Smart Factories

How can manufacturers realize the potential of digital industrial revolution

Executive Summary

Engineering the smart factory: key findings from our global research

The prize:

- Smart factories could add $500 billion to $1.5 trillion in value added[a] to the global economy in five years

- Manufacturers predict overall efficiency to grow annually over the next five years at 7 times the rate of growth since 1990

- We estimate that smart factories can nearly double operating profit and margin for an average automotive OEM manufacturer

The challenge:

- 76% of manufacturers either have a smart factory initiative that is ongoing or are working on formulating it. And more than half of manufacturers (56%) have aligned $100 million or more towards smart factories.

- However, only 14% of companies are satisfied with their level of smart factory success. Only 6% of manufacturers are 'Digital Masters': at an advanced stage in digitizing production processes and with a strong foundation of vision, governance and employee skills.

- Digital Masters outpace all other categories in realizing the benefits of smart factories

- The US Bureau of Economic Analysis defines industry value added as the contribution to the overall GDP of an industry or sector. It is calculated as the difference between an industry's gross output and the cost of its intermediate inputs. U.S. Bureau of Economic Analysis, FAQ: "What is industry value added?", March 2006.

Smart Factories: A Revolution in the Making

A revolution in manufacturing is firmly underway. Infineon, a German semiconductor manufacturer, is investing $105 million in the next five years in order to turn its Singapore plant into a smart factory[1]. It took robots and 3D Printing to make Adidas bring back manufacturing to Germany[2]. A leading fragrance maker in Switzerland ramped up capacity by a third in the past three years[3], all through addition of robots. A Chinese factory added robots to its operations which drove production increases of 250% and defect reductions of 80%[4].

To assess how manufacturers can drive most value from smart factories, we surveyed 1000 senior executives of large companies across key sectors and countries. We also conducted focus interviews with executives leading smart factory initiatives. Further information on our research methodology is at the end of this paper.

Smart factories turbo-charge manufacturing performance

In the next five years, manufacturers expect smart factories to drive performance improvements that significantly exceed previous efforts:
- On-time-Delivery of the finished products is expected to accelerate by 13 times, while quality indicators are expected to improve at more than 12 times the rate of improvement since 1990.
- Important cost items such as Capex & Inventory is predicted to be rationalized at 12 times and material, logistics & transportation cost expected to be rationalized at 11 times the rate of improvement since 1990
- Overall productivity and labor cost improvements are reported to accelerate at 7 times and 9 times the rate of growth since 1990, respectively.

Figure 1: Manufacturers are expecting big gains from smart factories
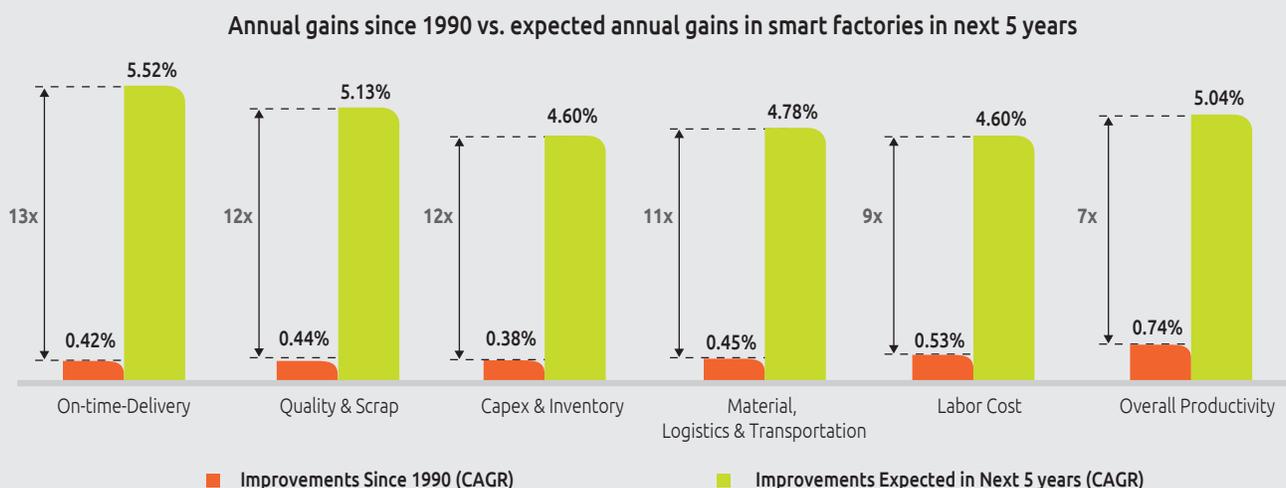
Annual gains since 1990 vs. expected annual gains in smart factories in next 5 years

	On-time-Delivery	Quality & Scrap	Capex & Inventory	Material, Logistics & Transportation	Labor Cost	Overall Productivity
Improvements Since 1990 (CAGR)	0.42%	0.44%	0.38%	0.45%	0.53%	0.74%
Improvements Expected in Next 5 years (CAGR)	5.52%	5.13%	4.60%	4.78%	4.60%	5.04%
Multiplier	13x	12x	12x	11x	9x	7x

■ Improvements Since 1990 (CAGR)   ■ Improvements Expected in Next 5 years (CAGR)

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017

The expectations of manufacturers from smart factories hold strong ground since manufacturers across segments have already started realizing potential of smart factories, with industrial manufacturing[5] seeing the biggest gains in productivity and quality of output (see Figure 2). GE, in its 'brilliant factory' in Grove City, has been able to reduce unplanned downtime by 10 to 20%, improve cycle time and reduce costs[6] (GE describes its 'brilliant' concept as a sophisticated factory that combines lean manufacturing, advanced and additive manufacturing with advanced software analytics to enhance productivity). Faurecia, one of the largest international automotive parts manufacturers, plans to save €10 million on the purchase of plastic material via scrap reduction and production improvements owing to digital manufacturing[7]. Faurecia also expects to save €30 million on improving its business processes by 2020.

Figure 2 : How much benefit have manufacturers realized from smart factories so far?
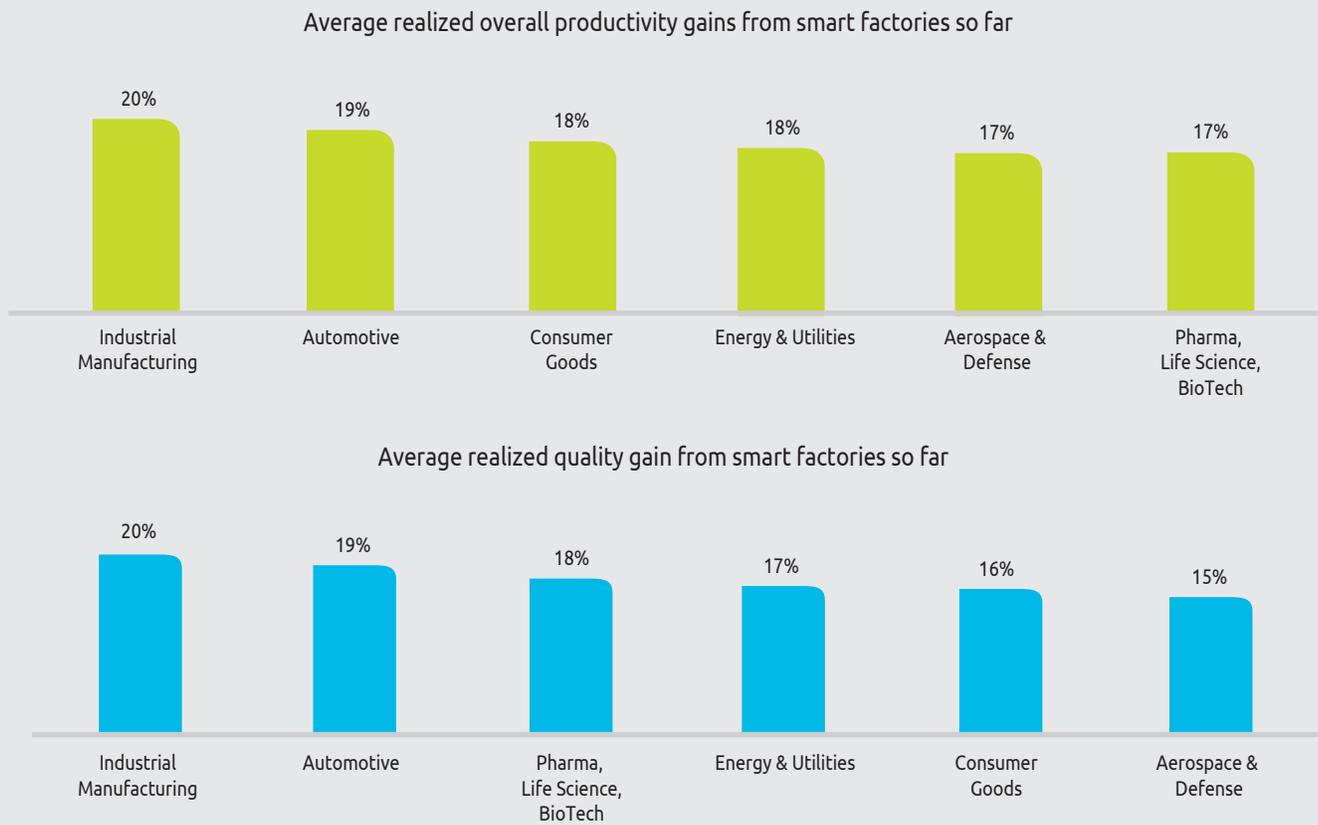
Average realized overall productivity gains from smart factories so far

