ARTIFICIAL INTELLIGENCE IN THE REAL WORLD

The business case takes shape

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Contents

About the report

Artificial intelligence in the real world: The business case takes shape is a report from The Economist Intelligence Unit (EIU) sponsored by Wipro Limited. The report was written by Denis McCauley and edited by Charles Ross. It draws upon a survey conducted in the second half of 2016 of 203 executives around the globe. Respondents were evenly split among the financial services, manufacturing, retailing, as well as the health and life sciences industries. Just less than half (48%) had an annual global revenue of greater than US$1bn. C-level executives formed 50% of the sample, and those located in Asia-Pacific (35%) and North America (36%) formed the majority of respondents.

To complement the survey, The Economist Intelligence Unit conducted in-depth interviews with the following executives and AI experts from the industries under investigation (listed alphabetically by surname):

Matteo Berlucchi, chief executive officer, Your.MD (UK)

Paul Clarke, chief technology officer, Ocado (UK)

Eric Colson, chief algorithms officer, Stitch Fix (USA)

Chris Gelvin, chief operating officer, Group COO functions, UBS (Switzerland)

Ben Goertzel, chief scientist, Aidyia (Hong Kong)

James Hendler, director, Institute for Data Exploration and Applications, Rensselaer Polytechnic Institute (USA)

Ralf Herbrich, director of machine learning, Amazon (Germany)

Matthew Howard, European lead, IBM Watson Health (UK)

Jerry Kaplan, visiting lecturer, Stanford University (USA)

Frank Kirchner, head, Robotics Innovation Center, German Research Center for Artificial Intelligence (Germany)

Yann LeCun, director, AI research, Facebook (USA)

Markus Lorenz, partner and managing director, Boston Consulting Group (Germany)

Per Vegard Nerseth, managing director, Business Unit Robotics, ABB (Switzerland)

John Straw, AI venture capitalist (UK)

Jared Teo, senior program officer, Health Innovation Fund, California Health Care Foundation (USA)

Gerrit van Wingerden, managing director, Tora Trading Services (Japan)

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Note that not all answers add up to 100%, either because of rounding or because respondents were able to provide multiple answers to some questions. All monetary amounts are in US dollars. ■

Executive summary

Artificial intelligence (AI) is no longer the future. For businesses, it is the here and now, and this study conducted by The Economist Intelligence Unit makes clear that executive suites and boardrooms around the world see it as such. They might be expected to be wary, given that much is unknown, even amongst scientists, about how AI capabilities might develop in the coming years. Or that policymakers and regulators have barely begun to study its potential implications for markets and workforces.

Many business leaders certainly expect AI to be disruptive. More than 40% of those surveyed for the study anticipate that AI will start displacing humans from some jobs in their industry within the next five years. Slightly more think their own role will be changed by AI in the same time frame. But they see this more as augmentation than marginalisation. An overwhelming majority believe AI will make their job easier and help improve their own performance. They clearly believe it will do the same for the businesses they manage.

The purpose of this study has been to gauge corporate attitudes toward AI in different regions and different industries. Based on a global survey of 203 senior executives, it finds that, especially in North America, companies in health and life sciences, in retail, in manufacturing and in financial services are actively testing the waters. Amongst this group, AI technologies and applications are in the exploratory phase at around one-third of companies, but another third have moved on to experimentation, and one-tenth have begun to utilise AI in limited areas. A small handful (2.5%) have even deployed it widely.

Defining AI

The term artificial intelligence (AI) refers to a set of computer science techniques that enable systems to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making and language translation. Machine learning and deep learning are branches of AI which, based on algorithms and powerful data analysis, enable computers to learn and adapt independently. For ease of reference we will use "artificial intelligence", or AI, throughout this report to refer to machine learning, deep learning and other related techniques and technologies.

Following are other key findings from the research:

- **The pace of adoption is quickening**. AI will be "actively implemented" in their companies within the next three years, according to 75% of surveyed executives. Another 3% say this is already the case. The pace will remain the quickest in North America (active implementation in 84% of firms there) and, in industry terms, in retail (also 84%).

- **North America and the health sector lead the way.** Converting the survey results into an index, the AI implementation score is 2.40 on a 1-5 scale, where 1=nascent, 2=exploratory, 3=experimental, 4=applied and 5=deployed. North American companies in the study have advanced furthest

with AI (a score of 2.61) as, amongst industries, have health and life sciences (2.53) and retail firms (2.50).

- **Competition—or the anticipation of it—is spurring companies on**. The spectre of established or new technology companies using AI to enter and disrupt their markets is leading businesses to advance their own AI plans. Delaying these will make them vulnerable to new tech entrants, say 43% of survey respondents. Almost half (46%) are more worried about AI-based competition from start-ups rather than incumbents.

- **Better user experience is the key prize for many**. AI implementation may help some firms to boost revenue, their operating efficiency or their margins. However, better user experience is the main benefit many executives – especially those in the health sector – look for. Healthcare companies are today using AI to deliver self-service diagnostic services to users. One profiled in this report uses an AI-based mobile app to diagnose, and provide advice about, users' non-acute health complaints. Users benefit from faster diagnosis; GPs stand to benefit also—from shorter queues and thus more time to spend with patients.

- **Better decisions should also result**. More accurate decision-making is another desired outcome, a benefit particularly sought by financial services providers. AI-driven algorithms are actively being put to work now, for example, in equity trading and some areas of investment management. AI's advantage, says one trader interviewed for this study, is about the accuracy of investment decisions rather than about their speed. Deliberate but more accurate decisions should ultimately mean better returns and reduced risk.

- **Efficiency and flexibility gains beckon for retailers and manufacturers**. Respondents from these sectors seek improvements in operating efficiency as their chief benefit from AI. Manufacturers' efficiency gains may initially be realised not on the production floor but in areas such as predictive maintenance and product design. Some retailers, meanwhile (including one profiled in this report), are putting ambitious plans in place to streamline logistics and delivery with the help of AI technologies.

- **Cost, data quality and cultural resistance hold companies back**. Of the numerous practical challenges to AI implementation, cost figures most prominently, especially among manufacturers. Smaller companies can manage costs, however, by using third-party cloud platforms, developers can also take advantage of open-source AI platforms that are becoming available. Issues with data availability and quality will take longer for some organisations, particularly in healthcare, to remedy. Cultural resistance to change may be the toughest nut to crack, but many companies are looking to sidestep internal silos with external help, including from partnerships and from open innovation.

- **Building the AI business case is anything but straightforward**. This is complicated, say around 29% of respondents, by the fact that AI technologies and applications are not yet mature. Much remains unknown about how they will develop, which may also explain why another 30% say senior management lack an understanding of AI, further hindering the business case.

Introduction

Scientists and academics sat up and took notice in 2016 when Alpha Go, Google DeepMind's AI-driven computer, won its five-match series against Lee Sedol, the reigning world champion in Go, the ancient Asian board game. Business leaders should also have paid heed. Alpha Go's victory demonstrated in a very public way the learning capacity that AI-based technologies now possess. Humans didn't teach the computer—it taught itself how to master the game by playing it millions of times with another computer (through a set of techniques called "deep learning"), and independently responded to Mr Lee's moves.

