BANK OF ENGLAND

Speech

The Future of Work

Speech given by

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2018 Whitaker Lecture, Central Bank of Ireland

14 September 2018

I am grateful to Clare Macallan and Jennifer Nemeth for their assistance in preparing these remarks. I would also like to thank Will Abel, Andy Haldane, Carsten Jung, Rana Sajedi and Greg Thwaites for the background research and analysis they conducted.

It is a pleasure to deliver this lecture in honour of TK Whitaker.

Whitaker's career in public policy spanned a period of profound structural change in the Irish economy. In 1956, when he became Secretary of the Department for Finance, the Irish economy was isolated and uncompetitive. Growth in output per capita was lagging the rest of Europe and the steady tide of emigration was gradually shrinking the population. By the time Whitaker's career drew to a close, the Celtic Tiger was roaring: Ireland had caught up with even the most prosperous nations in the EU, GDP growth was averaging over 5%, and the population had increased by two-thirds as emigration switched to immigration.

The catalyst for this transformation was opening up to foreign trade and investment. Beginning with the 1958 report *Economic Development*, Whitaker strongly advocated replacing the old strategy of self-sufficiency with a new one of export-led growth, which led in time to Ireland joining the EU. For many, this is the greatest long-term consequence of his work.

But as students of economic history know (and policymakers learn at their cost), without the right institutions, structural changes – whether large changes to trading relationships or technological revolutions – can be painful.

Whitaker recognised that "Readiness to adapt to changing conditions is a sine qua non for economic success"[1] and that adaptability required a series of changes to Ireland's institutions. Major reforms to education were essential to match the skills of the Irish workforce to the potential jobs that increased inward investment could bring. A 1964 report on Manpower Policy, which Whitaker oversaw as chair, advocated greater investment in the STEM subjects, readying a generation for the IT revolution.[2] More broadly, Ireland repeatedly increased standards of education, beginning with the introduction of universal secondary schooling in 1967, resulting in levels of educational attainment today that exceed the OECD average.[3]

Whitaker also advocated reforms of labour market institutions – to tackle restrictive work practices and ensure pay was more closely linked to productivity.[4]

Emphasis was also placed on a competitive environment for business to help attract foreign capital, in part through the overhaul of the corporate tax regime. And improvements were made to infrastructure, such as power supplies and transport services.

[1] Taken from "Economic Development", a report on the Irish Economy overseen by Whitaker and published in 1958.
[2] Whitaker played a central role in improving education in the public sector. His concern "that the variety and difficulty of administrative problems have so increased, and the tools and techniques for solving them have so developed, as to render administration more than ever a science" resulted in the creation of the Institute of Public Administration in 1957. To this day, the Institute continues to provide education, training and research to the public sector, enabling better policy making through a better understanding of the Irish economy. In addition, Whitaker was instrumental in setting up the *Economic and Social Research Institute* – the first institution to provide independent research and analysis of the Irish economy.
[3] For example, nine Regional Technical Colleges were established during the 1970s to provide vocational tertiary level training. The Industrial Development Authority ensured that government funding of higher education adapted to meet businesses' increasing demands for skilled labour in areas such as engineering and computer sciences, helping to ensure people could develop the skills necessary to work in the expanding sectors.
[4] Whitaker, TK (1955/1956) 'Capital formation, saving and economic progress', Dublin: Journal of the Statistical and Social Inquiry Society of Ireland, Vol. XVIX, pp. 184-209.

The Irish experience over the past half century reinforces the lessons learnt in the UK from the three profound technological revolutions – institutions are essential to smooth the major transitions and to ensure their promise is realised by as many as possible.

Getting institutions right is critical not just for core economic outcomes but for broader well-being.

The fundamental challenge is that alongside the great benefits they ultimately bring, every technological revolution mercilessly destroys jobs and livelihoods – and therefore identities – well before the new ones emerge.

This was true of the eclipse of agriculture and cottage industry by the industrial revolution, the development of the production line, the displacement of manufacturing by the service economy.[5]

We are on the cusp of a Fourth Industrial Revolution, which has the potential to transform fundamentally the nature of both work and commerce through advances in AI, automation and interconnectedness.

Our economies are reorganising into a series of distributed peer-to-peer connections across powerful networks – revolutionising how people consume, work and communicate. The nature of commerce is changing. Sales are increasingly taking place online and over platforms, rather than on the high street. Intangible capital is now more important than physical capital.[6] We are entering an age when anyone will be able to produce anything anywhere through 3-D printing, where anyone can broadcast their performance globally via YouTube or sell to China whatever the size of their business via Tmall.