Industrial Manufacturing	Automotive	Consumer Goods	Energy & Utilities	Aerospace & Defense	Pharma, Life Science, BioTech
20%	19%	18%	18%	17%	17%

Average realized quality gain from smart factories so far

| Industrial Manufacturing	Automotive	Pharma, Life Science, BioTech	Energy & Utilities	Consumer Goods	Aerospace & Defense
20%	19%	18%	17%	16%	15%

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017

Visualizing the Smart Factory: Capgemini Smart Factory Framework

The smart factory revolution is part of the broader digital transformation of the manufacturing industry (see Figure 3). A smart factory draws on a number of elements from our Digital Manufacturing Framework which is designed to help manufacturers focus on improving the digital maturity of core manufacturing functions across product and asset life cycle management, operations management, system simulation, and industrial cybersecurity. Operations management forms a bulk of smart factory components, in addition, digital asset management and 3D continuity from the product and asset management side are also relevant to smart factories.

Figure 3: Capgemini Smart Factory Framework
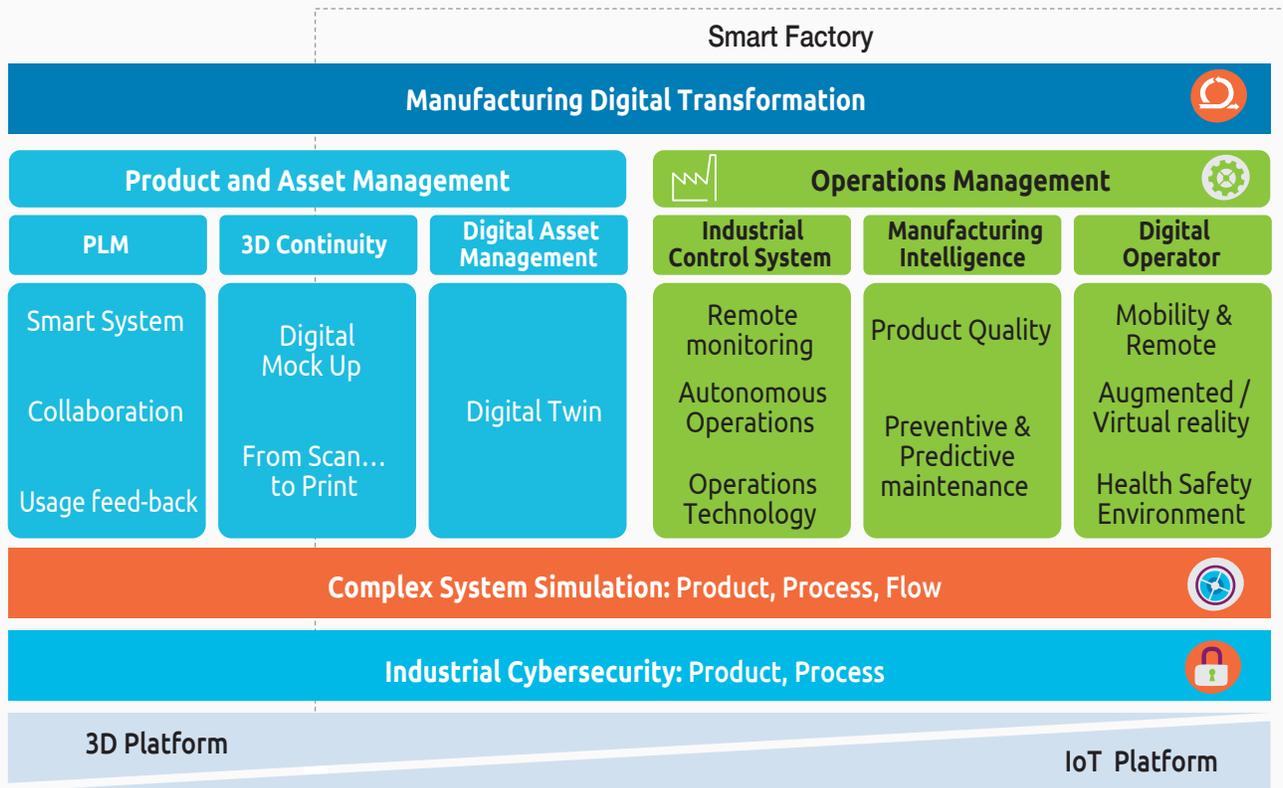
Source: Capgemini Digital Transformation Institute Analysis

Manufacturers are modeling smart factories based on what elements align with their strategic objectives:

- GE invested over $200 million in a flexible "brilliant factory" in Pune, India. For the first time, the company is able to produce diverse products, from jet engine parts to locomotive components, for four different GE businesses all under one roof. This multi-modal capability enhances flexibility. "The plant will allow us to quickly adjust production as demand comes in, using the same people and space," says Banmali Agrawala, president and CEO of GE South Asia[a].
- At its Indiana-based facility, automotive equipment leader Faurecia draws on self-learning autonomous intelligent vehicles (AIVs), collaborative robots, and continuous data collection to support the company's Industry 4.0 agenda. Mike Galarno, plant manager, says: "This facility represents our entry into Industry 4.0, a revolutionary concept incorporating connectivity, automation, data processing and hardware to advance the manufacturing industry. We are proud to be the first plant to incorporate many of these leading technologies under one roof to create efficient systems and an innovative working experience for employees."[b]

a. GE Reports, "GE's Brilliant Advanced Manufacturing Plant In Pune, India", February 2015;
b. Robotics & Automation News, "Faurecia launches $64 million smart factory in Columbus, Indiana", October 2016

Early adopters emerging in key geographies and sectors

Nearly half of all the manufacturers we surveyed (43%) have an operational smart factory initiative and another 33% are in the process of formulating an initiative (see Figure 4).

- Key geographies: Our research shows that the US and Western Europe in particular have made an early head start. Nearly half of manufacturers in the US, France, Germany, and UK have an ongoing smart factory initiative. In the Global Manufacturing Competitiveness Ranking released by the US Council on Competitiveness, the US climbed from #3 in 2013 to #2 in 2015 and is expected to displace China as #1 by 2021[8]. In China, a quarter of companies have an ongoing smart factory initiative (25%). While this is low compared to some countries, 53% are formulating a smart factory initiative, meaning that 78% are either in progress or have the intent.
- Key sectors: Industrial manufacturing (67%) and aerospace and defense (62%) lead in terms of launching smart factories. In contrast, only about a third of Life sciences and Pharma companies have an operational smart factory initiative.