Machine learning, a subcategory of AI techniques which automate the learning process through algorithms and the super-powered analysis of data, has been around since the 1950s. Business applications were trialled in the financial industry as early as the 1980s but did not go far. In recent years, advances in science combined with huge increases in (and declining prices of) computing power, swelling oceans of data and increasingly sophisticated analytics have for all practical purposes made machine learning and AI business-ready.

It also helps that expertise in the field is now available to companies. "AI was very difficult to do for most companies until now partly because the number of experts in the field was extremely small," explains Yann LeCun, director of AI research at Facebook, a social media giant. "This shortage is easing, as even young graduates now have knowledge of AI techniques. There are also tools and platforms being built for people who are not yet experts to get started on developing AI applications."

Technology companies are busily hiring AI experts—and in some cases acquiring start-ups—to perfect real-world AI-based applications. Firms in other industries are doing the same. "We're seeing a burst of energy in machine learning, deep learning and other kinds of AI," confirms Ben Goertzel, chief scientist at Aidyia, an AI-powered hedge fund based in Hong Kong. "Every major financial firm is hiring loads of AI experts now."

> "After Google's AI success with Go, a lot of businesses who were not especially looking into deep learning are now doing so and will be piloting with it soon."
>
> Gerrit van Wingerden, managing director, Tora Trading Services

Open-source platforms of the type Mr LeCun mentioned are likely to add momentum to AI development. Google, Amazon, Facebook, Microsoft and other technology powerhouses have all made public many of their AI algorithms and invited third-party organisations and independent developers to try and improve them. (Examples are Google's TensorFlow framework and Amazon's deep-learning DSSTNE platform.)

AI is still in its early days in business, however, and much remains unknown about where it will take companies and their employees—an apprehension held by many of our survey respondents and interviewees. Its imperfections, and the related

downsides, were demonstrated not long after the Alpha Go victory with Microsoft's abortive launch of its AI-powered Tay "chatbot". Designed to converse with Twitter users about Microsoft services, the bot was quickly overwhelmed with abusive language and offensive comments, backfiring badly on the company. The first highway fatality believed to result from an error in the self-driving mechanism of a car, in May 2016,[1] has added to the apprehensions.

> "AI systems are already better than all but a very few people and also much more reliable. They're not going to get drunk and fail to show up at work. They're not going to embezzle money. They're not going to quit and go work for someone else."
>
> Ben Goertzel, chief scientist, Aidyia

Longer term concerns revolve around the future successes of AI rather than its failures. Some economists, for example, fear that automation powered by data and AI technologies will lead to the large-scale displacement of humans from the workplace.[2]

Notwithstanding such fears, companies are actively testing the waters with AI in a number of different fields, as our research demonstrates. Pilots as well as some service introductions are not difficult to find in several industries. Are companies placing hard bets on AI's business potential or merely hedging them? This report explores the plans for, and hopes and fears about, AI in boardrooms and executive offices across the business world, with a focus on the health and life sciences, retail, financial and manufacturing sectors. ■

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1 The accident, occurring in the US state of Florida, involved a Tesla Motors electric car being operated in self-driving mode. "What the First Driverless Car Fatality Means for Self-Driving Tech", Scientific American, July 1, 2016.
2 The most prominent exposition of this argument is found in "The Future of Employment: How susceptible are jobs to computerisation?", an academic paper published in 2013 by Oxford University professors Carl Benedikt Frey and Michael Osborne.

1 Testing the waters

When new families of technology grab the headlines, business leaders often get anxious. "Is this just another round of tech hype?", they may ask themselves, "Or is this one for real?" Judging by the results of our research, executives in several industries are taking AI seriously.

> "We're exploring AI applications in various parts of UBS. We're taking a stepwise approach, putting in the building blocks—the control frameworks, the technology, centres of expertise—and making sure we have use cases to help us flesh out our thinking across all our businesses."
>
> Chris Gelvin, chief operating officer,
> Group COO functions, UBS

One taking it seriously is Paul Clarke, chief technology officer at Ocado, a UK-based online grocer. "AI has to be the centre of everything we do now. I am sending that message to all of the technology teams in Ocado. Previously the message would have been 'Collect all data and make sure everything is measurable.' The new message is 'Collect the data and make sure everything is architected for AI from day one.'"

Few companies are currently as resolute about AI as Ocado, but many are testing the waters. Most of those in the survey are at early stages of work with it. Just over one-third of respondents' companies are experimenting with AI technologies in 1-2 areas of operation. About one-tenth have begun to utilise AI in a limited fashion. A small number (2.5%) even say their firms have deployed AI widely in their operations. And exploratory research is under way for another third of respondents.

Figure 1: The US and the healthcare sector lead the way in AI application
AI implementation score: regional vs. industry comparison
(Scale: 1=nascent, 2=exploratory, 3=experimental, 4=applied, 5=deployed)
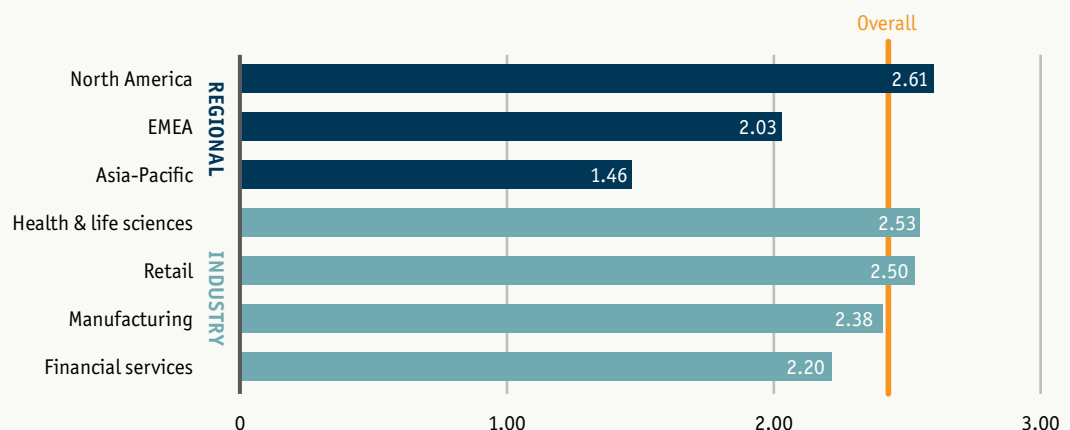
The AI business index

Expressed in an index, the AI implementation score across all the firms represented in our survey is 2.40 on a 1-5 scale, where 1=nascent, 2=exploratory, 3=experimental, 4=applied and 5=deployed. This signifies a transition for many firms from exploratory research to active experimentation.

The index score is highest in North America (2.61), confirmation that work with AI is considerably more advanced there than elsewhere (figure 1). This is not surprising given the dominant role of US laboratories and universities over the years in basic AI research, and the plethora of Silicon Valley and other start-ups taking it forward into practical applications. Nearly one-fifth of North American firms in the survey have begun to use AI technologies actively in their business.

Regional comparison
The EMEA score of 2.03 suggests that firms in that region are at the early stage of exploratory work, while a 1.46 score indicates that business use of AI in Asia-Pacific is at a nascent stage (figure 1).

