Destructive creation: explaining the productivity paradox in the digital age

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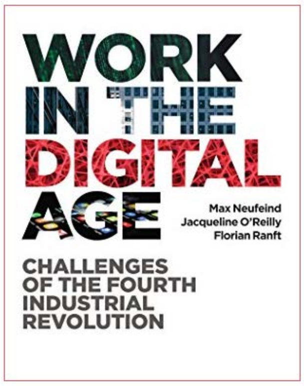

in Neufeind M., O'Reilly J. and Ranft F., eds, *Work in the digital age,* 2018

> The technology in itself is neither good nor bad. It is the use which human beings make of any technology which determines both the nature and extent of the benefits.
>
> —Christopher Freeman

Debate regarding the impact of new technologies on jobs and the organisation of work has raged for decades, if not centuries. While notable, this is hardly surprising. After all, we talk today about the fourth industrial revolution, following on from the first, second and third industrial revolutions. To gain insights into what the potential impact of the current phase of disruption might be, taking a look at previous industrial revolutions is both logical and revealing.

In this short contribution, I will attempt to provide some analytical insights into the possible consequences of the fourth industrial revolution for work and incomes. In doing so, it follows the more detailed analysis of Daniel Arnold and colleagues on the digitalisation and automation of manufacturing processes (Arnold et al. 2016; see also Arnold et al. this volume). My analysis will primarily be based on comparing current developments with the immediately foregoing, third industrial revolution, the one most closely linked to the emergence and rapid diffusion of microelectronics and the computer in the last quarter of the 20th century. I limit myself to such a comparison for two reasons.

First, most of the technologies associated with the fourth industrial revolution can undoubtedly be described as 'new' and 'disruptive' in their current and future applications, but are in essence based on improvements and developments to technologies which are characteristic of the third industrial revolution, including microelectronics and in particular the continuous exponential improvements in the performance of integrated circuits following Moore's law.[1] As Klaus Schwab of the World Economic Forum put it, this built on the foundations prepared by the third industrial revolution. The improvements of these technological advancements, and improvements to processing speeds, continuously opened new areas for further research in robotics, and many other technologies associated with the fourth industrial revolution: 3D printing, quantum computing, artificial intelligence (AI) (Petropoulos this volume), the 'internet of things' (Fernández-Macías this volume), nanotechnology, biotechnology, materials science, energy storage, and in many other fields. Unsurprisingly, since the 1990s, microelectronics has been identified by economists as the most characteristic example of a so-called general purpose technology – one that affects all sectors of the economy (Bresnahan and Trajtenberg 1992).

Second, having written articles and books in the 1980s and 1990s on the impact of microelectronics and computerised technologies more broadly on employment and the organisation of work,[2] I feel that I am well placed to highlight in these pages some of the similarities and differences that exist between these two phases of industrial transformation as they have confronted our economies over the last 40 years. In particular, when debating the possible consequences of revolutionary transformations one can enter quite quickly into debates in which speculation and visions based more on science fiction of future societies can become dominant, which ultimately offers little help to policymakers. This contribution seeks to address this shortcoming in the literature.

SIMILARITIES WITH THE PAST: THE FEAR OF JOB LOSSES AND A PRODUCTIVITY PARADOX

The first similarity when comparing the third with the fourth industrial revolution is the fear of significant job losses. The similarity between Clive Jenkins' 1979 book *The Collapse of Work* and the multitude of current analyses on the likely job losses associated with AI and robotics is striking and characteristic of the intrinsic fear of the way that new technologies can replace labour and automate routine jobs (Jenkins 1979). Arntz et al. (2016) refer to a widespread "automation angst". In the 1970s and 1980s, following the widespread adoption of microelectronics, similar references were made to the literature of the 1930s and 1940s about the fear of 'permanent' technological unemployment, that would be brought about by automation.[3] Whereas such fears were particularly articulated in Europe in the 1980s,[4] far fewer concerns were raised about these issues in the US, where the debate shifted quickly to a more positive vision of the potential employment 'displacement' aspects of new technologies and the potential 'skill-bias' dimension associated with it – the fact that new technologies favoured skilled over unskilled labour, which increased the productivity of skilled labour, and hence the demand for skilled labour.[5] Thus, the temporary friction that new technologies could introduce would be solved by education and training.

