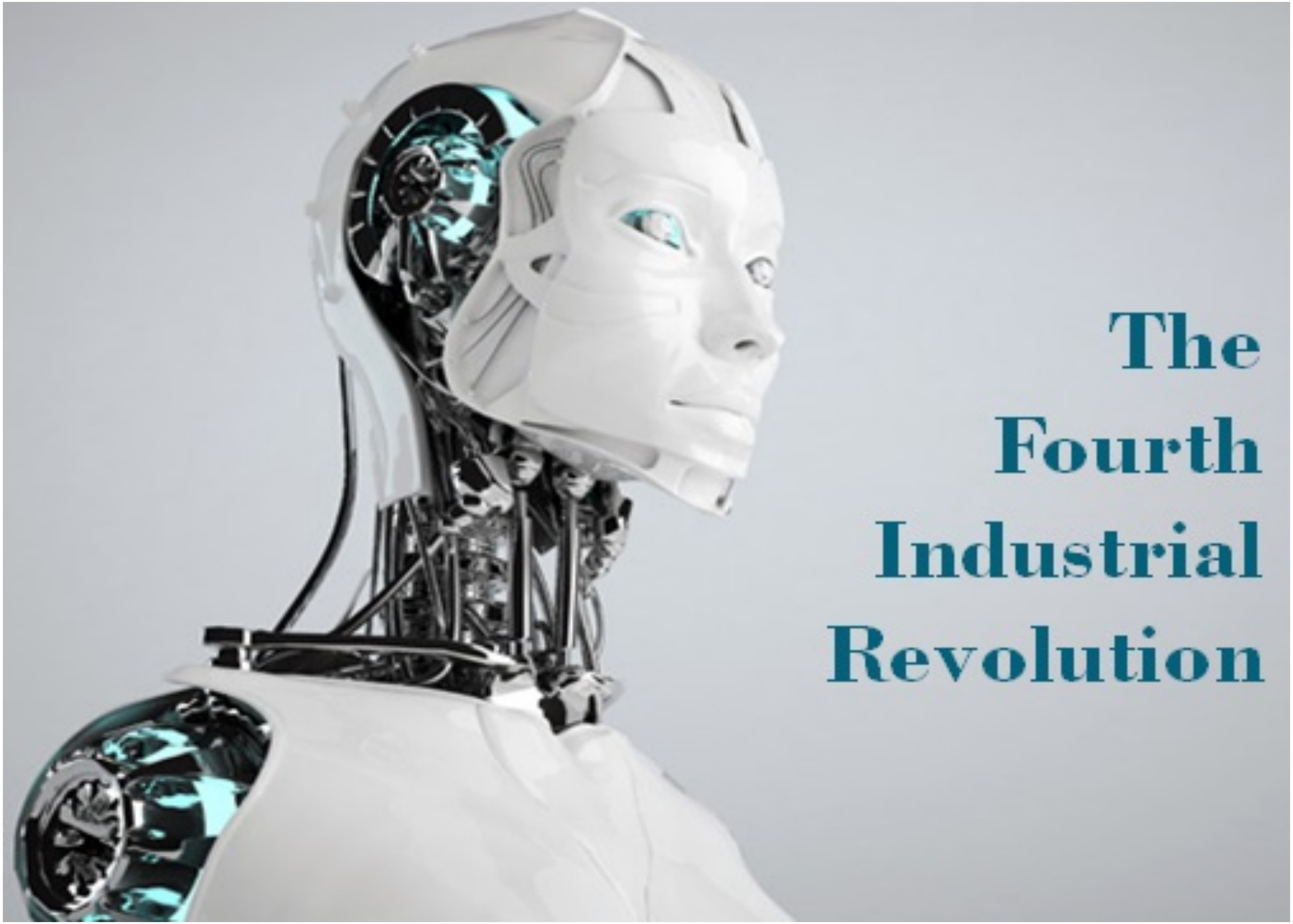
IPS
Class
THE FOURTH INDUSTRIAL REVOLUTION

Sandrine Labory


The
Fourth
Industrial
Revolution

CONTENTS

1) The new constellation of technologies

Big technological changes and innovations in the last 20 – 30 years:

ICTs and computers

Genomics, biotechnologies

Nanotechnologies

Robotics

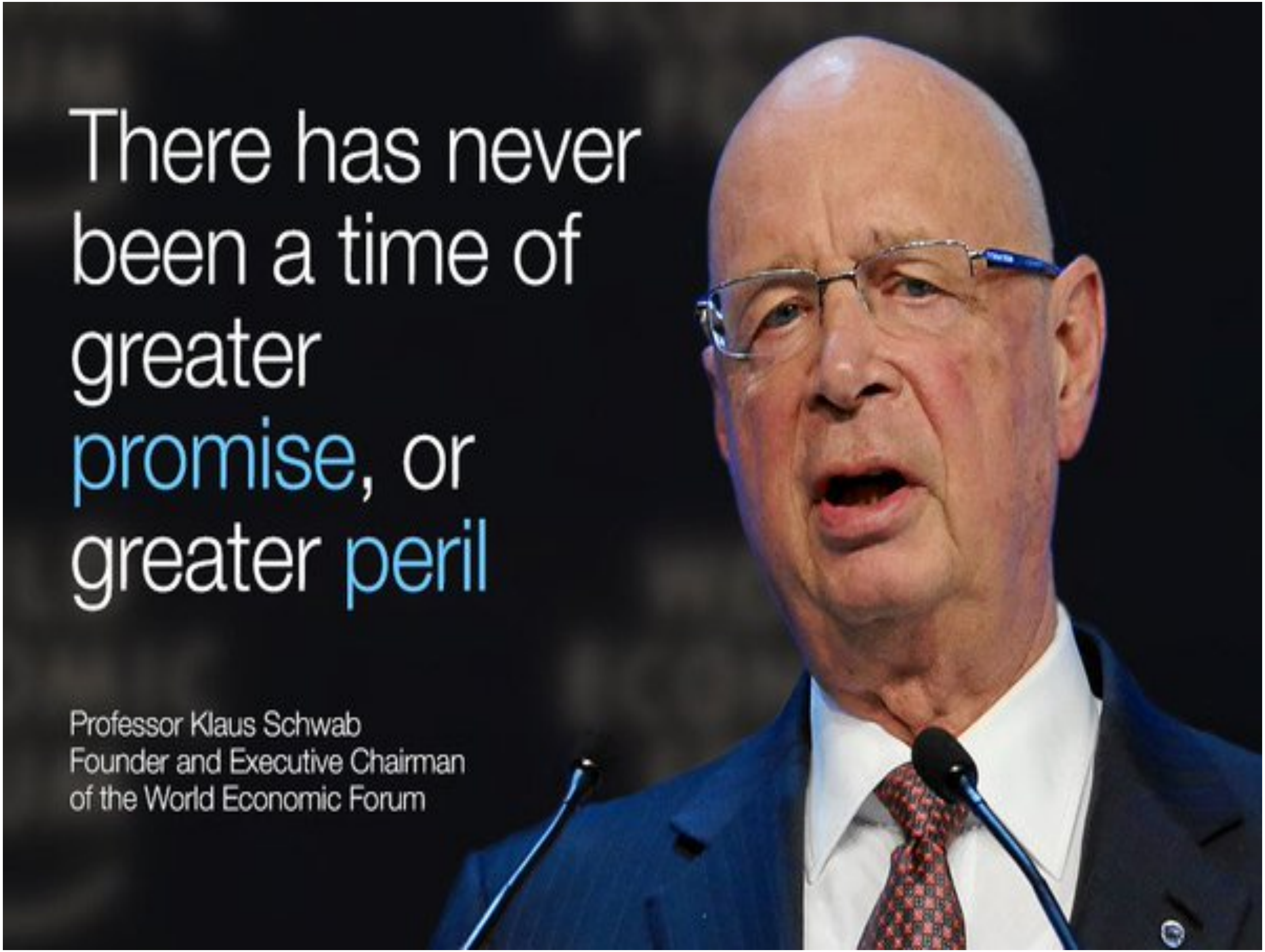
New materials

New technologies are converging to offer new products and new production processes


Digital is the main reason just over half of the companies on the Fortune 500 have disappeared since the year 2000
Pierre Nanterme
CEO of Accenture


The Fourth Industrial Revolution is still in its nascent state. But with the swift pace of change and disruption to business and society, the time to join in is now
Gary Coleman
Global Industry and Senior Client Advisor, Deloitte Consulting


I believe the auto industry will change more in the next five to 10 years than it has in the last 50
Mary Barra
CEO and Chairman of General Motors


There has never been a time of greater promise, or greater peril
Professor Klaus Schwab
Founder and Executive Chairman
of the World Economic Forum

Sciences become so interrelated that they depend on each other and converge:

“. . . if the Cognitive Scientists can think it, the Nano people can build it, the Bio people can implement it, and the IT people can monitor and control it”

=> NBIC technologies: acronym for Nanotechnologies, Biotechnologies, Information tehcnologies and cognitive sciences

What will this convergence imply?