43%
Percentage of manufacturers that have an operational smart factory initiative

Figure 4: Industries across countries are enthusiastic in embracing smart factories

North America

US 54%

Audi's €1 bn smart factory in San José Chiapa in Mexico, the entire plant was simulated virtually before operations began

Faurecia's $64 million smart factory in Columbus, Indiana aims heavy use of digital technologies to drive efficiency and innovation

Western Europe

UK 43%

Sweden 39%

Germany 46%

France 44%

Italy 33%

Adidas' high-tech Speedfactory in Germany aims to leverage 3D Printing, digital twin and a flexible production system

Siemens' smart plant in Amberg, Germany has machines and computers handling 75 percent of the value chain on their own

India and China

China 25%

India 28%

GE's "brilliant Factory" in Pune, India is capable of producing diverse products, from jet engine parts to locomotive components

ABB's smart plant in Beijing, China has 99.94% reliability of deliveries and improved average lead time from eight days to two

Penetration level: ■ 50 - 60% ■ 40 - 50% ■ 30 - 40% ■ 20 - 30%

Percentages indicate the share of companies in the respective country that has a smart factory initiative ongoing

Smart factory implementation status across geographies

	Yes - operational	Yes - being formulated	No - plan in 3-5 yrs	No - not likely
Global Average	43%	33%	8%	16%
United States	54%	24%	11%	10%
Germany	46%	30%	8%	15%
France	44%	36%	3%	17%
United Kingdom	43%	27%	14%	16%
Sweden	39%	31%	12%	18%
Italy	33%	42%	7%	18%
India	28%	42%	5%	25%
China	25%	53%	1%	21%

■ Yes - we have an ongoing smart factory initiative - (operational)

■ Yes - it is currently being formulated - (not in operation)

■ No - but we plan to have a smart factory initiative in the next 3-5 years

■ No - we are not likely to have a smart factory initiative anytime in future

Share of manufacturers who have an ongoing smart factory initiative

| Industry	Share
Industrial manufacturing	67%
Aerospace and defense	62%
Automotive and transportation	50%
Energy and Utilities	42%
Consumer goods	40%
Life sciences, biotech, pharma	37%
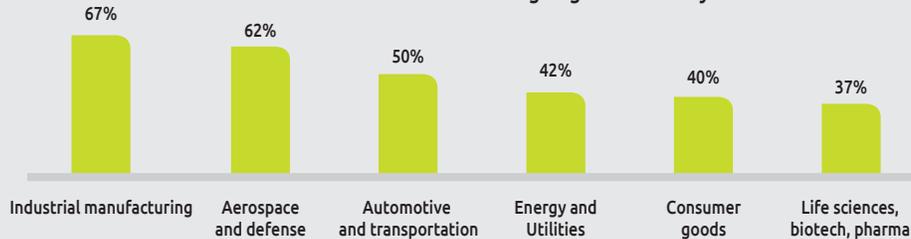
Percentages indicate share of organizations in each industry which reported they have an ongoing smart factory initiative

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017

Over $100Mn
Amount invested by more than half of manufacturers

Firms are making significant investments to drive progress. Over the last five years, more than half of manufacturers (56%) have aligned $100 million or more towards smart factories (see Figure 5).

Figure 5: More than half of the manufacturers invested over $100 Mn in smart factories

Distribution of manufacturers based on their smart factory investments in the last five years
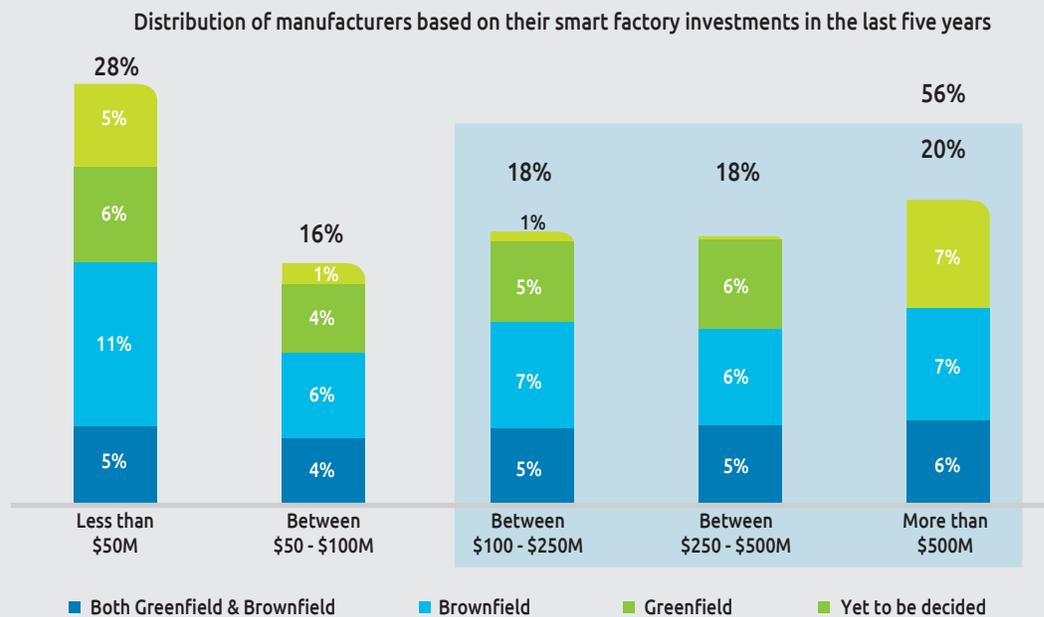
Percentages indicate share of organizations in each spend category who said they will launch either of: Greenfield, brownfield, both Greenfield and brownfield smart factories or were undecided. Numbers might not add up to the total because of rounding

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute Analysis

Examples include:

- Audi's €1 billion+ investment in a smart plant in Mexico, which opened in September 2016[9]
- GE's $200 million+ investment in its "brilliant factory" in Pune, which opened in February 2015[10]
- Faurecia's €57 million investment to launch a smart factory in Columbus, Indiana, which opened in October 2016[11]

These are all examples of Greenfield smart factories, but organizations are also constantly upgrading their existing factories to strive to make them smarter and more digital.

Smart factories on the rise, but manufacturers a long way from digital maturity

The impetus behind smart factories is encouraging. However, manufacturers that want to win in the tomorrow's increasingly connected and disrupted environment will need to move from being organizations with a smart manufacturing capability to become digital enterprises.

To understand how manufacturers were progressing in that aim, we analyzed the digital maturity of manufacturers, using two dimensions:

	Digital Intensity – the "what"	Illustration
1	How far essential processes (production, inventory management, quality, planning and forecasting) have been digitized and how much use is made of digital technologies such as robotics, internet of things, artificial intelligence, big data analytics etc.	Siemens' plant in Amberg, Germany is a highly automated facility, with machines and computers handling 75 percent of the value chain on their own[12]. The factory manufactures 12 million products of the Siemens' Simatic product line per year at a quality of 99.99885 percent.

|	Transformation management intensity – the "how"	Illustration
2	How well the transformation is being managed to drive benefits, including key aspects such as the manufacturer's smart factory vision, governance, and the digital skills of its workforce.	Grégoire Ferré, Chief Digital Officer, Faurecia: "Our digital transformation program runs in parallel across five streams – Operations, R&D, Sales & Programs, HR & Communications and Purchasing. This ensures that key processes supporting smart plants are developing together and benefiting from each other. In the initial phase of our transformation, we identified areas that needed digitization and launched a number of pilots. In the current phase, we are digitizing and industrializing the tools developed earlier. These will become standards that will drive future stages of transformation".

75%
Percentage of the value chain that machines and computers handle on their own at Siemens' plant in Amberg

6%
Percentage of manufacturers that are digital masters

For separating the leaders from followers, we filtered out organizations that received a high score on both the dimensions of digital maturity. The analysis reveals four clear categories (see Figure 6):

- **Digital Masters:** We found that only 6% of firms are what we call Digital Masters, which are those firms that score high on both dimensions of digital and transformation management intensity. They are at an advanced stage in digitizing production processes, and have a strong foundation of vision, governance and employee skills.
- **Conservatives** score well on the transformation management intensity but fall short on digital intensity. Their low level of process digitization and lower scale of leveraging digital technologies yield sub-optimal benefits.
- **Fashionistas** score high on digital intensity but fall short on transformation management intensity. This group has progressed the digitization of key manufacturing processes. However, this effort lacks a clear vision, governance and skills to reap the rewards of digitization in a competitive and sustainable manner.
- **Beginners** score low on both the dimensions, with smart factory implementation and yet to realize compelling benefits.