Paradoxically, the debate today regarding the fourth industrial revolution appears much more a feature of the US American rather than the European academic and public discourse, with important contributions from the likes of Erik Brynjolfsson and Andrew McAfee – curiously called *The Second Machine Age* – focusing on past trends towards jobless growth following economic recovery in the 1990s, and the role played by new digital technologies in replacing routine jobs (Brynjolfsson and McAfee 2014). The focus of the debate on employment displacement today has also shifted from the consideration of unskilled to routine jobs. The possibility that technology could be causing jobless US recoveries was first suggested by Jaimovich and Siu (2012), who argued that middle-skilled jobs involving routine tasks are susceptible to replacement by new technologies, and were likely to become permanently destroyed during recessions, which would result in slower job growth during any recovery. The focus here was again on new computer-based technologies, but the impact of employment displacement on routine white-collar work would be far greater than in the past. As Jerry Kaplan (2015), author of *Humans Need Not Apply*, puts it: "automation is now blind to the colour of your collar". Brian Arthur (2011) describes this as the arrival of an underground, totally automated, digital 'second economy' that involves little to no physical employment in the 'first economy', while the title of Martin Ford's (2015) book is *The Rise of the Robots*.

The dominance of the debate on the implications of new technologies linked to the fourth industrial revolution on jobs can be explained by the fact that no evidence for such trends can be found outside the US, where modern technologies appear unlikely to be causing jobless recoveries (Graetz and Michaels 2015). This is in all likelihood also a reflection of US global dominance in the new digital technology industries, as illustrated by the impact of the public statements on these topics by some of the leading American high-tech chief executive officers such as Elon Musk and Bill Gates (Delaney 2017; Kharpal 2017). In the 1980s it was similarly IBM who asked Chris Freeman and me to write a report on the impact on employment of computers (Freeman and Soete 1985). The report had no impact in North America however. In Europe, by contrast, with unemployment remaining stubbornly high and barely recovering from the 1982 recession, the report led to a European Commission-backed expert study on the information society (European Commission 1996) and the inclusion in the Jobs Study launched in the mid-1990s by then secretary general of the OECD, Jean-Claude Paye, of a specific chapter on the potential impac of technology on employment and skills (OECD 1994). Today despite high levels of youth unemployment in many European countries there is, paradoxically apart from Germany, little interest and attention being paid to the emergence of new technologies that affect future jobs and the organisation of work.

A second, more striking similarity between the third and fourth industrial revolutions is the puzzling evidence of trends in productivity growth following the emergence of the aforementioned radical new technologies that are identified with the fourth industrial revolution, the 'core' variable in any econometric analysis on the impact of research and innovation on growth and welfare. Generally speaking, productivity refers to a measure of how much output (or income) is generated for a fixed amount of input, typically an average hour of work. Productivity growth is essential for understanding any discussion on the impact of new technologies on employment. Over the long run, the only way a society can generate higher standards of living is if the average level of productivity grows.

Rather surprisingly, and in contradiction to the revolutionary evidence on the emergence of new technologies, productivity did not increase following the third industrial revolution. In the 1980s, this became known as the 'Solow paradox', following a remark by Robert Solow (1987):

> what everyone feels to have been a technological revolution, a drastic change in our productive lives, has been accompanied everywhere, including Japan, by a slowing-down of productivity growth, not by a step up. You can see the computer age everywhere but in the productivity statistics.

Even more surprisingly, the current evidence regarding the fourth industrial revolution appears to be accompanied by a similar lack of evidence of productivity growth. As Millar and Sunderland (2016) point out:

> in a period where not only many new technologies are being introduced, more firms and countries are integrated into global value chains, [and] workers are more highly educated than ever, it remains surprising that productivity growth is not rising. For sure the financial crisis may be part of the explanation, but OECD data show that productivity growth has been slowing since the early 2000s in Canada, the United Kingdom and the United States (Millar and Sunderland 2016).

