Industry 4.0: Building the digital enterprise

2000+

respondents in 26 countries

US$493 bn

in digital revenue gains p.a.

US$421 bn

p.a. in cost and efficiency gains

US$907 bn

in annual digital investments

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Contents

PwC's 2016 Global Industry 4.0 Survey is the biggest worldwide survey of its kind, with over 2,000 participants from nine major industrial sectors and 26 countries. The study explores the benefits of digitising your company's horizontal and vertical value chains, as well as building your digital product & service portfolio. Based on the findings and our experience working with first movers, we've also crafted a blueprint for success to help you secure your company's position as a leading digital enterprise in tomorrow's complex industrial ecosystems.

Industry split of survey respondents

Forest, paper & packaging 4% — Aerospace, defence & security 2% — Metals 8% — Industrial manufacturing 21% — Other 8% — Automotive 9% — Transportation & logistics 9% — Electronics 10% — Chemicals 11% — Engineering & construction 19%

Industry split
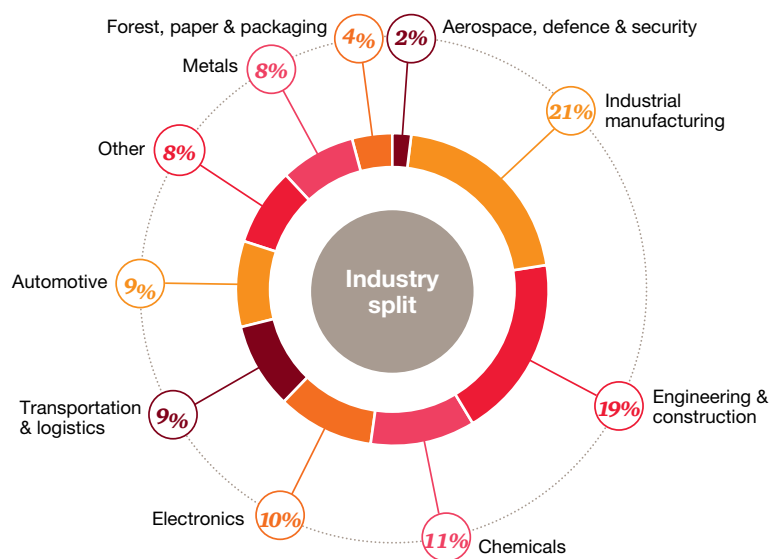
Participating countries

Canada — Denmark — Sweden — India — Netherlands — Austria — China — USA — UK — Poland — Japan — Finland — Middle East — Singapore — Mexico — Portugal — South Africa — Brazil — France — Italy — Australia — Spain — Germany — Switzerland
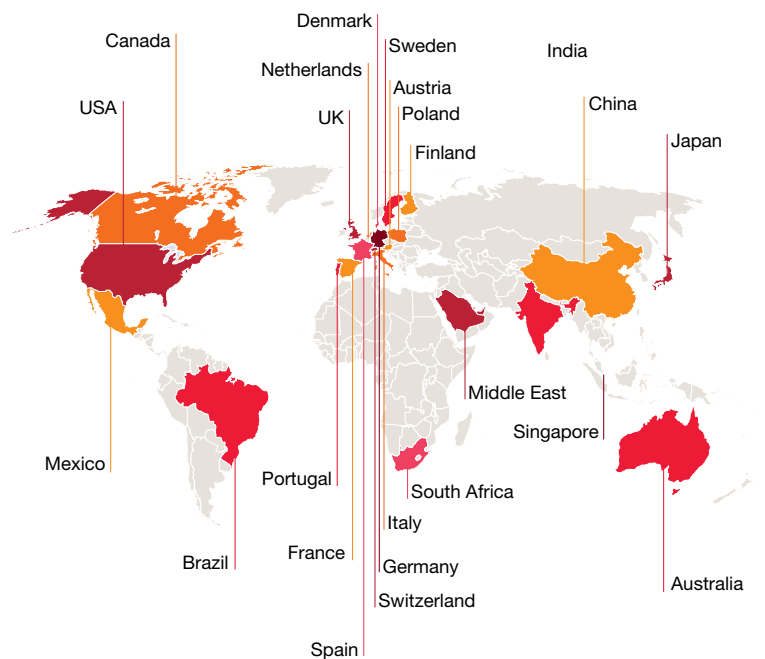
Introduction

Behind the scenes of the world's leading industrial and manufacturing companies, a profound digital transformation is now underway.

Industrial leaders are digitising essential functions within their internal vertical operations processes, as well as with their horizontal partners along the value chain. In addition, they are enhancing their product portfolio with digital functionalities and introducing innovative, data-based services. The 2,000+ companies that we surveyed are expecting to dramatically increase their overall level of digitisation. While just 33% rate their company as advanced today, that number jumps to over 70% looking ahead to 2020.

While terms like the industrial internet or digital factory are also used to describe these changes, in this report we use Industry 4.0 as a shorthand to describe a journey industrial companies are taking towards a complete value chain transformation *(see What we mean by Industry 4.0).*

At the end of this transformation process, successful industrial companies will become true digital enterprises, with physical products at the core, augmented by digital interfaces and data-based, innovative services. These digital enterprises will work together with customers and suppliers in industrial digital ecosystems.

These developments will fundamentally change individual companies, as well as transform market dynamics across a whole range of industries. And that's true in countries all around the world – in both the developed as well as the emerging markets. Here's what's driving change:

- ***Annual digital revenue increases of 2.9%*** on average – and a significant minority that expect total increases of more than 50% over five years. That adds up to US$493 bn in increased annual revenues for the next five years across the industrial sectors we surveyed.

- ***Cost reductions of 3.6% p.a.*** on average. Digital technologies enable shorter operational lead times, higher asset utilisation and maximum product quality; all told, our survey respondents expect to save US$421 bn in costs each year for the next five years.

- ***Incremental and revolutionary product & service innovation***
  To generate these additional revenues, companies will introduce new industrial products with digital features and augment their existing portfolio. Digital services based on data analytics, or even complete digital solutions serving a customer ecosystem, will drive breakthrough revenue growth.

- ***A strong commitment to invest***
  Industrial sectors are planning to commit US$907 bn p.a. to Industry 4.0 – around 5% of revenue p.a. A major focus of these investments will be on digital technologies like sensors or connectivity devices, and on software and applications like manufacturing execution systems. In addition, companies are investing in training employees and driving required organisational change. 55% of the investments expect a payback within two years.

To keep up, you'll need to transform your business.

Focus on people and digital transformation

The biggest challenge of industrial leaders isn't technology - it is the people. While digital technologies are rapidly becoming a commodity, success largely depends on an organisation's Digital IQ[1], especially how well its digital leaders like the CEO, CTO, or CIO define, lead, and communicate the transformation. It's also dependent upon the digital qualifications of the employees who need to roll out digital processes and services. Radical disruption isn't always comfortable for the people who make it happen, so change management will also be critical. And with data analytics becoming a core capability for every industrial company, enhancing skills and organisational structures will be critical.

Digital trust is key

With so much change in store, there's one area that companies can't afford to ignore: digital trust. Digital ecosystems can only function efficiently if all parties involved can trust in the security of their data and communication, as well as the protection of their intellectual property. Protecting your company and ensuring digital trust requires significant investment and clear guidelines for data integrity and security.

The key findings we explore in the first half of this report confirm that no industrial company can afford to ignore the fundamental changes that Industry 4.0 will bring. The second half provides a pragmatic, step-by-step blueprint for how industrial companies can successfully build a digital enterprise.

Please reach out to us for more details on our research or to discuss our approaches. The digital transformation is underway: now is the time for your company to act!

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1 PwC, 2015 Global Digital IQ Survey, September 2015.

What we mean by Industry 4.0

In this report, the term 'Industry 4.0' stands for the fourth industrial revolution. Other related terms include the 'Industrial Internet' or the 'Digital Factory', although neither takes as complete a view. While Industry 3.0 focused on the automation of single machines and processes, Industry 4.0 focuses on the end-to-end digitisation of all physical assets and integration into digital ecosystems with value chain partners. Generating, analysing and communicating data seamlessly underpins the gains promised by Industry 4.0, which networks a wide range of new technologies to create value.

While the term Industry 4.0 is becoming increasingly familiar, we use it in a specific way in this report. In our view, Industry 4.0 is driven by:

1) Digitisation and integration of vertical and horizontal value chains

Industry 4.0 digitises and integrates processes vertically across the entire organisation, from product development and purchasing, through manufacturing, logistics and service. All data about operations processes, process efficiency and quality management, as well as operations planning are available real-time, supported by augmented reality and optimised in an integrated network.

Horizontal integration stretches beyond the internal operations from suppliers to customers and all key value chain partners. It includes technologies from track and trace devices to real-time integrated planning with execution.

2) Digitisation of product and service offerings

Digitisation of products includes the expansion of existing products, e.g. by adding smart sensors or communication devices that can be used with data analytics tools, as well as the creation of new digitised products which focus on completely integrated solutions. By integrating new methods of data collection and analysis, companies are able to generate data on product use and refine products to meet the increasing needs of end-customers.

3) Digital business models and customer access

Leading industrial companies also expand their offering by providing disruptive digital solutions such as complete, data-driven services and integrated platform solutions. Disruptive digital business models are often focused on generating additional digital revenues and optimising customer interaction and access. Digital products and services frequently look to serve customers with complete solutions in a distinct digital ecosystem.

Industry 4.0 framework and contributing digital technologies
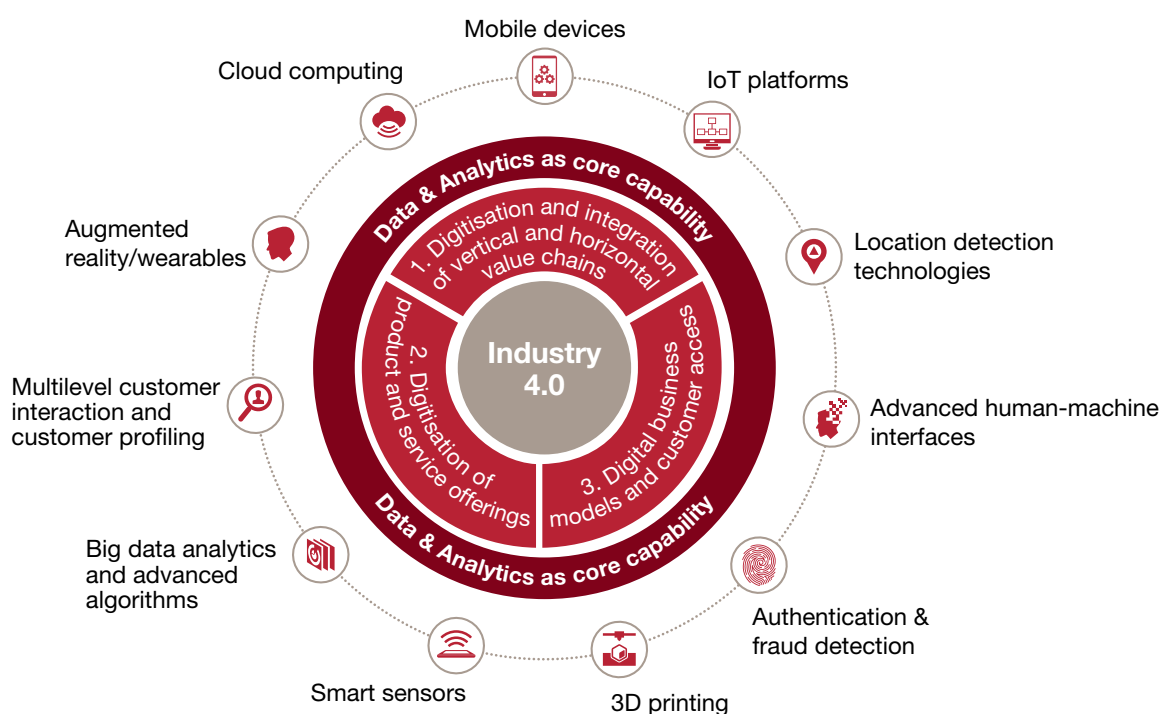
Executive summary
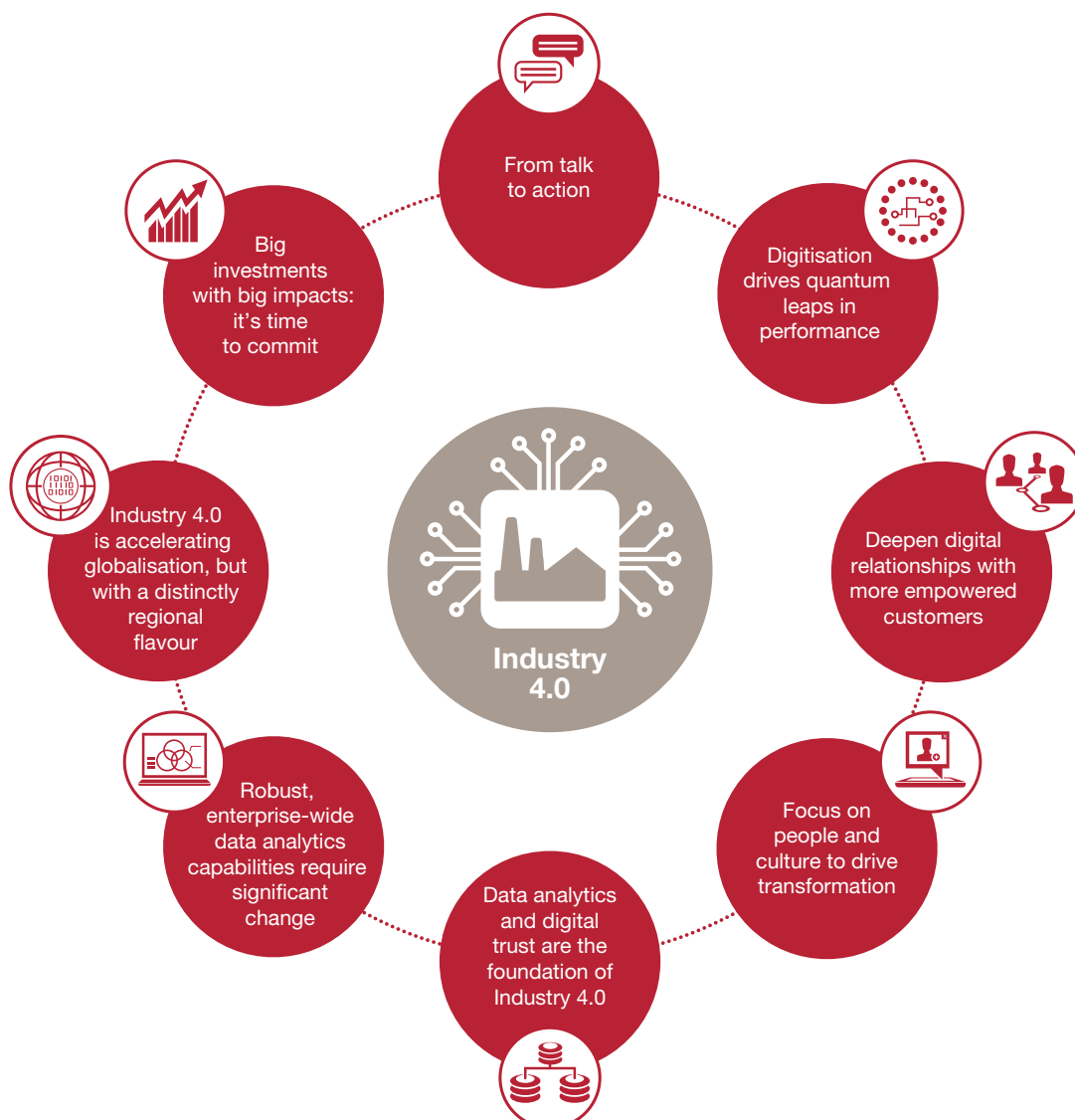
PwC's 2016 Global Industry 4.0 Survey of industrial companies is the biggest survey of its kind studying Industry 4.0 to date.

