Leveraging the upcoming disruptions from AI and IoT

How Artificial Intelligence will enable the full promise of the Internet-of-Things

pwc

Businesses across the world are rapidly leveraging the Internet-of-Things to create new networks of products and services, that are opening up new business opportunities and creating new business models. The resulting transformation is ushering in a new era of how companies run their operations and engage with customers.

However, tapping into the IoT is only part of the story. For companies to realise the full potential of IoT enablement, they need to combine IoT with rapidly-advancing Artificial Intelligence (AI) technologies, which enable 'smart machines' to simulate intelligent behaviour and make well-informed decisions with little or no human intervention.

Over the coming years, ongoing advances in AI will have profound impacts on jobs, skills and HR strategies in virtually every industry—underlining the fact that companies don't have the luxury of time as they map out their plans for an AI-enabled world. Already, integrating AI into IoT networks is becoming a prerequisite for success in today's IoT-based digital ecosystems. So businesses must move rapidly to identify how they'll drive value from combining AI and IoT—or face playing catch-up in years to come.

Artificial Intelligence: A disruptive technology on a par with the PC…

In a recent thought leadership paper[1], we described why the advent of the Industrial Internet of Things (IIoT) is a once-in-a-lifetime business disruption one that requires organisations to develop or acquire new capabilities in managing direct relationships with customers, supported by transformed operating and business models. But realising the promise of the IoT also requires something else. To achieve its full potential, the IoT needs to be combined with an equally powerful and disruptive set of technologies categorised as Artificial Intelligence (AI).

The exponential growth of the IoT is well-known, as underlined by the projections in the accompanying information panel. However, less widely appreciated is the profound impact that AI will have on every aspect of our personal and working lives—an impact that will be magnified and multiplied by its combination with the IoT.

In fact, the titanic shift and ongoing disruption caused by AI is set to be similar to that caused by the introduction of the personal computer in the 1980s. Like the PC, AI will lay the foundations for an immense acceleration in innovation throughout and beyond the coming decade, creating a significant boost for the global economy. In the 1980s, nobody could have fully imagined the broad and deep changes that PCs would bring to our lives. Similarly, few people today can envision what AI will mean to us over the coming decades.

…enabling business to capitalise on the era of 'smart machines'…

So, what kind of impacts are we looking at? One effect is the creation of a vibrant and expanding market for AI solutions and services: Bank of America Merrill Lynch (BAML) estimated in December 2015[2] that the robot and AI solutions market will surge to US$153bn a year by 2020, comprised of US$83bn for robots and robotics, and US$70bn for AI-based analytics. BAML added that adoption of robots and AI could boost productivity by 30% in many industries over the coming decade, while cutting manufacturing labour costs by between 18% and 33%.

Whatever the precise growth trajectory, it's clear that AI is gaining ground rapidly, an advance that reflects the scale of the benefits it can bring to businesses. At its core, AI is about simulating intelligent behaviour in machines of all kinds—and since IoT is about connecting those machines, there is a clear intersection between AI and IoT.

The early forms of AI were 'brittle' and unable to handle all situations with the same level of accuracy. So they were good at narrowly defined tasks, but failed to scale well, and often required human intervention. However, this represents just the first step in the evolution of AI, with the next wave being active intelligence—the ability to act in real time with little or no human intervention. Once devices and machines are enabled with this level of AI, we enter the era of 'smart machines'.
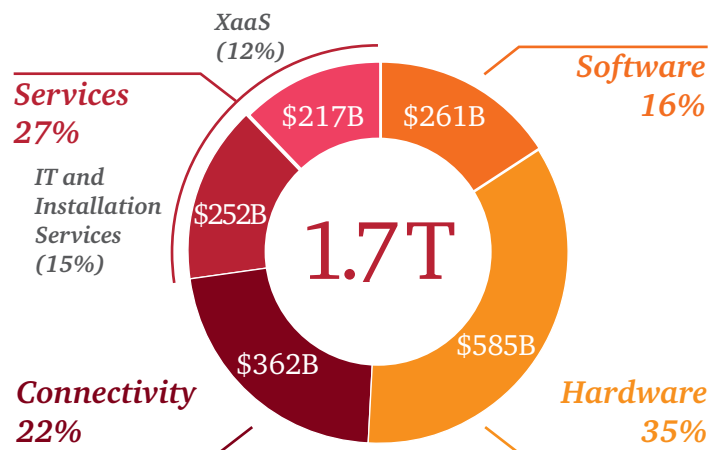
As AI continues to evolve, the benefits for businesses will be transformational. Given the power and scalability of AI solutions, tasks that used to take humans weeks or months to complete will be actionable in minutes or seconds. Also—as with today's mobile technologies—the pace of adoption by businesses will be augmented by pressure from employees, who will want to experience the same convenience and personalisation of AI applications in their working lives that they're accustomed to at home.

