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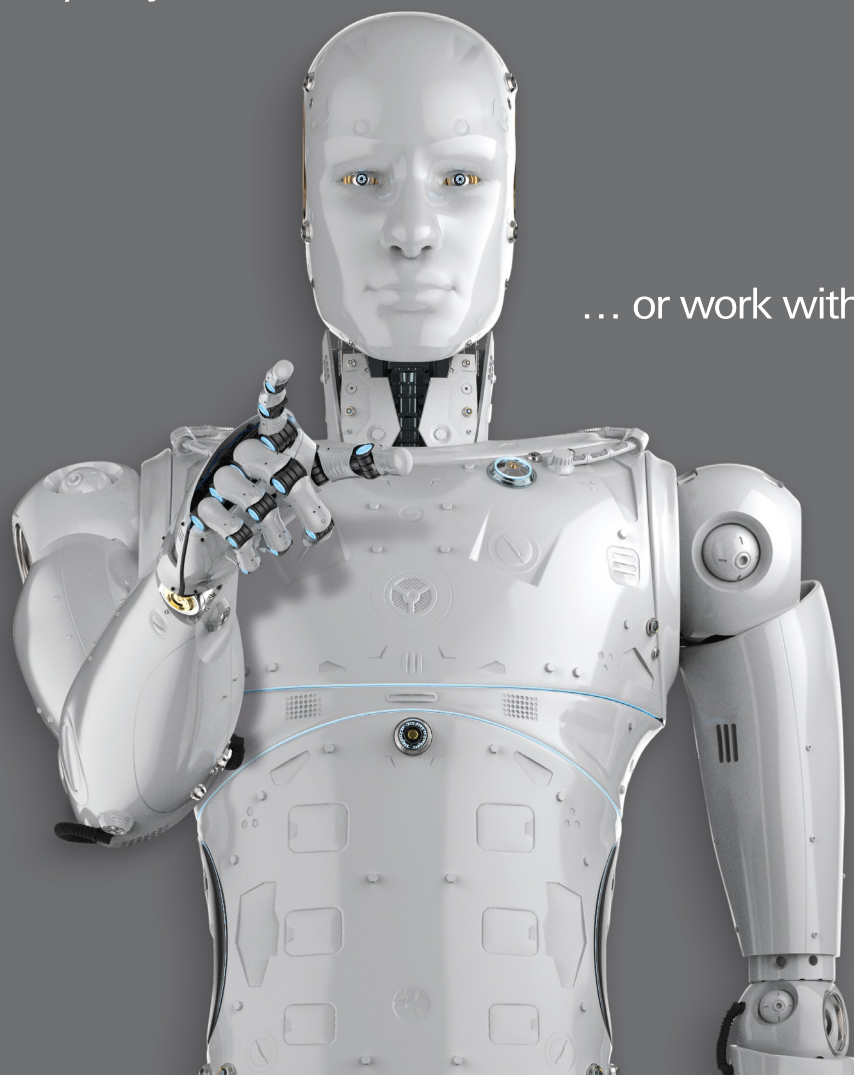
Automation – not a job killer

Will I take your job …



… or work with you?

June 2018

13

Cover story
Automation – not a job killer

About 250 years on from the first industrial revolution, we appear to be on the brink of a new age of automation, one dominated by complex robots and artificial intelligence. In this issue, we examine the impact of the next generation of automation on workers, industry, and society at large. Evidence from history, economics, and our industry analysts suggest that robots are more likely to complement us than replace us.

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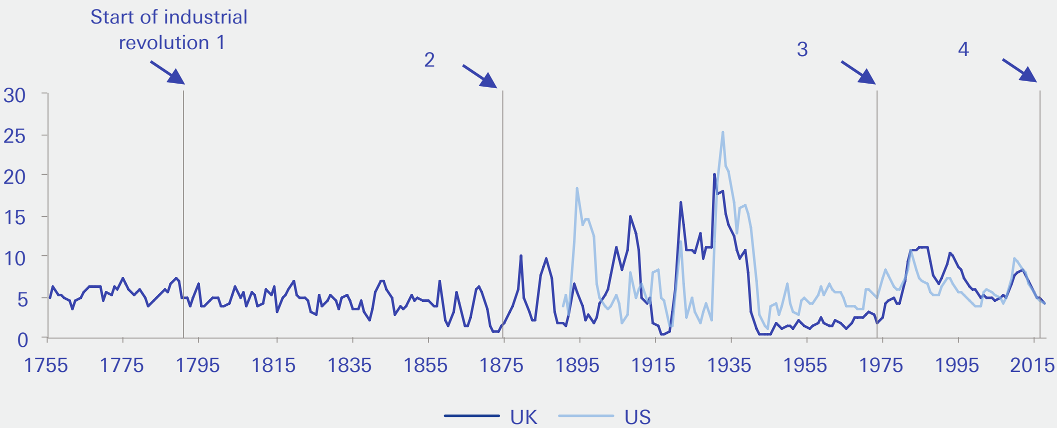
Editorial

Over the last couple of years I've been very vocal about my view that a surge in the global labour force between 1980 and 2015 has been the main cause of depressed real wages, repressed inflation, high corporate profits and even the rise of populism. This has been amplified by China integrating itself into the global economy – for the first time in centuries – with a huge pool of cheap workers. This helped apply downward pressure on pay in an increasingly globalised workforce. However, the growth of the labour force in the most economically important areas of the world is now levelling off, including in China, and will likely decline in the years and decades ahead.
As such, I believe we will look back on the middle of this decade as the turning point for the post-1980s relationship between capital and labour. Workers will finally get some pricing power back.

Despite this optimistic assessment, in almost every client meeting where I've espoused this view, there has been a strong counter that automation or robotics is on the brink of adding to the woes of the worker. People are scared that wages and inflation will stay structurally low. Whilst their argument is understandable, it doesn't stand up to the scrutiny of history.
We are now over 250 years on from the first industrial revolution, which began around 1765, while economic literature has proclaimed a second and third starting in 1870 and around 1969 respectively. The question is, are we on the brink of a fourth revolution – one dominated by robots and automation? If so, will it really have a different impact on workers than the previous three? A look at the unemployment rate in major economies through this quarter-millennium period suggests that the parade of constant (and mindboggling) labour saving improvements has had no structural long-term impact on the unemployment rate. The types of jobs may change, causing understandable stress for those impacted, but automation should open up new employment areas and the economic progress seen over the last 250 years should continue.
If we are correct that there will be fewer workers to share that progress, then wages should structurally rise in real terms.

Long-term US and UK unemployment impacted by cycles not "labour destroying" industrial revolutions



Source: Deutsche Bank, GFD

There are differences with this coming automation revolution. Today's robots are automating cognitive tasks rather than the physical tasks they have done in the past. But given the weight of historical evidence in favour of automation, the burden of proof should lie on those who argue against automation improving our lives rather their those who embrace it in the hope of higher living standards.

So we say, learn to love your robot colleague. In this edition of Konzept we look at the future of automation from different angles. Our cover feature expands on the macro-economic discussion but a common thread throughout is that robots and automation will complement humans and make the world a different place. They will not destroy the fabric of work. One statistic to consider: In 1907, Britain had 40,000 cars on the road. By 1939, this had risen to 2,000,000. Today, it is ten times that number. Could robots be the 21st century version of the car?

Summaries of all the pieces are included at the front as a taster. We hope you enjoy the magazine and, unless a robot has replaced us, we'll be back in the autumn.

Jim Reid
Global Head of Fundamental Credit Strategy and Thematic Research

To send feedback, or to contact any of the authors, please get in touch via your usual Deutsche Bank representative, or write to the team at luke.templeman@db.com and sahil.mahtani@db.com

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Summaries

Tomorrow's robots and economic history – Not a job killer
Jim Reid, Luke Templeman, Sahil Mahtani

In recent years, a fear has risen that automation will destroy jobs and lower incomes. There is, in fact, little historical evidence for these concerns. Automation both destroys and creates jobs, and human beings have adapted to productivity improvements by finding ways to complement machines, which have boosted living standards. It is true that automation has hollowed out the middle, both in jobs and wages, and certainly overall wage growth has not been as strong as many would like. But these declines in the labour share of income have more to do with the rise of China, growing market consolidation, and expensive real estate than automation.

Industrial internet of things – Data over design
Felicitas von-Bismarck

Investors tend to fawn over the automation-related efficiency gains achieved in the car industry. But it is easy to make the mistake of thinking this success story is easily replicable in other industrial settings. Take the warehouse industry. The rise of e-commerce has led to demand for more sophisticated logistics. Yet the degree of automation in most warehouses is quite low as it is still too expensive and structurally unreasonable to upgrade existing infrastructure with the best available robotics. For capital goods manufacturers to convince customers of the value of their products, they will have to provide more data-driven services derived from sensors inside machines.

Chinese automation – How to beat the demographic hangover
Zhiwei Zhang and Yi Xiong

As China’s labour force shrinks and labour costs continue to rise, the country is quickly turning to automation and robotics to maintain its industrial edge. It has a long way to go and the gap between it and more developed-world markets should fuel strong demand for automation for the foreseeable future. Consider that China has just 68 robots per 10,000 workers. Even if China absorbs 30 to 40 per cent of global robotic production, it will take a decade to reach a density of 200, and that will still be far below the 300 in Japan and 600 in South Korea.

Machine vision – 3D cameras eye a new application
Karen Lau

If robots are going to perform more sophisticated tasks, they need a more sophisticated pair of eyes. That comes in the form of cameras that can see in three dimensions, taking machine vision to the next level. The technology is expensive, about ten times the price of a two-dimensional camera. But when it is combined with deep learning technology, it allows robots to handle tasks where objects may not be standardised in appearance. Facial recognition is one key application, sorting defective products is another, with a particular application in agricultural settings where produce varies widely in appearance.

Remote mining – Just warming up
Matthew Greene

Pick-and-axe style mining is giving way to video game mining, where technicians in air-conditioned offices in a far-off city manoeuvre driverless trucks and automated equipment remotely. But this transition is only in its early stages and will likely take years before it becomes the norm. The upfront costs are high, and the process of automating a mining operation is highly disruptive to ongoing operations and profitability. Paradoxically, it may take a collapse in commodity prices or a major slowdown in China to spur a more rapid transition to automated mining.

Climate change – The automated shift to clean energy
Caroline Cook and Tim Rokossa

Automation lies at the heart of the drive away from fossil fuels, not just by helping technology in its own right, but as an accelerator of utilisation and uptake. For starters, automated sensors connected to the internet of things are helping reduce absolute demand for energy. Another example is through increasing the utilisation of electric autonomous vehicles as the average car is only in use around five per cent of the time. To boost this, a connected platform that makes hailing a car for a variety of uses is necessary to encourage people to give up their own car.

Low-wage outsourcing – The factories will stay put
John Chou

As wages rise in many emerging countries, pressure has increased on the world’s largest apparel makers to move production to lower-wage locations. Similarly, many have talked up the prospects for re-shoring as recent automation developments have limited the labour needed on a production line. But large-scale moves from existing locations are unlikely.

Significant investment has already been made in sophisticated factories in existing locations, and there are few lower-wage countries that do not come with difficult political risk or a lack of professional management. Customers will be the winners as much as manufacturers as automation allows for new and different products to come to market far quicker than in the past.

Robot taxes and the safety net – Navigating to utopia
Sebastian Becker

As with prior automation revolutions, societies are right to question whether the market can distribute the rewards of automation equitably across society. If not, governments will have to intervene and to do this, there are several ideas. A robot tax could slow the speed of automation while a universal basic income could ensure displaced workers are not left impoverished. Yet both these ideas have serious flaws that could lead to lower productivity and a decrease in the labour supply.

Populism – Not the enemy of automation
John Tierney

Several strains of populist governments have come to power around the world in recent years. But although these governments claim to represent displaced workers, populism is not necessarily the enemy of automation. Indeed, it frequently seeks to extend the benefits of industrialisation and automation to a broader population. Yet, if the problem of displaced workers grows, it is essential that productivity rises to provide the tax revenues and fiscal headroom necessary to support them. The new wave of automation may help boost productivity levels that have been lagging historical levels for several decades.

Leisure productivity – Mismeasuring the tech boom
Dominic Konstam

Gross domestic product may be the standard measure of economic well-being, but a broader measure is welfare, or the sum of GDP and consumer surplus – the difference between what consumers pay for goods and what they might be willing to pay. Automation and technology have given companies a unique ability to profile customers and determine their willingness to pay, potentially transferring the consumer surplus to corporate profits. Yet amidst these concerns, it is easy to forget that automation and technology will likely greatly expand overall welfare and the quality of leisure time. The extent to which transfers to profits do not occur can be thought of as a new concept– "leisure productivity."

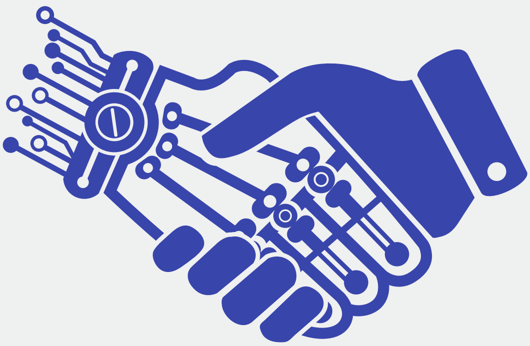
Emerging markets – From robots to co-bots
Michael Spencer

Many people tend to associate robots with big industrial machines found on the factory floor. But another emerging class of robots is designed to work with and collaborate with people –'co-bots'. Asian countries and especially China are taking the lead in co-bots and the striking parallels with the development of the smartphone suggest low-priced co-bots could allow for a 'technology skip' in emerging markets, potentially boosting productivity and output.
As a result, the rise of robotics is not the threat to emerging market economies that it has been made out to be, but rather an opportunity for further development.

Japanese automation – The leader in complexity
Takeshi Kitaura

Japan is emerging as a leader in the rapidly growing market for industrial robots, which is projected to grow 16 per cent annually in the coming years. Yet, since the financial crisis, Japan is the only country to reduce its robot density as a proportion of workers. Paradoxically, this is because it has developed far more productive robots. With China ramping up its 'Made in China 2025' plan, its need for robots is accelerating and Japan is poised to become a major exporter of this technology.

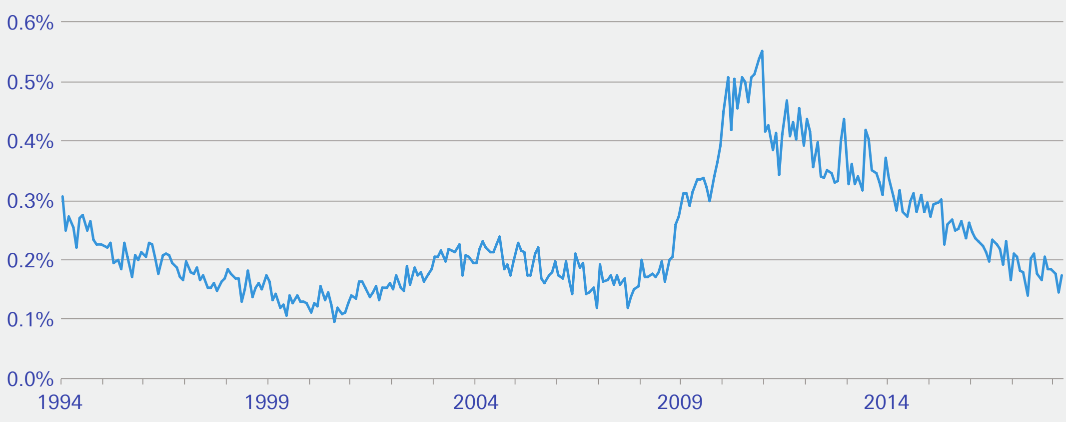
Tomorrow's robots and economic history – Not a job killer



Anxiety about job-killing robots has a long pedigree. In 1589, Queen Elizabeth I refused to grant the inventor of a mechanical knitting machine a patent lest it put manual knitters out of work. Some 400 years later, Queen Elizabeth's fear is still with us. Not a day goes by without several articles on the future of work, the rise of precariousness, and wage stagnation. The fear is that we are entering a new age in which robots are mastering not just physical abilities, as in the 19th and 20th centuries, but also cognitive abilities, leaving humans with increasingly little to do.

The popular perception differs sharply from the view of historians and economists. Those often warring tribes have typically been united in their response to these concerns. The unanimous answer seems to be: far from destroying jobs, automation makes them better; far from decimating wages, automation boosts them; and

Proportion of the US workforce that is "discouraged" from jobseeking



Source: Haver Analytics, Deutsche Bank

Jim Reid, Luke Templeman, Sahil Mahtani

far from making the world a worse place, automation should be welcomed.

In our view, the latter argument is probably right as automation allows people to find jobs that complement the tasks robots can now do. In other words, every time a machine is invented, human beings become more powerful. For example, a financial analyst can use Microsoft Excel or Python to transform the task at hand.

At the very least it should be clear that some of the crudest fears about automation are wrong. The unemployment rate in many western countries sits around multi-decade lows despite advances in automation and technology.

If robots killed jobs with any finality, unemployment would be much higher. After all, automation in some form or another has been happening for at least the last hundred years. Employment-to-population ratios, which factor in a wider view of unemployment than conventional measures, are down in OECD countries since the financial crisis but are no lower than they were in the early 1990s (and are up in some countries; the UK's is at its highest level since records were collected in 1971).

Furthermore, in the US, the natural rate of unemployment hovers close to its all-time low. And while it is true that the participation rate has fallen from 67 per cent to 63 per cent over the past two decades, the proportion of people who are not looking for a job because they are discouraged is just 0.18 per cent of the population older than 16 years. That rate has been declining steadily since the financial crisis and is now close to its 25-year average. That suggests automation has not demoralised the work force yet.

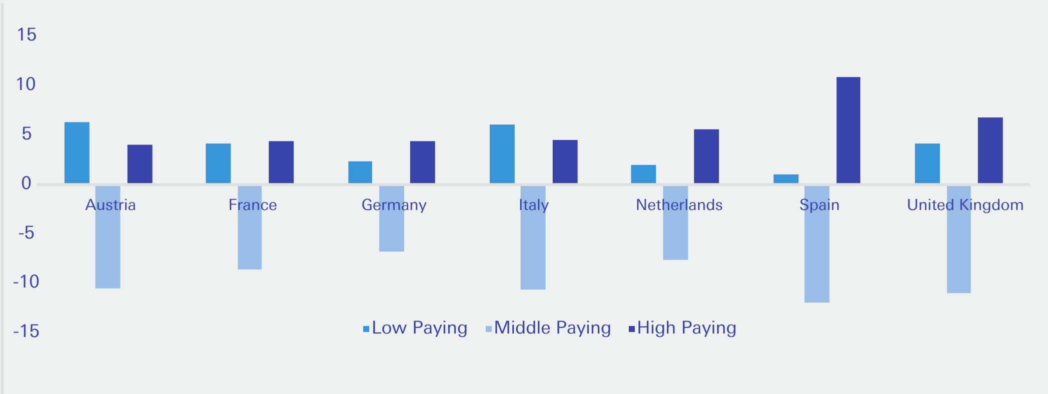
So what are the more realistic ways in which we should be concerned about automation? After all, even with history on his side, it is understandable that a worker may be concerned about the risk of job displacement, or about whether a new job will be low-paid. He could point to data showing real wages having been stagnant for years. He could cite many new media reports about developments in robotics and artificial intelligence. Or indeed the economic studies that have estimated that between one-third and one-half of jobs may be automated in the near future.