The link between productivity growth and technological change is not that straightforward, however. In earlier analyses I compared the evolution of technological change and its impact on productivity growth to the movement of a snake, where the head (technological progress) moves ahead while the tail remains more or less in the same place.[6] In this analogy, productivity growth, as expressed by the average progress of the snake, is relatively limited, versus the tail moving to join the head, which remains more or less in the same place with little or no technological progress, while average productivity increases rapidly. It is as if the gap in productivity growth between global firms and the more domestically oriented firms has grown during the fourth industrial revolution, with the body of the snake expanding. As the current OECD secretary general, Angel Gurria (2016), put it: "The knowledge and technology diffusion 'machine' is broken."

A lot has been learned over recent decades from research that analyses previous productivity 'paradoxes'. There is broad agreement that much more attention needs to be paid to the time lags involved in the diffusion of new, 'radical' technologies. Those new technologies might for example involve a first phase of declining capital productivity as Paul David and Gavin Wright (1999) argued on the basis of historical comparisons, or might require essential organisational changes to fully exploit the often, in the first instance at least, unnoticed efficiency gains associated with new technologies, as Chris Freeman and Luc Soete (1987) and Paul David (1990) argued with respect to the second industrial revolution and the introduction of electricity. Here the authors point to the importance of the discovery of unit electric drive replacing line shaft (Devine Jr. 1983). Such changes also required the development of new skills and on-the-job learning before new technologies would result in overall efficiency gains, dubbed "the race between technology and schooling" by Jan Tinbergen (1975).

To conclude this first section; given the current low global productivity growth trends, concerns about the negative impact of the fourth industrial revolution on employment and job displacement appear not entirely convincing. There seems to be a tendency to overestimate both the speed and the impact of the new technologies associated with the fourth industrial revolution (Atkinson this volume), including AI, robotics, 3D printing, automotive driving, quantum computing and nanotechnology. For example, just look at the complexity involved in using robots simply to lift patients in a hospital, which requires numerous physical security interaction problems, or using AI to assess written exams. Historically, the evidence of skills disappearing as a consequence of the introduction of new technologies has not ushered in mass unemployment. Rather, digital technologies appear to have dramatically increased the distribution of the gains associated with the emergence of new technologies, as if monopoly capitalism has re-emerged now in digital form. Let me turn to these concerns in the next section.

DIFFERENCES WITH THE PAST: FROM GENERAL PURPOSE TO GLOBAL PLATFORM TECHNOLOGIES

In so far as the core of the fourth industrial innovation is primarily associated with the application of digital technologies across the board – not just in production processes but also in the delivery of goods and services – it has become associated with a more systemic 'digital transformation' process across society and across the world – what many economists today describe as 'digitalisation'. Contrary to the previous third industrial revolution, digital innovation in this transformation process is based much more on a number of well-known principles of information economics, which are discussed below.

Traditionally, industrial innovation involves major structural transformations in the economy as incumbents, and sometimes whole sectors, are challenged by new unexpected innovators which force them to adjust or disappear. The previous industrial revolutions are dramatic historical illustrations of such structural transformations, in which Joseph Schumpeter's process of 'creative destruction' became dominant. Such structural change came to be seen as essential to lead society to a higher level of economic development and welfare, as many incumbents are destroyed to the benefit of newcomers. In this process newcomers can benefit from extraordinary innovations in market 'rents'. Introducing an innovation endows the innovator with an advantageous but temporary exclusivity over their rivals. This is sometimes formalised through intellectual property rights (IPR) protection. Sometimes it is based on secrecy, which allows the innovating firm to set prices well above marginal costs gaining extraordinary rents. Those gains should be considered temporary, however. While the innovating firm would often have incurred substantial costs in the R&D phase of any new innovation, and must absorb the risks of launching the new product or process, competitors are often quick to acquire and exploit the knowledge behind the innovation, which economists explain by the non-rivalrous nature of knowledge. As a result, Schumpeterian competition involves the continuous emergence of new innovating firms which undermine the initial extraordinary innovation rents yielded by innovative firms. History is full of examples of innovating 'boom and bust' firms, which illustrates the process of creative destruction, as described by Schumpeter.