Today, I want to discuss how we can apply the lessons from the history of the first three industrial revolutions to the fourth to secure a future that benefits all.

Crisis? What Crisis?

Some economists wonder what all the fuss is about. They argue that there has been little evidence, over the long term, of technological unemployment. After all, average employment and unemployment rates today are similar to those in the 18th century.

[5] The First Industrial Revolution (1760 – 1840) saw the mechanisation of (mainly the textile) industry with the introduction of steam power, moving people from home-based to factory-based production in urban areas. The Second Industrial Revolution (1860 – 1914) was driven by the introduction of electricity to manufacturing, extending mechanised, assembly-line mass production to broader industries. The Third Industrial Revolution (1970 – 2000) was defined by the move from mechanical/analogue to digital, with wide-spread adoption of electronics from both the home and work environment. The Fourth Industrial Revolution (2000 – current) anticipates the dawn of true Artificial Intelligence in light of advances in robotics, nanotechnology and quantum computing.

[6] In the UK, intangible investment rose above tangible investment in the early 2000s, and stood at 11% as a share of output in 2014 compared with 10% for tangible investment. Investment in intangibles also exceeded that in tangibles in the US, Sweden and Finland [on average over 1999-2003], but not in other European countries including German, Italy and Spain. See Haskel, J and Westlake, W (2017), 'Capitalism Without Capital: The Rise of the Intangible Economy', Princeton University Press; and Goodridge, P R, Haskel, J and Wallis, G (2016), 'Accounting for the UK Productivity Puzzle: A Decomposition and Predictions', Economica, Vol. 85, Issue 339.

But such big transitions take time. Workers generally cannot move seamlessly to new jobs in which they can be productive. The benefits of the First Industrial Revolution, which began in the latter half of the 18th century, were not felt fully in productivity and wages until the second half of the 19th.[7]

Indeed, at the start of the 19th century in the UK, despite a sharp pickup in productivity, wage growth stalled and the labour share fell – a period dubbed "Engels' pause".

A Framework for Examining Technical Change and the Labour Market

To understand such dynamics it helps to have a common conceptual framework.[8] The impact of technological change on employment and wages can be depicted as the sum of three major effects: destruction, productivity and creation.

The destruction effect is the focus of most alarmist accounts: the replacement of labour by technology, with an associated reduction in labour demand, wages and employment.

Less commonly acknowledged are the positive effects on aggregate demand of new technologies, what can be termed the productivity effect.

This effect is analogous to the classic *Say's law* in which supply creates its own demand. Technology makes those in work more productive, in time boosting wages and increasing the returns to those who own capital. This greater income boosts aggregate demand and leans against the destruction effect.

When technological change is disruptive and widespread, the productivity effect is generally insufficient to counteract completely the destruction effect, partly because of the time it takes for the full potential of new technologies to be realised, and partly because of the phenomenon of greater job polarisation – to which I will turn to in a moment.

As a consequence, over the medium term, technological change tends to reduce labour's share of income.

Historically, however, technological progress has not led to permanent declines in the labour share because of a third effect – the creation of new tasks for labour.[9] When combined with the productivity effect, this ultimately has counterbalanced the displacement effects of technology, boosting productivity and wages while leaving employment unaffected.

[7] Partly there is a lag in reorganising enough of the economy to the advantage of the new general purpose technology for aggregate productivity growth to increase.
[8] The following is based on Acemoglu, D and Restrepo, P (2018), 'Artificial Intelligence, Automation and Work', NBER Working Paper No. 24196.
[9] This creation effect need not be fully exogenous to the technological change, for example because the new technologies allow new jobs to emerge that wouldn't otherwise be possible – though of course factors like education and skills are important in determining how quickly and smoothly these gains come about.

Could this time be different?

The Fourth Industrial Revolution could differ from its three predecessors in terms of scope, scale and speed.

Scope

Thus far, each wave of technological change has increased the importance of cognitive tasks relative to non-cognitive ones. In other words, machines have largely substituted for human hands not heads. Workers have been able to improve their skills and take on newly created sets of cognitive, higher value tasks – tasks beyond the cognitive limits of machines.

