**Employment displacement in the fourth industrial revolution: torn between fear and past evidence[[1]](#footnote-1)**

***Luc Soete***

(January 2018)

(UNU-MERIT, Maastricht University)

**Introduction**

It is fascinating to observe with which regularity the debate about the impact of “new technologies” on jobs and the organisation of work has taken place over the last century, if not centuries. Fascinating, but from different perspectives, not really surprising. After all we talk today about the “fourth” industrial revolution, following on from the first, second and third industrial revolution. What more logical and natural than to look at previous industrial revolutions to get some insights on what the potential impact might be of the current industrial revolution. For Klaus Schwab of the World Economic Forum who initiated the term “Fourth Industrial Revolution” back in 2015: “the First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres.[[2]](#endnote-1)”

In this short article, I will focus in the attempt to provide some analytical insights into the possible consequences for work and income, primarily based on the previous, third industrial revolution; the one most closely linked to the emergence and rapid diffusion of microelectronics and the computer in the late 70’s and 80’s of the previous Century. I limit myself to such a comparison for two reasons.

First, most of the new 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 further technological improvements in what characterized the third industrial revolution: “microelectronics” and in particular the continuous exponential improvements in the performance of integrated circuits following Moore’s law[[3]](#endnote-2). As Klaus Schwab put it in the quote above: “building on the Third” industrial revolution. Those improvements opened continuously new areas for further research in robotics, and many of the other technologies identified with the fourth industrial revolution such as 3-D printing, quantum computing, artificial intelligence, the Internet of Things, nanotechnology but also in biotechnology, materials science, energy storage, etc[[4]](#endnote-3). Not surprisingly, microelectronics became identified in the economics community as the most characteristic example of a so-called “General Purpose Technology” (GPT) affecting all sectors of the economy[[5]](#endnote-4).

Second, having written myself numerous articles and books in the 80’s and 90’s on the impact of microelectronics and more broadly computerized technologies on employment and the organisation of work[[6]](#endnote-5), I feel privileged to be in a position to highlight in these couple of pages out of personal experience what the similarities and differences are between those two faces of industrial transformation as they have confronted our economies over the last 40 years or so. In short: less as a historian which I am not, but as an economist in the area of technological change and innovation. Particularly when debating the possible consequences of revolutionary transformations one enters quite quickly debates in which speculation and science fiction visions of future societies appear to become dominant with ultimately little help to policy makers.

1. **Similarities: from the fear of job loss to a productivity paradox in the aftermath of an industrial revolution**

The first similarity when comparing the Third with the Fourth industrial revolution is of course the fear of significant job losses. The similarity between Clive Jenkins’ 1979 book called “The Collapse of Work” and the many, present analyses on the likely job losses associated with AI and robotics is striking and characteristic of the intrinsic “fear” of the way new technologies replace labour; in short automate routine jobs. In the 70’s and 80’s following the spreading of microelectronics, extensive reference was made to the literature of the 30’s and 40’s on the fear of “Permanent Technological Unemployment[[7]](#endnote-6)” following the impact of automation. Whereas these fears were particularly outspoken in Europe in the 80’s[[8]](#endnote-7), far less concerns were raised about those issues in the US where the debate shifted quickly to a more positive vision on the employment “displacement” aspects of new technologies and their potential so-called “skill-bias” aspects: the fact that the new technologies favoured skilled over unskilled labour increasing the former’s productivity and hence also the demand for skilled labour. A temporary friction solved through education and training.

Paradoxically, today the debate within the context of the Fourth industrial revolution appears much more a US than a European debate with contributions amongst others from Erik Brynjolfsson and Andrew McAfee, interestingly called “The **second** machine age”[[9]](#endnote-8) focusing on the past trend towards jobless growth following economic recovery in the 90’s and the role in there of new digital technologies replacing routine tasks. The focus on employment displacement also shifted from unskilled to routine jobs. The possibility that technology could be causing jobless US recoveries was first suggested by Jaimovich and Siu (2012) arguing that middle-skilled jobs involving routine tasks susceptible to replacement by new technologies were likely to become permanently destroyed during recessions, resulting in slower job growth during the recovery. The focus was again on new computer-based technologies, but on the employment displacement side much more on the impact on **routine** white collar work. As Jerry Kaplan (author of “Humans need not apply”) put it: “automation is now blind to the colour of your collar”. Brian Arthur put it in terms of a *Second Economy* emerging describing an underground, totally automated “digital economy” involving little to no physical employment in the “first economy” while Martin Ford talks about the *Rise of the robots*.

