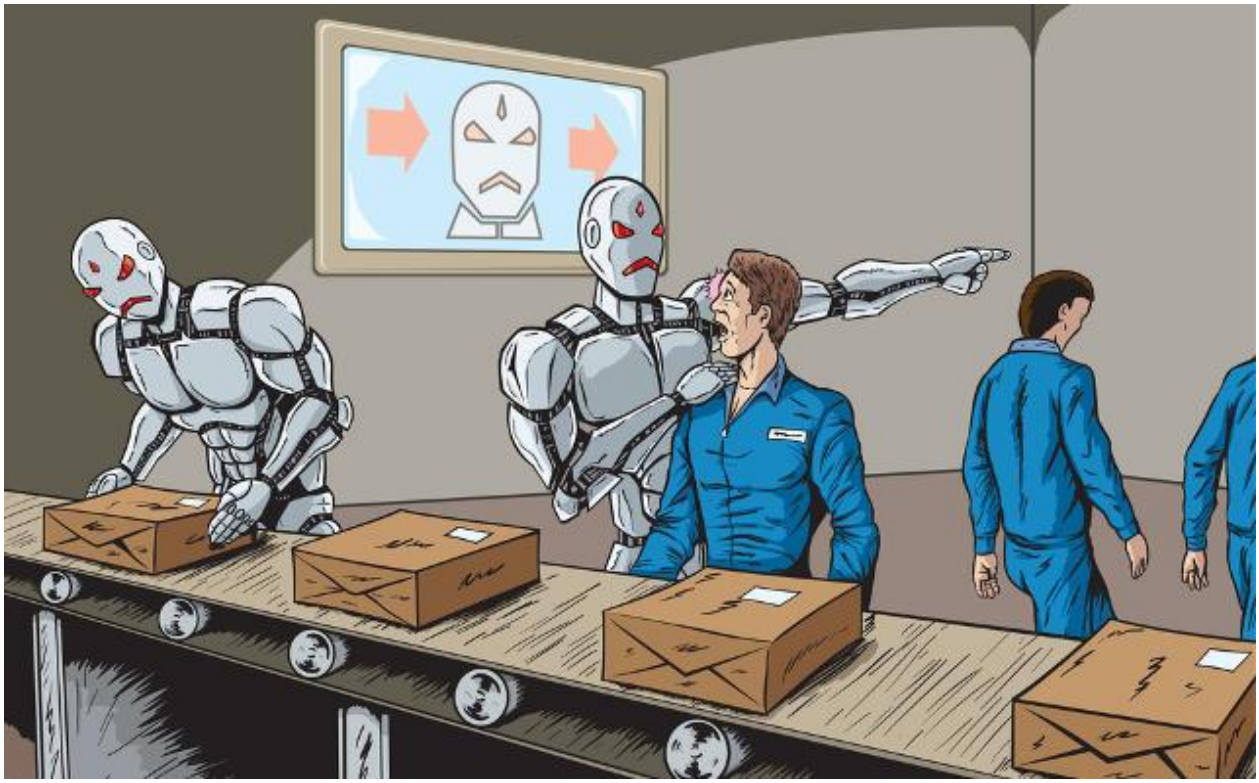
A Future Without Work?

A.I. Robots and Employment



Ray Hammond

A Future Without Work?

The idea that robots and artificial intelligence systems (A.I.) are coming to take our jobs and make humans permanently unemployed is a very hot topic at present.

The media has been full of headlines such as “Robots Will Take Our Jobs” and “Humans Need Not Apply”.

And several reports from eminent universities and consultancies have suggested that intelligent machines will eventually render a huge percentage of our species redundant.

Perhaps the most influential report was “The Future of Employment” by Carl Benedikt Frey and Michael Osborne of the Oxford Martin School. It was published in 2013.

The report examined the probability of automation for 702 occupations and found that 47% of workers in America had jobs at high risk of potential automation. In particular, they warned that most workers in transport and

logistics (such as taxi and delivery drivers) and office support (such as receptionists and security guards) “are likely to be substituted by computer capital”, and that many workers in sales and services (such as cashiers, counter and rental clerks, telemarketers and accountants) also faced a high risk of redundancy because of automation.

As a result, many newspapers and TV stations ran headlines suggesting that almost half of U.S. workers will become unemployed because of the introduction of automation.

But I think it likely that between now and 2030 most of the workers whose activities will be automated will be displaced into other jobs and occupations, rather than becoming permanently unemployed.

I have been studying the impact of technology on society for nearly 40 years and I have observed as successive waves of automation have arrived in sectors such as banking, printing, telecoms, graphic design and retail.

Often, humans have been displaced from their existing jobs, but the economic stimulus created by the automation has resulted in many new jobs – and new types of job – being created. Automation has not, so far, caused mass unemployment in the general population.

To give you some examples of the new type of jobs created:

Think back thirty years: How many professional wedding planners were there in the 1980s in the USA or in Western Europe?

How many personal trainers were keeping us fit? How many pet groomers and dog hairdressers were there and how many restaurant-food delivery riders were on the roads 30 years ago?

How many app developers were there, how many web developers, how many social media marketing executives and how many search-engine optimisation specialists were there?

