AI AND ROBOTICS

INVESTING IN THE FUTURE **NOW**

AI AND ROBOTICS: INVESTING IN THE FUTURE NOW

WORRIED YOU MIGHT LOSE YOUR JOB TO A ROBOT? HERE'S HOW TO HEDGE YOUR BETS

As any smart investor knows, exposure to frontier technology and science is a risky bet. Predicting which technologies will take on or which companies' execution of them and business model will propel them into market leaders is not easy. iPhone or Blackberry anyone?

But as any smart investor also knows, not having exposure to technology and science that changes the way we live and fundamentally shifts the foundations of the world's economy is far, far riskier. No investor wants to be the one to have stubbornly held on to their shares in Kodak and ignored Apple. Or Blockbuster at the expense of Amazon or Netflix.

Getting in right at the beginning of a company developing brand new technology that still hasn't been rolled out in an applied environment or demonstrated a viable commercial model is how brave investors become multi-millionaires and even billionaires. It's also the riskiest kind of investment, coming as it does with so many variables and open questions.

The most successful investors in new technology spread their risk over multiple investments in the knowledge that only one needs to come off to pay back handsomely. That doesn't necessarily mean the technology investment becomes an Apple, Amazon, Google or Facebook – though it would be nice if it does. A Nest or a DeepMind, companies subsequently acquired by the big boys, is the real target with anything else a bonus.

For investors of more modest means with a different risk profile, the approach should be different. The target is the next stage in the development of new technologies. Investing in technology that it is already clear will be huge and shape the next 5, 10 or 20 years and identifying the companies that have valuable patents or applications of that technology that have huge commercial value.

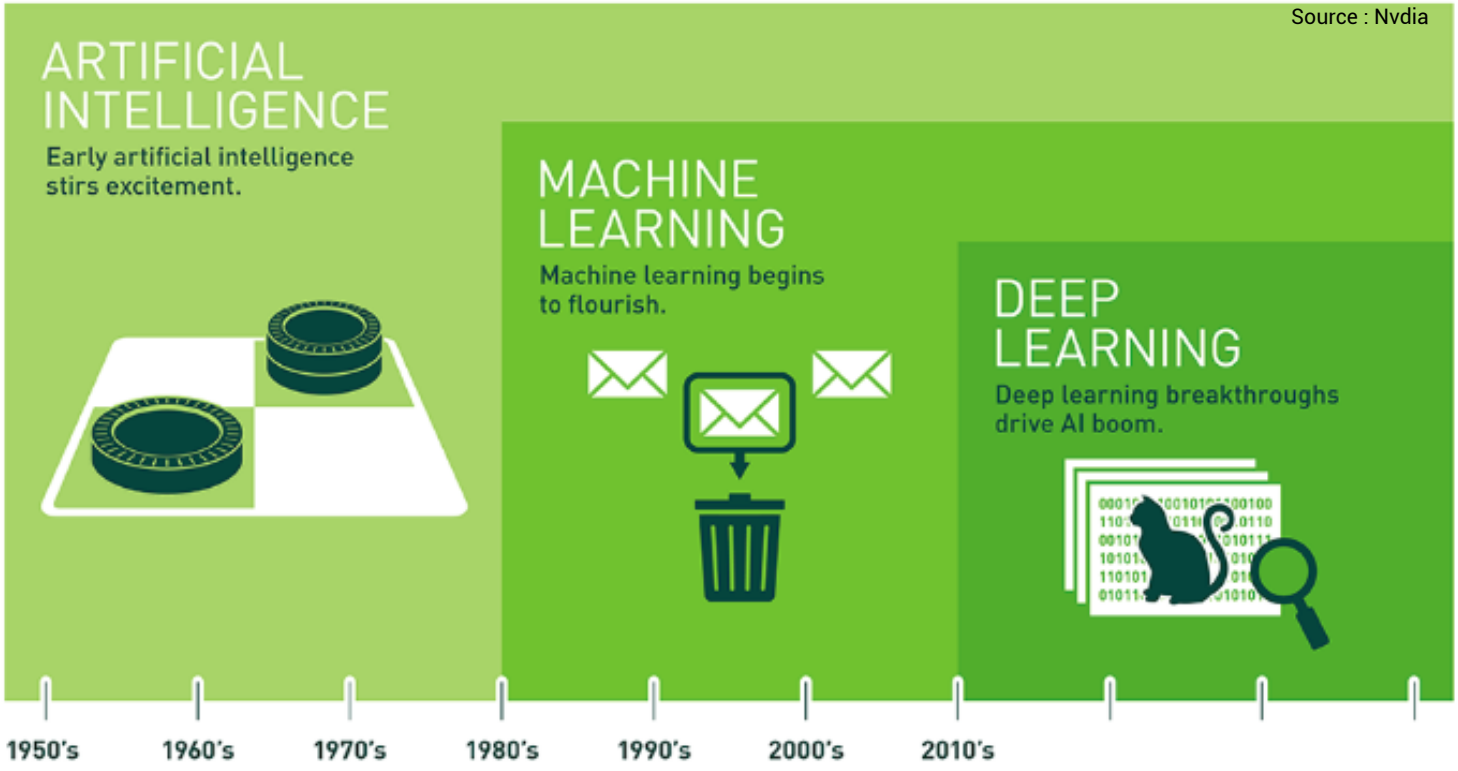
This report will focus on just such a branch of technology. Or rather, the space where two branches of technology on the cusp of driving the fourth great industrial revolution meet – AI and robotics. What exactly is AI? Why and how AI and robotics will change the fabric of society? What does the next several years hold for the market? Just how valuable will it be? And finally, an exploration of some of the most commercially attractive applications and the investment opportunity the sector represents.