The shift towards the US in the debate on the job implications of new technologies linked to the Fourth industrial revolution can be explained by the fact that no evidence for such trends could be found outside the United States, where modern technologies appear unlikely to be causing jobless recoveries (Graetz and Michaels “Is Modern Technology Responsible for Jobless Recoveries?” forthcoming, American Economic Review Papers and Proceedings)[[10]](#endnote-9). It is in all likelihood also a reflection of the US global dominance of the major new digital technology players as illustrated in the public statements on the topic by some of the leading High-Tech CEO’s such as Elon Musk[[11]](#endnote-10), Bill Gates[[12]](#endnote-11). In the 80’s it was similarly, a US company, IBM who asked Chris Freeman and myself to write a report on the employment impact of computers. The report[[13]](#endnote-12), however, had no impact in the US. In Europe by contrast with unemployment remaining high and barely recovering from the 1982 recession, it led to an EC expert study on the Information Society[[14]](#endnote-13) and the inclusion in the Job Study launched in mid-90’s by the then Secretary General of the OECD of a specific Chapter[[15]](#endnote-14) on the technology impacts on employment and skills. Today there is relatively speaking much less interest and attention being paid, at least in continental Europe, to the emergence of new technologies affecting future jobs and the organization of work[[16]](#endnote-15).

A second, more striking similarity between the Third and Fourth industrial revolution is the puzzling economic evidence on the trend in productivity growth following the emergence of those radical new technologies: the “core” variable in any econometric analysis on the impact of research and innovation on growth and welfare. Productivity refers generally speaking 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 in the 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 productivity at the average level grows.

Rather surprisingly, and in contradiction with the revolutionary evidence on the emergence of new technologies, productivity did not increase following the third industrial revolution. In the 80’s this became known as the “Solow paradox”, following a side remark of Bob Solow’s review in the New York Times Book Review of Stephen Cohen and John Zysman 1987 book: “… what everyone feels to have been a technological revolution, a drastic change in our productivity 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” (Bob Solow, 1987).

Even more surprisingly, the current evidence on the Fourth industrial revolution appears to be accompanied by a similar lack of evidence with respect to 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, 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” (Sunderland, 2016). The link between productivity growth and technological change is, however, not that straightforward. In earlier analyses[[17]](#endnote-16) I compared the impact of technological change on productivity growth to the movement of a snake: the head (technological progress) moving ahead while the tail would remain more or less in the same place – productivity growth expressed by the average progress of the snake being relatively limited – versus the tail moving ahead to join the head remaining more or less in the same place – average productivity increasing much more rapidly. With respect to the current Fourth industrial revolution it is as if, the gap in productivity growth between global frontier firms and the lagging, more domestically oriented firms has grown, the body of the snake expanding. As the OECD Secretary General, Angel Gurria, put it: “the knowledge and technology diffusion “machine” is broken” (2016).

A lot has been learned over the last decades from research analyzing 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. The latter might e.g. involve a first phase of declining capital productivity as Paul David and Gavin Wright argued on the basis of historical comparisons (1999); or require essential organizational changes to exploit fully the often, in first instance, unnoticed efficiency gains associated with the new technology as Chris Freeman[[18]](#endnote-17) (1987) and Paul David[[19]](#endnote-18) argued with respect to the second industrial revolution pointing to the importance of the organisational discovery of unit electric drive; or require a major effort in skills and on the job learning before those new technologies would result in overall efficiency gains – the race between technology and schooling as Jan Tinbergen would put it (1975).

To conclude this first section; given the current low productivity growth trends, the concerns about the negative impact of the Fourth industrial revolution on employment and job displacement, appear not really convincing. There seems to be again a natural tendency to overestimate both the speed and the impact of the new technologies associated with the Fourth industrial revolution, such as AI, robotics, 3-D printing, automotive driving, quantum computing, and nanotechnology. Just look at the complexity involved e.g. in using robots to simply lift patients in a hospital, involving numerous physical security and other machine-human interaction problems, or using AI in assessing written exams. Historically the evidence of disappearing skills as a result of new technologies has not been at the core of the emergence of mass unemployment. Rather, and let me turn to those concerns in the next section, digital technologies appear to have increased dramatically the distribution of the gains associated with the emergence of new technologies: as if monopoly capitalism has re-emerged now in digital form.

