Work in the digital economy: sorting the old from the new

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Introduction

If some media reports are to be believed, the world of work is set to be hit by a veritable digital tsunami, shattering our present preconceptions about employment. A substantial proportion of the jobs we know today will be rendered obsolete by the latest generation of robots and their newfound capacity to perform tasks such as printing 3D objects, translating documents, drafting insurance policies, taking care of elderly people in their homes, telling doctors what might be wrong with patients and many more, each more astonishing than the last. The very concept of a 'job' may become outdated and replaced by an ever-shifting portfolio of commissions and projects assigned through online platforms, with the 'Uberisation' of work lying just around the corner.

Similar discourses about the implications of computerisation for jobs – whether pessimistic or optimistic in tone – have been articulated many times before, with the debate often rekindled by ground-breaking technological developments. In the early 1980s, as the Fordist model of the economy became ever more deeply engulfed in controversy, the appearance of the first microprocessors and personal computers in workplaces fanned the flames of speculation about job losses. Around the turn of the millennium, the explosion in use of the Internet – at the same time as the bubble of interest in the somewhat vaguely titled 'e-economy' – led to conjecturing about an upswing in growth which would call for unprecedented levels of flexibility on the part of workers. Phenomenal leaps made recently in the fields of robotics, communicating objects, big data processing and virtual platforms have placed a question mark over the relevance and longevity of the social model of paid employment. In the meantime, digital technologies have become an integral and familiar feature of our day-to-day lives at work and at home; the Manichean view of technology as either a blessing or a curse which was popular 30 years ago has fallen out of favour, particularly among younger people.

The aim of this working document is therefore to analyse the digital economy and the transformation of work by considering whether specific developments in this respect can be better characterised as a continuation of previous trends or a departure from the past. Based on more than 25 years of research experience in the field, the authors firstly investigate which aspects of the digital economy model can be deemed genuine novelties and potential harbingers of major breaks with the past, and which are merely amplified versions of existing trends for industry and service-sector restructuring and workplace transformations. The second part of the document examines the major technological breakthroughs which are currently disrupting workplaces, as well as their transformative potential, while the third part looks at new forms of work – particularly virtual work – in the digital

economy. The fourth and final part of the document deals with the relationship between geographical distance and social bonds and the regulatory challenges posed by unstructured working patterns, before concluding with a reappraisal of the meaning of work in professional environments where virtual worlds cross over into real life.

1. The digital economy: the search for change

The starting point must be to determine which of the developments associated with the digital economy (apart from a renewed fascination for technical performance) are genuinely novel, and the first pitfall to avoid in this respect is a definition based solely on digital technologies. No one used the terms 'steam economy' or 'electrical economy' to refer to previous technological revolutions, preferring instead the more accurate terminology which emerged for this purpose. The economic model which characterised the second industrial revolution that occurred in the 20th century has become known as Fordist growth, for example, and this concept – which has been the subject of a great deal of research by both economists and labour scientists – embraces the many different groups of technologies which underpinned the revolution, in the electrical, chemical, energy, pharmaceutical, IT, transport and telecommunications sectors. What we must now do is look beyond digital technologies in order to pinpoint the founding principles of a new era of economic and social development.

1.1 The founding principles of the digital economy

It is already possible to find definitions (albeit brief) of the digital economy, such as the following by France Stratégie: 'The digital economy has four specific features: the irrelevance of geographical location, the key role played by platforms, the importance of network effects and the use of big data. These features distinguish it from the traditional economy, particularly as a result of the associated value chain transformations' (Charrier and Janin 2015).

There is still no consensus on the founding principles of the digital economy, however, as revealed by a literature review carried out for ETUI (Degryse 2016). The impressionistic outlines which emerge from the literature should be approached critically, but can be summarised as follows:

1. Digitised information has become a strategic resource, and the network has become the chief organising principle of the economy and society as a whole. A new generation of digital technologies are now generating unprecedented quantities of data and providing the tools needed to harness this asset and leverage its value.

2. The digital economy – along with an ever increasing range of tangible and intangible economic activities – follows the principles of growing returns (positive network externalities) and zero or quasi-zero marginal costs.

3. New business models are springing up to take advantage of two-sided markets and the platform-based economy, particularly those involving collaboration or sharing, and new competitive dynamics – dominated by the 'winner takes all' model – are taking hold in markets for digital goods and services.

4. A newly emerging model of industrial production (sometimes referred to as 'Industry 4.0') involves short production runs of mass-customised goods, the global fragmentation of value chains, the networking of productive capacities and the blurring of boundaries between producers, sellers and consumers on the one hand and industry and the services sector on the other.

5. Profitability calculations for technological investments have been revolutionised by a plunge in the cost of hardware and software paired with a leap in their performance and productive efficiency. Nevertheless, a cause-and-effect link between technological innovation and productivity gains has not yet been directly established, and the relationship between technology and productivity is still heavily dictated by society's take-up of innovations and organisational changes within companies.

These five developments are novel in very different ways. Some, such as the arrival of the information and knowledge economy, are long-heralded but have recently undergone a reinterpretation, whereas others were debated in the substantial body of literature published on the new economy or eeconomy around the first decade of the new century. Other developments, such as the platform-based economy and two-sided markets, are more recent and have yet to be explored in depth. As a first point of departure, therefore, the five developments outlined above will be examined more closely in order to determine whether they represent a continuation of previous trends or a break away from the past.

1.2 Digitised information as a strategic economic resource

We start with the development which undoubtedly enjoys the broadest consensus in the literature on the digital economy, and whose history stretches back to the 1970s, well before the emergence of methods for the digital encoding of every possible form of information and communication. In *The Coming of Post-Industrial Society*, published in 1973, the sociologist Daniel Bell was one of the first authors to posit that the post-industrial economy would be dominated by intangible production and consumption based on the processing and dissemination of information, the latter being defined as 'the storage, transmission and processing of data as a basis for all economic and social exchanges' (Bell, 1973). In his best-selling work *The Third Wave*, published in 1979, the futurist Alvin Toffler popularised the concept of a new information era underpinned by several key ideas, including the demassification of media, the end of mass production and mass consumption, customised products and services, decentralisation, interactivity and full but hyper-flexible employment. Toffler believed that the dawning of this new era would be heralded by information and communication technologies.

Ever since, economists and international institutions alike have shown sustained interest in the growth of an information and communication industry purveying both tangible and intangible products and services[1]. Its huge potential in terms of economic growth has been highlighted by many experts, even though a general consensus is still lacking, as will be discussed below in connection with productivity (Mansell, 2009; Weygand, 2008). The 1990s saw the appearance of two key political initiatives in the shape of the information superhighways in the USA and the European information society[2], as well as a shift of sorts in the terminology used by European institutions (the Lisbon Summit in 2000 marked the move from the 'information society' to the 'knowledge-based society'), yet the underlying idea remained that of a newly emerging economy based on digitised information and communication, a concept also championed in various influential scientific works by authors such as Christopher Freeman and Luc Soete (1994) or Manuel Castells (1996). In his preface to the new 2010 edition of *The Rise of the Network Society*, Castells revisited the key trends which he had identified 15 or so years earlier in order to pinpoint the directions in which they were now moving:

– Information is no longer merely a tool used to cut transaction and coordination costs in a networked economy; instead – and thanks in particular to phenomena such as user-generated content, geolocation data, open data and the capabilities provided by big data mining and analytical software – it can now genuinely be seen as an increasingly abundant resource which generates value and profit for actors in both the digital and the traditional economy at the same time as shifting the balance of power between companies.