Ralf Herbrich, director of machine learning at Amazon, an online retailer, believes the US lead is also partly due to its high excitement levels for consumer technology. However, he notes that Europe has taken the lead in areas of AI such as natural language processing for multi-lingual settings. And at least one forecaster predicts that Asia-Pacific will experience faster growth of AI technologies than other regions between 2016 and 2020.[3]

Industry comparison
The highest sectoral score (figure 1) belongs to health and life sciences (2.53), followed closely by retail (2.50). The health sector's lead is no surprise to several of the experts we interviewed for

this study. Both Jerry Kaplan, a visiting lecturer at Stanford University in California, and James Hendler, director of the Institute for Data Exploration and Applications at Rensselaer Polytechnic Institute in Troy, New York, believe that in the medium term healthcare provision holds brighter prospects for AI application than other fields.

For Mr Kaplan (author of Humans need not apply: A guide to wealth and work in the age of artificial intelligence), AI's potential in healthcare is predicated on the enormous volumes of patient data and medical research that the industry has accumulated. "The broad availability of data on outcomes, procedures, clinical trials, expenditures and other areas mean that the use of machine learning techniques can offer very unique and useful insights."

Gathering momentum

The pace of AI implementation is likely to quicken everywhere. Three-quarters of survey respondents anticipate AI to be "actively implemented" in their part of the business within the next three years. Another 3% say this is already the case in their firms. The pace will remain the quickest in North America (active implementation in 84% of firms); amongst sectors more retail respondents (84%) say this than others.

John Straw, an AI venture capitalist, believes the retail industry will be experiencing significant change from AI as early as three years from now. He expects, for example, to see AI-driven chatbots performing much of retailers' customer service and sales information functions within that time frame. High Street stores, he believes, will not disappear but will largely take on the role of showrooms, where a combination of AI and virtual reality technologies will help customers view and experience products before they buy. ■

Case study 1: Algorithms for your evening wear

Stitch Fix, an online personalised clothing retailer, has machine learning in its DNA, according to Eric Colson, its chief algorithms officer. Founded in 2011 in San Francisco, its business model from the start has been predicated on the marriage of personal stylists, detailed customer-provided data and powerful algorithms. Machine learning techniques are increasingly being used to refine the algorithms and augment—rather than replace, says Mr Colson—the work of its personal stylists and, ultimately, its customers' satisfaction with the clothing they purchase.

At the heart of things is the company's "styling algorithm", which selects clothes for the customer once he or she completes a detailed online questionnaire about size measurements, colours and other preferences. It is performed, according to Mr Colson, by both machines and humans. "An algorithm is just a set of instructions. And all the steps in the instructions are performed by different types of processors. Some are better suited to machines; others to humans."

A machine learning component, he says, more precisely learns what the customer's 'true' size is. There are no standards for sizing across apparel brands. Stitch Fix uses feedback received from customers after trying on the clothing to determine how each brand actually fits. The algorithm is able to learn about each customer's individual preferences and how each piece of merchandise fits on various types of customers. "That's a machine task, involving millions of calculations," says Mr Colson. "You can't ask a human to perform that."

Customers, however, often include deeply personal notes in their questionnaire responses, and they expect a human to respond, explains Mr Colson. An example: "A woman's husband is returning from a six-month tour of military duty overseas, and she wants an outfit for a very special date night. Only the personal stylist, a human, knows what that means to the customer. They can empathise." For the algorithms to perform well, he says, "you need the right resource to do each of those tasks. The machines are one and humans are another."

The company recently launched a "computer vision" algorithm which enables machines to use images to learn a customer's style. "Sometimes it's easier for a customer to articulate preferences with a picture than in words," explains Mr Colson. "Our customers make us Pinterest pinboards of things they like, and we—both our human stylists and our machines—ingest them. Then we can find out what to the customer is edgy or bohemian chic."

2 | Hopes and expectations

Given the novelty and still futuristic perceptions of AI popularised in the media, why are many companies moving so decisively to develop AI capabilities? In time-honoured business fashion, it is a combination of fear and hope. Competitive pressures are spurring companies on, and there is a sense of urgency amongst many industry managers about not falling behind. Over one-third of survey respondents,

for example, believe AI will enable technology companies to enter and disrupt their industry.

44% of executives say delaying AI implementation will make their business vulnerable to new, disruptive tech start-ups

Figure 2: AI is bad news for slow movers
Delaying AI implementation will make business vulnerable to start-ups (% of respondents)

- Agree — 44%
- Neither agree nor disagree — 40%
- Disagree — 17%
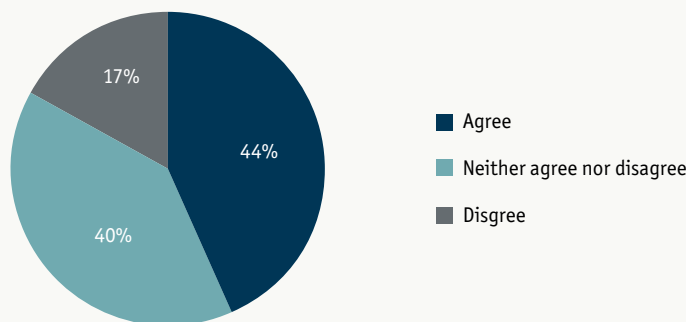
Figure 3: AI could revolutionise technology start-ups
Market players that are most likely to bring about the greatest change in your industry (% of respondents)
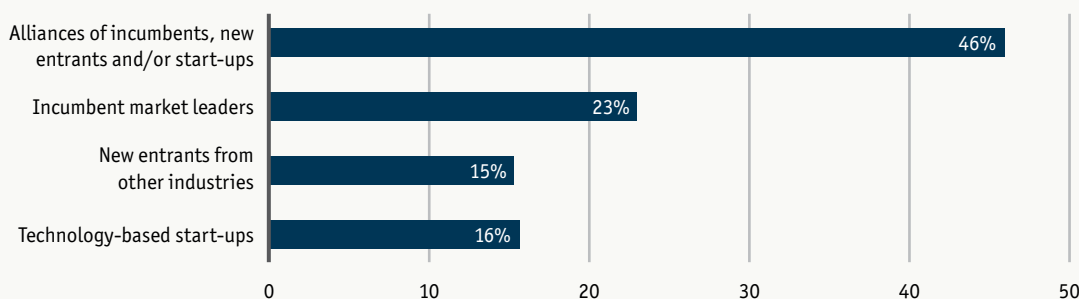
- Alliances of incumbents, new entrants and/or start-ups: 46%
- Incumbent market leaders: 23%
- New entrants from other industries: 15%
- Technology-based start-ups: 16%

Even more (44%) say that delaying AI implementation will make their own business vulnerable to such technology-based raiders (figure 2). Almost half (46%) believe it will be start-ups rather than incumbents who shake their markets up the most (figure 3).

The shape of returns to come

Along with the fear of disruption comes the hope of handsome returns. The business expectations run high, although not necessarily in relation to financial results (at least in the short term).