Figure 1: Forecasted worldwide IoT revenue by technology element in 2020

Investment in IoT solutions: An exponential growth path

According to current projections:

- A cumulative total of US$6 trillion will be spent on IoT solutions between 2015 and 2020.

- IoT investments by businesses will grow from US$215 billion in 2015 to US$832 billion in 2020, while consumer spending on IoT solutions will rise from U$72 billion to US$236 billion.

- According to IDC, the IoT marketplace will be worth US$1.7 trillion in 2020, with the biggest portion being hardware, followed by services, connectivity and software.

XaaS (12%)
Services 27%
IT and Installation Services (15%)
$217B
$261B
$252B
1.7T
$585B
$362B
Software 16%
Hardware 35%
Connectivity 22%

Sources: "IDC's Worldwide Internet of Things Taxonomy, 2015," IDC, May 2015;
"Worldwide Internet of Things Forecast, 2015 – 2020," IDC, May 2015.

…while bringing profound impacts for companies' skills requirements…

However, as companies direct increasing investment into AI over the next few years, the impacts will extend far beyond business performance—simultaneously generating massive change in the number and nature of jobs in many industries. Essentially, we are set to see growing use of AI in every job and service, triggering reduced demand for low-value, high-volume skills. To scope out how profound these effects will be, and help companies develop their approaches to AI investments and capability building, PwC has been analyzing the potential value that can be generated by AI, and what impacts they can expect on their jobs and skills base. Some of our headline findings are showcased in the accompanying information panel.

While the debate in society over the rights and wrongs of replacing workers with smart machines will continue, our research makes it clear that any company that fails to seize the AI opportunity will face a significant competitive disadvantage—meaning no leadership team can afford to ignore it. And with the adoption of AI and IoT accelerating, the window for planning and weighing the options is shrinking fast.

These messages are supported by other independent research studies. For example, a 2013 report entitled *The Future of Employment: How Susceptible are Jobs to Computerisation*?[3] by Carl Benedikt Frey[4] and Michael A. Osborne[5] of Oxford University, divides the US labour market into high-, medium- and low-risk occupations, depending on their probability of computerisation. The authors write: "According to our estimate, 47 percent of total US employment is in the high-risk category, meaning that associated occupations are potentially automatable over some unspecified number of years, perhaps a decade or two."

AI's impacts on jobs and skills

According to a study by Carl Frey and Michael Osborne, within the next couple of decades, AI has a high likelihood of automating 70% of today's jobs in the energy sector, and 65% of today's jobs in consumer staples. In a separate report from S&P Capital IQ, if AI were to deliver a 5% uplift in EBITDA (which some people believe may not be an unreasonable assumption), it would mean an EBITDA uplift of US$33 billion in the energy industry and US$29 billion in consumer staples.

# …and radically reshaping the HR and jobs landscape

The prospect of almost half of today's jobs in the US being automated out of existence must give any business pause for thought. True, new jobs will emerge to take up some of the slack: witness the recent growth in employment in areas like cyber security. But it's clear that the arrival of AI in both our personal and business lives will create a skills gap that will require both the retooling of people's existing skillsets and the wide-scale hiring of new workers.

These imperatives spring from the fact that AI will eliminate or vastly reduce the number of employees in many employment categories while simultaneously augmenting the effectiveness of all jobs, thereby requiring a massive transformation of the labour force. As a result,

the transition to an AI-enabled world will pose many challenges for companies in all sectors, as they decide how to adapt to their changed recruitment, retention and training needs in such an environment.

As Figure 2 illustrates, the new AI-enabled world will see work undergo a fundamental shift away from the traditional focus on low-value activities and towards high-value ones. For companies, the effects will include widespread automation of lower-skilled jobs, and a move towards creating a workforce that combines lower headcount with higher productivity. At the same time, there'll be a greater focus on human capital development, and on applying new—and more agile—hiring strategies to reflect rapidly-changing skillsets.