Guellec and Paunov (2017) highlight how the process of digitalisation is being magnified in two ways. First, thanks to the much wider use of information, software and data in the current 'digital transformation' process, the marginal cost of production of goods and services is coming close to nil with the intangible component of capital including IPR, branding and reputation now representingmost, if not all, of the value of digital products. As a result, one is now witnessing the emergence of what Jonathan Haskel and Stian Westlake (2017) have called ‘capitalism without capital’ – a new form of intangible capitalism. In previous industrial revolutions, physical tangible capital led to significant scale and increasing returns, linked to continuous improvements associated with incremental product and process innovations and ‘learning by doing’.[7] However, gains were always ultimately limited, as variable costs never reached zero, but required additional materials, labour, energy and other inputs. Notably, this is not the case with digital transformations. Here so-called ‘winner-take-all’ dynamics become dominant as market concentrations allow the winners to extract profits globally, and for a much longer period of time. Going back to our previous analogy, the long tail of the snake has grown significantly while at the same time its head has grown exponentially.

The process of digitalisation raises dramatic, near endless, opportunities for ‘creative destruction’ by potentially reducing significantly barriers to entry (Kenney and Zysman this volume). As Guellec and Paunov (2017) point out,

> the capital requirement for programming software, the core of digital innovation, is much lower than for other types of innovative activities, such as those requiring special facilities to develop innovations (eg laboratories and experimental settings in pharmaceuticals).

The intangible nature of knowledge, and the opportunities for rapid scaling-up, facilitate creative destruction. This is exemplified by the ‘app economy’ (Guellec and Paunov 2017) – the full range of economic activities, from selling applications and advertising revenues as well as hardware devices, on which apps are designed to run for mobile applications. Digitalisation can potentially lead to significant reductions in the costs of incremental innovations and product design, and the versioning of products and services for different consumer and users groups. Furthermore, digitalisation allows for global markets to be reached practically instantaneously, which opens up many new opportunities for product and service delivery, including product upgrades, which obviate the need to purchase a new product. For example, the word processing programme used to type this chapter is based on a 10-year-old software programme, which is updated nearly every month.

In short, while digitalisation has increased the fluidity of markets and the ease of entry, it has also dramatically increased society’s dependency on global digital platforms. These digital platforms enable direct digital interaction between producers and consumers, but they also facilitate interactions of almost any kind involving two parties – so-called 'two-sided markets', with one selling, and the other buying services in areas as diverse as jobs, finance, travel, advertising, medicine, entertainment and leisure.[8] The increase in global market access, fluidity – the speed with which prices will clear markets – and the achievement of scale without mass resulting from digitalisation, has undoubtedly contributed to much more competition. At the same time, though, the fact that digital platforms are crucially dependent on network externalities on both sides of the market leads naturally to monopolistic structures with various 'locking in' strategies. Compared with the general purpose technologies of the third industrial revolution (Bresnahan and Trajtenberg 1992), the general purpose platforms of the fourth industrial revolution appear intrinsically more monopolistic, which reflects the emergence of a new form of digital monopoly capitalism, in which winner-take-all features are becoming world leading.

CONCLUSIONS

Back in the mid-1990s, while I was chairing a high-level expert group for the European Commission on the information society, the prevailing view was that

> a large proportion of public opinion was sceptical about the new opportunities offered by the information society and even fearful about the job losses, employment displacement and work insecurity associated with a future Information Society (European Commission 1997).