Many respondents expect AI to have a positive impact on their key performance metrics over the next five years, such as revenue, operating efficiency and quality of decision-making (figure 4). For most companies, though, AI's greater impact is likely to be felt in the area of user experience. John Straw believes the use of AI technologies will, for example, lead to more productive and efficient customer service interaction (notwithstanding the current imperfections of chatbots). But the bigger reward is what services (and products) companies can provide based on analysis of the data they are gathering from customers.

 "Ultimately it starts with improving the customer experience," says Chris Gelvin, chief operating officer for Group COO functions at UBS, a Swiss bank. "Customers will notice the faster responses, reduced error rates and new insights we're able to provide. We will also obtain some nice benefits of increased control, better insights for ourselves, and better ways to become more effective and efficient. If you attack this as a cost play, you'd be limiting the possibilities that these technologies have to offer."

AI's potential for improving the user experience is readily visible in the healthcare sector, where users are both patients and practitioners. Mr LeCun of

Facebook includes healthcare amongst the sectors likely to experience a sizeable impact from AI technologies in the next 3-5 years. "The impact will go beyond medical image analysis to such areas as genomics, predictive models that can predict the course of development of an illness and suggest a plan for treatment."

Matthew Howard, European lead of IBM Watson Health, adds that AI systems can do this at unprecedented scale. "If in performing a literature review you need to look through 25 scientific papers and you want to extract a series of data points from them, that is quite a labour intensive exercise. You really want to be doing the high value-added analysis. AI techniques will help do that much faster and with a reduced risk of missing anything. But you also increase the scale of what you can feed into it. So instead of looking at 25 papers you can look at 10,000."

Mobile apps which help individuals to monitor diet and fitness levels, and recommend courses of action to improve them, are now commonplace, numbering in the thousands. A more recent phenomenon is apps that diagnose users' maladies. One such service is provided by Your. MD, a London-based firm; the AI-based software behind the app analyses user-provided and public health service data not only to diagnose an individual's ailment but to suggest non-prescription medicines or home procedures that could relieve the symptoms [see "Creating a new healthcare market with AI"].

Artificially intelligent decisions

There are few clearer examples of AI's cognitive power than in equity trading, where investment firms are beginning to deploy powerful machine learning algorithms that make frequent and sizeable portfolio decisions. Large fund managers

Case study 2: Creating a new healthcare market with AI

In the UK, a common complaint about the National Health Service (NHS)—from staff as well as the public—is that general practitioners (GPs) and primary care surgeries are overburdened. Some GPs and support staff grumble about visitor overload and excessive bureaucracy, while in London and other big cities, waiting times for GP appointments stretch ever longer. Matteo Berlucchi, chief executive of Your.MD, a digital healthcare firm, offers an explanation: "The reason there are so many problems with primary care is that there is no 'pre-primary care'. There is no shield or gateway which filters people from when they're not well to primary care." Too often, he believes, people see a GP when they don't really need to.

Your.MD, a firm founded in Norway of which Mr Berlucchi is chief executive, has created a mobile app which uses AI techniques to provide users with personalised advice about their medical complaints. Along with personal factors, the app records the user's symptoms and matches these with a 'map' of clinical data about illnesses compiled from public sources with the help of contributing doctors. According to Mr

Berlucchi, Your.MD engages about 30 doctors to conduct research on symptoms, conditions and treatments and to "teach" the AI system. Additional information is gathered through crowdsourcing on web forums. The more data it ingests from multiple sources and the more interactions it has with users, he says, the more accurate its diagnoses become.

For Mr Berlucchi and Your.MD, the opportunity is to create a new, "pre-primary care" market which does not exist today. Far from displacing humans in healthcare provision, he says, such systems will ease the existing burdens of medical staff and help improve their work. "We think initial screening of non-acute conditions could be done digitally," he says, "thereby giving doctors more time with patients that would benefit from a consultation." The benefit to users, he says, is providing them with information and suggestions for relieving their symptoms without having to wait for a GP appointment.

Figure 4: AI will improve operational efficiency, decision making and customer service

Main benefits from introducing AI to business (% of respondents)

	Reduce headcount	Improve decision-making	Improve operating efficiency	Improve customer service	Enhance security	Improve regulatory compliance	Enhance the customer experience	Increase sales revenue	Reduce risk
Overall	20%	27%	29%	26%	19%	20%	20%	17%	23%
Retailing	18%	28%	34%	22%	20%	20%	20%	12%	26%
Manufacturing	15%	21%	35%	23%	25%	23%	17%	25%	15%
Healthcare	20%	22%	27%	35%	12%	22%	20%	18%	25%
Financial services	26%	38%	20%	22%	18%	16%	22%	12%	26%

Legend:
- Reduce headcount
- Improve decision-making
- Improve operating efficiency
- Improve customer service
- Enhance security
- Improve regulatory compliance
- Enhance the customer experience
- Increase sales revenue
- Reduce risk

such as Blackrock and Bridgewater, as well as small players such as Aidyia, have been quietly testing AI trading strategies for three or more years. Mr Goertzel emphasises that AI trading systems like Aidyia's are much more about accuracy of investment decisions than about their speed.

The same will be true in retail investing, where "robo-advisers" today make automated online recommendations to individual investors about individual trades or wider portfolio decisions. Robo-advice has thus far been generated for clients using pre-programmed algorithms. Financial management firms are now beginning to apply AI techniques to robo-advice delivery; when fully integrated, the machine-generated recommendations will be based on a wider-scale and more in-depth analysis of market and environmental data (including social media sentiment) as well as each individual's past investment behaviour and preferences. The algorithms will, moreover, evolve and adapt themselves as situations and data change.

Banks are similarly planning to upgrade their automated services provided to customers with the help of AI. The UK's Royal Bank of Scotland, for example, will employ AI-powered robo-advisers to provide investment advice to its wealth-management customers. Switzerland's UBS is doing the same. In part they are responding to the challenge laid down by successful robo-adviser start-ups, such as UK-based Nutmeg and Wealthfront in the US.

In the healthcare field, Mr Howard cites another reason why AI systems should improve decision-making. "Unlike humans, AI-based machines are unbiased. For example, once it is appropriately trained, an AI system may give a senior leader a very unbiased, unblinkered view of the information and possible options, and the individual can then decide on what actions to take."

Customer experience may be a high priority, but the goal of improving efficiency is, of course, never far from a good CEO's or CFO's mind. It is integral to the AI business case for most organisations considering it,

Case study 3: AI in financial markets: risk agent or risk minimiser?

Equity trading is no stranger to algorithm-based automation, but the results have not always been as anticipated. High-frequency trading (HFT), for example, accounted for a large share of trading volumes in the US and other major markets between 2008 and 2013, but since then its popularity amongst trading firms has tailed off, mainly due to declining margins from such activity. However, HFT is also widely believed to have caused or contributed to several bouts of extreme market volatility (notably the 2010 "Flash Crash" in the US).

AI-powered trading is vastly different, says Ben Goertzel, chief scientist of Aidyia, a small Hong Kong-based hedge fund which has been trading in the US using machine learning techniques since early 2016. Both its, and HFT systems are fully automated, but the similarities end there. "What we're doing is not about speed at all," he explains, but the ability to identify patterns humans could not be expected to see when analysing vast amounts of data. "It's about the accuracy of investment decisions rather than about speed." He adds that some decisions made by its system may be a few weeks or more in the

making, as it needs to view time series of data in order to identify patterns. Seen from this vantage point, AI systems' greater accuracy and deliberation should help to reduce the risks of market volatility rather than heighten them.