AI EXPLAINED IN A NUTSHELL

The broad definition of AI is software that works and react like humans, or achieve a good approximation of how a human would be expected to work and react. It's not a precise definition but, according to the Techopedia definition, roughly incorporates machines that are able display one or a combination of:

- Knowledge
- Reasoning
- Problem solving
- Perception
- Learning
- Planning
- Ability to manipulate and move objects

The last category of AI capabilities involves robotics that AI software works in tandem with and we will cover later. AI is also often referred to as Machine Learning or Deep Learning. The easiest way to think of it is that they are all AI and that Machine Learning and then Deep Learning are simply increasingly sophisticated forms of AI.



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

AI is also not a new thing. It's just that it's only over the past several years that it has developed to the point at which breakthroughs have accelerated and applications genuinely ground breaking. More powerful GPU processors, cloud storage and Big Data have all contributed towards that sudden acceleration of AI development.

"AI has been part of our imaginations and simmering in research labs since a handful of computer scientists rallied around the term at the Dartmouth Conferences in 1956 and birthed the field of AI. In the decades since, AI has alternately been heralded as the key to our civilization's brightest future, and tossed on technology's trash heap as a harebrained notion of over-reaching propellerheads. Frankly, until 2012, it was a bit of both." - Nvidia

What we have at the moment is defined as 'narrow AI'. Machines able to perform specific tasks to the same level, or more competently or quickly, than humans. Narrow AI is as distinct from 'general AI', which would be the humanoid machines of science fiction that have all of our senses and reason, and perhaps even emotion, working together – Johnny 5, C-3PO….the Terminator. We're still some way off general AI being a realistic possibility.

MACHINE LEARNING (ML) is an example of narrow AI. An algorithm is able to parse data, isolate patterns that exist, 'learn' from these and make a determination or prediction about something in reality connected to the database learned from or similar data. ML algos are based on decision tree learning, inductive logic programming, clustering, reinforcement learning, Bayesian networks and other processes that resemble some of the ways we learn as humans.

Until recently, outside of very controlled environments, ML was rigid and prone to error. For example, computer vision based on ML would be able to identify a cat or read a sign. But only if the cat or sign were clearly visible and met common standards. A sign partly obscured by a tree or bad weather or a cat curled up behind a cushion would be beyond ML of the recent past. That kind of ML had useful applications but those limited to sterile, homogenised environments such as data processing or controlling robotics in a production line. You couldn't throw those algorithms into a 'real world' environment with its many variables and gradients.

DEEP LEARNING added the layered processing of 'neural networks' that are closer to the biological understanding we have of our own brains. These chop the decision making process up and pass it through a system of checks and balances. For example, if we

return back to the example of a road sign partially obscured by a tree, the first layer of neurons will judge the shape of the sign. Obscured by some branches, the clear outline of a rectangle or circle may not be visible. However, enough will be visible for a second layer of neurons to decide the only, or most, logical conclusion is that the shape is a rectangle, disrupted by something else overlaid on it, breaking the lines, from the point of view of the visual image from that angle.