– Digital technologies have permeated all facets of the economy and society, particularly since the precipitous rise in the use of interactive and mobile communication tools which took place during the first decade of the 21st century. The take-up of developments such as social networks, interactive services and mobile Internet has exceeded all expectations, as has the creative potential they have unleashed.

– It is increasingly clear that a network approach is a good fit for the growing complexity of interactions in the economy and, more broadly speaking, in society as a whole; nevertheless, it is also capable of creating or amplifying problems, as was the case with the chain reactions which lent momentum to the systemic financial crisis of 2008. In an indirect response to criticism from certain quarters claiming an excess of determinism in the application of network logic to the organisation of the global economy (Gadrey 2000; Garnham 2000), Castells underlines the flourishing variety and inventiveness of the different forms of networking, as well as the new social divides which have appeared in their wake and hit certain groups hard in terms of job security.

1. The OECD's *Information Technology Outlook* has been published on a biennial basis for over 25 years, for example.

2. Cf. in particular Al Gore's report *'The national information infrastructure: an agenda for action'* (1993) and Bangemann's report *'Europe and the global information society'* (1994); the latter was a driving factor behind the liberalisation of telecommunications markets in the European Union.

– The flexibility which is an inherent feature of digital technologies and forms of networking due to their ready adaptability has continued to give rise to far-reaching upheavals in the production structures inherited from the Fordist model of growth and to lend impetus to the emergence of a new model of flexible working, albeit one which in some respects would have been almost unimaginable just 15 years ago.

These developments serve as proof of what certain authors have referred to as the transition from an Information Age to an Internet Age (Huws 2013), said to have occurred between 2000 and 2010 and particularly noteworthy for having heralded an explosion in 'virtual work', which in this context refers to online and networked tasks which are easy to outsource at global level and which are based on algorithmic design and the manipulation of characters, harking back to the idea of the 'symbolic analysts' described by Robert Reich as long ago as 1991 (1991, 2001). Virtual work is also characterised by a blurring of time and space, of professional and private life and of work and leisure. The majority of industrial activities and services still call for a mixture of face-to-face and online activities, but virtual work is now gaining ground as a new model or even a new standard, with the model of paid employment within a company – even with the advances in flexibility made at the end of the 20th century – being relegated to second place.

1.3 Innovations with growing returns and zero marginal costs

Most definitions of the digital economy refer to the idea of 'zero marginal cost', popularised by authors such as Jeremy Rifkin (2014), as a cornerstone of current economic change. Such definitions categorise digitised goods and services as both intangible and non-rival with reference to the fact that they may be possessed without necessarily being owned, are used on a non-exclusive basis and have zero or quasi-zero marginal costs of reproduction, a good example being e-books in comparison to paper books.

This phenomenon was envisioned 15 years ago by authors writing about the new economy (Volle 2000; Rochet and Volle 2015), and can be attributed to the growing returns which are an inherent feature of digital technologies thanks to positive network externalities, meaning that the value of a digital good or service increases as a function of network size without any attendant increase in costs. One of the implications of the principle of growing returns is that the costs of production and distribution bear little or no relation to the volumes produced, but must be paid when the initial investment is made. The marginal cost of production is accordingly close to zero, and so although the digital economy is highly capital-intensive, digital goods can be reproduced in vast quantities at zero or quasi-zero unit cost (Blomsel 2007). Digital economy experts believe that markets for digitised goods and services follow a model of monopolistic or oligopolistic competition, hegemonised as they are by a few large companies which are frequently born of mergers and acquisitions and whose strategies boil down to locking in customers and keeping competitors at arm's length.

Criticism can be levelled at the quasi-zero marginal cost theory on the basis that it focuses exclusively on positive network externalities and ignores negative externalities, in particular environmental concerns such as the consumption of electricity and scarce mineral resources and the production of electronic waste. A number of 'whistleblowers' (Flipo *et al.* 2013) have warned of the potential for exponential growth in this area too, but their words have been little heeded to date. Their warnings have been countered by authors such as Jeremy Rifkin (2014) who claim on the one hand that it is also possible to generate electricity at quasi-zero marginal cost by using renewables, and on the other that the zero marginal cost principle will promote the development of a sharing economy based on local trade, reuse and recycling and a return to frugality.

The idea of innovations delivering growing returns represents a break away from previous technological systems which were governed by the principles of economy of scale and economy of scope. The gains in efficiency and profitability generated by technological investment in any technical system are initially very high, but then decline and become increasingly incremental as the innovation becomes widespread. In the long term, this technological 'burn-out' means that innovations deliver diminishing returns (Rosenberg 1994)[3] until the technical systems are regenerated by radical innovations[4]. A number of experts on the digital economy believe that this mechanism no longer operates, and that instead we have entered an age where innovations yield growing returns. They hypothesise that key innovations frequently originate from the recombination of existing technologies, and acquire the title of 'disruptive' when they reach a certain threshold beyond which the potential for recombination is multiplied exponentially. The global and instantaneous dissemination of a rapidly expanding body of knowledge and new ideas means that this threshold has now been reached (Brynjolfsson and McAfee 2015).

1.4 New business models in the digital economy

Online platforms are triggering the emergence of new business models which have been described by economists as 'two-sided markets' (Wauthy 2008)[5], with the theory behind these markets based on the idea of products and services which cater to two distinct user groups at once – the two sides of the market – through a platform which can be accessed from a computer, smartphone or tablet.

One side of the market is made up of consumers who benefit from access to low-cost or free services and positive network externalities, since the services become

3. The Rome Club report *Limits to growth*, published back in 1973, identified the problem of the diminishing returns delivered by innovations.

4. The research into technical and economic paradigms and long cycles carried out by members of the school of evolutionary economics (the neo-Schumpeterians), in particular Giovanni Dosi, Christopher Freeman, Luc Soete and Carlota Perez, is also interesting in this respect. The latter recently published a reinterpretation of their evolutionary angle which takes account of the newly emerged digital economy (Perez 2004).

5. The French economist Jean Tirole, who won a Nobel Prize in 2014, actively contributed to the development of two-sided market theory.

more attractive as user numbers grow; by accessing these services, however, and whether they realise it or not, they are supplying the platform with sets of data on their personal profile, location and consumer habits. The other side of the market comprises economic players which are involved in the provision of platform-based services and which also benefit from positive network externalities in proportion to the size of the consumer base. The value of a service for the actors on one side of the market correlates to the number and quality of the actors on the other; economists refer to such phenomena as 'cross network externalities' and regard them as a typical feature of two-sided markets. Platforms of this kind are funded by levies on transactions between the two sides of the market, but the information which is collected is also valuable to the actors on both sides, representing not only a source of data but also a body of knowledge; the platform itself is therefore the primary location of value creation for both sides. Examples of platforms which correspond to this description include Google, Booking, Uber, Amazon and many others, and the fact that some of their services are superficially 'free' (Google when used by individuals, for example) is in reality merely a manifestation of the optimum pricing model for one side of the market.

This business model has introduced the concept of 'prosumers', or in other words individuals who both produce and consume digitised information. Although rarely paid, prosumers carry out work by supplying data and services for which salaried employees were previously at least partly responsible, such as amateur reviews of services or products, user generated content and data entry.

The online platform business model can also be applied to not-for-profit operations such as collaborative platforms for exchanging services in areas as varied as DIY, car sharing, childcare and equipment hire, and the concept of 'prosumers' is also relevant in this area. Although networks for exchanging services are not a new phenomenon as such, they have become more visible thanks to their development into mainstream websites and more efficient thanks to the online platform model. The natural tendency of platforms to capture the value created on both sides of the market explains why a number of collaborative platforms (such as AirBnB) have been able to position themselves as market leaders.