1. **Differences: from General Purpose Technologies 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 the production 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 describe today as “digitalisation”[[20]](#endnote-19). Contrary to the previous Third industrial revolution, digital innovation in this transformation process is much more based on a number of well-known principles of information economics.

Traditionally industrial innovation would involve major structural transformations in the economy: incumbents, sometimes whole sectors would be challenged by new unexpected innovators forcing them to adjust or disappear. The first, second and third industrial revolutions are dramatic historical illustrations of such structural transformations, in which Joseph Schumpeter’ process of “creative destruction” became so dominant that such structural change would be essential to lead society to a higher level of economic development and welfare – destroying many incumbents to the benefit of much more newcomers. In this process newcomers would benefit from extraordinary innovation market “rents”. Having introduced an innovation endows the innovator or innovating company with a temporary exclusivity over its rivals, sometimes formalized through intellectual property rights (IPR) protection sometimes based on secrecy having become part of the firm’s brand reputation, allowing the innovating firm to set prices well above marginal costs and hence gain extraordinary rents from innovation. Those gains would be considered temporary though. While the innovating firm would often have made substantial costs in research and taken the risks of launching the new product or process, competitors would be quick to acquire the knowledge behind the innovation, what economists explain through the non-rivalrous nature of knowledge. As a result, Schumpeterian competition involves the continuous emergence of new innovating firms which undermine the initial extraodinary innovation rents. History is full of examples of innovating “boom” and “bust” firms illustrating well the process of creative destruction described by Joseph Schumpeter[[21]](#endnote-20).

As Dominique Guellec and Caroline Paunov[[22]](#endnote-21) highlight with digitalization the process 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 (IPR, brand reputation) representing now most, if not all, of the value of the digital product. As a result one is now witnessing the emergence of what Jonathan Haskel and Stian Westlake[[23]](#endnote-22) have called “capitalism without capital”: a new form of intangible capitalism. In previous industrial revolutions, physical tangible capital would lead of course to significant scale and increasing returns advantages linked to continuous improvements associated with incremental product and process innovations and learning by doing[[24]](#endnote-23), but would ultimately always be limited because variable costs would never reach zero but require additional materials, labour or other input. Not in the case of digital transformation. Here so-called "winner-take-all" dynamics become dominant with market concentration allowing the winner to extract globally **and** for a much longer period innovation rents. In terms of our previous analogy, the long tail of the snake has grown significantly while its head has grown exponentially at the same time.

Second digitalisation raises dramatic, near endless opportunities for “creative destruction” reducing significantly entry barriers. As Guellec and Paunov 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 (e.g. laboratories and experimental settings in pharmaceuticals). The intangible nature of knowledge and the opportunities for rapid scale-up facilitate creative destruction. This is exemplified by the "app economy"[[25]](#endnote-24).” In terms of innovation, digitalisation leads to a significant reduction in the costs of incremental innovations and product design, as well as in the versioning of products and services to different consumer and users groups. Furthermore digitalisation allows that global markets can now be reached practically instantaneously, opening many new opportunities for product and service delivery, including product upgrades rather than the act of purchasing of a new good – the word processing used to type this article on my laptop is based on a ten year old software programme which has been updated nearly every month.

In short, while digitalisation has increased the fluidity of markets and the ease of entry, it has also increased dramatically society’s dependency on global digital platforms. These digital platforms have enabled direct digital interaction, not just between producers and consumers, but also interaction of any kind involving two parties – so-called “two-sided markets”[[26]](#endnote-25) –, one selling, the other buying services in areas as diverse as jobs, finance, travel, advertising, medicine, entertainment, leisure, etc. The increase in global access to markets, fluidity, achieving scale without mass resulting from digitalisation has undoubtedly contributed to much more competition. At the same time though, the fact that digital platforms as enabler of the emergence are crucially dependent on network externalities on both sides of the market, leads rather naturally to monopolistic structures with various “locking in” strategies. Compared to the General Purpose Technologies of the Third industrial revolution[[27]](#endnote-26) the General Purpose Platforms of the Fourth industrial revolution appear intrinsically more monopolistic in nature, reflecting a new form of digital monopoly capitalism emerging in which winner-take-all features are becoming world leading.