Others see a different type of risk involved with AI systems. For Gerrit van Wingerden, who manages the Japan office of Tora Trading Services, it's the risk of the unknown. He explains: "Before when you had an algorithm that was coded using human rules, you would know exactly how the algorithm works. Now it's more of a black box; you're throwing data at it, the algorithm comes up with an approach that might deliver great results, but you really don't know necessarily what the algorithm is doing."

This is all the more reason, says Mr van Wingerden, why humans need to remain involved in the process, setting the risk parameters. Even then, he warns, financial regulators, not to mention risk managers, are wary about the potential fall-out should a company's trading algorithms go awry.

Case study 4: Ocado's "flying swarms of intelligent robots"

Logistics and digital technology both lie at the heart of the business model of Ocado, an online-only grocery retailer based in the UK. Working with academic and other partners, Ocado has in recent years been developing and piloting different types of warehouse systems that incorporate AI elements, according to its chief technology officer, Paul Clarke. One is a humanoid robot, dubbed "Second Hands", which is designed to assist maintenance engineers as they fix mechanical problems at its own (and ultimately its customers') facilities. What will make Second Hands different to earlier factory-floor robots, says Mr Clarke, is its ability to "learn on the job, applying lessons gained from its work with its human colleagues to other situations".

Should another technology programme meet its objectives, Second Hands will be far from the only AI-powered robot operating in Ocado's warehouses. A fully automated facility soon to open in Hampshire will, according to Mr Clarke, "have swarms of thousands of robots flying around that are controlled by a very sophisticated, machine-learning-based traffic control system." He likens the warehouse to a chessboard: "Imagine rooks moving down rows or columns. The 'chessboard'

actually overlays stacks of storage bins; a rook, or robot, can pick up a bin from the top of a stack and either move it to another stack or bring it outside of that grid. There, different machines pick items from it and other bins and place them in a customer order." Human involvement with the flying robots will be minimal, says Mr Clarke.

AI also figures prominently in other Ocado initiatives. These include the robotic picking of groceries—"much more complex than picking up components in a production line", according to Mr Clarke, requiring intelligent vision systems and dexterous handling. Another is autonomous guided vehicles (AGVs), such as drones and driverless cars.

As beneficial as such initiatives are expected to be for Ocado's efficiency and competitiveness, its management has even grander plans—to become a platform provider. The company wants to make its AI, robotics and other technologies available to other retailers looking to make the shift to online without having to invest in their own technology. "We want to offer the same shortcut to moving online to large bricks-and-mortar grocery retailers around the world," says Mr Clarke.

and the chief benefit that manufacturers and retailers in particular hope to gain.

Markus Lorenz, Munich-based partner of the Boston Consulting Group (BCG), believes that the gains in manufacturing will be won less on the production floor, where (human-programmed) robots have been a presence for many years, and more in areas such as predictive maintenance of machinery and in product design. When it comes to the latter, he says, AI will help designers learn how better to produce and assemble a new product. "What will be the product's wear and tear properties? How can it be best assembled? How can it be best serviced? That's a massive amount of data that an engineer or designer cannot credibly own. But an AI system will provide all that information and inform the designer of the trade-offs that need to be made."

Ralf Herbrich of Amazon describes the advantage AI brings to large-scale stock handling: "In the past a stock manager may have been able to manage a portfolio of 1,000 different products during a day. Now, a person can probably manage 100,000 different products, thanks to the past accuracy of the patterns identified by the algorithms. Some are still erroneous, but with the help of scientists and engineers, this can probably be pushed to a million products per person. That helps an individual to reach a much higher level of efficiency, because the easy-to-predict patterns and decisions are taken care of by algorithms."

Jared Teo, senior program officer with the Health Innovation Fund, California Health Care Foundation, also sees big potential for efficiency gains in healthcare. Improvements in workflow and operations, for example, will boost hospitals' operational efficiency by helping staff make better choices around resource allocation. AI systems, he says, can take data about weather patterns and local events and make predictions about emergency room traffic, allowing the hospital to staff more efficiently. ▪

3 Industry perspectives on the AI impact

The AI impact on business functions will play out differently in the different sectors. In financial services firms, AI's impact is expected to be felt most strongly in the area of customer interaction (figure 5); in manufacturing firms—product development (figure 5).

Respondents from health and life sciences firms, meanwhile, anticipate the AI impact will be greatest in management decision-making (figure 5). Retail executives believe the effects will be equally tangible across transport and logistics, pricing and promotion, supplier interaction, and management decision-making (figure 5).

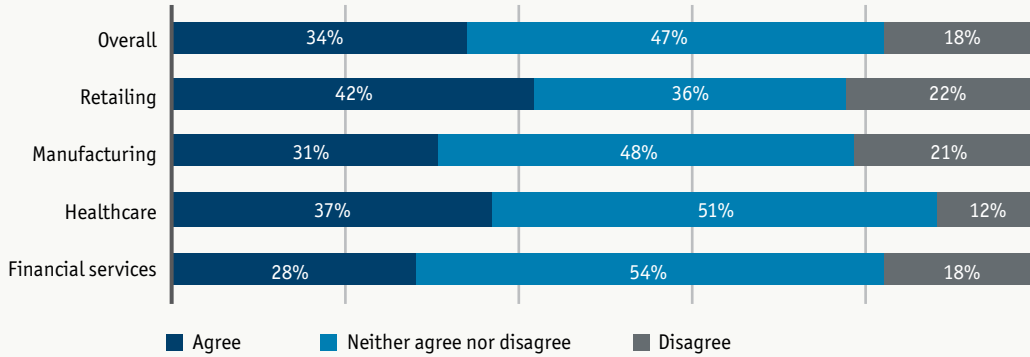**Figure 5: Industry comparison of AI impact on business functions**
Functions on which AI will have the greatest impact in the next 5 years (% of respondents)