The newly developed platform-based business model has rewritten the rules of competition in the market sectors in which these platforms operate by promoting a 'winner takes all' approach. The digital goods and services which outperform their competitors are the winners (Brynjolfsson and McAfee 2015), and walk away with almost all of the market (bar a few niche segments) in the absence of a significant price difference which might motivate a consumer to choose an inferior product. 'Winner takes all' markets are increasing in number for three reasons: the growth in digital goods and services as substitutes for material goods, universal access to networks and the existence of largely positive network externalities. This represents a point of departure from traditional markets, where competition is based on absolute performance determined by price and quality criteria and there is space for several competitors to compete with each other and share the market.

1.5 Innovative features of the Industry 4.0 model

Leaving aside the mystery of why we use the name 'Industry 4.0'[6] given that we talk about the third industrial revolution or the second machine age, it is possible to identify a number of trends which are innovative to varying extents and which typify this new model of industrial production whose emergence has been reported by many different authors from the worlds of both academia and consulting (Escande and Cassini 2015; Hermann *et al.* 2015; Rüssman *et al.* 2015):

– *Mass customisation* refers to the ability to produce custom-made goods on a large scale at the same time as decentralising manufacturing to locations near to where the goods will be consumed and developing user-centric product design methods. One of the key technologies which makes this possible is additive manufacturing (3D printing, for example), which will replace subtractive manufacturing (turning, boring, milling and other traditional factory techniques) and allow the low-cost production of prototypes or customised objects.

– The industrial-scale use of *communicating objects* (Internet of Things) is based on the constant interconnectedness of vast numbers of sensors, RFID chips, mobile phones, laptops, etc. allowing direct interactions between machines (M2M communication). The Internet of Things will foster the development of cyber-physical systems (CPS) which make it possible to use a virtual representation of physical processes for their surveillance or control. To a certain extent, these innovations build on developments in the fields of flexible robots and expert systems, but performance levels are markedly better thanks to real-time interaction between communicating objects and ever-faster processor speeds.

– The development of *autonomous robots* marks the dawn of a new era in the history of robotics. Autonomous robots are designed to analyse and adapt to their environment, in particular by leveraging big data to learn new behaviours and harnessing the burgeoning potential of simulation tools and exponential improvements in shape, image and speech recognition abilities. Many authors believe that these new levels of performance go far beyond incremental improvements to existing robots.

– The new opportunities presented by *decentralised production networks* may herald a turning point in the organisation of industrial production, particularly as regards the balance of power between large and small companies. This is not a new trend; back in the late 1980s, many management textbooks referred to the telematics networks used by the textiles industry (and pioneered by Benetton) as a method of optimising decentralised production, and it was at this time that models were advanced for the analysis of industrial specialisation in the information age (Foray and Freeman 1992), often based on the theory of

6. The term originates from a joint programme launched by the German Government and German industry in 2011. It later found its way into the lexicon of the European Commission, and of the regions (Wallonia's Marshall Plan 4.0, for example). The term *smart manufacturing* is preferred in the USA.

industrial specialisation developed by Michael Piore and Charles Sabel (1989). There is no clear indication that the new generation of digital technologies represents a genuine break with these past developments, apart from their potential in terms of coordinating cyber-physical systems.

– Over the past few years, many different authors have analysed the *fragmentation of the value chain* at global level since it represents one of the key features of globalisation (Huws 2007). It involves both the ever more pronounced fragmentation of different business functions along value chains and the restructuring of these functions as part of a new international division of labour. There is now nothing to stop the global offshoring of certain functions, particularly the mass production of tangible and intangible goods, while other functions are relocated to be closer to centres of decision-making power. The aforementioned rise in the popularity of virtual work is consistent with this global restructuring of value chains, and it is readily apparent that the new generation of digital technologies will only strengthen this trend, at the same time as potentially altering the balance of power. For example, Brynjolfsson and McAfee (2015) suggest that the relative advantages of relocating operations to low-wage countries may be neutralised by the decreasing cost of robots able to outperform a low-skilled workforce.

– *Blurring of the boundaries between industry and services and between production and consumption* is a trend which was reported back in the 1990s but which is an even more pronounced feature of Industry 4.0, due not least to the interactions between producers, distributors and consumers which are made possible by communicating objects and online platforms.

The innovative nature of the Industry 4.0 model derives from the convergence and combination of these six trends, despite the fact that some of them can be regarded as long-established rather than ground-breaking when viewed in isolation.

1.6 The productivity paradox

The link between computerisation and productivity was called into question back in 1987 by the American economist Robert Solow, in his famous quip now referred to as the Solow paradox: 'You can see the computer age everywhere but in the productivity statistics.' The author's intention was to highlight the fact that productivity gains (i.e. the rate of increase in the ratio between the inputs and outputs of an economic activity) exhibited a downward trend in spite of large-scale and continued investment into computerisation and automation, whereas traditional economic theory posits that technical progress per se makes work more productive. The Solow paradox has aroused controversy within the academic community for getting on to 30 years (Greenan and L'Horty 2002); certain authors claimed that it had been settled around the time of the dotcom bubble and the brief flare of interest in the e-economy at the start of the millennium (Karsenti 2000), but developments proved otherwise when it became clear that this very specific outcome of strong growth in the ICT sector in the USA in the second half of the 1990s had not been reproduced in either Europe or Japan (Askénazy and Gianella 2002).

It is therefore worth reviewing the main arguments put forward in opposition to a causal link between technological innovation and increased productivity, with a view to determining the extent to which the terms of this controversy are being altered by the emergence of the digital economy.

– Companies which invest in information and communication technologies record increased productivity, but this micro-economic effect has very little impact at macro-economic level due to the fact that these gains come at the expense of companies which are less extravagant or less efficient investors. The attention paid (in particular by the media) to a number of spectacular successes in this respect has lent widespread appeal to the idea that technology always increases productivity, as has the demonisation of computers and robots as being to blame for large-scale job losses, especially in the manufacturing industry. Closer analysis of the processes underlying job creation and loss reveals that technology is often used as a pretext or opportunity to push through industrial restructuring processes motivated primarily by financial profitability, wage cost reduction or international competition considerations (for evidence that this is not a new observation, see Freeman and Soete 1994).

– The true impact of information and communication technologies on productivity is revealed only in the long term, many years after the initial investment and the experimental stage during which the potential of these technologies is recognised. The Solow paradox reflects the gap between the exponential growth in technological performance on the one hand and the slower rate at which innovations are adopted and appropriated by companies and other organisations on the other.

– The Solow paradox presents most problems in respect of its claim that 'You can see the computer age everywhere'. Computerisation – as well as adoption of the Internet and the new generation of digital technologies – has an uneven take-up rate, with companies differing considerably depending on their size, geographical location, industrial sector, etc. If we follow the terms of the paradox, however, a technology must be 'everywhere' before its impact on productivity can be assessed.

– Assessments of the impact of information and community technologies on productivity are necessarily problematic or poorly executed because economic indicators and national systems of economic accounting are not designed to capture the value of intangible goods and services. How can an indicator such as GDP measure the strategic importance of goods and services in the digital economy which have a quasi-zero marginal cost? Should the value generated by the sharing economy be taken into account? According to Brynjolfsson and McAfee (2015), traditional indicators measure growth and productivity 'with a time machine'.

