Focus

Long live the technology revolution

- *The third 'industrial' revolution is entering a transformative and disruptive phase*
- *Part of this revolution involves combining existing technologies in new ways*
- *Another part involves newish technologies, notably IT, that are still coming through*
- *And now, artificial intelligence (AI), is about to burst on the scene*
- *These technologies offer huge benefits; but millions of activities will be displaced*
- *Companies and economies that handle change well will fare well: others will languish*

This time could well be different

Today's technology stands to deliver unprecedented change

Technology – the application of scientific principles to practical purposes – can transform entire economies and societies, changing fundamentally the way that people live and work, and in the process exerting a profound influence on output, the labour market, productivity, and prices.

Although it is difficult to assess a situation that is in a process of rapid change, our judgement is increasingly that the current era of technological innovation stands to be both more transformative and more disruptive than any of its predecessors. Not everyone agrees with this: notably Robert Gordon, a doyen in this field, has real doubts.[1] But we are increasingly convinced that something immense is afoot, and a summary of our basic reasoning is set out below.

The third quite different wave

The two industrial revolutions, those of the 18th and 19th centuries, are widely recognised as bringing unprecedented technological innovation and dramatic economic and social change. The first, beginning around 1750 and eventually coalescing into the second, centred on textiles, iron, and the steam engine. The second, starting in the mid-1800s, brought mass industrialisation, and revolved around steel, railroads, petroleum, chemicals and, finally, electricity.

The third industrial revolution began in the late 20th century with simple electronics, information technology (IT), and automation. Through many concurrent technological advances, and spurred by international competition, the effects have grown progressively. And there is more to come.

It is of course possible to exaggerate the likely impacts of such advances. It takes time to turn scientific discoveries or inventions into workable technologies. And in the workplace systems and working practices often evolve only slowly. The constraint is frequently humans' absorptive capacity.

More and more of the economy will be transformed

Both the nature and the pace of these changes pose major issues of measurement. But the direction of travel is clear: in a march that seems inexorable, the new technologies will continue to transform more and more of the economy – goods-producing industries and services alike.

In manufacturing, robotisation is spreading widely, and global supply chains are being transformed. In wholesale and retail trade, online sales are proliferating, and inventory management has changed out of all recognition. The media and communications industry is evolving in spectacular ways. Higher education is increasingly moving online. Healthcare is benefitting from advances in robotics. In finance, non-traditional funding sources are starting to emerge, and algorithms increasingly dominate elements of securities trading.

Some key elements

To illustrate the power and pervasiveness of this latest technological revolution, consider four of its most important, conceptually distinct, elements:

1. Combinatorial technology
2. Growth in computing power and Artificial intelligence (AI)
3. Digitalisation and dematerialisation
4. Energy technology

1. Combinatorial technology

Combinatorial effects quicken the pace of change and disrupt

Technological breakthroughs do not always derive from deployment of single new technologies: often they result from emerging technologies being combined with other new and existing areas of knowledge and expertise – so-called 'combinatorial growth'. The iPhone and driverless cars are

two cases, being the product of synergistic amalgamation of a slew of innovations, some novel, some long-standing, including: GPS; motion sensors; ever-cheaper and more compact computing power; random-access memory; the internet; spatial recognition.

Such combinatorial breakthroughs can result in new products that few working in individual areas envisaged, yet which generate enormous demand, and more rapidly than many imagine.

IT and AI stand at the core of this new era …

2. Growth in computing power and Artificial Intelligence

Growth in computing power and IT, which accelerated dramatically in the late twentieth century, has by no means run its course. Yet meanwhile a new and quite possibly even more radical development, artificial intelligence (AI), is bursting upon the scene. Whether this should be considered part of the IT revolution, or as a (fourth) industrial revolution in its own right, remains to be seen. But for the moment that scarcely matters. Classification can be left to historians.

… as computational capacity now matches the human brain

Many of the most important applications of AI will stem from modestly-priced computers now being on the cusp of matching the computational ability of the human brain, and programmes increasingly being able to learn by experience – witness the recent 4-1 victory of Google's AlphaGo machine over the world champion of the world's most complex game.