As for the claim that automation, robots, and artificial intelligence will destroy up to one-half of jobs, it is worth looking at the assumptions behind the scary figures. An OECD study recently argued that most of the jobs at risk of being automated still have significant elements that are far out of reach of automation—for example, the need to negotiate complex social relationships, creativity, or carrying out tasks in an unstructured work environment—and therefore must still be performed by humans. The OECD study uses new data which accounts for the differences between workers with the same job title, and as a result has credibility. Taking this into account, it is likely that only nine per cent of jobs in OECD countries will be eliminated by automation over the coming years. Automated processes, therefore, will complement, rather than eliminate, jobs and make workers more productive.

One supportive anecdote for this argument comes from the UK, where the number of accountants has doubled as a proportion of the workforce over the last forty years, according to Deloitte estimates, even though there have been incredible advances in automation and technology in the sector.

Of course, aggregate numbers can disguise sub-groups that are adversely affected, but this does not appear to be happening. First of all, many low-skill jobs, staffed by some of the more vulnerable people in society, are not close to being at risk from automation. In fact, for most periods since 1979, low-skilled occupations have experienced higher growth in employment share than all but the very highest of skilled occupations. For instance, in Europe between 1993 and 2010, nearly every country saw low-paying and high-paying occupations increase

Changes in occupational employment shares in low, middle and high-wage occupations in 7 EU countries, 1993-2010



Source: Goos, Manning, and Salomons (2014, table 2)
Notes: High-paying occupations are corporate managers; physical, mathematical, and engineering professionals; life science and health professionals; other professionals; managers of small enterprises; physical, mathematical and engineering associate professionals; other associate professionals; life science and health associate professionals. Middle-paying occupations are stationary plant and related operators; metal, machinery, and related trade work; drivers and mobile plant operators; office clerks; precision, handicraft, craft printing, and related trade workers; extraction and building trades workers; customer service clerks; machine operators and assemblers; and other craft and related trade workers. Low-paying occupations are labourers in mining, construction, manufacturing, and transport; personal and protective service workers; models, salespersons, and demonstrators; and sales and service elementary occupations

employment—the middle-paying were the casualties. This means, at least, that lower-skilled people are unlikely to lose their jobs to automation. At the other end of the spectrum are high-skilled workers. These people, too, have less to fear from automation as they work in roles that require significant cognitive input, something that is still very hard for machines to replicate, despite the advances in artificial intelligence.

It is middle-skilled jobs that have been most negatively affected by automation. By way of example, official statistics show that since 2000, sales and office roles (which are canonically middle-skilled occupations) saw job losses of seven per cent. In contrast, service jobs (which tend to be low-skilled) and management jobs (which tend to be high-skilled) experienced growth of 27 and 36 per cent respectively. So while the middle has hollowed out, more people have moved up the skill ladder than down.

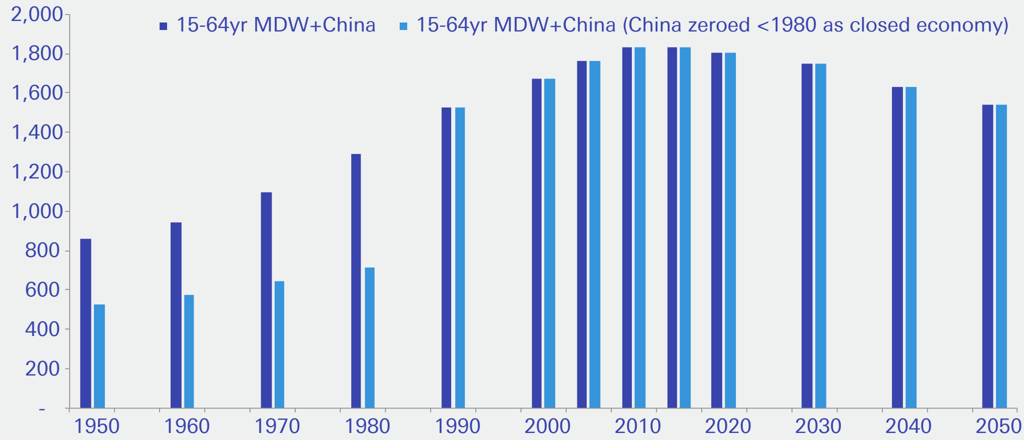
But if more people are working in low-skill jobs, won't wages be supressed? This question raises significant concerns, particularly if the hollowing out of middle-skill jobs results in a polarisation of wages. Yet the picture is much more mixed.

On the one hand, wages for the bottom wage quintile have certainly trailed those of the top quintile. Between 1979 and 2016 hourly real wages shrank by one per cent for the bottom 20 per cent compared to growth of 27 per cent for the top 20 per cent.

However, occupational percentiles paint a more mixed picture. Labour economist David Autor ranked all occupations from lowest to highest by their initial skill level, as measured by their 1979 mean hourly occupational wage, and sorted them into 100 percentile units. Then Autor plotted their changes in wages over the subsequent decades. While the middle group of occupations always experienced slower wage growth compared with the top quintile of occupations, the bottom quintile actually saw faster wage growth in the years between 2007-2012 and between 1989 and 1999. In other words, the middle group of occupations were always being hit relative to the top quintile between 1979 and 2016 but the lowest occupations were only sometimes experiencing lower relative wage growth. What explains the difference? Wage growth by occupational percentile is less concentrated than wage growth across wage percentiles because the highest earners are found across a variety of occupations.

While technology and automation have clearly played an important role in recent economic growth, the capital stock figures suggest they cannot explain the recent declines in labour share.

Labour force of More Developed World (MDW) and China (in mln)



Source: Deutsche Bank, UN Population Division

Even if one wanted to blame automation for the observed decline in middle-skill occupations, it is undeniable that the years between 1980-2015 saw extraordinary one-off developments: China's re-emergence into the global economy, the collapse of the Soviet Union, and the economic liberalisation of India in 1991. The combination of all these three things has integrated over a billion cheap workers into the global economy, increased labour competition and, on balance, pushed wages lower. It is therefore difficult to isolate the impact of automation in the data above. In particular, the size of the Chinese working age population integrated was roughly the same size as the entire combined workforce of the more developed world. This quantity of new workers hitting the workforce no doubt contributed to the decline in labour's share of economic output in parts of the developed world. Yet this was a one-off event and in fact, globalisation should prove a tailwind in the coming years as the pool of labour integrated into the global economy begins to shrink. Indeed, between 2015 and 2050 China's working age population will shrink by about 250 million.

Given the context, the underperformance of middle-skill occupational wages seems understandable and the outperformance of US low-skilled occupations during much of that period downright remarkable. Autor suggests that the outperformance of low-skill workers relative to middle-skill workers is likely because the demand for manual labour is income elastic, so as automation drives higher incomes in some quarters, there is a corresponding increase in the demand for services and the rates of pay for these workers. Whatever the reason, it is happening.

Fears of a widening polarisation of society based on jobs therefore seem overblown. Although middle-skill jobs are indeed being reshaped, wage growth for low-skilled workers is outpacing all other roles except for the very highest-skill workers. If this trend continues, the gap between the two groups will shrink, not grow.

Delving further into history provides a further rationale for why we should be cautious about the idea of perpetual proletarianisation. This is the idea that while automation may cause aggregate productivity to increase, it causes wages to stagnate, and income inequality to rise as profits increasingly go to the owners of capital

This was a world first described by Friedrich Engels in 1845, when he wrote Conditions of the Working Class in England in 1844: "since the Reform Act of 1832, the most important social issue in England has been the condition of the working classes, who form the vast majority of the English people…what is to become of these propertyless millions who own nothing and consume today what they earned yesterday?...The English middle classes prefer to ignore the distress of the workers and this is particularly true of the industrialists, who grow rich on the misery of the mass of wage earners."

In the mid-19th century, that observation seemed close to the truth. Output per worker had exceeded wage growth in Britain for all of Engels' short life—he was 25 when he wrote Conditions. Between 1760 and 1800, real wages in Britain grew slowly (0.39 per cent per annum) but so did output per worker (0.26 per cent).

Between 1800 and 1830, however, the famous inventions of the industrial revolution came on stream and boosted output per worker to 0.63 per cent while real wages did not grow at all. Between 1830 and 1860, output per worker rose to 1.12 per cent and real wages finally started to pick up, to 0.86 per cent annum. Only later, between 1860 and 1900, did real wages surpass output per worker, with the former growing at 1.61 per cent against the latter's 1.03 per cent. Unsurprisingly, productivity, which grew at 0.69 per cent between 1800 and 1830, quickened to 0.94 per cent between 1830 and 1860.

Perpetual proletarianisation proved to be temporary proletarianisation, and workers benefited from economic growth, thereby establishing the modern pattern of output per hour growing in line with productivity. From 1760 to 1870, the labour share of output declined, from 60 per cent to 45 per cent. But over the next 30 years it rose back to 60 per cent. True, the long period of time this took is enough to upset even the most patient worker, however, this was the beginning of the world's experience with large companies and their owners wielded far more power than they do today. Employees had few legal rights or protections, workers councils did not exist, and unions were sparse to non-existent as was collective bargaining and state welfare. Ironically, Marx and Engels published The Communist Manifesto in 1848, just as labour's share of income had started to catch up to capital's share.

What did Marx and Engels get wrong? When economic historian Robert Allen, who coined the phrase "Engel's Pause" to describe the period from 1800 to 1830, looked at the data, he found that the ratio of capital to labour was weak during the first period of the industrial revolution—the period of Engel's pause—but stronger during the period of wage growth.

Allen suggested this was because there was a low elasticity of substitution between capital and labour in the first period. In other words, there was not enough scope to make investment in the first part of the industrial revolution. At the plant level, production processes had not advanced sufficiently to scale up despite the falling price of inputs like cotton and energy.

Only later was extra investment made in capital stock which translated into higher productivity factory work that began to replace the crafts trade at scale. By 1850, Britain was the "workshop to the world." At that point, as Allen points out, it "set the stage for the most sustained rise in real wages ever seen."

Could something similar be at work today? When Thomas Piketty wrote about the rise of capital over labour in his 2013 book Capital, he noted similar trends in the last 40 years to those Allen noted in the first half of the 19th century: high productivity despite little growth in real wages, income inequality, and low rates of investment. If history does rhyme, perhaps the years between the 1970s and today will eventually be described as "Piketty's Pause."

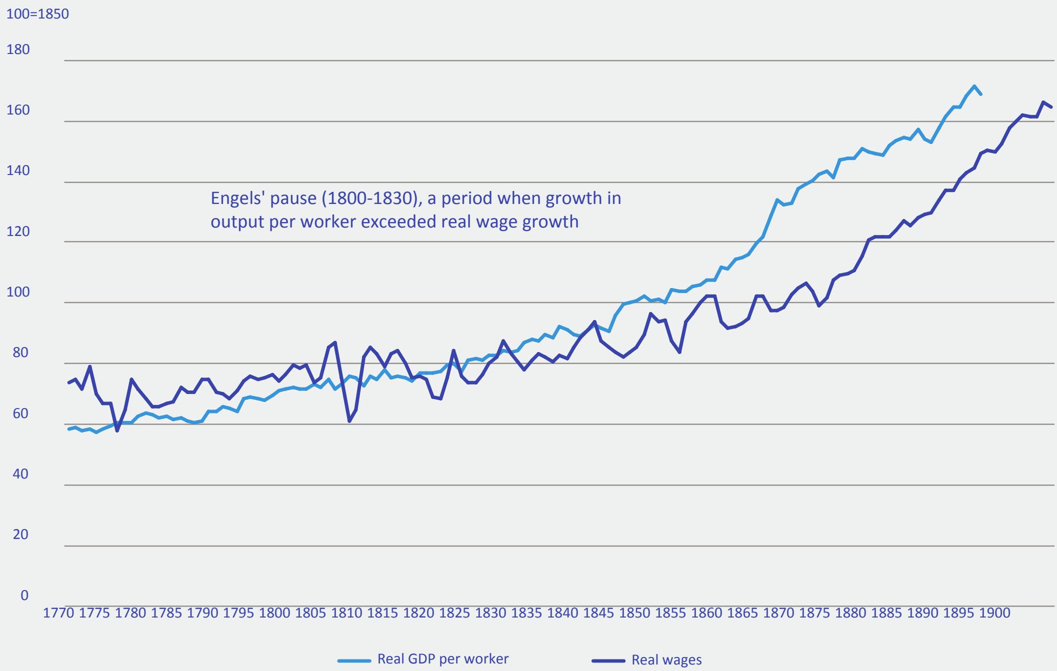
Why is not enough investment being made? Just as Engels' observations were reasonable, so too are Piketty's. Piketty's book mainly highlights the rise of capital's share of output. In advanced and developing economies alike, the share of national income received by labour (as opposed to capital) has declined steadily over the last thirty years, just as it did in the 19th century.

This trend began well before the Great Recession, with the biggest break starting from around the 1970s. Between 1947 (when data begin) and 1969, the US average labour share was 63.9. Since then, it has averaged 59.9. Since 1990, it has averaged 57.9. Just as in the 19th century, economic growth per worker outstripped growth in real wages.

The United States is not unique. Research on other countries has found similar declines in the labour share. Between 1990 and 2009, the median labour share in OECD countries declined to 62 per cent from 66 per cent. Even in emerging economies, where labour shares have been more variable, they show a clearly declining trend since the 1990s, when data become available.

Declines in labour share of output are the most important reason why real wages are falling. Mathematically, real wage growth is a function of two things: changes in productivity and changes in the share of national output attributed to labour.

Pickup in real wages lagged productivity in the first industrial revolution 1770-1900



Source: Bank of England

If the share of economic output going to workers doesn't change, then real wages simply track productivity. But of course labour shares have declined. If the labour share had remained the same, American workers would be receiving an extra $1 trillion per year. Instead, that money accrued to capital holders, who are concentrated in the upper end of the income spectrum.

Why is the labour share in decline? Some have argued that declining labour shares are due to offshoring to low-cost producers. But the decline in labour share of income is a global phenomenon, visible not only across the North Atlantic but also in China. And the labour share has fallen in both tradable and non-tradable sectors. Offshoring, then, cannot be the primary cause. Others have argued that declining union membership has contributed but empirical studies have found limited correlation here.

Automation, then, may seem a more convenient culprit. Yet as Northwestern economist Matt Rognlie has pointed out, robots and automation—broadly defined—are a tiny part of US capital stock by value, worth at most 15 per cent of the American economy, a fraction that has been roughly stable over the last several decades. By contrast, the value of structures—houses, apartments, offices—is equivalent to 175 percent of economic output. Of course, labour and capital shares are flow figures, whereas these are stock figures, but the significant difference in scale between automation-related capital and real estate-related capital should caution against seeing robots as the primary cause of recent wage weakness. While technology and automation have clearly played an important role in recent economic growth, the capital stock figures suggest they cannot explain the recent declines in labour share.

A better explanation for the decline in labour share of economic output is the increased labour competition from the integration of a billion people that we discussed above, but also diminished competition, and a rise in real estate prices.

The decline in corporate competition is something we have addressed in previous editions of Konzept[1]. But few people think their own houses have anything to do with stagnant wages, and that is worth focusing on for a second. The rise of inflation targeting among central banks in the 1990s, the persistence of low inflation, and, before that the economic liberalisation of bank lending in the 1980s all produced a benign policy and macroeconomic environment for house-buying. Much of the increase in the capital share of income has subsequently gone to real estate. As renters or homebuyers know, the more you pay in rent or mortgages, the less disposable income you have. By one account, the share of housing in total output is three times higher today than in the 1950s.

Besides bank lending, a key driver of higher house prices in many cities is regulation that limits increases in housing supply. These underpin high house prices and maintain the wealth of a specific class of capital holders—owners of pricey property.

The rise of expensive real estate in cities has also reshaped labour migration patterns. A seminal research paper by economists Peter Ganong and Daniel Shoag shows that janitors earn seven per cent less in New York than in the Deep South after adjusting for housing costs. This contrasts starkly with the same figures from 1960 that show janitors in New York made 70 per cent more than janitors in the Deep South, again after adjusting for housing costs. High housing costs are effectively locking out low-skilled workers from high-income areas, and therefore reducing the mobility of labour.

If in the 19th century the barriers to investment were largely to do with know-how, today the barriers to wage-raising investment are largely due to a lack of competition among companies and ossified housing markets that are preventing cities from absorbing more people. So while it is easy to blame automation for real wage stagnation and the hollowing out of some occupations, this is too easy. Other causes, including intentional policy decisions surrounding globalisation, competition, and particularly an unsustainable real estate market, should be of more concern. Understanding these factors is crucial so that policymakers can address the correct problems. While automation may need to be regulated in a sensible way, constructing onerous barriers to technological progress would be worse than a distraction; it would just be another thing holding back living standards. ●

1 Please see: "Beyond QE–the resilience of corporate America" October 2017, and "From concentrate–America's diluted competition", June 2015

Industrial internet of things – Data over design

Many people have torn their hair out while putting together flatpack furniture. Those frustrations may soon be a thing of the past now that engineers at Nanyang Technological University in Singapore have created a robot that can build an Ikea chair in just 20 minutes. Of course, home use for this kind of sophisticated automation is still a long way off, but it is becoming more common in logistics and warehouses. But while the benefits will certainly revolutionise these businesses, they are a poisoned chalice for other businesses within the same value chain.

The companies in this value chain include, logistics providers, capital goods companies that make machines for them, and software groups. All three love to emphasise the opportunities arising from automation, digitisation, and the so-called industrial internet of things. Certainly, the concept of digitally connected machines which talk to each other and act with as little as possible human intervention seems like a level of efficiency made in heaven. But while there are obvious advantages, mostly in boosting asset efficiency, reducing throughput times, trimming energy costs and fine-tuning maintenance, the enthusiasm for actually putting these concepts into practice is sometimes exaggerated.