– Productivity gains are a corollary of the organisational changes facilitated by technological innovations rather than the technologies themselves, and will be achieved only by companies which adopt new forms of work organisation at the same time as the new technologies (Askénazy and Gianella 2002). Solow's

claim regarding their invisibility obscures the fact that the situation within companies can vary dramatically depending on the intensity and efficiency with which organisational changes have been implemented, and the importance of such changes has been highlighted not only by economists, but also – and in particular – by researchers working in the social and management sciences (Vendramin and Valenduc 2002; Orlikowski 2010). Despite their unconcealed technological optimism, Brynjolfsson and McAfee (2015) also recognise that organisational change is a vital precursor to unlocking the potential of digital technologies, even though they omit any details of what the necessary organisational changes or change strategies should look like.

A failure to take account of the diverse nature of organisational change within companies and the complex nature of take-up processes for innovations is one of the main flaws of the study by Frey and Osborne (2013), who claim that the new generation of digital technologies will lead to the disappearance of many of today's jobs. The conclusions of this paper, which received a great deal of attention from the media[7], are premised on the assumed existence of a direct cause-and-effect relationship between emerging technological innovations on the one hand (in particular learning machines and mobile robotics) and the anticipated productivity gains to be made by using robots as a substitute for human labour on the other (based on the likelihood of this substitution occurring for the individual tasks within a job). A number of different consultancy firms have replicated these results – without any attempt at maintaining a critical distance – by following the same methodology as Frey and Osborne (using statistics and lists of job titles from the USA), and the same pessimistic forecasts (30%-40% of jobs at risk within the next 15-20 years) have been reproduced for the European Union as a whole and a number of its Member States (in particular Belgium, France, Germany and the Netherlands), further boosting the popularity of the initial research carried out by the Oxford-based duo. Nevertheless, this study fell into all of the traps laid by the Solow paradox.

1.7 Interim conclusion

Whereas some of the change factors which make up the founding principles of the digital economy are radically new, others are merely a continuation of trends stretching back several decades.

The former include firstly the development of a platform-based economy founded on new economic models of market operation and business, which on the one hand 'reshuffle the pack' in terms of economic power by promoting the rise of new 'winner takes all' monopolies or oligopolies, but on the other hand also foster the development of sharing economies based on peer-to-peer exchanges. Secondly, the proliferation of digitised goods and services which can be produced and

7. At the time of writing (December 2015 – January 2016), an interactive module allowing individuals to assess the likelihood of their job being replaced by robots within the next 15-20 years was available on the BBC website: http://www.bbc.com/news/technology-34066941

reproduced at quasi-zero marginal cost thanks to positive network externalities, albeit without yet taking full account of the associated negative environmental externalities, is also a radical innovation.

The second group of change factors includes the championing of digitised information as a strategic economic resource, which is not a genuinely new phenomenon, since it can be traced back to the ideas of the networked society and knowledge-based economy which became popular in the late 1990s. What is new, however, is the massive growth in the volume of digitised information available and the vastly improved performance of data processing and modelling software. The same is true for the Industry 4.0 model, which is merely an accelerated version of existing trends in terms of production network decentralisation, product and service customisation and the changing structure of value chains at global level, but draws its innovative force from the potential of the Internet of Things and the latest generation of robots. Finally, the digital economy has rekindled the debate about the cause-and-effect relationship between technological innovation and increased productivity gains. The Solow paradox, which was formulated back in 1987 and which appears to have emerged triumphant from the 'new economy' bubble of the early 2000s, still represents a hurdle to be overcome when assessing the impact of technological innovations on productivity and jobs.

2. A technological revolution in the workplace?

Having singled out the aspects of the digital economy which perpetuate existing trends and those which represent a break with the past, it is worth broadening our perspective to take in non-technological developments in order to avoid the distorting effects of emphasising only what is new and novel. A number of authors have pointed to the existence of a threshold effect for digital technologies in connection with their exponential leaps in performance ('first little by little, then all at once', to use the expression coined by Brynjolfsson and McAfee 2015), whereas others have attempted to identify the 'new new technologies' (Holtgrewe 2014) likely to trigger a fresh wave of changes in the workplace, basing their work on a long tradition of research into the interactions between technological innovation, work and jobs.

We will start by summarising the main factors involved in what may prove to be a full-blown technological revolution, before examining their transformative potential in the workplace.

2.1 New new technologies

The cloud

Cloud storage means the large-scale storage of data in virtual locations, whereas *cloud computing* refers to the parallel use of hardware infrastructures which may be remote in geographical terms. The development of cloud technologies started to gain momentum in the mid-2000s, and the ever increasing availability of high-speed Internet access means that the cloud has become a key factor in the proliferation of intangible and geographically independent activities. From a technical point of view, there is nothing to stop mobile applications, software and data sources being easily accessed wherever they are located, whether by individuals (using services such as Dropbox, OneDrive, iCloud and GoogleDocs) or by companies and their employees. At global level, cloud technologies also facilitate the development of services based on leasing and outsourcing arrangements (software, managed services and computational or storage capacities) rather than capital investment within the user companies.

From a work-related point of view, the cloud represents not only a driver for the growth of all forms of remote and virtual work, but also a valuable tool for implementing outsourcing and offshoring strategies, particularly in the IT service and call centre industries. Workers who use cloud services are often forced to

modify their working environments and working relationships in order to handle more complex and unpredictable situations which impose increased availability demands (Holtgrewe 2014).

Big data

Developments in the field of cloud technologies have led to the emergence of large-scale physical infrastructures in the shape of data centres and high-speed connections. The recent quantum leaps in the performance of data mining and modelling software mean that it is now possible to analyse vast quantities of digitised data as a basis for activities such as consumer profiling, behaviour modelling, movement tracking, interaction mapping and diagnosing car breakdowns or human illness. The principles underlying the use of big data have been nicknamed the four Vs: volume, velocity, variety and value (Escande and Cassini 2015), and the predictive power of big data software is improving apace thanks to its skill at shuffling together volumes of data which surpass current human understanding. By way of an example, machine translation tools now draw on a huge corpus of digitised texts in every conceivable language rather than using linguistic algorithms alone.

Expansion of the big data industry has also fuelled open data policies aimed at providing public access to (anonymised) data held within a wide variety of databases established by public authorities and services, particularly in the fields of cartography, meteorology, legislation, public health, mobility, socio-economic statistics, official archives, historical documents, etc., and various directives and regulations have already been adopted within the European Union on the provision of access to open data and the conditions for its use (Robertshaw 2015). The rise of open data represents not only a welcome development in terms of democratic transparency, but also a huge business opportunity for many different players in the economy.

From a work-related perspective, big data collection and analysis has implications in terms of surveillance and monitoring in the workplace and the tracking of employee activities. Big data modelling solutions are making it ever easier to use quantitative or qualitative performance standards as a basis for individual benchmarking and performance profiles; these are not new weapons in the managerial arsenal, but the tools now available for their implementation are increasingly powerful. The use of consumer-generated big data is also transforming working practices in the fields of commerce, marketing and financial services; more generally speaking, the same applies to all client-facing activities, where the aim now is to customise products and personalise services (Lestavel 2015). The impact of big data on developments in the robotics sector will be discussed below.

Mobile apps

The majority of platforms feature mobile apps which can be downloaded onto smartphones and tablets and which allow access to online services and social

networks without a PC-based browser. Apps provide access anywhere (and any time) a connection is available, and can also be installed on communicating objects or household appliances such as heating systems, electricity meters, printers, televisions or cars, ensuring that computers fade into the background of daily life. Apps are more than just firmware; they are also tools for collecting and supplying data to the data centres of online platforms. They are an excellent example of the phenomenon known as pervasive computing, or in other words the ubiquitous presence of computers in all professional and domestic settings, with their users being ever more frequently unaware of their presence or unable to understand their real purpose.

Although most people are familiar with apps because of their usefulness in day-to-day life, they also have an indirect impact on work by perpetuating the perceived need to be constantly online. Mobility, health or energy consumption apps could potentially transform working practices in these sectors.