- Improving work efficiency and learning, - Enhancing individual sensory and cognitive capabilities,
- Revolutionary changes in healthcare
- Improving both individual and group creativity
- Highly effective communication techniques including brain to brain interaction
- Perfecting human-machine interfaces including neuro-morphic engineering

2) New production system: smart manufacturing or Industry 4.0

Smart manufacturing = Industry 4.0

= cyber-physical systems (CPS) and dynamic data processes that use massive amounts of data to drive smart machines

It is changing industry, due a number of drivers:

- falling prices and rising performance of enabling hardware and software
- the digitization of industry
- increasing connectivity
- mounting pressure on manufacturers to be more flexible and eco-friendly

Survey by Boston Consulting Group of largest US firms (sales of more than $ 1 billion):

72% are investing in smart manufacturing

Why? Productivity increases are expected:

- increase in flexibility by making it feasible for manufacturers in some industries to offer customers the option to "have it your way."
- Products made in small batches for specific customers, adjusting production lines in response to design changes, and even speed time to market by generating prototypes very quickly.

- Positive effects on innovation: creation of

New kinds of products that can't be made cost effectively with conventional processes.

High-quality goods made to buyers' exact specifications.

Sustainability: these processes are good for the environment because they often consume fewer raw materials and generate less scrap. They improve safety as well, by exposing workers to fewer hazardous materials.

5 MAIN TECHNOLOGICAL TOOLS IN SMART MANUFACTURING:

1. AUTONOMOUS ROBOTS

A new generation of automation systems links industrial robots with control systems through information technology. New robotic and automation systems equipped with sensors and standardized interfaces are beginning to complement—and, in some cases, eliminate human labor in many processes

2. Integrated Computational Materials Engineering (ICME).

By creating computer models of products and simulating their properties before they are fabricated—rather than building and testing multiple physical prototypes—engineers and designers can develop products better, faster, and cheaper.

3. Digital Manufacturing.

Virtualization technology can be used to generate complete digital factories that simulate the entire production process.

Engineers can save time and money by optimizing the layout of a factory, identifying and automatically correcting flaws in each step of the production process, and modeling product quality and output. Entire assembly lines can be replicated in different locations at relatively low cost.

4. The Industrial Internet and Flexible Automation.

Manufacturing hardware can be linked together so that machines are able to communicate with one another and automatically adjust production based on data generated by sensors. They can "see" into the supply chain.

5. Additive Manufacturing.

Commonly known as 3D printing, it creates 3D objects based on digital models by successively depositing thin layers of materials.

Use of 3D printing already for making prototypes in some industries, including aerospace, automotive parts, and basic consumer items.

In the future, these processes are expected to be used to build small batches of new kinds of products made out of one solid piece of material, such as hollow spheres that have no seams.

The above-mentioned new technologies (related to ICTs) imply hyperconnection:

Signals from sensors in smartphones and industrial equipment, digital photos and videos, the nonstop global torrent of social media, etc., all combine to put us in an era of “big data” (Brynjolfsson and MacAffee, 2017)

Big data supports the development of artificial intelligence and machine learning (the more data are available, the more machines can learn)

IBM estimates that 90% of all the digital data in the world was created within the last 24 months!

This helped by more and more powerful networks:
5G networks are about to be available, there are 50 times faster than 4G !!!

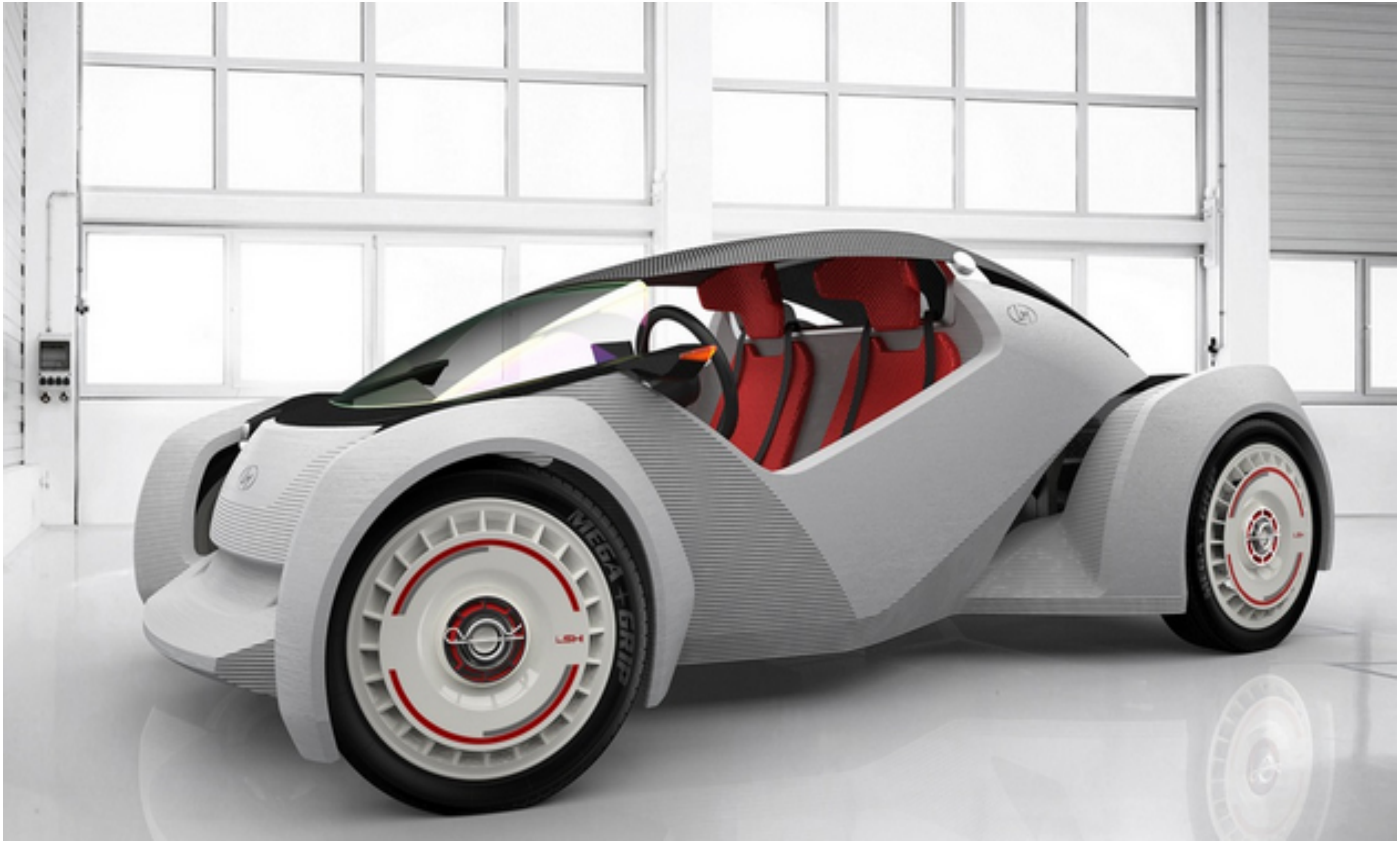
Imply better and faster data accumulation, constant communication of robots and flying drone that can coordinate and work more effectively

Big data and cloud computing

Cloud computing make big data available to organisations and individuals:

- Barriers to entry are lowered: cost of access to the big data much lower (even SMEs can get them)
- Robots or drones access to this huge amount of information and quickly learn that new information (so get more effective)

FIRST CAR MADE BY 3D PRINTING (US company Local Motors)



ROBOTICS

Development in robotics and artificial intelligence are offering new opportunities in many fields including health (assistance to the elderly and the disabled), services (robots assisting in house cleaning, restaurant services, etc.) as well as in production (as most simple tasks in manufacturing are increasingly being performed by robots).