A good description of those features can be found in Peter Thiel’s *Zero to One: Seven surprising keys to Market-Creating Innovation*[[28]](#endnote-27)*.* Peter Thiel was one of the main beneficiaries of the selling of PayPal in 2002 for 1.5 billion $[[29]](#endnote-28). According to Peter Thiel: “Monopoly is the condition of every successful business. Monopolies drive progress because the promise of years or even decades of monopoly profits provides a powerful incentive to innovate. Then monopolies can keep innovating because profits enable them to make the long-term plans and to finance the ambitious research projects that firms locked in competition can’t dream of” (Peter Thiel). For Thiel the task of business is essentially one of creating an enduring monopoly through breakthrough technology. The technology must have the capacity to generate a very large future cash flow. LinkedIn and Twitter are valued highly, not because of any profits today, but because they are perceived as the capacity to generate massive cash flows over the coming decades. In his view “there are four main factors to be considered: 1) proprietary technology, 2) network effects, 3) economies of scale, and 4) strong branding. Firms like Google, Facebook, Twitter have these elements, Zynga and Groupon don’t.... The way to build an enduring successful monopoly is to start by creating a monopoly in a small market, just as Facebook started by dominating the social space at Harvard University. Once you have dominated a small market, then move into related and broader markets. Thus Amazon began with books and then steadily spread into virtually every product. What matters is the endgame, not being the first mover. It’s much better to be the last mover – that is to make the last great development in a specific market and enjoy years or even decades of monopoly profits. The way to do this is to dominate a small niche market and scale upfront there, toward your ambitious long-term vision... you must study the endgame before everything else.”

Interesting from this perspective is the observation that turnover at the top of the largest companies in the world has more or less stopped over the past 5-10 years, that General Purpose Platform firms often take over any new innovating digital firms operating in particular niches as pre-emptive strategy and the particular emphasis put on proprietary standards including various strategies to make customers and users captive to the platform[[30]](#endnote-29).

**Conclusions**

Back in the mid-nineties, at the time of chairing a High-Level Expert Group for the European Commission on the Information Society[[31]](#endnote-30) the feeling 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.” Let me quote from that 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 ICTs 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 IS and the employment growth in new areas.”

Viewed in retrospect, the “ideological” line of the HLEG 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 naïve. 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 have to characterize any European version of the Information Society. To achieve this, so it was argued, would however imply substantial changes in the traditional structures of the welfare state, and in particular the shift towards an active rather than passive concept of solidarity. Little happened, on the contrary.

Thirty years later, on the eve of the advent of the Fourth industrial revolution, the concerns about massive employment losses, moves away from long-term jobs towards self-employment linked now more closely to new digital technologies from robotics, AI, Internet of Things, The Cloud, 3-D printing, blockchain, virtual/augmented reality to big data analytics, are again widespread. To quote from a recent piece in Computer Weekly: “Unless there is a concerted effort from governments and the private sector, this will put pressure on economies and may lead to social unrest, said Cecilia Reyes, chief risk officer of Zurich Insurance Group. “Without proper governance and reskilling of workers, technology will eliminate jobs faster than it creates them,” she said. “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.”[[32]](#endnote-31)

It is important to realize though that these predicted social disruptions are, despite the global nature of the digitalization transformation process associated with the Fourth industrial revolution, not given. Following the historical evidence on the productivity slowdown, it is clear that most of the productivity impact of the new digital technologies has either as yet not occurred, or remains more or less invisible. At the same time private investment, also in new technologies, has been lagging in Europe. One interesting argument here 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. The latter in itself provided little incentive for most firms to invest in productivity enhancing capital. From this perspective, the lack of productivity growth, despite growing shortage of labour following the retirement of baby-boomers in many European countries calls for the diffusion and more rapid implementation of more robots and AI. In short, employment displacement following automation is in the present context of increasing labour shortage not really an issue[[33]](#endnote-32).

What has become for me 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 has, since the last Third industrial revolution and the naive optimism as expressed in the HLEG report mentioned above, been disappointing to say the least. The result has actually been rising inequality, with also a trend towards a “race to the bottom” of existing European social welfare systems, to use Jacques Drèze term. As Guellec and Paunov neatly illustrate in their OECD paper, quoted above, the “rents” from digital innovation affect directly income distribution and benefit in particular the top income groups [[34]](#endnote-33) 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. By contrast average workers have been confronted with more competition in the labour market, increasingly employed in temporary work arrangements and becoming subject to national low-wage competition policy pressures. Adding it all up explains why the share of capital (vs. labour) in national income has increased particularly in innovation-intensive economic activities.

It is therefore essential to reframe the technology employment debate focusing on the need for alternative income systems disconnected from employment, such as “basic income”. Following Jahoda’s study of unemployment in Marienthal in the 30’s, employment could still be considered today to represent one of the most important factors for social integration and personal recognition. At the same time, and given the tremendously grown opportunities for social contact outside of the sphere of employment following the development of social media over the last twenty 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 his health and happiness, as well as to the benefit of society.