Figure 2: The shift in work from low-value to high-value

Future

High value

Low value

High value

Low value

Today
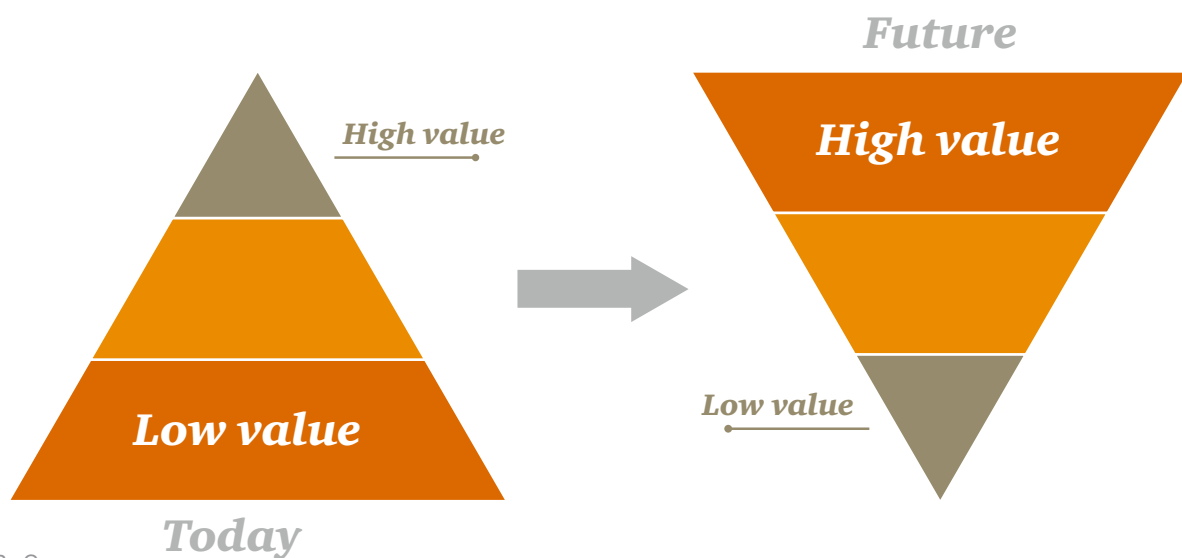
Source: PwC

While the effects on HR and people will be pervasive, some job categories are likely to be impacted faster and more profoundly than others. The jobs set to be affected most directly by AI would include roles like

personal assistants, cab drivers, retail cashiers, call centre employees, hospitality staff and bank tellers. And as uptake of AI gains pace and scale, the list of jobs affected by it is set to keep growing.

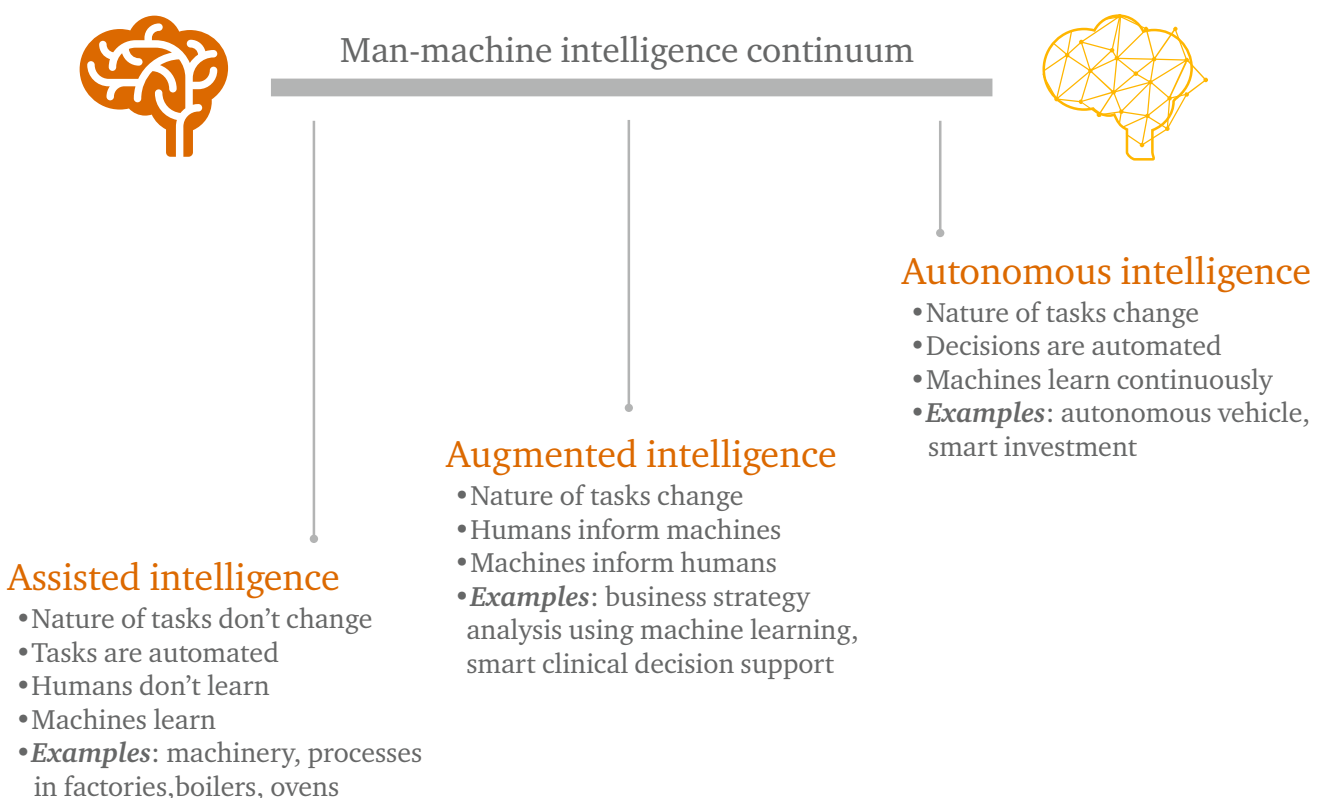# As AI advances along the man-machine intelligence continuum…

The time when companies must face up to these new realities is fast approaching. Today, the AI in smart machines is advancing from the ability to handle traditional applications of repetitive tasks to the capability to adapt to continuously changing tasks. As Figure 3 shows, this evolution is seeing AI applications progress from Assisted Intelligence to Augmented Intelligence, and ultimately Autonomous Intelligence. Each stage builds on the one before, bringing to bear its own specific capabilities and characteristics.