How many independent chocolatiers, finger-nail artists, life coaches or professional dog walkers existed before the year 1990?

How many sustainability advisors, environmental officers, corporate reputation advisors and how many chief knowledge officers were there?

These are all examples of job categories which did not exist 30 years ago – and this is not to mention all of the self-employed "gig economy" jobs that have been created, such as Uber drivers.

When we think about the coming impact of A.I. and robots on employment we must wonder how many completely new human job categories will be created over the next ten or twenty years.

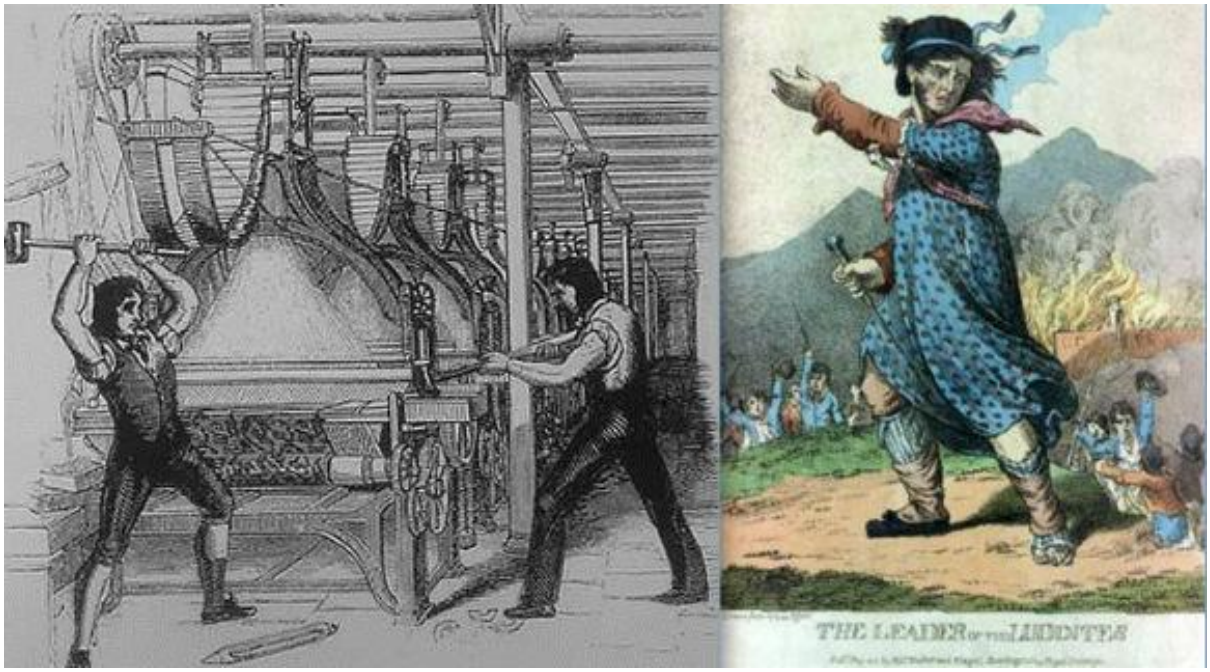
As a result, it is by no means certain that increasingly intelligent automation and robotics will lead to wide-scale unemployment in the next fifteen years or so.

What automation will do is hold down wages paid to human workers – but more of that later.

Will A.I. and Robots Cause Mass Unemployment In The Next 15 Years?

The first alarm bell about machines taking jobs from humans was sounded by a textile worker in Nottingham, England back in the year 1811 – not long after the Industrial Revolution had begun.

That worker was called Ned Ludd and he led a revolution against the introduction of the first mechanised weaving looms in Britain's textile mills. He and his followers – known as the Luddites - were convinced that their hard-won skills as weavers would become valueless as machines were introduced. Over a two-year period, the group destroyed mechanised looms and set fire to mills in an attempt to halt what we would now call automation.



But the mechanised looms allowed the mill owners to increase production by 50 times, and the mills hired more and more staff to oversee the machines, to feed in raw material, to deal with the frequent break-downs, to provide what we now call quality control and to remove and pack finished cloth. Mill automation did not cost human jobs; it just changed the sort of jobs that were available.

In the 20th Century the famous British economist, Sir John Maynard Keynes was the first modern thinker to suggest that technology might eventually cause widespread and general human unemployment.

In 1930 Keynes produced a paper called "Economic Possibilities For Our Grandchildren" in which he suggested that what he called "technological unemployment" would become a widespread problem as automation increased. He thought that by the year 2,000 is was likely that many people would be living a life of enforced leisure with their living costs met by the increased productivity of machines.

Then, in the 1950s, the American writer Kurt Vonnegut produced "Player Piano – America In The Coming Age Of Electronics", a book which painted a picture of a future without work. This concept was picked up and amplified by the media and in the late 1950s and all through the 1960s many western schoolchildren (including me) were taught that by the year 2,000 many of them would only be working one or two days a week.

Many subsequent writers and commentators in the 1960s and 1970s developed the theme of a leisured future, especially as computers entered the business mainstream.