Geolocation

Nowadays it is not only smartphone and tablets with geolocation capabilities but also most laptops, using a combination of GPS chip, relative geographical position in the 3G and 4G mobile networks and the identification of nearby wi-fi hotspots. Provided that geolocation has not been disabled by the user, the devices will supply online platforms with location data which may have significant market value. Geolocation is becoming an increasingly widespread technology as individuals and companies replace their smartphones and computers (including in-vehicle computers).

From a work-related point of view, geolocation has already had a major impact in terms of the planning, monitoring and tracking of mobile workers engaged in tasks such as making deliveries, performing maintenance, repair and inspection operations at industrial plants and carrying out site visits, and the ability to use geolocation services to track goods as well as individuals is expected to have an impact on work organisation in the transport and logistics sectors. The combination of geolocation with other new digital technologies such as big data, apps, IoT, online platforms and peer-to-peer networks represents a particularly rich source of innovation.

Internet of Things (IoT)

The term ‘Internet of Things’ is shorthand for the communication protocols and operating systems which allow digitised data to be exchanged between objects (physical or virtual) equipped with sensors, telemetry tools, RFID chips or QR codes and apps embedded in computer, telephone or robot hardware. Provided the relevant interoperability conditions are met, particularly in terms of shared technical standards, miniature interconnected objects can play a useful role in work settings (component and product tracking, employee surveillance, sales monitoring, access control), public spaces (urban traffic, public transport,

electricity and water supplies, waste management) and private spaces (home automation, digital wearables, sports equipment). Connecting objects boosts their value creation potential, since services can be embedded in them and data mined from them (Nemri 2015; Rifkin 2015).

From a work-related perspective, the changes which have emerged relate primarily to the multitude of challenges involved in managing the flow and availability of goods, services and people in all sectors of industry (Hermann *et al.* 2015). The popularity of smartphones has also made it possible to develop targeted experiential marketing measures (interactions between consumers and the shop they are visiting, for example), as well as audience-specific tourist information and leisure services. Although a number of spectacular prototypes have seen the light, the implementation of IoT-based apps necessitates a relatively long experimental phase, not only for technical and organisational reasons, but also to build their popularity and acceptance among the various groups of actors; immediate impacts on work and jobs are therefore unlikely. The snail's pace introduction of barcodes (an 'old new technology') into commercial operations and logistics chains provides a suitable comparison. The integration of connected objects into a vast array of industrial equipment and vehicles will also call for those working in these sectors to be upskilled in the fields of microelectronics and IT.

Learning machines and mobile robots

By definition, a robot is a programmable automaton with feedback capabilities, i.e. the ability to adapt to changes in its environment. Improvements to these feedback systems are thus not a genuinely novel development, but the new generation of robots is more accurately characterised by its learning and perception skills (Frey and Osborne 2013). 'Learning' machines build on progress made in recent years in terms of computing power and memory (big data, electronic vision, shape and speech recognition) in order to adapt their behaviour on the basis of their knowledge of past events and analysis of their environment. One of the consequences of the advances made in relation to shape recognition is improved mobility for humanoid and non-humanoid robots alike (even if the spectacular nature of the former means that they are much preferred by the media), and the movements of these robots depend on their ability to interact with connected objects.

From a work-related point of view, the impact of developments in the field of learning and mobile robotics will not be limited to sectors with a history of automation, but will extend over a wider gamut of tasks including goods handling, maintaining and repairing industrial plants, managing waste, spare parts, parcels and letters, restocking and performing operations in hostile environments (EU-OSHA 2015b). It forms an integral part of the production restructuring processes subsumed under the heading of 'Industry 4.0'. At this stage, however, it is difficult to evaluate the real potential of such systems in vastly diverse real-life working situations based on the performance of prototypes in experimental settings. History shows that it has sometimes been necessary to build entirely new factories to accommodate robots (in the automotive industry, for example) due to the impossibility of incorporating them efficiently into existing plants.

2.2 Transformative potential in the workplace

A shift in the boundary between human and machine capabilities

The codification of knowledge has been the subject of continued research interest since the late 1990s (Lundvall 1997; Foray 2000). *Codified* knowledge can be transcribed using structured procedures, theoretical logic, algorithms, databases, expert systems and other means of formalisation. This knowledge then becomes a marketable product, marking a shift from the codification of knowledge to its 'commodification' (Fleissner 2009). By way of contrast, *tacit* knowledge remains dependent on human involvement and cannot be translated into a computer language or recorded in a specific format. Tacit knowledge encompasses actions which are performed without the individual responsible being able to explain exactly how, as well as skills and reasoning processes generally referred to as intuitive. A worker's skill base always consists of a mixture of codified and tacit knowledge.

Several landmark papers (Brynjolfsson and McAfee 2015; Frey and Osborne 2013) posit that recent technological innovations may lead to a major shift in the boundary between codified and tacit knowledge, to the detriment of the latter. This hypothesis rests chiefly on the emergence of technological innovations in the fields of big data processing and learning machines, which have already made it possible to codify cognitive tasks such as translation or handwriting recognition.

The potential of these innovations in terms of knowledge codification can be identified on the basis of a classification of tasks and skills, distinguishing firstly between cognitive and manual tasks and secondly between routine and non-routine tasks as an indicator of the extent to which human labour can be replaced by computers/robots (Autor *et al.* 2003):

– *Non-routine cognitive* tasks which require reflection, expertise and problem solving cannot be codified in procedures. Computers cannot yet replace human labour in these areas, although they can support and enrich it. Other non-routine cognitive tasks involve complex communications between individuals at interpersonal or organisational level; computers may again be used in a support role by facilitating e-mail exchanges or video-conferences, for example.

– *Routine cognitive* tasks can be codified in procedures, rules and algorithms, and there is a growing (and relatively recent) trend for human labour to be replaced by computers/robots in this area. This applies to sectors such as commerce, logistics, finance, accounting and legal services and technical inspection services.

– *Routine manual* tasks can be codified and standardised due to their repetitive nature, and substitution between human labour and computers/robots in this area is a long-established tradition.

– *Non-routine manual* tasks cannot be codified in algorithms because they require highly sophisticated sensory-motor skills, practical or aesthetic

intuition, craftsmanship or other forms of tacit knowledge. These types of tasks are performed not just by those working in small-scale industrial or artisan operations, but also by those in client-facing roles, and they demonstrate the potential for complementarity between human labour and machines.

Frey and Osborne (2013) suggest that two types of innovation are important in this respect. The first relates to innovative uses of computers to perform non-routine cognitive tasks by leveraging big data and machine learning algorithms, leading to reduced human error, zero fraud, computerised diagnostic procedures, automated legal transactions, the use of sensors instead of inspections and monitoring and the production and translation of standardised texts (user manuals, technical data, press releases and official letters). The second relates to the innovative utilisation of computers to perform non-routine manual tasks such as maintaining technical facilities, implementing logistics systems and driving vehicles (industrial and agricultural vehicles rather than cars at present).

Will robots substitute or complement human labour?

Brynjolfsson and McAfee (2015) put forward the argument that society now needs to learn to work together with robots or, as they put it, 'race with the machine rather than against it'. They believe that the future of work will depend on achieving an optimum balance between the new generation of high-performance machines and human skills, which is a very different perspective to the traditional view of machines as a substitute for human labour espoused by Frey and Osborne (2013).