Once “basic income” is viewed as the monetized “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. At the same time, the erosion of social welfare systems and more general state revenues following the digitalization of society should become a central issue of policy debate in experimenting with new tax revenues. More than thirty years, I proposed in the HLEG report mentioned above on “The Information Society for us all” to levy an Internet tax, the so-called “bit tax”[[35]](#endnote-34). Thirty years later a draft report to the European Parliament (EP) from the Committee on Legal Affairs proposes that there might be a “need to introduce corporate reporting requirements on the extent and proportion of the contribution of robotics and AI to the economic results of a company for the purpose of taxation and social security contributions.”

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

1. Paper to be presented at the "Economic of Innovation" series, Collegio Carlo Alberto, Torino on January 26th, 2018.

  [↑](#footnote-ref-1)
2. <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/> See also Klaus Schwab, “The Fourth Industrial Revolution, What it means and how to respond”, *Foreign Affairs*, December 12th, 2015. [↑](#endnote-ref-1)
3. Gordon Moore, co-founder of Fairchild and Intel, predicted back in 1965 that the number of transistors on an integrated circuit would double every two year, at least until 1975. What became known as Moore’s law proved valid at least until 2015. This continuous logarithmic improvement in chip performance has been one of the major “enabling” factors behind digitalisation and the emergence of smart mobiles, 3-D printing, robotics and artificial intelligence. [↑](#endnote-ref-2)
4. For Klaus Schwab, “there are three reasons why today’s transformations represent not merely a prolongation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: velocity, scope, and systems impact. The speed of current breakthroughs has no historical precedent. When compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. Moreover, it is disrupting almost every industry in every country. And the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance.” As much as this may seem the case today, I would not directly identify this with the emergence of new revolutionary technologies but rather with transformations resulting from further innovative applications and global diffusion of innovative business models. We come back to this issue below. [↑](#endnote-ref-3)
5. Bresnahan, T. and M. Trajtenberg, (1992), General Purpose Technologies "Engines of Growth?" NBER Working Paper No. 4148, August 1992 [↑](#endnote-ref-4)
6. Something we referred to as “The Biggest Technological Juggernaut that ever rolled”, the title of Chapter 3 in Freeman, C. and L. Soete (1996), *Work for all or Mass Unemployment*, Frances Pinter: London. [↑](#endnote-ref-5)
7. See e.g. Neisser, H. (1942), “ Permanent Technological Unemployment”, *American Economic Review*, Vol. 32, Number 1, pp. 50-71. [↑](#endnote-ref-6)
8. See e.g. Freeman, Chris, John Clark and Luc Soete (1982), *Unemployment and Technical Innovation: a study of long waves and economic development*, Frances Pinter, London, UK, pp. 214, and more recently Soete, Luc and Bas ter Weel (Eds.), 2005, *The Economics of the Digital Society*, Edward Elgar [↑](#endnote-ref-7)
9. Brynjolfsson, E. en a. McAfee (2014). *The second machine age*. Work, progress, and prosperity in a time of brilliant technologies. New York: W.W. Norton & Company; and also Michaels, G. en G. Graetz (2015). Robots at work. CEPR Discussion Paper 1335, March 2015. [↑](#endnote-ref-8)
10. See Graetz and Michaels “Is Modern Technology Responsible for Jobless Recoveries?” forthcoming, American Economic Review Papers and Proceedings [↑](#endnote-ref-9)
11. <https://www.bing.com/videos/search?q=jobs+losses+and+AI&view=detail&mid=B21B8F9649DC60B7C312B21B8F9649DC60B7C312&FORM=VIRE> [↑](#endnote-ref-10)
12. <https://qz.com/911968/bill-gates-the-robot-that-takes-your-job-should-pay-taxes/> [↑](#endnote-ref-11)
13. Freeman, Chris and Luc Soete, 1985, Information Technology and Employment: an Assessment, IBM, Brussels, Belgium [↑](#endnote-ref-12)
14. See EC-HLEG (1996), Building the European Information Society for Us All, Interim Report, January 1996, Brussels. [↑](#endnote-ref-13)
15. See OECD (1996), The OECD Jobs Strategy: Technology, Productivity and Job Creation, Vol. 2, Analytical Report, OECD, Paris. [↑](#endnote-ref-14)
16. In Europe the debate seems limited to the UK, and in particular analyses carried out by various consultancy firms such as McKinsey and PWC. To quote a recent study from the latter: “We are facing a paradigm shift which will change the way we live and work,” the authors say. “The pace of disruptive technological innovation has gone from linear to parabolic in recent years. Penetration of robots and artificial intelligence has hit every industry sector, and has become an integral part of our daily lives...this revolution could leave up to 35% of all workers in the UK, and 47% of those in the US, at risk of being displaced by technology over the next 20 years, according to Oxford University research cited in the report, with job losses likely to be concentrated at the bottom of the income scale.” PwC’s UK Economic Outlook report was published on Friday 24th March. [↑](#endnote-ref-15)
17. See e.g. Soete, L. and R. Turner (1984), Technology Diffusion and the Rate of Technical Change, *Economic Journal*, vol. 94, no. 375,The Economic Journal [↑](#endnote-ref-16)
18. Freeman, C. (1987), “Information Technology and Change in the Techno-economic Paradigm”, in Freeman, C. and L. Soete (Eds.), *Technical Change and Full Employment*, Basil Blackwell, Oxford. [↑](#endnote-ref-17)
19. David, P. (1991), “Comp