But, as we now know, these projections turned out to be completely wrong. Automation did arrive in both manufacturing and office work but sixty years later, human employment is at record levels in most developed economies while the unemployment level is falling steadily in many developing nations.

What was wrong with these predictions of endless leisure?

It seems clear to me that these thinkers looked at the possibilities of the emerging technologies and, rightly, predicted that future automation would be able to replace many human workers.

But I don't believe these writers considered *human* nature sufficiently.

I think most humans wish to work, to improve themselves and, for many people, work gives purpose and meaning to their lives. I believe this is a trait left over from our evolutionary heritage in which the urge to survive was closely connected with the urge to provide for ourselves and our families.

I believe work is an evolutionary imperative.

Therefore, when automation did start to displace jobs in the 1980s, those who were displaced quickly found an alternative type of employment – most did not sit back and take welfare benefits.

It is the human desire to work that drives economic growth and although many workers have been displaced from their trades and professions in the last 30 years, the vast majority of them have adapted and have taken up new types of job. Some have re-trained or re-skilled, but many have simply learned on the job itself.

It is this very human quality of "adaptability" which is my main reason for asserting that in the next couple of decades there will not be widespread general unemployment caused by the introduction of automation.

Mass unemployment can be created by other means, such as financial crashes, political instability or even deliberate government policy, but although A.I. and robots will be entering the workplace in huge numbers between now and 2030, I do not believe the machines themselves will be the cause of any mass unemployment that does occur.

Automation will cause many of us to change what we do and how we do it, but machines will often set us free to do what we do best.

For the next ten years or so robots and A.I. are likely to *increase* total human employment and productivity because they will be our co-workers, not our replacements. They will also give the global economy a massive and much-needed boost.

A.I systems have already started to enter offices to displace human back-office workers and although some redundancies are being seen, there is still a strong job market at present for human office workers.

Co-operative robots (co-bots) that work *with* humans in manufacturing are just starting to undertake heavy, monotonous, fiddly and dangerous jobs and so free up skilled humans to undertake those tasks that require advanced human cognition - supervision, materials evaluation, quality control and project organisation.

And although self-driving vehicles are making headlines, the reality is that outside of inner cities they will not be widely deployed on the open roads for at least a decade and a half – the difficulty of mixing them safely with human-controlled vehicles is a major challenge. As a result, the jobs of most professional human drivers are secure until at least 2030 – a subject I will return to later.

<u>Understanding The Capabilities of Artificial Intelligence</u>

A.I. systems are at the heart of all robotics as well as cloud-based and networked A.I. entities themselves. Therefore, it is important to understand just how intelligent or how dumb today's cutting edge A.I. systems are.

We have all seen the stories about A.I. entities with neural networks, deep learning capabilities and the skills needed to beat the best human players at chess, the TV quiz "Jeopardy", the board-game Go and even poker! Recent reports tell us that A.I. systems are better than human doctors at diagnosing

cancers and suggesting treatments. And we know that A.I. systems can successfully recognize human faces as well as other objects.

These so-called “breakthrough” skills are trumpeted by the media (and by the makers of the systems) as if new forms of artificial super-intelligence are already emerging on the planet.

These reports and claims have prompted many eminent scientists, thinkers and entrepreneurs such as Professor Stephen Hawking, Elon Musk and Bill Gates to warn society about the immense danger that super-intelligent A.I. systems will pose to humanity.

Stephen Hawking has said, “Artificial Intelligence could wipe out humanity when it gets too clever as humans will be like ants”

He has also said, "I believe there is no deep difference between what can be achieved by a biological brain and what can be achieved by a computer. It therefore follows that computers can, in theory, emulate human intelligence — and exceed it.

"In short, the rise of powerful AI will be either the best, or the worst thing, ever to happen to humanity. We do not yet know which."

Elon Musk said recently, "Deep artificial intelligence is a dangerous situation."

And Bill Gates observed, "I am in the camp that is concerned about super intelligence. First the machines will do a lot of jobs for us and not be super

intelligent. That should be positive if we manage it well. A few decades after that though the intelligence is strong enough to be a concern."

Given the celebrity of the speakers, these comments created a lot of headlines around the world.

But while I think these warnings are appropriate for the longer term – say 20 or more years from now, as Bill Gates suggests – my knowledge of the power of the best of today's A.I. systems leads me to believe that – despite the super-rapid progress we expect from accelerating, exponential, technology development – humankind has nothing to fear from machine intelligence until the mid 2030s.

In terms of general intelligence, today's best A.I. systems and robots have less mental capability than a rodent.

Being better than humans at single tasks such as possessing a vocabulary, scanning documents, reading medical scans, playing complicated games or repeatedly making a perfect weld is completely different to general intelligence which embodies common sense, context and a sense of place and time (as distinct from merely knowing the time).

The truth is that A.I. systems can be trained today to be extremely good at one thing, but they completely lack any understanding of the task they are doing or the context in which they are working.

A super-intelligent machine (one that has human-level problem-solving capability) requires what scientists call “general intelligence”, which is another way of describing human-type intelligence.

But despite the news stories about A.I. using such phrases as “neural learning networks” and “Deep Mind A.I.”, these concepts are, for the present, just hype.