The problem is that 'more efficient' for customers means less demand for suppliers. For instance, ABB, the engineering group, estimates that digitalisation technologies could be a $20bn revenue opportunity. Yet, at the same time, it could result in $1tn of annual savings in operating expenditures for their customers. That will remove a big chunk of demand for industrials. The pie will thus become smaller and the competition for it fiercer with new players arising, especially from the software side.

Felicitas von-Bismarck

First, let's look at the opportunity, even if it is frequently overestimated. Investors tend to draw on stellar examples like the enormous efficiency gains achieved in the car industry by automating production lines. But it is easy to make the mistake of thinking this success story is easily replicable in other industrial settings and that all processes are prone to be taken off human hands.

The automation of the warehouse industry is being driven by two structural themes: the digitisation of how we buy things and the digitisation of how we receive things, all set against the backdrop of structural growth in the warehousing market. The rise of e-commerce has caused a higher fragmentation of logistic chains and a vast multiplication of (smaller) packages to be shipped and processed. To put it oversimplistically, ten years ago shoppers would walk into a bricks-and-mortar store and buy–after careful consideration–a pair of blue shoes. For the store to have these available, its logistics system would order one big package every four weeks carrying hundreds of shoes from a warehouse. Due to the long lead times, product lines did not change often and smaller stores found it tough to find an edge against the large, established competitors.

Today, shoppers have become used to ordering shoes over the internet. Choice has increased tremendously as new players take advantage of the lower required capital investment. As a result, product lines now vary more frequently and keep customers intrigued. But shoppers do not just order one pair of blue shoes on the internet. In the same purchase, they will order a pair in light blue and another in dark blue; and perhaps order all three in sizes 37 and 38. That is six packages in total. Of course, five will end up being returned at different channels, shipped, organised, checked and repackaged. The entire process has to be quick and easy or customers will go to one of a hundred other competitors.

The logistical complexity of the online economy has thus increased massively and, as a result, logistics costs often account for one of the largest items on the e-commerce profit and loss statement. In turn, this increases the demand for the most efficient handling of these packages. Hence the race to provide the cheapest, most efficient systems in automated warehouses.

Investors may then picture a lights-out warehouse where automated vehicles cruise smoothly through the building collecting orders drawn directly from the internet, and then sending them in a nice box on a conveyor system to a waiting truck. Sometimes that indeed is the case. Unfortunately, in the vast majority of cases, the reality is nowhere near this advanced. The degree of automation in most warehouses is actually quite low. As an example, we have toured advanced warehouses and were disappointed to see that most automated vehicles actually creep very slowly through the buildings on a predetermined route, stopped dead by any little disturbance.

In some markets, the low degree of automation will likely stay this way as it is expensive and structurally unreasonable to fully automate warehouses. In other markets, automating only makes sense if certain bottlenecks are removed.

On the first point, automation currently only makes sense if a warehouse stocks a large number of comparable, easy-to-grab products. Think of a vehicle production line. The extent of this success was only made possible by the fact that there were thousands of similar cars running off the production line every day. On the other hand, e-commerce companies that sell clothing need to change collections quickly, sometimes weekly. There is no point in storing these lines somewhere on a high rack system and having to re-programme a sophisticated guided vehicle with an even more sophisticated flexible robot arm to pick it up when it is ordered. Rather, the most economically sensible thing is for an employee with a headset to go to a big box and pull out the, say, pair of red socks and a pair of trousers and then pack them into a box. After that, the labelling and the conveyor systems are often fully automated.

In terms of bottlenecks that prevent automation, consider the largest online groups, such as Amazon, Asos or Alibaba. E-commerce companies of their size are quite rare. The overwhelming majority of (much smaller) firms rarely own their logistic chains but rather outsource them to third-party providers. These providers normally have an investment horizon of three to five years, in the line with their leases. This contrasts with the payback of a fully automated warehouse which lies rather somewhere between seven and ten years.

As such, mainstream automation of warehouses will only realistically escalate when there is either an increase in returns compared with the initial expenses, or investment horizons lengthen as more companies own their own warehouses. On the latter, what is necessary is for the large, established bricks-and-mortar firms to invest in automation in their warehouses. But these companies are still wrestling with the more structural problem of how to approach their e-commerce strategies to begin with, in the face of back-breaking competition from e-commerce giants such as Amazon.

On the first problem, a lack of quick returns, the most promising form of value-add in the new age of automation comes from data analytics and consultancy. How this works is best illustrated with an example of a customer. Take, say, a brewery which has thousands of valves securing the smooth transfer of liquids through its machines. From time to time, one will break causing downtime or, even worse, a contamination of the product. To avoid this, the norm is to exchange all valves at specific intervals based on historic projections of breakage rates.

For the manufacturer of brewery equipment, this process makes for a predictable stream of recurring and sometimes inflated revenue. However, in a world where sensors can measure real-time data from every part of a machine, analyse them according to algorithms, and notify the owner when one valve needs to be exchanged before it breaks, we arrive at a predictive maintenance model.

As this example illustrates, this would offer real value to the customers as it evades unnecessary downtime of the machines when something breaks while at the same time avoiding 'over-service' – instead of exchanging thousands of valves at a time, they only exchange those at risk of breakage.

Consultancy is the other advantage following this type of data analytics. Here, algorithms can be used to explore the tonnes of data provided by a warehouse. This can then be used in various ways, including a connection with enterprise resource planning systems and maybe even with suppliers. The goal is better strategic and operational decision making, for example, about how to manage the flow of goods within a warehouse and where to store what most efficiently.

The key bottlenecks to fully capturing these fruits are that, first, most customers are still very hesitant to share data, especially in real-time with their equipment suppliers and, second, most equipment suppliers still lack software and algorithm skills whereas most software companies still lack industry and process know-how to give data context and use it to make decisions.

For the former, more standardised systems, scalable benefits, and customer and vendor education will help. So too will standardised data security schemes which will create more trust over time. For the latter, more partnerships must evolve that will fill the gaps in each sides' knowledge and expertise.

While the opportunities are often exaggerated, the threats are often not taken seriously enough. Consider that most industrial companies currently make the vast majority of their money not in selling a piece of equipment but rather in servicing it. Operating a classical razor/razor blade business model, the service revenue gives them a predictable and recurring income stream from their installed base. As we have discussed in the examples above, the rise of data analytics will decrease the demand for services, while the competition for this revenue pie will become fiercer as new players arise from the software side.

Today, most equipment suppliers service their own installed base and are regarded as the experts in their field. This provides a strong barrier to entry in the industry. However, by measuring vibration, noise, pressure, temperature and so forth, data-crunchers can learn more about the machines and even surpass the knowledge of the original manufacturer. Software companies will therefore look to take advantage of the industrial internet of things to take a part of the (anyway decreasing) service pie.

As the value-add for the customer shifts towards software, the risk is that hardware becomes more commoditised. Although sensors will be added and data collected, that is the easy part. The real value-add comes from turning that data into actionable decisions. This is where some industrial groups are currently behind as they often lack the digital know-how and sophisticated analytics tools. For them to grow, they must change their business model to satisfy the demand for replacing machines less often and with a lower maintenance spend. They must shift away from regular mechanical service and towards data analytics, system integration and automation. In other words, they must position themselves in a new part of the value chain to focus on services for smart machines, such as software upgrades rather than exchanging spare parts. If they don't, the data-driven software engineers will.

Yet software companies should also not expect a smooth ride as the new wave of automation crashes in. Software skills are useless without the industry knowledge that some customers are reluctant to provide. As a result, more formal tie-ups may be necessary. However, integrating these completely different businesses will be an operational and cultural challenge.

So far, very few companies have an edge in both data analytics and industrial know-how. Yet both sides fear losing their competitive edge to the other. So while it is hard to reconcile their differences, the first groups to do so will gain a first mover advantage and reap the rewards. Those that don't will enter an inescapable period of decline. ●

The logistical complexity of the online economy has thus increased massively and, as a result, logistics costs often account for one of the largest items on the e-commerce profit and loss.

Chinese automation – How to beat the demographic hangover

When future economic historians look back at China, they might see the years 2014-2015 as a turning point. This was the time when the total working age population peaked, sending China into a new phase in which its pool of workers will likely shrink by between two and three million people each year. This shrinking labour force is one of the biggest long-term challenges for China.

Not long ago, China was still seen as an economy with an abundant supply of cheap labour, similar to Korea and Japan in their early stages of development. Over the past four decades, China’s large pool of working-age labour, combined with its relatively small share of young and old non-working population enabled the economy to rapidly grow. This has now changed: the dependency ratio bottomed out in 2010 and is expected to rise rapidly, as the population ages.

A cross comparison shows that China's demographic dividend period, that is, the period when the dependency ratio continued to decline, lasted for a shorter time than its East Asian peers. As a result, China reached the demographic turning point at a relatively low per capita income level of $9,400 in terms of purchasing power parity. That is just one-third the income level in Japan and Korea when their dependency ratios were at the lowest point.

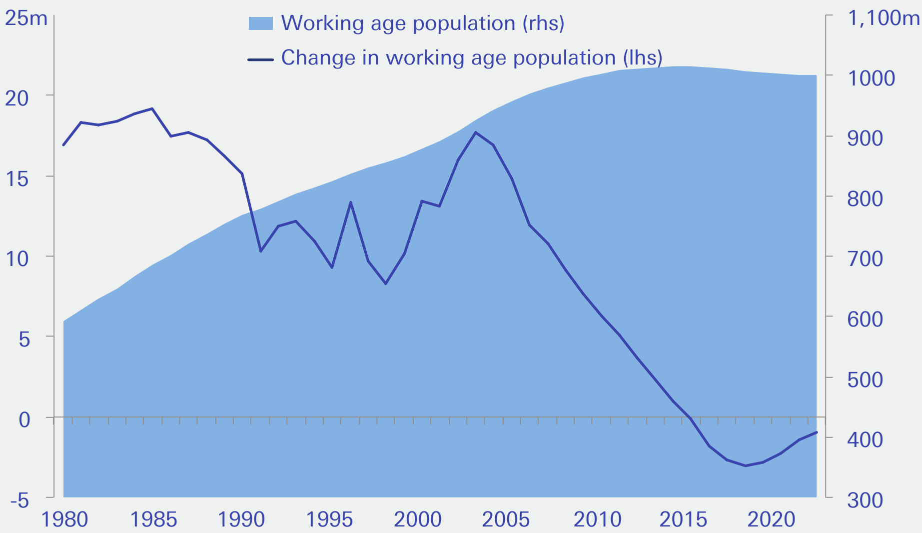
Zhiwei Zhang, Yi Xiong

On top of population ageing, workers are moving away from labour-intensive jobs in the manufacturing sector as part of the evolution of the economy towards services. Employment in the secondary sector (mining, manufacturing and construction) is declining at a rate of two to three million jobs per year. In contrast, the services sector adds between ten and fifteen million jobs each year. To be sure, manufacturing job pay is increasing: in the textile industry, hourly wages doubled between 2006 and 2010, and doubled again over the next five years. At $3.30 per hour in 2015, wages are much higher than in Vietnam at $1.90 per hour. Yet some two million workers have moved away from the textile industry over the past decade. A restaurant or delivery job may pay just as well, if not better, and does not require working night shifts.

Not surprisingly, China is losing competitiveness in labour-intensive goods. The country’s market share for footwear and apparel in the US was 48 per cent in 2010. It has now declined to 39 per cent. In contrast, Vietnam’s market share doubled to 16 per cent over the same period.

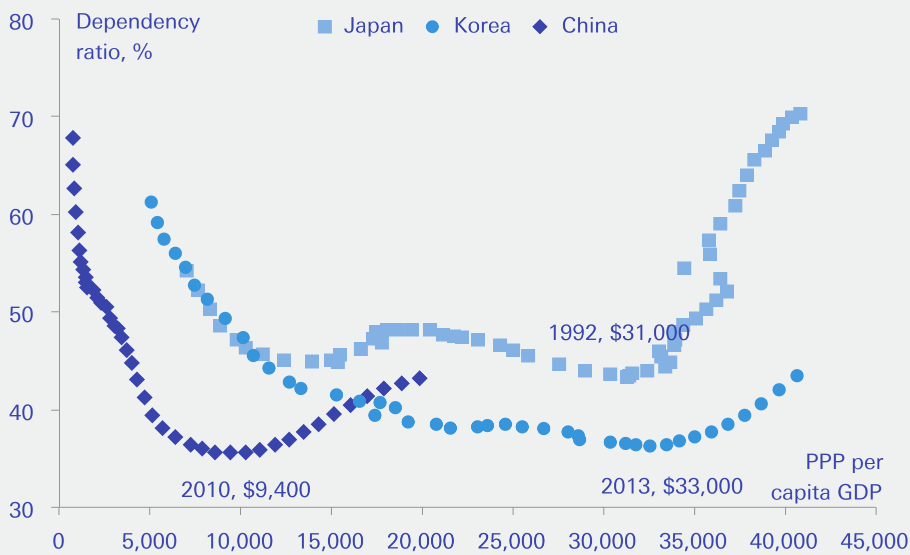
To cope with rising labour costs, Chinese manufacturers must either invest in machinery and equipment that reduces the dependence upon labour, or move outright away from labour-intensive industries into more capital-intensive ones. Both approaches require a significant investment in industrial automation.

China's working age population



Source: Deutsche Bank, Haver Analytics

The demographic dividend began fading at a low income level

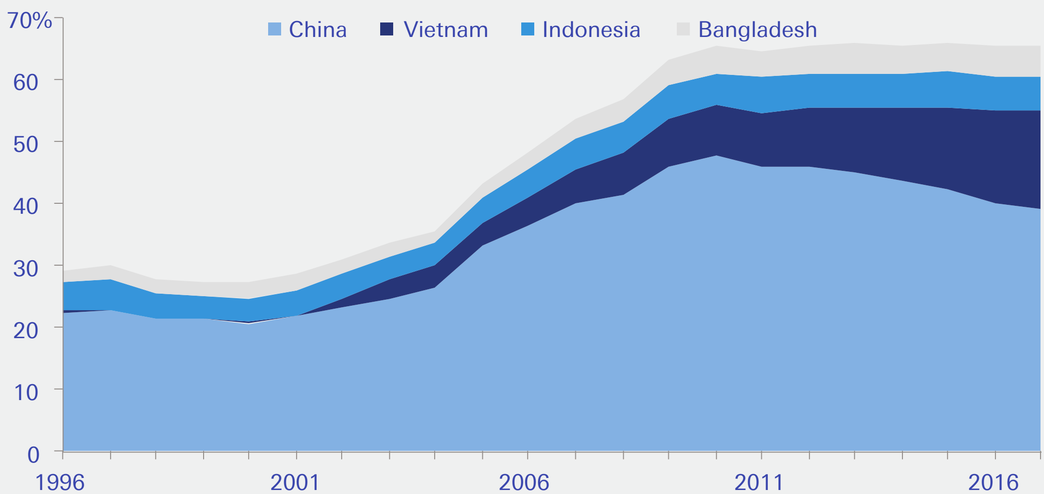


Source: Deutsche Bank, Haver Analytics
Note: Dependency ratio is defined by the United Nations as the ratio of population age 0-14 and 65+ per hundred population age 15-64. The per capita GDP is in 2011 international dollars.

Hourly wage in the textile industry

Source: Economist Intelligence Unit, US Census Bureau

US import market share, footwear and apparel



Source: Economist Intelligence Unit, US Census Bureau, Deutsche Bank

In Foshan, a satellite city of Guangzhou, a recent government survey of 200 firms suggested that almost half of them now use industrial robots.

That push towards automation is already happening. The Chinese government has made automation a top priority. The 'Made in China 2025' plan, issued in 2015, envisages the value added/output ratio in the manufacturing sector will increase by four percentage points by 2025, and labour productivity will grow at an annual rate of seven per cent in the coming decade.

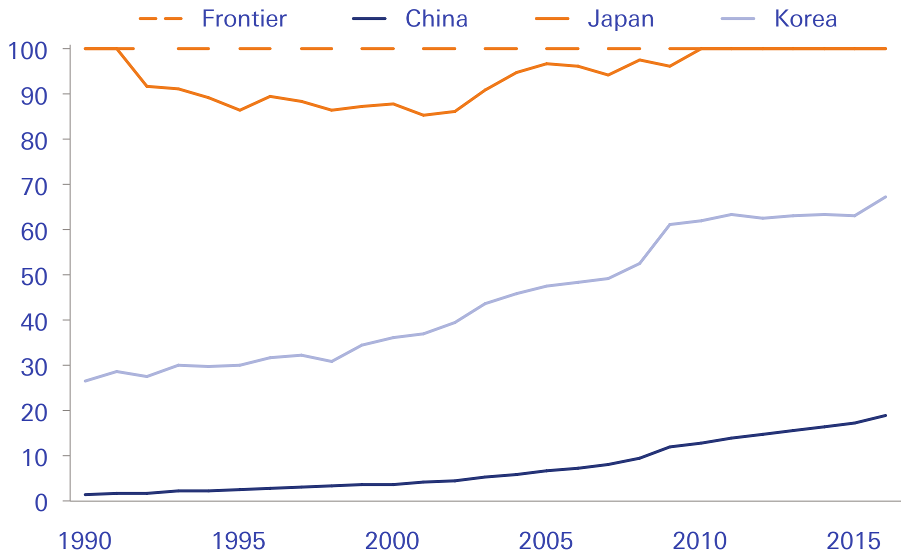
To achieve this, the government has stepped up efforts to promote investment in areas such as intelligent manufacturing and industrial robots. Some 200 pilot projects in intelligent manufacturing were singled out in the two years to 2017. This year, the government has committed to raising tax benefits for machinery and equipment investment, and building pilot industrial zones for intelligent manufacturing. At the Communist Party's Congress last year, President Xi's speech suggested that supply side reform priority has shifted from reducing capacity to promoting advanced manufacturing. He also emphasised the promotion of "disruptive innovation", which suggests the government may support innovations even if they cause disruptions to existing players.

The scope for investment in industrial automation is enormous in China. Manufacturers in the country are still far away from the production frontier. Production efficiency, measured by output per manufacturing worker, is only one-fifth of the frontier occupied by Japan and is comparable to Korea's productivity level in 1990. The use of industrial robots in China is still at a very early stage. Robot density, measured by the number of industrial robots per 10,000 manufacturing workers, is only 68, compared with over 300 in Japan and Germany and over 600 in Korea.