With over 2,000 participants from companies in nine major industrial sectors and 26 countries, it goes to the heart of company thinking on the progress towards transforming into a digital enterprise.

We've distilled the results of our research into eight distinct key findings. The first half of our report explores each finding in more detail. Based on the findings and our experience working with some first movers, we've also crafted a blueprint for implementation success. In the second half, we detail six steps to help companies move from initial strategy all the way to taking a leading role in tomorrow's digital ecosystems.

Key findings from our survey research

- From talk to action
- Digitisation drives quantum leaps in performance
- Deepen digital relationships with more empowered customers
- Focus on people and culture to drive transformation
- Data analytics and digital trust are the foundation of Industry 4.0
- Robust, enterprise-wide data analytics capabilities require significant change
- Industry 4.0 is accelerating globalisation, but with a distinctly regional flavour
- Big investments with big impacts: it's time to commit

Industry 4.0

Key findings from our survey research

1) Industry 4.0 - from talk to action

The buzz around Industry 4.0 has moved from what some saw as PR hype in 2013 to investment and real results today. Respondents expect to significantly increase their portfolios of digital products and services; more than twice as many expect to be at an advanced level in this area by 2020 compared to today. Similarly, almost three-quarters of companies expect to have highly digitised horizontal and vertical value-chain processes in five years.

Investment plans are extremely ambitious, with first movers in particular already making significant Industry 4.0 investments and realising both above-average digital revenues and operational savings. Their plans for the next five years are even more ambitious and far-reaching, with digital products and services paving the way for disruptive business models.

2) Digitisation drives quantum leaps in performance

Companies that successfully implement Industry 4.0 no longer need to choose between focusing on a better top or bottom line. They can improve both at the same time. Over the next five years, the companies we surveyed expect to increase annual revenues by an average of 2.9% and reduce costs by an average of 3.6% p.a. First movers who combine high investment levels with advanced digitisation are set to achieve even more dramatic gains.

All told, our survey respondents expect to see US$421 bn in cost reductions and US$493 bn in increased annual revenues p.a. for the next five years. If even half of these expectations are met, Industry 4.0 will fundamentally reshape the competitive landscape and bring fundamental change to established industries.

3) Deepen digital relationships with more empowered customers

Customers will be at the centre of the changes to value chains, products and services. Products, systems and services will be increasingly customised to customer needs, and many of our survey respondents say they plan to use data analytics to understand and meet them. First movers who are able to establish successful industrial platforms will have a significant advantage over competitors. Ultimately, industrial companies will need to own relationships with the end customers who drive demand or at least integrate with platforms that allow them to access the end customers efficiently.

4) Focus on people and culture to drive transformation

Our survey respondents say that their biggest implementation challenge isn't the right technology, it's a lack of digital culture and skills in their organisation. This finding is also consistent with our Digital IQ research, which for nine years has explored how organisations across industries can derive value from digital investments[2]. Digital IQ emphasises that while investing in the right technologies is important, ultimately success or failure will depend not on specific sensors, algorithms or analytics programmes, but on a broader range of people-focused factors. Industrial companies need to develop a robust digital culture and to make sure change is driven by clear leadership from the C-suite. They'll also need to attract, retain, and train digital natives and other employees who are comfortable working in a dynamic ecosystem environment.

5) Data analytics and digital trust are the foundation of Industry 4.0

Data fuels Industry 4.0 and successful data analytics is the prerequisite for successful implementation of digital enterprise applications. It's time to move from a phase of discovery and understanding what data is available and what it is worth to one of insights and action. 'First movers' are already making the shift and using data analytics to help drive decision-making.

As digital ecosystems expand, so does the importance of establishing strong levels of digital trust, backed up by transparency and non-repudiation that provides proof of the integrity and origin of one's own and third-party data. Strong risk management and data integrity systems can help companies avoid breaches and manage disruption to operations better – the #1 data security concern of our survey respondents.

6) Robust, enterprise-wide data analytics capabilities require significant change

Industrial companies will need to develop robust organisational structures that support data analytics as an enterprise-level capability. Half of the surveyed companies have established dedicated data analytics functions, either on a corporate level to bundle talent or on a business unit level to remain close to the operational business. However, 38% of companies currently rely on selective, ad-hoc capabilities of single employees; another 9% have no significant capabilities at all.

7) Industry 4.0 is accelerating globalisation, but with a distinctly regional flavour

Industry 4.0 will create digital networks and ecosystems that in many cases will span the globe, but still retain distinct regional footprints. Both developed and developing markets stand to gain dramatically.

Companies in Japan and Germany are the furthest along in digitising internal operations and partnering across the horizontal value chain. With high investment in technology and employee training, they view their digital transformation primarily in terms of gains in operational efficiency, cost reduction and quality assurance. Our experience working with companies in the US suggests that they are planning to invest more heavily in developing disruptive business models, as companies move quickly to digitise their product and service portfolios.

China's industrial companies stand out in all aspects of digitisation: they are expecting both above-average cost reductions as well as increased digital revenues through to 2020. China is one of the countries that stands to gain the most from automating and digitising labour-intensive manufacturing processes and needs to find a solution to rising employee remuneration. In addition, Chinese companies are highly flexible and open to digital change.

8) Big investments with big impacts: it's time to commit

Industry 4.0 investments are already significant and our research suggests that global industrial products companies will invest US$907 bn per year through to 2020. The major focus of this investment will be on digital technologies like sensors or connectivity devices, as well as on software and applications like manufacturing execution systems (MES). In addition, companies are also investing in training employees and driving organisational change. More than half of respondents expect their Industry 4.0 investments to yield a return within two years or less, given investment of around 5% p.a. of their annual revenue.

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2   PwC, 2015 Global Digital IQ Survey, September 2015.

Blueprint for digital success

To move forward with Industry 4.0, digital capabilities are all-important. These take time and concentration; a step-by-step approach is important. But move with deliberate speed, so that you don't lose the first-mover advantage to competitors.

1) Map out your Industry 4.0 strategy

Evaluate your own digital maturity now and set clear targets for the next five years. Prioritise the measures that will bring the most value to your business and make sure these are aligned with your overall strategy. Make sure company leadership is ready and willing to champion your approach.

2) Create initial pilot projects

Use them to establish proof of concept and demonstrate business value. Target a confined scope, but highlight the end-to-end concept of Industry 4.0. Not every project will succeed, but they will all help you to work in a cross-functional and agile approach with customers and technology partner - the new norm of the future. With evidence from early successes, you can also gain buy-in from the organisation, and secure funding for a larger rollout. Design pragmatically to compensate for standards or infrastructure that don't yet exist. Collaborate with digital leaders outside your organisation, by working with start-ups, universities, or industry organisations to accelerate your digital innovation.

3) Define the capabilities you need

Building on the lessons learned in your pilots, map out in detail what capabilities you need to achieve your vision. Include how enablers for Industry 4.0, like an agile IT infrastructure, can fundamentally improve all of your business processes.

Remember to develop strategies for attracting people and improving

processes as well as for implementing new technologies. Your success with Industry 4.0 will depend on skills and knowledge. Your biggest constraints may well be your ability to recruit the people needed to put digitisation into place.

4) Become a virtuoso in data analytics

Consider how you can best organise data analytics; cross-functional expert teams are a good first step. Later these capabilities can be fully embedded in your functional organisation.

Learn to get value out of data by building direct links to decision-making and to intelligent systems design. Use the data to improve products and their use in the field to offer and build new service offerings. Think big, but start small, with 'proof of concept' projects.

5) Transform into a digital enterprise

Capturing the full potential of Industry 4.0 often requires company-wide transformation. Look to set "tone from the top", with clear leadership, commitment and vision from the C-suite and financial stakeholders. Foster a digital culture: all your employees will need to think and act like digital natives, willing to experiment with new technologies and learn new ways of operating.

Remember that change doesn't stop once you've implemented Industry 4.0. Your company will need to re-invent its capabilities at faster rates than in the past to stay ahead of the game.

6) Actively plan an ecosystem approach

Develop complete product and services solutions for your customers. Use partnerships or align with platforms if you cannot develop a complete offering internally. You may find it difficult to share knowledge with other companies, and you may prefer acquisition. But look for ways to bridge this gap – perhaps with technical standards – so that you can profit from being part of platforms that you don't fully control.

Real breakthroughs in performance happen when you actively understand consumer behaviour and can orchestrate your company's role within the future ecosystem of partners, suppliers and customers.

Don't buy the hype. Buy the reality. Industry 4.0 will be a huge boon to companies that fully understand what it means for how they do business. Change of this nature will transcend your company's boundaries – and probably the national boundaries of the countries where you do business.