There is no development going on with A.I. that uses human-type neural circuits or deep learning as a neuroscientist would understand those terms. These descriptions are just “marketing speak”.

The reality is that in comparison to the human brain, even the fastest A.I. systems are incredibly slow. Today’s cutting edge machines have around a billion neural connections compared with around 100,000 billion in the human cortex.

A.I. developers can’t even work out how to simulate human vision in a computer. We can attach cameras to A.I. systems, but although they may be trained to recognise faces, objects and actions, they cannot describe what they are looking at – they have no way to put the data they analyse into context.

The amount of data we absorb through our senses and which we instantly analyse in just a few seconds (both at the conscious and unconscious levels) would overwhelm even a network of today’s super-computers running the latest A.I. systems.

One major reason that A.I. development is still at such a basic stage is that we still don't understand how the human mind itself works. We don't how it develops context, understanding and memory references – let alone knowing how consciousness emerges.

Today, the very smartest A.I. system that exists can be rated with an I.Q. level that is the equivalent of a 4-year-old child if tested on vocabulary. But if tested on visual understanding, memory selection, common sense or sensory perception and interpretation, the most advanced A.I. today doesn't even register on the human I.Q. scale.

For these reasons we must think of A.I. as being in the very early stages of development – and that means robots are also at the very earliest stage of development.

But the trend of accelerating, exponential technology development means that A.I. and robots will develop quickly, very quickly and in some single-task and limited multi-task roles they are already displacing thousands of human workers.

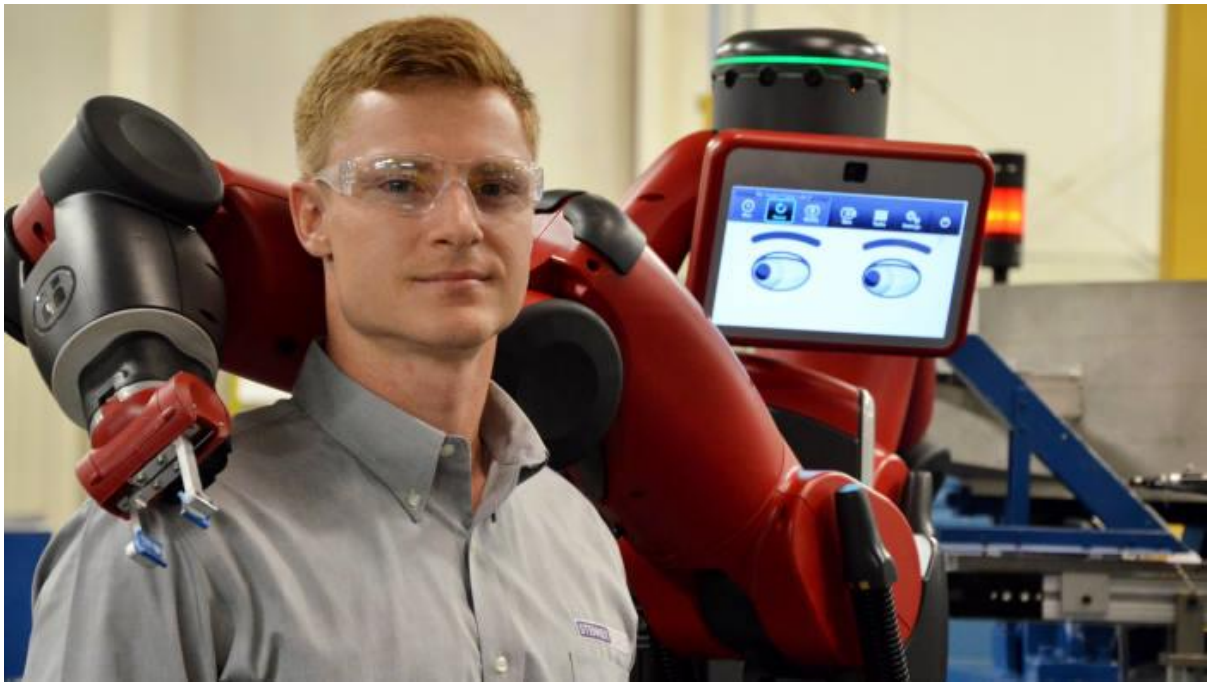
Robots In Manufacturing And Industry

Until recently, almost all robots used in manufacturing were of the heavy, expensive industrial variety which had to be fixed firmly to the floor and surrounded by a cage for the safety of human workers.

These robots are most commonly used in auto manufacture, heavy industry and large assembly lines. Typically, such robots cost $500,000 each and are used for heavy and dangerous tasks such as welding, painting and moving heavy objects. These “industrial robots” still make up 90% of all the world’s robot installations.

However, in the last few years a new generation of low-cost, flexible, easily re-programmable robots has been developed to work safely alongside human workers.

Often called “collaborative robots” (co-bots) or “soft robots”, these robots are sometimes mobile, sometimes fixed and typically cost between $30,000 and $50,000. US dollars.



Stationery co-bots often work on packaging and electronics assembly lines, moving items across conveyor belts, inserting products into boxes, inserting components into a circuit board, or carrying out quality control checks.

Usefully these co-bots can be quickly reprogrammed to perform new tasks, often by mimicking the actions and moves of a human worker.