Part of the reason that IT has proved, and AI stands to be, so powerful is that these technologies permeate the entire economy – not just the industrial sector, but also most parts of the services sector too. Scarcely any activity stands to remain untouched.

3. Digitalisation and dematerialisation

Dematerialisation offers global scale almost instantly

Products and indeed whole sectors are becoming digitalised – the information media for example – and thereby can penetrate global markets rapidly via the internet. Moreover, digital platforms do not require large manufacturing or production plants, or warehousing in the traditional sense, which significantly shortens the time to take products to market, and at massive scale: Facebook and Airbnb were founded only in 2004 and 2008 respectively.

4. Energy technology

New energy technologies, though narrower, are powerful

Unlike IT, AI, and digitalisation, the new energy technologies, most notably fracking and enhanced oil recovery, directly affect only part of the economy – the hydrocarbon sector. However, energy use being so ubiquitous, the resultant collapse in oil and gas prices – which we judge will persist for many years – is ramifying throughout economies right across the world.

The crash of hydrocarbon prices has raised the real incomes of consumers of oil and gas: but it has sharply reduced the real incomes of the producers. If our prognosis is right, oil and gas producing economies will have to make enormous changes to the structure of their economies if they are again to enjoy anything like their real income levels of the past.

Challenges and benefits at all levels

Employment is being 'hollowed out', wage distribution widened

Technological change both poses challenges and offers benefits – for individuals; for companies; for sectors; for whole economies. Already, the third industrial revolution has increased consumer incomes and widened consumer choice. Over the longer term, the new technologies stand to encourage higher aggregate demand and production through the increased purchasing power of those whose productivity and real incomes have been enhanced. Many boats will be lifted.

Not all boats will be lifted, however. There are always casualties. The new technologies have already contributed to a hollowing out of employment in a number of industries; a widening distribution of wages (i.e. higher income inequality); and a falling share of labour income in GDP. And matters may not stop there.

Questions to which only time will provide the answer include:

And matters may not stop there

- Will there be a re-run of the eighteenth and nineteenth centuries, with productivity gains eventually boosting wages and labour share in general? Or something rather different?
- Will the wage premium for those in skilled jobs go on rising, further widening income inequality, creating a destabilising bifurcation between a high-skilled elite and the rest?

Adjustment

Millions of activities will be challenged, many are safe …

The challenge for structural adjustment is large: the numbers are big. Over the coming 5 to 10 years, it has been estimated, up to half of all existing jobs in the US (around 80 million), and up to a third in the UK (around 15 million), are likely to be significantly challenged by technology.[2]

… for now

The consequences are likely to be particularly large in lower-skill activities, in areas including sales, office and administrative support, production, and transportation and material-moving. But there are also likely to be casualties in professional services, including banking and accountancy.

And opportunities are aplenty …

Activities which appear likely to be less at risk are those that involve 'perception and manipulation'; 'creative intelligence'; and 'social intelligence'. Robots have yet to match the breadth and depth of human perception. Robots find handling irregular objects difficult. Psychological processes underlying human creativity are hard to specify. Human values change over time and differ across cultures, making encoding difficult. And while robots can reproduce some aspects of human interaction, real-time recognition, let alone the ability to respond intelligently, remains a challenge.

In this environment, because there will be losers as well as gainers, social and political opposition stands in many cases to be powerful and enduring. Hence there will be a premium on finding, and implementing, ways for the losers in the process to be compensated or, preferably, re-equipped without unduly slowing the pace of change.

… with structural policies determining the winners and losers

It is impossible to say with any certainty how countries' economies and societies will compare in the extent to which they succeed in this. However, a broad indication at the macro level can perhaps be obtained by considering the growing range of quantitative measures that purport to measure the quality of various policies that affect the ability and capacity of economies to adjust.

On the evidence summarised in Figure 1 below, some OECD countries seem well placed, but others do not. Amongst non-OECD economies (not shown, but available on request), the range is even wider – at both ends of what is a very wide spectrum.