Figure 6: The majority have a long way to go to digital maturity
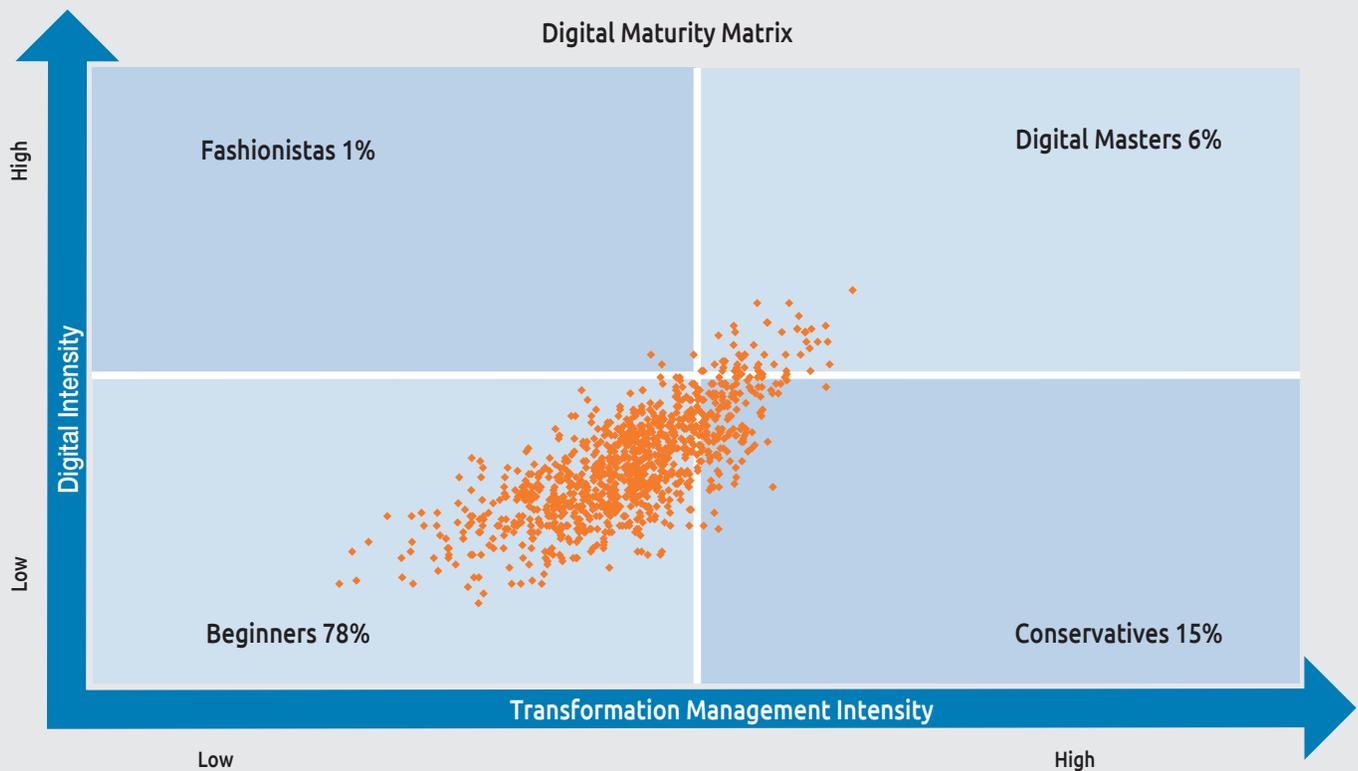
Digital Maturity Matrix

Fashionistas 1%

Digital Masters 6%

Beginners 78%

Conservatives 15%

Digital Intensity — High / Low

Transformation Management Intensity — Low / High

Smart Factories: How can manufacturers realize the potential of digital industrial revolution

By analyzing these two dimensions, we found that organizations that have made advances in both digital intensity and transformation management intensity are better placed to reap the rewards from smart factories. In the following sections, we outline the size of the prize for high performers and the factors that dictate success.

Figure 7: Digital maturity of firms across sectors
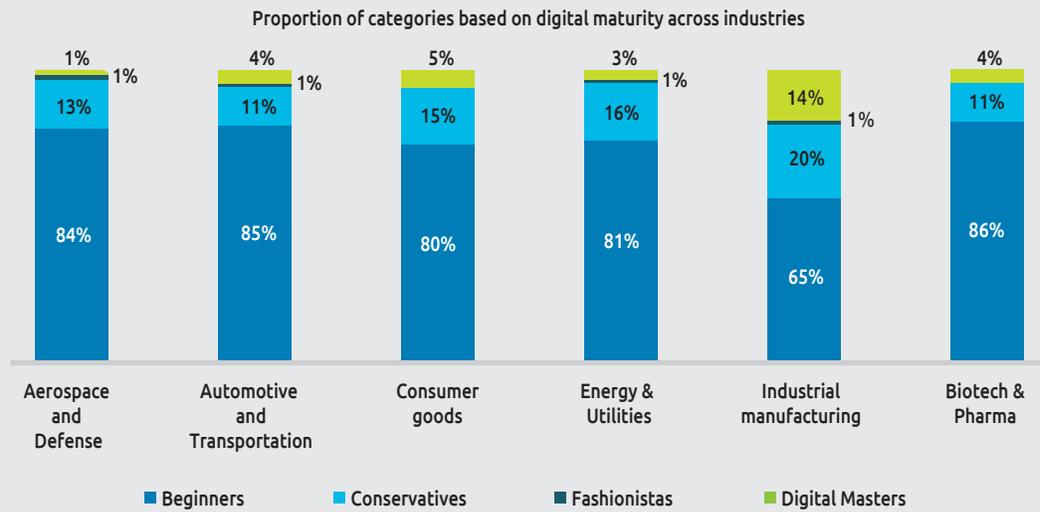
Proportion of categories based on digital maturity across industries

	Aerospace and Defense	Automotive and Transportation	Consumer goods	Energy & Utilities	Industrial manufacturing	Biotech & Pharma
Digital Masters	1%	4%	5%	3%	14%	4%
Fashionistas	1%	1%		1%	1%	
Conservatives	13%	11%	15%	16%	20%	11%
Beginners	84%	85%	80%	81%	65%	86%

■ Beginners　■ Conservatives　■ Fashionistas　■ Digital Masters

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017

$500Bn
What smart factories can add to the economy

The Size of the Smart Factory Prize is Too Large to Ignore

Smart factories have the potential to add $500 billion to $1,500 billion annually to the global economy in the next five years

We estimate that, in a conservative scenario, the added output to the economy from smart factories annually would reach a level of $500 billion in the next five years (see Figure 8). It represents 0.7% of world's annual GDP by 2015 estimates.[13] In an optimistic scenario where manufacturers accelerate their smart factory efforts and deploy or transform more than 50% of their plant base into smart factories, it would add up to $1,500 billion in eight surveyed geographies or 2% of world GDP.

Figure 8: Smart factories are expected to boost the global economy by adding $500 billion to $1,500 billion annually to the global economy in next 5 years

Total value added (total sales less interim costs) by manufacturing in the eight surveyed geographies = USD 8.83 trillion

	Factors	Conservative Estimate	Optimistic Estimate
A.	Average expected overall productivity growth in smart factories	27%[a]	28%[b]
B.	Smart factories as a share of all manufacturing plants	21%	60%
C.	Added productivity by manufacturing organizations owing to smart factories (A*B)	5.7%	16.8%
D.	Incremental value added to the global economy, assuming enhanced productivity fully translates into added value (C*$8.83 trillion)	$500 billion	$1483 billion

Smart factories can nearly double operating profit and margin, propelling an average automaker to top of the league

The financial impact of smart factories becomes much more compelling when we consider their implications on cost as well. Cumulatively, smart factories will drive higher productivity at a lower cost base, strengthening manufacturing P&L in the short term and improving firms' competitiveness in the long run. To estimate the cumulative impact of smart factory initiatives on the financials of manufacturers, we conducted a business case analysis on a hypothetical car & truck manufacturer in the US with revenues of $1 billion and a 5% operating margin. This is approximately the industry average for the auto industry[14].

Our analysis shows that in the optimistic scenario, the productivity and efficiency benefits of smart factories could improve the company's operating margin to 10.4% over a period of five years (see Figure 9). This represents one of the best operating margins in the auto industry, catapulting the average player into the league of leading automakers.

Secondary research and interviews with industry executives helped us estimate key costs in a smart factory against a traditional factory. For instance, a senior executive at a large European vehicle manufacturer told us that they expect to bring down the amount of manual labor in vehicle assembly by about 20%. Another manufacturer is using a mix of technologies – advanced track and trace, paperless shop floors, autonomous material movers – to reduce the cost of logistics and administration by up to 50%. These ballpark estimates, coupled with data from the industry participants who took part in our survey and our experience with clients, helped us arrive at estimates of improved costs for an average manufacturer.

