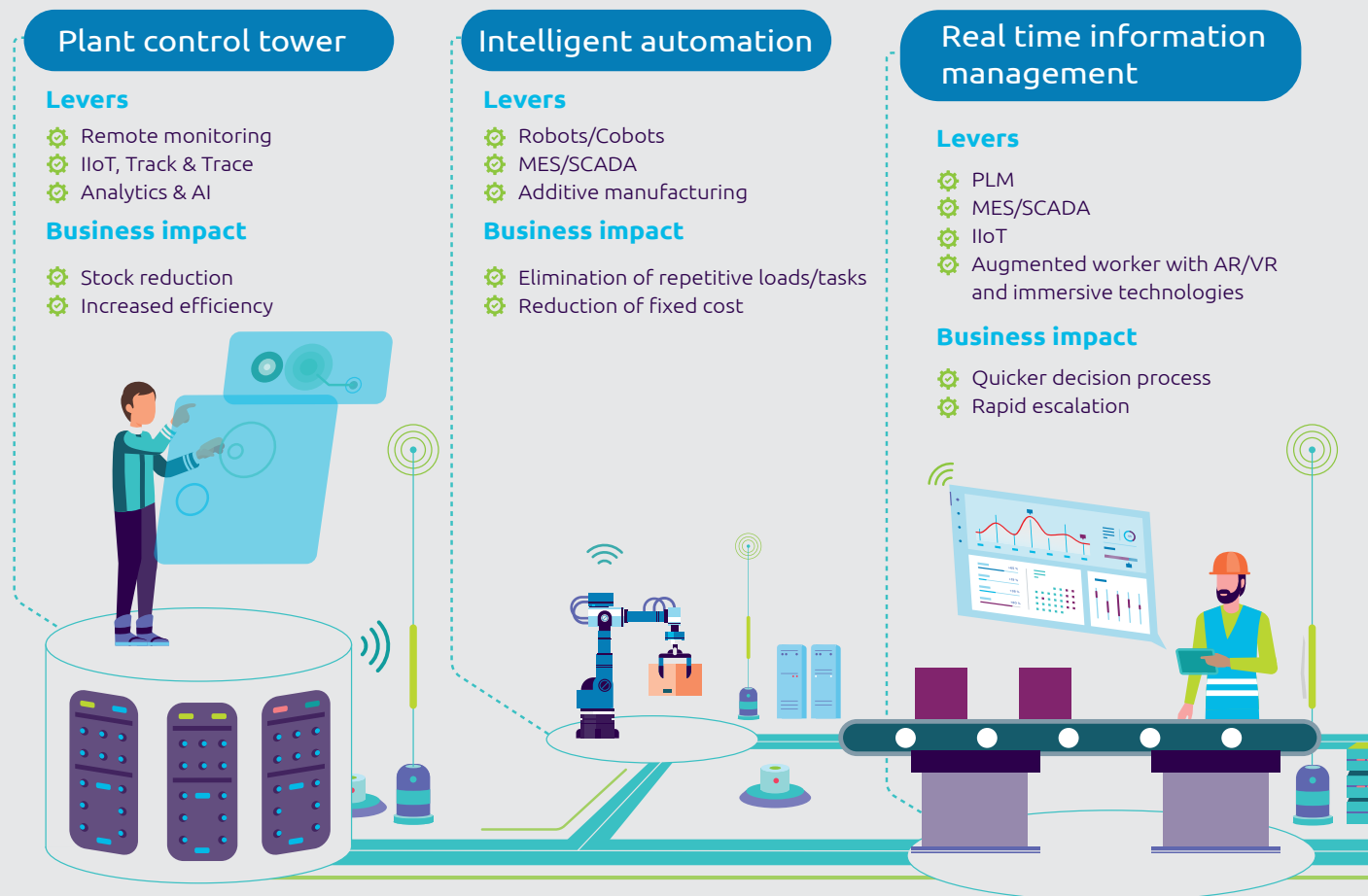
- **Connectivity:** for example, leveraging the Industrial IoT to collect data from existing equipment and new sensors
- **Intelligent automation:** for example, advanced robotics, machine vision, distributed control, and drones

- **Cloud-scale data management and analytics:** for example, implementing predictive analytics/AI.

These digital technologies will also enable IT–OT convergence to support end-to-end digital continuity from design to operations (digital twin).

The main characteristic of a smart factory is closed-loop, data-driven optimization of end-to-end operations. Advanced analytics are initially used for decision support, but the ultimate goal is to reach self-optimizing operations. This is where the factory constantly adapts to demand, variations in supply, and process deviations.<sup>6</sup>

**Figure 2** Smart factory operations leveraging digital technologies



## Energy management

### Levers

- ⚙️ Smart energy management leveraging sensors and IIoT
- ⚙️ Analytics and AI (prescriptive & predictive)

### Business impact

- ⚙️ Energy savings
- ⚙️ Reduction of peak consumption

## Enhanced operator

### Levers

- ⚙️ Augmented worker with AR/VR and immersive technologies
- ⚙️ Remote assistance

### Business impact

- ⚙️ Quality improvement
- ⚙️ Increased efficiency
- ⚙️ Operator empowerment

## Quality analytics and Adaptive testing

### Levers

- ⚙️ Analytics and AI

### Business impact

- ⚙️ Improving efficiency
- ⚙️ scrap reduction

## Predictive maintenance

### Levers

- ⚙️ Analytics and AI
- ⚙️ IIoT
- ⚙️ Predictive analytics

### Business impact

- ⚙️ OEE, MTTR, MTBF improvement
- ⚙️ Minimize downtime

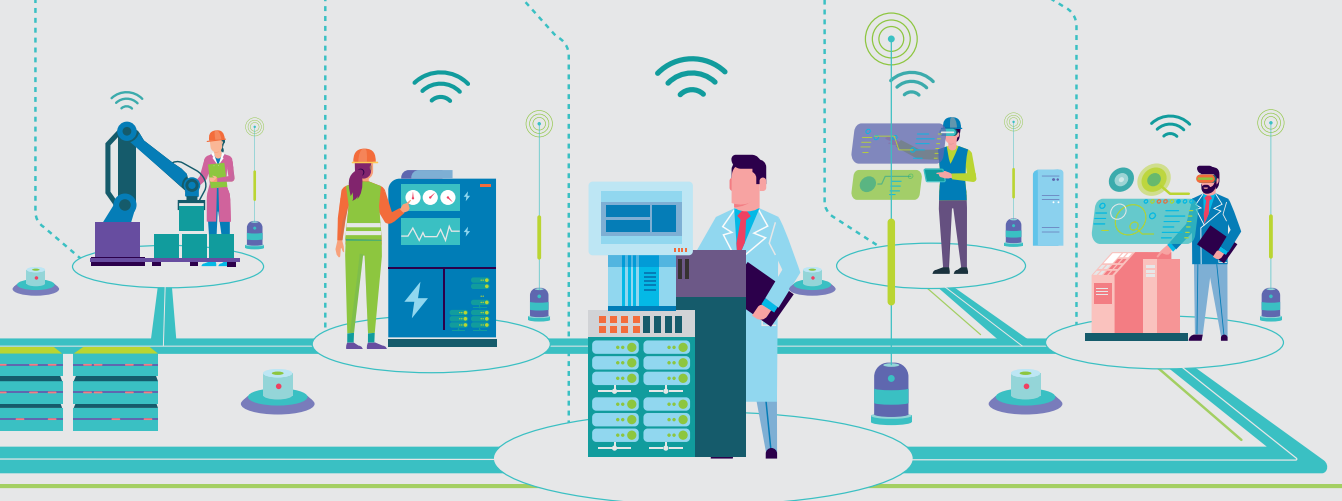
## Flow simulation

### Levers

- ⚙️ Digital twin
- ⚙️ IIoT
- ⚙️ Simulation with AR/VR

### Business impact

- ⚙️ Line balancing
- ⚙️ Virtual commissioning
- ⚙️ Reduction of production risk



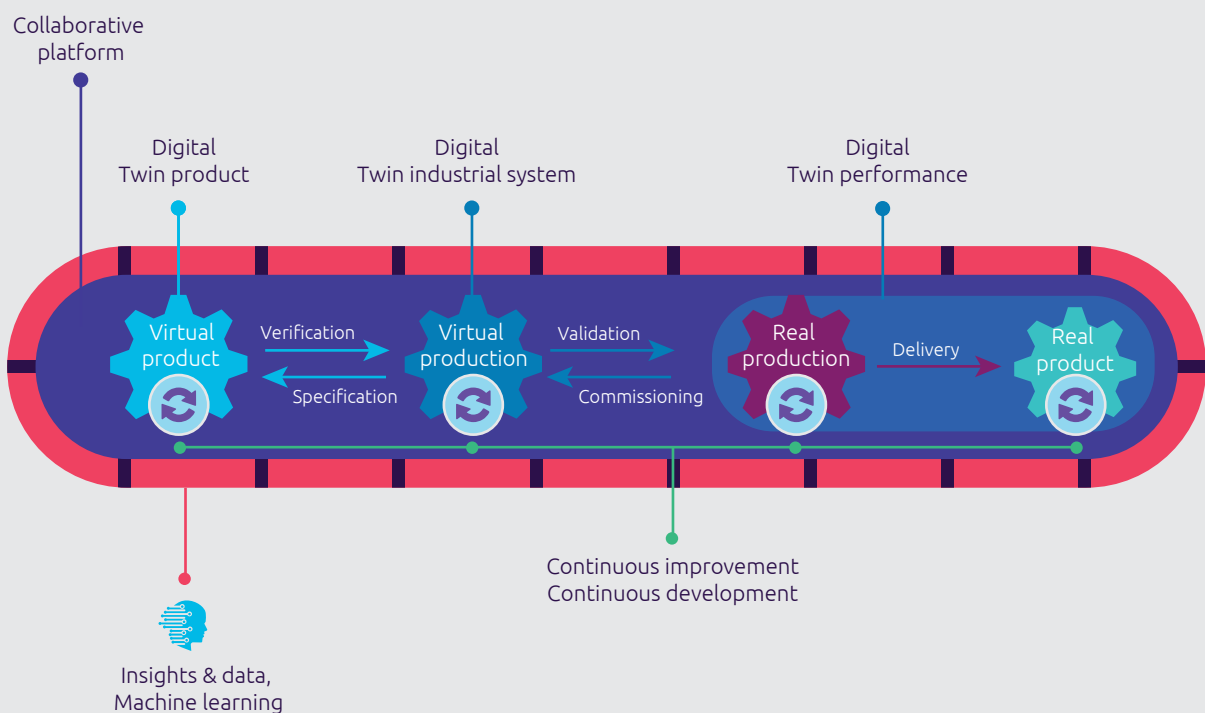
Source: Capgemini Invent and Capgemini Research Institute.

## What is a smart factory? (continued...)

Industrial Digital Twin is an essential part of the smart factory operations. Experimenting on physical products and industrial systems can be a timely and costly process. A digital replica, however, can be quickly edited

to test new product introduction, design changes and to run simulations. A digital twin further allows behavioral simulation and line balancing, virtual build and virtual simulations while being connected to shop floor. This connectivity will enable a direct continuous improvement of the factory. Figure 3 shows a high-level conceptualization of digital twin in manufacturing.

**Figure 3** Digital Twin in manufacturing



Source: Capgemini.

## Nearly one-third of factories have undergone a smart transformation in the past two years

Both auto OEMs and suppliers are focusing on smart factory initiatives. For example, Bosch invested 31 million euros in an Indian plant that features the latest Industry 4.0 solutions.<sup>7</sup>

Toyo Tire Corporation, a Japanese-based tire and rubber products corporation, announced a new plant in Serbia in July, 2019. The new factory, complete with a manufacturing execution system and enabled by IoT technology, aims to achieve high quality at a low cost.<sup>8</sup>

This commitment is reflected in this latest research. We found that auto industry players have made 30% of their factories smart in the last two years. As Figure 4 shows, this is higher than the 24% they planned for in our previous 2017–2018 research.



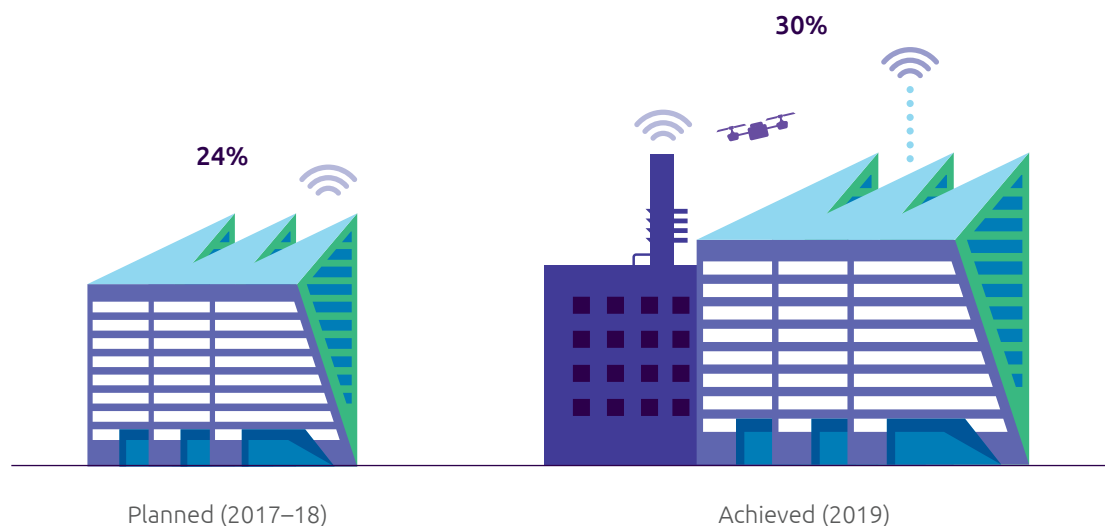
*Bosch is taking a further step toward more efficient, more flexible, and sustainable manufacturing in India in order to boost competitiveness and meet rising demand in the local market. The new Bidadi plant will further boost India's strong role in the Bosch Group's global network."*

**Volkmar Denner**, Chairman of the Board of Management of Robert Bosch GmbH, while inaugurating the expanded smart factory for mobility solutions.

source: online automotive magazine.