Blueprint for digital success

| Map out your Industry 4.0 strategy | Create initial pilot projects | Define the capabilities you need | Become a virtuoso in data analytics | Transform into a digital enterprise | Actively plan an ecosystem approach |
| 1 | 2 | 3 | 4 | 5 | 6 |

Key findings from our survey research

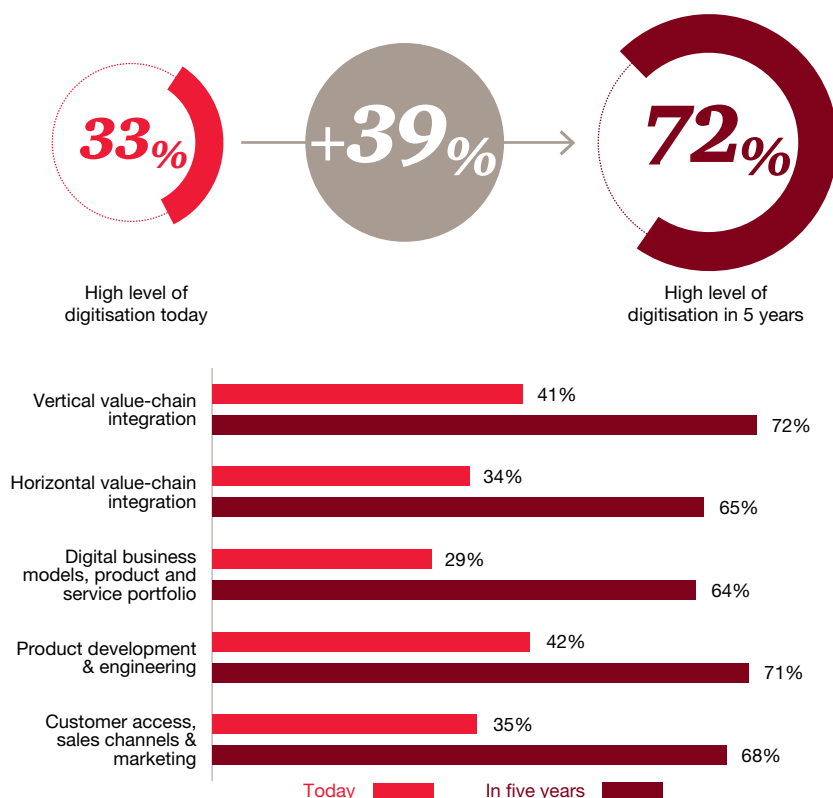## Industry 4.0 has moved from talk to action

When PwC conducted its first set of research on Industry 4.0 in 2014 , it was on the radar for many companies – but relatively few were actually in the process of implementing it. That has changed dramatically this year.

Industry 4.0 is no longer a 'future trend' – for many companies it is now at the heart of their strategic and research agenda. Companies are combining advanced connectivity and advanced automation, cloud computing, sensors and 3D printing, connected capability, computer-powered processes, intelligent algorithms and 'internet of things' (IoT) services to transform their businesses.

Change is happening fastest in areas close to the core business

Just over two-fifths of companies report that they believe their product development and engineering and their vertical value chains are already benefiting from an advanced level of digitisation and integration (see Figure 1). Areas of focus include digitising and connecting functions

Figure 1: **Respondents expect to more than double their level of digitisation by 2020**

33% High level of digitisation today

+39%

72% High level of digitisation in 5 years

	Today	In five years
Vertical value-chain integration	41%	72%
Horizontal value-chain integration	34%	65%
Digital business models, product and service portfolio	29%	64%
Product development & engineering	42%	71%
Customer access, sales channels & marketing	35%	68%

Shown: Percentage of companies surveyed reporting high degrees of digitisation and integration

Q: How would you classify the current level of digitisation and integration in the following areas in your company? What levels of digitisation and integration are you expecting in the next five years?

such as digital order processes, customised product development and the automated transfer of product data to connected planning and manufacturing systems, and further on to integrated customer service. These are also the areas that they anticipate will also be furthest advanced in five years' time.

Advanced digitisation and integration of the horizontal value chain, with suppliers, customers and other value-chain partners, and digitisation of customer channels are progressing a little slower than with the vertical value chain. Big advances are expected in five years' time but these are areas that companies believe will be more challenging than those closer to their core production activities.

First movers are set to outpace their competitors

Some companies report advanced or very advanced current levels of digitisation and integration. There are also companies who rate themselves ahead of their main competitors when it comes to building digital operations capabilities. And some companies have made early investments in Industry 4.0.

There is also a select group of companies who score highly on all three of these key dimensions. We identified 71 companies (around 4% of the whole survey population) who are setting the fastest pace. We call these companies "first movers," and they're already gaining a nearly insurmountable advantage over competitors, as we'll show throughout this report.

'First movers' expect to gain significant benefits from their more advanced digital capabilities and greater levels of investment. They are far more likely to be forecasting both revenue gains of more than 30% and cost reduction of more than 30% at the same time (see Figure 2). They're more likely to expect efficiency gains too. Put these all together and you have an enormous impact.

Figure 2: **First movers are almost three times more successful in combining high revenue increases with significant gains in cost reduction**
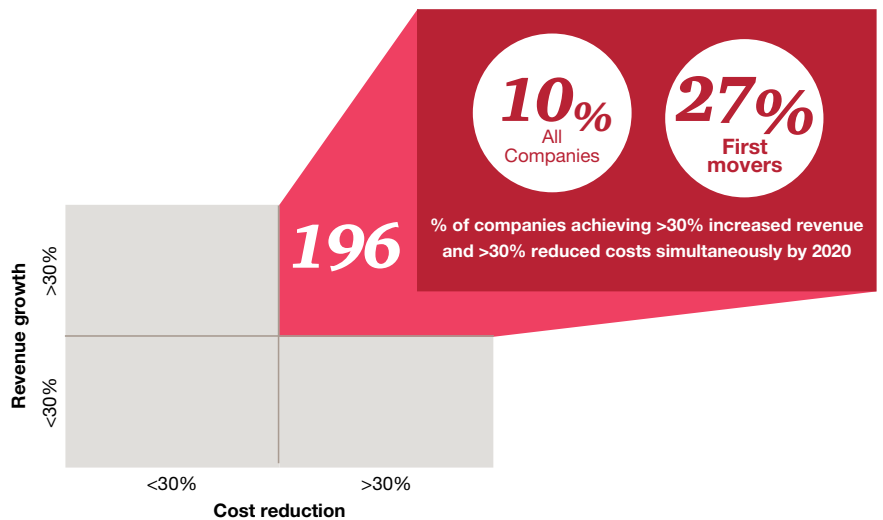
Q: What cumulative benefits from digitisation do you expect in the next 5 years? Lower costs, increased revenues.

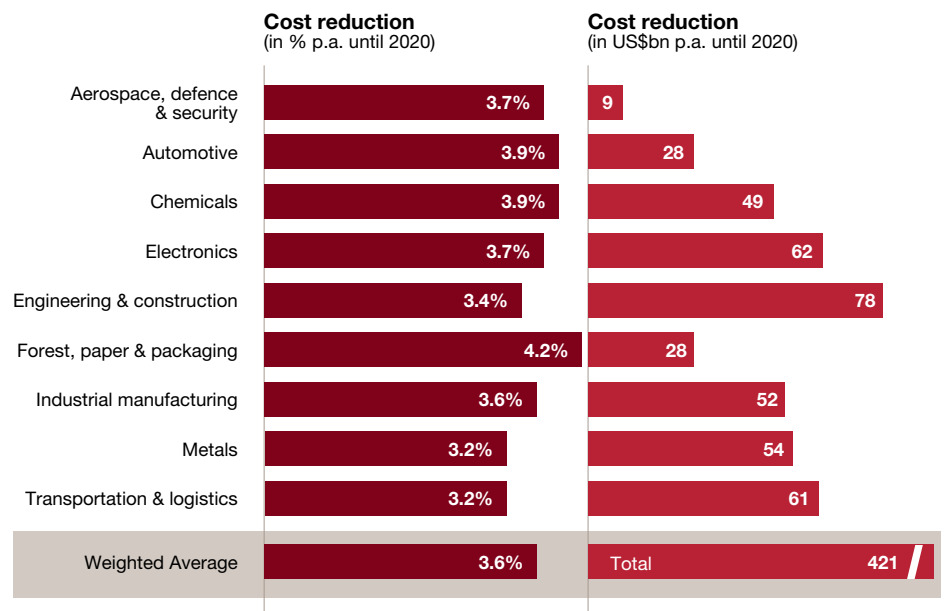# Digitisation drives quantum leaps in performance

Our survey respondents anticipate significant gains from the implementation of Industry 4.0 initiatives.

On average, companies expect to reduce operational costs by 3.6% p.a., while increasing efficiency by 4.1% annually. High levels of cost reduction are expected in every industry sector we studied (see Figure 3). Some of these cost savings can be achieved by implementing smart manufacturing initiatives. For example, companies are moving to integrated planning & scheduling for manufacturing. Such systems combine data from within the enterprise – from sensors all the way through to ERP systems – with information from horizontal value chain partners, like inventory levels or changes in customer demand. Integrated shop floor planning improves asset utilisation and product throughput time. Another example is predictive maintenance of key assets, which uses predictive algorithms to optimise repair and maintenance schedules and to improve asset uptime.

System based, real-time end-to-end planning and horizontal collaboration is now possible using cloud-based planning platforms. Companies that use such systems to become better integrated with horizontal value chain partners, including suppliers and key customers, can significantly improve efficiencies and reduce inventories. In addition, the implementation of track-and-trace devices on products will lead to better inventory performance and reduced logistics cost.

Figure 3: *Companies in every industry sector expect significant cost reductions*

	Cost reduction (in % p.a. until 2020)	Cost reduction (in US$bn p.a. until 2020)
Aerospace, defence & security	3.7%	9
Automotive	3.9%	28
Chemicals	3.9%	49
Electronics	3.7%	62
Engineering & construction	3.4%	78
Forest, paper & packaging	4.2%	28
Industrial manufacturing	3.6%	52
Metals	3.2%	54
Transportation & logistics	3.2%	61
Weighted Average	3.6%	Total 421

Q: What cumulative benefits from digitisation do you expect in the next 5 years? Lower costs.

Figure 4: *Revenues from digitising the product and service portfolio will grow significantly in future*

47% Digitisation of the existing product portfolio

44% Introducing a new digital product portfolio

42% Other digital services to external customers

38% Big data analytics services to external customers
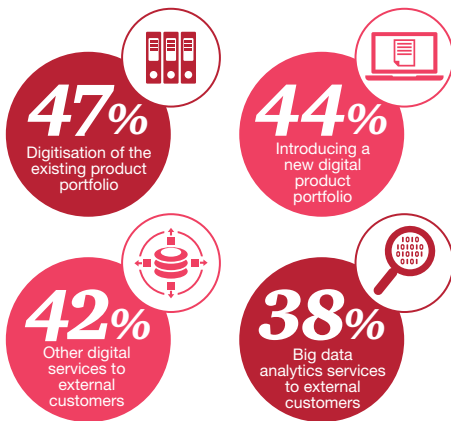
Note: Companies achieving 10% or more additional revenue in the following areas over the next 5 years. Multiple answers possible

Q: Which of the following new digital products or services do you plan to introduce and expect will generate more than 10% of your future revenue over the next 5 years?

The new competitive landscape

Efficiency gains of the magnitude uncovered by our survey have the potential to change the competitive landscape within a very short space of time. If even half of the expectations outlined are realised, some companies may find themselves unable to compete. In an increasingly cost-competitive market, no industrial company can afford to lose out in operational efficiency against their market peers. The next two to three years will be crucial for companies looking to catch up.

Significant revenue opportunities ahead

Survey participants expect additional digital revenues of 2.9% p.a. until 2020. To generate these additional revenues, companies will introduce new industrial products with digital features and augment their existing portfolio (see Figure 4). Digital services based on data analytics, or even complete digital solutions serving a customer ecosystem, will drive breakthrough revenue growth.

In addition, real-time data availability will enable companies to manufacture personalised products and customise solutions. These customised products usually generate significantly higher margins than mass-manufactured offerings.

Improved customer insight from smart data analytics also allows companies to better focus on additional high-margin business.

In the new industrial reality, most companies (86%) expect to secure simultaneous gains from both lower costs and added revenue in the next five years.

And the impact is far-reaching for every industry we studied. At least a third of companies in every sector expect to secure efficiency gains and cost savings of more than 20% and many anticipate that these will be accompanied by additional revenues of the same magnitude.

How Industry 4.0 is delivering revenue, cost and efficiency gains

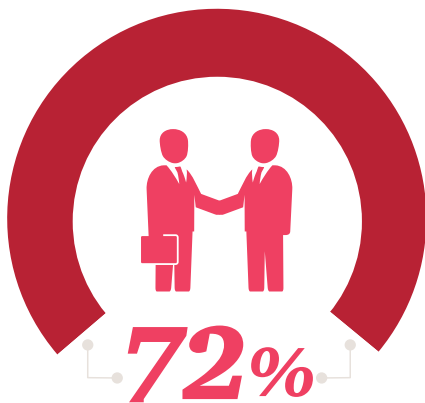| Additional revenue from:	Lower cost and greater efficiency from:
Digitising products and services within the existing portfolio	Real-time inline quality control based on Big Data Analytics
New digital products, services and solutions	Modular, flexible and customer-tailored production concepts
Offering big data and analytics as a service.	Real-time visibility into process and product variance, augmented reality and optimisation by data analytics
Personalised products and mass customisation.	Predictive maintenance on key assets using predictive algorithms to optimise repair and maintenance schedules and improve asset uptime
Capturing high-margin business through improved customer insight from data analytics	Vertical integration from sensors through MES to real-time production planning for better machine utilisation and faster throughput times
Increasing market share of core products	Horizontal integration, as well as track-and-trace of products for better inventory performance and reduced logistics
	Digitisation and automation of processes for a smarter use of human resources and higher operations speed
	System based, real-time end-to-end planning and horizontal collaboration using cloud based planning platforms for execution optimisation
	Increased scale from increased market share of core products

Deepen digital relationships with more empowered customers

As Industry 4.0 develops, the traditional model of products pushed out to the market will fade and 'customer pull', with customers intimately involved in a more collaborative relationship with manufacturers, will be much more the norm. Industry 4.0 will greatly enrich the opportunities to retain and grow the customer relationship but it will also make the fight for the customer more intense.