Simply by taking a co-bot's mechanical arm and moving it as desired creates a new program which the co-bot will then continue to do tirelessly until stopped and reprogrammed.

The best known examples of co-bots are, Baxter by Rethink Robotics of Boston, Universal Robots of Denmark with the UR range and ABB's Yumi.

Over the next decade co-bots are going to appear in many manufacturing workplaces large and small in both the developed and the developing world. They are already displacing significant numbers of human workers.

Case Study – Foxconn, Taiwan

Foxconn, the world's largest electronic contract manufacturing company based in Taiwan has replaced more than half of its workforce with artificially intelligent co-bots.

Foxconn—known for manufacturing Apple iPhones, iPods and iPads as well as select products for Sony, Microsoft, Amazon, Dell, Google and Nintendo—laid

off 60,000 employees in May 2016, which reduced the workforce in a single Taiwanese factory from 110,000 down to 50,000.

This huge number of redundancies is the largest industrial layoff so far in the world that has been directly attributed to the introduction of automation.

But despite Foxconn's decision, Taiwan's unemployment rate in early 2017 is an incredibly low 3.97 per cent, and the redundant workers have a vibrant job market available to them if they wish to find alternative employment (although this may require relocation).

Prices of soft robots will fall further as production of fixed co-bots is ramped up (especially in China) and these gentle and flexible robots will rapidly gain new and improved functions and capabilities, which will displace more human workers.

These new abilities will include image and object recognition, improvements in sensory input (e.g. touch and hearing), improvements in vision systems (e.g. infrared and ultraviolet), better object and face recognition, improved gripping and lifting of delicate objects and, of course, improved scanning and data analysis for quality-control purposes.

A separate type of co-bot is fully mobile and is widely used in pick and packing operations in warehousing, and for moving goods around manufacturing facilities.

Case Study - Amazon

In 2012 Amazon.com bought Kiva Systems, the makers of warehouse co-bots, for $750 million.

It was another two years before Amazon deployed the Kiva co-bots in its warehouses but the company now uses Kiva mobile co-bots in 20 of its fulfillment centres in the USA and plans to roll the use of the co-bots out to its other 100 U.S. fulfillment centres that don't yet have them.

Warehouses in the rest of the world are also being supplied with Kiva co-bots as rapidly as they can be manufactured (and Kiva itself uses robots to manufacture more robots). A total of 35,000 Kiva co-bots have been deployed in Amazon facilities so far, and since purchasing the company, Amazon does not allow Kiva co-bots to be sold to other customers.

Amazon's Kiva co-bots don't replace human pickers and packers but, by moving the goods around the warehouse more efficiently, they reduce human walking time. Each Kiva robot weighs 320lb (145kg) and can carry the weight of a small car. These co-bots take their instructions by scanning QR codes

In mid-2016 Amazon said, "Kiva robots have cut operating expenses by about 20%, which translates to roughly $22 million in cost savings for each fulfillment center. "

The company also stated: "Cycle times have been cut from 60-75 minutes to roughly 15 minutes after deploying Kiva robots, while inventory space grew 50% due to smarter use of space, such as building narrower aisles or getting rid of certain handling systems."

These are huge savings and massive gains in productivity. Getting a 50 per cent increase in the usage of real-estate would alone justify the deployment of co-bots, but slashing the time it takes for a human to pick and pack an item by 75% makes the investment highly attractive. It is certain that Amazon's competitors and other warehouse operators will have noticed Amazon's results and will already be planning their own co-bot installations.

Now that Kiva no longer sells warehouse robots on the open market, new companies such as Fetch Robotics and Locus have spring up to build competing warehouse co-bots. We can be certain that warehouses and fulfillment centres all over the world are now placing orders for mobile co-bots.

But we are still only at the very start of the robot revolution. The productivity increases and the savings to come will be massive and will provide a huge boost for the world economy.

But what has been the impact on human employment at Amazon. Has the arrival of robots reduced Amazon's workforce?

In 2014 Amazon employed 154,100 humans worldwide.

In 2015 Amazon employed 230,800 humans worldwide.

In 2016 Amazon employed 341,400 humans worldwide.

So even as they have been rolling out mobile co-bots which have reduced operating costs at each fulfilment centre by 20 per cent, Amazon has been increasing the size of its human workforce by around 50 per cent a year. No Amazon "associates" – as the company calls its human staff members – have been laid off in any of the facilities in which Kiva co-bots have been introduced.

For Amazon, robots have created more wealth which has created more jobs for humans.

Of course, Amazon is an extreme case, a company famously fixated on perpetual growth. The real question is, how will smaller companies treat their human labour force as the cost of co-bots falls and more and more are installed?

Sadly, it is too soon to know for sure whether the owners and managers of smaller companies (those with less than 500 human employees) will deploy robots to increase productivity or to reduce the number of humans who are employed.

A couple of research studies have been conducted which suggest that in smaller companies co-bots are creating rather than destroying jobs, but these studies have been carried out by researchers funded by the robotics industry itself and must therefore be treated with caution.

There is also a significant amount of anecdotal evidence that most smaller companies are using co-bots to boost productivity rather than reduce head

count. But it is important to note that co-bots are so new in the market place that they accounted for only 5% of all robot sales in 2015.