AI's progression along the continuum is being fuelled by a wide range of drivers, including the levelling-off of the technology cost curve and the maturing of underlying technologies, including mobile connectivity, cloud infrastructure, the proliferation of sensors, advances in processing power, machine-learning software and storage. In addition, other major trends contributing to the growth in AI are the rise of the open-source software movement and the ongoing democratisation of AI.

As AI continues to evolve and machines become smarter, significant opportunities will emerge across the complexity spectrum. First, repetitive and routine manual and cognitive tasks will be automated to provide assisted intelligence; next, in situations where the complexity of decisions is greater, AI will augment human decision-making; and finally, when machines are able to learn enough about the situation and make reliably predictable recommendations that humans can trust, they will become autonomous.

Figure 3: The evolution of AI

Man-machine intelligence continuum

Autonomous intelligence
- Nature of tasks change
- Decisions are automated
- Machines learn continuously
- *Examples*: autonomous vehicle, smart investment

Augmented intelligence
- Nature of tasks change
- Humans inform machines
- Machines inform humans
- *Examples*: business strategy analysis using machine learning, smart clinical decision support

Assisted intelligence
- Nature of tasks don't change
- Tasks are automated
- Humans don't learn
- Machines learn
- *Examples*: machinery, processes in factories,boilers, ovens

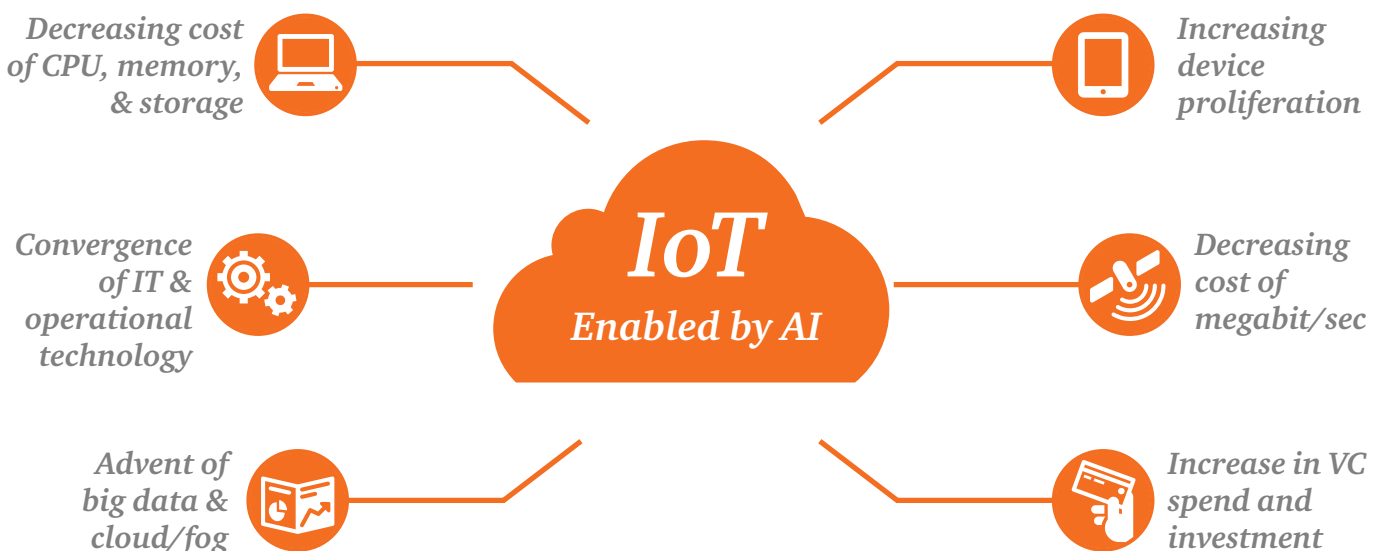Source: PwC

…it's converging with the IoT…

The ongoing advance of AI is also having a further impact: it's causing AI to converge with IoT, to the extent that it's rapidly becoming indispensable to IoT solutions. The core components of IoT—connectivity, sensor data and robotics—will ultimately lead to a requirement for almost all 'dumb' devices to become intelligent. In other words, the IoT needs smart machines. Hence the need for AI.