The issue of complementarity was examined in more detail in the executive summary of an expert report produced for the Netherlands Government and published in December 2015 (Went *et al.* 2015). Its authors argue in favour of *inclusive robotics* and set out four groups of proposals aimed at ensuring that the idea finds its way onto the agendas of government authorities, social partners and researchers:

– The first group of proposals by the authors are linked by the concept of 'co-creation' and based on the premise that that top-down innovation – an approach whereby technology suppliers foist unilaterally developed solutions on society – has never proved successful in the field of information and communication technologies. They suggest that innovation strategies should be founded on closer collaboration between the designers and users of new technologies, with engineers and workers sitting down together to develop a new generation of robots.

– The second group relates to the development of educational models which prioritise areas of knowledge and skills that complement machine capabilities. Instead of trying to identify the tasks which machines are not yet able to perform, we should spend more time thinking about the tasks, relationships or responsibilities which must unequivocally remain in human hands, whether on an individual or collective basis.

– The third group concerns the autonomy of workers, since current research into various aspects of work – whether negative, such as stress and burn-out, or positive, such as fulfilment and self-development – highlights the importance of autonomy in terms of work organisation and the amount of control a worker has over his working environment. Efforts must therefore be undertaken to find ways of maintaining autonomy and control in environments with ever smarter technologies.

– The fourth group is aimed at preventing the emergence of new social divides, since it is likely that certain workers will find themselves on the fringes of the digital economy, but it is not easy to identify the groups most at risk of exclusion. Both researchers and political decision-makers should prioritise measures to mitigate this risk.

Issues relating to the complementarity of human labour and robots bring us to the topic of developments in the field of human-machine interfaces (HMI). The research available on worker-robot interactions in real-life settings is still extremely limited (EU-OSHA 2015b), and most human-machine interfaces currently in use involve hardware devices such as keyboards, screens and network connections together with software designed to model human-machine interactions. The new generation of robots, with artificial intelligence which allows them to adapt their behaviour and with visual and speech recognition skills, represents a challenge to the very fabric of human-machine relations. What do we really mean when we talk about working together with a robot? How might we develop a certain reciprocity of communication? Little research has yet been done into these and similar questions.

An uncertain vision of the future

Most publications on the subject, whether intended for the general public or the academic community, conjure up a vision of the future which is heavily shaped by the front-runners in the digital industry, with the spotlight firmly fixed on developments such as Google's self-driving car, IBM's Watson computer (which can now diagnose diseases as well as play chess), the humanoid robot Nao (which assists patients in hospitals and has even visited the Élysée Palace), and many other superstars among the new generation of robots, although a number of authors criticise Brynjolfsson and McAfee for being carried away by the arguments of Google, Apple and IBM engineers and their all-consuming technological determinism (Irani 2015; Dortier 2015). This vision of a future dictated by technology often forms part of a discourse which sounds yet another death knell for the paid employment model (Rifkin 2014; Stiegler 2015).

It is difficult to put forward an alternative perspective when the dominant narrative has been regurgitated so uncritically by so many media outlets. A number of attempts have, however, been made to document the renewed enthusiasm for sharing and other alternative forms of economic exchange based on peer-to-peer arrangements or the pooling of tangible or intangible assets through sharing platforms, and a body of literature – beyond the usual reports of innovative

developments – is beginning to build up on the subject (Coriat 2015). These narratives are also starting to resonate with institutional players (Brighenti 2015), but they remain somewhat nebulous, as it is hard to forecast the directions in which the sharing economy will move (with Uber and AirBnB standing as prime examples of wayward trends in this respect).

The lessons of the past

The early 1980s – a time when rising unemployment following the oil crises of 1973 and 1974 coincided with the appearance of personal computers on the market and the integration of microprocessors into automated industrial plants – marked the first period of intense research into the effects of computerisation on jobs.

A classic study which was published in France in 1981 under the direction of the economist Olivier Pastré, and which built on the analyses of the Fordist crisis produced by the regulation school (Pastré *et al.* 1981), broke away from the traditional application of Alfred Sauvy's 'spillover theory' (1980), and instead took an innovative meso-economic (i.e. midway between macro-economic and micro-economic) approach to the relationship between technology and jobs, focusing on employment sectors, branches of industry and regional systems of innovation. The authors identified eight overarching categories of technological innovation and investigated whether and to what extent individual employment sectors would be affected, which skills would be at risk or in demand and what the foreseeable impact would be on jobs in France, coming to the conclusion that the direct impact on jobs would be negative overall, and that positive outcomes would result only from indirect effects such as the emergence of novel economic activities linked to these new technologies. With the benefit of hindsight, it is possible to say that Pastré *et al.* were for the most part right – albeit overly pessimistic – with regard to industrial sectors, but largely mistaken in respect of private and public services. The main criticism which can be levelled at the evaluation model developed by the authors stems from their belief in a direct causal link between the potential of technologies and their effect on skills and jobs; the same can also be said about the writings of Frey and Osborne (2013), despite the passage of 30 years. By way of contrast, the relevance of a meso-economic approach to technological change has been endorsed in many later studies.

The distinction between industrial and service sectors in terms of the effects of computerisation on jobs became more pronounced during the 1980s. According to a research review produced by the OECD (Brainard and Fullgrabe 1986), three conclusions can be drawn in this respect:

– Many researchers overestimate the rate at which new technologies are adopted and their level of productive efficiency, while at the same time underestimating the organisational and social constraints which hinder or mitigate their impacts.

– The real effects of computerisation on jobs are likely to remain insignificant compared to other factors such as fluctuations in growth and the development of global trade.

– The most significant impacts relate to changes in employment structure rather than job numbers. Computerisation creates jobs in certain sectors and professions while eliminating them from others, but these effects are not distributed uniformly between regions or countries. Its repercussions are likely to be positive for most service-based sectors, but the opposite for industrial branches.

These conclusions were confirmed by a more detailed study carried out 10 years later, again under the aegis of the OECD (Soete 1996), and they are still relevant to current research.

Issues relating to the effects of computerisation on jobs gradually fell by the wayside during the 1990s in favour of research into the organisational changes accompanying the spread of information and communication technologies, with a particular focus on flexibility, changing skills requirements and the intensification of work and a shift away from quantitative towards qualitative approaches. It was not until the bubble of interest in the 'new economy' (also known as the net economy or the e-economy) at the turn of the millennium that a new line of research into computerisation and jobs was initiated, prompted by a major technological innovation involving the appearance of the Internet in companies and the attendant (and aforementioned) concepts of a network society and knowledge-based economy. Forward-looking studies heralded the arrival of 'convergent' technologies which would unlock synergies between information technologies, biotechnologies, nanotechnologies and cognitive sciences (Boyer 2002; Nordmann 2005), and research aimed at investigating the cause and effect relationship between information and communication technologies and jobs fell out of favour; any studies which were carried out in this area yielded the familiar flawed predictions[8]. Forecasts of the impact of information and communication technologies on jobs were more optimistic in tone, in keeping with a growth approach, and the Internet was analysed as a growth factor[9] and net creator of jobs, or rather a force which will create more jobs than it destroys overall. The fall-out from the economic and financial crisis of 2008 means that this emphasis on the Internet as an agent of growth is unlikely to remain credible, however.

In the period between 2007 and 2009, the European Commission provided financial backing for a large-scale research project aimed at reviewing the current state of knowledge on the social impacts of information and communication technologies (Nett *et al.* 2010). The report distances itself from previous deterministic approaches in the field of work and employment, instead referring

8. This is certainly true for a number of research papers on ERP (Enterprise Resource Planning) software published in the early 2000s, which forecast heavy job losses in the accounting and supply chain management sectors. The introduction of ERP systems did indeed result in major restructuring, but job numbers were not affected to any significant extent. In actual fact, accountants and logistics specialists are today on the list of professions exposed to skills shortage.