Rapid improvements in computing power, the increased availability of big data and advances in artificial intelligence and machine learning mean smarter machines are already replacing a broader range of human activities than before, reaching well into the range of "heads". New technologies may increasingly provide intelligence, sensory perception, and reasoning which previously only labour could provide. Technological optimists[10] believe future automation will move beyond substituting for the 'routine-manual' human tasks technology performed in the late 20th century to almost the entire spectrum of work.[11]

It may be left to people to provide "hearts" – that is, tasks that require emotional intelligence, originality or social skills such as persuasion or caring for others. And if new forms of bespoke mass creativity are made possible by the new global economy, human "hands" may once again take over (a form of cottage industry going full circle).[12] One thing that could be different is the effects of demographics. An ageing population will lead to greater demand for care and a straight decrease in labour supply.[13]

Scale

The greater scope of the Fourth Industrial Revolution could mean its scale is larger too. Unlike in previous episodes, the jobs most at risk of automation are likely to lie across the entire spectrum of wages.[14]

At one extreme, Frey and Osborne (2017)[15] estimate that around half of US employment is at 'high risk'[16] of automation, over an unspecified period of time.

[10] For example, Brynjolfsson, E and McAfee, A (2014), 'The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies'. The most extreme view of this is put forward by Daniel Susskind, who highlights the possibility that in the future machines can perform all tasks leading to technological unemployment (Susskind, D (2017), 'A model of technological unemployment', University of Oxford, Department of Economics Series Working Papers, No. 819).
[11] The question at the heart of this debate is whether we can overcome 'Polanyi's Paradox' - that "we can know more than we can tell" (Polanyi 1966). Our inability to detail these tasks (such as social interactions) in a formulaic manner currently makes them difficult to encode and automate.
[12] McKinsey (2017) also suggest demand for creative and social skills will increase.
[13] I am grateful to my colleague Silvana Tenreyro for suggesting this point.
[14] Brynjolfsson, E, Mitchell, T and Rock,D (2018), 'What Can Machines Learn and What Does It Mean for Occupations and the Economy', *AEA Papers and Proceedings*, Vol. 108, pp. 43-47.
[15] Frey, C B and Osborne, M (2017), 'The future of employment: How susceptible are jobs to computerisation?', *Technological Forecasting and Social Change*, Vol. 114, pp. 254-280.
[16] Defined as roles with over 70% chance of automation.

However, this estimate does not take into account the heterogeneity of tasks within jobs, focusing instead on just the key tasks within each occupation. Each job usually has some components which cannot be automated, even if many of its central components can be.

Indeed, evidence increasingly suggests that while large parts of many jobs will be subject to automation, relatively few jobs will be completely automated.[17] Felten, Raj and Seamans (2017)[18] show that recent advances in technology can be used to predict future changes in the task structure of occupations, lending further support to the argument that technological advancement will likely change the nature of many jobs rather than eliminate them completely.

The more extreme estimates are often based purely on technical feasibility of automation with limited consideration of economic feasibility. For example, it may be possible to automate the pouring of drinks in bars, but doing so may not present a cost saving over hiring bar staff to do the job let alone the ancillary benefit of being able to tell them your troubles.

Taking these additional considerations into account reduces the share of jobs at high risk of automation to some 10% in the UK and 15% in Ireland.[19] That appears comparable with the three previous episodes of technological revolution, which saw the share of aggregate employment accounted for by the most exposed industries fall by between 10 to 20% over long periods.

Some argue that the greater scope and scale of tasks (as opposed to jobs) at risk of replacement by technology means that new job creation might no longer increase overall employment. That is, the destruction effect may outweigh the combined impact of the productivity and creation effects.

At the same time, the range of tasks at risk could substantially increase the impact on inequality for several reasons. Most fundamentally, the more new technology substitutes for labour rather than complements it, the more the gains would accrue to capital rather than labour. An unequal distribution of capital means that increasing automation will push up inequality by construction. In the transition, what economists euphemistically call frictions can lead to depressed local or national labour markets, boosting inequality.[20]

And if education is unable to keep pace with the changing demand for skills, those who already have the skills to use new technologies will earn even higher premiums.[21] Job polarisation will increase the supply of labour competing for lower skilled jobs.[22] Greater global interconnectedness will reinforce these dynamics.