A wide range of industries, including automotive, electronics, and food and beverages, is increasingly using robots, which flexibility, responsiveness and sensing are constantly improving.

Robots can fulfil tasks previously performed by humans, especially repetitive ones, or those performed in unhealthy atmospheres or with other risks.

Robots can work without any interruption, day and night, and do not need any rest.

In addition in factories requiring clean and aseptic environments such as food and beverage preparation and packaging, robots can perform tasks without the risks of human handling.

Thus for instance in Italy the food business Barilla is using robots in its packaging phase, and has recently inaugurated a completely automated plant.

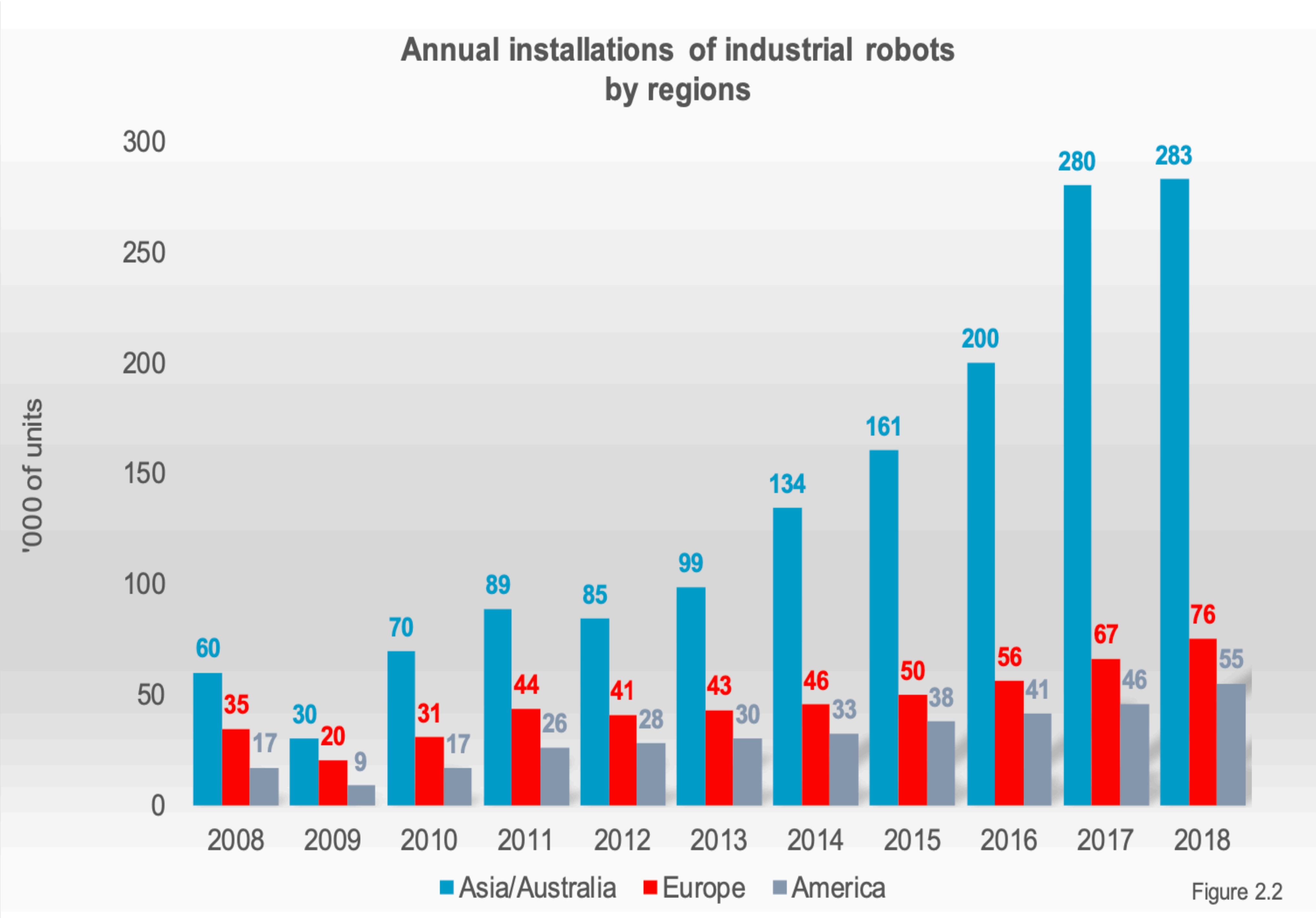
(magazzino Automatizzato Pedrignano)

Spending on robots worldwide is expected to increase from $15 billion in 2010 to $67 billion by 2025.

The international supply of industrial robots has continuously increased in the last fifteen years (Figure 1, International Federation of Robotics, 2016), apart from a reduction at the beginning of the financial crisis. The increase has become steeper in the last five years.

70% of global robot sales went to five countries: China, Japan, the US, South Korea and Germany.

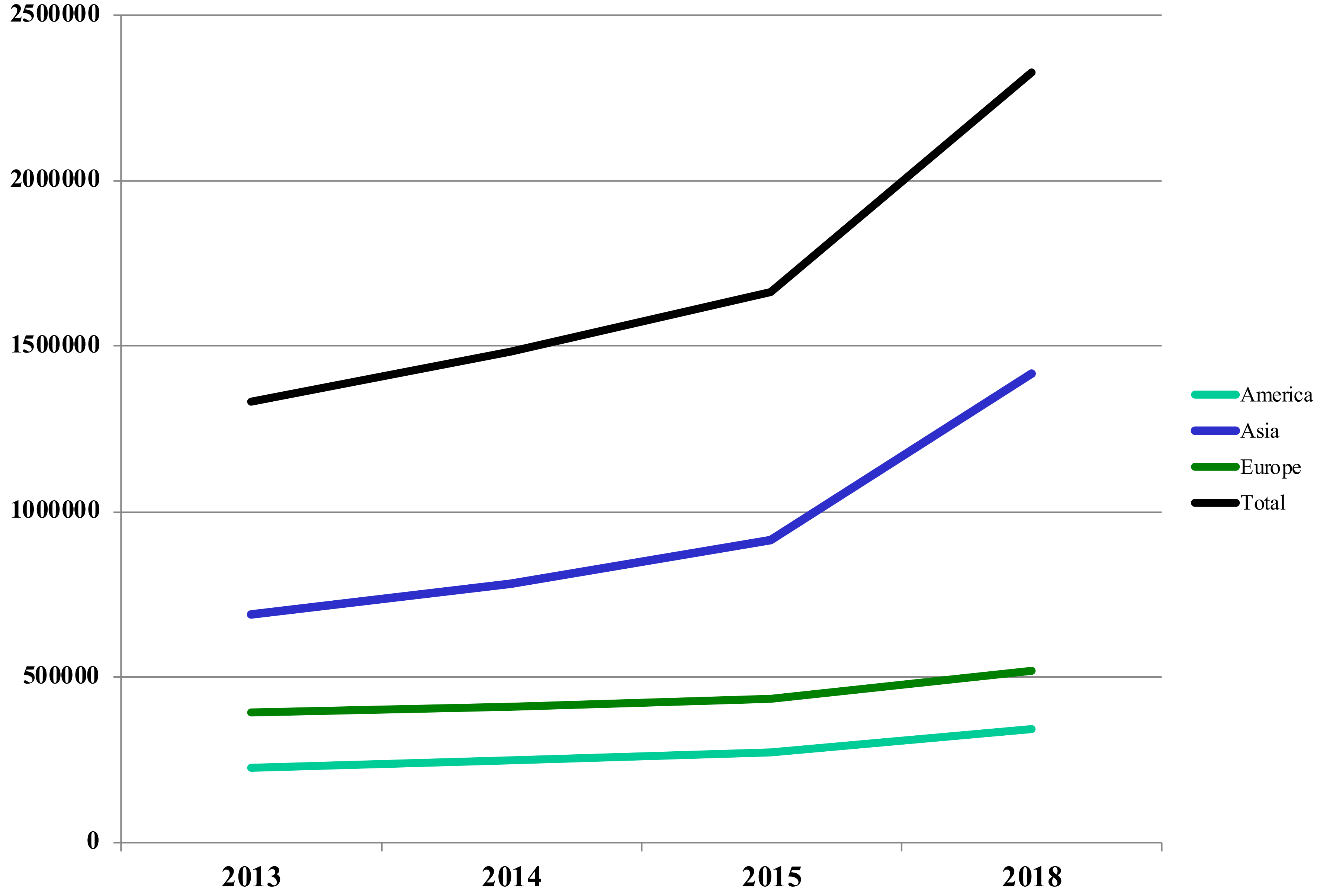
Italy is the second largest robot market after Germany, and is the 7th largest market worldwide.