Figure 4

Three out of 10 automotive factories have been made smart in the past 18–24 months



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=100 automotive manufacturers; Smart factory survey 2017–18.

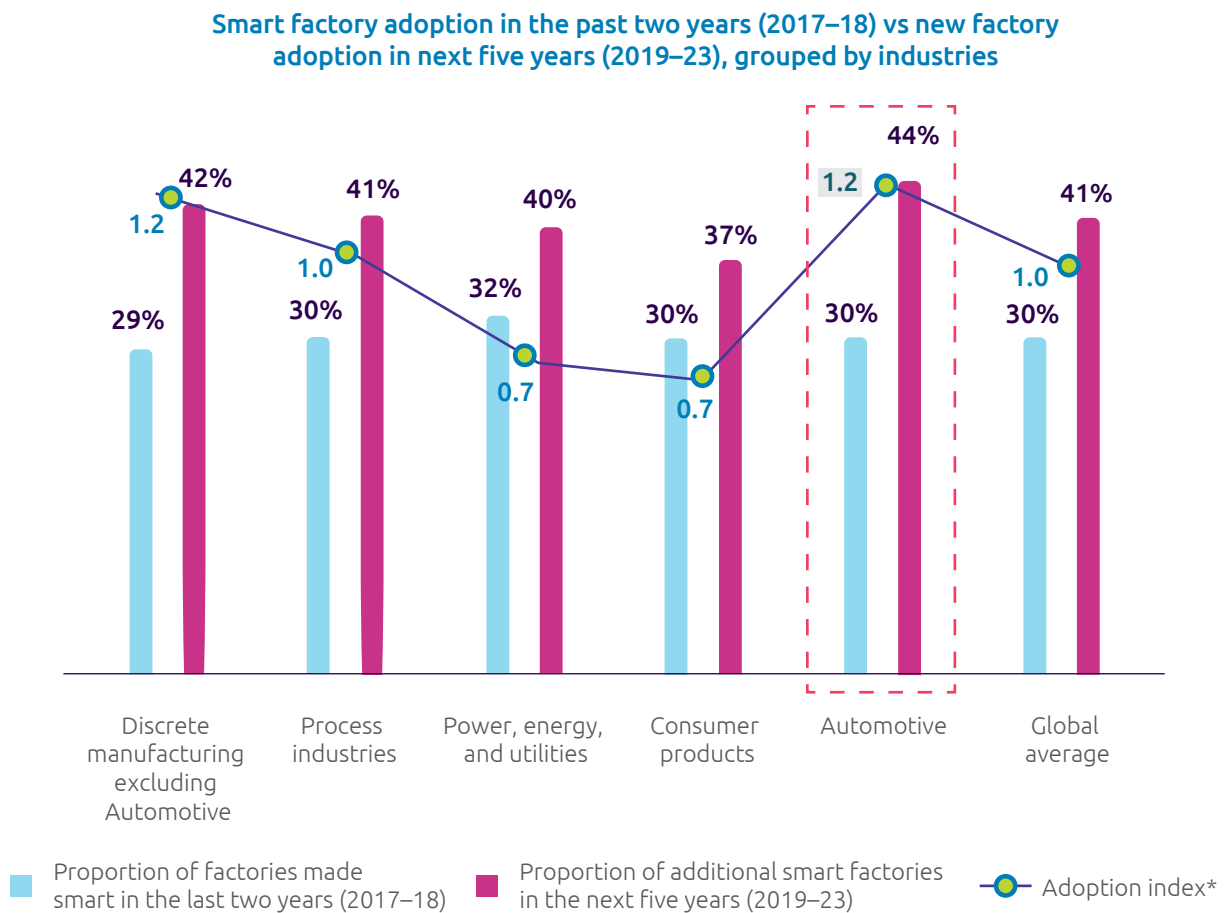
# 30%

*Share of automotive factories that have been made smart in the past 18–24 months*

# The industry has aggressive plans for smart factory adoption

Not only does the industry have ambitious plans for the next five years, it is more bullish than the rest of its peers in the manufacturing industry. We developed a smart factory adoption index that shows appetite for smart factories in the next five years (2019–23). The automotive industry has an adoption index of 1.2, similar to its peers in discrete manufacturing, but ahead of other industries.

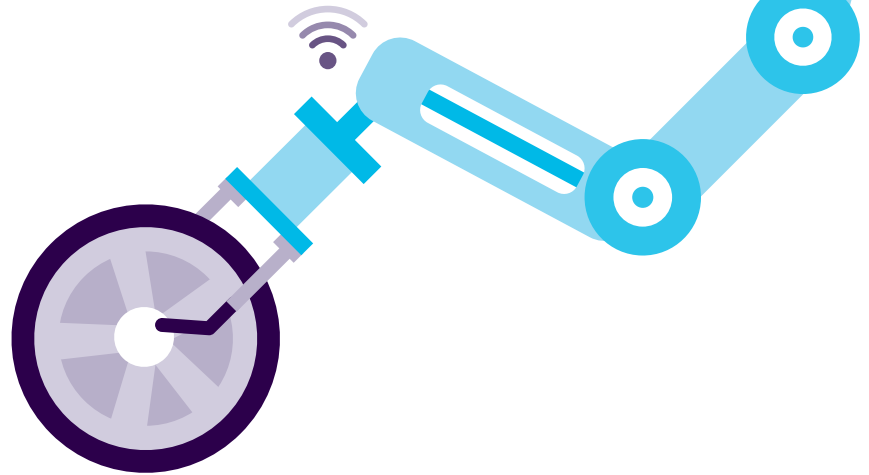
**Figure 5** The automotive industry plans to convert 44% of its factories into smart factories in the next five years



\*The smart factory adoption index shows the future expansion plans. An index greater than one means that the sector has a more aggressive expansion plan in the future compared to the average and vice-versa.

**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers that have existing smart factory initiatives globally; N=98 automotive organizations with smart factory initiatives.



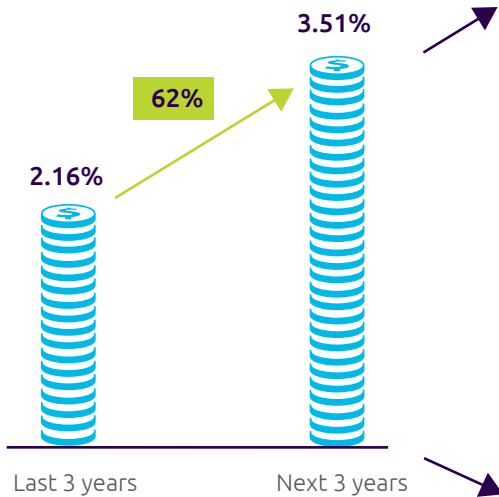


As a result, automotive firms are also planning to commit greater investment in the future. Over the last three years, they invested the equivalent of around 2.2% of revenue. Over the next three years, this will increase to the equivalent of

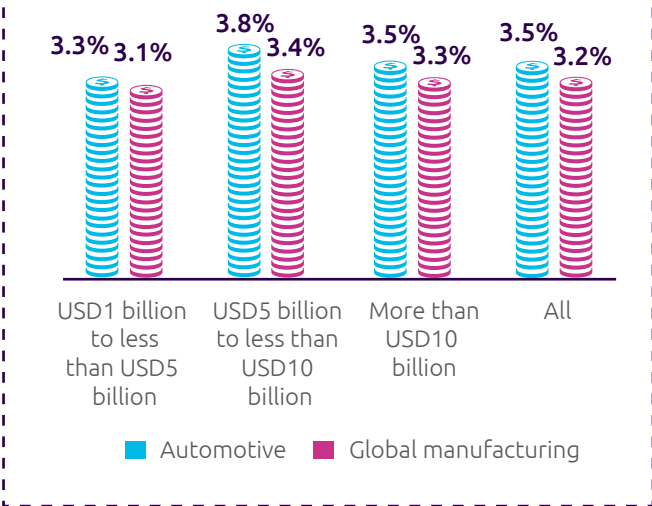
3.5% of revenues – a 62% rise. Overall, they plan to invest at a greater rate than the global manufacturing average (3.5% for auto; 3.2% for the industry as a whole).

**Figure 6** The automotive industry plans to increase investment in smart factories, as a percentage of revenue, by more than 60%

**Automotive industry's average annual investment in smart factories as a percentage of revenue**



**Average annual investments in smart factories as a percentage of revenue, in the next three years**



**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers that have existing smart factory initiatives globally; N=98 automotive organizations with smart factory initiatives.

**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=1000 manufacturers; N=100 automotive manufacturers.

## One in four auto firms are prepared to invest in a greenfield factory strategy

In our previous research, we estimated the cost of setting up a new greenfield factory for a top-ten auto OEM to be between USD1bn–1.3 bn. In comparison, the cost for a brownfield setup was estimated to be between USD4mn–7.4mn per factory:<sup>9</sup>

- Given the costs involved, it is perhaps not surprising that 44% intend to follow a hybrid approach, combining both greenfield and brownfield implementations and 31% intend to pursue brownfield opportunities (see Figure 7).

- However, a quarter (25%) intend to pursue a greenfield strategy, and this drops to 20% for the manufacturing sector as a whole. This appetite for greenfield stems from the fact that more than half (56%) said that a factory must be first efficient by design. This efficiency by design is more easily accomplished in a greenfield setup.

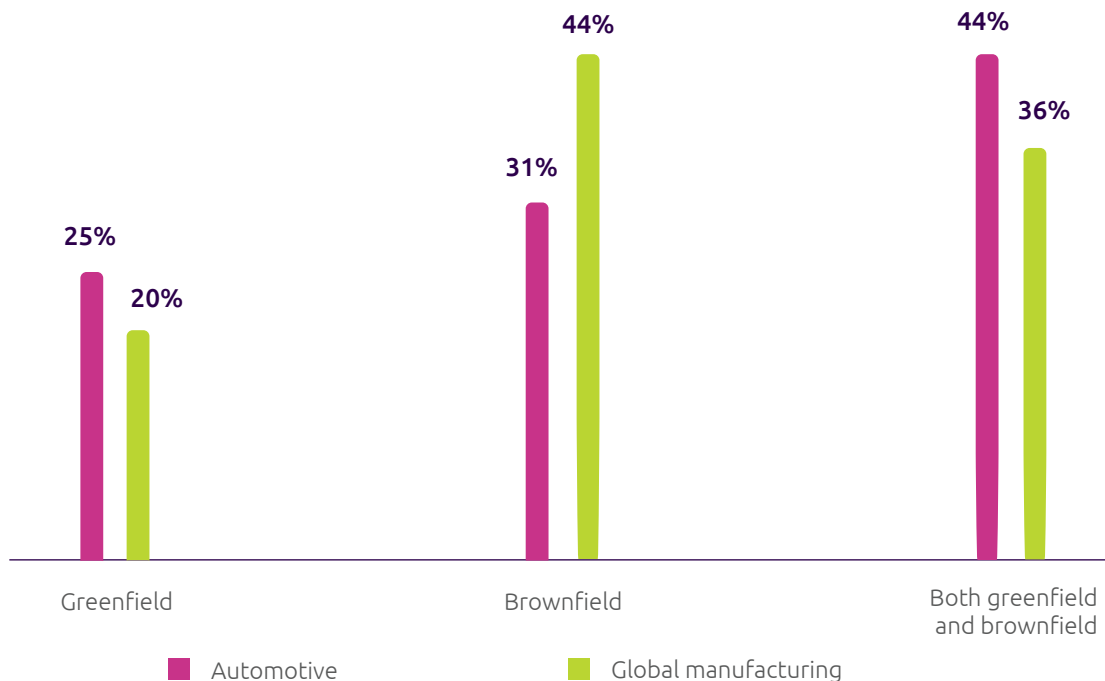


*“It takes a lot less effort on our part to get the job done right from the beginning than it does to do kaizen as re-work to get it right much later.”<sup>10</sup>*

**James P Womack,**  
founder, Lean Enterprise Institute

**Figure 7** One in four auto firms prefer to establish greenfield factories

Which approach did you take/have you taken/will you take to establish your smart factories?



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1000 manufacturers; N=100 automotive manufacturers.

# 80%

Share of automotive manufacturers who believe 5G would be key to their digital transformation over the next five years

## The Industrial IoT and 5G are gaining prominence, while focus on 3D printing has dipped since 2017–18

We analyzed what technologies are capturing organizations' attention in 2019. It showed that:

- The IIoT is gaining prominence**  
 The Industrial IoT is one of the prominent areas of focus for automotive manufacturers. While there are considerable challenges in scaling IIoT solutions – with only one in five auto firms saying IIoT is scalable – around a third agreed that it holds significant benefit potential. This is in line with our previous research on the Industrial IoT.<sup>11</sup>
- 3D printing has lost momentum**  
 Our research has shown that auto firms are not as focused on 3D printing as they were in 2017–18. While additive manufacturing has important use cases, its economical value for high-volume production is yet to

be demonstrated. Most of the common applications are for custom or spare parts for low volume production, which is how the technology is used by Bugatti and Porsche, for example.<sup>12</sup> However, additive manufacturing will likely play a critical role as the trend for mass customization becomes increasingly important.