Deepening customer relationships through co-creation and customisation

Digital integration with the customer and new technological opportunities to move production closer to the customer, for example with 3D printing, will enable greater individualisation and customisation of products. Most companies we spoke to are expecting to strengthen their digital offering to customers, either by digitising existing products or by developing new digital products. The opportunity is there not only to greatly increase the ability to respond flexibly and more rapidly to customer demands but also to anticipate demands, helping the customer move ahead in a range of predictive ways.

Using data to enhance customer service and responsiveness

Nearly three-quarters of companies (72%) expect that the use of data analytics will substantially improve customer relationships and customer intelligence along the product life cycle (see Figure 5). Greater integration of data between manufacturers and customers can open up new collaboration opportunities. Clever use of pooled data, for example, can allow manufacturers in B2B markets to help customers in value-chain planning, driving efficiencies within the customer's operations as well as vice versa. Many companies have such collaborative opportunities in sight. Over a third (38%) of companies in our survey said they plan to offer their big data services to external companies.

Figure 5: **Industry 4.0 is helping industrial companies optimise customer relationships**

How industrial companies are getting closer to customers

72%

Q: In which areas will your company use data analytics in five years? Improving customer relationship and customer intelligence along the product life cycle.

Basing product/service development on customer specifications

Innovation in customer service

Using data analytics to meet customer requirements and improve operational performance

Customising products all the way down to a lot size of 1

Building a customer-focused supply chain

Driving customer-centric marketing and channel access

Key types of platforms

Product Lifecycle Management (PLM) systems: connect market intelligence with product development and operations, all the way to smart services – both within a manufacturing company as well as with key value-chain partners.

Manufacturing Execution Systems (MES): connect the data input and transfer between the equipment of multiple vendors, as well as facilitating communication between multiple software and systems applications, extending from a company's Enterprise Resource Planning (ERP) all the way to shopfloor quality applications.

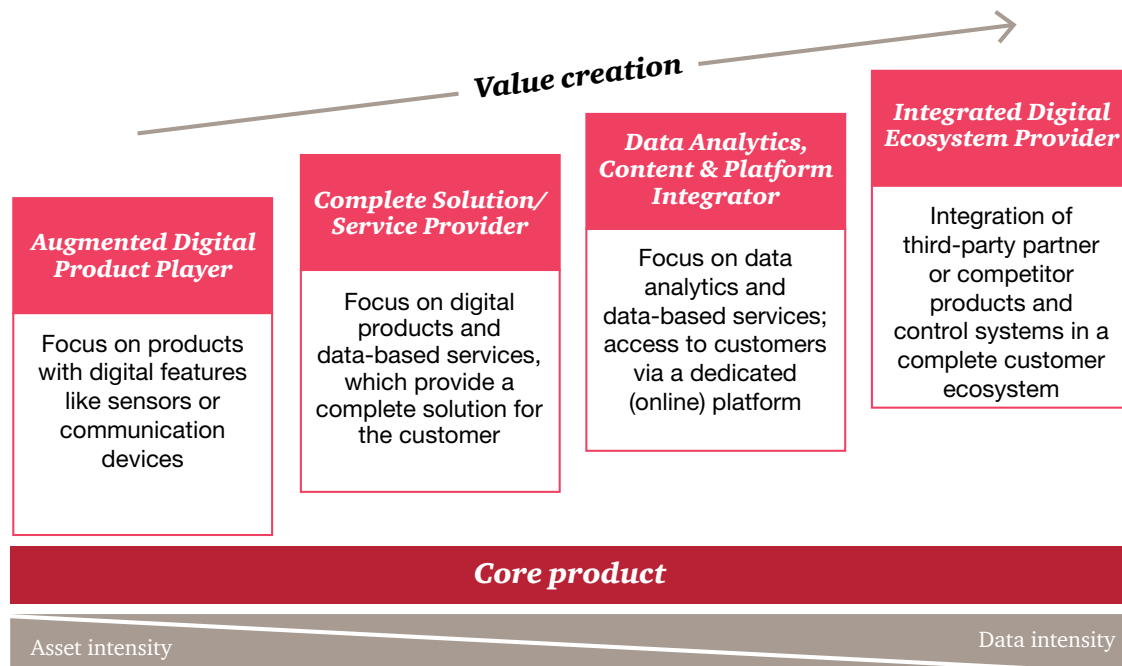## Developing a platform approach to stay close to customers

Integrated solutions or value-added services are characterised by significantly higher customer benefits and will revolutionise existing product portfolios and performance relationships. Foremost among these is a platform approach. A platform is a nexus of exchange and interoperable technology, which allows a wide range of vendors and customers to interact seamlessly. The most successful first movers of the software and internet industries all cemented their positions with powerful and distinctive platforms.

First movers on Industry 4.0 will seek a similar advantage. GE and Siemens, for example, are already rushing to solidify themselves as platform providers. Each has developed a cloud-based system for connecting machines and devices from a variety of companies, facilitating transactions, operations and logistics, and collecting and analysing data.

Other industrial companies are also moving from simply augmenting their products with digital features to more comprehensive digital offerings. These can range from complete digital solutions to becoming a platform integrator.

An effective platform must, by definition, bring the customer close to operations. Industrial companies that share these platforms will also have access to customer data, which will be analysed to better forecast their needs, improve products and develop new ones. Whoever owns the platform thus owns the customer, owns access to the customer, and ends up aggregating the work of a lot of other enterprises. Ultimately this can lead to providing a full digital ecosystem.

Industrial companies are moving towards greater digital value creation, from augmented products to serving digital ecosystems

Value creation

Augmented Digital Product Player

Focus on products with digital features like sensors or communication devices

Complete Solution/ Service Provider

Focus on digital products and data-based services, which provide a complete solution for the customer

Data Analytics, Content & Platform Integrator

Focus on data analytics and data-based services; access to customers via a dedicated (online) platform

Integrated Digital Ecosystem Provider

Integration of third-party partner or competitor products and control systems in a complete customer ecosystem

Core product

Asset intensity   Data intensity

Focus on people and culture to drive transformation

Industry 4.0 has massive implications for the nature of how a company chooses to organise itself and its delivery model.

Companies will need to make sure staff understand how the company is changing and how they can be a part of it. From our interviews with industrial companies, the biggest challenges centre around internal issues such as culture, organisation, leadership and skills rather than external issues such as whether the right standards, infrastructure and intellectual property protection are in place or whether concerns about data security or privacy concerns can be overcome.
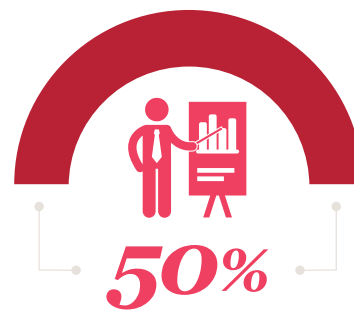
The absence of a digital culture and the right training was identified as a top challenge by more companies than any other (see Figure 6). That was equally true for companies rating themselves as advanced. And it held true across industries and regions as well.

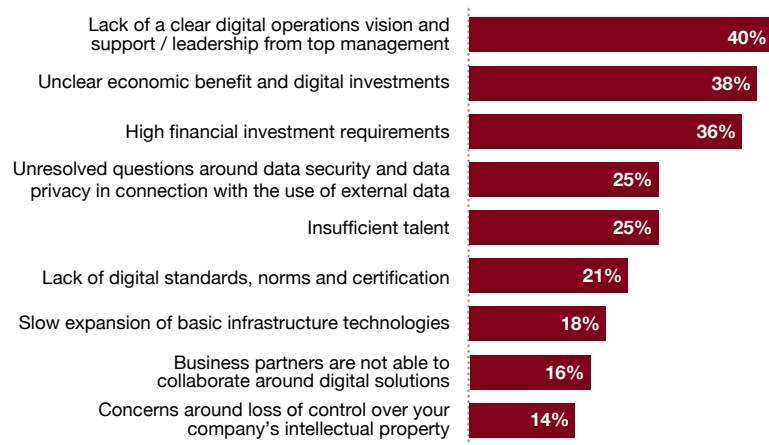### *Skills issues loom large for data analytics too*

Lack of skills or competencies in the company's workforce is also the biggest challenge survey respondents see when it comes to making use of data analytics. It's not surprising, then, that over two-thirds (69%) cite increasing in-house data analytics technology and skill levels as the single biggest improvement route to boost data analytics capabilities. Some companies also say external partnerships have a role to play, through the provision of technology or training, and a minority of companies (18%) expect to use M&A to acquire outside companies.

69% say increasing in-house data analytics technology and skill levels is the top route to boost data analytics capabilities

Figure 6: *Lack of digital culture and training is the biggest challenge facing companies*

50%
Lack of digital culture and training

Challenge	%
Lack of a clear digital operations vision and support / leadership from top management	40%
Unclear economic benefit and digital investments	38%
High financial investment requirements	36%
Unresolved questions around data security and data privacy in connection with the use of external data	25%
Insufficient talent	25%
Lack of digital standards, norms and certification	21%
Slow expansion of basic infrastructure technologies	18%
Business partners are not able to collaborate around digital solutions	16%
Concerns around loss of control over your company's intellectual property	14%

Note: Included as one of three possible responses

Q: Where are the biggest challenges or inhibitors for building digital operations capabilities in your company?

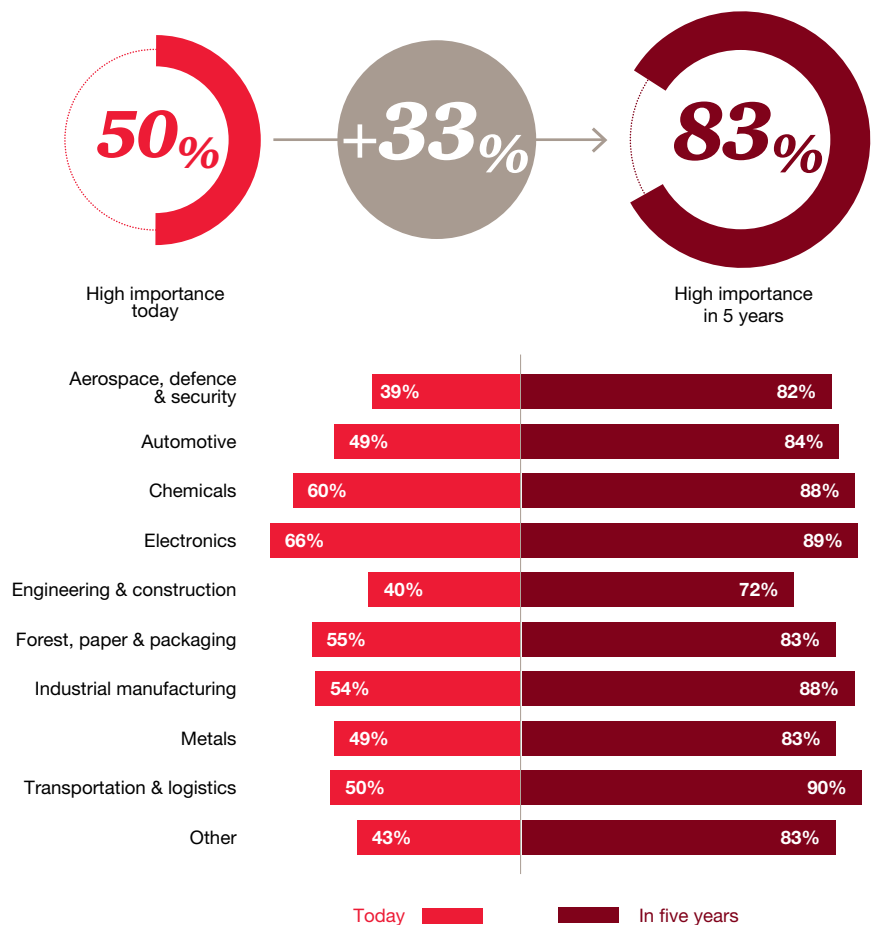# Data analytics and digital trust are the foundation of Industry 4.0

Data lies at the heart of the fourth industrial revolution, but the massively growing information flow brings little value without the right analytics techniques. The rapidly growing number of sensors, embedded systems and connected devices as well as the increasing horizontal and vertical networking of value chains result in a huge continuous data flow.

Data is coming from multiple sources, in different formats, and there is a need to combine internal data with data from outside sources. Expert and effective data analytics is essential to using data to create value. And with so many points of entry, companies need to take a rigorous, proactive approach to data security and related issues and work to build digital trust.

Advanced companies use data to drive decision-making

While most of our respondents (83%) expect data to have a significant impact on their decision-making in five years, only about half are currently using data to drive decisions (see Figure 7). Our research suggests that companies who are already ahead on their digitisation and integration journey are also much more likely to be putting data analytics to work. Among those with advanced levels of digitisation and integration, nearly three-quarters (73%) say that data and analytics play a significant role in their decision-making, compared to just 38% of those who have low levels of digitisation and integration.