A simple calculation highlights the market potential for Chinese automation. Take the 300,000 industrial robots that were sold globally in 2016, of which 30 per cent were sold in China. Assuming China's market share increases further to 40 per cent, it will still take more than a decade for China to reach a robot density of 200. That is still far behind today's levels in Japan and Korea. And this does not even account for the need to retire and replace old robots. This suggests two things. First, that China's automation will take many years and, second, that the market for industrial robots, as well as other advanced manufacturing equipment, will have to expand to accommodate China's demand.

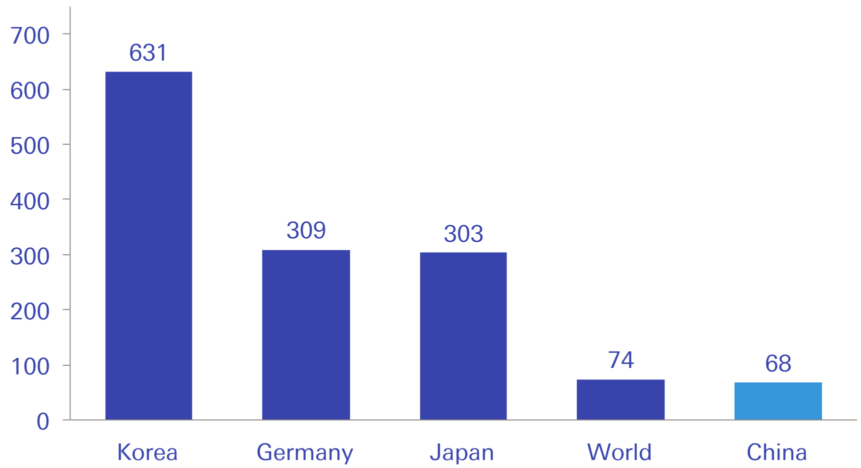
Unfortunately, there is limited research on the systemic impact of automation in China. But the anecdotal evidence shows great potential. For

US import market share, footwear and apparel



Source: Deutsche Bank, Haver Analytics
Note: Frontier is defined as the highest labor productivity amoung all the OECD countries

Industrial robots per 10,000 workers



Source: Deutsche Bank, WIND

instance, Foxconn, the world's biggest contract electronics maker, has been developing and deploying industrial robots as it targets 30 per cent automation at its Chinese factories by 2020. It reportedly cut the number of workers by more than half, from 110,000 to 50,000, by deploying robots in an Apple factory. The factory was located in Kunshan, a coastal city one hour's drive away from Shanghai, where labour costs appear to be rising.

Midea, a top appliance manufacturer in China, is also increasing the use of robots in its factories. By deploying over 200 robots in its Wuhan factory, it increased production capacity by a quarter while reducing the number of workers by more than half. Midea recently announced it will set up a joint venture with German industrial robotics manufacturer Kuka to expand its automation business in China.

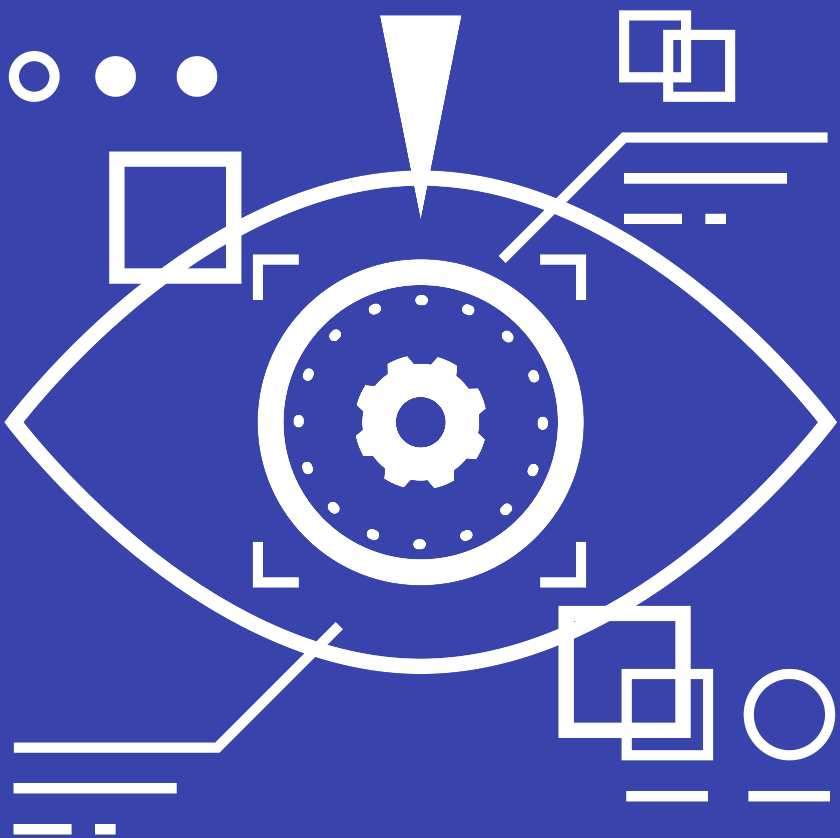
In Foshan, a satellite city of Guangzhou, a recent government survey of 200 firms suggested that almost half of them now use industrial robots. This has improved productivity by between 10 and 30 per cent, thereby reducing labour demand. One report noted that a toy factory halved its employment while maintaining the same production level. Against this disruptive backdrop, Foshan's average wage level almost tripled in the decade to 2015.

What will be the macro impact of all of this? For one thing, automation will help China avoid a sharp decline in potential growth beyond 2020. Employment in the manufacturing sector will likely drop, but it will be more than offset by an increase in productivity. The increase in labour productivity will also support continued wage growth in the manufacturing sector. The spillover effects will hit the services sector which will see a continued increase in employment.

The rise in automation will delay the decay of competitiveness in labour-intensive industries. China is likely to eventually lose competitiveness in these industries to other developing countries, just as Japan, Korea, and Taiwan lost to China in the past. The 'flying geese' model of capitalism predicts labour-intensive factories will move to countries such as Vietnam, the Philippines and India. But automation technology may delay such a process, as labour costs shrink as a share of total costs in the incumbent. Our article, "Low-wage outsourcing", examines this point in detail.

Finally, automation is likely to hold back higher inflation. This is important as the high level of corporate leverage is a major concern. While higher inflation would reduce the value of outstanding debt, the remedy–higher rates–would both increase interest expense and potentially cause an unwanted economic slowdown. As China searches for ways to encourage corporations to reduce their reliance on credit, it may be the growth in automation in the country that indirectly brings some relief to an overlevered economy. ●

Machine vision – 3D cameras eye a new application



Karen Lau

It is said that 80 per cent of a human's sensory perception comes through the eyes. So what of the cameras attached to industrial robots and so-called co-bots – which work collaboratively alongside human beings? These are often held to be the poster children of automation, yet although machine vision is becoming a key aspect of advanced automated manufacturing, it has received far less attention than it deserves.

At its essence, machine vision is the technology that provides imaging-based automatic inspection and analysis, thereby allowing a robot to perform functions such as, identification, gauging, measuring, and guiding in a manufacturing process. For instance, a two or three-dimensional smart camera can replace a human worker and perform an in-line part inspection or work with an industrial robot or a co-bot to perform pick-and-place functions. These cameras can be as cheap as several thousand dollars or cost as much as $40,000. Of course, industrial robots that perform a specialised task may not need machine vision, but more complex robots that do multiple tasks, or that need to select different parts, certainly do require a vision system.

While machine vision technologies have been around for the past three decades, declining component prices and rising labour costs, especially in emerging markets, have become powerful driving forces for the acceleration of machine vision adoption. For example, since the early 2000s, the price of critical hardware components such as LED lighting and image sensors have fallen by more than half. At the same time, speed and reliability have improved with more powerful chip sets and computers. Today, a machine vision application with a smart camera can be set up for $2,000. Contrast that with the mid-1980s when a considerably more primitive system could cost up to $60,000.

Furthermore, with device sizes shrinking for many products, such as tiny medical or consumer electronics devices, or automotive parts, a higher level of precision in manufacturing is required. Some of the tasks associated with this simply cannot be performed by humans. This is where machine vision becomes invaluable and is just one reason why progress in its technology is likely to be a long-term secular trend.

Shipments of machine vision systems grew at a low to mid-teens rate between 2010 and 2015 in North America and Germany, and that growth rate is expected to continue in the coming years. There are several factors driving that growth. The first is e-commerce and logistics. Our separate piece on the industrial internet of things delves into this in more detail. In short, the demand for automated warehouses and distribution centres is rapidly expanding. The reason is that e-commerce firms prefer centralised warehouses and automated distribution systems to meet their delivery requirements. These warehouses require advanced scanning equipment to keep track of inventory and sort through items on a conveyer belt. The most advanced ones use robots to store and retrieve goods. Prologis, a leading owner of industrial property, estimates that a traditional brick-and-mortar retailer needs 350,000 square feet of warehouse or distribution space per $1bn of sales. In contrast, e-commerce retailers need triple this space. As a measure of demand, Prologis data indicate that over the past several years, the occupancy rate for high-end warehouses has climbed from 93 per cent to 96.5 per cent. As a consequence, rents have risen 10 to 15 per cent annually. With e-commerce sales growing at more than ten per cent per year, and claiming an increasing share of overall retail sales, this is a clear growth market for machine vision systems.

Beyond traditional applications, artificial intelligence and deep learning capabilities are gaining traction within the field of machine vision.

One promising area is 2D, and especially, 3D scanning equipment. Of course, scanners have been a commodity for years and almost everyone is familiar with the 1D scanners that use lasers to read barcodes in a supermarket. More advanced 2D scanners are camera-based and read labels that contain more information than 1D codes. So far, these have mostly been used in manufacturing settings. As the cost of 2D scanners has fallen, 2D codes have become more widespread. But so far, only half the installed base of 1D equipment has transitioned to 2D.

More advanced use cases require that a robot have the ability to perceive motion, depth of field, and shading. This requires a 3D camera. While still in relative infancy, these are being used today to work with robots that do pick-and-place tasks, and for precision manufacturing tasks such as gauging gaps on spark plugs used in automobile engines. The 3D scanner market is still relatively small, with annual sales of $200m versus $1bn for 2D scanners. Partly that reflects the fact that 3D equipment is ten times more expensive than 2D kit. As such, it will be several more years before 3D technology becomes more widespread but history shows that once falling prices of technology hit a tipping point, adoption quickly goes mainstream.

Analysts are watching to see which countries become the leading consumers of machine vision products and China is expected to one of them. As detailed in our piece, "Chinese automation", the ‘Made in China 2025’ plan calls for heavy investment in automation, both to upgrade China’s industrial base and to offset the pressures of a shrinking labour force. On the logistics front, e-commerce in China now surpasses that in the US, yet China’s per capita warehouse stock is less than one-tenth the size of the US – and modern logistics facilities account for less than 15 per cent of that already small stock. China will be investing heavily in modern logistics systems for years to come.

Beyond traditional applications, artificial intelligence and deep learning capabilities are gaining traction within the field of machine vision. Deep learning involves feeding a computer system a lot of data, which it can use to make decisions about other data, and the idea is to combine this with machine vision and powerful software to better handle tasks where objects may not be standardised in appearance. Facial recognition is one key application. At a recent machine vision industry tradeshow, we noticed deep learning as one of the key emerging themes and the number of these exhibitors, both established and start-ups, at tradeshows has increased considerably over the past few years.

Generally speaking, the ‘learning’ computations need to be done with powerful Graphics Processing Units, while the run-time executions can be done with more ordinary computer chip in some cases. The image samples required can range from 100 to several thousands, depending on the software and the complexity of the tasks. Some solutions require end users to send the image samples to the provider who performs the ‘learning’ in-house. Other solutions allow end users to perform the ‘learning’ locally, which can be more efficient and scalable. The price of this deep learning software varies widely and can be as cheap as several thousand dollars or over $100,000 for customised programmes.

With regards to machine vision, deep learning addresses applications that previously could not be solved by traditional machine vision products as these frequently only process objects with a standardised appearance. It can also reduce the need for extensive programming that may be required by systems that do not have a deep learning capability. Deep learning machine vision is now being used to sort defective products on a conveyor belt, where defects may differ in various ways or change over time. They are also being used in agricultural settings to help sort produce which can vary widely in appearance. Beyond facial recognition, deep learning systems are being trained to interpret different types of human movement and gestures. The use cases for these types of systems are numerous. Just one is to help law enforcement officials analyse surveillance video for suspects.

A final emerging theme in machine vision is embedded vision. This is a small hardware component that can be integrated into a piece of commercial or industrial equipment, such as a light. It then combines machine vision sensors with processors to interpret images within an integrated unit. This differs from traditional machine vision systems which combine a smart camera or sensor and a computer to process the image. Embedded vision systems are being developed for driverless cars, drones, biometric applications, and handheld scanning devices. They will also play an increasingly important role in the design and operation of automated factories.

As with human vision, it is easy to take machine vision for granted. Yet, as computer processors become smaller and more powerful, it becomes possible to greatly extend the reach of machine vision into more connected and automated devices. Indeed, without the recent advances in machine vision, many of the emerging and exciting advances in robotics and automation would still be the stuff of science fiction. ●

Remote mining - Just warming up

"You have to blow dust in their faces to make them feel like they're in the Pilbara, otherwise it's too comfortable." Those were the words of a Rio Tinto executive, overseeing the desk-bound engineers who operate the mining company's autonomous rigs as they dig into the rock. The office is in the city of Perth, a two-hour flight away from the 16-mine network in Pilbara, Western Australia, where Rio has its largest operations.

The automated system allows trucks to be operated by a central controller rather than a driver. It uses pre-defined GPS courses to automatically navigate roads and intersections and knows the actual locations, speeds and directions of all vehicles at all times. In addition, Rio Tinto is automating the driving capabilities of its train system as well as adding the ability for them to be loaded by remotely-controlled machines. The safety benefits are significant. So too are the financial ones.

With stories like this trickling out of the financial press in recent years, it is no wonder that mining is frequently thought to be among the industries in which automation is most advanced. Driverless trucks, automated underground digging equipment, all operated from thousands of miles away, are just some of the very tangible and colourful examples of the success of automation in a field where human labour can be very expensive. The long hours, hard work and intense weather means fly-in fly-out workers can command average wages of between $A150,000 and $A180,000 a year. Stories abound of degree-educated office workers leaving their comfortable life in Sydney to become truck drivers in the isolated mines. That makes the industry ripe for automation.

Matthew Greene

Yet for all the eye-popping examples of automation in the mining sector, this is probably just the beginning. For instance, while Rio Tinto has pursued automation in its trucking fleet since 2008, just one-fifth of its 400 trucks in the Pilbara are automated today, and the target is to hit just one-third by the end of next year. But this is just the Pilbara; most of Rio's other trucking operations still operate without significant automation.

As automation in the industry progresses, the impact will be significant. Without the need for coffee or toilet breaks or driver changeovers, Rio estimates that each automated truck can work nearly 700 hours more than its conventional hauling trucks each year. This lowers unit costs for loading and haulage by 15 per cent through

the reduction in the number of capital intensive trucks required to achieve the same production rate.

Aside from haulage trucks, automated sensors at the plant, rail systems and port have leveraged off mass data analytics to prevent production, storage and loading issues; this has further aided the availability and utilisation of equipment from mine to port, improving overall productivity.

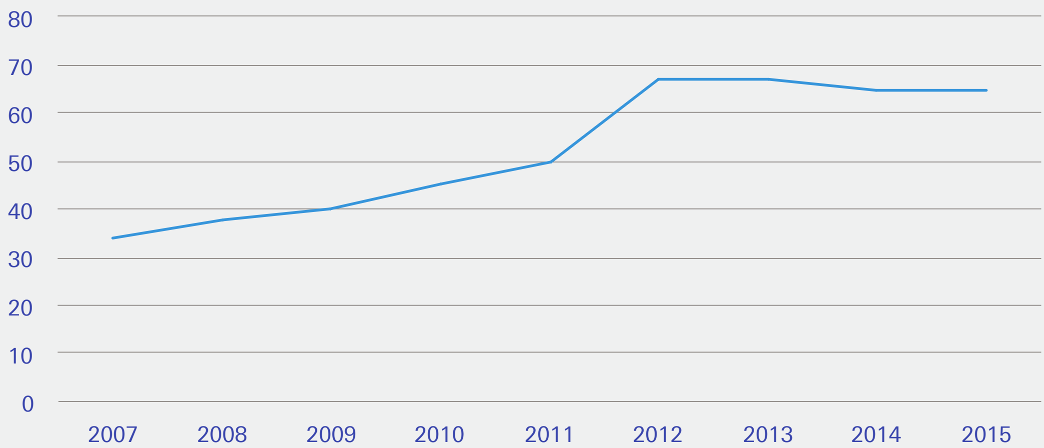
What this almost certainly means is that employment at Rio, which has seen its workforce fall by 30 per cent to 47,000 employees since 2013, is likely to fall further. True, these employment figures are impacted by asset divestments and industry conditions, but going forward, they will be driven by automation. For instance, Rio has said it will axe 200 trucking jobs at two of its Pilbara mines next year as a result of automation. The same trend can be seen at other mining firms. Indeed, while employment in the Australian metal-ore mining industry doubled in the five years to 2012, since then it has dropped a little.

There are several reasons why the mining sector has been slower to automate than many investors have expected. Despite a longstanding availability of technology, the initial setup and implementation is expensive and highly disruptive. Contingency plans need to be in place, expensive software needs to be tweaked to iron out bugs, new staff need to be hired and trained in new programmes. All this involves downtime and a loss of profits. Against the backdrop of low prices for many commodities in recent years, the short-term pain of implementing automated systems is too much to bear for some firms.

Moreover, there are probably limits to mining automation. It is not surprising that automation has come to iron ore mining before other types of mines. Iron ore is a bulk material that requires material movement at the lowest cost. The scale of iron ore mines is larger than most other types of mines globally—it involves more trucks and the payload per truck is larger as well.

It is also not surprising that this has happened in the Pilbara before other areas. The Pilbara mines are experiencing increasing waste stripping (the amount of waste moved to access economic ore) due to lower iron ore prices. This leads to increasing the amount of material moved to maintain the steady production of ore. Automation has reduced the number of new trucks required, while also saving on diesel costs.

Employment in metal-ore mining in Australia (thousands)



Source: Australian Bureau of Statistics

Paradoxically, as the recent jump in some commodity prices has made mines more profitable, there is less pressure to pursue automation. For some mining firms, it is only when they are compelled by circumstance to make changes that they push ahead and do it. For example, Fortescue Metals, which concentrates on iron ore, was struggling just a few years ago. As a smaller miner, it had weak pricing power compared with that of the majors. Its ore was of lower grade than that of Rio Tinto and BHP, and as a near pure-play in iron ore, it was disproportionately affected by the decline in commodity prices in the summer 2015 – its net profit plummeted by nine-tenths.