Let me quote from the group's report in some detail:

> The lack of public support is also a reflection of the 'technology dominated' nature of the European Information Society policy debate. The latter offers little freedom of manoeuvre for policy action. Such an 'international competitiveness/technological determinism' argument runs as follows. We are forced through international competition to adopt new information technologies as rapidly as possible. It is an illusion to think we would be able to govern the speed of such change. Consequently, the only relevant policy issue is one of liberalising and deregulating. Any delay would be extremely costly. At the social level, while there could be 'local' employment destruction, the cost of such destruction is minimal when compared to the aggregate employment 'price' rigid societies might have to pay in terms of loss of competitiveness when failing to adopt the new information and communication technologies quickly enough. In other words, these employment losses have to be accepted as a minimal cost, outweighed by the positive global welfare impact of the Information Society and the employment growth in new areas (European Commission 1997).

Viewed in retrospect, the 'ideological' line of the high-level expert group report that the information society is malleable and that there could be different models of information societies, just as one had different models of industrialised societies, seems somewhat naive. However, this view was based on a strong conviction that the so-called European model of social welfare, with its strong ethos of solidarity, would ultimately also come to characterise any European version of the information society. To achieve this, so it was argued, would imply substantial changes in the traditional structures of the welfare state, and in particular a shift towards an active rather than passive concept of solidarity. Despite this logic, little happened in this respect, and while the welfare state has remained, it has become based even more on a passive concept of solidarity.

Thirty years on, at the advent of the fourth industrial revolution, concerns about massive employment losses have again led to widespread moves away from long-term jobs towards self-employment, linked more closely to new digital technologies, robotics, AI, the internet of things, the cloud, 3D printing, blockchain, virtual and augmented reality and big data analytics. Cecilia Reyes, chief risk officer of Zurich Insurance Group, was quoted in a recent article in Computer Weekly:

> Unless there is a concerted effort from governments and the private sector, this [digital technology] will put pressure on economies and may lead to social unrest. . . . Without proper governance and reskilling of workers, technology will eliminate jobs faster than it creates them. . . . Governments can no longer provide historic levels of social protection, and an anti-establishment narrative has gained traction, with new political leaders blaming globalisation for society's challenges. Governments, academics and businesses should be planning for huge social disruption because there are many real-life examples across the world of AI replacing people in the workplace (Flinders 2017).

It is important to realise though that the social disruptions that some, including Reyes, predict are yet to manifest. Following the historical evidence on the productivity slowdown, it is clear that most of the impact on productivity of the new digital technologies has either not yet occurred, or remains more or less invisible. At the same time private investment in new technologies in Europe has been lagging behind other parts of the world. One notable line of argument is that the slowdown of private capital investment is directly linked to the macro-economic policies pursued in most European countries following the financial crisis of low-wage competition. This in itself provided little incentive for most firms to invest in productivity enhancing capital. From this perspective, the lack of productivity growth calls for the diffusion and more rapid implementation of more robots and AI, despite the growing shortage of labour following the retirement of baby-boomers in many European countries. In short, employment displacement following automation is in the present context of increasing labour shortage not really an issue.[9]

What has arguably become the central concern in the current industrial revolution debate is the increasingly skewed distribution of the innovation rents associated with digital innovations and the digitalisation transformation. The record on addressing the distribution of innovation rents since the third industrial revolution has been disappointing to say the least. The current stage of development is typified by rising inequality, and a trend towards a race to the bottom in existing European social welfare systems (Bell this volume). As Guellec and Paunov (2017) neatly illustrate in their OECD paper, the 'rents' from digital innovation affect income distribution and benefits directly, particularly in the top income groups through shareholders and investors, top executives and key employees of the 'winning firms' who often own capital and hold managerial and leading positions in firms:

> In line with a Schumpeterian vision, innovation gives rise to rents from market power and scale economies. This is magnified with digital innovation, in which the intangible component (the source of rents) is much larger than in traditional manufacturing innovation. Highly concentrated market structures ('winner-take-all') allow rent extraction. In addition, digital innovation tends to increase risks because even only marginally superior products can take over the entire market, hence rendering market shares unstable. Instability commands risk premia, hence higher expected revenues, for investors. Market rents accrue mainly to investors and top managers and less to the average workers, hence increasing income inequality.