Figure 7: *Data and analytics are becoming increasingly important to decision-making.*

High importance today — 50% +33% → 83% High importance in 5 years

Industry	Today	In five years
Aerospace, defence & security	39%	82%
Automotive	49%	84%
Chemicals	60%	88%
Electronics	66%	89%
Engineering & construction	40%	72%
Forest, paper & packaging	55%	83%
Industrial manufacturing	54%	88%
Metals	49%	83%
Transportation & logistics	50%	90%
Other	43%	83%

Today   In five years

Shown: Summarised percentages of companies surveyed reporting high levels of significance

Q: What significance does the gathering, analysis and utilisation of data for decision-making have for your company?

It's important to remember that data analytics provides tools for decision-making, rather than a complete replacement for sound judgement on the part of management. In other research we've explored the "art and science" of decision-making, and found that data analytics will play an increasingly central role in the future –but it won't fully replace other factors, particularly when it comes to major strategic decisions[3].
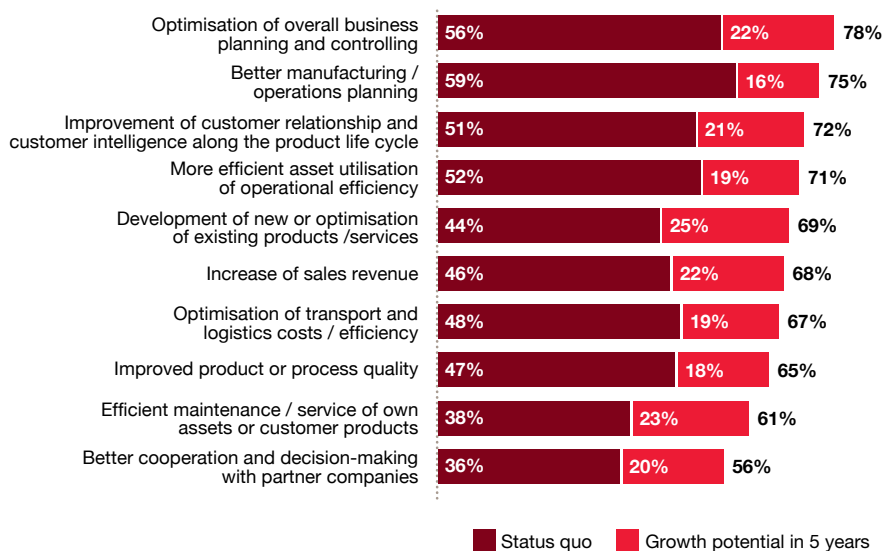
Companies need to expand their use of big data

Many companies already use data analytics to analyse and report on processes (see Figure 8). Our survey respondents say their companies are focusing most on using data analytics to control and improve their overall business planning and manufacturing operations, followed closely by efforts to get closer to their customers, both today and in five years. Around three-quarters of companies are deploying or plan to deploy data analytics in these areas. But these approaches are just the beginning.

There are other uses for data analytics that far fewer companies have on their radar screen. These include better service and maintenance of companies' own assets and products owned by customers, and better cooperation and decision-making with partner companies. These open up possibilities for new service offering and ways of working, so companies may want to start paying more attention.

To succeed, companies will need to use data in predictive, forward-looking ways that make sense of market developments and customer behaviour to improve products and develop new products and services.

Figure 8: **Are companies underestimating the scope of data analytics?**

	Status quo	Growth potential in 5 years	Total
Optimisation of overall business planning and controlling	56%	22%	78%
Better manufacturing / operations planning	59%	16%	75%
Improvement of customer relationship and customer intelligence along the product life cycle	51%	21%	72%
More efficient asset utilisation of operational efficiency	52%	19%	71%
Development of new or optimisation of existing products /services	44%	25%	69%
Increase of sales revenue	46%	22%	68%
Optimisation of transport and logistics costs / efficiency	48%	19%	67%
Improved product or process quality	47%	18%	65%
Efficient maintenance / service of own assets or customer products	38%	23%	61%
Better cooperation and decision-making with partner companies	36%	20%	56%

■ Status quo   ■ Growth potential in 5 years

Q: In which areas are you using big data analytics today? In which additional areas will your company use data analytics in five years?

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3   PwC, Global Data & Analytics Survey 2014: Big Decisions™

Building digital trust should be a top priority

Digital ecosystems and broad use of data also raises important issues around cybersecurity. More touchpoints where data is collected and exchanged also means more potential points of entry for an attacker. Our survey respondents flagged a wide range of concerns around data security, with operational interruption from cybersecurity breaches at the top of their list (see Figure 9). Other issues like liability risks, unauthorised access to data and damage to company reputation are on the radar too.

There's some good new though. Many of our survey respondents are confident that they've made strong progress here – just 16% rate unresolved questions around data security and data privacy as one of the top 3 challenges that are slowing down their Industry 4.0 efforts. To make sure that stays on track, many companies will need to make building and maintaining digital trust a priority.

For example, as companies move towards operating increasingly in ecosystems, it will be important to integrate a whole range of technical domains into the system. These include managing organisational functions and transactions, controlling automation assets and supporting the creation and delivery of products and services, in some cases focused towards end-users. Making security an integral part of all systems and processes can help deter attacks and speed up response time if they do happen. Third-party assurance is also an important way to confirm that systems are robust and strengthen the trust of ecosystem participants in your platform's integrity.

Also important will be working together with ecosystem partners; with possible points of attack spread out throughout the ecosystem, responsibility needs to be shared broadly.

Digital trust is a complicated issue, but it's based on three pillars: transparency, legitimacy and effectiveness. In other research, we look at ten issues which centre around the ethics and control of data access and use, interaction through the internet, digital risk resilience and value-creation in the digital age[4]. The emergent and interconnected nature of these issues – and the regulatory response to them – highlight the challenges organisations face. Industrial companies will need to stay focused to meet them.

Digital trust is a complicated issue, but it's based on three pillars: transparency, legitimacy and effectiveness.

Figure 9:   *Operational disruption is the top data security concern*
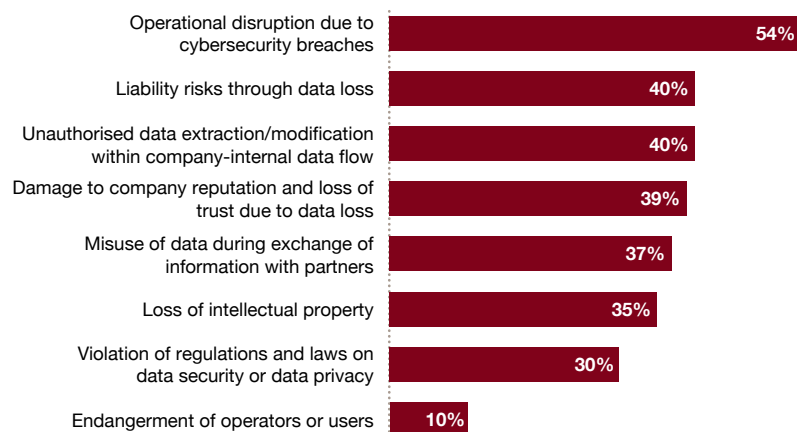
Note: Included as one of three possible responses

Q: What are the main concerns in terms of data security?

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4   Norbert Schwieters, PwC, "Ten digital trust challenges," 4 December, 2015

Robust, enterprise-wide data analytics capabilities require significant change

The companies we surveyed understand that it's critical to have data analytics capabilities in order to successfully drive digital transformation. But there's still a long way to go before these reach the level of sophistication needed to really drive Industry 4.0 applications.

Only 18% of survey respondents rate the maturity of their data analytics capabilities as advanced (see Figure 10), and more than half say that the lack of skills and competencies in their company's workforce is a key challenge to making full use of data analytics.

Moving beyond ad-hoc approaches

Ad-hoc approaches to the organisation and governance of data analytics may be part of what's holding companies back. Almost half lack a structured approach to data analytics organisation and governance (Figure 11). Thirty-eight percent of respondents say their companies rely on the selective, ad-hoc data analytics capabilities of individual employees, while another nine percent have no significant data analytics capabilities at all.

In contrast, just over a third have embedded data analytics into specific functions, giving themselves the flexibility and proximity to business knowledge to fully utilise the potential of data analytics. Another 14% of companies have a dedicated department for data analysis serving many functions across the company. First movers are much more likely to have pursued these two options – 43% have embedded their data analytics in specific functions and 24% have a dedicated department.
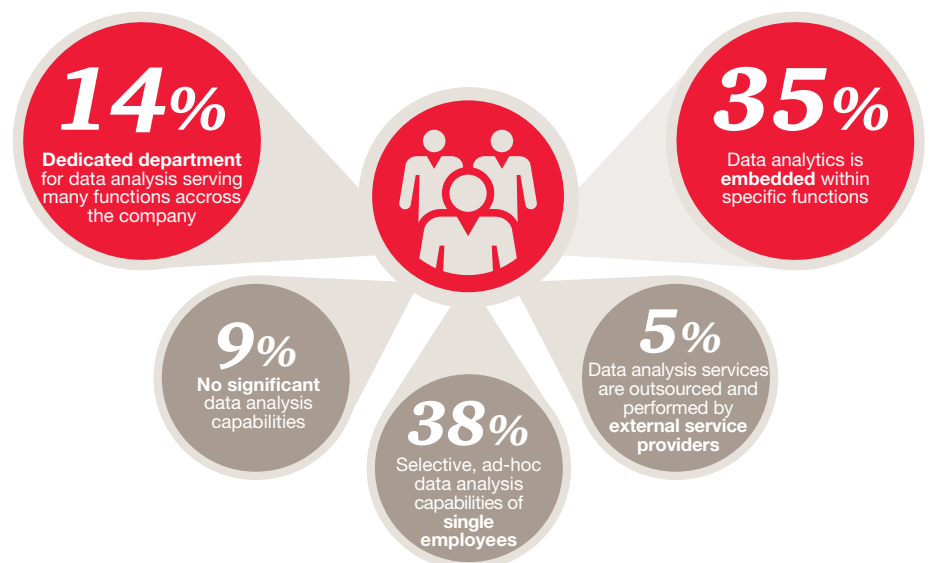
To reach excellence in data analytics, industrial companies will need access to a wide variety of skill sets, including those of data scientists and algorithm architects. They will also need process expertise, advanced algorithms and workflow integration for decision support. In some situations outsourcing can help supplement internal capabilities or bridge temporary gaps.

Figure 10: *Most companies don't yet have mature data analytics capabilities*

52% Medium

18% Advanced

22% Poor

8% Outsourced to external partners
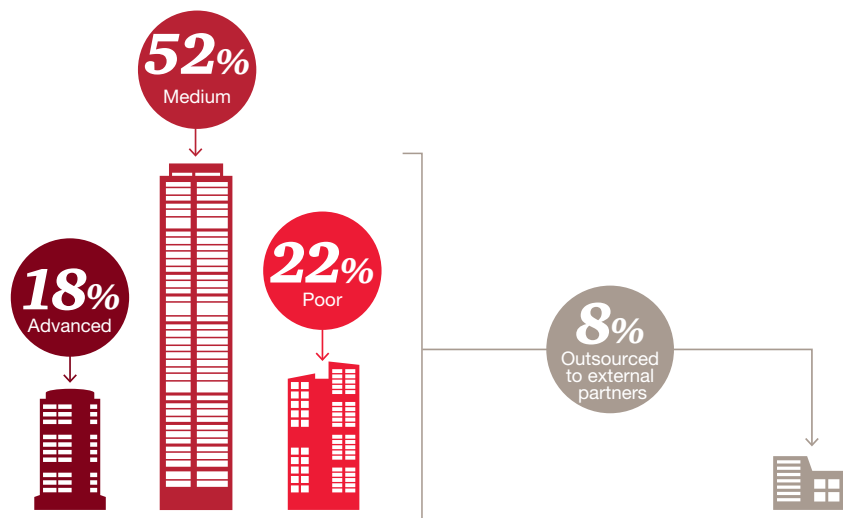
Q: How mature are the data analytics capabilities in your company?

Figure 11: *Nearly half of companies still need to develop a robust organisation that supports data analytics excellence*

14% Dedicated department for data analysis serving many functions across the company

35% Data analytics is **embedded** within specific functions

9% No significant data analysis capabilities

5% Data analysis services are outsourced and performed by **external service providers**

38% Selective, ad-hoc data analysis capabilities of **single employees**

Note: Answers shown are rounded

Q: How are data analysis capabilities organised in your company?