The third, fourth, fifth layers, etc., will break down the sign into further components such as colours visible, lettering visible and so on. We don't read a full word usually when part of a sentence, but the beginning and end letters, but our layered neural networks can come to a pretty reliable conclusion on the word from the letters that are processed and their context within the sentence and wider text. In the same way, Deep Learning (DL) neural layers break a task down into components that each will assess, attach a weighting to its own input to the final output and the conclusion arrived at is a combination of those weightings. The final output is a 'probability vector' or educated guess.

A DL algorithm also learns from any mistakes made. As it is being developed, it will be fed vast reams of data to process and its conclusions graded as right or wrong. Due to the speed this external data can be processed and results verified, deep learning AIs can very quickly 'learn' to iron out mistakes as a result of the huge number of variables and combinations of variables the algorithm has experience of. As a result, their educated guesses becomes extremely accurate.

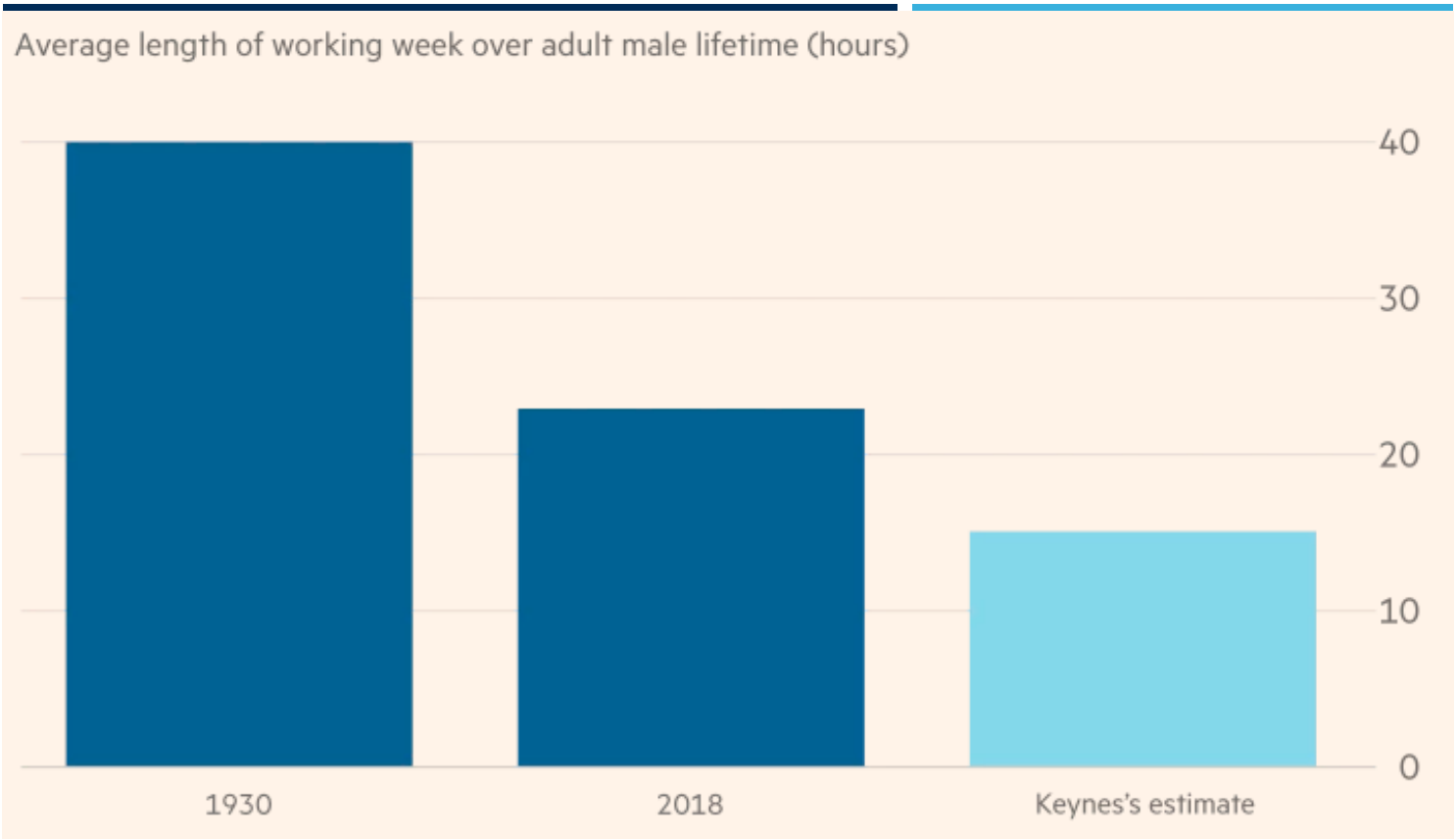
PRACTICAL APPLICATION OF THE NEW GENERATION OF AI DEEP LEARNING

While still within the 'narrow AI' category, Deep Learning allows for much broader 'narrow' tasks and roles to be performed by algorithms than was the case until the last few years. Perhaps the most influential DL application that will go mainstream over the next decade is autonomous vehicles. This development will profoundly reshape the world economy and our day to day lives.

AI performs best in rules-based situations. The perfect example of this is the board games such as chess and, more recently Go, at which AI algorithms have defeated the best human players. Driving is also a 'rules based' situation. However, the difference is there are so many rules, variables to the rules and random disruptors of those rules. That makes it hugely difficult.