By contrast, average workers have been confronted with more competition in the labour market, are increasingly employed in temporary work arrangements, and are becoming subject to national low-wage competition policy pressures. Adding it all up explains why the share of capital (as opposed to labour) in national income has increased, particularly in innovation-intensive economic activities.

It is therefore essential to reframe the technology employment debate by focusing on the need for alternative income systems that are disconnected from employment, such as the notional 'basic income' (Palier this volume). Following Jahoda, Lazarsfeld and Zeisel's (1932) study of unemployment in Marienthal, Austria, in the 1930s, employment could still be considered to represent one of the most important factors for social integration and personal recognition today. At the same time, and given the tremendously increased opportunities for social contact outside the sphere of employment following the development of social media over the last 20 years, it is also reasonable to assume that an unconditional 'basic income' could well lead to a substantial voluntary shift in labour market participation, based on free choice and ultimately to the benefit of the individual, even to the health and happiness of the individual, as well as to the overall benefit of society.

Once 'basic income' is viewed as the monetised 'digital manna from heaven', resulting from technological change, the concept seems like a simple and attractive way to redistribute the gains from technical change to all throughout society. At the same time, the erosion of social welfare systems and more general state revenues following the digitalisation of society should also become a central issue of policy debate in experimenting with new tax revenues. More than 30 years ago, as part of our deliberation process on the information society, I proposed that states should levy an internet tax, or so-called 'bit tax'.[10]

It is clear that the global digitalisation transformation of society has many more implications than those dealing with employment and the organisation of work, as has been discussed here. Probably the most immediate question is the extent to which the extreme concentration of wealth and economic power associated with digital innovation will ultimately lead to a similar extreme concentration of political power, which might ultimately undermine democracy.

NOTES

1. In 1965, Gordon Moore, co-founder of Fairchild and Intel, predicted that the number of transistors on an integrated circuit would double every two years, at least until 1975. What became known as Moore's law proved valid at least until 2015. This continuous logarithmic improvement in microchip performance has been one of the major enabling factors behind the processes of digitalisation and the emergence of smartphone technology, 3D printing, robotics and AI.

2. This is something we referred to as The Biggest Technological Juggernaut that ever rolled, which is the title of chapter 3 in *Work for All or Mass Unemployment* (Freeman and Soete 1996).

3. For further insight into this, see for example Neisser (1942).

4. For further insight into this, see for example *Unemployment and Technical Innovation* (Freeman and Soete 1982) and more recently *The Economics of the Digital Society* (Soete and ter Weel 2005).

5. Typically, the use of computers requires certain human skills in order to be fully operational and to make use all available new opportunities the machines offer.

6. For further insight into this, see for example 'Technology Diffusion and the Rate of Technical Change' (Soete and Turner 1984).

7. These have been studied in more detail in industrial economics. The process of industrial innovation was first and foremost characterised by incremental process innovation improving nearly continuously such scale advantages and the accompanying increasing returns leading to various forms of monopoly capitalism as described by Paul Baran and Paul Sweezy. The process of creative destruction linked to new, radical innovations now and then undermined such trends towards monopoly capitalism (Baran and Zweezy 1996).

8. For further insight into this, see for example 'Two-sided Markets: a Progress Report' (Rochet and Tirole 2006).

9. For an argument along similar lines on the US economy, see the *Washington Post* interview with Josh Bivens (Bivens 2017).

10. Arthur Cordell first developed the proposal for a 'bit tax', which would be applied to all interactive digital services. It was based on a simple count of bits flowing over telecommunications lines. The argument in favour of such a new tax was primarily based on the way that globalisation undermines traditional national tax bases. At the same time, the disincentive to the diffusion and use of new information and communication services could be assumed to be marginal, because generally speaking these new services offer a new bundle of product or service characteristics (Cordell 1996).

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