As this convergence continues, the ongoing headlong growth of IoT is being driven by six factors (see Figure 4)—of which arguably the most powerful is the advent of big data and cloud/fog computing. The IoT's growth will in turn drive an exponential rise in the volumes of data being generated, with IDC[6] estimating that the number of devices connected to the Internet will surge from 11 billion in 2016 to 80 billion in 2025—generating 180 zettabytes of data every year, up from 4.4 zettabytes in 2013 and 44 zettabytes in 2020.

This expanding flood of data will present businesses of all types with some key challenges. These include:

- Determining how to manage, analyse and create meaningful insights from all this data.

- Maintaining the accuracy and speed of analysis.

- Balancing centralisation and localisation of intelligence—how smart or dumb do you want the sensors and devices to be?

- Balancing personalization with the need to maintain the privacy and confidentiality of data.

- Maintaining security in the face of growing cyber risks and threats.

Figure 4: Drivers of IoT growth

Decreasing cost of CPU, memory, & storage

Convergence of IT & operational technology

Advent of big data & cloud/fog

IoT
Enabled by AI

Increasing device proliferation

Decreasing cost of megabit/sec

Increase in VC spend and investment

Source: PwC

…and becoming critical to success in the IoT-enabled world

As organisations accelerate their embrace of IoT, it's increasingly clear that AI must play a pivotal role in their strategies to tackle and overcome them. IoT is primarily about data; data is the currency of the digital economy; and, as we've highlighted, the IoT will trigger and sustain exponential growth in data volumes.

However, data is only useful if it is actionable. And to make data actionable, it needs to be supplemented with context and creativity. It is about 'connected intelligence'—which is where AI and smart machines come into the equation. AI impacts IoT solutions in two key dimensions—firstly in enabling real-time responses, for example via a remote video camera reading license plates or analysing faces; and secondly in post-event processing, such as seeking out patterns in data over time and running predictive analytics.

Through these capabilities, AI supports enhanced IoT applications by enabling:

- Predictive analytics – *'What will happen?'*

- Prescriptive analytics – *'What should we do?'*

- Adaptive/continuous analytics – *'What are the appropriate actions/decisions, and how can we adapt to the latest changes?'*

The interdependence between IoT and AI also works the other way. IoT's capacity to enable real-time feedback is critical to adaptive learning systems, since other technologies do not really enable this advanced type of AI/analytics. So they both need each other.

Case study: Face detection – a specific form of object detection focused on identifying the unique attributes of specific people

PwC developed prototype facial recognition and tracking software and deployed it on an embedded, robotic platform. The data collected from the image sensors on the robot are processed on-board the device in order recognise who is in an image and where they are within the image. Additional software was created to enable it to track specific individuals, adjusting the robot's position and location based on what it sees.

Source: PwC

The value proposition of IoT and AI

Smart sensors: Delivering pervasive benefits

The mutually beneficial relationship between IoT and AI is manifesting itself in many successful integrations of the two technologies in the B2B and B2B2C space. The value propositions that underpin the fusion of IoT and AI include smart sensors (or intelligent sensors), which combine IoT and AI to provide real-time data and feedback that enables systems to fulfil the three capabilities we highlighted above—namely:

- *Predictive:* Real-time data can be analysed to determine when a large piece of machinery or equipment will break down, enabling the failure to be prevented through proactive intervention. For example, today a GE jet engine collects 500Gb of data per flight, taking a 'snapshot' every second of over 5,000 parameters including air speed calibration, altitude, cooling, exhaust gas temperature and flow, and ground speed. This is in stark contrast to previous generations of jet engine technology, where just 1 kb of data was generated per flight from three snapshots (take-off, cruising, landing) on 30 parameters. The resulting insights enable GE to boost performance by 287 times while also delivering a seven-fold reduction in costs.

- *Prescriptive:* Intelligent sensors can suggest *immediate* action at the edges of the organisation, thus avoiding outages and even disasters. For example, sensors on railway tracks can warn the control centre of any track failures. Similarly, lane centring technology in cars self-corrects when the driver veers away from the centre of the lane.

- *Adaptive/autonomous:* Continuous data feeds from sensors can enable systems to learn the right actions to take autonomously. For example, in a healthcare context, blood glucose sensors can automatically change the level of insulin delivered in response to patient need. Similarly, monorail systems in many airports and cities run autonomously without any human drivers.

Case study: combining AI and IoT to develop the 'smart cooler' that is transforming the beverage industry

PwC developed a prototype cooler equipped with pre-packaged and custom-built sensors. The image data from the cooler can be used to track stock and inventory management, allowing for real-time analysis of metrics. The refrigerator sends images to a cloud-based application programming interface (API) capable of processing the raw image using deep learning models. The system is also highly scalable as the number of coolers grows.