It would be relatively easy to programme an algorithm for autonomous vehicles to drive around safely and efficiently in a controlled environment. However, when you throw in changeable weather conditions, the position of the sun, branches being blown onto the road, a cat darting out in front of traffic or a human driver not signalling or breaking the rules of the road in any other of the minor or major ways that happen all the time in a real life environment, the matrix of decisions the AI has to take suddenly becomes an immense challenge.

But with the latest Deep Learning technology and techniques, combined with oceans of data and cloud storage, the challenge becomes surmountable. Driverless vehicles, usually with a human 'safety' driver ready to take the controls immediately, have clocked up millions of miles of driving. The DL algorithms have been fed with the data from what happened in what circumstances and with what outcome of those millions of driven miles. Added to that is hundreds of millions more 'simulated' miles that driverless cars have been driven.



These include a detailed simulation of a stretch of road driven in all weather and light conditions imaginable, with road signs missing or defaced, with human drivers making human errors of judgement, encountering potholes, cats, plastic bags being blown over sensors and every other real world variable imaginable. By the time driverless cars are a regular sight on our streets, the AI algorithms controlling them will have immeasurably more experience in the optimal way to react to the millions of possible variables and outcomes than any human driver.

Autonomous vehicles of course also incorporate robotics, which is simply the wider term for a machine capable of carrying out a complex series of actions automatically. The classic understanding of robots are machines that interact with and influence an external physical third party but this is not necessarily the case. A robot could also be entirely digital and have an exclusively digital output.