Figure 9: Smart factories can double the operating profit and margin of auto manufacturers in five years

	Factors	Conservative Estimate	Optimistic Estimate
A.	Average expected overall productivity growth in smart factories in automobile industry (in the next five years)	28%	28%
B.	Average number of factories becoming smart in the automotive industry (in next five years)	20%	60%
C.	Revenue growth attributable to smart factoring assuming enhanced productivity translates into extra revenue (A*B)	5.6%	16.8%
D.	Reduced manufacturing costs owing to reduction in logistics, administration, direct labor and material costs	Between 0.4% and 5.2%	Between 1.2% and 15.6%
E.	Operating profit (in USD) compared to current level of $50mn	$71.8mn	$121.3mn
F.	Gain in operating profit (Increased revenue less reduced cost base)	1.44x	2.43x
G.	Operating margin compared to the current level of 5%	6.8%	10.4%
H.	Gain in operating margin (over the current value of 5%)	1.36x	2.08x
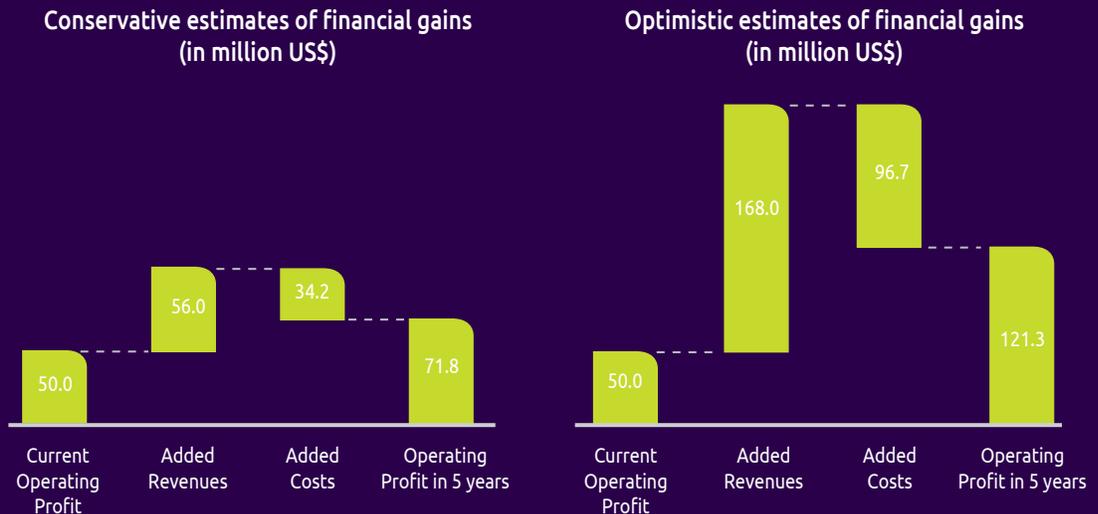
Conservative estimates of financial gains (in million US$)

Current Operating Profit	Added Revenues	Added Costs	Operating Profit in 5 years
50.0	56.0	34.2	71.8

Optimistic estimates of financial gains (in million US$)

Current Operating Profit	Added Revenues	Added Costs	Operating Profit in 5 years
50.0	168.0	96.7	121.3

How will smart factories impact the skill demand globally?

Participants expect accelerations in gains primarily in areas of processes and material with On-time-Delivery (13 times), Quality & Scrap (12 times), Capex & Inventory (12 times), and Material Cost (11 times). Although these are the major areas where organizations expect biggest gains, the realization of these benefits will depend on how effectively manufacturers fulfill the demand for digital skills. The shift to smart factories will hence transform the global labor market, and while previous waves of automation have reduced low-skill jobs, organizations have recognized the skills imperative and are now acting on it:

• 54% of respondents are providing digital skills training to their employees
• 24% are spending a significant amount of their training budget to train employees in digital skills. Some countries such as India and China seem to have grasped this imperative better than others. 72% and 65% of executives surveyed in these countries respectively are investing a significant amount of their training budget to build digital skills.
• 44% are investing in digital talent acquisition to bridge the skill gap.

Senior executives also see automation as a means to remove inefficiencies and overheads rather than jobs:

"*In the assembly line, the automation level is still not very high because there are things that a man can do better than a machine. Nevertheless, you can help people with a robot if it's a repetitive task such as adding a drop of oil every second"* **– Former Senior VP at one of the largest European auto manufacturers**

"*One of the big reasons for automation has definitely been to make the jobs easier for the workforce on a daily basis by sharing all their manual workload. I think most people can see that they can benefit from this"* **– Ejvind Skodt, Site Director – Production, Arla Foods**

How Can Organizations Make Smart Factory Initiatives Successful?

Smart factory success proves elusive to most

Only 14% of companies are satisfied with their level of smart factory success and 39% said they were not satisfied and give themselves a low rating in terms of success levels (see Figure 10). This 39% may feel they are struggling because they are not meeting their targets. For instance, 297 out of 580 organizations have yet to achieve their productivity improvement targets. A closer look at the challenges faced by organizations reveals that nearly a third are struggling with two key challenges: lack of coordination among different units and lack of investment.

Figure 10: For every successful manufacturer, nearly three organizations are struggling in their smart factory initiative

Percentage of organizations that are successful or struggling

39%

14%

Successful organizations   Struggling organizations

Percentages indicate share of organizations that rated themselves 6-7 (successful) and 1-3 (struggling) on a scale of 1 to 7

Top challenges in formulating smart factory strategy

Lack of coordination among different organizational units	32%
Lack of leadership commitment	28%
Lack of a clear business case	28%
Lack of ownership	23%
Lack of a vision	21%

Top challenges in implementing smart factory strategy

Lack of investment	29%
Lack of maturity in lean shop floor automation processes	22%
Organizational inertia	21%
Challenges in identification and prioritization of opportunities	21%
Lack of a roadmap	20%

Percentages indicate share of organizations that selected the particular option as a challenge area out of 8 challenges areas in strategy formulation and 12 areas in implementation; percentages do not total to 100 as multiple options could be selected

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017

To understand how organizations can overcome these challenges and deliver value, we took the digital maturity framework outlined earlier and analyzed it in the context of benefits realized. Our analysis confirms that digital masters outpace all other categories in terms of benefits realized (see Figure 11). In productivity benefits alone, digital masters have realized an average 24% of productivity improvement, outperforming the other three categories.

Figure 11: Digital masters are reaping the rewards of their digital maturity

|	Beginners	Digital Masters
Selling, General & Admin Costs	17%	29%
Raw Material, Logistics & Tranportation	18%	27%
Direct labor Cost	16%	27%
Quality & Scrap	17%	26%
Overall productivity	18%	24%
Overall Equipment Effectiveness (OEE)	17%	21%
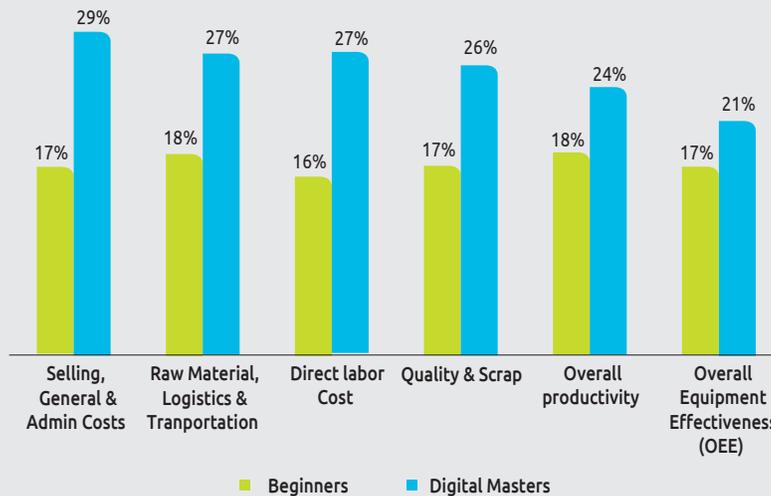
Percentages indicate average benefit realized by the organizations on the KPI in their respective smart factory initiatives so far
Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute Analysis

When we quantify the cumulative impact of these gains on the P&L of manufacturers, the advantage enjoyed by digital masters becomes much more apparent. If we take two average auto manufacturers with $1 billion in revenue and a 5% operating margin, the one in the digital master category would be able to derive – from smart factories – an extra $28m in profits and a lead of 2.3pp in operating margin over the other firm (see Figure 12).