However, since then, Fortescue's profitability has rebounded, driven by improved cost efficiency from automation. Its unit production costs have declined from nearly $50 a ton in the 2012 fiscal year to around $12 in 2017. At its Solomon mine, there has been a nine-fold increase in its driverless fleet to 56 trucks since 2012. The only role human workers play in the mining process is to assist the self-driving vehicles. But it is not just trucks that are being automated. So are hydraulic mining drills, and explosive denotation procedures. Fortescue's example suggests that automation only becomes an all-encompassing pursuit when a company's back is against the wall. It also shows that pursuing these extensive upgrades can lead to efficiencies and serious financial improvements.

As other miners look nervously for signs of a slowdown in China, they may have in mind that any prolonged slowdown within the economy of their most important customer could, in fact, augment the process of automation rather than slow it down.

Driverless trucks, automated underground digging equipment, all operated from thousands of miles away, are just some of the very tangible and colourful examples of the success of automation in a field where human labour can be very expensive.

Climate change – The automated shift to clean energy

Caroline Cook, Tim Rokossa

Sometime this century, energy may become as ubiquitous as broadband. You will pay only a connection fee, as electrons produced only by solar, wind, and water flow through a smart grid for consumption regardless of quantity. Distributed, local generation will widen energy access (and enable economic development) in a manner inconceivable to today's centralised energy giants.

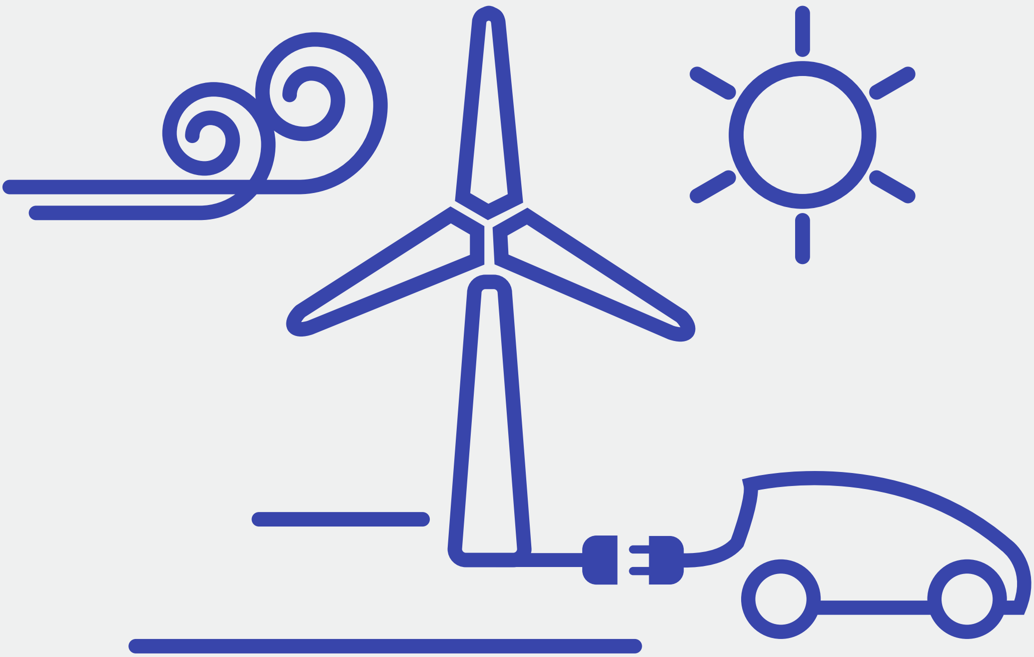
Such a future may be closer than many think and, indeed, it is now the subject of serious academic research. The pace of renewable progress over the last decade has resulted in cost reductions of between 40 and 80 per cent in new wind and solar generation respectively, making them close to being cost competitive with fossil generation in most major markets. As such, the debate has moved rapidly from primary capacity to network integration: to energy storage, smart grids and demand management.

Indeed, decarbonisation is transforming energy from generation through to the means and ends of use. Such will be the extent of change across industry value chains that straight carbon avoidance is not the solution for investors. In fundamental equity research we are approaching the theme through the lens of alignment; the volume of oil, coal, cars, and solar panels will not always align with value, as measured by margins, profits, and share prices. We have encapsulated this in DeCAF – the Deutsche Carbon Alignment Framework. In this article we take a look at automation as an accelerator of technology impact and, by implication, a creator of new products, markets and participants.

Inevitably, automation will lie at the heart of this development; not just as a technology in its own right, but as an accelerator of utilisation and uptake. As the world progresses to this point, it will bring the damage caused by carbon emissions inside the economic framework through direct pricing. Automation will help accelerate the uptake of the alternatives. Here are three examples.

Until recently, lighting accounted for an eye-watering 15 per cent of global electricity use. This is equivalent to more power than can be produced by all of the world's nuclear stations. Lighting is often taken for granted in developed countries, but in developing countries, it is fundamental to education and economic development. The advent of cheap LED bulbs is, therefore, transforming the lighting market. Using just one-tenth of the electricity that a traditional filament bulb uses, LEDs cut basic power consumption to the extent that small, distributed solar panels in developing countries can bring useful light to people far off the grid. In the same way that mobile phones allowed for a 'technology-skip' for people in developing countries who could acquire a phone and not worry about needing a desktop computer, the automation of LED lighting through solar panels is allowing them to avoid the need to be connected or acquire a traditional generator and be dependent on sometimes unreliable fuel supplies.

The second example involves the significant second-order energy savings that can be generated through automation. These come about through the integration of sensors and controls with networked communication. This can all now sit easily within an LED framework. Intelligent sensors and timers can reduce the demand on systems which are often 'on' for



hours on end. In fact, the US Energy Information Administration estimates that as LEDs rise to take over nine-tenths of the lighting market share over the next two decades, over two-fifths will be controlled, connected, or both by smart, integrated systems. Within the US, just the LED component alone should cut projected lighting demand by over one-third while intelligent controls could increase this saving by a further one-fifth. Automation will amplify the transition benefits by enhancing the savings; less power demand, fewer light bulbs manufactured and shipped, less carbon dioxide emitted, and more high value product opportunities.

Such networked control may ultimately be at play across all electrical devices. Some of the biggest potential gains lie in appliances, particularly heating and cooling which comprise up to half of electricity demand. Beyond within-device optimisation, such as 'sleep' functions, or more efficient boilers, lie smart meters and time-of-use electricity pricing. Marginal shifts in selected space or water temperatures can create significant energy savings, just as automated timing on washing machines or electric vehicle chargers can shift demand by the few hours necessary to better match the peaks in renewable energy generation. By some estimates between one-tenth and one-quarter of demand can be shifted this way. It is still early days, but this ability is a prerequisite for cost-effective wind and solar penetration, particularly if it rises to generate more than 30 per cent of the grid mix, and for the avoidance of excessive peak-load from electric vehicles which is a risk if they comprise more than five to ten per cent of the fleet.

For this automation to take hold, there is a need, first and foremost, for regulatory reform in the power sector. It is necessary to move from 'dumb pricing' to 'time-of-use' managed by networked smart meters that can control devices and communicate with the grid. The obvious concern here is that this system requires an invasion of privacy and level of cyber-risk that societies may find difficult to negotiate. Indeed, a significant cyber-event could reverse progress towards a smart grid and this remains one of the major risks to the entire world's energy transition.

The final example concerns electric vehicles; not the vehicles per se, but their utilisation. Consider that the global transport fleet is responsible for almost one-quarter of the world's carbon dioxide emissions, and passenger vehicles comprise two-fifths of that. First of all, electrification of these light vehicles offers a high potential way to move away from traditional engines as conversion efficiency from source to wheel increases from 30 per cent in traditional gasoline and diesel-driven vehicles to over 70 per cent under an electrified drive train.

The real opportunity, though, for utilisation benefits stems from the fact that the average car is only in use around five per cent of the time. It is less a transport machine than a parked object.

Many academic studies point out that self-driving cars will dramatically reduce the number of vehicles on the road. Indeed, one study by the University of Utah found that a single RoboTaxi could replace 12 conventional vehicles. Another study concluded that the entire population of Singapore could be served with one-third the current number of vehicles if they were all autonomous.

Furthermore, attitudes towards car ownership are changing. While 75 per cent of Americans prefer to own a car, only 64 per cent of younger consumers view a car as their preferred method of transport. That lower proportion makes sense against the backdrop of data that shows the proportion of 16-24 year olds holding a driver's license has dropped from 76 per cent in 2000 to around 70 per cent today. Similar trends exist in European countries.

The trends against car ownership seem almost certain to continue given that autonomous driving carries the promise of personal transportation on demand, allowing people to break free of direct car ownership. In turn, if cars are commoditised and shared, it will be easier to boost utilisation rates. That will help reduce carbon emissions if these cars are largely electrified.

Indeed, even if such an automated fleet only matched the average utilisation rate of current taxis, utilisation rates would rise to 50 per cent. The optimisation of routing and pricing could boost this to 70 per cent. Assume first that electric vehicles become one-tenth of the fleet and one-quarter of sales by 2030. If we then assume that one-fifth of all miles driven will be by shared electric autonomous vehicles, the number of electrified miles will be more than double our base assumptions, thereby cutting the oil-fuelled share by a further 15 per cent. That will save 3.5m barrels of oil per day on top of the 2.5m barrels our model already predicts will be generated from base fleet electrification. That is equivalent to six per cent of today's oil demand and about 700m tonnes per year of carbon dioxide, or two per cent of current carbon dioxide emissions.

Of course, for utilisation rates to be improved by sharing conventional electric vehicles, automation and connectivity need to improve. In particular, a platform that allows people to hail a car for a variety of uses is necessary to encourage people to give up their own cars. Of course, ride-hailing platforms currently exist, but none have capabilities wide ranging enough to account for the many varied use cases that many people who own cars currently demand.

As in all our examples, automation of the vehicle optimises and accelerates the spread of a more energy efficient, lower carbon technology. Yet, unfortunately, things are not that simple and there are many barriers to the adoption of electric vehicles. Just one is that the re-tooling of the auto industry is time consuming and expensive. A second is that people around the world have invested in around one billion passenger cars and it will take time to replace them.

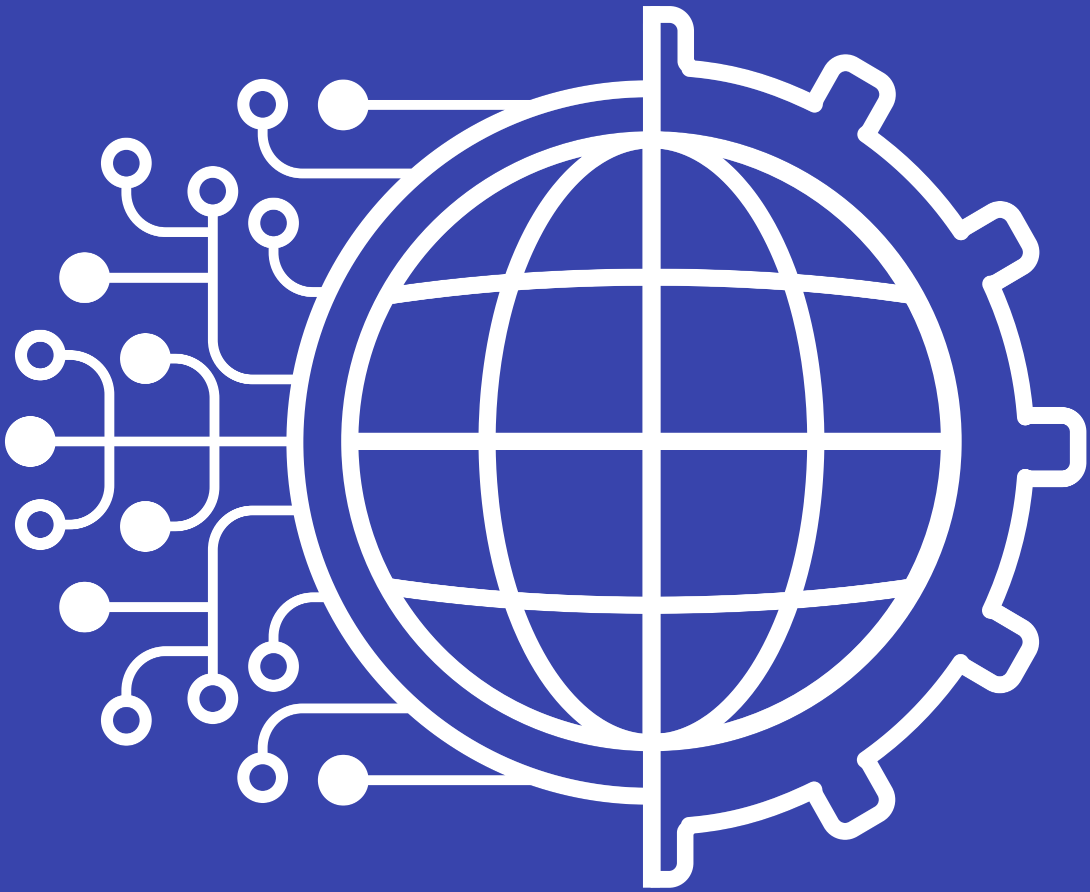
Despite the barriers to adoption, the good news is that if the utilisation rate of those electric vehicles that are sold can be increased, the electrification of miles driven can push ahead of fleet turnover. That will decrease the global dependency on oil demand, and reduce carbon emissions at a faster rate than would be expected by merely replacing vehicles one-for-one.

That brings us back to the vision of the not-too-distant future where energy is ubiquitous. If we could switch on this renewable energy nirvana tomorrow, we could care less about aggregate demand and efficiency. Yet, in the real world, the existing capital stock will take time to turnover, leaving us reliant on fossil fuels well into the second half of the century. Even an optimistic interpretation of the actual commitments made in the 2015 Paris agreement project minimal declines in coal, oil, and gas generation over the next quarter century.

To cut carbon emissions and limit the potential for global warming, fossil burn must be forced lower, faster. To create a 50 per cent chance of a less than two degree warming, nations must go well beyond the Paris agreement. The achievement of this pathway is dependent on a few critical shifts, each of which can be enhanced and accelerated through automation. The next step, then, is to push for supportive government regulations. Which takes us back to where we started: policy is external – complicating markets, and creating opportunities for the misalignment of volume and value. The Deutsche Carbon Alignment Framework (DeCAF) is designed to reflect just such anomalies.

The trends against car ownership seem almost certain to continue given that autonomous driving carries the promise of personal transportation on demand, allowing people to break free of direct car ownership.

Low-wage outsourcing – The factories will stay put



John Chou

The videos of Adidas' Speedfactory look like something out of a science fiction film. Sophisticated robots heat, stitch, and mould cutting edge materials into the latest pair of running shoes. The factory in Germany can produce a pair of shoes in five hours. That is the speed of light considering producing the same pair of shoes in Asia and shipping them to Europe will take over a month. >

Nike and other apparel companies employ similar types of robotic setups in their factories. Of course, the pursuit of lower manufacturing costs has been a crucial part of textile and footwear manufacturing since at least the industrial revolution.

The nature of cost reduction is changing, though. In the past decade, most cost optimisation took the form of geographic relocation as firms moved production to China and then Vietnam as they sought lower-wage workers. But despite the rise in labour costs in these countries, a migration to new lower-wage nations is unlikely.

It is true that a lot of noise has been made about reshoring to developed countries, particularly the US. Adidas has opened a partially automated factory in Atlanta, while Under Armour has discussed plans to open a manufacturing centre in Baltimore.

So far, though, the large apparel groups have not done this en masse. True, Adidas has said it wishes to increase the output of its Speedfactories in Ansbach and Atlanta to 1m pairs of shoes each year by 2020. But this is equivalent to just one day's requirement.

The 'real' investment by Adidas in its Speedfactory programme has already taken place in Vietnam. The world's largest shoe contract manufacturers have invested over $200m each year recently to automate production lines that produce over 50m pairs of shoes each year. Rival Nike has completed a similar plan with its manufacturing partners. Its automation investment in China and Vietnam has been very fruitful for the company.

Several facets of the current environment encourage apparel companies to keep their automated factories in their current location. The first is that only in recent years has robotics reached a state of sophistication that the large manufacturers can incorporate several linear processes into their existing production flow.

The second is that the trade-off between the risk and reward of another major migration appears unjustifiable. Companies moved their off-shore plants to China and Vietnam years ago to take advantage of cheaper labour costs. As a result, these two countries now account for half of the world's textile production. Now that labour costs are rising in these and other developing countries, questions are being asked about whether companies should move again to the new low-wage geographies.

New locations, though, are difficult to find. For starters, there are very few truly low-wage countries left in Asia which leaves Africa as the only remaining geography. However, the heightened political risk on the African continent will make many corporate executives hesitant about a move there. Another restriction regards the increasing standards of environmental, social, and governance policies. In fact, there are few untapped, low-wage countries that fit the current policy standards. Few frontier countries may fit the bill and those that do often have a shortage of factory infrastructure and sophisticated managers. When these factors are considered, it makes sense for companies to look to drive efficiencies via automation rather than moving their operations to a lower-cost jurisdiction.

While the current geopolitical climate may negate the benefits of moving to lower cost countries, automation in modern textile and footwear manufacturing means the business is less about costs than it was when companies first outsourced their factories and production lines.

Upgrading factories to the top automated specification saves labour. Automated lines in Vietnam can reduce worker count by one-third or more per production line. But it is expensive. For instance, Atom's automated cutting tools and Brother's computerised sewing machines require only one-sixth the number of workers to produce the same output compared with older-style cutting and sewing work stations. Yet, the cost of capital expenditure and its depreciation is such that shoes produced on automated production lines in Vietnam are 20 per cent more expensive than those made on traditional lines that are sometimes located under the same roof.

At the current stage, the automated apparel factories are more about control and predictability of a company's finances rather than merely reducing the costs. Automated factories eventually become cheaper and thus more widespread, but the timing of that is still unknown.

From the point of view of a firm's income statement, automation will cause labour costs to be replaced by depreciation charges related to the capital expenditure on machines and robots in the factories. These depreciation charges are very easy to forecast over the life of the factory whereas the wage policies of individual countries are less predictable. An automated factory, therefore, aids with financial planning and pricing decisions. Furthermore, automation enhances the consistency of output quality and thus helps managers better plan production flow.