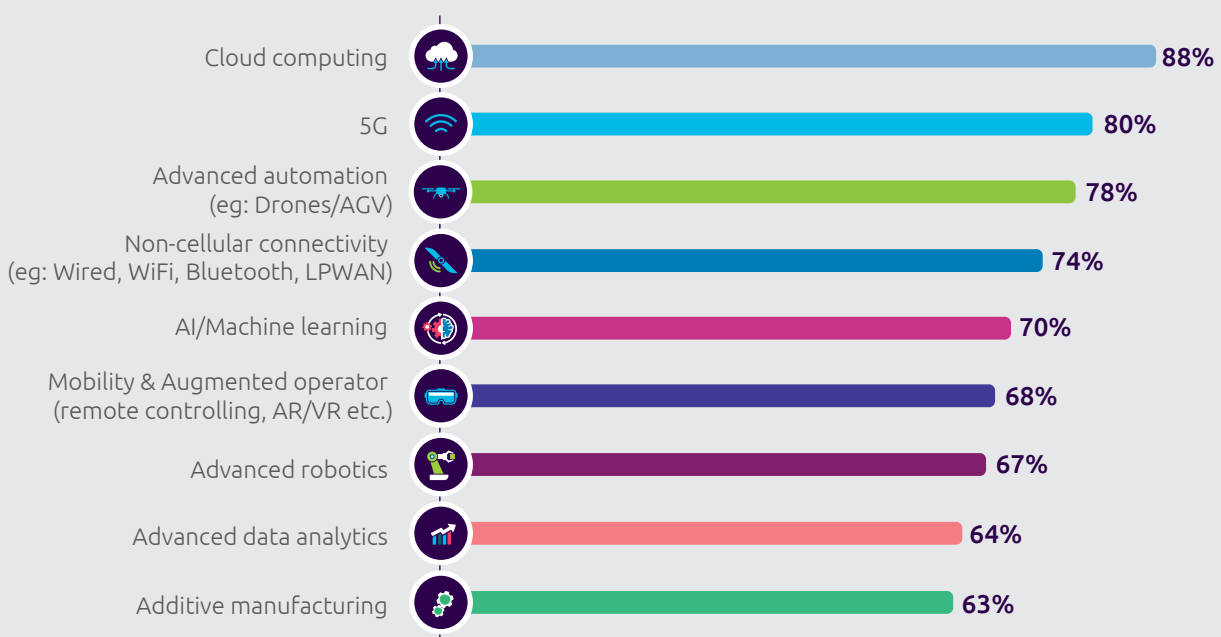
- 5G is a critical element in the automotive industry's digital transformation**

Earlier research that we have conducted into 5G's impact on industrial operations found that auto firms consider 5G to be a key, top-two enabler of their digital transformation, just behind cloud computing (see Figure 8).

The use of these technologies, however, cannot be undertaken in isolation, and requires work on some key foundational areas. For instance, organizations will need to have strong analytical and AI capabilities if they want to leverage IIoT applications such as edge analytics.

**Figure 8** 5G ranks second, after cloud computing, in the enablers of digital transformation

### The technologies that are key to digital transformation over the next five years



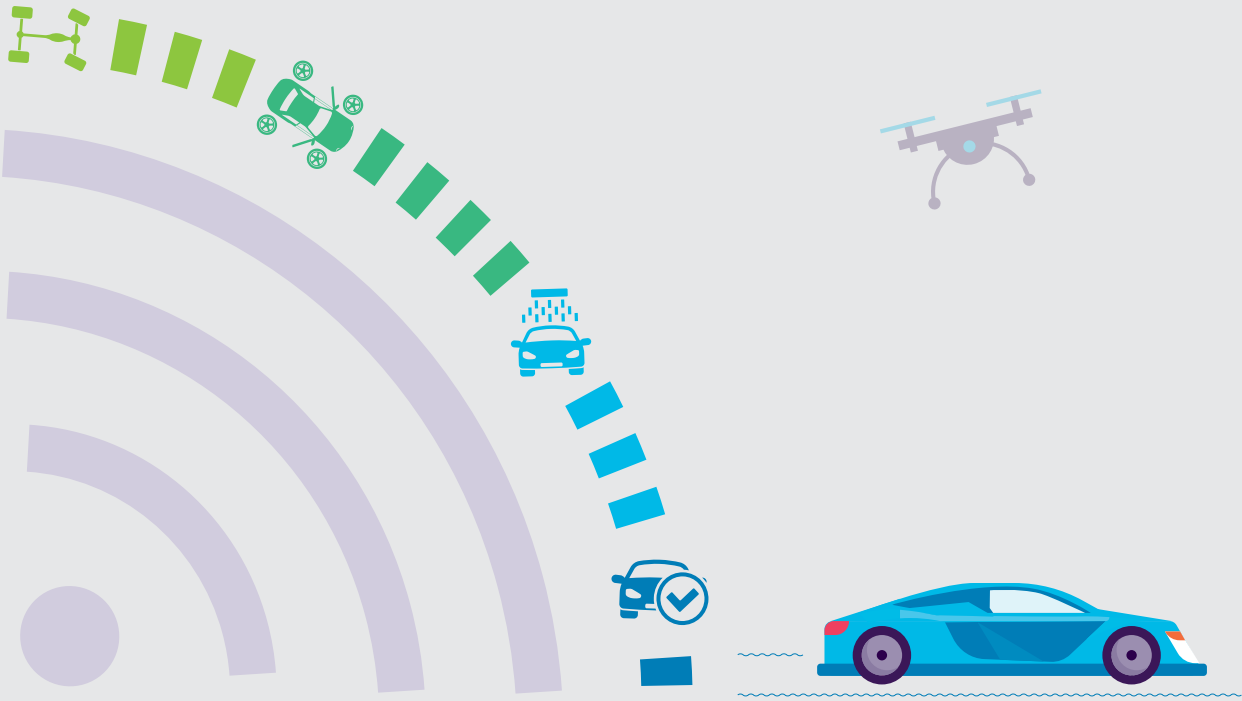
**Source:** Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies; N=97 automotive organizations.

That earlier 5G research also found that approximately a third (32%) of automotive organizations aim to acquire 5G licenses, with 28% planning to adopt 5G within a year of availability and 38% looking to adopt within 1–2 years.<sup>13</sup> Below, we outline the top 5G use cases for the industry.

**Figure 9** Top 5G use cases for the automotive industry

Manufacturing and shop floor operations	Supply chain operations
Tele-operated motion (e.g., collaborative robots, AGVs, drones)	Virtual testing of parts and packaging from suppliers through virtual reality
Real-time analytics leveraging edge computing	Self-triggered order placement based on inventory level
Troubleshooting through augmented reality	

**Source:** Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies; N=97 automotive organizations.



## 2. How can the automotive industry benefit from smart factories?

The bullishness of the industry for smart factories reflects the potential of the prize. A number of major firms, for example, have driven significant results from intelligent operations:

- **Mercedes-Benz** can virtually simulate its production process, right from the press plant to final assembly. To illustrate the scale of this, around 4,000 individual processes are examined for assembly alone, before production begins. They also used advanced data analytics to create self-learning and self-optimizing production systems. For example, its cylinder head production system captures and evaluates 600 parameters that influence quality, which has helped to reduce the rejection rate by a factor of 4.<sup>14</sup>
- **Renault** makes extensive use of technologies – such as collaborative robots, autonomous guided vehicles and augmented worker technologies – to produce a vehicle every four seconds. The use of exoskeleton technologies has helped Renault to reduce approximately 15 kg of load per plant-operator, and the use of tablets is saving one hour per day for their plant foremen.<sup>15</sup>

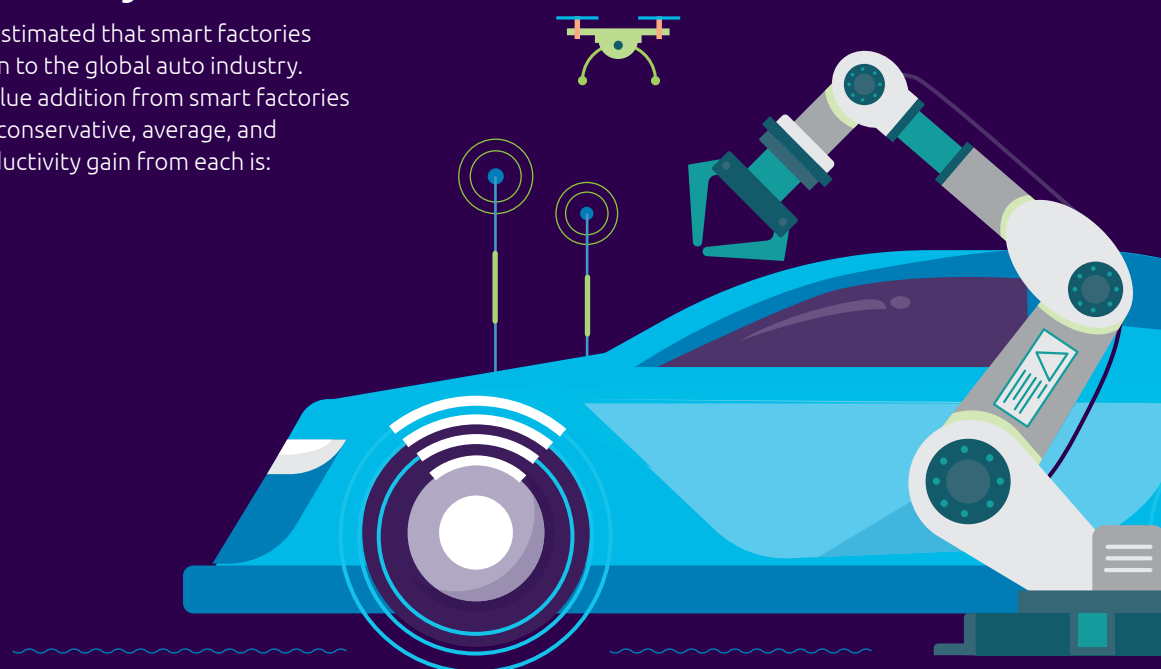
### The smart factory prize could be worth USD167 billion to the industry

In our previous research, we estimated that smart factories could add up to USD160 billion to the global auto industry. This time, we looked at the value addition from smart factories in three different scenarios – conservative, average, and optimistic. The potential productivity gain from each is:

- Conservative: USD104.3 billion
- Average: USD135.3 billion
- Optimistic: USD167.0 billion.

The average and optimistic estimates for productivity gains are made possible through an average productivity gain of 3.6% and 4.4%. Smart factory programs when deployed at scale will allow auto firms to achieve such gains.

To arrive at these estimates, we looked at the target productivity gains expected from each factory, as well as the share of additional factories the industry has planned for, in the next five years. We combined these with the existing factories and the gains from these. We then used the current value-add from auto industry to the global GDP and arrived at the final estimates. In Figure 10, we quantify these productivity gains.



**Figure 10**
**The automotive industry can gain up to USD167bn through smart factories**

	Conservative scenario	Average scenario	Optimistic scenario
A. Share of factories in automotive industry that had begun smart factory initiatives in 2017–18 (source: survey data)	25.9%	30.4%	32.1%
B. The difference between target productivity gain by 2023 and achieved productivity gain in the automotive industry so far (source: survey data)	14.0%	17.4%	19.9%
C. Share of additional factories in the automotive industry that will have smart factory initiatives in the next five years (2019–23) (source: survey data)	40.5%	44.5%	45.5%
D. Productivity gain target in next five years (i.e. by 2023) at factory level in the automotive industry due to smart factory initiatives (source: survey data)	28.2%	32.0%	39.0%
E. Productivity gain in the automotive industry due to smart factory initiatives by 2023 (A*B)+(C*D)	15.1%	19.5%	24.1%
F. Average annual productivity gain in the automotive industry due to smart factory initiatives until 2023 (CAGR computation from E)	2.8%	3.6%	4.4%
<b>G. Approx. automotive industry value added in the surveyed geographies in 2017</b> (source: Capgemini Research Institute analysis)	<b>USD692.6 billion</b>		
<b>H. Expected additional value addition by automotive industry due to productivity gain in smart factories by 2023<sup>17</sup></b> (sum of realized value and capacity gain) (F*C)	<b>Total value added:</b> USD104.3 billion	<b>Total value added:</b> USD135.3 billion	<b>Total value added:</b> USD167.0 billion

**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=100 automotive manufacturers, United nations' database for national accounts, accessed June 2019.

## 1. Audi: a greenfield smart factory in Mexico

Rising manufacturing and regulatory complexity – as well as changing market needs and consumer expectations – are increasingly requiring innovative technologies and an increasing number of vehicle variants. This means that the traditional fixed-time assembly line is becoming less efficient. The growing number of model derivatives and variants creates significant complexity and mean new routines need to be integrated into what is a rigid, sequential process. Audi is tackling these challenges, and developing a completely new proposition, which it calls “modular assembly.”