9. The growth premise is amply illustrated by a series of around 20 national reports published by McKinsey Global Institute between 2008 and 2010, all of which have the title *Internet matters* and a separate sub-title. A summary was published in 2011 (Pélissier du Rausas *et al.* 2011).

to information and communication technologies as a 'trend amplifier', and recommends paying particular attention to the development of the Internet of Things and other forms of pervasive computing. Prominence is given to the assertion that ICT investments will yield positive impacts on productivity only if they are accompanied by effective organisational changes, particularly as regards employee participation, the decentralisation of responsibilities and autonomy at work. The rationalisation strategies made hard-hitting by information and communication technologies cover a wide span, from automation aimed solely at cost cutting through to innovative forms of value creation based on better mobilisation of workforce skills. The trends which are identified in the report as being amplified by information and communication technologies include in particular the development of virtual work and new forms of employment based on networking and the proliferation of collaborative platforms – subjects which are examined in the third part of this document.

2.3 Interim conclusion

Over the past 10 years, the accelerated development of six new areas of technological endeavour has marked a genuine turning point. They include the use of the cloud as a storage location for immense quantities of data and a tool which facilities the parallel use of hardware in different geographical areas, as well as the boom in big data and multi-platform mobile apps and geolocation. More recent developments include the Internet of Things, learning machines and mobile robotics, which have also passed critical performance thresholds and made inroads into a number of different areas. Although this new technological order has resulted in a shift in the boundary between human and machine capabilities, it would be at the very least premature, if not entirely wrong, to conclude that human labour will soon be replaced by machines; instead, the future should be envisaged and built on the basis of complementarity. The lessons of the past show that the relationship between technology and jobs is complex and frequently misjudged due to a failure to take account of key parameters such as the take-up rate of innovations by society.

3. Virtual work and new forms of employment

Various authors[10] seeking to identify the unique aspects of work in a digital economy have employed the concept of *virtual work* – a generic term used to refer to all forms of work carried out either at home, in public spaces or in non-traditional working environments using the Internet, computers or other IT-based tools. The rise of these new (or quasi-new) forms of work has been accompanied by new forms of employment which combine unconventional workplaces, the use of technologies and new contractual arrangements.

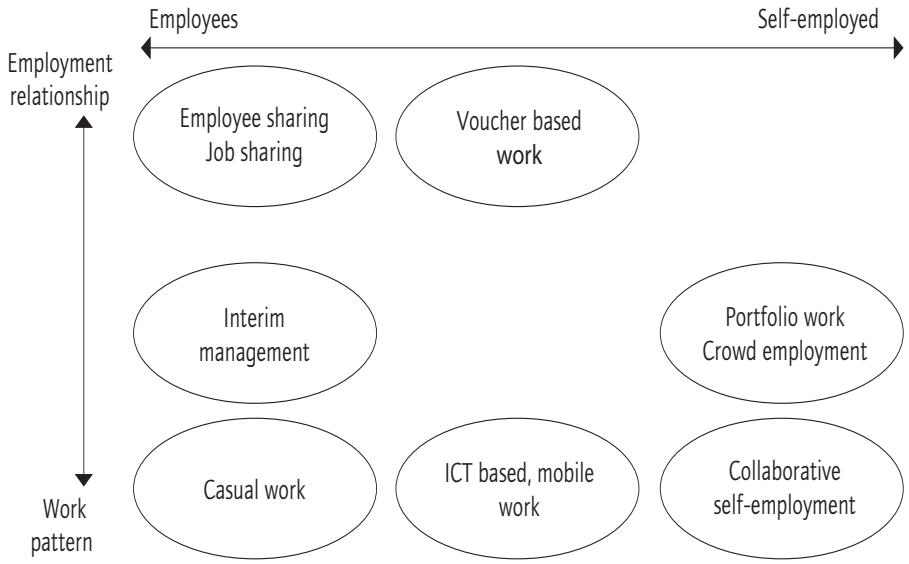
The first part of this section provides an overview of new forms of employment which are moving ever further away from standard employment relationships and typical working conditions. The following three parts examine three forms of employment which have developed in close step with digital technologies and highlights the associated implications for working conditions and the labour market. The last part takes a more cross-cutting approach to the issues and challenges posed by virtual work.

3.1 New and quasi-new forms of employment

After evaluating the situation in 27 countries, Eurofound researchers identified nine new forms of employment (Eurofound 2015); some had emerged only around the first decade of the new millennium, whereas others were amplified versions of pre-existing trends. As shown in the following diagram, these nine new forms of employment can be plotted along two axes, where the first relates to the nature of the employer-worker or client-worker relationship and the second to the model of work, or in other words the way in which the work is performed.

10. Cf. in particular the publications by the COST network *Dynamics of Virtual Work*, an international interdisciplinary research network on the transformation of work in the Internet Age: http://dynamicsofvirtualwork.com.

Figure 1 **New forms of employment**



Source: Eurofound, 2015

The Eurofound researchers defined these new forms of employment as follows:

– employee sharing, where an individual worker is jointly hired by a group of employers and works within different companies on a rotational basis;

– job sharing, where a single employer hires two or more workers to fill a single job, working on a rotational basis to perform the same role within the same company;

– interim management, where a highly skilled expert is hired temporarily by an employer, often for a specific project;

– casual work, where an employment contract allows employees to be called as required on a flexible basis rather than being given regular work hours by their employer;

– ICT-based mobile work, where workers do not use their employer's premises (or their own premises if they are self-employed) as their main place of work, and spend most of their time working with information and communication technologies (computers, the Internet, e-mail and social networks). Their work differs from familiar forms of mobile work such as visiting clients or patients, working on construction sites, making deliveries or driving vehicles, and can be characterised as remote work without a fixed location;

– voucher-based work, where the employment relationship involves paying for services with a voucher purchased from a third-party organisation (generally a government body) that covers both pay and social security contributions;

– portfolio work, where a self-employed individual carries out small jobs for a large number of clients;

– crowd working, where an online platform matches employers to workers and projects are often split up into micro-tasks and divided among a 'virtual cloud' of workers;

– collaborative self-employment, observed in a number of countries where more flexible forms of collaboration (such as co-working spaces) are used to escape the confines of traditional business partnerships.

Not all of these forms of employment are relevant to the scope of this report; in our opinion, those that will be most influenced by the emergence of a digital economy are ICT-based mobile workers, crowd working and – in certain respects – casual work. The challenges posed by these three increasingly popular forms of employment in terms of the jobs themselves and the associated working conditions will therefore be examined in depth, incorporating the conclusions drawn by the Eurofound researchers on the basis of their case studies (Eurofound 2015).

3.2 ICT-based mobile workers

ICT-based mobile workers work mainly from locations other than their employer's or their own premises, and make extensive use of computers, the Internet and e-mail in the course of their work. They may be employed or self-employed, and their work relies on the use of information and communication technologies and access to shared computer networks with no fixed place of work, since activities are performed outside employer and client premises. The informal agreements which generally govern arrangements of this kind are frequently tailored to the demands of local legislation, collective agreements and individual contracts.

According to the European Working Conditions Survey, 7% of workers in the European Union spent at least one quarter of their working lives somewhere other than their usual office (or permanent place of work) in 2005, with the figure rising to 24% by 2010 (Parent-Thirion *et al.* 2012).

Mobile work may also be virtual. Some workers are able to work online despite the fact that they travel a great deal, whereas in other cases – geographically dispersed virtual teams, computer-based video-conferencing, virtual meetings bringing together avatars of real people, remote monitoring of industrial facilities, remote maintenance, etc. – real-life mobility is less important than the ability to be present in multiple virtual locations. By allowing people to be present everywhere in virtual form without physically relocating, digital technologies foster the emergence of new virtual forms of work organisation (Orlikowski 2010).