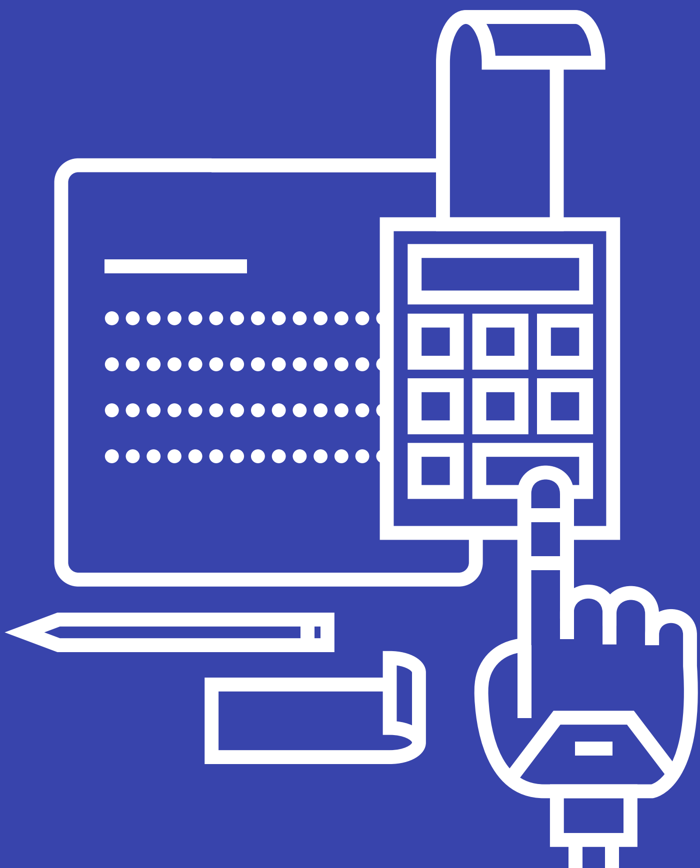
Extending this further, the financial benefit of automation is effectively a stronger connection between cost and revenue. Consider that the ultimate driver of the cost of an item of textile or footwear is wage inputs and the oil price. On the other hand, revenue is often primarily determined by the retail discount which is itself driven by both the product design and the time it takes for it to arrive at market – less popular designs or out-of-fashion products require a greater markdown to promote. Yet, experience shows that using more expensive labour does not necessarily reduce the retail discount. In contrast, more sophisticated tools, such as Shima Seiki's knitting machines that produce Nike's latest Flyknit shoes, and big data lead to better product appearance and, more importantly, a shorter time to market. As a result, the manufacturer can expect to offer a lower retail discount.

Perhaps the ultimate goal within the industry's eventual transition to automation is to track data throughout a consumer good's lifecycle: from design, to manufacture, to retail. This has become increasingly important as internet shopping has made customers more used to a greater array of designs, and thus there has been a structural increase in demand for variety. Successful stores are those that quickly bring to market new designs.

In this regard, the potential is already starting to be seen. Nike's Flyknit shoes are made with a highly automated process, as the knitting machines, located in China, feed back production data to help designers and engineers located in the US. This allows more rapid upgrades and changes to be made to the product. The data generated also helps Nike further optimise future design and production processes.

In the end, customers are as much the winners as are the manufacturers. Automation allows for new and different products to come to market far quicker than in the past. Meanwhile, manufacturers are likely to stop migrating to ever-lower cost countries. As they consolidate in the developing countries in which they currently sit, they will benefit from and will increase the standards of environmental, social, and governance policies. ●

Robot taxes and the safety net – Navigating to utopia



Sebastian Becker

As with prior automation revolutions, societies are right to question whether the current rise of automation will be inclusive or exclusive. Our cover story argues that automation will not lead to mass unemployment or permanently low wages, however, a separate but related uncertainty is whether the market can distribute the rewards of automation equitably across society, or if they will primarily flow to a small group of wealthy capital owners. >

If the latter, entrepreneurs, economists and politicians have already floated several ideas to make the distribution more equitable. These include directing taxation systems towards the ultimate beneficiaries of automation, implementing a robot tax, and rolling out a universal basic income. This piece will briefly examine why these responses are unlikely to be a panacea for the potential negative side effects of automation.

If, during the reorganisation of the labour market, the benefits of automation lead to structural inequalities, governments will have to rethink their economic and public welfare models. Indeed, many, particularly in developed countries, will likely struggle to sustain the current size and generosity of their social welfare systems. Fiscally weakened governments would, therefore, be forced to cut social expenditures and, ultimately, lose control over social policies.

Some alternative systems have been raised to deal with a more automated economy. The first is directing the taxation system towards the ultimate beneficiaries of automation and digitisation. Specifically, governments could raise taxation on capital income and wealth, such as financial or immovable real estate assets, or levy a special sales or value added tax on luxury goods. Alternatively, they could tax the whole national income – not just labour income and corporate profits – for instance, with net value added being used as a tax base. The aim here would be to make up for the loss of taxes and social security contributions linked to human employment.

In order to successfully regain their fiscal power with these new policies, governments would need to secure a high level of tax coordination and public policy cooperation between countries to avoid income and wealth shifting to low-tax destinations. The higher degree of mobility of capital relative to human employment could also complicate governments' desire to raise taxes on capital income. Higher taxation on the consumption of goods and services could possibly be another way out, although governments already struggle to receive their piece of the digital cake.

A second measure to boost fiscal coffers in the automation age is a so-called 'robot tax'. Microsoft co-founder Bill Gates has been an enthusiastic proponent of this measure and, at a first glance, it appears to be a powerful idea to avoid a social crisis due to rapid automation and job displacement. In Gates' view, a robot tax could slow the spread of automation, at least temporarily, and hence give societies and governments more time to deal with the negative externalities in the labour market.

On closer inspection, though, it becomes clear that a big drawback is that it would reduce the incentive for companies to become more cost-efficient through automation. Indeed, there are many good reasons for entrepreneurs to use machines and robots instead of human labour: they can be more effective, error-free, and facilitate the production of a large number of high quality goods in a short space of time. As wages and salaries ultimately depend upon labour productivity, the greater use of machines and robots can actually raise distributable labour income. Hence, a robot tax could unnecessarily lead to inefficiencies and high production costs as well, as would constraining the level of productivity gains and distributable income to employees. The result: high-priced, worse-quality goods and services, and lower real income and consumption levels.

A more innovation-friendly and technologically neutral way of dealing with the labour market downside of automation and digitisation could be to simply make labour cheaper relative to machines by reducing the tax wedge. To compensate for the related loss in labour income taxes and social security contributions, governments could increasingly tax profits of

As a result, a universal basic income could weigh heavily on the supply of labour, aggravate current capacity constraints in developed economies when the unemployment rate is already low, lead to outsourcing, and suppress overall national income those firms that benefit the most from the automation transformation. Societies could then enjoy the benefits from innovation, productivity gains and rising income, but in a more equitable way. In addition, governments could also levy taxes on the increased value added that is created by large multinational digital corporations. Specifically, they could broaden their taxable base beyond labour and capital income as well as corporate profits, for instance, by taxing an economy's net value added.

The second idea for dealing with potential inequalities from automation stems from this redirection of the taxation system. A Basic Income is an idea that has been knocking around for a while, but for which there is little hard data on its effects. Such an idea could take various forms, ranging from an unconditional or universal basic income to a negative income tax as advocated by Nobel Prize winner Milton Friedman. Moreover, a basic income could be introduced as a substitute to current social spending programmes or serve as a complement to some retained social spending elements, such as public health insurance or housing allowances.

Under a universal basic income scheme every citizen regardless of their economic or personal status would be paid by the government the very same statutory amount in cash. It is revolutionary as it is the opposite to today's predominantly means-tested public transfer and contribution-based social security system. Indeed, a universal basic income would completely decouple income and employment as everyone would receive the same amount.

While some see a universal basic income as a utopian response to the threat of automation, there are key questions that need to be answered. For example, what are the implications of the scheme on the supply of labour and economic output? How large would such an unconditional payment need to be? Would it help to reduce inequality?

In Germany, 58 per cent of the population supports the idea of a universal basic income, according to a poll by Splendid Research. On average, they deem an amount of about €1,100 per person per month as reasonable. Given a population of 83m, this would imply a fiscal cost of €1.1tn per annum, about one-third of Germany's entire economic output.

Whether this can be financed is the obvious question. One way could be to abolish most other social spending or raise taxes, such as the value added tax, the gift and inheritance tax, or environment taxes. Furthermore, new taxes could be introduced on wealth and, particularly, real estate. Still, the fiscal cost would be onerous and it is questionable as to whether the government could secure the funds.

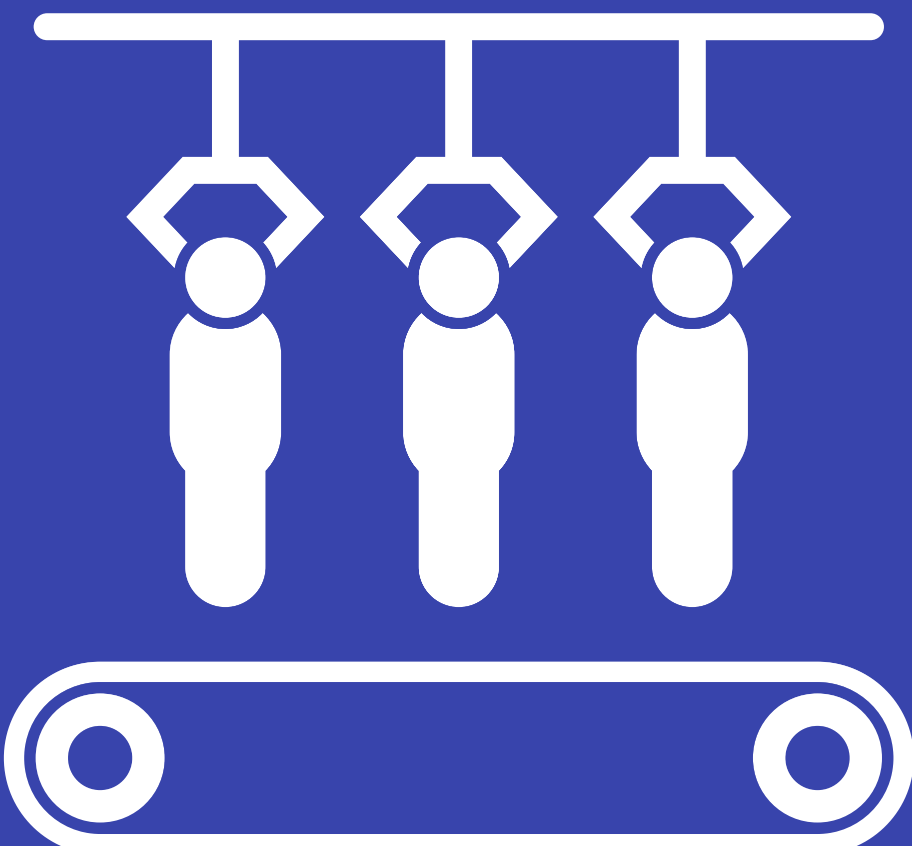
Perhaps the key negative aspect of the scheme is a reduced incentive to work given the unconditional nature of the payments. Indeed, according to the poll, up to two-fifths of the population would consider changing jobs, reducing the number of hours worked, or not working at all, depending on the size of the payment. For example, one-quarter of employed persons with a vocational-training background would consider giving up work, as would one-fifth of academic employees. As a result, a universal basic income could weigh heavily on the supply of labour, aggravate current capacity constraints in developed economies when the unemployment rate is already low, lead to outsourcing, and suppress overall national income.

There will soon be some evidence to help governments make a decision. In Finland, the government has almost completed its two-year experiment with a universal basic income. Under the pilot project, an unconditional cash payment of €560 per month was made to a group of 2,000 randomly selected unemployed people. The people could also seek additional employment if they so wished with no reduction in the payment. The results from the experiment will be not published before the end of 2019 but when they are, they will shed some light on how the scheme affected peoples' attitudes towards work as well as other indirect effects.

The long-term impact of the latest wave of automation and digitisation on labour markets, the economy, and public finances, is still highly uncertain. So too is the resulting effect on the architecture and sustainability of welfare states. A lot depends on the speed of this automation given societies tend to turn like a battleship. Even so, the responses to the challenges all have flaws. Given the significant shortages of skilled labour in most developed economies at present, the introduction of a universal basic income seems questionable at this juncture as it would reduce the incentive to work. That would intensify labour shortages and slow economic and income growth. In addition, the potential benefits of a robot tax appear most likely to be outweighed by the costs incurred, including a slowdown in productivity and the loss of international competition, jobs and income.

As long as there is no clear evidence towards a move into a jobless world, societies are better off refraining from radically changing their taxation and social welfare policies. Displaced employees will, of course, need to be financially supported but that provision should be made within today's mainly means-tested social security networks. It is certain that automation, robots, and artificial intelligence will disrupt the labour market, at least in the short term. However, it seems questionable that a universal basic income or robot tax are the correct solutions.

Populism – Not the enemy of automation



John Tierney

To the consternation of many in the West, several strains of populist governments have come to power around the world in recent years. It is easy to assume that these governments are, among other things, representing people who oppose automation. After all, statistically, the profile of the average supporter of populist movements tends to be someone in lower-wage groups – someone who understandably feels that their job is threatened by the latest wave of automation.

But populism isn't necessarily the enemy of automation and progress. Indeed, it frequently seeks to extend the benefits of industrialisation and automation to a broader population. A note of caution, though, comes from the fact that this appears to be occurring alongside the rise of more authoritarian governments. Even as automation promises to open new economic vistas, there is some risk that less welcome social and political change is attached.

One strand of populism is developing in Eastern Europe, where voters in Poland, Hungary and to a lesser extent the Czech Republic have turned to more authoritarian governments. Their rise has come through a backlash against immigration and a perceived loss of national sovereignty to the European Union.

Despite this, factory owners in these countries are turning to robots because their economies are near full employment. And consider that the governments of Hungary and Poland have been chastised repeatedly by the European Union for their populist and anti-democratic ideals, but the countries have educated workforces, and as part of nationalistic fervour have sought to deepen their economic bases using automation as a means to this end.

Another form of populism is rising in parts of Asia, with the Philippines perhaps the best example. Here too, many governments are pursuing mercantilist and export-oriented policies with the goal of bringing the benefits of industrialisation and trade to more people. China, with its long-established communist government, might not fit the template of a rising populist government but it certainly has strong populist roots. Its government has sought to maintain its power by attempting to spread the benefits of industrialisation across society. And it has abetted and upgraded its industrial base through technology and automation.

And then there is the rise of Donald Trump and his largely blue collar base in the US, and the Brexit vote in the UK. Both were spurred by workers who felt angry at being left behind economically by the globalisation and free trade of the past 30 years.

A look through history shows that populism has not necessarily been the enemy of automation or innovation. True, there is the classic example of weavers in 19th century Britain rising up against factory owners and their mechanised looms. But the impetus of many populist movements both historically and today has been to find ways to better distribute the spoils of automation, both in terms of more and better jobs and higher wages, although, admittedly, results have been mixed over different time periods

If we follow the standard model, the automation wave of the future should ultimately improve peoples' lives as it has in the past. And putting aside the politics of the recent populist turns, it may help spread the benefits across society. Yet, there are also qualitative differences between the automation of the 19th and 20th century and what lies ahead in the 21st century that could have unintended political and social consequences.

Until recently, most automation was mechanical in nature. In the 19th and 20th century it was about replacing physical human labour with machines that allowed people to either produce far more or freed them from subsistence tasks so they could do other more productive things. Mechanical looms, cotton gins, steamships, typewriters, elevators, automobiles, telephones, mainframe computers, to name a few things, all greatly extended the reach of human beings. Of course, there was disruption and displaced workers. But new jobs were spawned as a result. Horse-drawn cart and carriage drivers became truck drivers. Accounting clerks became computer programmers. And so on.

The automation that is happening in much of the less developed world still fits that template. It is a different story in the developed world where automation is increasingly digital rather than mechanical in nature. Blue collar labour will continue to be an obvious target, with software-powered smart robots replacing factory workers and smart trucks replacing drivers. But increasingly, the target is white collar professional work. Artificial intelligence programs will soon do much of the routine work of lawyers, accountants, money managers and even doctors. We already see a tendency toward job polarisation, where work is increasingly bifurcated into high education/high-paying roles and low education/low-paying roles. The question is whether that trend continues.

There is of course the status quo scenario, where things sort themselves out, even if the path forward doesn't seem clear now. In the past, as automation took over, many of the emerging and better paying jobs were within the reach of displaced workers; it was just a matter of retraining to qualify for them. That might very well happen again over the coming decade.

Another less sanguine scenario is that the high skill and high paying jobs of the future may require a level of talent and training that is simply beyond the reach of most people, leaving them with little choice but to take lower paying jobs.

A rough parallel might be the globalisation over the past 30 years that caused high-paying manufacturing jobs in the US to migrate to low-wage countries. Most of those displaced workers couldn't find work that paid what they previously earned, and they probably lacked the background to retrain for emerging professional careers thus effectively pushing them out of the middle class. Likewise, the automation of the future may have the effect of displacing many mid-level white collar workers who thought they were firmly in the middle class even as it opens opportunities for others.

If the problem of displaced workers does continue to grow, in the sense they cannot find jobs offering comparable pay, then certain things will have to happen to avoid major disruption. First, it is essential that productivity rise. Politically, it is far easier to divvy up and redistribute a growing pie than an existing one. Automation and digitisation are a likely source for productivity growth that has been lagging historical levels for several decades.

Second, it is essential that public infrastructure be upgraded, especially in the US. The American Society of Civil Engineers estimates that US will have to spend $2tn more than is currently projected over the next decade to fully upgrade roads and bridges, ports and waterways, waste water treatment facilities and the electric grid. Anyone who has lived through a few days (or even weeks) without power due to extreme weather or outdated equipment failure knows first-hand how quickly life can turn primitive. If infrastructure isn't upgraded, it will be far more difficult to distribute many of the benefits of the coming automation era. And if those benefits can't be more broadly distributed it may be difficult to realise any potential productivity gains.

The third necessary stimulant to society is a greater investment in education. Unfortunately, some developed countries, such as the US, are going in the other direction and cutting education budgets, causing teachers in some states to walk off the job. Teachers aren't being pushed out of the middle class by automation, but they are an example of how white collar workers are capable of being swept up in a populist wave. More troubling for an automated future is that a lack of investment in education makes it more likely that as young people enter the workforce they will lack the necessary skills to qualify for the better paying jobs that automation creates. They will be the populists of the future, with unpredictable results.

There are other trends that bear watching.

While the rise of more autocratic governments may be supportive of automation, there is the risk that they turn to the tools of the digital era for darker purposes. The ability of foreign hackers to obtain sensitive information and to allegedly interfere with elections is an obvious example. Another possibility is that some countries use the internet and other tools of the digital era to control the flow of information that people receive. It wouldn’t be a large leap for governments to start deploying for this purpose the kinds of algorithms large technology companies use to gather consumer information and place targeted advertisements.