To put it simply, it is too soon to tell whether co-bots in small and medium-sized companies will create jobs, destroy jobs or have a neutral impact on employment.

The question is important because SMEs are the largest contributor to GDP in almost all countries in the world. In OECD countries, small and medium-scale enterprises employ 60-70 per cent of the workforce and are responsible for a similar percentage of GDP output.

Imagine a small company that makes windows and double-glazing units, and that employs 250 people. The owners decide to invest in a couple of co-bots which can carry out repetitive tasks in making window-frames. The humans who were doing these tasks are used initially to train the new co-bots and are then temporarily assigned to other tasks.

After the co-bots have bedded down it is noted that production of window frames has risen by 20 per cent. The question is, do the owners or managers of the firm now let a few human workers go, or are the displaced workers still needed to handle the increased output?

The answer, of course, is that it all depends on sales volume. If the window manufacturer has lots of orders, the managers will keep the humans and invest in more robots. If sales are slow the managers might be tempted to make the displaced human workers redundant.

Low-cost soft robots will soon be found in manufacturing all over the world and production is increasing rapidly.

The worldwide collaborative robot market is expected to be worth $95 billion by 2024, according to January 2017 report by Transparency Market Research. This is an increase from $10 billion in 2015 – a ten times increase over a period of nine years.

Service Robots

Another category of robot is described as “service robots”, co-bots which are people-friendly and which work as waiters, hotel receptionists, hamburger cooks and which also take the guise of friendly, furry toys which are currently being used in Japan to provide company and comfort to lonely old people.

Today, service robots that are people-facing, like the hotel receptionists at the “ Henn na” – or Weird Hotels – in Japan are located near resort attractions and are primarily novelties, as are the waiters at some fast-food restaurants in China and at least one outlet of Pizza Hut in the USA. Today, these robots are there to make children and adults smile. In the future they will become more capable at carrying out specific tasks (e.g. taking baggage to a room).

Also in this category of “service robots” are the home robots which cut lawns, vacuum floors and perform other household tasks.

The fantasy concept of a general-purpose robot butler or housemaid is just that – a fantasy. But special purpose household robots built for single tasks (e.g. picking up clothes from the floor) will rapidly increase in number over the coming decade.

The question is, will service robots make human workers redundant? The answer is, almost certainly not. Humans want to interact with other humans in public spaces.

And jobs done by humans and which require them to smile and connect with other humans as part of their duties are safe from replacement by automation.

Driverless Vehicles

Will self-driving cars, trucks and busses make professional drivers redundant?

The media often suggests that autonomous trucks and cars will make professional drivers redundant and it is true to say that if such drivers were displaced, they would have to re-train completely in order to get alternative employment.

The problem for such workers is that few medium-skilled jobs offer the same sort of salaries now earned by long-distance truck drivers, which is typically $40-$60,000 per year in the USA. It must also be said that automation will itself start to impose wage restraint in the trucking sectors and in almost every sector in which automation is deployed, which will mean that securing a job which is as well paid as today's truck driving jobs may prove very difficult.

The numbers of humans employed driving vehicles – trucks, buses, cars – is huge.

in the USA alone there are around 3.5m long-haul truck-drivers. When all trucks are self-driving, it would seem that they will be thrown brutally out of work.

But things aren't quite so simple. In the time frame we're considering (the next 15 years) it is likely that most trucks on the road will have reached what is called "Level 4 Autonomy", which means they can drive themselves but they will require human supervisors to be in the vehicle at all times.

Full "Level 5 Autonomy" (fully self-driving without human presence) will also have been achieved well before 2030, but because most public roads will be in mixed use (they will be available to both semi-autonomous vehicles and manually-driven vehicles), it is likely that vehicles will still be limited to driving at Level 4 autonomy (i.e. with humans present).

And demographics suggest that in some nations, truck drivers will be retiring naturally by the time Level 5 arrives. (It stands to reason that as self-driving trucks start to appear on the roads far fewer new drivers will be entering the profession.)

In the USA, the average age of a long-haul driver is now 49, and around 90,000 drivers leave the industry every year, half of them though retirement.

Today the American trucking industry thinks it has a shortage of around 50,000 drivers, and that number is increasing - people are leaving the trucking business faster than they can be replaced.

Truck driving can be an unhealthy, uncomfortable job with a difficult lifestyle. Hence, on these numbers, over half the current driver base in the USA will have left in ten years, around the time that most people think full, Level 5 autonomy might be arriving.

In the short term, Level 4 autonomy in vehicles makes the job of a “truck supervisor” more attractive, since such supervisors can rest in the truck until they’re needed to supervise instead of having to stop to rest at mandated times.

But on a 20-30 year view effectively all of America’s current truck drivers will have quit or retired anyway – they won’t be replaced, but few drivers will be directly put out of work.

This demographic pattern is likely to be different in different nations, and different in the developing world. Each workforce will have its own demographics and will therefore face different options.

In inner city areas, university campuses, airports and industrial parks self-driving cars and buses will be operating by 2025, which is likely to displace some bus and taxi drivers, but these areas will be small and strictly controlled. In the time frame we are considering the impact of self-driving on total human employment is likely to be relatively small. After 2035, it is likely to be a different story.