Source: PwC

By applying these capabilities, the impacts and benefits that can be realised—both financial and non-financial—include:
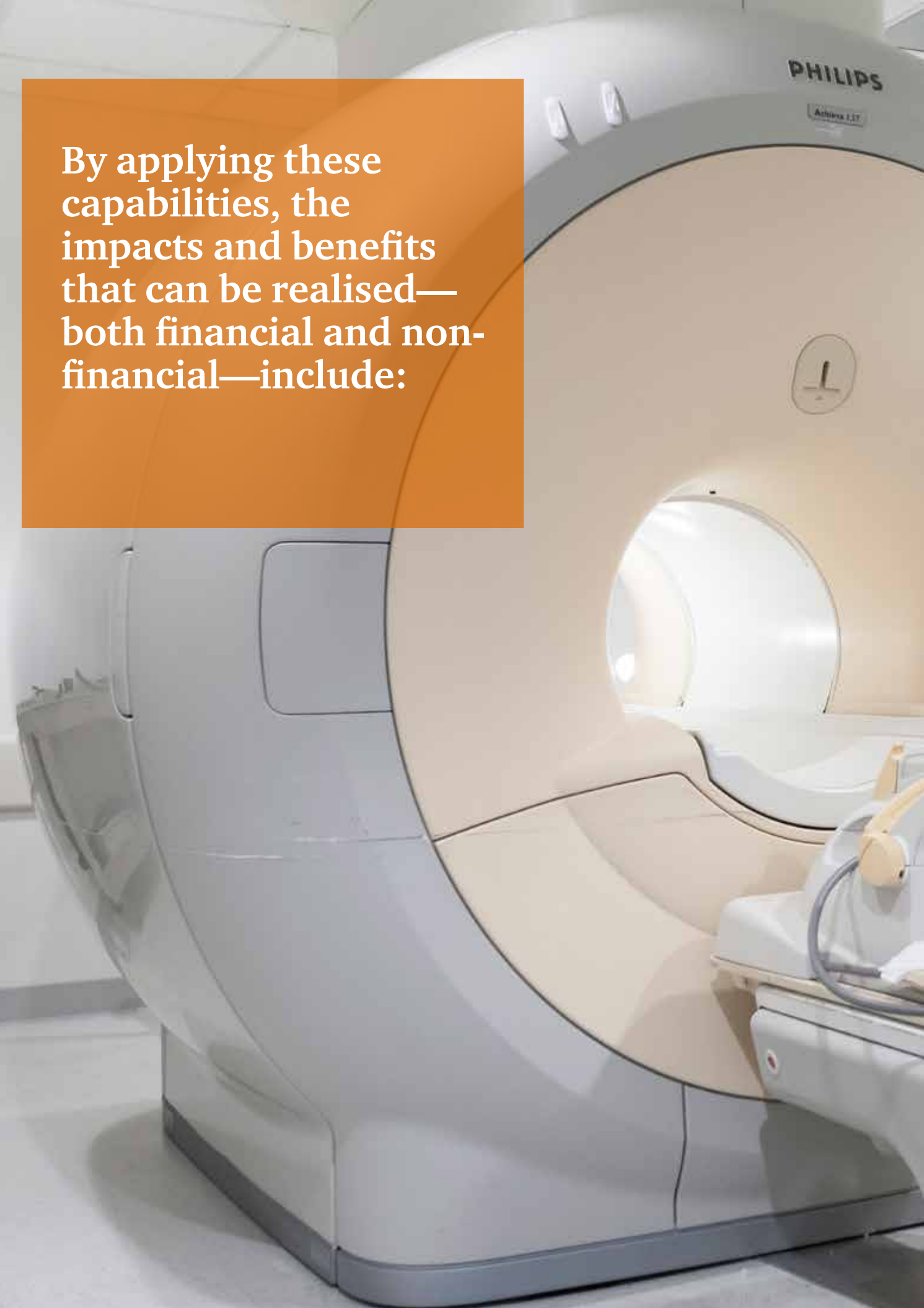
The creation of new markets

Experience shows that every disruption resulting from new technological innovations establishes new markets that did not previously exist—and indeed that nobody could have anticipated before the innovation itself took place. So, in the past, the creation of the internet opened the way to ecommerce markets; the invention of the PC created the possibility of connected PCs; and the advent of cloud computing paved the way for apps and the IoT.

AI will be no exception to this rule, opening the way to the creation of an entirely new market or markets that wouldn't previously have been possible or even imaginable. As Figure 5 illustrates, AI's potential to generate and support new markets will increase over time as it progresses along the continuum from assisted intelligence via augmented intelligence to autonomous intelligence.