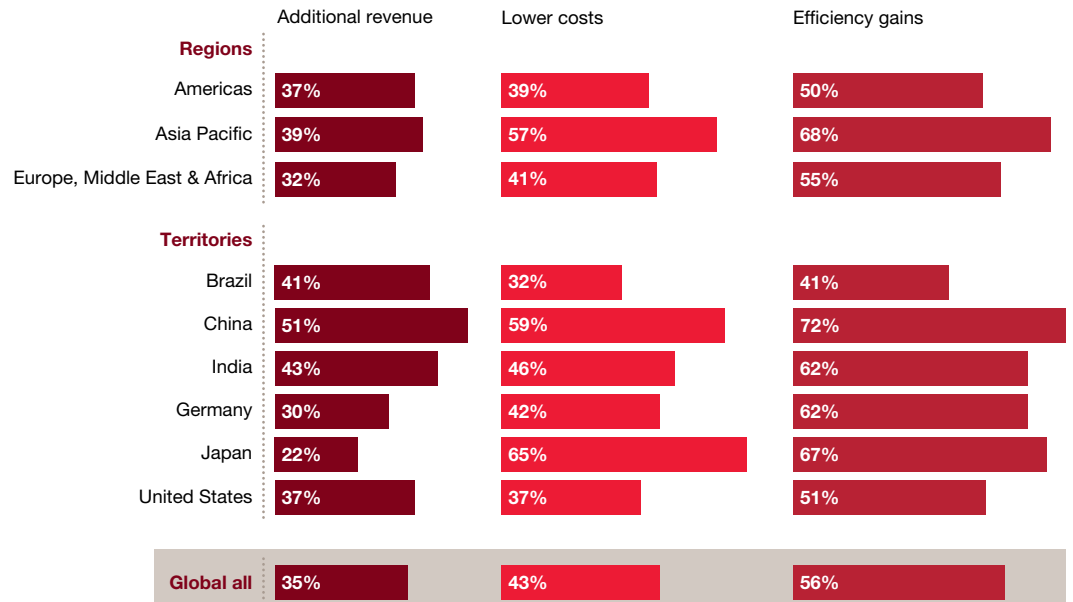# Accelerating globalisation, but with distinct regional flavours

As the fourth industrial revolution binds companies and countries ever more tightly together—through worldwide supply chains and data networks—it will increasingly promote globalisation.

Many industrial leaders operate worldwide facilities, so successful Industry 4.0 implementation is not limited to specific countries or regions. At the same time, many applications will link closely to local companies, as customised products often require regional manufacturing capabilities.

Our survey results show similarities between leading companies around the globe, but they also differ considerably by region.

Conventional wisdom suggests that developed economies could be the winners, in the short term at least, from Industry 4.0, as they are driving digital operations improvements to secure significant efficiency gains. So are emerging economies losing out? Our survey results indicate that emerging nations probably have the most to gain, as Industry 4.0 takes hold around the globe. They can leverage digitisation to gain efficiency in their horizontal value chain, efficiently working within a global manufacturing network to supply key components, products and systems. In addition, rising personnel costs and high potential to digitise processes will lead to above-average efficiency gains in emerging economies.

Figure 12: Big gains are anticipated by industrial products companies in all regions

	Additional revenue	Lower costs	Efficiency gains
Regions			
Americas	37%	39%	50%
Asia Pacific	39%	57%	68%
Europe, Middle East & Africa	32%	41%	55%
Territories			
Brazil	41%	32%	41%
China	51%	59%	72%
India	43%	46%	62%
Germany	30%	42%	62%
Japan	22%	65%	67%
United States	37%	37%	51%
Global all	35%	43%	56%

Shown: % of survey respondents in each region expecting gains of over 20% in the next five years

Q: What cumulative benefits from digitisation do you expect in the next 5 years?

Regional and country contrasts

Companies in Japan and Germany are the furthest along in digitising internal operations and partnering across the horizontal value chain. With high investments in technology and employee training, they view their digital transformation primarily in terms of gains in operational efficiency, cost reduction and quality assurance.

Our experience working with and interviewing executives in the US suggests that companies there are planning more investment in developing disruptive business models, as companies move more quickly to digitise their product and service portfolio. Their focus is more on digital revenue growth, rather than efficiency gains.

China's industrial companies stand out in all aspects of digitisation: they are expecting both above-average cost reductions as well as incr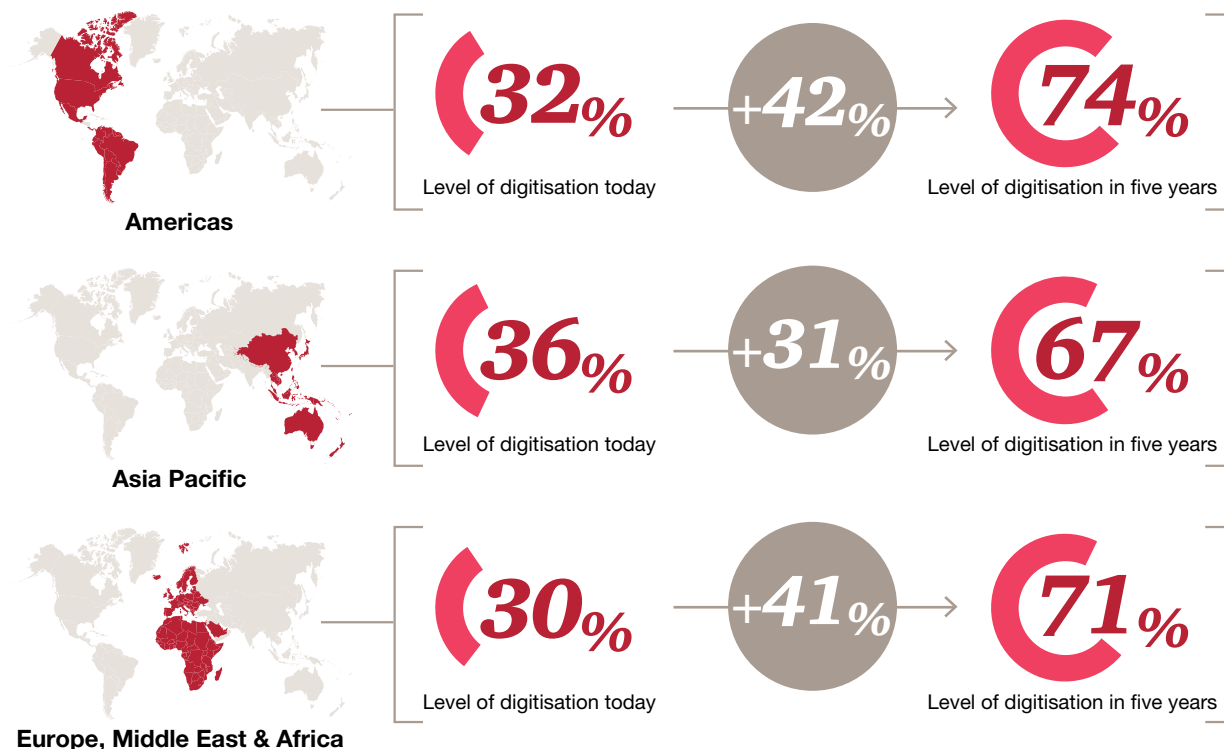eased digital revenues through to 2020. China is one of the countries that stands to gain the most from automating and digitising labour-intensive manufacturing processes and needs to find a solution to rising employee compensation. In addition, Chinese companies are highly flexible and open to digital change, and the Chinese workforce is embracing digital technologies.

A strong Asia Pacific push with other regions coming up fast

Industrial products companies in all regions are pressing hard on the Industry 4.0 accelerator and expect to secure significant benefits. But it is companies in the Asia Pacific region that are making the strongest running. They report making significant digital investments and they have already moved further forward in terms of current digitisation and integration. Two-fifths (36%) believe they are at an advanced level now, compared to a third (32%) of companies in the Americas and 30% of EMEA companies (see Figure 13).

Looking five years ahead, expectations of the level of digital integration are broadly comparable in all three regions (EMEA, the Americas and Asia Pacific). A large majority of companies expect to have advanced digitisation and integration capabilities, with Japan and Germany reaching digitisation levels above 80%. American, French and Swedish companies show similarly high levels of optimism. Although Asia Pacific companies report the highest digitisation and integration levels today, it is companies in the Americas, followed by those in EMEA, that expect to have the largest gains in digitisation levels by 2020.

Figure 13: *Companies all over the world are expecting to dramatically increase digitisation over the next five years*

Americas

(**32%** Level of digitisation today → **+42%** → C**74%** Level of digitisation in five years

Asia Pacific

(**36%** Level of digitisation today → **+31%** → C**67%** Level of digitisation in five years

Europe, Middle East & Africa

(**30%** Level of digitisation today → **+41%** → C**71%** Level of digitisation in five years

Q: How would you classify the current level of digitisation and integration in the following areas in your company? What levels of digitisation and integration are you expecting in the next five years?
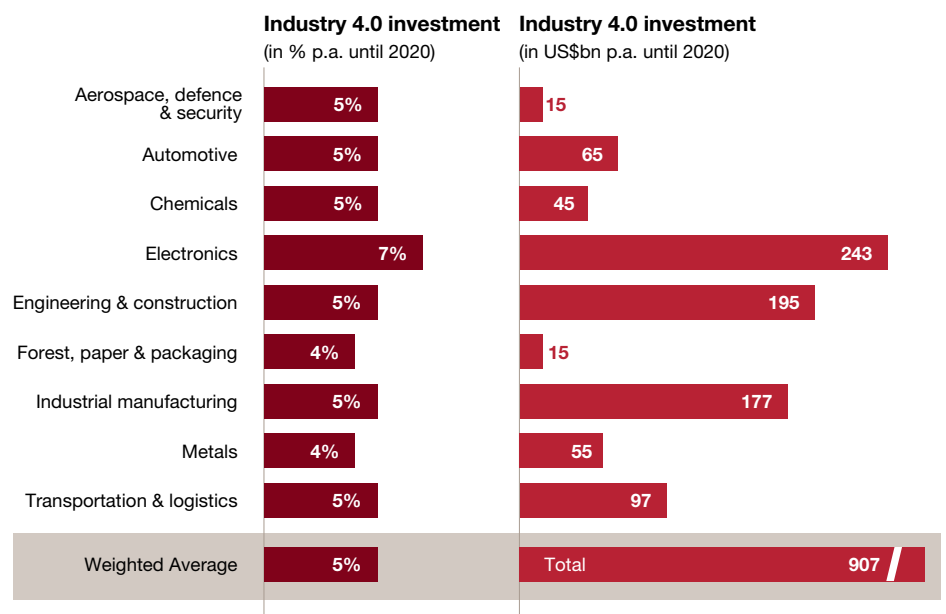
Big investments with big impact: it's time to commit

The nine industries we surveyed plan to invest US$907 bn p.a. globally in Industry 4.0 applications over the next five years. That's a staggering sum, but the benefits are even more impressive.

Survey respondents anticipate that those investments will lead to US$493 bn in additional revenues annually, in addition to strong gains in efficiency and reductions in cost. Investment levels will be highest in the electronics sector (see Figure 14). A major focus of this investment will be on digital technologies like sensors or connectivity devices, as well as on software and applications like manufacturing execution systems (MES). Companies are also investing significantly in training their employees, hiring new specialists and driving organisational change.

Within the next five years, advanced implementation of Industry 4.0 will become a 'qualifier to compete' and is also likely to be seen by investors as a 'qualifier for funding'.

Figure 14: *Companies in every industry sector are planning substantial investments*

	Industry 4.0 investment (in % p.a. until 2020)	Industry 4.0 investment (in US$bn p.a. until 2020)
Aerospace, defence & security	5%	15
Automotive	5%	65
Chemicals	5%	45
Electronics	7%	243
Engineering & construction	5%	195
Forest, paper & packaging	4%	15
Industrial manufacturing	5%	177
Metals	4%	55
Transportation & logistics	5%	97
Weighted Average	5%	Total 907

Q: How high are your company's current and future investment in digital operations solutions? (investment as a percentage of annual revenue)

Catching up is getting increasingly difficult

There's no time to waste when it comes to increasing investment levels. First movers expect to see truly game-changing improvements in cost structures, operational efficiency, and revenues and are therefore stepping up their investment levels. Other companies are doing so as well; in fact, 20% of companies plan to invest more than 10% of annual revenues in the next five years (see Figure 15).

Looking ahead, many of those who haven't invested significantly in the past two years plan to step up investment in the coming five years. That's one way to close the gap. But just over a third of companies still expect to keep their future investment relatively low. Some of these companies may be waiting for the 'perfect' technology. That's short-sighted. As we've already shown, the biggest challenge companies face isn't buying the right technology, it's transforming their organisation and culture. This requires long-term change programmes.

It simply won't be possible for companies to achieve advanced digitisation without making a step-change in investment, given the continued rapid progress anticipated by companies who are already leading. The investment required to catch up is likely to be too costly, and faster-moving companies will have a significant advantage when it comes to positioning their offerings as a 'platform of choice' within digital ecosystems. Perhaps most importantly, companies who try to jump in too late will find that their internal cultures have lagged behind.