Drones

And then of course we must consider the impact of drones. Drones are already widely used in agriculture, photography, surveying, security, rural deliveries, defence and property maintenance. Amazon has been developing

drones to deliver packets and parcels for some years, although regulatory restrictions have so far prevented commercial deployment.

It is too early to be able to estimate the likely impact of drone deployment on human employment but it may be significant in small niche areas, e.g. it could lead to a reduction in human workers required to inspect pipelines or to plant agricultural crops.

But, overall, the impact on general employment from the deployment of drones is likely to be limited.

Will A.I. Replace Office Workers and Professionals?

Much media attention has also been given recently to the idea that “white collar” workers will also soon be made redundant by A.I. systems.

Headlines suggest that powerful A.I. systems and big data analysis will soon hollow out back-office staff in banks, insurance companies and government services.

In some ways office staff seem to be more vulnerable to “technological unemployment” than manufacturing workers and some displacement of clerical workers is already occurring.

The best-known “brands” in A.I. are: IBM’s Watson (which famously wins gambling games and TV quizzes) and Google’s DeepMind (which is already deployed in the U.K.’s National Health Service).

And, at a less powerful level, the chat-bot assistants Apple’s Siri, Microsoft’s Cortana, Amazon’s Alexa Echo, Google Home and, most recently, Samsung’s Bixby.
Although a cute novelty, the conversational skills – or lack of them – within these voice-activated personal assistants quickly reveals the true shallowness to today’s A.I. systems.

Case Study - Fukoku Mutual Life Insurance

In insurance companies and banks risk assessment algorithms and other A.I. systems have started to replace human underwriters and loan managers.

Three months ago an insurance company in Japan made 34 human workers redundant when it installed IBM's Watson A.I. that can calculate payouts to policyholders.

The insurance company believes it will increase productivity by 30% and see a return on its investment in less than two years. The firm said it would save about one million pounds a year after the £1.4 million A.I. system was installed.

And in legal services, A.I. and automation threatens to displace human paralegals and junior lawyers in tasks such as contract revisions (in which multiple drafts of contracts have to be compared), searching for legal precedents, in due diligence searches and other types of "grunt work" which have traditionally tied up thousands of hours of juniors' time.

But in legal firms this is unlikely to lead to mass redundancies in the short-term. It simply frees lawyers and paralegals to spend more time on decision-making, writing, negotiating and litigating and other more valuable and more highly-billed work.

Case Study – Accenture

In early 2017 the financial services group and consulting firm Accenture announced that it had automated 17,000 back-office staff jobs without making a single layoff.

By retraining staff, employees were able to remain in the group without the need for layoffs. At the same time, automation helped the company to streamline processes and improve overall productivity.

Additionally, because automation replaced boring and repetitive tasks, allowing workers to progress to more complex tasks, Accenture thinks it may end up increasing worker satisfaction overall.

In automating jobs without making redundancies, Accenture has taken heed of its own advice. In a new report, "Harnessing Revolution: Creating The Future Workforce", the authors say:

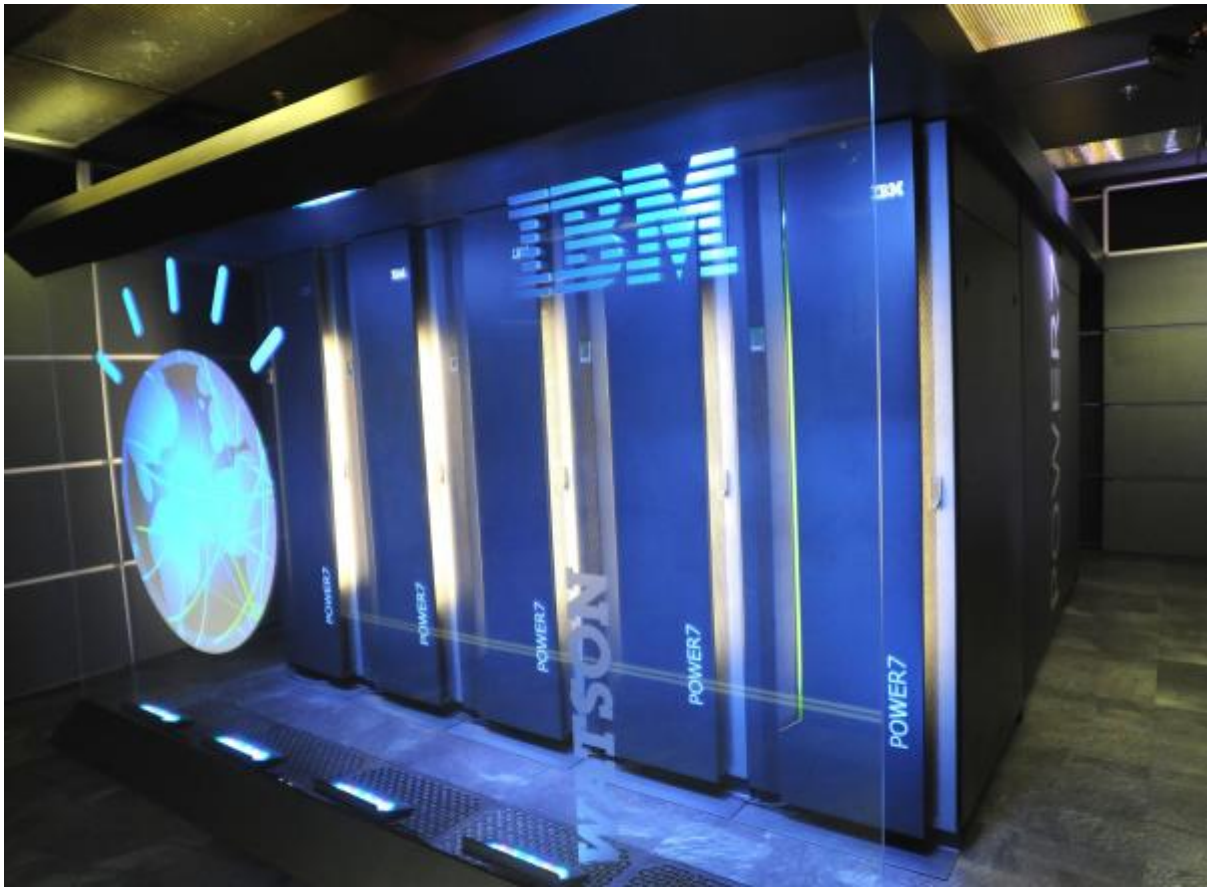
"In the UK, jobs that are at risk of being lost to automation could be reduced to less than 6% if companies work to reallocate employees and retrain them in future-appropriate skill sets. In Germany, job loss could be reduced to 10% and in the US to 4%."