HOW AI AND ROBOTICS WILL CHANGE THE FABRIC OF SOCIETY

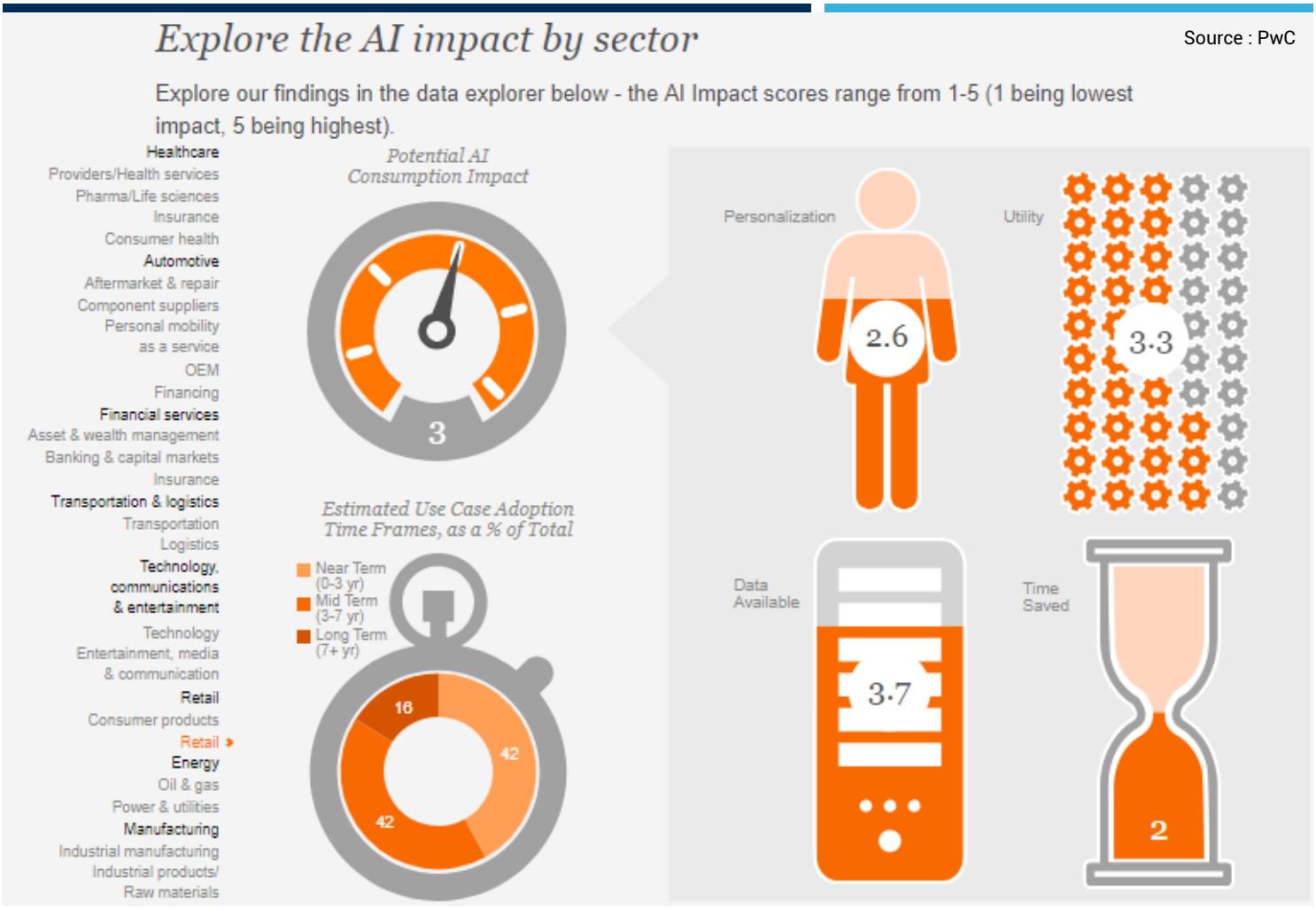
To go into the all of the potential applications of the latest and future generations of Deep Learning AI would require a library and not a report such as this one. However, major sectors that are at the vanguard of what will be some of the most immediately obvious changes include manufacturing, autonomous vehicles, supply chain management, financial markets, biotechnology, medicine, retail and the domestic environment.

Most simply put, over the next two decades almost all tasks that involve processing and analysing data to isolate patterns and conclusions from it and rules-based tasks and functions, even in environments with multiple variables, will practically be able to be done by AI-powered robots.

Making bold statements around what the practical result of this will be is a fool's errand. Renowned economist John Maynard Keynes famously forecast that the advent of the steam engine would result in a 15-hour working week. 90 years and quite a lot of new technology since and we're a long way from that.

A Financial Times study of that prediction came to the conclusion that in 2018, the average British male (sexism was necessitated by the greater extent of historical data on employed males back in the 1930s) works just 9 hours less per week than in 1930 – at 38. If 10 years of additional retirement time is included in the calculation (which is a very generous way of doing it), with average life expectancy having increased to 85 from 75, the average number of hours worked per week drops to 23. That's still 8 more than Keynes's prediction.

Some believe that the AI and robot revolution could finally lead to Keynes's prediction becoming a reality. However, human society has a talent for finding work for itself and also not distributing that work especially



fairly. There's every likelihood that, as in the wake of developed economies losing much of industrial employment from the economic mix a few decades ago, AI replacing human workers will simply lead to an evolution of the work force.

There might well be pain involved in this but history teaches us we shouldn't be either overly negative or overly optimistic as to what the final output will be. It almost certainly won't be a society riven apart by mass unemployment and resulting poverty. It is just as unlikely to lead to a utopian lifestyle of us working an average of 3 hours a day for a superior lifestyle to that which our current average working day affords us.