Within the next five years, advanced implementation of Industry 4.0 will become a 'qualifier to compete' and is also likely to be seen by investors as a 'qualifier for funding'. Companies who have not kept up will not only find themselves struggling to maintain market share but are also likely to face higher capital funding costs.

Rapid returns on investment

Most companies believe they will see a return on investment (ROI) within two years or less (see Figure 16) for their Industry 4.0 projects. Just over a third of companies anticipate a longer timescale of three to five years, but very few think that it will take any longer than five years for Industry 4.0 investments to pay for themselves.

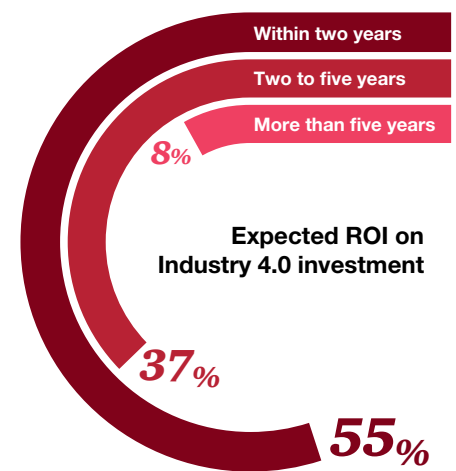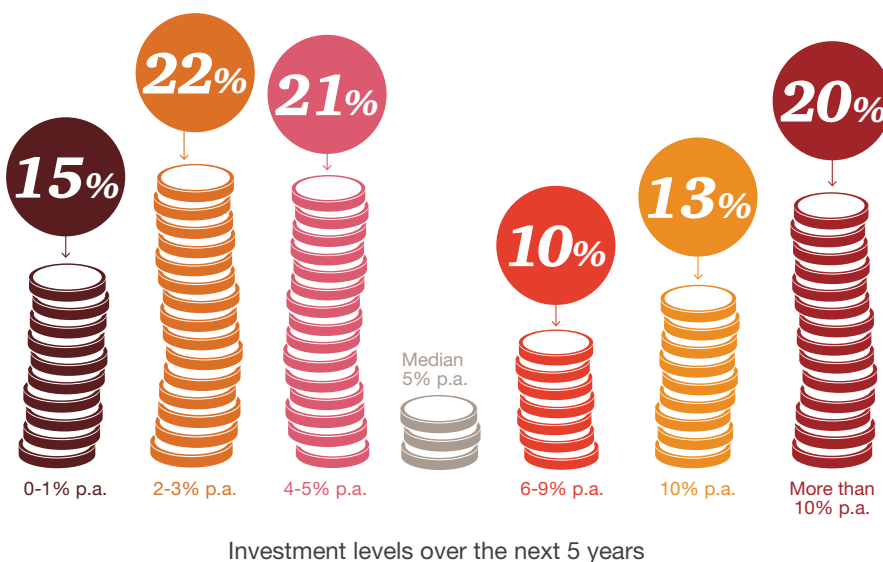**Figure 16:** *Most companies expect Industry 4.0 investments to pay back within two years*

- Within two years
- Two to five years
- More than five years

8%

Expected ROI on Industry 4.0 investment

37%

55%

Q: What return on investment period (ROI) do you expect from your digital investments?

Figure 15: *Companies that do not strategically invest will lose competitive advantage*

15% — 0-1% p.a.
22% — 2-3% p.a.
21% — 4-5% p.a.
Median 5% p.a.
10% — 6-9% p.a.
13% — 10% p.a.
20% — More than 10% p.a.

Investment levels over the next 5 years

Shown: Investments in % of annual revenues

Q: How high are your company's current and future investment in digital operations solutions? (investment as a % percentage of annual revenue)

Blueprint for digital success

To move forward with Industry 4.0, acquiring and rolling out digital capabilities across your company are all-important. This process takes time, so in order to gain or retain first-mover advantage over your competitors, you will need top management commitment and significant implementation investments.

Based on hundreds of transformation projects with leading industrial companies, we have defined six practical steps your company needs to take to lead tomorrow's competitive digital landscape.

Blueprint for digital success

Map out your Industry 4.0 strategy	Create initial pilot projects	Define the capabilities you need	Become a virtuoso in data analytics	Transform into a digital enterprise	Actively plan an ecosystem approach
1	2	3	4	5	6

Map out your Industry 4.0 strategy

Your Industry 4.0 strategy will shape every further step you take on the path towards becoming a fully digital enterprise, so it's important to take the time to clearly define your vision.

Evaluate your own digital maturity now and set clear targets for the next five years

Many industrial capabilities have already begun digitising their business, but often the process has started in organisational silos, rather than through a holistic approach. Take the time to evaluate your maturity level in all areas of Industry 4.0 so that you understand what strengths you can already build on, and which systems/processes you may need to integrate into future solutions. Our "maturity model" is one tool that can help speed up this process (see *PwC maturity model* on next page). Our Digital IQ Benchmark[5] is another tool that you can use to assess how well positioned you are for digital success.

As you start to think about where you want to go in the future, take the time to consider what you could gain by collaborating with customers, suppliers, technology partners and even competitors, without limiting your vision based on current constraints. Move your focus beyond technical details and consider what impact new applications could have on your value chain and your relationships with, and access to, your customers. Your roadmap will need to consider future changes in customer behaviour and how your relationship with them will change.

Moving from the current to the future desired state will need precise steps and a clear prioritisation. Companies that become a digital champion embark on a journey that starts small but ends ultimately in a transformation of the core business.

Questions to ask as you develop your digital strategy:

How mature are my current capabilities?

What could I gain by better collaboration with customers, suppliers, technology partners and even competitors?

How is customer behaviour changing and how does my relationship to customers need to change in response?

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5   PwC Digital IQ Benchmark

Make sure you engage champions throughout your business

Building up capabilities, adapting processes and IT and driving the cultural shift needed will take years. It's critical to provide clear leadership from your top management, but equally important is convincing the top stakeholders who will need to roll up their sleeves and implement the desired changes. One way to line up champions throughout the organisation is to educate stakeholders from the outset, for example through technology roadshows and visits to innovation hubs.

PwC maturity model - Industry 4.0 capabilities develop across seven dimensions and four stages

	1 Digital novice	**2 Vertical integrator**	**3 Horizontal collaborator**	**4 Digital champion**
Digital business models and customer access	First digital solutions and isolated applications	Digital product and service portfolio with software, network (M2M) and data as key differentiator	Integrated customer solutions across supply chain boundaries, collaboration with external partners	Development of new disruptive business models with innovative product and service portfolio, lot size 1
Digitisation of product and service offerings	Online presence is separated from offline channels, product focus instead of customer focus	Multi-channel distribution with integrated use of online and offline channels; data analytics deployed, e. g. for personalisation	Individualised customer approach and interaction together with value-chain partners. Shared, integrated interfaces.	Integrated Customer Journey Management across all digital marketing and sales channels with customer empathy and CRM
Digitisation and integration of vertical and horizontal value chains	Digitised and automated sub processes. Partial integration including production or with internal and external partners. Standard processes for collaboration partly in place	Vertical digitisation and standardised and harmonised internal processes and data flows within the company; limited integration with external partners	Horizontal integration of processes and data flows with customers and external partners, intensive data use through full integration across the network.	Fully digitised, integrated partner ecosystem with self-optimised, virtualised processes, focus on core competency; decentralised autonomy. Near real-time access to extended set of operative information
Data & Analytics as core capability	Analytical capabilities mainly based on semi-manual data extracts; Selected monitoring and data processing, no event management	Analytical capabilities supported by central business intelligence (BI) system Isolated, not standardised decision support systems	Central BI system consolidating all relevant internal and external information sources, some predictive analytics Specific decision support and event management systems	Central use of predictive analytics for real-time optimisation and automated event handling with intelligent database and self-learning algorithm enabling impact analysis and decision support
Agile IT architecture	Fragmented IT architecture in-house.	Homogeneous IT architecture in-house. Connection between different data cubes developing.	Common IT architectures in partner network. Interconnected single data lake with high-performance architecture	Single data lake with external data integration functionalities and flexible organisation. Partner service bus, secure data exchange
Compliance, security, legal & tax	Traditional structures, digitisation not in focus	Digital challenges recognised but not comprehensively addressed	Legal risk consistently addressed with collaboration partners,	Optimising the value-chain network for compliance, security, legal and tax
Organisation, employees and digital culture	Functional focus in "silos"	Cross-functional collaboration but not structured and consistently performed	Collaboration across company boundaries, culture and encouragement of sharing	Collaboration as a key value driver

Create initial pilot projects

With so much riding on the outcome of Industry 4.0 projects, companies will need to work hard to overcome initial challenges. It can be difficult to secure funding and stakeholder buy-in, as the economic benefit case of digitisation is not always easy to calculate. And initially teams will only be able to provide very limited proof of concept and demonstration of technologies.

Pilots can help address these issues. Not every project will succeed, but they will all help you learn the approach that works for your company. With evidence from early successes, you can also gain buy-in from the organisation, and secure funding for a larger rollout.

It's important to pick the right projects. We recommend targeting a confined scope, but highlighting the end-to-end concept of Industry 4.0. Possible options include vertical integration within one or two manufacturing sites including digital engineering and real-time data integrated manufacturing planning. Horizontal integration with selected key suppliers is another option, e.g. by installing track-and-trace devices on your shipments, helps to create end to end visibility. Or you could consider installing sensors and actuators on critical manufacturing equipment and using data analytics to explore predictive maintenance solutions. The diagram below provides an overview of possible areas for pilots.
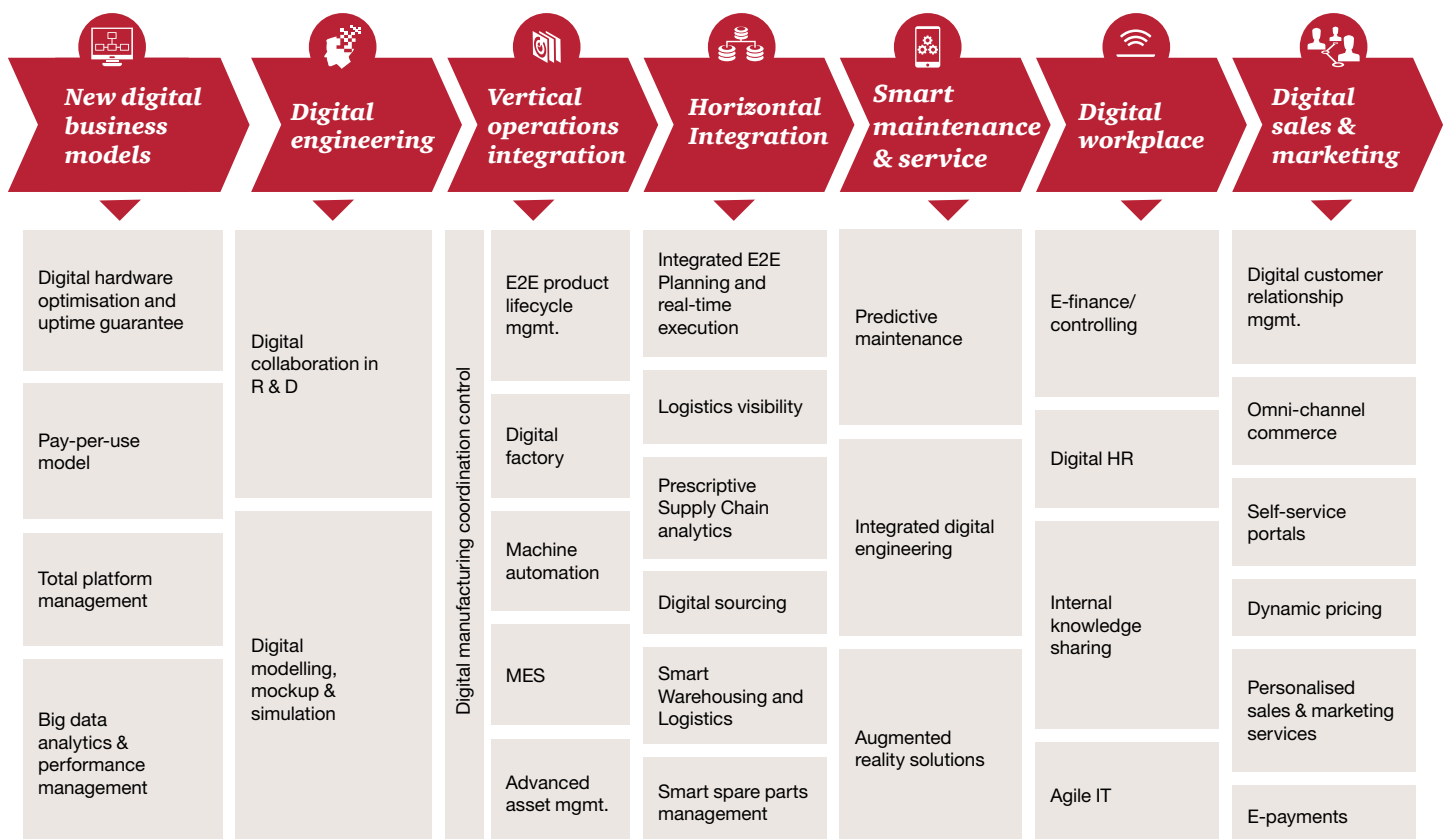
Setting up cross-functional teams has proven to be a solid strategy. These teams should be fully dedicated to the project with the freedom to think outside existing company boundaries and point the company in new strategic directions regarding technology, way of working and ecosystems. Enablers like IT and human resources play a major role and should be embedded in the cross-functional pilot teams.