Watch fors

Keep a keen eye on developments in four areas in particular:

- The response of governments in all areas of structural policy, but particularly education and training, consumer policy regulation, trade agreements, and active labour market policies;
- Statements by firms' managements that reveal the extent to which they appreciate the scale, both of the challenges and the opportunities, that the new technologies represent for them;
- Hard data on the extent to which firms are investing in facilitating change; and
- The adaptability and cooperativeness of workforces and their representatives.■

Figure 1: Structural policy areas heat map, selected OECD economies, 2015-2016

	GRC	MEX	TUR	ITA	CHL	ESP	KOR	OECD average	FRA	AUS	CAN	DEU	DNK	NZL	NOR	UK	SWE	JPN	NLD	US	CHE
Institutions	0.41	0.31	0.44	0.33	0.64	0.46	0.45	0.68	0.67	0.80	0.84	0.78	0.84	0.97	0.94	0.84	0.87	0.85	0.87	0.68	0.92
Infrastructure	0.47	0.41	0.61	0.41	0.53	0.82	0.77	0.70	0.87	0.60	0.72	0.85	0.85	0.62	0.65	0.71	0.77	0.92	0.96	0.82	1.00
Human capital	0.71	0.54	0.62	0.73	0.68	0.76	0.81	0.81	0.81	0.91	0.87	0.86	0.88	0.91	0.91	0.85	0.86	0.86	0.94	0.85	0.93
Goods market efficiency	0.47	0.49	0.59	0.51	0.62	0.53	0.69	0.70	0.63	0.68	0.80	0.73	0.76	0.89	0.76	0.83	0.78	0.84	0.87	0.79	0.88
Labour market efficiency	0.36	0.36	0.27	0.27	0.53	0.45	0.47	0.61	0.56	0.60	0.84	0.64	0.78	0.84	0.79	0.85	0.69	0.69	0.72	0.88	1.00
Financial market development	0.00	0.49	0.39	0.15	0.63	0.33	0.27	0.56	0.59	0.87	0.91	0.65	0.63	1.00	0.82	0.69	0.75	0.65	0.56	0.91	0.79
Technological readiness	0.59	0.28	0.37	0.59	0.57	0.77	0.75	0.77	0.85	0.79	0.84	0.89	0.92	0.86	0.92	0.97	0.95	0.81	0.91	0.85	0.97
Business sophistication	0.31	0.43	0.39	0.66	0.41	0.53	0.65	0.66	0.74	0.61	0.70	0.97	0.86	0.65	0.84	0.91	0.87	0.99	0.92	0.93	1.00
Innovation	0.24	0.28	0.28	0.43	0.31	0.39	0.72	0.63	0.73	0.63	0.65	0.92	0.80	0.62	0.77	0.78	0.91	0.93	0.88	0.95	1.00
Aggregate score	0.39	0.40	0.44	0.45	0.55	0.56	0.62	0.68	0.72	0.72	0.80	0.81	0.81	0.82	0.82	0.83	0.83	0.84	0.85	0.85	0.94

Source: Constructed by Llewellyn Consulting. Base data sources available upon request

Notes: Data have been normalised using the min-max method, and are expressed as 0-to-1 scores (best = 1.0; worst = 0.0). For each indicator, the best three scores are coloured dark green. Light green cells = average or above average scores. Pink cells = below average scores. Red = worst three scores. The aggregate score is the (unweighted) average of all the indicators for each country.

Authorship

This piece is taken from a body of work currently being undertaken by Ben Combes, Bimal Dharmasena, Russell Jones, John Llewellyn, and Preston Llewellyn.

#Focus: The third 'industrial' revolution is entering a transformative and disruptive phase: AI is about to burst on the scene

[1] See for example Gordon, R., 2012. *Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds*. NBER.
[2] Frey, C., and Osborne, M., 2013. *The Future of Employment: How Susceptible are Jobs to Computerisation?* Oxford Martin School.