 *Review*, Vol. 80, number 2. [↑](#endnote-ref-18)
20. In Dominique Guellec’s words: “Digitalisation is the transformation of society and the economy due to digital technologies. All activities are leaving a digital track record and can be handled by digital technology.” [↑](#endnote-ref-19)
21. A nice illustration of this can be found in the changes in the rankings of the world largest firms over the last 30 years. [↑](#endnote-ref-20)
22. See Guellec, D. and C. Paunov (2017), Digital innovation and the distribution of income, Contribution to the NBER CRIW Conference on Measuring and Accounting for Innovation in the 21st Century, February 23rd, 2017. [↑](#endnote-ref-21)
23. Haskel, J. and S. Westlake (2017), Capitalism without Capital. The rise of the Intangible Economy, Princeton University Press. [↑](#endnote-ref-22)
24. These have been studied in more detail in industrial economics. The process of industrial innovation was first and foremost characterized by incremental process innovation improving nearly continuously such scale advantages and the accompagnying 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 would now and then undermine such trends towards monopoly capitalism. [↑](#endnote-ref-23)
25. See Guellec, D. and C. Paunov (2017), *op.cit*. [↑](#endnote-ref-24)
26. See e.g. Rochet, J. and J. Tirole (2006), “Two sided markets: a progress report”, *The RAND Journal of Economics*, vol. 35, n. 3, 2006, pp. 645–667 [↑](#endnote-ref-25)
27. See above Bresnahan, T and M. Trajtenberg (1992), *op cit*. [↑](#endnote-ref-26)
28. See Peter Thiel: Zero to One: Seven surprising keys to Market-Creating Innovation, review by Steve Denning, October 15, 2014, *Forbes* [↑](#endnote-ref-27)
29. The so-called “Paypal Mafia” comprised: Elon Musk (Space X, Tesla Motors), Reid Hoffman (LinkedIn), Steve Chen, Chad Hurley and Jawed Karim (YouTube), Jeremy Stoppleman and Russel Simmons (Yelp), David Sacks (Yammer0, Peter Thiel (Palantir). All seven of those companies are worth today more than 1 billion $. [↑](#endnote-ref-28)
30. What has also been described as “attention economics” whereby the new “social” media platforms have as central purpose to “harvest” as much time as possible from the reader, watcher or listener and translate such time in revenue. [↑](#endnote-ref-29)
31. EC-HLEG (1995/6) The Information Society for us all, Brussels [↑](#endnote-ref-30)
32. From: <http://www.computerweekly.com/news/450415491/AI-and-robots-will-create-political-instability-until-humans-find-new-occupations> [↑](#endnote-ref-31)
33. For an argument along similar lines on the US economy with Josh Bivens <https://www.washingtonpost.com/posteverything/wp/2017/03/21/you-want-faster-productivity-growth-then-run-a-high-pressure-economy-an-interview-with-josh-bivens/?utm_term=.72d4fcf69674> [↑](#endnote-ref-32)
34. As Guellec and Paunov put it: “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.” [↑](#endnote-ref-33)
35. Arthur Cordell developed the proposal for a "bit tax" first which would be applied to all interactive digital services (Cordell and Ide, 1994). 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 globalisation undermined 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 these new services offer, generally speaking, a new bundle of product or service characteristics. [↑](#endnote-ref-34)