Figure 12: Smart factories would yield an extra $28mn for a digital master over a beginner automaker

	Factors	An average automaker in beginner category	An average automaker in digital master category
A.	Average expected revenue growth in smart factories (in the next five years)	3.6%	8.6%
B.	Reduced manufacturing costs owing to reduction in logistics, administration, direct labor and material costs	Between 0.4% and 3.6%	Between 0.7% and 10.4%
C.	Estimated operating profit (increased revenue less reduced cost base)	US$65mn	US$93mn
D.	Operating margin	6.2%	8.5%

Operating profit projection in 5 years: Beginners vs. Digital Masters
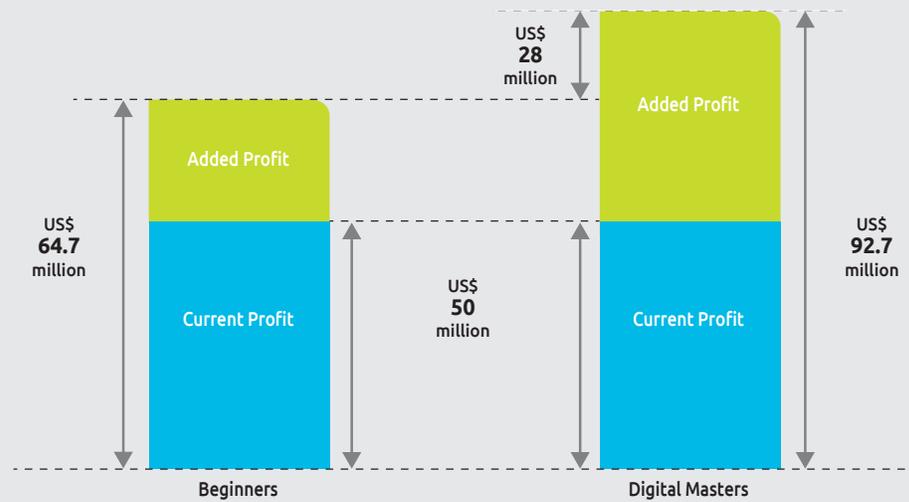
Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute analysis

Digital Masters have leapt ahead of beginners on key digital and transformation parameters

To understand what differentiates digital masters and beginners, we analyzed the parameters of our two dimensions: digital and transformation management intensity.

Digital Intensity

For digital intensity, digitizing processes and leveraging advanced digital technologies were two key differentiators (see Figure 13). We see that a significant majority of digital masters (approximately 80%) said that more than 50% of their processes in all the key areas have been digitized, while less than a third of beginners responded in the same way. Similarly, only a fifth of all beginners are leveraging key technologies such as big data or advanced robotics, whereas a significant majority of digital masters leverage these technologies.

Figure 13: Digital Masters' lead over beginners on digital intensity parameters

Majority of processes digitized

	Performance Management	Maintenance Management	Production	Inventory Management	Quality Management
Digital Masters with more than 50% processes digitized	87%	85%	82%	77%	77%
Beginners with more than 50% processes digitized	32%	29%	27%	27%	31%

- Digital Masters with more than 50% processes digitized
- Beginners with more than 50% processes digitized

High leverage of technologies in operations

	Big Data	Mobility & AR	IIoT	Advanced Robotics
Digital Masters highly leveraging the technology	83%	82%	72%	55%
Beginners highly leveraging the technology	18%	20%	23%	20%

- Digital Masters highly leveraging the technology
- Beginners highly leveraging the technology

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute analysis

Transformation Management Intensity:

Digital skills and governance are the two biggest differentiators in the transformation management intensity (see Figure 14). We found that very few beginners are satisfied with their skill levels in key areas such as data analytics, automation and cyber security; whereas most masters felt they have the skills required. In the governance area, a majority of the beginners are not following the basics of transformation governance, such as appointing a leader and establishing a roadmap.

Figure 14: Digital Masters' lead over Beginners on transformation management intensity parameters

Excellence in digital skills

	Analytics Experts	Cyber Security	Automation Experts
Digital Masters highly skilled in the technology	95%	88%	60%
Beginners highly skilled in the technology	37%	30%	17%

■ Digital Masters highly skilled in the technology   ■ Beginners highly skilled in the technology

Appropriate governance for transformation

	Established a roadmap to monitor progress	Coordinated the initiatives at organizational level	Set up committees & decision making processes	Formulated Strategy at the top management level	Appointed a leader
Digital Masters strongly agree	98%	97%	95%	93%	88%
Beginners strongly agree	41%	44%	39%	47%	35%

■ Digital Masters strongly agree   ■ Beginners strongly agree

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute analysis

The common characteristics of digital masters

Our analysis points to the key characteristics of digital masters.

- Digital masters are making better progress on smart factories compared to their peers.
  72% of digital masters have made good or better than expected progress on their smart factory initiatives, compared to only of 37% of beginners (see Figure 15). Worryingly, for beginners, 39% of them say that they are struggling with their smart factory initiatives.

Figure 15: Majority of digital masters are making good progress or better than expected progress on their smart factory initiatives
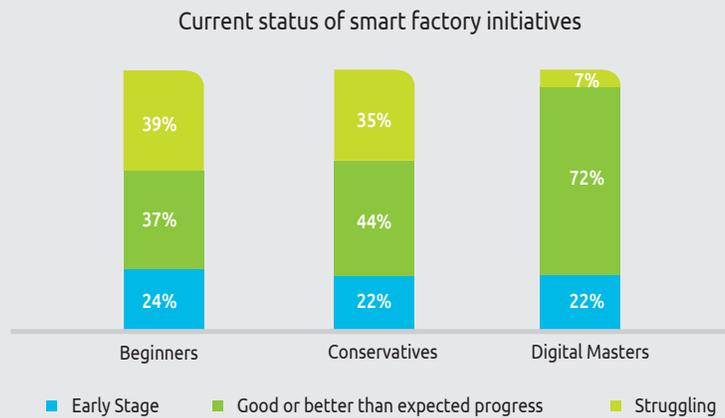
Current status of smart factory initiatives

	Beginners	Conservatives	Digital Masters
Struggling	39%	35%	7%
Good or better than expected progress	37%	44%	72%
Early Stage	24%	22%	22%

■ Early Stage   ■ Good or better than expected progress   ■ Struggling

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute analysis

- Digital masters are making aggressive investments, including training. 45% of digital masters have invested more than 10% of their annual revenues over the last five years in smart factory initiatives, compared to 17% of beginners (see Figure 16). And 73% of masters have spent a significant share of their training budget to build digital skills, compared to 17% of beginners.

Figure 16: Digital masters are making aggressive investments
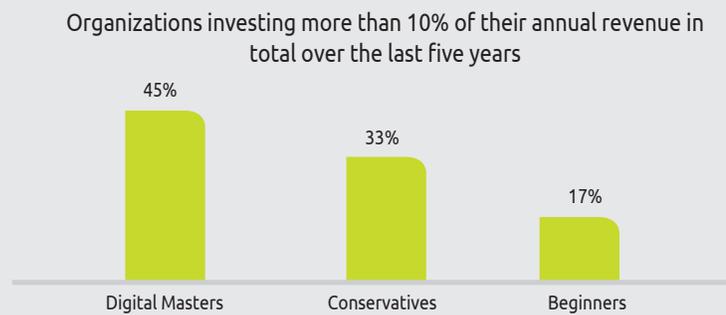
Organizations investing more than 10% of their annual revenue in total over the last five years

Digital Masters	Conservatives	Beginners
45%	33%	17%

Percentages indicate share of organizations in each category

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute analysis

- Digital masters have more aggressive targets. 58% of digital masters are aiming to achieve break even on smart factory initiatives within 5 years, compared to 18% of beginners (see Figure 17). Masters also have more ambitious operational KPI targets. For example, 40% have a quality target, compared to 26% of beginners. Key operational KPI targets for beginners also fall considerably short of the targets set by the digital masters.

Figure 17: Digital masters have more aggressive targets
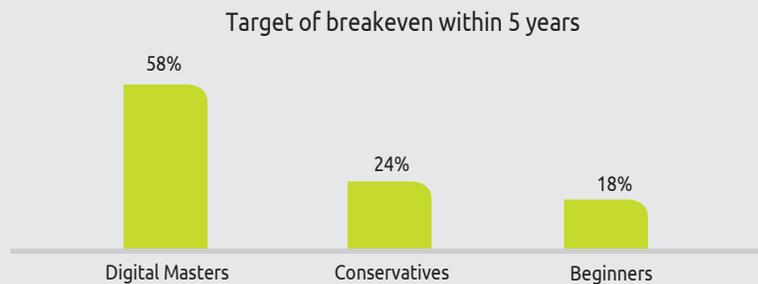
Target of breakeven within 5 years

Digital Masters	Conservatives	Beginners
58%	24%	18%

Percentages indicate share of organizations in each category

Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute analysis

How can Manufacturers Realize their Smart Factory Vision?