As part of this, Audi opened a 400-acre, USD1.3 billion smart factory in Mexico to produce the next-generation Audi Q5 for the world market. The plant has an annual production capacity of 150,000 of these premium SUVs and it will manufacture cars for consumers that are “tailor-made to their individual tastes.” It is considered to be one of the most state-of-the-art factories on the North American continent.

### An illustrative list of the technologies used in the factory includes:

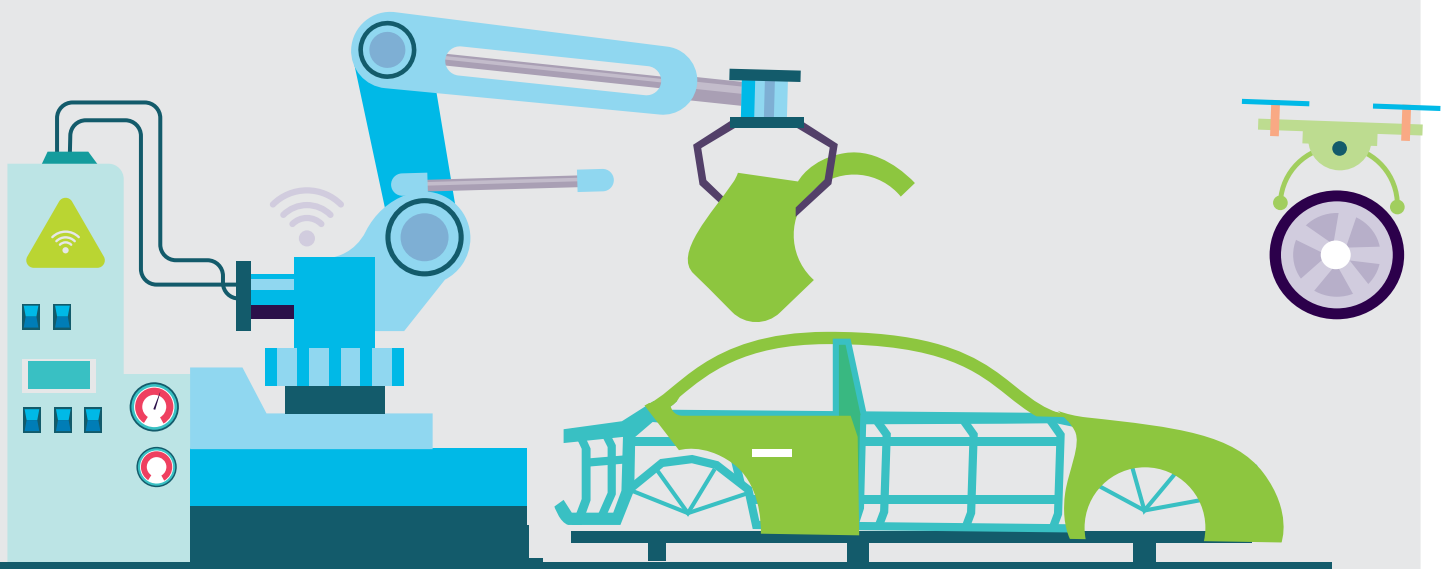
- Virtual assembly technology
- Autonomous ground vehicle
- Driverless floor conveyor
- Remote maintenance portal
- Metal 3D printing center
- Collaborative robots
- Drones

This is the first facility that Audi has put into operation completely virtually, i.e., using computer simulation, with factory planning undertaken with state-of-the-art technology. Next to the factory is a supplier park. Having this just-in-sequence (JIS) supplier park near the assembly line allows punctual delivery of components.

### Benefits: faster and better

Audi’s smart factory was put into operation 30% faster than usual. The factory also optimized the entire process chain. It employs centralized production control, RFID, smart logistics, and an automated quality-control process. These capabilities mean that Audi can coordinate production and supply chain with great flexibility, leading to very high productivity and efficiency levels.

The factory is also resource efficient. Water treatment methods, and the implementation of advanced technologies in the paint shop, will allow the plant to be free of wastewater. The equipment it uses will also significantly reduce water, gas, and electricity consumption.<sup>18,19,20,21</sup>



## 2. Smart factories at Mercedes Benz: Factory 56, Sindelfingen, Germany

“Factory 56” – the new smart factory from Mercedes Benz – is spread across an area of 220,000 m<sup>2</sup> and will be used to produce a range of cars, including luxury, hybrid, pure electric, and self-driving:

### Key elements include:

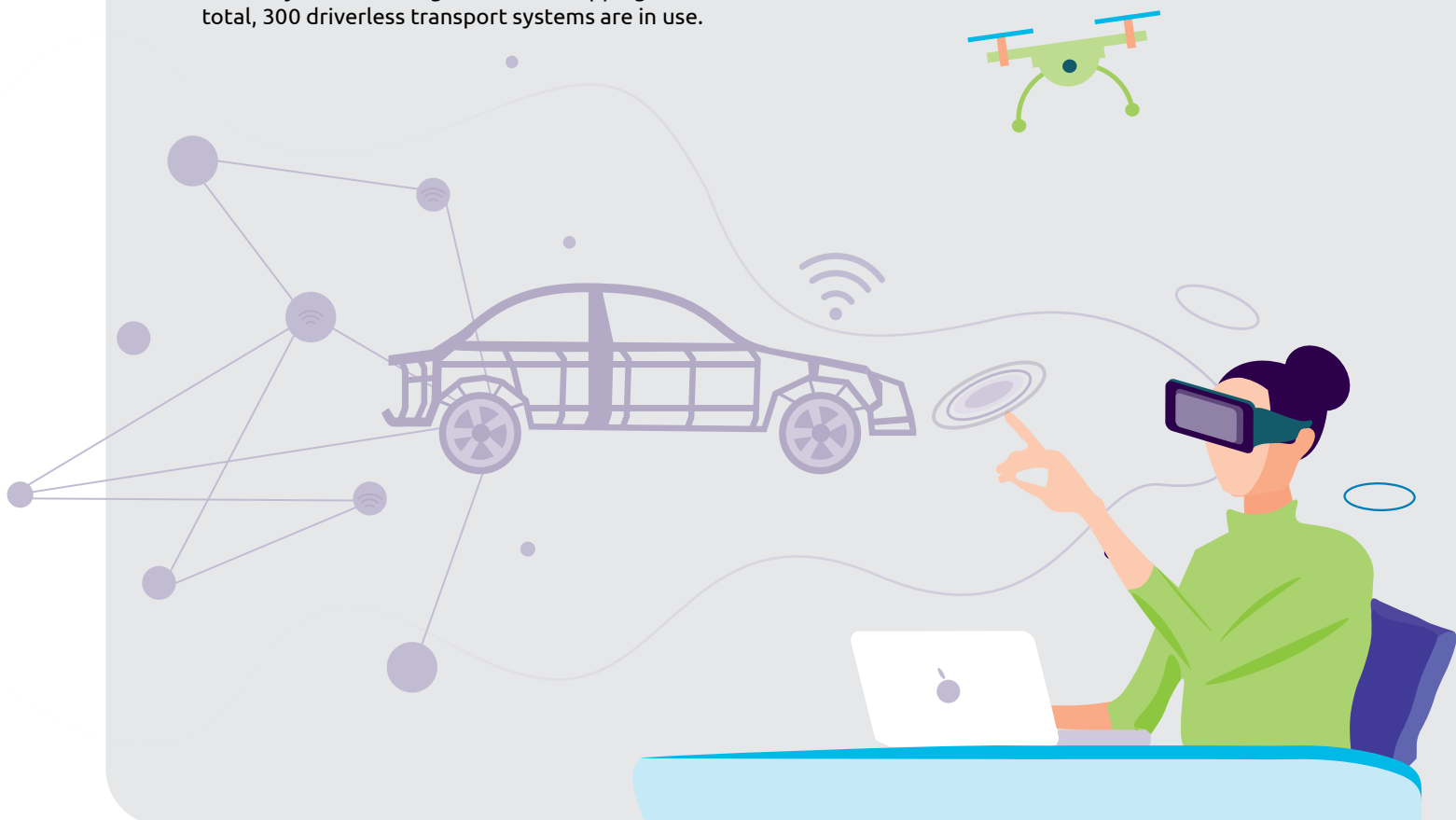
- In many areas, the traditional assembly line is replaced by “TecLines,” where driverless transport systems (DTS) move build-in-programs from section to section. By using DTS, individual assembly units can be expanded without interfering in the building’s structure.
- The IoT is used in assembly facilities and materials handling technology and is based on a mobile network. A pilot application is planned to test the use of 5G in assembly.
- The assembly hall is entirely paperless, with monitors and personal digital assistants used by employees.
- Intelligent picking systems automatically select materials/parts from pick-zones that are needed for assembly. These parts are then supplied to the assembly stations using driverless shopping carts. In total, 300 driverless transport systems are in use.

- Analytics technology is used to evaluate collected data and its findings are applied to improve existing processes. This helps prevent plant malfunctions and assists with predictive maintenance.

### Benefits of Factory 56

Combining an assembly line with “TecLines” makes assembly highly efficient and increases flexibility, so that production can be adjusted without any hindrance to current operation. This approach extends operating times and enhances quality. Quick reaction time is achieved by early detection of inconsistencies in the supply chain, using tracking and tracing.

The facility also aims for CO<sub>2</sub>-neutral energy supply. A photovoltaic system on the factory roof provides self-generated green electricity into the hall’s supply.<sup>22,23</sup>



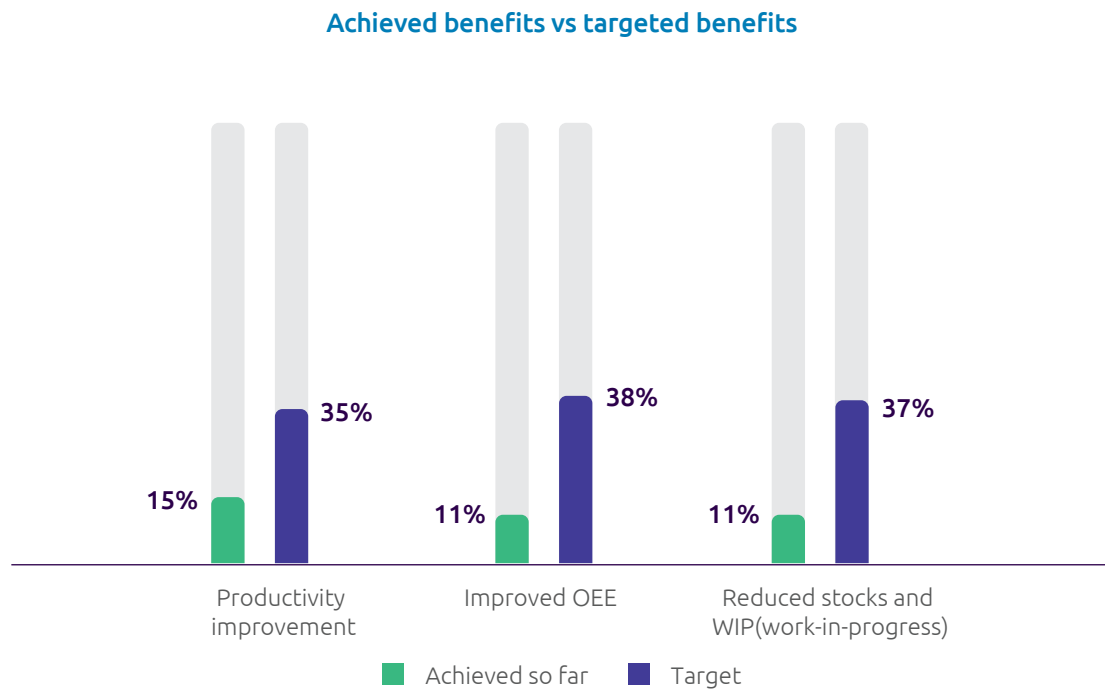


## Automotive firms, however, have a long road ahead before they can fully realize the potential of smart factories

As we saw earlier (Figure 5), automotive firms plan to convert 44% of factories into smart facilities in the next five years. And, these changes have the potential to generate significant productivity gains. But, while ambitions are high, delivering results is another matter. As Figure 11 shows, firms have set KPI improvement targets at upwards of 35% but achieved benefits has only hit 15% at best. While Audi's Mexican plant has shown that it is possible to gain benefits in excess of 30%, such results remain out of reach for many.

Figure 11

The benefits achieved lag behind the targets set



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=100 automotive manufacturers.