[17] For example, McKinsey Global Institute (2017), 'A Future that Works: Automation, Employment and Productivity' suggest that 60% of occupations could see over 30% of their tasks replaced by technology, based on O*NET analysis.
[18] Felten, E W, Raj, M and Seamans, R (2018), 'A Method to Link Advances in Artificial Intelligence to Occupational Abilities, AEA Papers and Proceedings, Vol. 108, pp. 54-57.
[19] Nedelkoska, L and Quintini, G (2018), 'Automation, skills use and training', OECD Social, Employment and Migration Working Papers No. 202. Similarly, McKinsey argue that across advanced economies 15% of the workforce in total will need to shift occupational categories because of digitisation, automation, and AI.
[20] This process has been well documented for the China Shock in the US (Autor, Dorn and Hanson 2015) and the collapse of local housing markets (Mian and Sufi 2015).
[21] If those who understand technology less well are less willing to trust it and work with it, this could further increase its polarising effects.

Speed

Could the Fourth Industrial Revolution happen faster? Certainly, the time taken for new technologies to be adopted has shortened dramatically since the dawn of the First Industrial Revolution.

The Story Thus Far

Current empirical work suggests on balance that, thus far, increased automation has been positive for employment in aggregate even though it has led to substantial compositional changes. Importantly, while technology has reduced middle-skilled employment, its effects on aggregate employment appear to have been more than offset by increased product demand and local demand spillovers. After all, the employment share in the UK is near all-time highs.

There are, however, signs that recent technological advances have increased inequality. Globally, labour has seen its share of income fall over the past twenty years and the IMF (2017) finds that technological progress during the 3rd Industrial Revolution has been the biggest contributor to this decline. The UK and Ireland[23] are outliers: in both countries, the labour share has been flat, and income inequality stable – if high – since the late 1980s.[24]

Moreover, there is strong evidence that advanced economy labour markets have been polarising since the 1980s – a structural shift that have generally been attributed to technological displacement of mid-skilled jobs resulting from the early stages of automation and digitisation of tasks. Employment growth has been strongest at the high and low skilled ends of the jobs spectrum, resulting in a hollowing out of mid-skilled employment. The polarisation of the labour market has also been evident in the returns to skilled labour, with earnings growth for those with higher levels of education far outstripping those with less schooling.

So in summary thus far, if the Fourth Industrial Revolution is similar to past technological revolutions, the overall effect will *eventually* be labour augmenting – boosting productivity and wages, while creating new jobs to maintain or even increase overall employment.

But that is in the long run. In the interim, if it is similar to previous industrial revolutions, it seems likely there will be a period of technological unemployment, dislocation and rising inequality.

Given that it could happen more rapidly, the challenge of workforce adjustment could be more difficult. The shifts required in employment from jobs involving heads to those with hearts and hands could be far greater each year than seen in previous episodes. Moreover, unlike in the previous industrial revolutions, the more rapid pace of adjustment and longer working lives means workers may not have the option of retiring. This

[22] Analysis by the IMF indicates that the extent of job polarisation depends far more on the ease of substitution between labour and technology than it does on the relative price of technology.
[23] Calculating the labour share using gross national income and removing distortions that stem from how multinational corporations account for their global operations by excluding retained earnings of firms that have re-domiciled to Ireland, the depreciation of foreign-owned intellectual property assets located in Ireland, and the depreciation of aircraft owned by aircraft-leasing companies.
[24] The low level of automation in the UK – which Hal Varian has suggested could be linked to the size of the automobile and electronics sectors – may be one reason why the UK labour share has remained resilient.

raises risks of substantial skills mismatch, leading to increased structural unemployment and adverse macroeconomic outcomes.

What could we do to shorten the lags? What does history teach us about building Whitaker's adaptability today?

Institutions to Cushion the Blow and Speed the Transformation

In past industrial revolutions, the actions of public, private and third party institutions have helped shrink the duration, impact and cost of the transition. It is worth reflecting on these interventions as we think about how to manage the transition to the Fourth Industrial Revolution.[25]

The skills bases of workers were fundamentally transformed by a series of reforms to enabling institutions including primary, secondary and tertiary education.[26] New insurance institutions were created to support those left behind in the transition, including unemployment insurance and universal health care.[27] And labour market institutions – cooperatives, trades unions, and the introduction of a minimum wage and private company pensions – plugged gaps in provisions.[28,29]

Throughout these periods, many employers helped create an environment in which employees could thrive. From charitable support in the First Industrial Revolution; to the Ford era of self-interested paternalism in between, and the GooglePlex, self-contained communities of today, business has shaped the welfare of many.