It is also possible that emerging autocratic governments may start trying to emulate the Chinese model, where the government maintains a tight grip on the information its society digests while simultaneously delivering the benefits of economic prosperity to most of its population.

The risk here is two-fold. First, if the current wave of populists, in their various forms, are indeed able to maintain and gain power and are also able to secure for the broader population some of the economic benefits of automation, then other countries could start following suit and choosing leaders that promise to emulate them. This could set off a gradual drift away from liberal democratic ideals of governance.

Second, true innovation thrives in an environment that encourages the free flow of information and ideas. Governments that limit this freedom may be able to copy or import another country’s innovations, but it is harder for them to foster the kind of creativity that gives rise to new ideas. With its industrial prowess, China is extremely effective at assembling complex gadgets like iPhones. But it still lacks the ability to design and manufacture semiconductors. Furthermore, despite its growing dependence on sophisticated industrial robots, it has struggled to design and build these machines at home.

It may be that economists are right, and the coming wave of automation brings economic benefits to society that offset the inevitable disruptions. But we also have to open our minds to the possibility that the other assumption – that society just adapts and moves on – may be more problematic. Over the last seventy years, liberal democratic ideals have flourished in the developed world. It is easy after a long spell to forget how fragile those institutions can be, and they may need nurturing to survive in their current form. If instead the populist movements of recent years develop deeper roots, especially in the West, the fight over those economic benefits could also usher in a period of social and governmental upheaval. ●

While the rise of more autocratic governments may be supportive of automation, there is the risk that they turn to the tools of the digital era for darker purposes.

Leisure productivity – Mismeasuring the tech boom

Dominic Konstam

It is easy to understand how technology boosts productivity growth. The same worker might be empowered to produce twice as much if given a faster computer. And yet, the observation can also be made that so much of the current trend in automation and technology is applied to activities outside the workplace. Of course, in some cases, non-work activities can take place during work hours. The obvious culprits are online shopping and social media. But it is more difficult to think about how these activities relate to welfare and economic growth. >

Some argue that these activities have the potential to transform how we think about gross domestic product as a measure of welfare and this is becoming increasingly pertinent as the new automation age deepens its reach into everyday life, particularly outside the workplace. Ultimately, there may be a mechanism by which the impact of new technologies on non-work activities changes how economists view potential growth, the path of interest rates, and equity valuations and these issues form the basis of discussion in this piece.

In economic theory, welfare is usually defined as the sum of gross domestic product and consumer surplus. Consumer surplus is the difference in the price that a consumer actually pays for a good and what they were willing to pay for it. In a perfectly competitive market, all consumers pay the same low price for a good, a price that is equal to the marginal cost of production. However, many consumers might be willing to pay more, a lot more, if their demand is insensitive to the price. For example, sports car aficionados are generally willing to pay far more for a new Ferrari than the car costs to produce. Measuring the consumer surplus, though, is difficult and, needless to say, it is one of those unobservable knowns.

If market conditions are competitive there is a huge welfare gain from lower prices that is not captured by GDP figures. If a market is not competitive, firms can charge more for their products and the consumer surplus is transformed into profit. This might boost the level of GDP at the expense of the consumer surplus. In that case, overall welfare will be lower due to what economists term ‘deadweight loss’. This represents a loss in production efficiency as less competitive industries tend to price above marginal cost. The extent of the deadweight loss, and how much consumer surplus is actually transferred, boils down to the degree of price discrimination that a producer can engage in. In other words, it is the extent to which a producer can charge higher prices to people willing to pay more. If a monopolist can truly price discriminate between every consumer, the entire consumer surplus can be transferred to profit and deadweight loss can be eliminated. Welfare is unaffected but it is all captured by GDP via the increase in profit.

Price discrimination is only possible if a producer understands every aspect of what drives an individual consumer to make a purchase. It requires tailored surveillance, something that is becoming increasingly possible as emerging automation technology allows large scale data collection on buying patterns. Most readers will be acutely aware of travel websites that show different prices for the same destinations as algorithms piece together a profile of the customer based on their browsing behaviour. In one study, computers with addresses in greater Boston were shown lower prices than those in more remote parts of Massachusetts. This clearly raises all sorts of ethical and regulatory issues that will undoubtedly become more widely discussed as technology progresses and interacts with economic welfare.

Yet to the extent to which this potential transfer does not occur, perhaps because appropriate regulation emerges to constrain personalised pricing, we can think about consumer surplus in terms of a new concept which we will call ‘leisure productivity’.

A day is divided between ‘work’ and ‘leisure’. In the workplace if the measured ‘output’ is larger for the same number of work hours this raises labour productivity and GDP. Income measures of GDP in the national accounts will then show a rise through an increase in profit from higher productivity, but also as wages rise in line with productivity growth. For expenditure measures of GDP, the increase comes from higher investment and consumer demand, reflecting the increased output purchased even if the price is the same or lower.

Similarly, outside the workplace if consumer surplus is increased for the same leisure hours, then there must also be an increase in ‘leisure productivity’. After all, there is more utility derived per unit of leisure consumed.

The most obvious example of leisure productivity is social media. A new computer in the workplace might free up an extra hour of work that is then reapplied to work. But the same technology might also free up an extra hour of leisure that can be reapplied to more leisure. Wages are the opportunity cost, or price, of leisure. So if wages rise because of higher labour productivity, then so too does the price of leisure. Therefore, the value of leisure grows with labour productivity assuming the distribution of hours between labour and leisure is unchanged.

Social media continues to be an excellent example of how leisure productivity increases. Search in general frees up enormous amounts of leisure time when it comes to mundane chores, such as grocery shopping, bargain-hunting, or vacation-planning. Imagine what consumers might pay for access to search websites or social media. Even if it were a few pennies each time or a dollar a day subscription, the implied consumer surplus is enormous. In large part, this should be directly attributed to the utility in leisure or leisure productivity. There have been various heroic attempts at measuring the consumer surplus embedded in the consumption of the internet and not surprisingly they easily run into the hundreds of billions of dollars.

So now imagine bringing together the strides in leisure productivity with the implicit growth in consumer surplus and the notion of price discrimination that is designed to transfer that consumer surplus. Social media companies currently fund themselves through advertising and this directly contributes to GDP. Advertising also creates value through the potential of price discrimination. To the extent that advertising captures all of the consumer surplus, then GDP will be substantially higher with overall welfare little changed. However if social media users opt to pay not to have advertising they effectively keep their consumer surplus away from the advertisers but incrementally transfer some to the social media companies. In the extreme they may transfer it all so that the ultimate distribution is still the same and it is only the conduit that varies, that is the consumer surplus to advertiser to social media company, or consumer surplus to social media company. In both cases, GDP is much higher and the consumer surplus transferred. The end result might be that GDP is then a better measure of overall welfare but against the backdrop of rapid automation and technological change, it is the transition that is interesting. That transition phase is where we are today. Welfare is likely rising relatively strongly but GDP is a poor indicator of total welfare.

What does this mean for asset prices and interest rates? The equilibrium interest rate or ‘r-star’ as the US Federal Reserve affectionately calls it, is largely reflective of potential growth, perhaps distorted by savings-investment balances from time to time. If welfare is high relative to GDP but is then transferred to GDP via the consumer surplus transfer, then potential growth estimates will be much higher. Labour productivity will be measured as being much higher relative to leisure productivity with both wages and profits being higher from the income side of GDP. In principle, this should entail a much higher r-star.

In some sense, that potential transfer can be capitalised in equity prices as higher equity valuations carry the price of that future transfer. If shareholders spend that wealth and anticipate the actual transfer, then real rates will need to rise higher earlier. After all, real output as measured is not any higher until the consumer surplus is fully captured. However, if the consumer surplus is still robust and welfare that much higher than GDP, it is equally not obvious why real rates needs to be any higher now than in relation to measured GDP potential.

Interestingly, this suggests that even if wages are still low because measured productivity is low, welfare can still be a lot higher due to the consumer surplus. Low wage shares in GDP don't necessarily create the 'social unrest' of the 1970s if a much higher consumer surplus is more than making up for it. Of course, this assumes the higher consumer surplus is distributed across society and not concentrated in the hands of a few. For the most part this seems to be the case – think of the ubiquity of smartphones. But if technology evolves in an increasingly exclusive direction, public policy would have scope to bear down on the issue.

In the Nicomachean Ethics, Aristotle said, "And happiness is thought to depend on leisure; for we are busy that we may have leisure, and make war that we may live in peace". Ultimately, GDP is a partial measure of true welfare via the opportunity cost of leisure. Completeness comes if we can properly incorporate consumer surplus, effectively through leisure productivity. The automation and technology revolution is a spur for rethinking welfare and the potential limited significance of traditional economic principles as they pertain to asset prices and interest rates. ●

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Emerging markets – From robots to co-bots

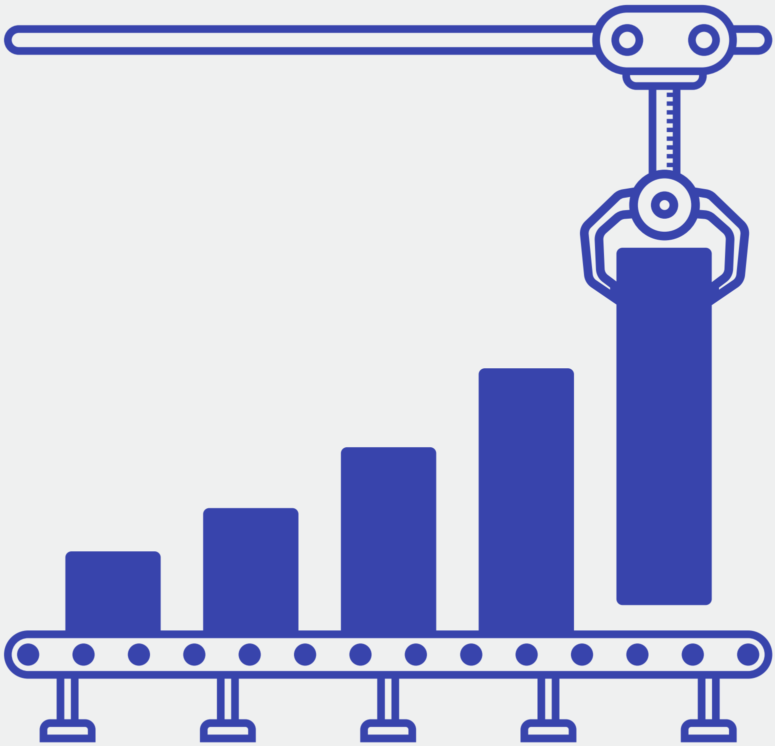
Baxter, a precocious redhead with inquisitive grey eyes, lanky arms, and the persistence of a six-year-old child has a seemingly infinite capacity to learn. Show him how to do something and he'll do it over, and over, and over, as many times as you desire. Baxter is a robot, the vanguard of a new generation of collaborative robots capable of working with, and around, humans and easily trainable to perform a myriad of tasks. No longer are expensive, bulky and dangerous machines needed to perform tasks that humans can't, such as flipping over a car chassis to provide an even coat of paint. The new generation of robots can do many things their human trainers can do and many more, such as assembling the tiniest of electronic devices, that they can't. And at a cost of $4 per hour they are cheaper than most humans, even in emerging market economies.

Baxter was conceived and made in the United States but it is in emerging markets that robots could have a bigger impact than many people expect. In fact, not only will such inexpensive co-bots be increasingly prevalent in emerging market economies, but the production of robots themselves will likely move to these regions. In turn, this could rapidly reduce prices and accelerate their deployment worldwide.

To see how robots could quickly proliferate around emerging markets and the rest of the world, it is worth examining the parallels with the development of the mobile phone. Indeed, the first device available to consumers was the Motorola DynaTAC 8000X. It debuted in late 1982 and came with a price tag of $3,995. That is more than $10,000 in today's money. It was indeed a 'brick' and weighed more than a kilogram. Indeed, in those days, mobile phones were genuinely better suited to being installed in a car – with the three-foot antenna sticking out of the roof – than being carried in a pocket.

A decade later, in 1992, the first smartphone retailed for $900, still $1,600 in today's terms. Then, mobile phones were a first-world product. Today, China produces almost all the world's handsets; more than 2bn were made last year.

Michael Spencer



These products have vastly superior processing speed and a seemingly infinite range of applications. Importantly, they can be bought for a fraction of the price of that first smartphone. In India and many African countries, consumers are able to purchase smartphones and access services, such as banking products, that have resulted in a surge of new opportunities.

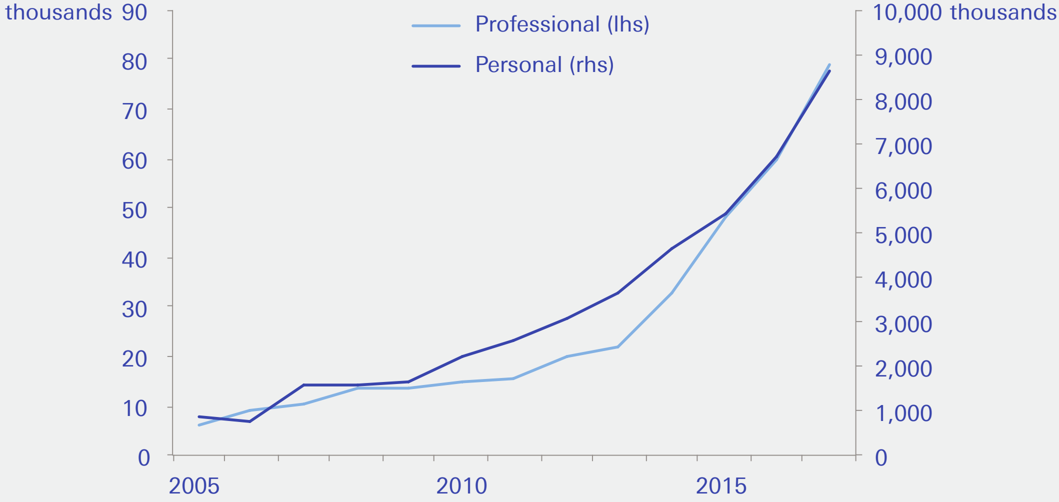
Industrial automation appears to be at the same point today as mobile phones were in the mid-1990s. Surging shipments of robots and a proliferation of models, rapidly falling prices, applications for a rapidly broadening range of uses, and growing consumer acceptance of the new technology lend credence to industry claims that we have passed an inflection point in robotics similar to, and in some ways more powerful than, that of the mid-1990s revolution in information and communications technology.

If this is true, then the rise of robotics is not the uniform threat to emerging market economies that it has been made out to be. Those concerned often point to robots that can automate large parts of the apparel manufacturing supply chain, and the decreasing proportion of manufacturing jobs in today's developing economies compared with those a generation ago, something economist Dani Rodrik called, "premature deindustrialisation."

While this is not all wrong, its impact needs to be offset against the benefit to emerging markets from becoming a robot production hub.

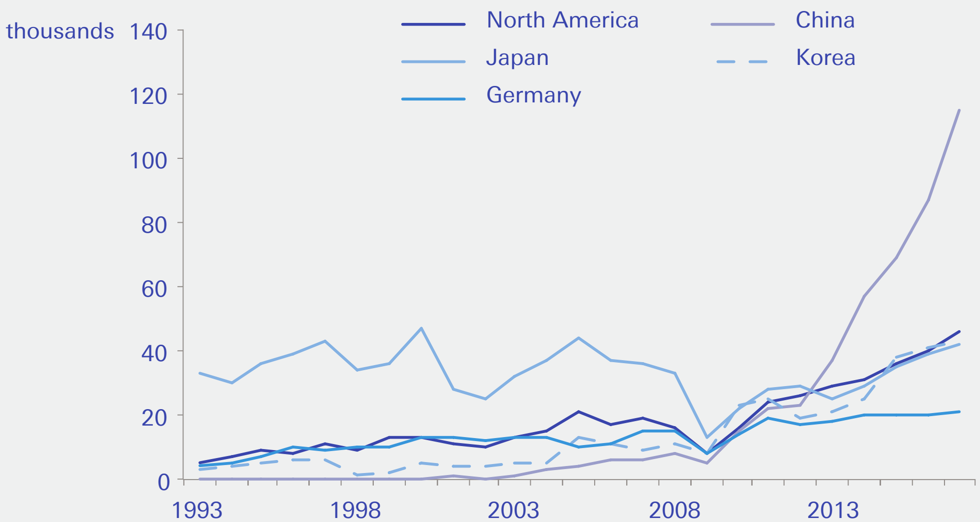
It is worth examining the evidence to understand the rising demand for robots. Shipments of industrial robots have risen at a compound rate of 16 per cent since 2010, more than doubling to about 350,000 installations annually worldwide according to the International Federation of Robotics. While these figures are based on industry surveys that are known to be incomplete, and so underestimate sales, the surge in sales since the global financial crisis has a strong foundation. There are probably more than 2m industrial robots in operation around the world. And even if growth slows slightly in the coming years, by the end of the decade, the number of working robots should top 3m.

Shipments of service robots



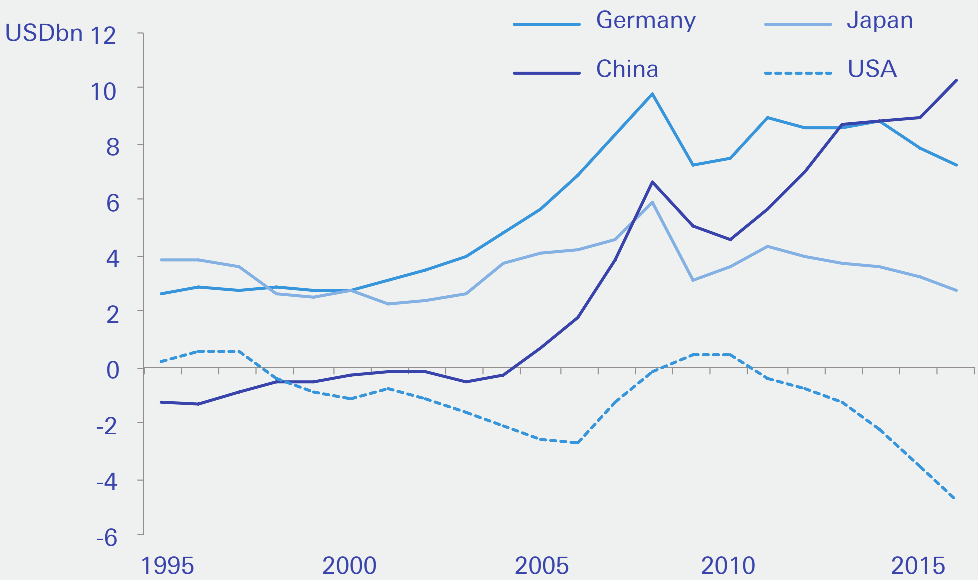
Source: IFR World Robotics 2017 and Deutsche Bank Research

Major industrial users of robots



Source: IFR World Robotics 2017 and Deutsche Bank Research

Trade balances in related machinery



Source: IFR World Robotics 2017 and Deutsche Bank Research

Bear in mind these figures are just for industrial robots. For the purpose of this analysis, industrial robots are defined as those capable of movement on three or more axes, and so exclude other forms of automation, which are also growing, for example, service robots that are already ubiquitous. Many readers will have one cleaning their carpets or entertaining their children. Indeed, Sony recently revived their robotic dog, AIBO, which first appeared in 1999 and has evolved over more than 100 generations. The IFR also estimates that 8.6m personal use robots that assist with cleaning, entertainment, or elderly care, were shipped last year. Professional use robots which are used mostly in logistics, farming, and defence applications, are far fewer in number but by some measures are growing faster, at a rate of more than 20 per cent compounded over the past seven years.