Accenture does not anticipate mass layoffs because of automation in the foreseeable future.

A.I. In Medicine and Healthcare

The healthcare profession is one of the most advanced in using artificial intelligence systems to boost productivity.

Today, IBM's Watson is working to diagnose cancer by comparing millions of normal and abnormal body scans, to personalize cancer treatment by analyzing tumour DNA and smoothing administration in healthcare systems.



Google's DeepMind (a U.K. start-up purchased by Google in 2014 for $400 million) is working in Britain's National Health Service and a leading hospital recently announced that the system is "saving nurses two hours a day".

But will A.I. cause widespread redundancies in health services? In this sector, the answer is almost certainly no. Health systems in general are so understaffed that the efficiencies brought about by automation are gratefully received. In the UK alone there are 24,000 unfilled job vacancies for nurses.

A.I. systems that can quickly examine thousands of body scans free up pathologists and doctors to research new methods of detecting diseases and provides healthcare professionals with more time to deal with patients. A.I. systems can also suggest diagnoses to doctors giving them the time to treat more patients.

There can be less certainty about the long-term job security of family doctors. Digital health tools are giving patients their own health monitoring systems and app-based medical services are providing doctor appointments via smartphones. But even as digital health technology democratizes primary healthcare, the demands made on family doctors are so great that I judge their jobs to be safe for the next 15 years at least.

Conclusion

In the next decade-and-a-half, millions of human workers will be displaced as robots, automation and A.I. systems enter the workplace. But I think it likely that the majority of displaced workers will be able to find alternative employment either with their existing employer, or elsewhere.

I am also confident that this sudden onslaught of automation will rapidly boost national and global wealth which, in turn, will offer many new job

opportunities for humans. And as we have seen, many of the jobs created will be totally new types of job, jobs which we can't yet imagine.

But wage restraint will be a significant side-product of increasing automation. As human workers are displaced they are likely for the foreseeable future to be able to find alternative employment, but the prospects of regular, significant pay rises for most workers have disappeared.

(Paradoxically, wage restraint will serve to *slow down* the spread of automation. While human labour remains relatively cheap, the economic incentive to introduce A.I. and robots to the workforce is reduced.)

As machines increase productivity (and simultaneously hold down wages) we will increasingly see the new economic paradigm of high productivity with low inflation becoming the new norm.

In recent years, economists have been struggling to understand this new phenomenon and I have come to the conclusion that the introduction of automation and digital technologies into our economies has shown up the deficiencies of current economic measurement methods – most particularly the measure known as Gross Domestic Product (GDP). Digital technologies are creating many economic efficiencies in business and society which are simply not included in today's GDP measurements.

To put it simply, we are currently undervaluing the economic output of most national economies.

After the mid-2030s I think it likely that there *will* be significant "technological unemployment" and millions of humans will indeed find themselves without work.

In the transition period there will be two sorts of humans employed, those who tell computers what to do, and those who are told what to do by computers. Soon afterwards, only the most highly skilled, creative and talented humans will find paid work.

Whether automation will have produced sufficient wealth to allow governments to pay millions of unemployed humans a "universal wage" is impossible to know. It is also a political decision that governments will have to make.

One proposal I made a few years ago is that robots and A.I. entities should be taxed on the output they generate, money which could be used to provide a living wage to the humans displaced by machines.

But even if humans are paid well just to be at permanent leisure, I am worried whether those humans of working age in the years beyond 2040 will be able to find purpose and meaning to their lives in a future without work.

Ends

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