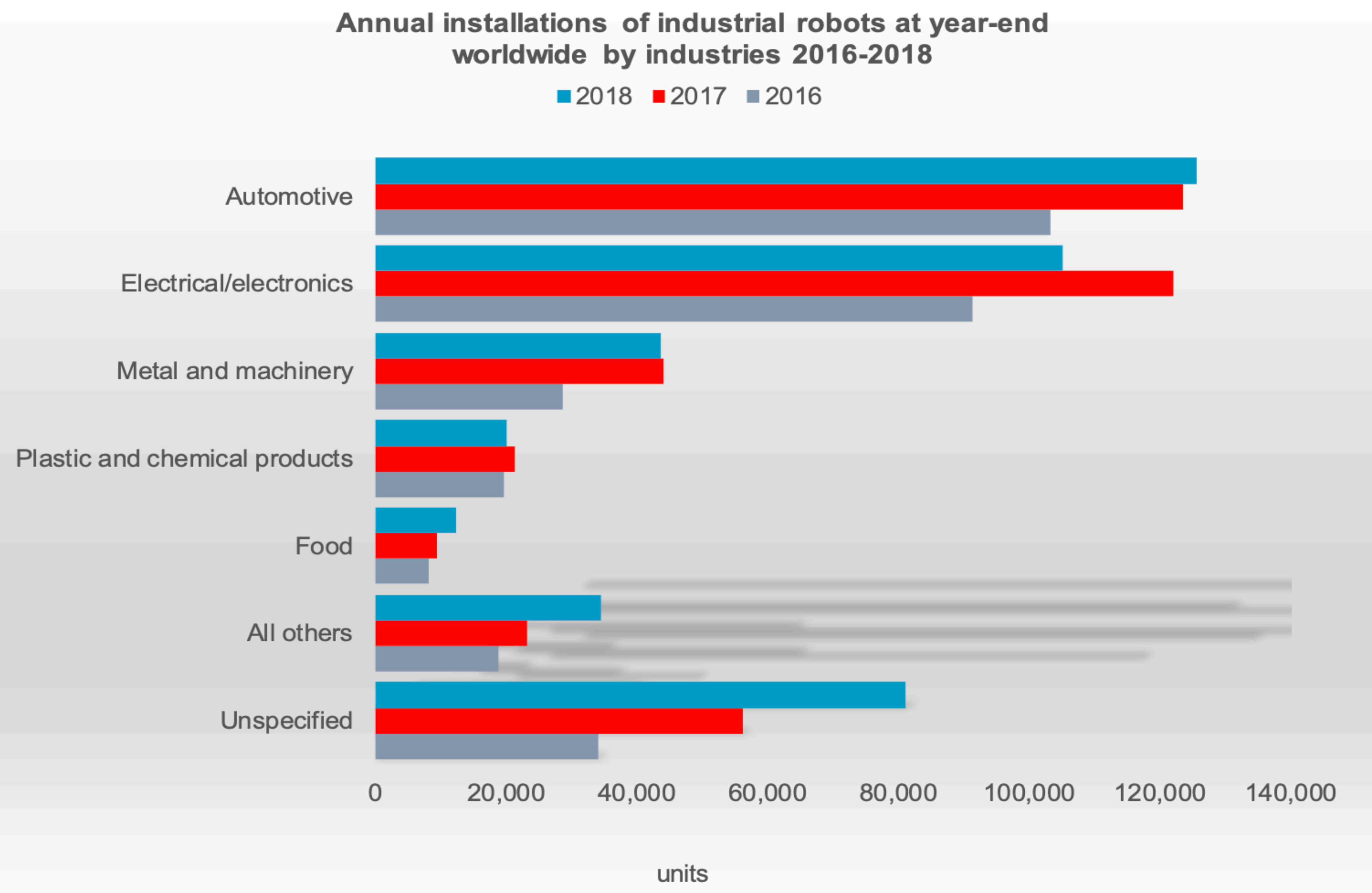


Annual installations of industrial robots
by regions
'000 of units
300
250
200
150
100
50
0
60
35
17
30
20
9
70
31
17
89
44
26
85
41
28
99
43
30
134
46
33
161
50
38
200
56
41
280
67
46
283
76
55
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Asia/Australia
Europe
America

Figure 2.2

Estimated total stocks of industrial robots




Annual installations of industrial robots at year-end worldwide by industries 2016-2018
2018
2017
2016
Automotive
Electrical/electronics
Metal and machinery
Plastic and chemical products
Food
All others
Unspecified
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
units
Figure 2.16

In the past robots were mainly used to perform repetitive tasks such as material handling and processing, welding and soldering, as well as assembly, which required speed and strength but little precision.

However, with the inclusion of sensors and their connection to big data, robots are increasingly able to realise precision tasks, feel and adjust to unexpected circumstances.

In the Netherlands, Philips uses 128 robots to make razors, in a factory where only nine humans perform quality checks (9 employees)

Amazon, the world's largest online retailer, created Amazon Robotics in 2003, a subsidiary based in the US aimed at developing automation of its warehouses and logistics system. It also acquired Kiva Systems in 2012, a company manufacturing warehouse robots. Robots are faster than humans, and work 24 hours a day.