The changing geographic pattern of robot sales and production is most interesting. As the second chart shows, Japan was through the 1990s and 2000s the largest market for industrial robots and likely the largest producer also. However, China has recently overtaken Japan to become dominant as a market for industrial robots and likely as a producer of personal robots. Indeed, China now accounts for one-third of global unit sales of industrial robots.

Like in other countries, the Chinese government has developed a national strategy for robotics adoption and research, but unlike other governments they have moved more quickly to implement this strategy. Whereas Chinese industry was formerly almost completely reliant on imports, local producers now supply more than one-third of the country's robots. It is true that robot design is a different skill to robot production, and China is lagging somewhat in the ability to pioneer new designs. That said, one particular metric bears out China's adoption of this technology. In 2011, automobile manufacturers used about one-eighth the number of robots of their developed market competitors. By 2016, that had grown to be just under half as many.

The figures report robot orders or installations by country, not production. So it is safe to say that China is now the world's largest market for industrial robots and Chinese firms now produce about as many robots as are installed in all of Western Europe. Among services robots, there is a stark difference in production locations between professional-use robots, which are mostly made in North America and Europe, and personal robots, which are overwhelmingly produced in Asia. For example, the iRobot Roomba is, like the iPhone, designed in America but made in China. More than 20m Roombas have been sold since 2002.

Trying to compile a picture of global trade in robots has so far proved elusive, but in the third chart we show net exports of mechanical handling devices, the most relevant component of trade data. In 2016, China accounted for almost one-fifth of global exports of such equipment, double its share of a decade ago, and it has gone from having a roughly balanced trade in this sector to an annual surplus of $10bn. Germany and Japan continue to report sizeable surpluses, but the US has seen substantial growth of its deficit in this sector.

While for most people, the word 'robot' conjures up a humanoid in a sci-fi movie or a massive Transformers-like machine, as Baxter has demonstrated, robots are now available at a scale and cost that rivals humans. Collaborative robots are both more versatile and less threatening to deploy. With China now leading the way in the use and, in certain sectors, the production of robots, we anticipate the price of robots will continue to fall, further supporting more widespread use. Undoubtedly, some humans will be displaced from work by robots, although we are in the camp that sees the current concerns about widespread mass unemployment as no different from the incorrect predictions that accompanied previous industrial revolutions.

The role of China in furthering the rapid adoption of this new technology both by virtue of its own economies of scale and in its ability to manufacture robots cheaply is strongly reminiscent of the development of the mobile phone industry some two decades ago. Just as in the early 1990s few people had any idea how important smartphones would become to peoples' personal and working lives, so too the world will be surprised at how quickly robots transform daily routines. ●

The new generation of robots can do many things their human trainers can do and many more, such as assembling the tiniest of electronic devices, that they can’t.

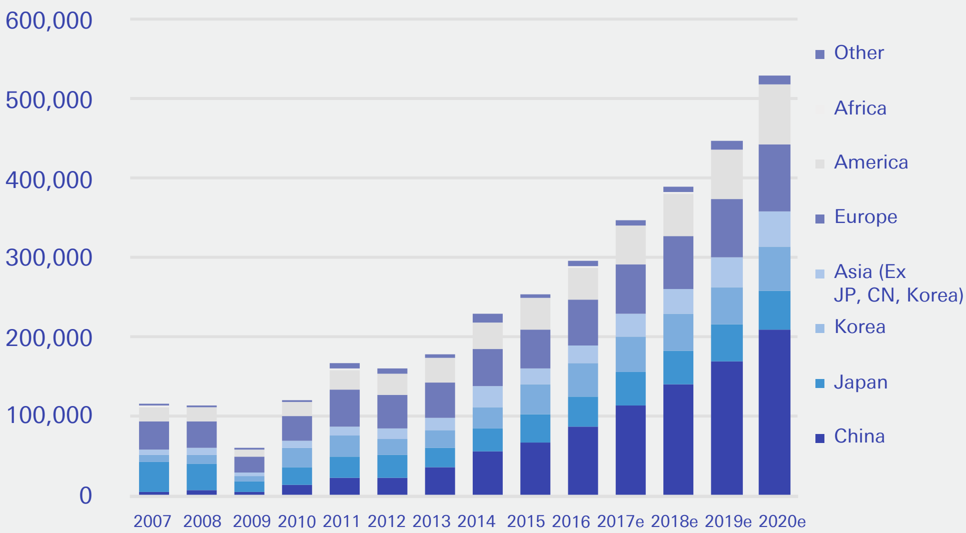
Japanese automation – The leader in complexity

While industrial robots have transformed the production landscape, few appreciate the extent of the growth potential that still exists. Industrial robot shipments across all regions rose to a record of almost 350,000 units in 2017 according to the International Federation of Robotics. This reflects growing demand for automation-related equipment, but also the ability of robots to replace humans in an ever-wider range of tasks.

Industrial robots are mainly used on the factory floor and are not simple machines but highly complex instruments, technically defined as multipurpose manipulators programmable across three or more axes. Growth of unit shipments averaged 16 per cent per annum between 2010 and 2016. Deutsche Bank's global industrial team expects that growth rate to continue until at least 2020. For industrial companies, a 16 per cent growth rate is extremely fast. To put it in perspective, it is two and a half times the predicted rate of nominal global economic growth.

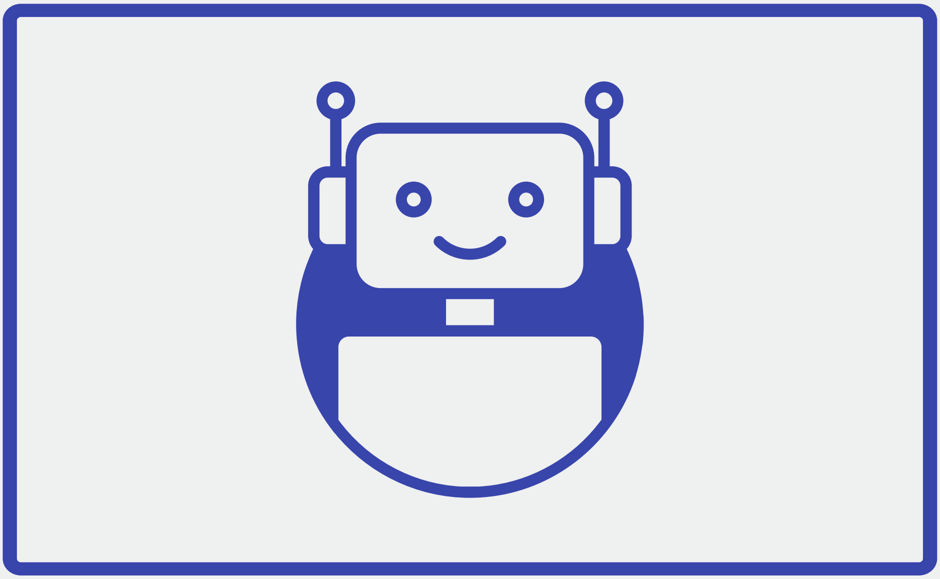
Underpinning the growth in robotics is the growth in wages. While macroeconomists fret

World robot shipments forecasts by region (DB estimates)



Source: IFR, Deutsche Securities estimates

Takeshi Kitaura



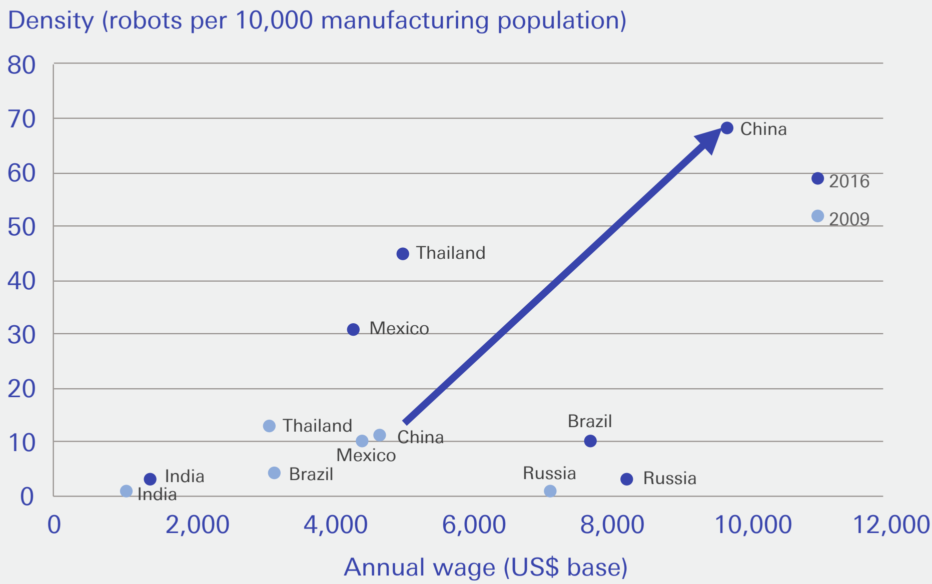
about low wage growth across the developed world, in some emerging markets wage growth is quite strong. While wages in developing countries, on an absolute basis, are still much lower than in developed countries, they are rising quickly. In China, wages more than doubled in dollar terms between 2009 and 2016. On a country-wide basis, China's per capita labour costs today run at about one-quarter the rates seen in Japan. However, anecdotal evidence suggests that wages in Chinese factories closer to the coast have already reached half the level of Japan.

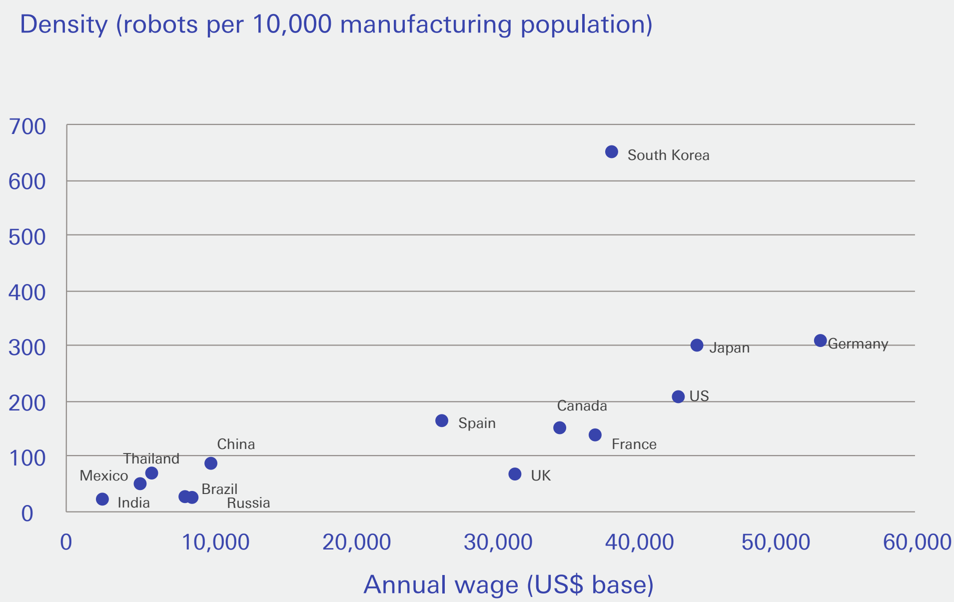
The economics involved are leading both developed and developing countries to increase their use of robots. The logical extension of this trend is that it will lead to a virtuous cycle in which a shrinking or slow-growing working age population in many countries will put upward pressure on wages. And because wages are positively correlated with robot density, higher wages will likely trigger greater robot utilisation.

Interestingly, among developed countries, only in Japan did robot density decline from 2009. Beginning around 2012, Japan started developing ever more sophisticated and productive robots. Rather than being a cause for concern, declining robot density in Japan is actually a sign of its dominance in this field. As global demand for these kinds of robots grows, Japan could emerge as a leading developer and exporter of this technology.

To examine why Japan will likely lead the progress with industrial robotics, it is worth dividing industrial robots into two categories: soft fixed assets and hard fixed assets.

Chinese wages have increased along with robot density in the last seven years, but emerging markets have a long way to go to catch up





Source: Various government data, IFR, Deutsche Securities

Soft fixed assets are relatively simple robotic machines that are typically made with low-cost components, such as sensors, motors and pneumatic equipment (those operated by air or pressurised gas). These machines are designed to simplify the work of one employee, or possibly replace them. The investment cost of building a simple automated apparatus with pneumatic equipment could be around ¥1m, or $10,000, and can be recovered within a year or so.

More complicated and expensive automation equipment, which includes complex robots and machine tools, are considered hard fixed assets. A robot model used in welding lines of automobile factories costs between ¥5m and ¥10m, or $50,000 and $100,000. When adding the required accessory equipment and the number of robots needed in each production line, the overall investment becomes quite large. An assembly line with a double-digit number of robots could entail an upfront investment amounting to tens of millions of dollars.

In the developing world, including China, most of the automation-related investment has been in the first category. As noted, many small, simple robots with few joints cost less than ¥1m and the pace of adoption of these low-cost robots is accelerating. However, it may take several more years before demand for more sophisticated robots mushrooms.

Meanwhile, Japan has been developing automation and robotic technology for decades. For a variety of reasons, capital goods manufacturing is more established in Japan than in other countries. High labour costs faced by Japan's manufacturers, as well as land constraints, play a major role. Furthermore, given that automobiles are Japan's mainstay industry, quality and safety have long been considered of the upmost importance.

Against the backdrop of a harsh competitive environment, developing the technology for sophisticated automation has been a key pursuit across the country, particularly during Japan's period of strong economic growth in the 1970s and 1980s. At that time, Japanese companies worked to raise the quality and performance of their products to the levels achieved by Western companies. However, it was not enough to improve just product performance; it was also necessary to improve production technology. This is because although it is possible to buy robotic components and achieve 70 per cent of the quality of the product, closing the last 30 per cent gap requires substantial effort.

As a consequence, Japan has become the leader in this area. Core Japanese firms own one-third of the global market share of industrial robots and over half the market share of multi-axis robots. That compares with Europe's share of 27 per cent and 38 per cent respectively, according to Nikkei market share estimates.

Today, many emerging market firms are producing automation-related equipment in various fields, but most have not succeeded in closing the last 30 per cent gap and are still producing basic soft fixed asset robots. These firms are likely to need substantial production technology advancement to catch up. That may not be a big issue yet, as most developing countries are more concerned with how to use the inputs they have–labour, capital and land–more efficiently, and they still have relatively low labour costs. But they will reach a tipping point when they experience a surge in labour costs or a deterioration in exports and will thus seek more sophisticated automation tools.

It may take several more years before a full demand environment develops for high-end robotics. But the tide is turning. China's release of its 'Made in China 2025' plan to improve product quality and introduce more sophisticated production technologies is already shifting Chinese buyers of robotic technology from price to quality. It is hardly a stretch to suggest that robotics could become a major export industry for Japan, just as automobiles were.

Ultimately, the trend towards automation and, particularly, robots requires both market demand for technology and its balancing supply. Globally, technology has tended to be ahead of demand as labour costs in developing markets remained low. However, demand has begun to catch up over the past five years as labour costs continue to see double digit growth in core developing countries. Today, both the demand and supply of technology are in place for the next stage of growth.

Developing an edge

The so-called internet of things has been widely heralded as the next step in automation and in Japan it is just beginning to ramp up. As such, it is worth looking at this particular area of automation more closely. Over the past year, the strategies of Japanese automation equipment companies surrounding the trend have become clearer. While focus has centred on cloud-based solutions, Japanese companies have promoted so-called 'edge-heavy' strategies that utilise a mix of their hardware specialty along with software for connectivity. Edge computing is a method of optimising cloud computing systems by performing data processing and analytics at the edge of the network, near the source of the data. This reduces the communications bandwidth needed between sensors and the central data centre.

Fanuc's FIELD system began in October last year. This is a network system that connects factory equipment, such as robots and machine tools, and optimises production efficiencies. Competitors are also gradually clarifying details of their own services. Mitsubishi Electric focuses on their e-F@ctory concept where they see core strength in edge computing within the realm of the internet of things.

As global competition in the market heats up, rivals are beginning to build cooperative relationships with each other. Edgecross, an open-source software platform for edge computing, was unveiled in early November. The consortium of Japanese companies backing the project includes Mitsubishi Electric, Omron, Advantech, NEC, IBM Japan, and Oracle Japan. They point out that edge computing using primary data-processing will be crucial, given the difficulties in processing the huge amount of data generated on factory floors in real time through clouds alone.

The primary objectives of Edgecross include: real-time diagnosis and feedback, a wide variety of applications used in edge computing domain, data-collection from the factory floor, seamless collaboration between various systems, and works on industrial computers.

Over 51 companies have now officially signed up to Edgecross and the consortium is promoting the formation of standardised Edgecross specifications and dissemination outside of conventional company and industrial frameworks. Future initiatives for international standardisation are also in the works.

This highlights just how much growth is set to come in the industrial robotics market. These projects and others will inevitably spring up as further demand rises to support the continued growth in the market at rates well above those of the wider economy. ●

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Konzept discusses the thematic issues that affect the world from a financial, social, and environmental point of view. In this edition, we examine the challenges and opportunities around the current wave of rapid automation. We discuss how automation will help reduce climate emissions and how it is making mining for iron-ore safer. In addition, we examine how governments can respond if the profits from automation create further inequality, and also investigate prior periods of economic revolution to see the effects on employment and wage growth.
Overall, we hope Konzept will contribute to the different aspects of the debate on automation.