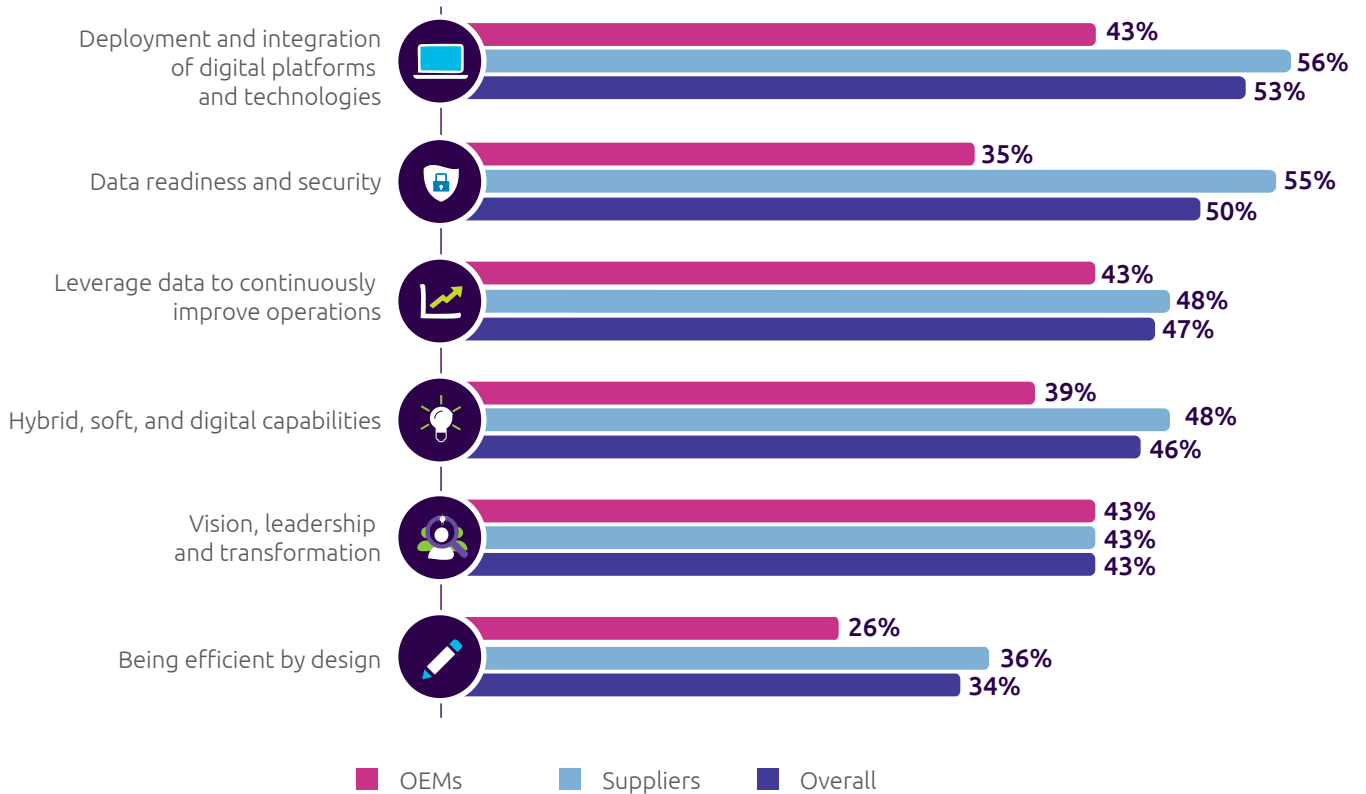
Higher magnitude benefits are only possible when initiatives are completely scaled within a factory and across factories. But for many, this is not happening, leaving them short of their targets. For instance, less than one in five auto firms have scaled remote assistance solutions. As Figure 12 shows, a number of challenges are putting a brake on achieving scale in smart factory solutions.

# 30%

*Audi's greenfield smart factory in Mexico was put into operation 30% faster than usual*

**Figure 12**

**Top challenges faced by automotive firms in realizing smart factory potential**



**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=23 OEMs, 77 suppliers and 100 automotive manufacturers.

To understand how ready companies are to address those challenges, we assessed the firms in our survey. The aim is to test their readiness for successfully driving their smart factory initiatives to scale. We looked at three main objectives:

- The vision and strategy required to deliver the transformation
- A focus on both efficiency by design and operational excellence while continuously ensuring virtual and physical consistency thanks to loopbacks
- Strong IT–OT convergence, which includes a command of technology capabilities.

(See “The smart factory transformation roadmap” in the Appendix for the dimensions that make up the framework.)

We used this analysis to group the organizations into three cohorts – Front runners, Experimenters, and Novices. The front runners are those who have mastered all the core areas of smart factories at scale and are in a position to realize the full potential offered. As Figure 13 shows, this group is in a minority. Among automotive firms, for example, only 10% are front runners. The vast majority – 73% – are novices and not in a position to seize the smart factory prize.

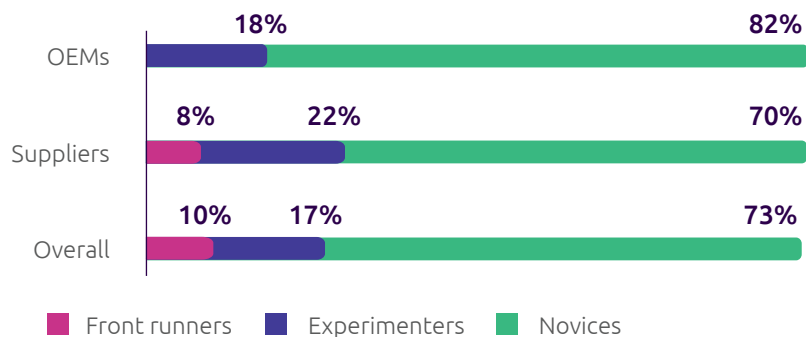
# 10%

Share of automotive firms that are in a position to realize the full potential of smart factories

**Figure 13**

**Only one in 10 automotive firms are able to reap significant benefits from smart factories**

### Readiness of automotive industry for scaling smart factory initiatives



**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=22 OEMs, 76 suppliers and 98 automotive manufacturers with existing smart factory initiatives.

### 3. Great Wall Motor: Chongqing, China

Great Wall Motor's Chongqing smart factory is intended to open a new chapter in its globalization strategy. Located in Yongchuan District, it has a capacity of 160,000 vehicles, was built with an investment of CNY4.5 billion (USD629 million) and covers an area of 708,000 m<sup>2</sup>.

#### Technologies

Intelligent manufacturing and automation are at core of this factory. This includes:

- 98 robots from FANUC in its welding workshop
- 46 gumming and spraying robots in its painting workshop
- Two automatic high-speed stamping continuous production lines
- An AGV-based automatic delivery system in the final assembly workshop
- Production planning coordination, quality management, equipment management, supply chain coordination, etc. are realized with APS, MES and other systems

- A warehouse management system and logistics executive system provide intelligent logistics management, including internal and external logistics management, logistics quality management, distribution management, and order-driven warehouse management.
- An enterprise application software platform and a virtual cloud system are employed to realize intelligent digital operation management of e-procurement, human resources, asset management, and office automation, among others.

#### Benefits

The factory only took 14 months from commencement of construction to commissioning. The welding workshop has a 100% automation rate and the final assembly workshop has 70% automatic on-line rate. The factory also treats a range of emissions – VOC, COD, and amine-chlorine – in parallel to help drive its green credentials.<sup>24,25</sup>

## Suppliers are positive about the smart future, but very few are in a pole position to reach their goals

In our 2017–18 research into this topic, we found that automotive OEMs were outperforming a majority of suppliers in smart factory adoption (excluding the top suppliers). In the last 18 months, however, suppliers seem to have made greater progress.

While 48% of the overall auto respondents said they were making good or better than expected progress on their adoption roadmap (as seen in Figure 1), this increases to over half (52%) of suppliers.

Ambition is also high among suppliers: they plan to make 44% of their factories smart in the next five years. But while that ambition is encouraging, as we have seen, only 8% of suppliers are classified as front runners – the group that is in a strong position to realize the full potential of smart factories. Overall, suppliers face some significant challenges in a number of areas (see Figure 12):

### I. Deployment and integration of platforms and technologies:

- Only 45% of suppliers agree that it is critical to integrate their PLM systems with smart factory systems
- Just 42% have a well-defined and progressive OT-IoT-IT convergence roadmap
- Only 30% of suppliers have an end-to-end integrated platform from device to analytics.

### II. Data readiness and security and the ability to leverage data for operational excellence:

- Fewer than one-third (32%) of suppliers have a complete view of the data flows across all processes and all IT–OT systems
- More worryingly, a quarter of suppliers said they had experienced a cyber-attack in their factories over the past 12 months.

### III. Shortage of talent

- Skills in short supply include: advanced robotics and smart automation, track-and-trace solutions, mobility, and augmented operator solutions, cloud computing, and IoT.
- Significant effort and investments are needed to build the skills needed for smart factory implementation:
  - Over half of respondents said they have a gap in the required technical and soft skills for smart factory implementation
  - Only around a third (35%) have defined the competencies and new job roles needed for smart factory initiatives.

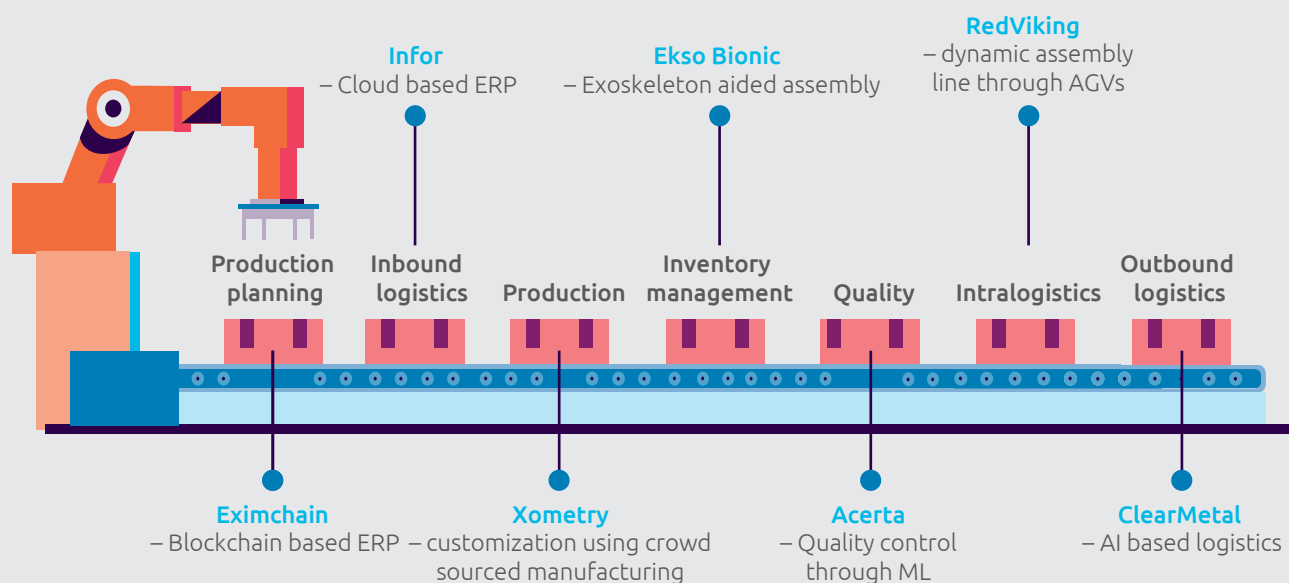
Suppliers have a daunting task ahead and face greater challenges than OEMs in key areas, such as attracting talent. Later in this report, we look at critical areas that they can address to achieve scale and success with their plans.

## The impact of startups on the smart factory space

A range of startups are helping OEMs across the manufacturing value chain. Below we provide an illustration of their capability and the impact they can have:

**Figure 14**

### How startups add value to the manufacturing value chain



**Source:** Capgemini Research Institute.

- Eximchain – uses a single system to cover all ERP needs, helping build transparency in tier-2/3 suppliers. It also enables other functions, such as product recalls and root cause failure analysis.<sup>26</sup>
- Infor - uses a cloud-based system to integrate various systems across all functions. This approach provides a “single source of truth” and mitigates against excess inventory and supply chain disruptions.<sup>27</sup>
- Xometry – an on-demand industrial parts marketplace, providing access to 3D printed, block, and injected parts when time is short and the need urgent.<sup>28</sup>
- Ekso Bionic – bionic devices that enhance workers’ lifting ability while reducing strain and stress from repeated manual labor.<sup>29</sup>
- Acerta - utilizes AI to cover production quality control and root cause analysis of product failures.<sup>30</sup>
- RedViking - By utilizing AGV for an assembly line, RedViking enables them to be dynamic rather than linear thereby enabling customization within the shop floor.<sup>31</sup>
- ClearMetal – through transparent end-point logistics, OEMs can reduce finished inventory while recognizing revenues faster. This is critical as customization increasingly becomes the norm.<sup>32</sup>

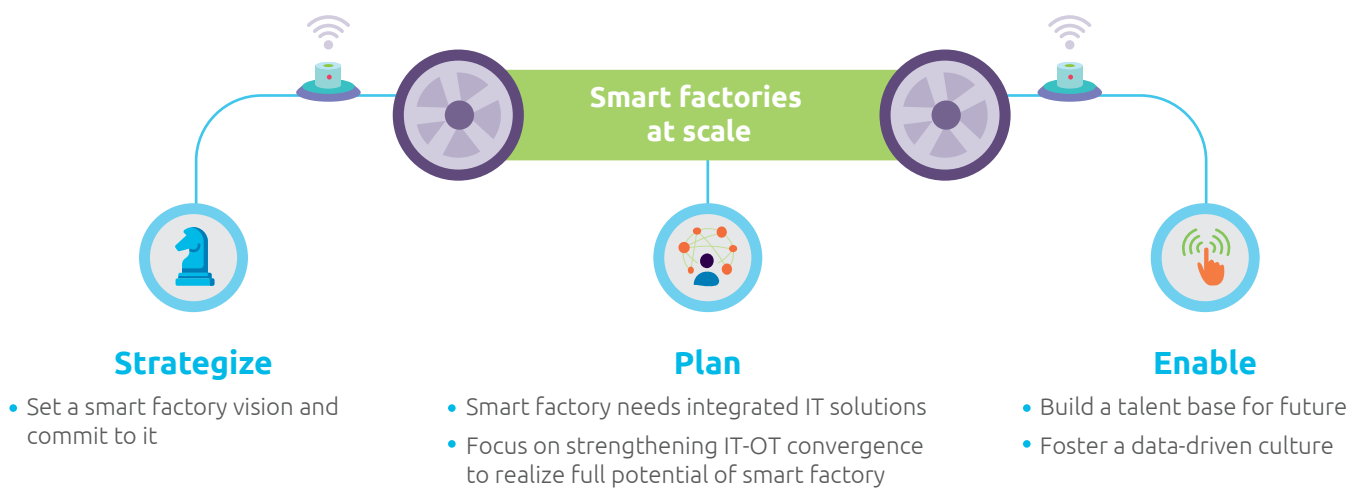
# 3. The way forward for auto OEMs and suppliers

From our analysis of the capabilities that the front runners display – as well as our own experience and interviews with industry executives – we believe that there are three areas automotive organizations need to strengthen in order to

achieve the full potential of smart factories and join our front-runner cohort. We define these as Strategize, Plan, and Enable (see Figure 15).