Figure 5: The expanding market potential of successive waves of AI
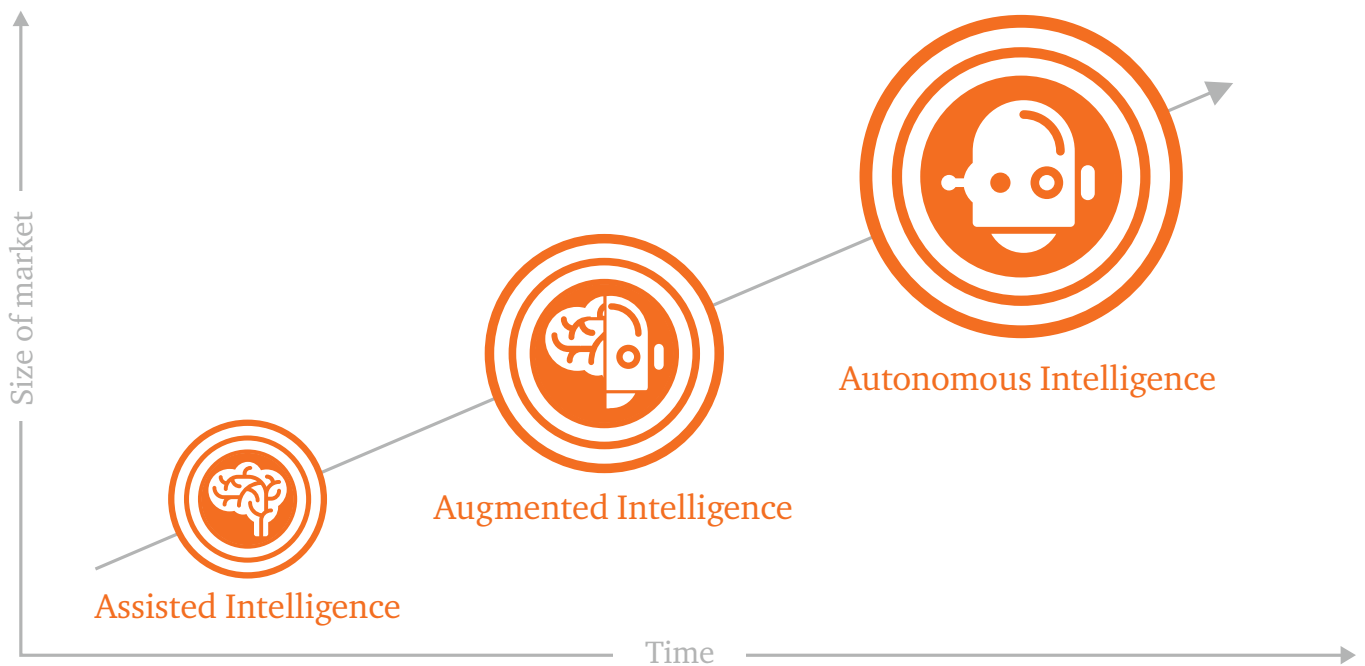
Source: PwC

A changing competitive landscape

By augmenting the degree of intelligence in products, people and services, AI will require companies to change and adapt their product portfolios to new realities, thereby creating the potential for new leaders and laggards to emerge across all industries. Rising adoption of AI will drive these changes by triggering five key changes in the competitive landscape:

- *Higher revenues:* There are three categories of businesses that will benefit from increased revenues due to the combination of the IoT with smart sensors, devices and AI: firstly, IoT device manufacturers; secondly, IoT data and information providers/aggregators; and thirdly, companies offering application services based on smart sensors.

- *Enhanced safety:* Real-time monitoring will prevent disasters from occurring and hence raise overall safety. Some security cameras use AI to distinguish between people, animals and vehicles, and can take actions—such as turning on lights or sending an alert—based on what it senses.

- *Reduced losses from accidents and other causes:* Real-time monitoring will reduce loss of lives and damage to assets.

- *Lower costs:* Smart monitoring of devices— electricity grids, home smart metres, or even sensor-enabled domestic appliances—will result in lower operating costs for homes and businesses.

- *Enhanced customer experience:* Smart sensors can adjust to the individual behaviours of users/ consumers by learning their preferences. For example, some smart thermostats can learn the ideal personal temperature setting of individual users within the household, thus knowing what temperature they want when, and significantly improving customer comfort and experience.

IoT/AI applications will impact all industries

Given the scale and range of potential benefits on offer, it's hardly surprising that companies in many industries are beginning to take steps to seize the opportunities presented by combining IoT and AI. Here are a few examples.

- **Airlines:** Sensors on aircraft continuously monitor the status of various systems and sub-systems, helping to pinpoint existing faults and pro-actively predict future faults and their degree of severity. The result is higher safety and lower aircraft delays or downtime. As an example, a leading airline wanted to reduce flight delays and cancellations caused by maintenance issues which were costing the airline US$135mn a year. PwC created an analytical model that predicted 30% of maintenance-related potential delays and cancellations within a two to three-day window.

- **Oil rigs:** Oil companies spend substantial amounts on procuring and operating special-purpose oil drilling machinery. When these machines fail, companies can incur huge losses—yet the cost of the equipment means having spare machines on standby is not economically viable. Smart sensors attached to oil rigs and the related equipment can continuously monitor and recommend preventative maintenance, enabling significant reductions in operating costs.