AI IMPACT ON DIFFERENT INDUSTRIES
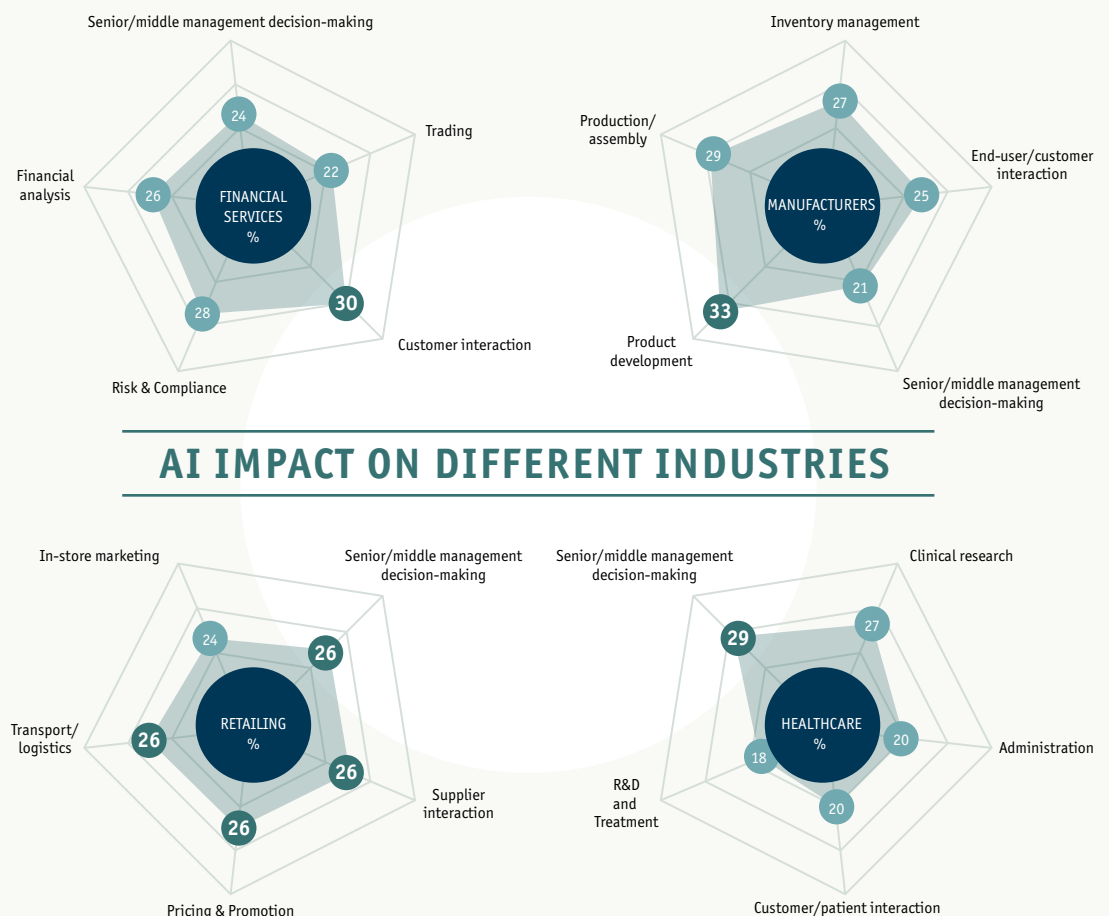
Figure 6: Executives in retail industry are wary of AI
AI poses more risks than opportunities (% of respondents)

	Agree	Neither agree nor disagree	Disagree
Overall	34%	47%	18%
Retailing	42%	36%	22%
Manufacturing	31%	48%	21%
Healthcare	37%	51%	12%
Financial services	28%	54%	18%

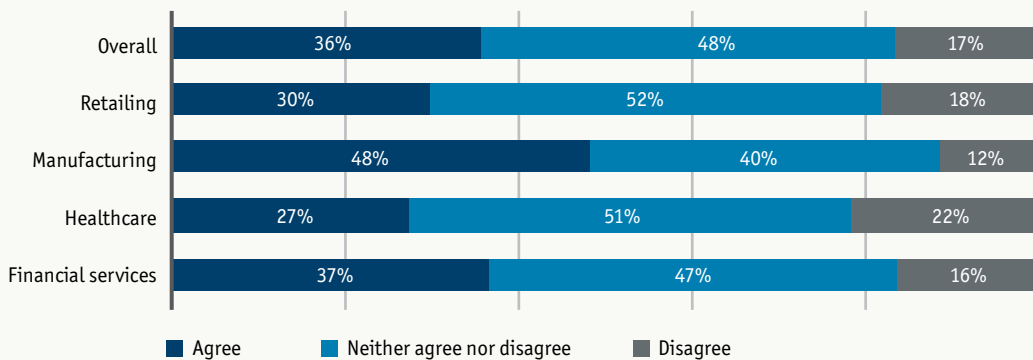■ Agree ■ Neither agree nor disagree ■ Disagree

Retailers express greater concern than peers from other industries with the risks that AI poses to businesses (figure 6).

Manufacturers are particularly wary of AI-driven disruption to their industry from technology entrants (figure 7).

Operating efficiency is the primary area where manufacturers and retailers hope to see gains from AI implementation, whereas healthcare and life sciences firms place the greatest hope on customer (patient) service gains. For financial service providers, better decision-making is the chief reward (figure 4). ▪

Figure 7: Executives in manufacturing think AI is a threat to their industry
AI will enable disruptive technology entrants (% of respondents)

	Agree	Neither agree nor disagree	Disagree
Overall	36%	48%	17%
Retailing	30%	52%	18%
Manufacturing	48%	40%	12%
Healthcare	27%	51%	22%
Financial services	37%	47%	16%

■ Agree ■ Neither agree nor disagree ■ Disagree

4 Rising to the challenges

Past dawns of emerging business technology have often been followed by executive disappointment once the implementation challenges they posed became clear. The executives in our survey appear reasonably level-headed about AI from the outset, however. Asked about the impact AI will have on their organisation over the next five years, half (49%) believe it will be moderate, and another 20% expect little or no impact at all.

One reason for the sober thinking may be that, for many non-technology managers, AI remains a futuristic concept. Building a business case for investment in AI projects is not straightforward when senior management lack a clear understanding of AI and machine learning and the concepts behind them (a complaint of over 30% of survey respondents).

30% of surveyed executives admit that senior management lacks sufficient understanding of AI which makes building a business case for AI challenging

Even for those managers knowledgeable about AI, the business case is complicated by the immaturity of the technologies and their business application. Ocado's Mr Clarke emphasises that much remains unclear about AI, and for some companies it will raise more questions than answers. "If you're not going to build platforms and applications yourself like we do, who will? Standards are still missing in many product areas, as are guidelines around privacy and security. Many pieces of the puzzle are missing."

Cost and data

Businesses will not be able to answer most of these questions themselves, but they can do more to address the practical challenges of implementing AI technologies. Top of this list for respondents—and by some distance for manufacturers—is cost (figure 8).

Mr Clarke agrees that AI-powered robotics used in warehouses or production floors involve large adoption costs. Small companies can manage these by using third-party cloud platforms. Developers at smaller businesses can also take advantage of the open-source AI platforms that big technology companies have recently made available. Gerrit van Wingerden, managing director of Japan Tora Trading Services, reports that smaller firms like his are utilising such platforms to good effect. "You can do the training much more quickly than you could internally, and the rates are affordable. Plus, you don't really have to worry about the software because it's fairly easy to use the platform. Now many more firms can use these algorithms."