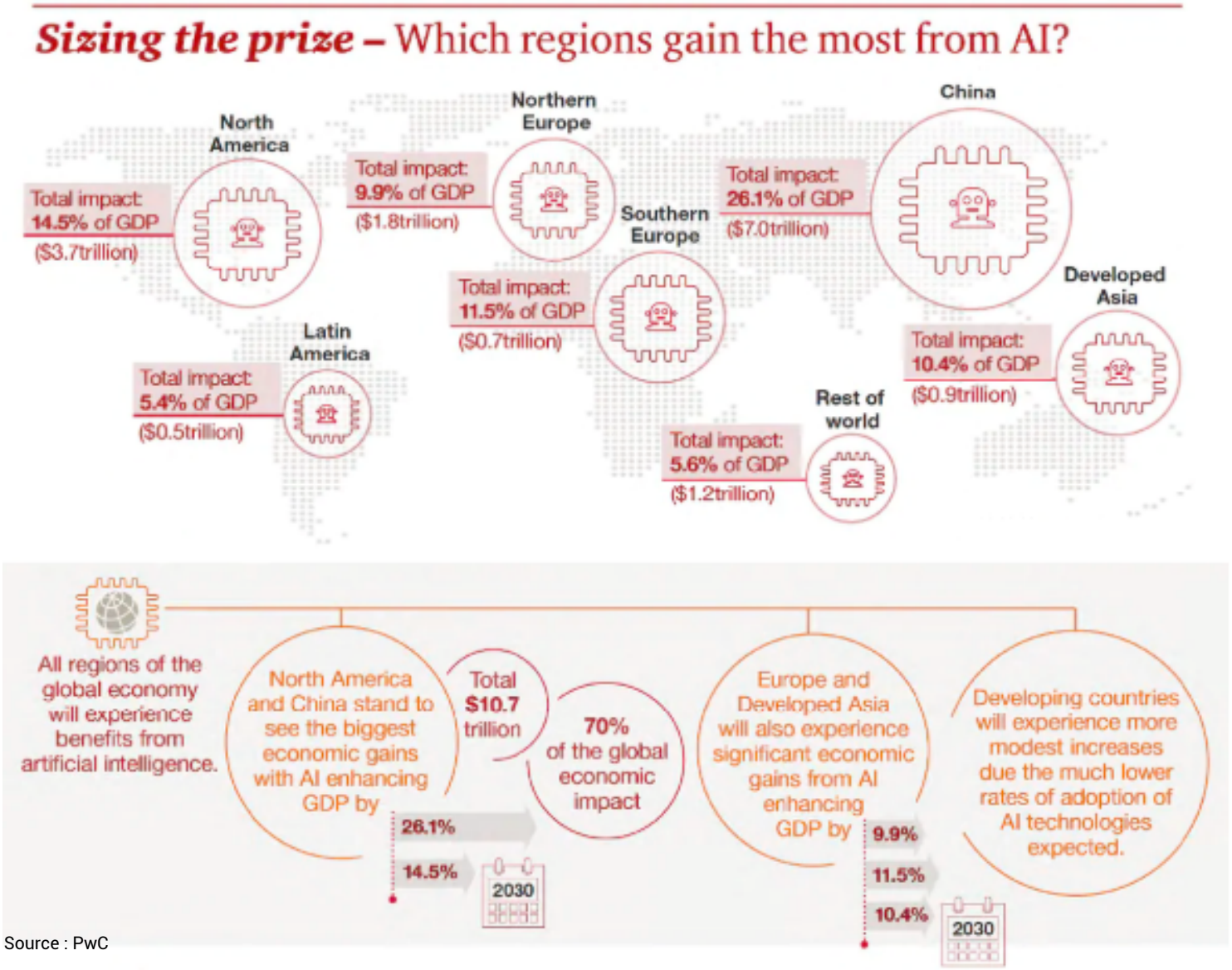
However, there will be big changes. Employment can be expected to adapt away from repetitive tasks to those which involve technology skills and knowledge or creativity of some description. We will almost certainly live longer on average as AI-powered medicine develops to find more cures for more diseases and conditions and body parts and organs become more like replaceable spare parts.

Domestic chores can be expected to become minimal and the perhaps the greatest hope is that humanity will become ecologically sustainable as the energy and materials we consume become fully based on renewables.