ADIDAS, NIKE

EVEN THE SHOE BECOMES A SERVICE, A HEALTH SERVICE: SHOE CUSTOMISATION IN ORDER TO FIT THE SHOE TO THE CHARACTERISTICS OF THE CONSUMER'S BODY

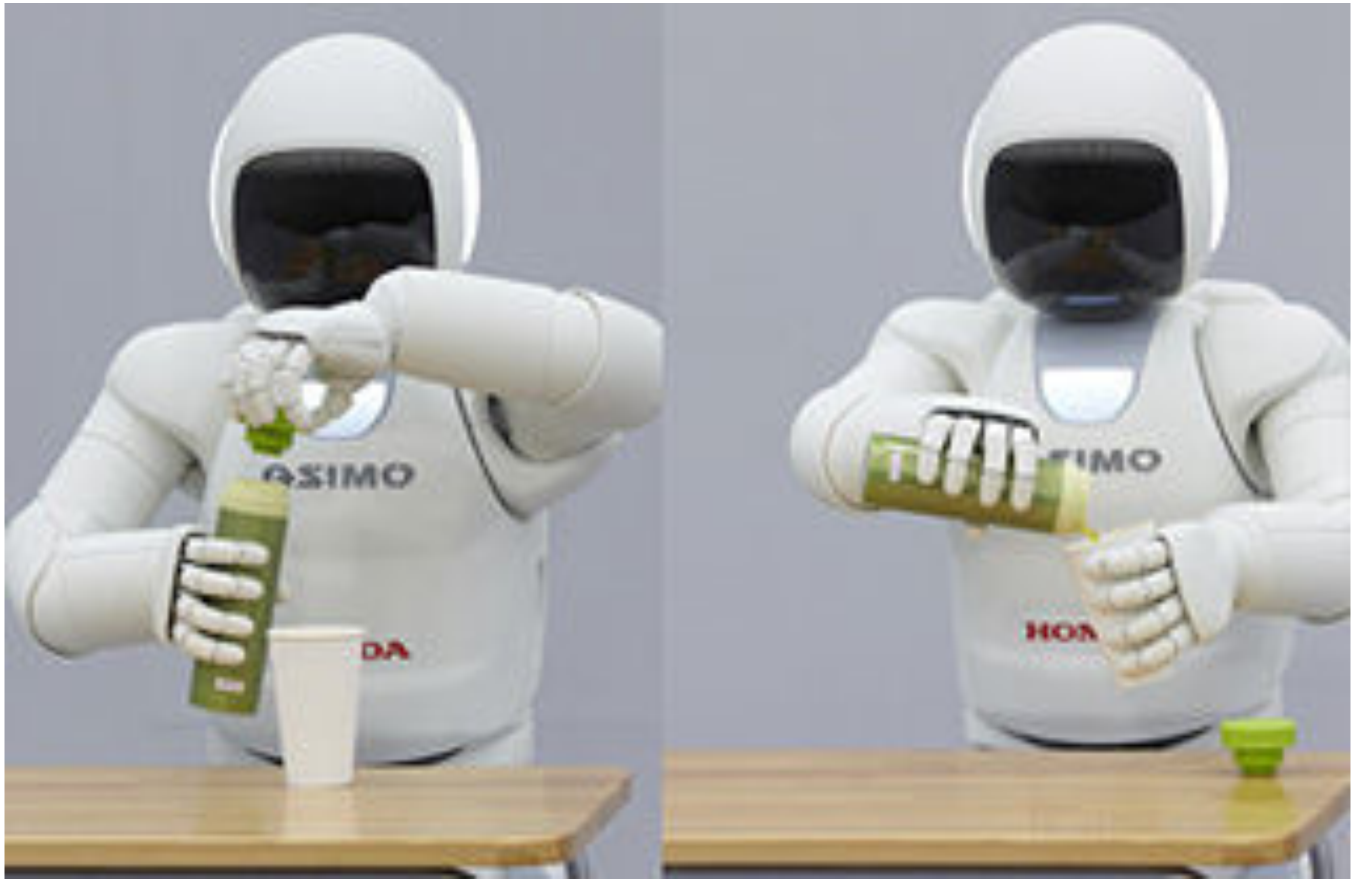
Adidas Futurecraft 3D: customised shoe sole printed in 3D

Nike:

https://www.nike.com/nike-by-you?mid=38660&cp=usns_aff_nike_080113_TnL5HPStwNw&site=TnL5HPStwNw-PsH69XhNQtVEEwZM3ErIfg

Robots are not only used in manufacturing: also in healthcare and nursing

Example: ASIMO by Honda, can help elderly people



Agricultural robots, or agbots, are being designed to pick fruit and vegetables, to minimize harvest time pressures, and to prepare for the day when labor laws make it tougher to get large numbers of migrant workers to help with harvesting.

Implications for companies:

- Robotics can provide **cost-saving alternatives** in many areas and **complement human workers** in others.

- Robots can liberate workers from hazardous or unappealing jobs.

- Human Skill Gaps: in Japan, developers are exploring ways robots might provide nursing and elder care. Other scarce and needed skills and capabilities that robots can offer—such as data mining, rapid analysis, and super speed or strength—exist at levels not present in human beings.

Implications for companies:

- Mission-Critical Applications: tasks that demand exceptional precision, flexibility, or speed, such as electronic-chip production, or that require manoeuvering in small spaces lend themselves to robotics.

- High Complexity of supply chains and supplier networks: robotics offers a way to centrally manage and execute complex logistics and to customize products for different markets and even for individual customers.

Strategic considerations

The strategic implications of robotics vary according to firms and industries

However, there are a number of common strategic considerations:

- **Operational Flexibility and Financial Rigidity**. Robots make manufacturing flexible but not finance: when demand slows down, workers in many markets can be laid off, or moved to other assignments, but debt payments on financed capital equipment such as robots are due each month if the equipment is not liquidated.

- **Minimal Efficient Scale and Operating Architecture**. The greater efficiency and speed of robots can change the calculus on decisions related to production facility size and footprint. For instance, it may make sense to have robot-enhanced plants close to local markets so that products can be finely tailored to local tastes; or to set up large robotic plants in countries with cheap energy, since labour costs and availability will be less critical; or to locate facilities in areas with availability of expert workers and engineers who could work complementary to robots

- **First-Mover Advantage**.

Companies need to anticipate the robotic tipping points in their sector and move decisively. The cost advantage conferred by robotics will be whittled away as adoption becomes widespread. First movers will, therefore, capture a disproportionate share of the high margins that accrue to successful early adopters.

Leadership

Leaders must explicitly consider the capabilities and economics of robotics when making a broad range of strategic and operating decisions related to staffing levels, manufacturing footprint, facility location and size, and other aspects of the business model.

Companies that fail to stay abreast of the robotic megatrend risk making suboptimal choices—and ceding the competitive high ground to rivals.

3) Relation between man and machine

EFFECTS OF THE 4TH INDUSTRIAL REVOLUTION ON THE ECONOMY AND THE SOCIETY?

Focus on IT and artificial intelligence (robots)

EFFECTS ON THE ECONOMY

- New products, possibility to meet the UN Development goals (sustainability)
- More variety (even customisation) at low cost
- Rising output, rising productivity
- Robots will help humans in performing their jobs and activities
- However, robots will also substitute labour in many employments

Information technology (IT) is the key enabling technology of the 4th industrial revolution

- IT has constantly progressed since the invention of the integrated circuit in 1958.
- Computers' power has constantly improved, and so has artificial intelligence, which uses big data analytics to process and analyse large amounts of data in order allow the machine to "learn".

Example: breakthrough in 1997 when IBM's "Deep Blue" computer defeated the world champion of chess, Garry Kasparov.

In 2010 the supercomputer Watson from IBM succeeded in winning against the human champions of the TV show Jeopardy! based on quiz.

The supercomputer could rapidly process billions of data (200 million pages of content) in its memory (4 terabytes of hard disc, namely 4000 billion bytes or a bit more than 1,000 DVD of 4.7 GB each) to “understand” the question and provide an answer.

Will the rise of robots generate massive unemployment?

Not only blue-collar jobs but also white-collar jobs are increasingly threatened by the progress in robotics. Basically all that can be predictable, based on long-term learning, reflection from available information, can be automated.

Even lawyers, journalists and pharmacists are threatened by AI.

For instance, a pharmacist must know a wealth of information on existing medicines and their effects, and they increasingly rely on computers to find the medicine we need when we ask them: supercomputers could take our question about a possible medicine for a specific health problem and process big data not only on the medicines, their components and effects, but also on past experiences of people with the medicines, to tell us what is the medicine most fit for us.


Minocin
100 mg
perdolan

For the time being, robots can process large amounts of data to learn and find answers to questions. However, one big limit they have at the moment is that they cannot “see”, nor perceive.

However, big progress are being made in that respect too.