Our survey shows that digital masters take a holistic view of their transformation to smart factories (see Figure 18). Moreover, ninety-eight percent of digital masters have established a roadmap for their smart factory initiatives, compared to 41% of beginners. We have seen that digital masters are reaping the rewards of this structured approach.

Figure 18. Digital masters take a more holistic approach to smart factory transformation

Transformation approach taken by players in different categories

Category	Digital Masters	Conservatives	Beginners
Business case & roadmap definition by consulting firms	85%	63%	44%
Focused transformation such as operating model transformation, people transformation, and infrastructure transformation etc.	68%	38%	15%
Partnership with tech providers for feasibility study	67%	55%	29%
End-to-end technology solutions (e.g. Industrial IoT connecting all key manufacturing process etc.)	63%	46%	13%
End-to-End Transformation	55%	50%	30%

■ Digital Masters ■ Conservatives ■ Beginners

Percentages indicate the share of players in each category that take the said approach
Source: Capgemini Digital Transformation Institute, smart factory survey, February-March 2017; Capgemini Digital Transformation Institute analysis

However, a large majority of organizations are still journeying to attain the maturity level of digital masters. This means that there are different strategic imperatives for manufacturers depending on their digital maturity (see Figure 19).

Figure 19. Transformation imperatives depending on organization's digital maturity

Fashionistas

- Establish a roadmap and rally support of key leaders
- Measure and monitor business value of digital initiative and kill unprofitable ones
- Bridge the digital talent gap by partnering with ecosystem players

Digital Masters

- Maintain focus on your roadmap
- Sustain the momentum by keeping your people engaged
- Strive for a digital culture and mindset as you advance your initiatives

Beginners

- Craft a holistic vision; establish a foundation of strong leadership and governance
- Invest in digital initiatives aligned with the vision
- Launch proofs-of-concept and demonstrate early wins

Conservatives

- Ensure agility is factored in your governance models
- Prioritize and execute on your digital initiatives
- Scale your initiatives to the organizational level

Source: Capgemini Digital Transformation Institute analysis

Here's how organizations can put these imperatives into action.

Beginners

Craft a smart factory vision focusing on the financial impact of an end-to-end manufacturing transformation rather than technological improvements

Our experience with clients, and the survey results, point to the fact that digital masters have a holistic view of their transformation. In our research, 55% of digital masters said they are working with their suppliers on an end-to-end transformation, compared to 30% of beginners. Digital masters understand that the true advantage of digital manufacturing in smart factories will be harnessed at an industrial scale and have aligned their vision accordingly:

- 48% of digital masters expect that more than 40% of their products will be produced by smart factories in five years' time, compared to 11% of beginners
- In the next two years, 27% of digital masters aim to have a network of smart factories – multiple facilities that coordinate with each other to optimize operations. But only 5% of beginners have the same target.

Establish leadership and governance to oversee smart factory strategy

Leadership and governance play a critical role in the success of smart factory initiatives. 88% of digital masters have appointed a leader for their smart factory initiative, whereas only around a third of beginners have done so (34%).

The importance of this appointment was reinforced by conversations we had with senior executives, with a former Senior VP at a large European automobile manufacturer telling us: "You have to nominate one person to take the responsibility of driving this transformation. He or she then has to establish a team of

executives who must meet regularly to discuss progress, potential issues and next steps. Every function that is touched by smart factories must have a representative in this core team."

Launch Proofs-of-Concept and demonstrate early wins

One of Capgemini's clients, a large manufacturer with a global presence, was struggling to cope with rising competition and increasing product complexity. It was felt that the organization lacked agility and innovation in manufacturing operations. To jumpstart the digitization of its factories, the company identified 200 digital use cases, launched 40 proofs-of-concept in just a few weeks, and identified nine digital solutions that are being industrialized and replicated across a network of over 200 plants globally. The demonstration of early wins from proofs-of-concept helps leaders to build a stronger case and rally support for the next leg of transformation.

Conservatives

Ensure agility in your leadership and governance

Conservatives need to be cautious that their process-driven and structured approach does not hinder experimentation that is vital for advancing digital intensity. More agile leadership is also critical, as a Vice President of Innovation at a leading French manufacturer outlines: "A very senior executive is at the helm of our organization's Industry 4.0 initiative. The leader has formed a steering committee with key leaders from supply chain, manufacturing and technology. The steering committee has to meet several times a month to evaluate the program and ensure that it is moving forward at the right pace." Our survey found that for 70% of digital masters, the leader of smart factory initiatives reports directly to the head of manufacturing, while only a third (34%) of beginners have this level of reporting.

Prioritize initiatives, execute on them and scale to the organizational level

Industry executives pointed to two key challenges in smart factory implementation: organizational inertia and identifying & prioritizing opportunities. Leading organizations focus on a set of key initiatives and scale them up to the organizational level once proven, as Brian Tessier, Vice President, Global Supply Chain Innovation at Schneider Electric, outlines. "Our smart factory industrialization program has identified a set of 10 plants globally which we're developing as our showcase Industry 4.0 plants," he explains. "We conducted a maturity modeling of these plants to determine their level of digitization on technology and process to move them along the maturity curve. Once these plants reach a desired level of maturity, we will standardize the tools and processes to our entire network of over 200 plants in 44 countries."

Fashionistas

Establish a roadmap and rally support of key leaders

Fashionistas have an uphill task ahead of them in the form of bringing a structure to their largely uncoordinated digital initiatives. They can start by laying down a foundation of governance that involves:

- Having leadership or governing committees with defined decision-making processes
- An established roadmap to monitor the progress of smart factory initiatives
- Defining and measuring progress on a standard set of key performance indicators
- Tracking benefits at regular intervals to fine tune approach

General Manager, Site Operations of an American pharmaceutical and medical equipment manufacturer told us about involving key leaders in governance, "We have ensured the support and involvement of key leaders in governing our smart factory initiatives. This enables our end-to-end transformation. Our governing council includes leaders from supply chain, IT and business that oversee local steering bodies. These local teams are tasked with the implementation and rollout."

Measure and monitor business value delivered by digital initiatives

Due to the wide-ranging impact of smart factories, devising and following through on a business case is key. Our current research reveals that near all digital masters are tracking the business case and making use of a standard set of KPIs for monitoring progress whereas only 41% of beginners are doing so.

Be prepared to bridge the digital talent gap

Although Fashionistas launch a number of digital initiatives, they usually do so without a long-term view of maturing these initiatives as technology and consumer expectations evolve. Building and retaining a digital talent pool is a crucial part of this. In our survey, 54% of organizations that have invested heavily in building digital skills have made better than expected progress with their smart factory initiatives. Digital skills, such as big data analytics, automation and mechatronics, are undoubtedly crucial. Fashionistas can look up to strategies adopted by digital masters for bridging the skill gap:

- Up-skilling employees (82% of digital masters do this)
- Forming strategic partnerships with technology providers (75%)
- Nurturing (57%) and acquiring startups (47%)

Digital Masters

Strive for a digital culture and mindset as you advance your initiatives

Building digital skills is important however industry leaders are going a step further and focusing on changing culture by cultivating a digital mindset. Our previous research with MIT has established that a digital-first mindset is a distinguishing feature of a digital organization,[15] where the default position is to employ a digital solution first.

Swapnil Choudhari, Director Global R&D – Professional Laundry Systems and Dishwashers, Electrolux, underlines the significance of mindset. "Skills are necessary, but the importance of the right mindset can't be overstated. When you transform from a traditional way to a new way, mindset makes it easier and more effective to develop new skills, build new relationships and harness new opportunities." Grégoire Ferré, Chief Digital Officer, Faurecia believes mindset plays a crucial role as firms advance their smart factory initiatives. "The key part of the transformation is the change of mindset," he explains. "At some point during your transformation, you have to shift from an 'innovation mindset' to a 'deployment mindset', establish standards, set up structures, and so on."