The data-crunching power underpinning AI and predictive analytics involve two types of costs, believes Amazon's Mr Herbrich. One is the cost of training, referred to above. The other he calls the "cost of predictions", which scale differently. "These are the hardware and energy costs that are run up with every single computation and prediction. As we think about deploying AI technology worldwide, per individual, the prediction costs will scale with every use."
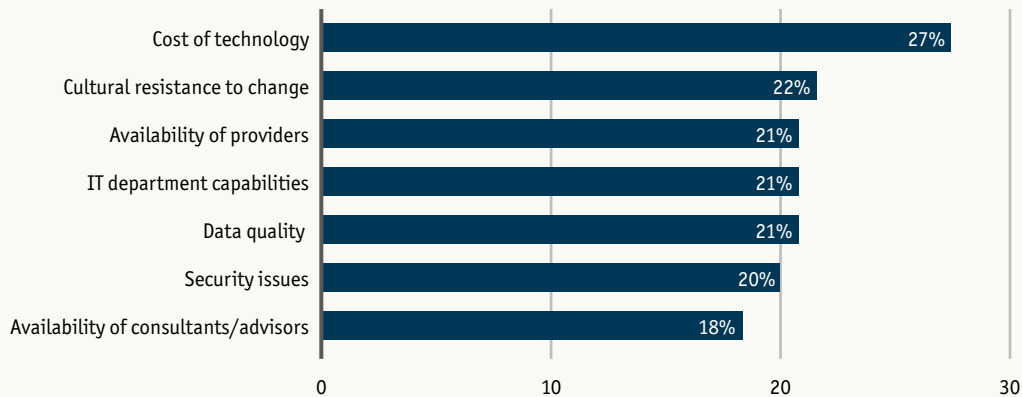
AI's effectiveness rests on its ability to analyse and learn from large volumes of data. It goes without

Figure 8: Executives cite technology cost as the biggest obstacle for AI
Practical challenges to implementing AI in business (% of respondents)

Challenge	%
Cost of technology	27%
Cultural resistance to change	22%
Availability of providers	21%
IT department capabilities	21%
Data quality	21%
Security issues	20%
Availability of consultants/advisors	18%

saying that the learning and the predictions will only be as good as the quality of the data. Matteo Berlucchi believes this presents enormous challenges for the healthcare industry: "Countries' healthcare systems are typically fragmented and based on old models. Only a few hospitals embrace data collection in the correct way. Data quality and quantity is a challenge for most companies in the industry, especially start-ups."

Mr LeCun agrees: "The obstacle to AI implementation in healthcare is not technological but access to data. Research is hampered by difficulties in accessing large medical data sets, for legal or other reasons. It's particularly tough for start-ups in the field; larger players already have access to such data."

Cleaning your data is Mr Herbrich's chief recommendation for companies embarking on AI projects. "The most important thing any company must do is start collecting clean data. If you don't have clean data—identities about your product, your vendors, your customers, other information that is accessible—you will not have the input to generate accurate predictions. Noisy data, where identities are

re-used, or records are missing, is hard to correct. It is better to have no data."

40% of North American firms and 38% of manufacturers say they are acquiring or funding technology start-ups

Culture skirmishes

Cultural resistance to change—also high on the list of practical challenges provided by respondents—will be a tougher nut to crack for many companies. Ben Goertzel deems this the biggest implementation challenge that the financial sector will face with AI. "It's very cross-disciplinary at this point to get AI to work really well in the finance domain…. It will take a while for finance industry companies to build up the cultural and intellectual assets where you have finance people who know enough about machine learning and machine learning people who know enough about finance, and they can work together productively to get these applications to work." He observes that this
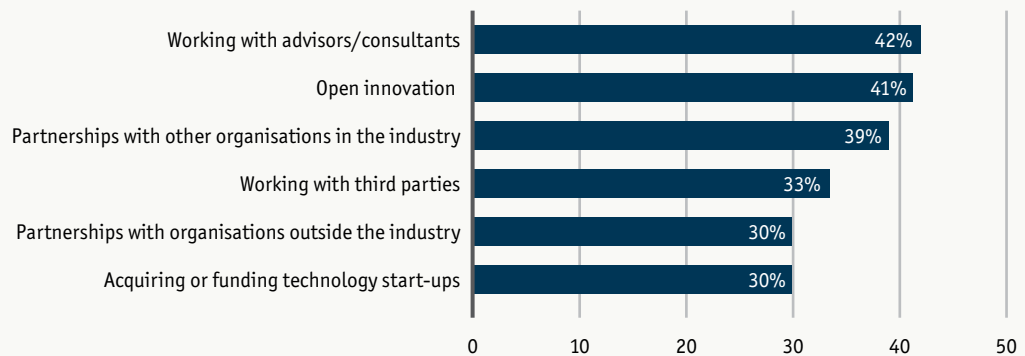
Figure 9: External collaboration and openness are key to AI implementation
Companies explore different ways to develop AI capability (% of respondents)

Category	Value
Working with advisors/consultants	42%
Open innovation	41%
Partnerships with other organisations in the industry	39%
Working with third parties	33%
Partnerships with organisations outside the industry	30%
Acquiring or funding technology start-ups	30%

is easier done in a start-up than, say, a large bank. "Start-ups can bring together people from different backgrounds and let them work together freely. Banks, though, are rigidly structured and not always agile. It often takes them years or decades to change each time a paradigm shift comes along."

Business leaders are all too familiar with internal resistance to technology-led change. When it comes to developing AI capabilities, relatively few are relying on internal assets alone. Large numbers in the survey, particularly in North America and Asia-Pacific, say their firms are looking to crowdsourcing and other forms of open innovation to develop AI applications (figure 9). Many others are partnering with other organisations inside and outside their sector. Almost one-third (40% of North American firms and 38% of manufacturers) are acquiring or funding technology start-ups. Such partnerships often allow companies to sidestep entrenched silos in order to implement new processes or services based on new technologies. ■

Case study 5: AI visions for manufacturing

According to Per Vegard Nerseth, managing director of the robotics business unit at ABB, an industrial engineering company, there are no standardised manufacturing robots today that have real AI or machine learning capabilities. They are very much part of his "factory of the future", however. Tomorrow's intelligent robots, he expects, will master the extremely complex (for robots) processes of assembly. Using cameras, for example, the robot will observe the steps the human engineer is taking to assemble a car or a mobile device. Machine learning will enable the robot to repeat and perfect the process itself, and over time it will perform the assembly without any programming at all.

Frank Kirchner, head of the Robotics Innovation Center at the German Research Center for Artificial Intelligence, also sees an intelligent robot emerging. "In contrast to the standard robots familiar to manufacturers, which are no more than 'automation tools', the intelligent robot is equipped with sensors and computing equipment, and can not only read sensor data but also interpret it and modify its actions according to this interpretation." Mr Kirchner and his colleagues foresee "hybrid social teams" working on the production floor in the not-too-distant future,

consisting of both stationary and mobile robots, working in direct, "handshaking" interaction with one or more human beings.

Beyond greater operating efficiency, the chief benefit for manufacturers will be much greater flexibility, believes Mr Nerseth. "Consumers want to have more specialised products and shorter delivery times. This means production will need to get closer to the market again, requiring much greater production flexibility." Machine learning will be one the agents of such specialisation. Its companion agent, he emphasises, is the Internet of Things and its multitudes of embedded sensors connecting devices to production machinery.

It will take a few years, however, before AI-powered machinery becomes commonplace on the shop floor, says Mr Nerseth. Manufacturers will likely deploy it first in front-office functions. The reason is the need for absolute certainty of reliability. "When it comes to high-volume manufacturing, no management team would risk [deploying AI] before they are 100% sure of a system's reliability. They need to be certain of very high levels of uptime. An outage of just 15 minutes could be devastating for large producers."