Example: videogames and Nintendo

Robots’ eyes started to appear commercially when Nintendo introduced its Wii video game console.

Nintendo’s machine included a wireless wand that could detect motion in three dimensions and then output a data stream that could be interpreted by the console.

Video games could now be controlled by body movements and gestures.

Competitors:

Sony Corporation copied Nintendo’s invention and created a similar wand for its Playstation.

Microsoft came up with another innovation: the Kinect add-on to the Xbox 360 game console eliminated the need for a controller wand entirely.

(a webcam-like device that shoots an infrared beam in the room and calculates distances).

The company Rethink Robotics has developed a robot called Baxter that can "see", namely perceive the presence of humans around it and avoid bumping at them if they are in the same room.

Does this mean robots will completely substitute humans?

Answer: NO

There is a field where robots cannot beat humans:

CREATIVITY

Namely create new ideas, new concepts, using capacity to “think outside the box”, using emotions and sensitivity

=> In the future it will be important to be able to work with the robots

Humans (workers) and robots as COMPLEMENTS

- There are robots able to create sentences **but not poetry**
- Robots (computers) can analyse huge amounts of data but not elaborate new hypotheses
- Robots put together ingredients and prepare simple meals **but not add a new recipe on the menu**
- Robots can make simple reports putting together information (on sport events, evolution of the stock exchange) **but not sense a scoop**

Robots and business

Example: Fashion business

Many fashion firms use computers to decide what clothes to produce for the next season: statistical analysis of past tendencies, patterns and sales to forecast what’s next

NOT ALL however

Zara: Fast fashion, low cost but trendy clothing for essentially young people, with very rapid change of collections

ZARA

The decision on what clothes for the next collection is made on the basis of suggestions from shop directors all over the world

Directors look at past sales, talk to clients to get a feeling of the new tendencies and new needs, and make suggestions to the headquarters where new collections are created

⇒ Concept creation, creativity, communication and innovation are human capacities that robots are not likely to have in the future

⇒ Rather than substitution, it is likely that robots and human workers will become **complement** in the future

⇒ BUT only people with capacities such as creativity, sensibility, communication, (all what robots and computers cannot do) will have jobs!

EFFECTS ON SMEs???

- Like in all industrial revolutions, existing firms which do not adapt risk disappearing

- Many new firms are created, using the new technologies or transforming products and industries: new entrants are generally SMEs

4) Digitalisation and its effects

Biggest disruption of the 4RI:

DIGITALISATION

= ADOPTION OF ICT TOOLS IN BUSINESS PROCESSES AND MODELS

What are these tools?

high-speed broadband, Big data, cloud computing, 3D printing and the Internet of Things (IoT)

What is the impact of digitalisation on business processes?

1. Production process: mass customisation

- Hyperconnection means that both consumers and the factory (with sensors everywhere) can be connected in real time
- Consumers can send their requests and the factory system replies in real time by producing the specific product

➔ Mass customisation: very small batch (one product) is efficiently produced

Consequence: the activities of the firm become customer-driven

The customer (single or in the community on the firm's platform) directly interact with the members of the firm

He/she can even participate in the production process, making suggestions

Example: GE's launch of a new ice maker based on participation of customers

GE's Opal ice maker (2015)

(in book by MacAffee and Brynjolfsson, *Machine, Platform, Crowd*)

- GE develop a prototype for an ice maker for the home by interacting frequently with its online community (which gave indication on how it should look, whether it should have a scoop, how to sense it was full, etc.)
- July 2015 GE launches a crowdfunding campaign on Indiegogo, initially asking people to contribute $399 for the development of the ice maker.

➔ By August 2015 GE had collected more than $2.7 million !!!

GE’s Opal ice maker (2015)

The finished product was shipped to 5,000 preorder customers

➔GE did not need the money to finance its R&D for the ice maker

➔ but it gained market intelligence (suggestions and comments made by the online community) + secured the market for the ice maker!!!

GE is a very large firm: but SMEs could do exactly the same!!!

SMEs usually have more difficulty in

- Accessing financing: crowdfunding such as GE’s campaign can do
- Access distribution channels: building and maintaining an online community like GE’s is very cheap!

Other consequence of the new technologies in the production process:

SERVITISATION

= bundling of services together with physical products

Allows to differentiate from competitors

Example: RollsRoyce

(Christopher and Ryals, Journal of Business Logistics, 2014)

RollsRoyce = craft engine maker

Product: craft engine

In 1999 the company launched a new product, **TotalCare**

Physical product is still plane engine

But the company now sells reliable power for planes

For TotalCare, airline companies (Rolls Royce clients) now pay for every hour the engine is in flight

Rolls Royce sells the engine, but also all the services linked to it: maintainance, repair, etc.

With the sensors on the engines Rolls Royce is always connected to the engines and can monitor their state and their need for repair

In 2005, Rolls Royce engineers were remotely monitoring the performance of 3,000 engines of 55 airline companies, ensuring maximum uptime (time in which engines are functioning)

➔ The business of Rolls Royce is now uptime rather than physical engines, i.e. the company extracts more value from the service rather than from the physical product

➔ Enormous value for the customers: example

Flight Singapore to New York where an engine was struck by lightning. Rolls-Royce's service team in Derby was able to assess the condition of the plane's engines in flight and advise the pilot that it was safe to continue, saving the airline between $1 m and $2 m in disruption costs!

➔ **This is servitisation**

➔ Can you think of other examples of servitisation?

Consequence of servitisation:

SUPPLY CHAINS BECOME DEMAND CHAINS

i.e. driven by the customers, to whom the company offers a product and the services of the product

The new technologies of the 4^{th} Ind Revol allow this

DEMAND CHAINS AND SUSTAINABILITY

In a sustainable world, the supply chain needs to be designed from the customer backward (demand pull) instead of from the factory outward (supply push), making it responsive to customer demands and **reducing waste and returns**.

ROLLS ROYCE calls TotalCare a **circular economy** product

OTHER EXAMPLES:

- Xerox no longer sells printers but sells Document Management Systems (to optimize document management in the whole organisation)

- IBM no longer sells computer hardware (almost) but sells SOLUTIONS to its clients (big data services)

- Michelin: no longer sells tyres but sells number of aircraft landing or number of kilometres travelled

Can you think of examples of SMEs which have servitised their products???

Do SMEs servitise products?

Study for the European Commission (2018):

- The service component amounts to 12% of EU manufacturing turnover in SMEs.
- 10% of full time employees of all manufacturing SMEs are responsible for developing service offers.
- Servitisation brings a 1-10% increase in annual turnover to the servitised SME.

Do SMEs servitise products?

The main barriers to servitisation are:

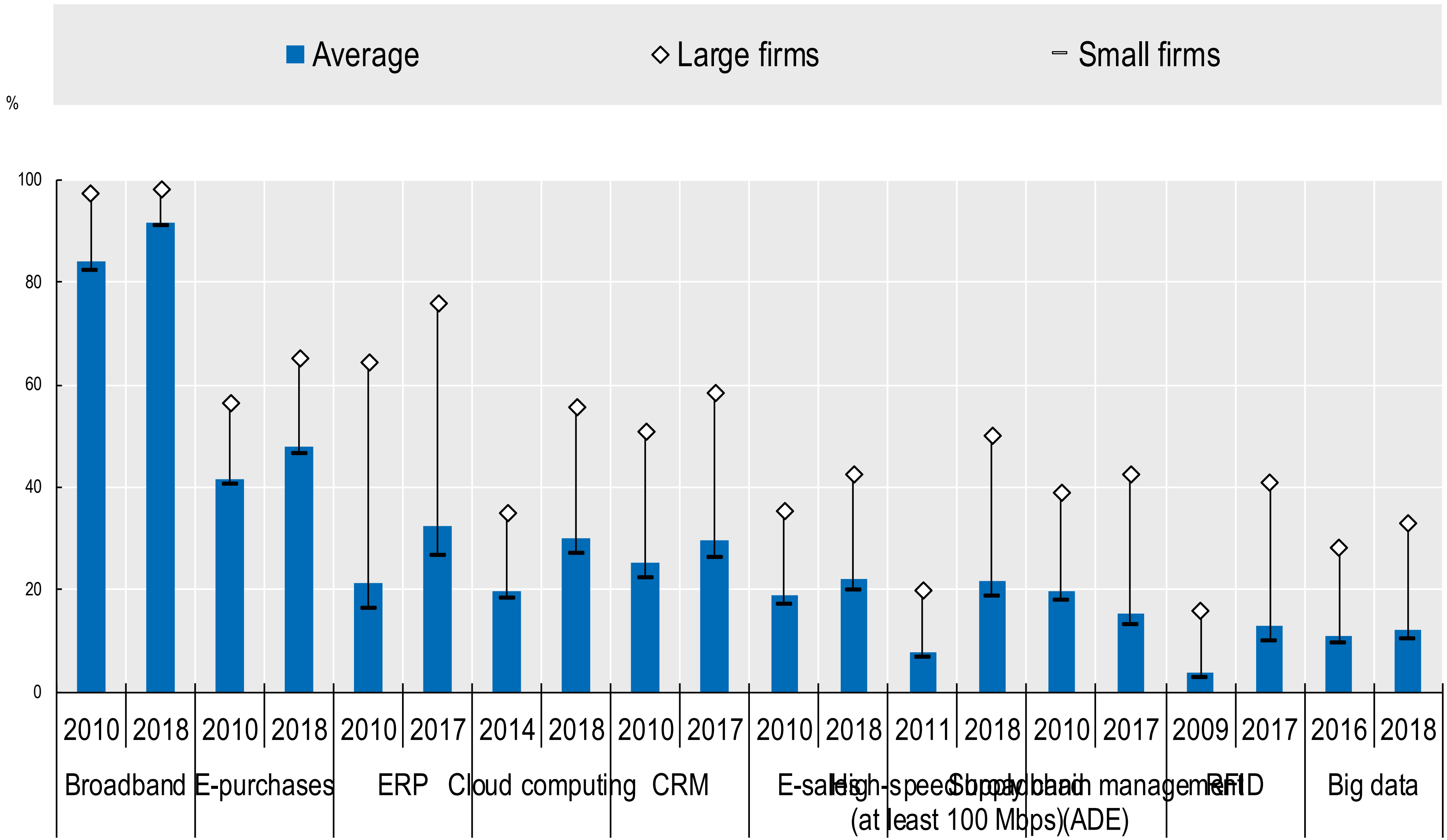
- The skill set of current staff and difficulties in hiring staff with the right skills
- Organisational structure and culture not fit for providing services
- Finding the right suppliers and partners
- Access to financial resources
- Barriers related to regulation (data, privacy, and the Single Market)

What is the state of digitalisation in existing enterprises?
The OECD provides data

High speed Broadband access: all large firms have access, only 20% of SMEs

Cloud computing access is diffusing rapidly: 56% of large firms and 27% of SMEs purchase cloud computing services in 2018

Larger firms make greater use of advanced technologies of the 4RI, but SMEs adopt infrastructure and software technologies at similar rates



Average
Large firms
Small firms
%
100
80
60
40
20
0
2010
2018
2010
2018
2010
2017
2014
2018
2010
2017
2010
2018
2011
2018
2010
2017
2009
2017
2016
2018
Broadband
E-purchases
ERP
Cloud computing
CRM
(at least 100 Mbps)
(ADE)
Big data

Digitalisation is having a strong impact on market conditions and SME performance, via:

- cheaper digital tools (ICT equipment) that provide scope for new innovative firms to enter the market,
- provision of digital services (which reduce the space between consumers and producers), or
- access to new (including international) market places via digital intermediation platforms, such as Amazon and Task Rabbit, and other dedicated company websites.

In addition,

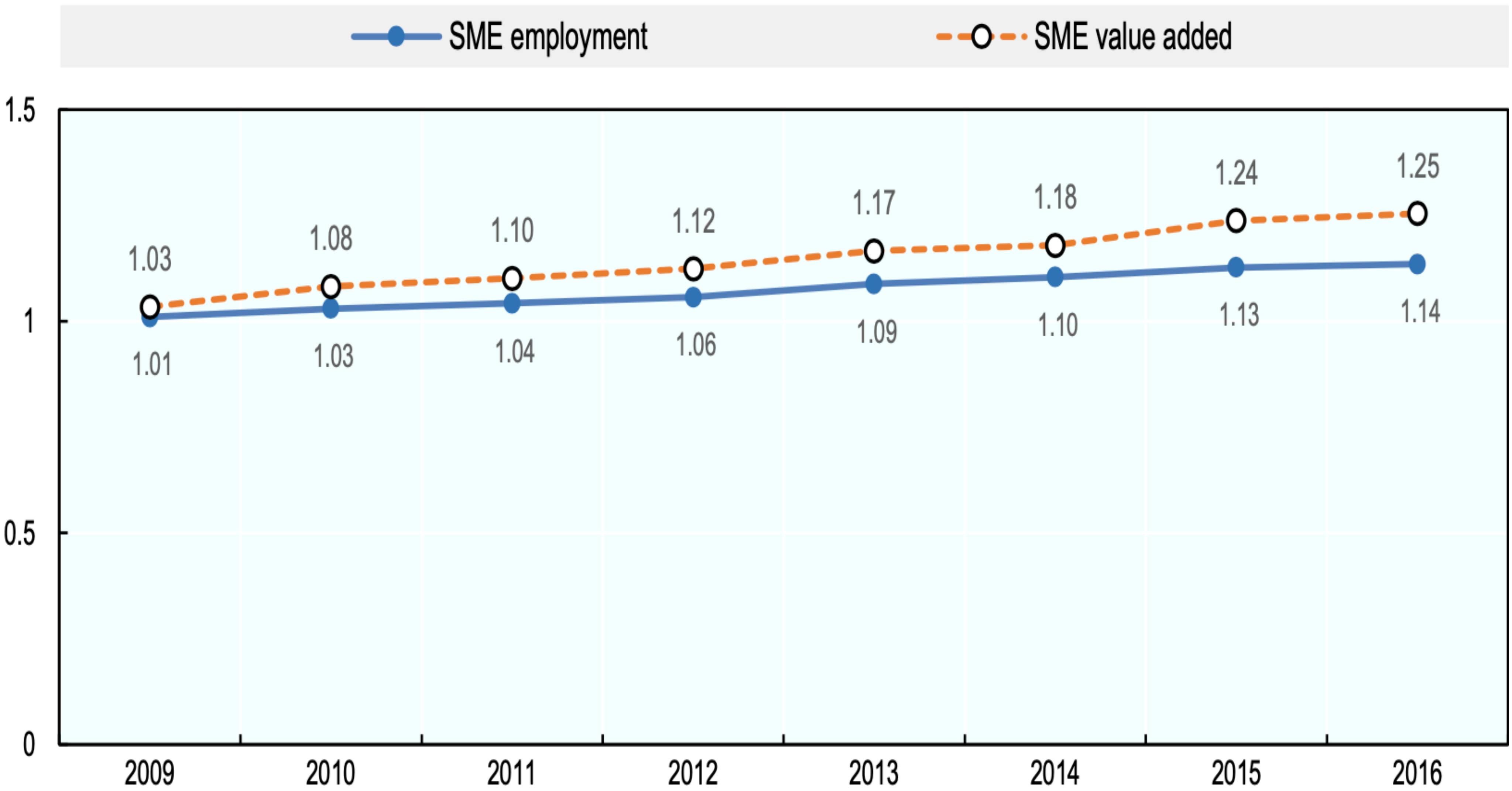
- Big Data and data analytics can enable a better understanding of the processes within the firm, the needs of their clients and partners, and the overall business environment
- Lean startups are emerging that leverage the internet to lower fixed costs and outsource many aspects of the business to stay agile and responsive to the market

In addition,

- The use of digital technologies can also ease SME access to skills and talents, through better job recruitment sites, outsourcing and online task hiring, as well as connection with knowledge partners
- Also easing of access to financing for SMEs thanks to new instruments: mobile banking, online payments and other new financial services

Figure 1.23 High-digital intensity SMEs have higher growth

Ratio of high over low digital intensity sectors growth rate of employment and value added



Source: *OECD Structural and Demographic Business Statistics Database*, 2018, http://dx.doi.org/10.1787/sdbs-data-en.