Sustain momentum by ensuring your people are part of the journey to foster collaboration, manage concerns and deliver change

Like any large transformation initiative, the success of smart factories also hinges on how effectively the workforce is involved in the program. A number of the executives we spoke with emphasized on the importance of ensuring people are part of the journey right from the start. Marc Fevrat, Director of Manufacturing Engineering at one of the largest heavy vehicle manufacturers told us, "In a program such as smart factory, where people have to adjust to new processes and ways of working, it is crucial to have ambassadors to get people adjusted to change. People are much more open to change when a colleague tells them how new technology may help them or ease their burden."

Use of robots introduces uncertainty among workers. A majority (57%) of organizations in our research said that they are looking to use advanced robotics & smart automation to augment the work of existing operators. The role of management communication becomes crucial therefore, as operators become concerned about their jobs. Organizations can manage these concerns by communicating the advantages that technology offers, such as taking on repetitive tasks and allowing workers to focus on higher-skilled tasks. In fact, our research has found that up-skilling the existing workforce is the most popular approach

taken by manufacturers to bridge the digital skills gap. The head of manufacturing operations at a large Asian electric vehicle manufacturer whom we spoke to for this research, believes effective communication is critical to managing any potential resistance. "Employee resistance can stall the progress of your smart factory," he says. "A big role has to be played by the management by talking to employees, convincing them and making them comfortable with the objectives and benefits of automation."

CONCLUSION

We are firmly in the age of the smart factory. How things are made – from cars to pharmaceuticals – is being transformed. Manufacturers are achieving new levels of efficiency and productivity, costs are falling, and new revenue opportunities are being revealed. But as machines talk to each other and robots take on more tasks, the digital maturity of the organization becomes increasingly critical. Manufacturers need to be digitizing processes – from forecasting and planning to production – and making use of key technologies, from industrial internet of things, artificial intelligence to big data analytics. At the same time, they also need to be driving a coherent transformation, focusing on the vision, governance, and skills needed in a new future. Manufacturers that excel in these areas are delivering better results from smart factories, and will be much better placed to tackle the key challenges of smart factories, such as the threat of a backlash or resistance from existing workers.

Our research found that there is already a leading cohort of manufacturers who are excelling in those areas, and the gap between the leaders and followers will only get bigger as technologies accelerate. Up-skilling the workforce with digital skills will be necessary. However, it needs to be supplemented by making people a part of the journey and striving for a digital culture. It's time to catch up now, or this latest revolution in industry might leave you behind.

Research Methodology

Industry Survey - We surveyed more than 1000 executives at director or more senior role in manufacturers with reported revenue of more than $1 billion for FY 2015. The survey took place from February to March, 2017 in six manufacturing sub-sectors – Industrial Manufacturing, Automotive & Transportation, Energy & Utilities, Aerospace & Defense, Life Sciences & Pharmaceuticals, and Consumer Goods. Geographically, the survey covered eight countries – United States, United Kingdom, France, Germany, Italy, Sweden, China & India.

Distribution of survey responses across industries

Industry	%
Industrial manufacturing	26%
Automotive and transportation	22%
Energy, Utilities (Water, Electricity)	20%
Consumer goods	19%
Aerospace and defense	7%
Life sciences, biotech, pharma	6%
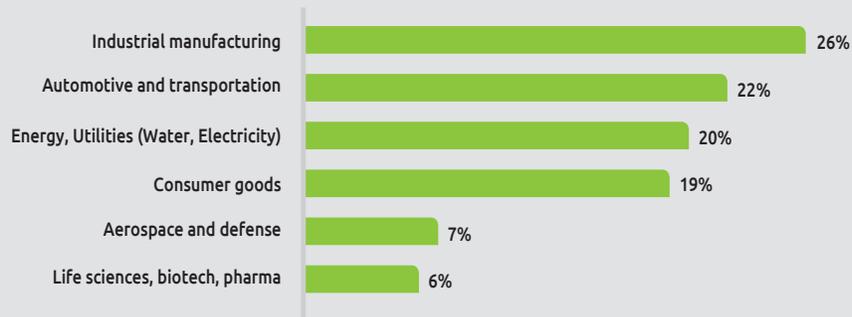
Distribution of survey responses across geographies

India 10%, UK 9%, US 40%, Sweden 4%, France 9%, Germany 9%, Italy 9%, China 10%
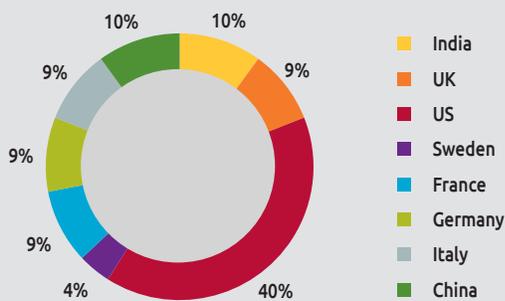
Distribution of survey responses across respondent roles

Production and operations 70%, IT/Technology 8%, Maintenance and support 4%, Finance 13%, Procurement 3%, Quality Control 3%
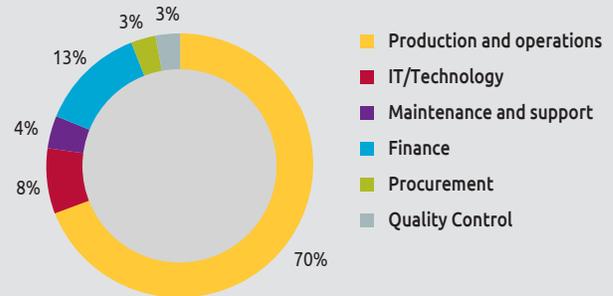
Distribution of respondents across company revenue groups (annual)

$1-2 billion 28%, $2-5 billion 27%, $5-10 billion 24%, $10-20 billion 15%, $20-$50 billion 5%, More than $50 billion 2%
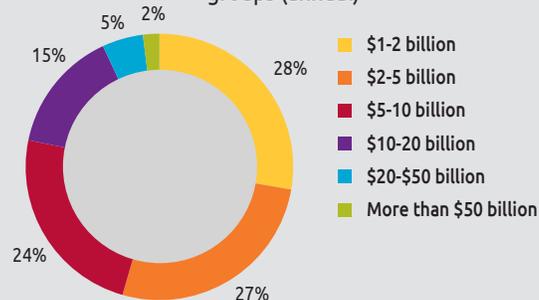
Focus Interviews – We conducted discussions with 18 executives who were directly involved with their organization's smart factory initiatives, and held director or more senior roles in companies with revenues of more than $1 billion each. In the discussions, we explored the vision, approach, measurement of success, and challenges of smart factory initiatives.

Web-based Research – In addition to industry survey and focus interviews, we have also conducted a web-based research to collect key data points to quantify the financial benefits of smart factory.

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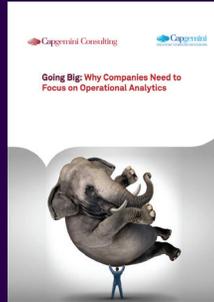
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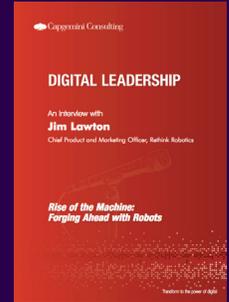
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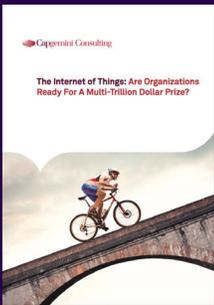
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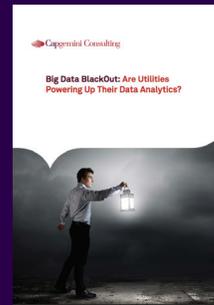
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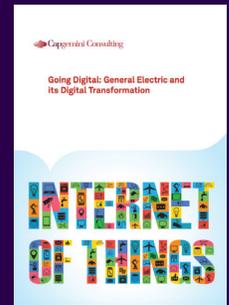
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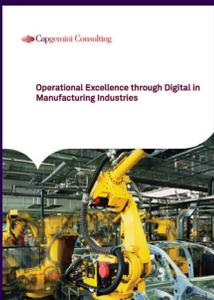
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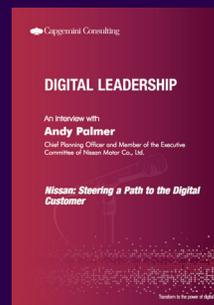
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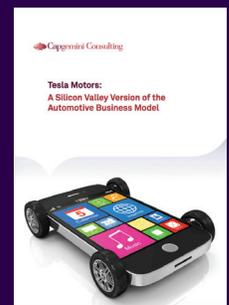
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