- **Manufacturing:** Large manufacturing and industrial companies—in markets as diverse as domestic appliances, aircraft, automobiles, ships and mining—are enabling their machinery with sensors to perform predictive maintenance and create the autonomous factories of the future. For example, a large beverage manufacturing company wanted to reduce machinery breakdowns without increasing its maintenance costs. PwC developed analytical models and leveraged sensors to identify key risk areas and root causes in order to reduce breakdowns and reduce maintenance costs.

- **Smart buildings:** Smart sensors attached to buildings can substantially increase safety by reducing risks such as fire and flooding, while also bringing down operational costs, and improving energy efficiency through capabilities such as monitoring the movement of people around the building and adjusting temperatures accordingly. Insurance companies are working with large enterprises and construction companies to create smart buildings and reduce the insurance premiums for companies that deploy such capabilities.

- **Smart homes:** Echoing the benefits achievable in smart public or office buildings, smart sensors in homes can simultaneously increase safety by reducing risks like fire and flooding, and—for example—carrying out real-time pollution or pollen counts to protect the well-being of asthma patients; bring down operational costs, for example by alerting consumers to the optimum usage of dryers/washing machines and reducing home insurance costs; improving energy efficiency, by switching heating and air-conditioning on or off at the right times to exploit off-peak rates; and enhancing the household experience, for example by optimising climate control to suit different individuals. For example, there are energy monitors available that plug into the user's electrical panel and learn the electrical signatures of their appliances to gather insights and generate notifications and recommendations (e.g., energy usage, garage door open, need to replace the refrigerator).

- **Body sensors:** Smart sensors can monitor various bodily activities and metrics to enhance safety and maintain health. For example, a construction company can use body sensors to monitor the load-carrying ability and posture of manual labourers, thus helping to avoid injuries, reduce compensation claims from workers and improve labour productivity. Certain devices can track people's activity levels and help change their behaviours to improve well-being, while medical sensors can support overall health, for example, by monitoring blood sugar levels and dispensing insulin when necessary.

Case study: Aerial imagery combining deep learning with drone images of construction sites

PwC created a structure to ingest drone imagery of construction sites, enabling construction progress to be compared with the planned timeline and quality. The data can be analyzed to deliver:

- *Object identification*: Identification and labeling of objects, including trucks, soil, cars and asphalt.

- *Advancement comparison*: Reviewing data collected over time and identifying changes to measure progress.

- *Volumetric measurements*: Identifying how much of an object is in the image.

These analysis techniques help clients monitor construction progress, verify conformity with construction plans, and systematically gather and update project documentation.

Source: PwC

Conclusion: time to create a strategic plan for IoT/AI

The combined disruption from AI and IoT will reshape our personal and business lives in a dramatic manner that is not fully imaginable or comprehensible by most companies today.

At one end of the scale, it will displace routine, monotonous human jobs with machines. At the other, it will radically disrupt the competitive landscape, by giving the early adopters of AI tremendous advantages in terms of lower costs, better customer experiences and a head-start in pursuing new business opportunities.

While the full impacts of this disruption will not arise overnight, they will come a lot faster and sooner than most businesses and individuals are currently expecting. So, smart companies and executives are not waiting for the tsunami of disruption to reach their shores before they react. Instead, they are moving now to start the strategic dialogue needed to fully understand and prepare for the disruptions before they arrive.

Companies that take this proactive, far-sighted approach can turn the upcoming disruptions from an irresistible force that could sweep them away, into a massive opportunity that they're well-placed to realise. Put simply, the AI revolution is here—and now is the time to get ready for it.

Contacts

Raman Chitkara

Partner, PwC US

Global Technology Industry Leader

raman.chitkara@pwc.com

Anand Rao

Partner, PwC US

Innovation Lead, Data & Analytics

anand.s.rao@pwc.com

Devin Yaung

Director PwC US

devin.s.yaung@pwc.com

Endnote

[1] The Industrial Internet of Things: Why it demands not only new technology—but also a new operational blueprint for your business – http://www.pwc.com/gx/en/industries/technology/publications/industrial-internet-of-things.html

[2] Source: Bank of America Merrill Lynch, Robot Revolution – Global Robot & AI Primer, December 2015 - https://www.bofaml.com/content/dam/boamlimages/documents/PDFs/robotics_and_ai_condensed_primer.pdf

[3] Source: http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

[4] Oxford Martin School, University of Oxford, Oxford, OX1 1PT, United Kingdom, carl.frey@oxfordmartin.ox.ac.uk

[5] Department of Engineering Science, University of Oxford, Oxford, OX1 3PJ, United Kingdom, mosb@robots.ox.ac.uk

[6] Source: https://whatsthebigdata.com/2016/03/07/amount-of-data-created-annually-to-reach-180-zettabytes-in-2025/