[25] My colleague Andy Haldane has also discussed these issues. See 'Ideas and Institutions – A Growth Story', speech given at The Guild Society, Oxford, 23 May 2018.
[26] In the UK in the late 18th and early 19th century, a mix of public, private and religious institutions – largely driven by charitable motives – brought education to children working in mills. In the second and third revolutions, the state established formal primary, secondary and tertiary education.
[27] For example, in the First Industrial Revolution, with no welfare state and only the (dire) prospect of a Victorian workhouse, employees set up Friendly Societies and Co-operatives to support colleagues falling on hard times. With trade unions outlawed until the end of the period, it fell to the will of charitable industrialists, the likes of Robert Owen and Sir Titus Salt to improve conditions inside mills.
By the end of the Second Industrial Revolution, spurred by a more organised labour force, the Government provided welfare for its population through workplace injury compensations, basic pensions and unemployment provisions. The interwar years ushered in universal healthcare, unemployment insurance and pensions.
By the dawn of the 3rd Revolution, individual enterprise and privatisation were ascendant. Reform of social services – to help create a society of equal opportunity – followed, supported by increased public spending for maternity and child benefits, early years education, and provisions for pensioners.
[28] The number of Friendly Societies rose to 27,000 by the end of the 1800s and Trade Union membership quadrupled from 2 million in 1889 to 8.3 million by 1920. Spurred by industrial unrest, the state introduced the precursor to the minimum wage in the first decade of the 1900s. Unionism has been in decline since the 1970s, with membership dipping below six million in 2012 for the first time since the 1940s.
[29] Recent work indicates that trade unions in the US played an important role in supporting the wages of lower-skilled workers during the years of the 3rd Industrial Revolution, thereby helping to limit increases in inequality over this period. See Farber, H S , Herbst, D, Kuziemko, I and Naidu, S (2018), 'Unions and Inequality over the Twentieth Century: New Evidence from Survey Data', NBER Working Paper No. 24587.

So building on the past, what could be done this time?

First, everyone can contribute to a better understanding of the new skills that will be required. That includes granular reviews by firms of the mismatches between their current talent pool and future needs; estimates by the creators of general purpose technologies of the breadth of their potential applications; and reporting by public institutions on the aggregate pace of automation and trends in the labour market.

The rate-limiting factor of technology adoption is often the skill-set of existing employees. For that reason alone, business has an enormous interest in effective workforce training. And the providers of general-purpose technologies have a responsibility to explore how they can develop their products in ways that maximise job-creation or broader social benefits. For example, DeepMind established an Ethics and Society Research Unit to help technologists put ethics into practice, and to help society anticipate and direct the impact of AI so that it works for the many.

New labour market institutions will need to balance facilitating labour mobility and encouraging appropriate protections of workers in non-standard forms of employment that emerge in industries, as considered in the UK by the Taylor review of modern working practices.[30]

Other issues range from technology solutions to improve matching to news frameworks data portability (including reputational histories).

Each industrial revolution has eventually been accompanied by major innovations in enabling or educational institutions.

The biggest issue may be how to institutionalise re-training in mid-career and to integrate it with the social welfare system.

The time for a quaternary system of education, founded on the same principle of universality as primary, secondary and tertiary education may eventually arrive.

There are also roles for retraining schemes, such as the UK's Flexible Learning Fund[31] and the Singapore SkillsFuture programme, which offers all its citizens aged 25 and over £250 credit to pay for approved work-skills related courses. Generous subsidies, of up to 90% for Singaporeans aged 40 and over, are available on top of this credit. According to SkillsFuture's Chief Executive, the returns on that spending matter less than changing the mindset around continuous reskilling.

An often overlooked but nonetheless critical element of the ecosystem is to build a financial sector consistent with the new economy.

[30] Available at https://www.gov.uk/government/publications/good-work-the-taylor-review-of-modern-working-practices.
[31] The Government has allocated £40m through the FLF in Spring2017 budget to run pilot projects.

Innovations in retail payments can transform checkout and ecommerce platforms can open new financing to SMEs. Innovation in, and greater connectivity across, wholesale payment systems have the potential to cut the costs of doing business across borders and unlock new trading opportunities. Intelligent use of big financial datasets could transform credit markets, closing the gap between financing opportunities available to small companies and those enjoyed by their larger competitors.