Data analytics is often done as part of a pilot or as a standalone pilot for companies looking to identify and prioritise data analytics use cases.

Often pilot teams will need to design pragmatically to compensate for standards or infrastructure that don't yet exist. While pilots may already bring business benefits, their most important purpose is to generate insight into how your company can work across functions or ecosystems and what changes you may need to make in IT, security, tools, and process and people capabilities.

You may want to consider collaborating with digital leaders outside your organisation, by working with start-ups, universities, or industry organisations to accelerate your digital innovation.

Industry 4.0 pilot opportunities exist along the full vertical and horizontal operational value chains

New digital business models	Digital engineering	Vertical operations integration	Horizontal Integration	Smart maintenance & service	Digital workplace	Digital sales & marketing
Digital hardware optimisation and uptime guarantee	Digital collaboration in R & D	E2E product lifecycle mgmt.	Integrated E2E Planning and real-time execution	Predictive maintenance	E-finance/controlling	Digital customer relationship mgmt.
Pay-per-use model		Digital factory	Logistics visibility		Digital HR	Omni-channel commerce
Total platform management	Digital modelling, mockup & simulation	Machine automation	Prescriptive Supply Chain analytics	Integrated digital engineering	Internal knowledge sharing	Self-service portals
			Digital sourcing			Dynamic pricing
Big data analytics & performance management		MES	Smart Warehousing and Logistics			Personalised sales & marketing services
		Advanced asset mgmt.	Smart spare parts management	Augmented reality solutions	Agile IT	E-payments

Digital manufacturing coordination control

Define the capabilities you need

Building on the lessons learned in your pilots, map out in detail your enterprise architecture and what capabilities you need. Include how enablers for Industry 4.0, like an agile IT infrastructure, can fundamentally improve all of your business processes.

The most successful approaches look at which capabilities are needed to enable new digital business models or internal digitisation. To implement a new capability, you'll need to consider four strategic dimensions: organisation, people, process and technology.

Fine-tuning your organisation

New organisational structures could include:

- Incubators to protect and grow a new business idea which won't be influenced by the legacy organisation

- Pods or Centres of Excellence to enable temporarily self-organised teams without any formal hierarchy to solve problems or develop ideas in an interdisciplinary team setup

- Ideation Labs to provide an inspiring, creative, and hierarchy-free working atmosphere where a trial-and-error culture is feasible

Focusing on people

Develop strategies for attracting people with the right digital skills. Your success with Industry 4.0 will depend on skills and knowledge. Your biggest constraints may well be your ability to recruit new employees or train existing ones who can put digitisation into place. You need to introduce new roles in your company, like data scientists, user interface designers, or digital innovation managers. And you'll probably need to update existing job profiles to take into account new digital skills.

Improving processes

One of the most important changes is to focus on an end-to-end process perspective. That will foster new collaboration models. Strong user interfaces are very important to meet growing expectations and enable consistent user experiences across different channels.

There are also a number of changes needed to build digital trust. These include processes to prepare data security approaches, access rights control and setup standards in managing sensitive customer data, and compliance processes. You'll need to establish information assurance compliance to oversee and evaluate security requirements. Your goal should be to ensure information security and trust in a collaborative environment by providing an end-to-end management of risks, threats and security issues.

Implementing new technologies

Not surprisingly, new technologies will be core to Industry 4.0 pilots. One of the most important will be to develop an agile IT function that can respond flexibly to business demand. By focusing on creating working solutions and responding to new requirements in an agile approach, an agile IT function helps you continuously improve services.

The other core technology capability is likely to be internet of things (IoT) management to monitor, control and orchestrate large amounts of diverse devices and provide central IoT services. This includes providing functionalities (via software upgrades), communication standards and connectivity and to ensure an appropriate level of security.

Make sure to keep a strong focus on building digital trust. Your goal should be to ensure information security and trust in a collaborative environment by providing an end-to-end management of risks, threats and security issues.

Become a data virtuoso

Identifying and gathering the right data, deploying it for the right purposes and effectively analysing it will be critical to make the right Industry 4.0 decisions.

Defining and developing an effective data analytics strategy will require a focus on:

- Predictive analytics and forecasting

- Prescriptive analytics

- Business-driven decision-making

- Automated feedback to the organisation and connectivity to employees

Consider how you can best organise data analytics; cross-functional expert teams are a good first step. Later these capabilities can be fully embedded as a standalone function in your organisation.

Companies will need to improve master data management - defining, cleaning up and maintaining data. A first step should be the identification of 'functional use cases' for early deployment. You'll need to build your own data pool, based on real-time cross-functional and externally connected data, as well as develop a suite of analytics tools, connected to existing and new data sources. To get value out of that data, you'll also need build direct links to decision-making and to intelligent systems design.

A key decision facing companies is the choice of data analytics platform, with the ideal being one single integrated solution. Existing ERP systems do not have full capabilities to handle the more sophisticated data trends, analytic methods and algorithms that need to be used to provide the more advanced business intelligence and foresight that will be needed in the Industry 4.0 era. A more sophisticated approach would be to invest in a data integration layer that is linked to the ERP systems and use tailored analytics tools by use case.

Transform into a digital enterprise

Lack of digital skills and transformation culture top the list of the challenges identified by survey respondents. We have already highlighted how important strong data analytics capabilities are, but Industry 4.0 calls for other technical skills as well.

Many industrial companies will need to develop digital skill sets around creative digital strategy design, technology architecture and design, user experience design, or rapid prototyping capabilities.

Without the right digital culture, the best talent will not want to stay. But what does a true digital mindset look like? It's highly collaborative, crossing company boundaries and outward to partners and customers. Companies that remain constrained by functional silos are unlikely to achieve the integration that is so central to Industry 4.0.

Cultivating a digital environment can only happen with committed leadership. Some organisations task the CIO with leading the digital transformation, while others appoint a CDO or other executive to lead the effort. Some companies establish a digital council that actively manages the development of digital enhancements, products, and services from the idea stage through to the rollout in operating units. A digital council can support cross-functional teams in proactively managing a digital pipeline.

Digital transformation will only happen if top management places Industry 4.0 squarely at the centre of the C-suite agenda and makes it a top priority.

Actively plan an ecosystem approach

Industry 4.0 needs to extend far wider than horizontal and vertical integration within your own organisation. First movers achieve breakthrough performance by going a step further to understand consumer needs and use digital technologies to create and deliver value to the customer in an integrated, innovative solution.

Fundamentally this is about developing complete product and services solutions for your customers. Companies can evolve their market offering across four layers moving from a traditional, physical core product to a comprehensive digital ecosystem play. In the earlier stages, use partnerships or align with platforms if you cannot develop a complete offering internally.

Real breakthroughs in performance happen when you actively understand consumer behaviour and can orchestrate your company's role within the future ecosystem of partners, suppliers and customers.

As the value of an ecosystem is driven by the number of involved partners and the intensity of their relationships, the biggest challenge is to set the right incentives and find suitable benefit sharing models that compensate everyone fairly for his contribution. The most basic business model in an ecosystem is a marketplace, which brings together multiple sellers and buyers capturing value from commissions on the transaction value.

You may find it difficult to share knowledge with other companies, and you may prefer acquisitions. But look for ways to bridge this gap – perhaps with technical standards – so that you can profit from being part of digital ecosystems, even if you don't fully control the entire value chain.

Moving from a product-oriented to a platform-focused approach
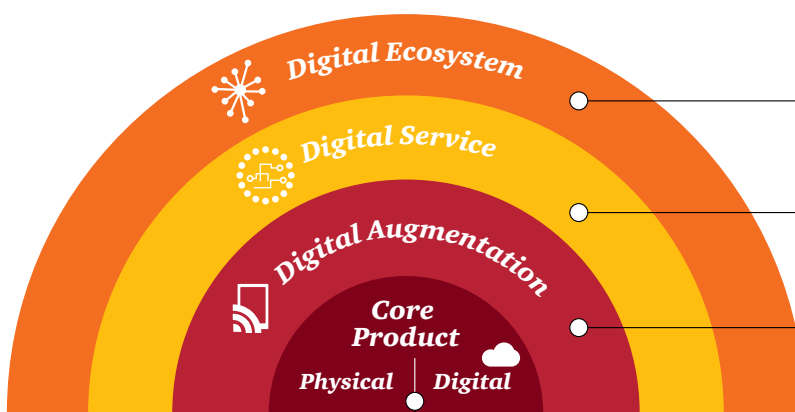
Digital Ecosystem: With interfaces to suppliers, partners & customers the product is embedded in an ecosystem for co-creation and additional/ new value capture

Digital Service: Digitally enabled services which, in combination with a physical product, can provide an end-to-end solution to a broader customer need

Digital Augmentation: Digital customer interfaces, visualisation, touchpoints and channels augment the experience and allow a variety of interaction models

Core Product: Two possible options at the core

• **Digital:** Data and IT define the product's value proposition and generate standalone revenues
• **Physical:** Traditional base offering, which can be 'digitised' by adding digital layers around it
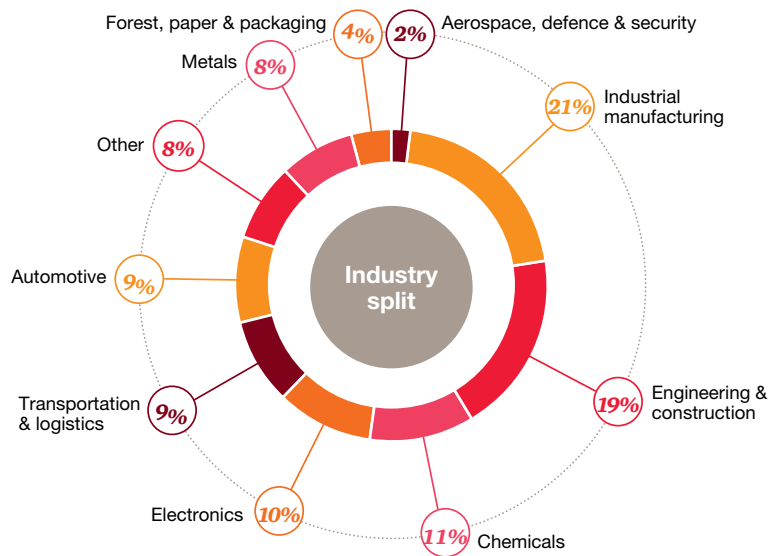
About the survey

The PwC Global Industry 4.0 Survey is based on research conducted between November 2015 and January 2016 with over 2,000 senior executives from industrial products companies in 26 countries across Europe, the Americas, Asia Pacific, Middle East and Africa.
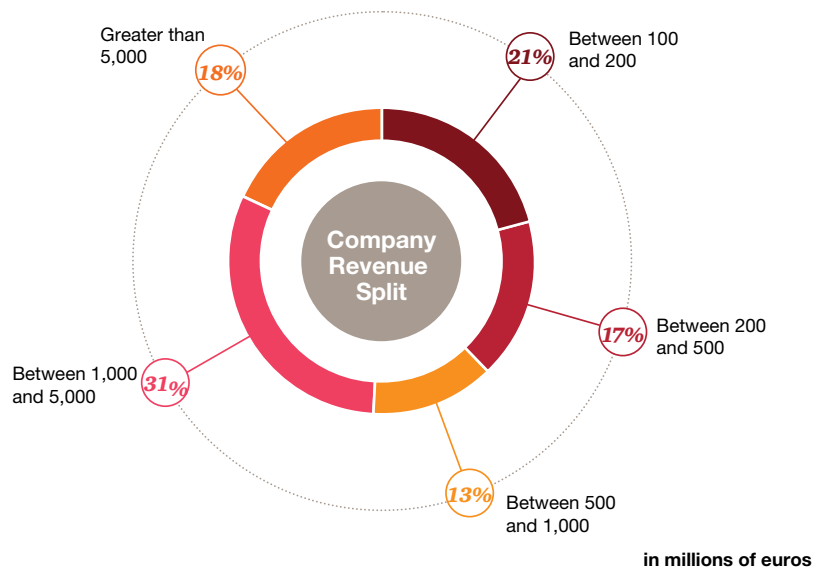
The majority of participants were Chief Digital Officers or other senior executives with top-level responsibility in their company for Industry 4.0 strategy and activity.

Results were weighted by country GDP to provide a balanced view in global totals.

Industry split of surveyed companies

Revenue split of surveyed companies

in millions of euros

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