**Figure 15**

**How OEMs and suppliers can scale their smart factory initiatives**



**Source:** Capgemini Research Institute analysis.

## STRATEGIZE

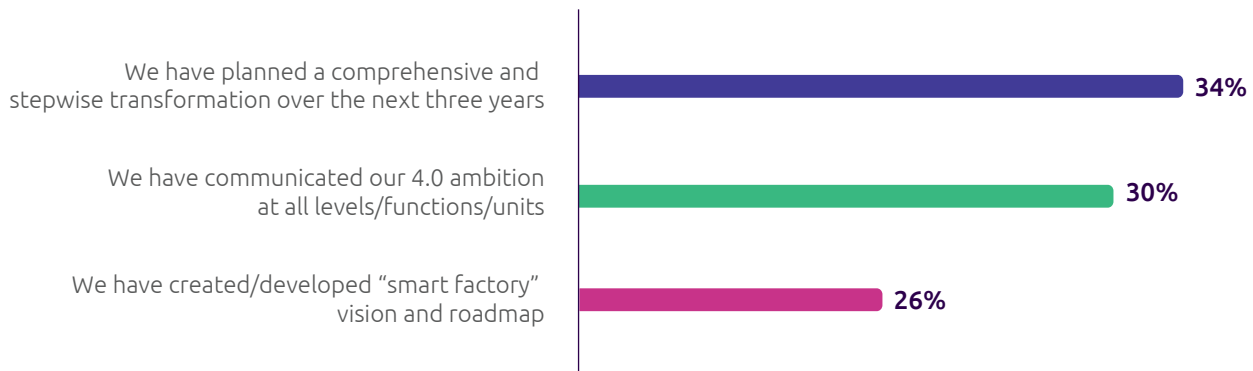
### Set a smart factory vision and commit to it

While digitization has been a major theme of the auto industry for many years, siloed deployment has often undermined

ambitions. Smart factories offer synergistic benefits across a range of areas, from quality testing to energy management (see Figure 2). However, we found that only around a third of organizations (34%) have defined a comprehensive transformation plan for the next three years (see Figure 16).

**Figure 16****Only one-third of automotive firms have a defined and comprehensive roadmap**

To what extent do you agree to the following?



**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=100 automotive manufacturers.

A number of leading organizations have embraced this need for transformation by establishing a group-wide smart factory vision.



*You have to have a well-defined vision and plan with clarity to what success looks like. Otherwise, you are going to spend a lot more money than you need to, replacing systems because you are disappointed that the systems you implemented are not growing or servicing the way you want. A clear vision addresses the longevity of the systems and the type of architectures you require. I think this is the main reason smart factories are so difficult to nail down because everything is advancing so quickly."*

**Diane Wilhelm**, chief engineer in advanced manufacturing, Harley Davidson

Given that the majority of suppliers would find it difficult to simply make a one-off investment of millions of dollars to achieve their goals, they should focus on a long-term, pragmatic approach. To begin with, they should define their long-term smart factory plan and finalize the initiatives to be rolled-out with each step.

They also need to recognize that different smart factory initiatives have varying degree of complexity. For instance, you cannot kick off a digital twin initiative at a factory level without having the required data readiness and processes in place. So, organizations should focus on the low-hanging fruit – targeting use cases that solve one of their pain points. For instance, our research into IoT applications found that asset tracking has a faster payback period than other areas.<sup>33</sup>

After these quick wins are identified, suppliers should run proofs of concept. The aim of this exercise is to understand the solution's feasibility – the required improvement areas in terms of data readiness, process maturity, and skills – that will be required in order to scale, and the best practices that can be drawn on in subsequent rollouts. Once, the solution has shown that it delivers quantifiable benefits, it can act as a "lighthouse" for other locations or plants to implement the same project. What is critical, however, is ensuring that these individual initiatives come together as part of the wider and long-term smart factory vision.

Once organizations are able to craft a detailed vision and roadmap, they need to ensure that the vision and plans are shared across all the units of the factory and at all levels. To ensure momentum, strong and visible senior leadership support for the vision is critical.

## PLAN

### Smart factory demands integrated IT solutions

As a result of acquisitions – as well as unilateral, factory-level decisions that have been taken over the years – it is not uncommon in the automotive industry to have multiple plants with different, unintegrated IT systems. This not only prevents applications developed for one factory from being easily ported to others, it also makes a unified view across the enterprise impossible.

While localized deployments are quick and deliver short-term benefits, an enterprise or group-wide IT strategy is critical to achieving synergies across multiple locations.

“*We have begun a number of initiatives, especially around ERP rationalization. Currently, we are putting a one consolidated instance for ERP applications on the cloud, which will help both in optimizing our business processes and also in our data management.*”

A global IT director of an automotive supplier of electronics.

Volkswagen has started a multi-year industrial cloud project that will combine the data of all machines, plants, and systems from 122 Volkswagen Group facilities. The aim is to optimize production processes and generate productivity improvements.<sup>34</sup>

### Focus on strengthening IT–OT convergence

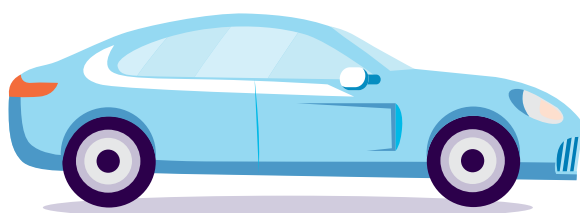
In our earlier definition of smart factories – “What is a smart factory?” – we outlined how connectivity is an integral part of these facilities. End-to-end digital continuity, from design to operations, is only possible when all systems can be connected and speak to each other in a common language. This is why IT–OT convergence is such a critical aspect of achieving scale with smart factories. However, in our research, only a minority of organizations (37%) said that they had set up new governance model to ensure that IT and OT work in synchronization. In addition, only around a third (34%) said they had complete view of the data flows across all processes and all IT–OT systems.

“*IT should work hand in hand with business, because a lot of this [smart factory] is about connected systems. We have a multitude of systems, for testing, for traceability and so on ... but we need to connect these and also to do it in a smart way and keep the costs in control.*”

**Magnus Dahlen**, senior director of engineering at Autoliv, a Swedish automotive supplier.

A factory can have thousands of sensors, so IT and OT need to work in tandem if it is to successfully deploy Industrial IOT applications.

For organizations that achieve this goal of IT and OT working seamlessly together, the benefits are wide-ranging. For instance, all the manufacturing systems, once connected, can be monitored for failure parameters and preventive actions taken. Other upsides include self-triggered inventory management, real-time analytics, and integration with suppliers.





## 4. Faurecia: US-based smart factory

Faurecia, a French-based global automotive supplier, has opened a new smart factory in Columbus, Indiana. Spread across an area of 37,000 m<sup>2</sup>, it employs 450 people to produce high-tech emissions control products for the commercial vehicle industry.

The plant incorporates connectivity, data processing, automation, and hardware to advance the manufacturing processes. All the machines in the factory are connected to the central network via a network of 1.3 miles of optic fiber. The factory will produce anti-pollution systems for one of its clients, to supply to its nearby plant.

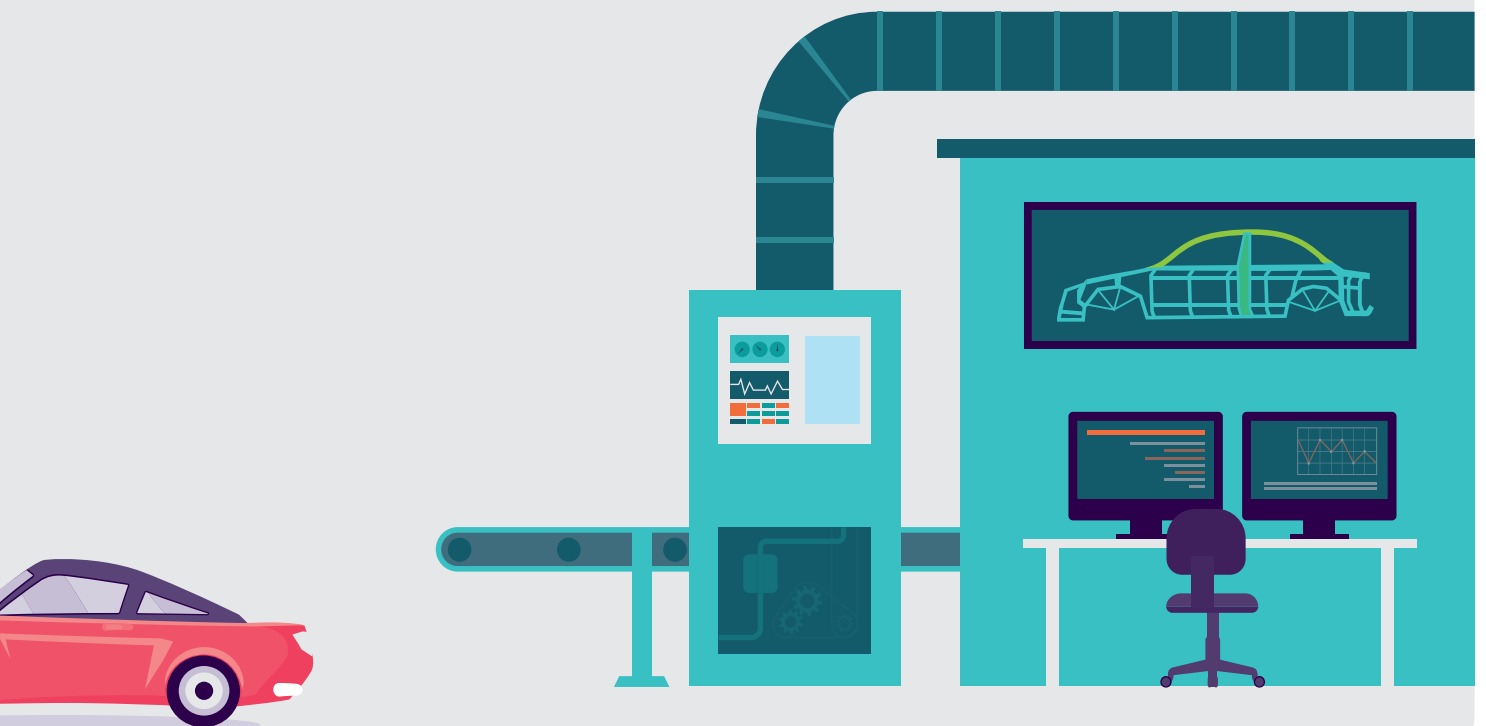
Its technologies include:

- Self-learning autonomous intelligent vehicles (AIVs) – These AIVs, which are used to carry parts to the assembly line, are able to adjust their routes automatically to avoid any interferences in their path. This ensures a continuous flow of materials.
- Collaborative robots or “cobots,” which are enabled with sensors and work in close proximity to humans.

- Laser scanning for early detection of variation to ensure quality.
- Computerized tracking of parts.
- Continuous data collection to help predict and prevent equipment failures and real-time monitoring of production efficiency and quality.
- An open-concept design and digital screens, laptops, and smartphones designed to foster real-time collaboration and communication. This is a completely paperless environment, keeping employees connected and informed with real-time information.
- Industrial robots from FANUC are used to place parts into a machine that then tests them for leaks.

### Benefits

The factory has helped reduce inventory storage space by 60% through its use of automated material handling via 30 guided vehicles. The factory is well equipped with wireless access points and back-up systems to reduce down time in the event of any failure.<sup>35,36,37,38</sup>



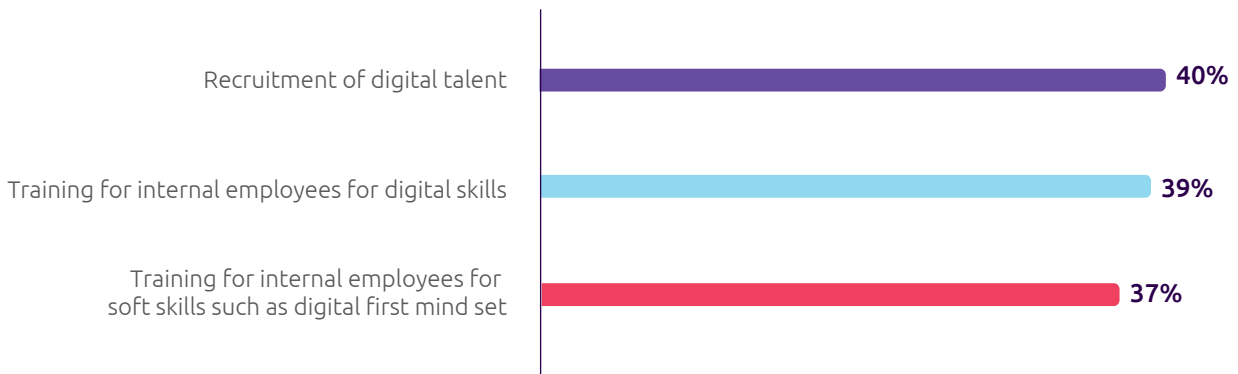
# ENABLE

## Build a talent base for future

As we saw earlier in Figure 12, close to half of suppliers (48%) and 46% of other organizations cite the lack of hybrid, soft, and digital capabilities as a challenge for smart factory transformation. Despite this, many organizations are not fully invested in bridging these skill gaps. As Figure 17 shows, for example, only 39% are training their employees in digital skills.