Given their position at the heart of the financial system, central banks have a crucial role to play in supporting the development of this new finance, not least through creating the new infrastructure that it will require.[32]

Monetary Policy's Role in Managing the Transition

As a former central banker, Whitaker would have recognised the importance of maintaining price stability during periods of large structural change.

The appropriate setting of monetary policy will be influenced by the structural changes wrought by the Fourth Industrial Revolution, including in the labour market, by its impact on price dynamics and on the equilibrium rate of interest.

To be clear, as these structural changes are real in nature, monetary policy cannot prevent them, and it would be unwise to attempt to accelerate them. For example, running the economy hotter is unlikely to be effective at increasing the rate at which workers displaced by technology can find new roles because it does not address the underlying frictions, particularly the lack of suitable skills.

However, as the structural changes take effect, they are likely to affect the balance between supply and demand, and monetary policy will need to respond accordingly.

In the long run, the Fourth Industrial Revolution should substantially boost productivity and supply. Based on past experience, the productivity of roles experiencing high levels of automation could expand at rates in excess of 5% per year, and aggregate productivity growth could increase by as much as ½ to 1½ percentage points per year.[33]

The increases in supply from automation and the Fourth Industrial Revolution should, in time, lead to higher demand as they flow through into higher incomes. With job destruction running ahead of the productivity and creation effects in the shorter term, however, demand is likely to be weaker for a period.

[32] For more details, see 'New Economy, New Finance, New Bank', speech by Mark Carney at the Mansion House, June 2018.
[33] The lower estimate is based on the productivity gains realised from the introduction of steam power, while the upper estimate is based on the improvements harnessed from the ICT revolution. See Crafts, N (2015), 'Economic Growth: Onwards and Upwards?', *Oxford Review of Economic Policy*, Vol. 31, pp. 217-241

As Chair Powell recently reminded us, the challenge for monetary policy during periods of structural change is to take into account its potential impact on the underlying dynamics of the economy. That is why, in the UK, the Monetary Policy Committee periodically takes stock of developments and updates its estimates of key variables such as the equilibrium rates of interest and unemployment.[34]

The MPC provided our assessment of the equilibrium rate of interest – the interest rate that sustains inflation at target and output at potential – in its August *Inflation Report*. The equilibrium interest rate provides a way to think about the forces acting on the economy, and whether policy is stimulative or contractionary. It is affected by shorter-term influences, such as headwinds to demand, and by slow-moving structural factors that affect the balance between the demand for capital and the stock of wealth available to finance it. For open economies like the UK and Ireland, those factors will be heavily influenced by global developments.

As the MPC noted at the time, increased automation could push the equilibrium interest rate up or down. On the one hand, the increases in productivity that result could increase businesses' demand for capital, pushing up the equilibrium interest rate for a period – and permanently if automation raises productivity growth.[35] On the other hand, however, increases in inequality would likely shift income to those with lower propensities to consume,[36] increasing the stock saving and pushing the equilibrium rate down.[37]

Monetary policy makers must also take into account how potential structural changes in the labour market and pricing dynamics that result from the Fourth Industrial Revolution might affect the evolution of inflationary pressures. These considerations can be illustrated using the Phillips Curve diagram.

Until the productivity and creativity effects catch up with the displacement effect, increased automation will impart disinflationary pressures through a reduction in businesses' demand for labour relative to supply. Even if the transition happens relatively quickly and smoothly by historic standards – taking 30 years and with a relatively quick rate of new job finding among those displaced by technology – total hours worked could be 2 per cent lower throughout, equivalent to a 2 percentage point increase in the unemployment rate or a 5 percentage point rise in the underemployment rate.[38]

[34] The Fourth Industrial Revolution could also affect the transmission of monetary policy through its effects on the financial sector. For example, advances in technology and data availability could lead to greater competition in the financial sector, potentially strengthening the pass-through of changes in monetary policy into the interest rates faced by households and companies.
[35] If automation increases the level, but not the growth rate, of productivity, it will only raise capital relative to output temporarily. This effect will be reinforced by an increase in the capital-output ratio during the job destruction phase, as labour is displaced by automation. However, the upward pressure on the equilibrium interest rate will lessen as the creation effect takes hold.
[36] The experience of past episodes suggests that, in the first instance, the returns from the Fourth Industrial Revolution are likely to flow more to the owners of the new capital than to the workers who use it – leading to Engels' pause in real wages. Owners of capital tend to be wealthier to begin with and evidence suggests that those with higher wealth have a higher propensity to save increases in income (this idea goes back to Kalecki (1954) and Marx before him). Increases in job polarisation and skills premia, which also shift income towards the top of the distribution, are likely to add to this effect. Globally, inequality could also increase as a result of the Fourth Industrial Revolution, which would further lower the equilibrium rate in open economies like the UK and Ireland.
[37] Summers (2016) has argued that rising market concentration may also have been an important cause for the fall in the equilibrium interest rate over recent decades. See http://larrysummers.com/2016/03/30/corporate-profits-are-near-record-highs-heres-why-thats-a-problem/.
[38] Measured as the proportion of people working part-time would who prefer a full-time job.