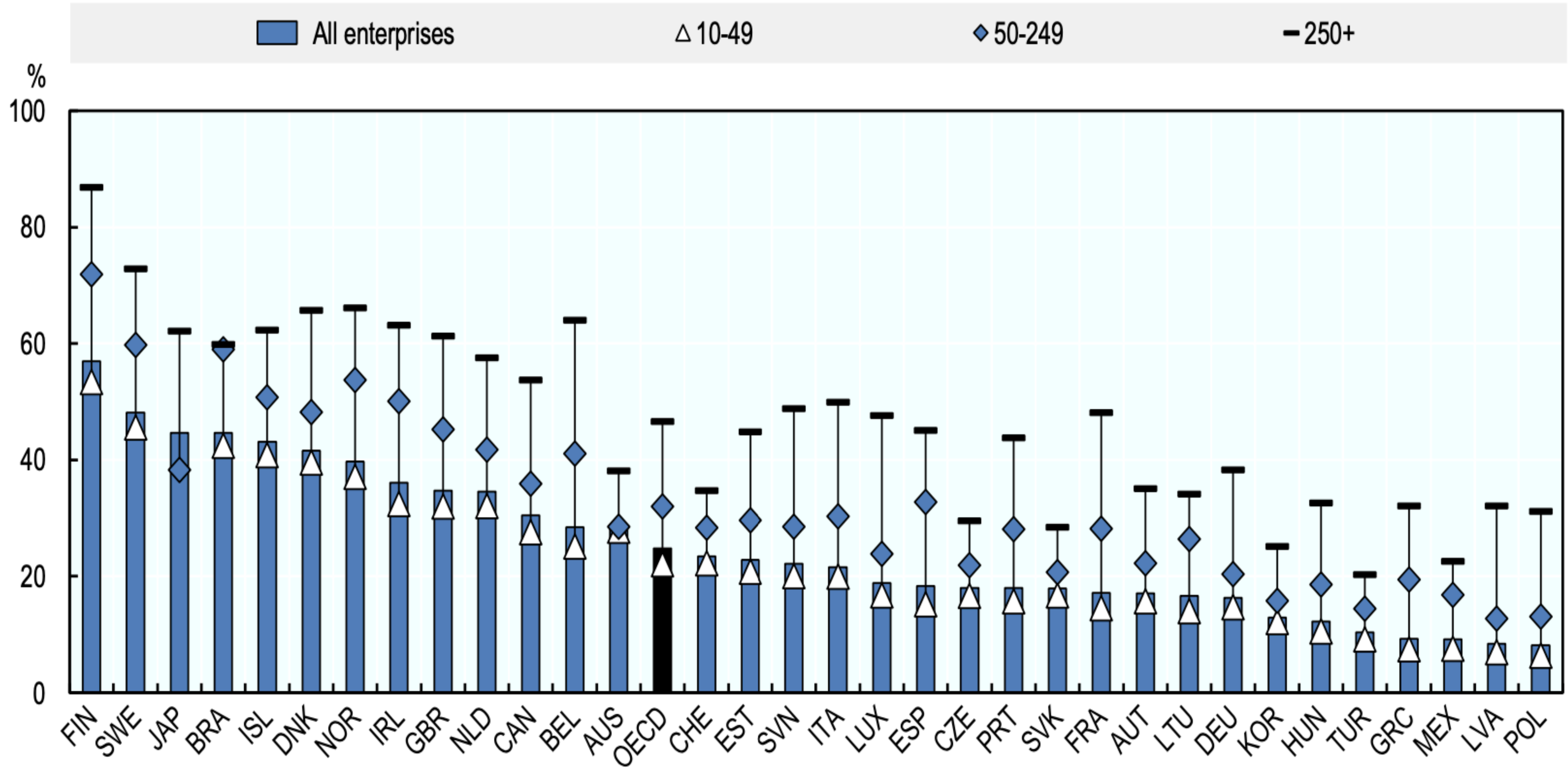
However, many SMEs have difficulties in digitalisation

Lag in adoption due to lack of investment in complementary knowledge-based assets, such as R&D, human resources, organisational changes and process innovation

+ problem of digital security and privacy risks higher in SMEs than in large firms, mainly due to lack of awareness, resources and expertise to assess and manage risk

Figure 1.24. SMEs lag in the adoption of more sophisticated digital technologies

Enterprises using cloud computing services, by firm size (2016), as a percentage of enterprises in each employment size class



Source: OECD ICT Access and Usage by Businesses (database), http://oe.cd/bus (accessed June 2017).

TO SUM UP:

- Fourth industrial revolution = many scientific discoveries in different fields leading to technological innovations that converge, leading to new products and processes
- Industry 4.0 = new production processes
- Digitalisation = application of new ICT tools and instruments

➔ STRONG IMPACT ON ALL FIRMS, LARGE AND SMALL, AND ON INDUSTRIES

5) Disruption of productive sectors: examples

NOTE THAT ALL INDUSTRIAL REVOLUTIONS HAVE DISRUPTIVE EFFECTS ON INDUSTRIES

Example: electricity transition at the beginning of the 20° century

USA: 40% of the industrial groups created between 1888 and 1905 failed by 1930

The market share of the firms which dominated in 1905 decreased from 69% to 45% (by 1930)

Failing firms did not succeed in redesigning their business following the electrification of activities (not only using lamps in offices but also redesign production processes)

STRUCTURAL CHANGES IN INDUSTRIES:

- ALL INDUSTRIES ARE DISRUPTED
- SOME DISAPPEAR
- SOME BRANCH INTRO NEW ACTIVITIES
- SUPPLY CHAINS CHANGE

EXAMPLES OF INDUSTRY DISRUPTION

- NEWSPAPER

- MUSIC

- PHOTO

= Some of the most disrupted businesses!

Newspapers:

Mid-1990s: there were 2400 newspapers in the USA, generating $46 billion revenue per year.

Revenue came from classified and non-classified ads and circulation sales

2013: the newspaper business had lost 70% revenue over the previous decade

13,400 jobs were lost

A number of newspapers went bankrupt

Newspapers:

All newspapers that have survived had to re-invent their business

Who buys a printed newspaper nowadays???

Music industry:

2000: there were about 10000 AM and FM radio stations in the US, making $ 20 billion per year.

People would hear music on the radio and then go to buy albums, making the recorded-music industry happy

The recorded-music industry was an oligopoly: few large firms such as Sony, HMV and Tower Records.

Music industry:

1999 to 2014: worldwide sales of recorded music fall by 45%

The oligopoly has now only 3 firms left: Universal Music Group, Sony Music Entertainment and Warner Music Group

HMV and Tower Records went bankrupt

Music industry:

Today everybody listens to music in streaming, on digital platforms

(see classes on platform businesses)

Photo industry:

Mid-1990s: people would take pictures on their cameras and go to the shop to print them

1997, film photography industry was worth $ 10 billion in 1997

Kodak was an important player: market capitalisation in first quarter of 1997 = $ 31 billion

Photo industry:

HOWEVER
KODAK WENT BANKRUPT IN 2012

Why? It missed the shift to digital cameras and then in any case the camera business disappeared with the development of smartphones

➔ MAIN DISRUPTION THAT AFFECTED THESE INDUSTRIES HAS BEEN

THE RISE OF PLATFORMS

(NEXT CLASSES)