**Figure 17** Organizations' efforts in bridging the skill gap are insufficient

### Key steps that you have been taking / will be taking to solve any smart factory implementation challenge



**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=100 automotive manufacturers.

OEMs also face this talent challenge, although it is of a smaller magnitude for this segment.

As well as a need for digital talent, our research has shown that a range of hybrid skills are also critical for smart factory transformation. These include safety and security, as well as soft skills such as collaboration and a digital-first mindset.

Organizations should begin by looking at the initiatives planned to determine what skills are needed, what gaps exist, and by when the skilled workers will be needed. Based on the timeline, they need to plan recruitment as well as internal training. A flexible contract-based workforce could be one way to meet a short-term gap. For the long term, however, they should design training programs and encourage employees to learn cross-functional skills.



*Many employees would like to work for one of the digital leaders and this is not limited to millennials but applies across all age groups, due to the influence of the digital environment. For smart factories in particular, I believe having a clear company-wide digital strategy for transforming the business will not only attract but also retain skilled employees. In addition, it will certainly help if the employees are continuously challenged, incentivized and receive support to grow in their roles, and to acquire additional skills so they can progress in their careers.”*

**Ulf Harring**, chief operating officer, EMEA, Bridgestone, a Japanese automotive manufacturer

From previous research we conducted into “The Digital Talent Gap,” we have identified some of the initiatives used by leading organizations to tackle this area. These include:<sup>39</sup>

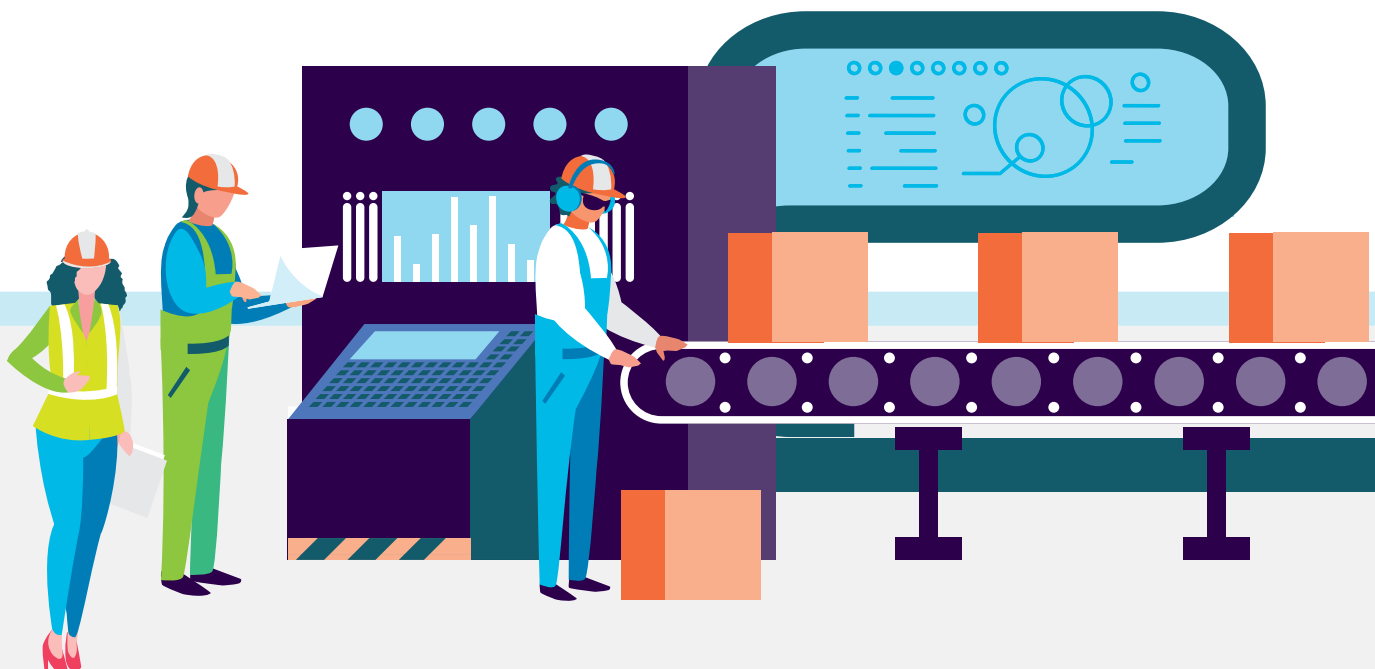
#### **a. Recruitment**

- Use of communities such as GitHub, Stack Overflow to identify the best digital talent
- Conducting anchor hiring (hiring experts in an area to attract more talent from that area)
- Collaboration with universities.

#### **b. Retention**

- Providing training and skill development through in-person/ classroom training
- Revamping of learning and development (L&D) models and using new L&D approaches for training digital talent
- Offering support (by means of devices, software, policies) to allow employees to work in a virtual environment
- Giving employees monetary or non-monetary benefits whenever they acquire new digital skills
- Designing career development programs that allow employees to pursue a career path across functions.

The upskilling programs should cater to all levels of employees – from line operators to plant managers. In addition to determining the required upskilling programs, OEMs and suppliers should also identify the skillsets that could be made redundant by the initiatives and design reskilling programs. This not only helps them find employees for new initiatives but will also improve the morale of the workforce.



## Foster a data-driven culture

It is not uncommon to find a multitude of systems and disparate data flows across the factory floor. Achieving digital continuity is key if organizations are to fully benefit from smart factory initiatives. A key aspect is to change the culture of manufacturing from being driven by experience to being driven by data. This requires strong leadership to drive this cultural change.

**“** *Cultural change is a function of great leadership. Leaders must cast the vision with their employees, starting with the person who runs the site. They should explain why they are doing what they are doing, the change that they are implementing, and they have to demonstrate that. And, they cannot expect others to do what they are not doing themselves. They have to hold people accountable, which starts with holding oneself accountable as a leader. Layered process audits, for example, are a great way to do that.* **”**

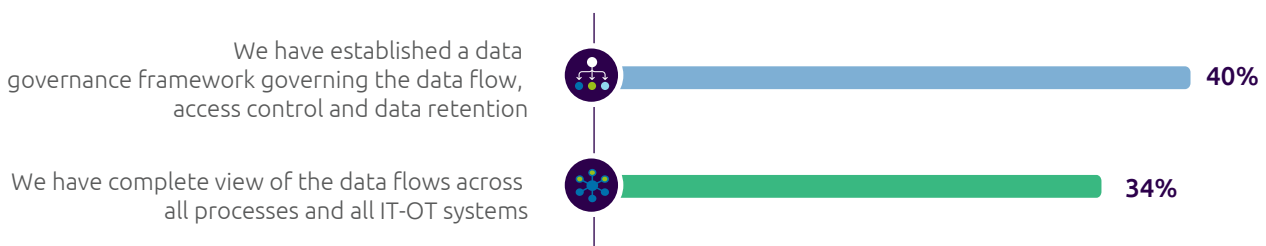
**Diane Wilhelm**, chief engineer in advanced manufacturing, Harley Davidson

Figure 18 shows that only 40% of organizations have established a framework for data governance and only around a third (34%) have complete visibility of their data flows.

**Figure 18**

### Fewer than two in five auto firms have strong data-driven operations

#### To what extent do you agree to the following?



**Source:** Capgemini Research Institute, Smart factory survey, April–May 2019, N=100 automotive manufacturers.

While localized implementations might be still successful without a strong focus on data readiness, it hampers the drive for scale. Organizations should work towards the following principles:

- Standardize data most commonly used across locations
- Ensure you can store, retrieve, and analyze data at the required granularity
- Create a view of data flows across critical systems and continually update it
- Make reporting and analytics tools available to decision makers

- Put in place training to encourage and support an analytical mindset among employees and encourage the move towards a data-driven, decision-making culture (rather than a decision-making culture based only on experience or intuition); also shift hiring criteria for executives so that hiring strategies focus on people with an analytical mindset.

A strong focus on data-driven operations will underpin successful collaboration between suppliers and OEMs. For instance, if suppliers can exchange data with OEMs, they can deliver advanced supply planning capabilities to their clients.

# Conclusion

The auto industry has a significant appetite for smart factories. And, that appetite is justified, given the significant prize on offer, with the industry looking to potentially gain multi-billion-dollar benefits from smart factories. While a few OEMs and a small number of the top suppliers have been able to progress on their smart factory journey and realize significant benefits, a large majority of them have to address certain areas before they could achieve scale and seize the smart factory prize. To achieve their goals, both OEMs and suppliers will need to accelerate on a number of priorities, including strategy, integrated systems solutions, IT-OT convergence, and a talent reboot.



# Appendix

## A: The smart factory transformation roadmap

We rated organizations based on six capability areas from our survey data. We have grouped those six areas into three objectives:

### OBJECTIVE ONE: TRANSFORMATION MASTERY

- 1. Vision and leadership:**  
Presence of a consistent smart factory vision backed by a concrete plan to implement and execute.
- 2. Hybrid, soft, and digital capabilities:**  
Availability of talent with the hybrid/cross-functional, soft, and digital skills needed, along with organizations' abilities in upskilling their employees.

### OBJECTIVE TWO: DEPLOYING VIRTUAL AND LOOPBACK PRACTICES

- 3. Efficiency by design:**  
The extent of optimization of production processes before physical production has even begun, using simulation and virtualization tools.
- 4. Operational excellence:**  
Maximizing the effectiveness of operations by leveraging data and advanced analytics to reach "closed-loop" and, ultimately, self-optimizing operations.

### OBJECTIVE THREE: IT-OT CONVERGENCE

#### 5. Deployment and integration of digital platforms and technologies:

The adoption and maturity of digital platforms and technologies in the IT-OT landscape, including production.

#### 6. Data readiness and cybersecurity:

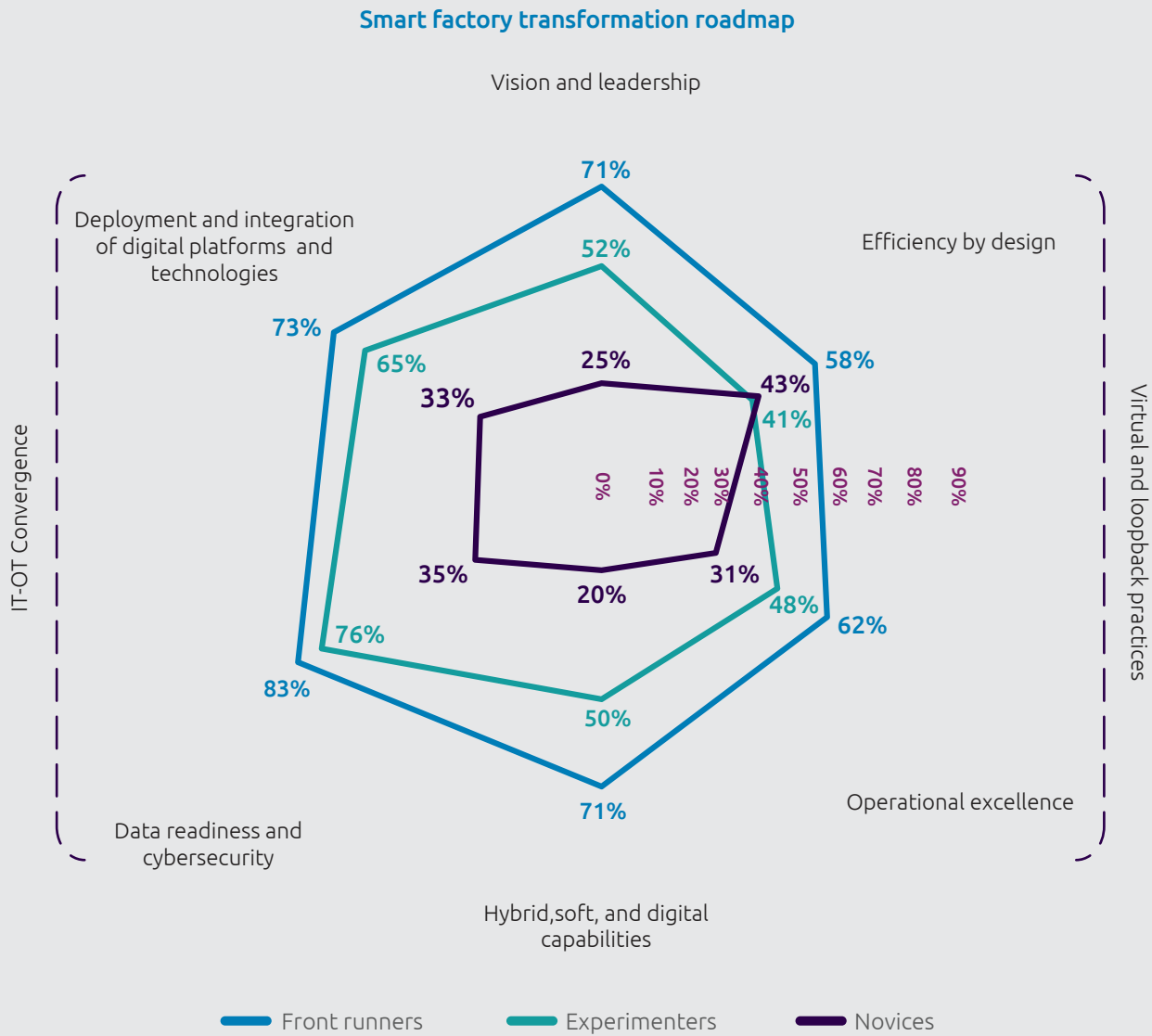
Data continuity and accessibility across the value chain while ensuring proper cybersecurity governance and norms.