The combination of these developments should genuinely mean we have, even if still gainfully employed for several hours a day, more free time. No house work, commute times reduced through optimally efficient traffic and the ability to work at distance, no need for parents to do school drop-offs of ferry kids to different extra-curricular activities and being able to read or relax while chauffeured in an autonomous vehicle.

The optimistic scenario of the AI-powered future is more time to relax, be creative, active and social and be healthier while doing it. If health, wealth and freedom are pillars of human happiness, the same can be said of companionship and social interaction. AI is expected to have an influence in that regard also. Most thought exploration of AI in this sphere focuses on the potential for romantic or sexual interactions between human and robot.

However, this would require 'general AI' and not the 'narrow AI' that is currently advancing at pace. As such, this kind of AI can be shelved for now as pure speculation and science fiction. But AI home help and realistic verbal interactions will soon be a practical possibility and then reality. AI robots that help the elderly, ill and infirm is an area that significant investment, research and progress is taking place in. As well as physical help, this kind of AI will soon be capable of the kind of



Source : PwC

verbal interactions and physical presence that, while a crude approximation of human interaction, will be close enough to provide comfort and assistance to the very young, elderly or sick.

One example of this kind of technology that already exists is a robotic cat built by toymaker Hasbro that AI scientists from Brown University have augmented with AI. The cat is lifelike enough to provide physical comfort to elderly patients suffering from cognitive impairments such as dementia. It can move around much like a cat would and roll over for a tummy rub. The Brown team have added additional abilities such as helping the owner to find lost objects, reminding them to take their medicine or visit their doctor. Even at the early prototype stage this kind of technology, termed Aries for 'Affordable Robotic Intelligence for Elderly Support, is currently at, it shows huge potential and the ability to improve lives.

TALKING FIGURES – THE VALUE OF THE AI SECTOR

The logical consequence of the expected influence and pervasiveness AI is set to have on the economy and everyday life is that it will also have immense economic value. Companies that develop successful AI products and patent AI technologies used in those products will make a huge amount of money.

PwC estimates that global GDP will be 14% higher in 2030 as a direct result of AI, amounting to a total value of $15.7 trillion. This will happen through a transformation of productivity growth rates and labour productivity in existing sectors. New commercial verticals that will result from AI and are hard to predict are not taken account of which means it is almost certain that gains will in fact be far more. These gains are expected to be strongest in China, where AI is predicted to add 26% to GDP in 2030, and North America with a 14.5% boost. For Northern Europe the figure is put at 10%.

Even without these less tangible additions to global wealth, the base figures mean that AI is by far the single biggest commercial opportunity in today's economy.

INVESTING IN THE AI REVOLUTION

Investors sensibly coming to the conclusion that their portfolio should have exposure to the AI sector have a number of options available to them. They all have their strengths and weaknesses and will best fit different investors individually or in combinations based on their investment approach, goals, appetite for risk and knowledge. The main AI investment vehicles are:

ACTIVELY MANAGED FUNDS:

A manager with expertise in the technology sector will select the stocks in an actively managed fund focused on the AI economy. Currently, most funds would be broader technology funds with AI exposure but there are also a number of more specialist funds with a narrower focus on AI in particular. Different funds might also zero in on a particular geography or smaller up-and-coming companies rather than big technology companies with interests in AI.

PASSIVE FUNDS:

Currently there is no AI-specific equities index for a passive tracker fund to mirror but there are technology index trackers that have significant exposure to companies focusing on AI research, developments, products and services. As time goes on the passive fund options focused on AI can be expected to increase.

INDIVIDUAL COMPANY STOCKS:

More experienced investors with a background in picking their own stocks might choose to invest in individual listed companies with an AI focus. The choice here is generally between big, already well-established technology companies such as Google, Nvidia etc. with heavy involvement in AI R&D but also with existing strong revenues or smaller companies that are more of a risk but stand to deliver big returns if they come out with a product or technology that proves to be commercially successful.

EIS/SEIS INVESTMENT OPPORTUNITIES:

The UK government-backed EIS and SEIS schemes offer more sophisticated investors the opportunity to back Britain's most promising young companies in the AI sector. Investing through these schemes involves taking an equity stake in young companies defined as 'knowledge based'. This kind of investment comes with significant tax breaks both on the initial investment's value as well as on any subsequent profits or losses. The combination of tax credits available to investments made through EIS and SEIS means that as little of 30% of the investment can be exposed, greatly swinging the risk to reward ratio.