5 A question of disruption

Notwithstanding the title of his recent book ("Humans need not apply"), Jerry Kaplan does not share the alarm some economists have voiced about the threat AI poses to employment. He sees AI as essentially an advanced form of automation. "AI has a big public relations problem," he says, "All we are doing is developing a set of new engineering techniques that can automate tasks that have resisted automation in the past." On the subject of jobs, he adds that "AI doesn't just replace people. There will be all kinds of new things that people will be able to do but can't do now."

> "AI will actually create more jobs in healthcare than it replaces. There is so much unmet demand [for health services] that needs to be addressed. If you equip healthcare professionals with tools like AI you can have more people join the industry and use these tools to service the unmet demand."
>
> Jared Teo, senior program officer,
> Health Innovation Fund, California
> Health Care Foundation

His views on job displacement are echoed by other experts. James Hendler of Rensselaer Polytechnic acknowledges that AI will inevitably eliminate some human roles, but for the most part will take over certain, especially repetitive, tasks performed by humans today and not necessarily entire jobs. "Most AI applications today need a human in the loop to some degree. We're seeing more interaction between the human and the machine but the human is still very involved."

Mr Berlucchi believes the displacement theory will not apply to healthcare any time soon. "It is true that AI and machines will perform many tasks performed by medical or clinical staff today. But because everyone is overworked by at least 100%, there will be few job losses; AI will optimise the professionals' work and relieve the pressure on the system."

The manufacturing sector has more experience than others in dealing with the fallout from automation, including from robots on the production floor. Mr Lorenz believes manufacturers will again see displacement of humans being partially attenuated by re-skilling. He relates that one of his clients is currently replacing some shop-floor employees with intelligent systems. Many of these individuals, however, are being trained to work with virtual reality (VR) headsets to help them become expert field service engineers, of which it currently has a shortage—and, he adds, command relatively high wages.

An exception to the optimism is John Straw, who believes significant job losses will be unavoidable in the retail industry. He cites a McKinsey report which suggests that by 2025 up to 40m white and blue collar workers will be out of a job in the West due to automation. "Unfortunately I think an awful lot of those are going to be in retail, and the channel will need to repurpose and retrain." He explains that a large number of retail jobs have a very precise and tight job description, with a large number of repetitive tasks. These jobs, he points out, lend themselves to AI-based automation. "You will still need retail workers at a senior level to teach the robots, but that is an interim step to full singularity where the robots will learn from each other. Such technology is already with us."

Happier employees?

Another retail industry representative, Eric Colson, chief algorithms officer of Stitch Fix, an online apparel shopping service, sees AI as a complement to the work of its human clothing stylists rather than a replacement. Their work is heavily influenced by the analysis and suggestions of the company's "styling algorithms". Mr Colson finds it more than a coincidence that measured job satisfaction amongst the stylists is highest than in any other category of employee in the company. [See "Algorithms for your evening wear".]

46% of executives anticipate that AI will displace humans from certain roles within the next 5 years

The majority of survey respondents believe this will be the case for themselves and their organisations. Over four in 10 anticipate that AI technologies will begin displacing humans from certain roles in their industry within the next five years (figure 13). Even more (46%) believe their own job is likely to be performed by an

AI-based technology in the same time frame. However, most respondents perceive this in a positive rather than negative light. Nearly 8 in 10 believe AI will make their job easier and make them more efficient.

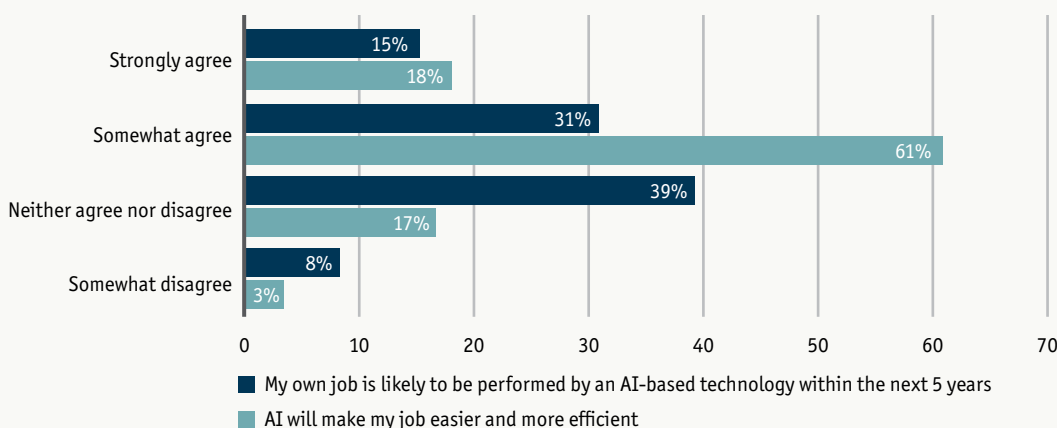**79%** of executives believe AI will make their job easier and more efficient

"A guy working 30 years on an automotive manufacturing line comes to the shop floor one day and there's an intelligent robot there in place of his old colleague. What is this guy going to think? It will be a drastic change for him. This will happen in the next five years."

Frank Kirchner, head, Robotics Innovation Center, German Research Center for Artificial Intelligence

Slightly more than half of executives also believe that machines "will never be able to make the types of intelligent business decisions that managers make."

Figure 13: AI stands to replace or improve most jobs
Executives expect AI will replace some jobs and bring more efficiency (% of respondents)

Legend:
- My own job is likely to be performed by an AI-based technology within the next 5 years
- AI will make my job easier and more efficient

Strongly agree: 15% / 18%
Somewhat agree: 31% / 61%
Neither agree nor disagree: 39% / 17%
Somewhat disagree: 8% / 3%

Yann LeCun isn't as sure: "Never say never. AI-based systems making business decisions on their own may not emerge tomorrow or in a couple of decades. It doesn't make sense for businesses to worry about this today. But it will happen, no question. It's a matter of time."

6 Conclusion: Embracing the unknown

How disruptive, then, will AI prove to be? Most survey respondents expect big changes at a broad level: seven in 10 believe that, like the Internet, AI will lead eventually to the creation of new industries and the demise of others. The experts we interviewed for the study stop short of such dramatic predictions, at least with the medium term in view. Some expect AI to have a transformative effect on their respective industries, but in the short and medium terms more in operational terms. Another anticipates the emergence of new business models but does not expect a major restructuring of sectors because of AI.

If AI realises its business potential in the next 3-5 years, there is little question that it will lead to significant improvements in processes, as well as in the precision and reliability, and possibly the speed, of operational business decisions. AI is also more likely to enhance security and improve risk management than to weaken them, although some have concerns about AI's potential misuse.

The greatest risks that AI poses to companies probably lie less in its potential for disruption, and more in the unknowns surrounding it. After all, AI has only recently made it out of the laboratory, and business leaders are only now realising its commercial potential. Scientists believe there is a long way to go before they even scratch the surface of AI's capabilities. It cannot be discounted that AI will take businesses and industries in directions they do not want to go. But its future development is at least as likely to uncover new and exciting applications that will benefit companies and consumers alike.

Either way, businesses cannot ignore AI's development. Some may decide AI is not right for them, but existing or future competitors will inevitably lay down a challenge with it. ■

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