Based on this framework, the following cohorts emerge:

- **Novices (73% of the sample):** lack most of the capabilities in these six dimensions.
- **Experimenters (17% of the sample):** perform well in some of the six dimensions but lag in others.
- **Front runners (10% of the sample):** This high-performing cohort outperforms the other groups on all dimensions of smart factory transformation

**Figure 19**

**Front runners consistently outperform others**



Note: Scores on each axis are rated from 0 to 100%, with 100% being a perfect score.

Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=98 automotive manufacturers.



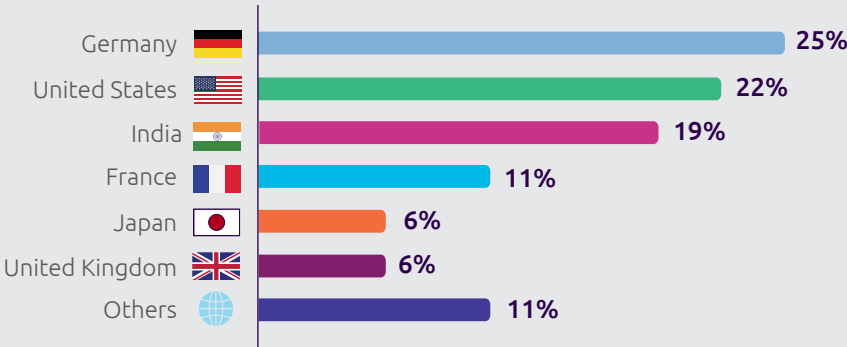


# Research scope and methodology

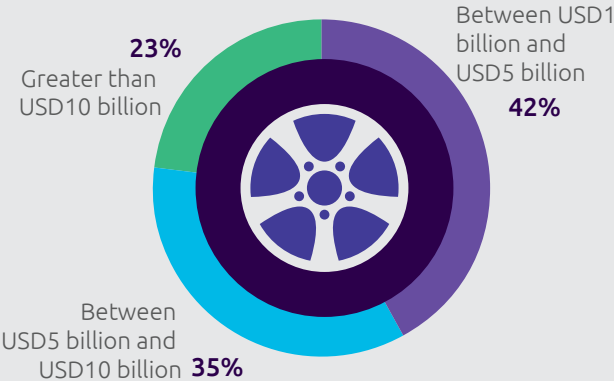
This research followed a two-pronged approach.

We surveyed 100 executives in automotive organizations, 98 of which had a smart factory initiative underway. All these organizations reported revenue of more than USD1 billion for the last financial year. The survey took place from April to May 2019 and covered eleven countries.

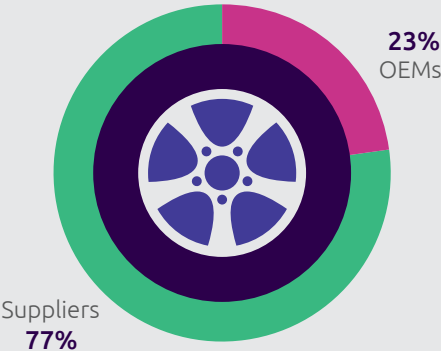
Organizations by country



Organizations by revenue



Subtype



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=100 automotive manufacturers.

In addition to the survey, we also conducted more than ten in-depth discussions with automotive executives overseeing a smart factory initiative or a smart factory. In these interviews, we discussed on the vision, the approach for smart factories, benefits, and the challenges in scaling the initiatives.

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The authors would like to thank Alexandre Capone, Udo Lange, Markus Rossman, Isabel Schneider, Subrahmanyam KVJ, Aritra Ghosh, Mohd Shahwaz, and Monika Hesper for their contribution to this research.

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The Capgemini Research Institute is Capgemini's in-house think-tank on all things digital. The Institute publishes research on the impact of digital technologies on large traditional businesses. The team draws on the worldwide network of Capgemini experts and works closely with academic and technology partners. The Institute has dedicated research centers in India, the United Kingdom and the United States. It was recently ranked number one in the world for the quality of its research by independent analysts.

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Capgemini – a leading provider of services for the ‘Intelligent Industry’ – offers a complete portfolio of services, reference architectures, platforms and solutions to accelerate and secure your smart factory program by helping you with:

- designing architecture for performance at scale
- accelerating and securing physical-digital convergence
- deploying and integrating digital platforms to ensure digital continuity and fuel extended collaborations
- breaking “silos” with collaborative and agile ways of working
- empowering your people and mastering the digital workforce
- delivering results to ensure success.

Capgemini reference architectures, platforms and solutions are agnostic, secure, ready to go and scale up.

### From consulting to technology services

Our end-to-end assistance to your smart factory journey includes:

- Smart factory analysis and design: complete assessment of the smart factory maturity, defining the strategy for scaling up and design of a consistent transformation roadmap comprising use cases, quick wins, digital platforms and IT-OT convergence, benefit cases, governance, change management

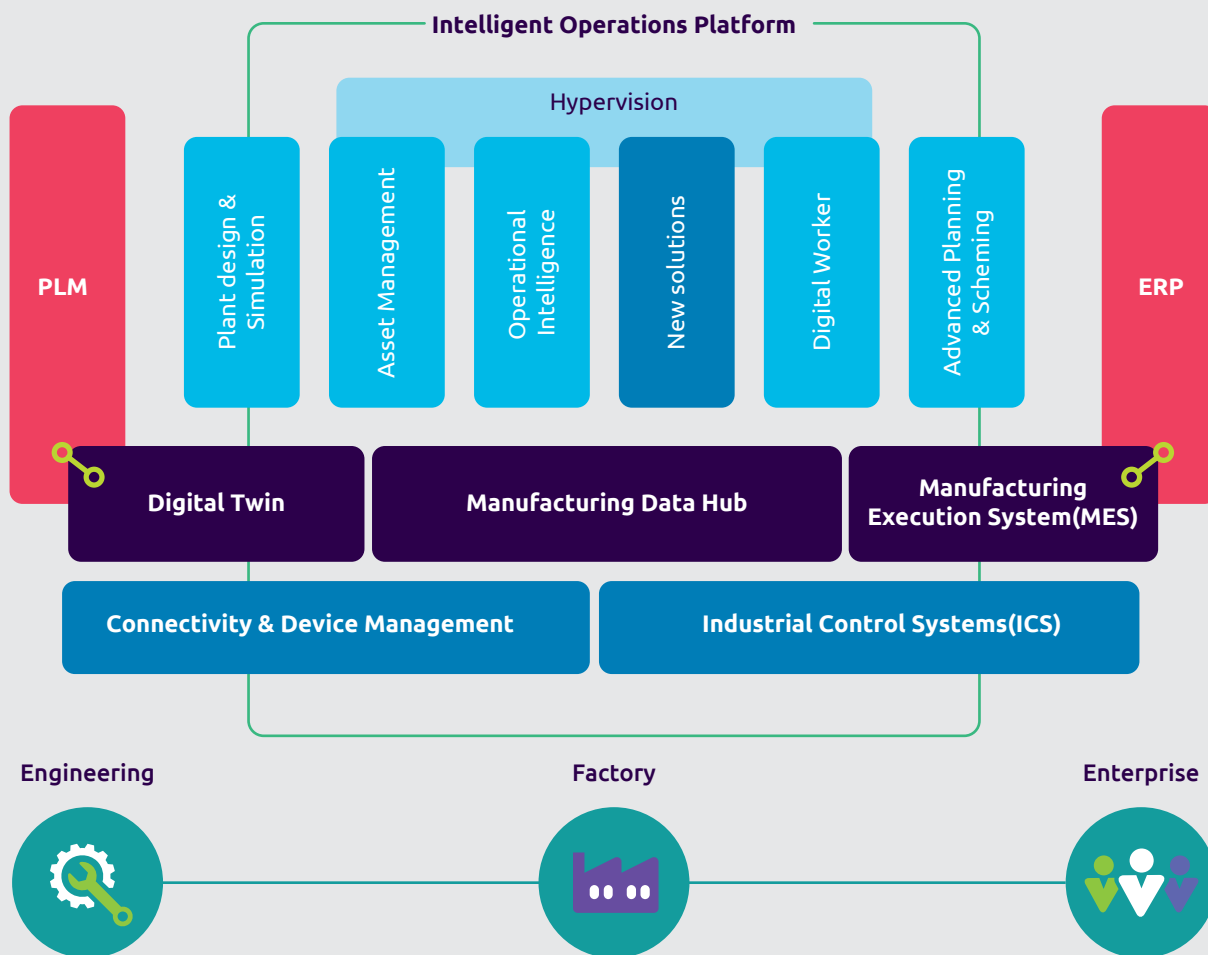
- Platforms and solutions’ set up - from business, architecture and IT design to build and deploy:
  - MES / SCADA
  - Asset management
  - Digital platforms: IIOT, analytics and AI, remote and mobile, digital twin and others
  - IT-OT architecture and integration/roadmap for convergence
- Smart factory applications’ maintenance
- Smart factory platforms and solutions as a service.

### Smart factory reference architecture and platform

Capgemini’s Smart Factory offer is designed around an integrated modular platform to accelerate and achieve the required scale with digital transformation for global manufacturers. The platform extends to provide the complete:

**Horizontal process coverage:** from the interface to product and process planning data - typically managed in a PLM application, to the ERP application on the other end. The ERP application interfaces the manufacturing data into the enterprise.

**Vertical integration of manufacturing technology layers:** from shop floor connectivity to advanced analytics and point solutions and applications for targeted users. The goal is to enable a seamless manufacturing stack.



To support data-driven operations, the Intelligent Operations Platform allows manufacturers to extend their traditional MES with flexible and scalable data management and analytics capabilities. This brings dimensions of intelligence and analytics and enables a true operations platform as opposed to just a dashboard. The Intelligent Operations Platform is at the heart of our Smart Factory Operating Model design.

### Smart Factory @ Scale with our integrated modular platform

Building the Smart Factory on an integrated platform allows organizations to combine fast incremental

innovation with deployment at scale. Issue-focused applications/ transversal solutions combine the agility of bottom-up innovation and the scalability that delivers tangible results. When combined with our integrated governance, from technology to culture change, platform-based innovation allows a sustainable transformation towards Industry 4.0.

Our Smart Factory offer leverages the flexibility of Industrial IoT platforms, alongside existing manufacturing systems to get the full potential of Industry 4.0 "one application at a time".

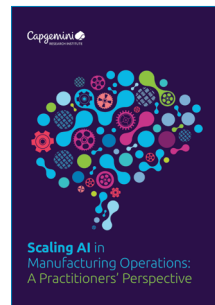
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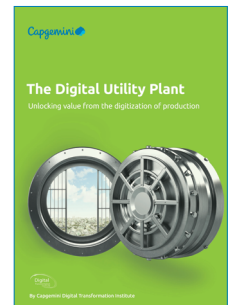
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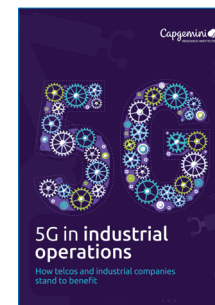
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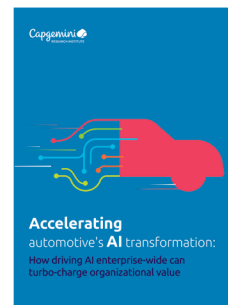
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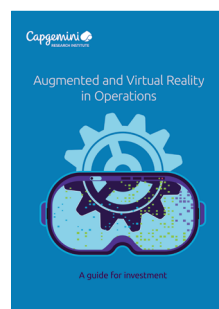
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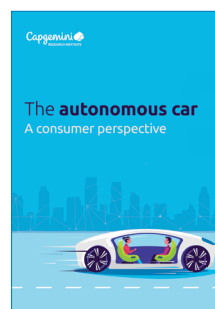
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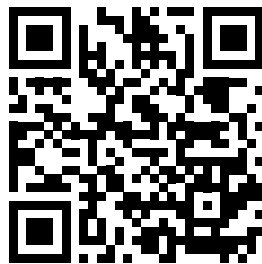
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## About Capgemini

A global leader in consulting, technology services and digital transformation, Capgemini is at the forefront of innovation to address the entire breadth of clients' opportunities in the evolving world of cloud, digital and platforms. Building on its strong 50-year heritage and deep industry-specific expertise, Capgemini enables organizations to realize their business ambitions through an array of services from strategy to operations. Capgemini is driven by the conviction that the business value of technology comes from and through people. It is a multicultural company of over 200,000 team members in more than 40 countries. The Group reported 2018 global revenues of EUR 13.2 billion.

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