This excess supply of labour available to work on non-automated tasks represents a shift along the Phillips Curve, imparting modest disinflationary pressures. For the UK, each additional percentage point of labour market slack is estimated to reduce annual wage growth by one third of a percentage point.

However, mismatches between the skills of the current workforce and those required by the new technologies or other substantial frictions to workers changing role could cause the equilibrium unemployment rate to rise alongside any increase in unemployment – particularly if the speed of adoption of new technologies is faster than in the past. That would shift the Phillips Curve up, reducing the disinflationary effects of automation.

At present, there is little evidence to go on to judge the likely size and persistence of any increasing in structural unemployment. Monetary policy makers will need to remain alert to this possibility, updating their assessment as the transition occurs. The experience of the 1970s shows that mistakenly ascribing a structural pickup in unemployment to cyclical factors can lead to the wrong macroeconomic policy setting, with long-lasting adverse effects.

A more automated world could also affect inflationary pressures through flattening the Phillips curve. The threat of robot substitutes could weaken workers' bargaining power. And advances in artificial intelligence and similar technologies could increase companies' ability to learn about their competitors' marginal costs and leading to greater synchronisation of price changes across companies. Already, there is evidence that online retailers adjust prices more frequently than those on the high street, while being less likely to vary prices by location.[39]

Conclusion

While the Fourth Industrial Revolution has the potential to transform the economy, the challenges it presents for monetary policy makers are in many ways not new.

In recent years, the MPC has increasingly focused on structural changes in the economy, including by instituting regular reviews and publishing our assessment of the most important variables, such as the equilibrium unemployment rate.

Over this period, as unemployment has fallen towards its estimated equilibrium rate and companies have found it harder to recruit and retain staff, pay growth has picked up. Across the economy as a whole, growth in average wages excluding bonuses has risen from around 1¾% a year during 2010-15 to around 2½% in 2016, and wage growth is expected to have picked up a little further to around 2¾% around the middle of this year. The most recent outturns support that judgement, with whole economy total pay increasing by 2.9% in the three months to July and private sector regular pay up 3% over the same period, and domestically generated inflation at rates consistent with the 2% inflation target.

[39] Cavallo, A (2018), 'More Amazon Effects: Online Competition and Pricing Behaviors', paper prepared for the 2018 Jackson Hole Symposium.

This brings me to a larger point. Although current rates of pay growth in the UK are below pre-crisis averages, this largely reflects continued weakness in productivity growth. While that weakness may reflect the early consequences of the Fourth Industrial Revolution, other factors seem more likely to be at play. In the years following the global financial crisis, the aftereffects of that shock and the subsequent euro-area crisis exerted a drag on business investment. More recently, uncertainty around Brexit has had an additional dampening effect.

As has been the case for some time, developments regarding the United Kingdom's withdrawal from the European Union are the most significant influences on the economic outlook. And while the impact of the Fourth Industrial Revolution may be felt over the coming decades, some of the Brexit effects on supply may be much more immediate.

The Bank of England is well-prepared for whatever path the economy takes, including a wide range of potential Brexit outcomes. We have used our stress test to ensure that the largest UK banks can continue to meet the needs of UK households and businesses even through a disorderly Brexit, however unlikely that may be. Our job, after all, is not to hope for the best but to plan for the worst. The MPC will respond to any persistent change in the outlook to bring inflation sustainably back to 2% target while doing what it can to support jobs and activity. The appropriate policy response is not automatic and will depend on the balance of the effects on demand, supply, and the exchange rate.

Whitaker's life work reminds us that achieving lasting economic prosperity requires us to be bold and to adapt. To do so, we need to have the right institutions in place, so that everyone can share in the gains. Such adaptability will be particularly important as both our economies embark on a new era of technological change and new degrees of openness.