Certain key requirements must be met before virtual mobile work is possible, for example ensuring that the job in question and the tasks it involves are suitable, since not all activities can be carried out remotely and online. Successful ICT-

based mobile working also requires a working culture based on trust in individuals and appropriate technical support so that work can be carried out efficiently.

In the late 2000s, there was a sharp upswing in the popularity of ICT-based mobile working. Although not confined to any particular industry, organisational size or management structure, this form of employment is observed most frequently in sectors such as ICT, engineering (automotive, aviation, construction), healthcare and decentralised industrial production. Employers are often motivated by organisational and image boosting considerations, in an attempt to find more flexible and innovative ways of organising work, attract a highly qualified workforce and improve their brand reputation while at the same time cutting costs and improving productivity. Workers are motivated by different goals, namely increased flexibility and a better work-life balance.

ICT-based mobile workers are predominantly highly skilled young male knowledge workers or managers, most of whom have permanent full-time contracts. In reality, this type of work is a version of remote work without a fixed location.

The implications of ICT-based mobile working in terms of working conditions are ambivalent, being positive in certain respects but negative in others. The advantages offered by this form of work include a high level of flexibility and autonomy, increased personal efficiency, enhanced ICT skills and improved communication and collaboration. The downsides are in many ways similar to those generally attributed to remote work: performance-driven pay, sophisticated monitoring and control systems, information overload and social isolation, the stress of being solely responsible for organising your work, the blurring of boundaries between work and private life, the risk of conflicts as a result of poor coordination, the hazards of being theoretically always available and an outsourcing of responsibility on the part of the employer.

The implications for the labour market are likewise mixed, since the potential transformation of work organisation practices may have both positive and negative consequences for the organisation as a whole. ICT-based mobile workers often report increased levels of job satisfaction, due in particular to their high degree of autonomy, and this form of work may foster the emergence of more inclusive labour markets by facilitating access to jobs for a broader range of people, including those whose health, mobility or availability prevents them from working regular hours at a single location. The flip side of this, however, is that this type of work may also displace certain groups from the labour market while also excluding them from other more traditional forms of employment.

Liability for the health and safety of ICT-based mobile workers is an important facet of the debate on this form of work.

3.3 Crowd working

The terms 'crowd working' or 'crowdsourcing of work' refer to work carried out through online platforms which allow organisations or individuals to gain access via the Internet to an undefined and unknown group of other organisations or individuals prepared to solve specific problems or supply specific services or products in exchange for payment (Green *et al.* 2013). These platforms (such as such as PeoplePerHour, ClickWorker or Amazon Mechanical Turk) are a type of marketplace for micro-tasks in fields including web development, design, software development, photo/video image recognition, data replication, translation, audio transcription, data-based research and the submission of bids for creative tasks (such as designing a logo).

The ambiguous relationship between companies and workers whose position lies somewhere between salaried work and self-employment is regulated by a number of arrangements which have emerged over recent years, and the new developments ushered in by the digital economy are rekindling the earlier trend of outsourcing salaried labour to self-employed workers through various platforms. This trend can be observed across an ever increasing range of industries, including not only design, IT, writing, transport, tourism and the multitude of tasks spawned by the Internet, but also 'real-life' tasks such as childcare, dog walking, etc.

Worker profiles vary from highly skilled IT and creative professionals to unskilled amateurs, but most crowd workers are young people looking for extra income such as students, unemployed persons or carers; few treat it as their main job.

Crowd working pits workers in competition against each other and makes no distinction between amateurs and professionals; this can be seen explicitly in cases where competitive bids are submitted (e.g. for a logo design) and only the winner receives payment. The competition in sectors such as the hotel trade or transport is less conspicuous but equally present, and certain platforms use a bidding system for payments which promotes a 'race to the bottom'.

The far-reaching implications of crowdsourcing in terms of working conditions tend to be negative rather than positive (EU-OSHA 2015a). On the plus side, it offers a high level of flexibility and autonomy, increased personal efficiency, enhanced ICT skills and a better work-life balance. Its downsides, however, include erosion of the fundamental principles of work and employment status; not only are wages low or rock bottom, payment by no means guaranteed and profits retained by the companies, but workers also suffer from a lack of social protection, information asymmetry and an absence of reliable dispute resolution systems. Workers are also likely to suffer boredom due to the undemanding and repetitive nature of the tasks, as well as social isolation, the stress of being solely responsible for organising their work and, finally, a blurring of the boundaries between work and home and potential intrusions into their private life.

Thinking more broadly about the labour market as a whole, this form of work has been lauded for the many opportunities it offers (in particular to creative workers) and for its potential in terms of income, mobility and accessibility to those who

are least able to access traditional forms of employment, as well as the platform administration jobs which it creates. On balance, however, the overall implications for the labour market at present have a negative slant; the risk factors which have been identified include the development of a task-based rather than employment-based market and a drop in the standard of work, but also – and more importantly – the flouting of labour standards.

Although dedicated crowdsourcing platforms are obliged to comply with general legislative provisions in the form of commercial law, consumer protection directives, the civil code and data protection regulations, specific legislation on crowd working has not yet been collectively defined at European level. Workers are effectively self-employed, and the platform's terms and conditions generally dictate all the details (such as pay, working conditions and intellectual property). Observations of this kind have led certain authors to use terms such as 'cybertariat' (cyber-proletariat, Huws 2003) or 'undifferentiated mass' (Colin and Verdier 2012) to refer to this form of work and employment which is unique to the digital economy.

'One way of looking at the recent exponential growth of online platforms in service delivery is to see it as a formalisation of the informal economy, with the transparency of an open market replacing the old word-of-mouth methods of finding work, and the replacement of unrecorded cash-in-hand payments by trackable online payments, opening up at least the possibility for taxes to be collected and fairness to prevail' (Huws 2016).

It remains difficult to put numbers to the phenomenon of crowd working; one way of doing so could be to multiply the estimated number of platforms by the estimated number of workers who use them, but this would be imprecise at best, partly because the platforms are so many in number and increasing rapidly, and partly because not all of the people signed up to a particular platform are active users, and the same person may have signed up with several platforms. It is also impossible to estimate the volume of work given the diversity of the tasks on offer (EU-OSHA 2015a).

3.4 Platform-based on-call work

On-call work is characterised by a continuous employment relationship without continuous work. The employer signs an employment contract with the worker but does not commit to supplying work on an ongoing basis, with zero-hour contracts being the best-known example of this phenomenon. Contracts of this sort are based on the principle that workers will be called in to work when they are needed, and the Eurofound report includes it in the same category as casual intermittent work, i.e. seasonal work or work restricted to a single task or service (in the arts sector, for example). Seasonal or intermittent work is not a new development, and there is no automatic connection between this form of employment and the digital economy, but online platforms for on-call work provide a new tool for matching demand for labour to pools of workers waiting for tasks and assignments.

The use of online platforms to organise on-call work makes it possible to pinpoint the geographical location of both labour demand, i.e. the locations where services are required, and labour supply, i.e. the geographical and time-related availability of the workers signed up to the platform. Web-based platforms, geolocation capabilities and mobile Internet can be combined to allow the real-time calibration of demand and availability, markedly increasing the efficiency of the on-call work system. Casual work platforms can also be developed in-house by companies in order to improve their management of a contingent workforce mobilised on a 'just in time' and 'just in case' basis.

A number of different contractual models have emerged, the most notorious of which is the zero-hour contract which is used in the United Kingdom, Ireland and the Netherlands and which involves a fixed contractual arrangement without a guaranteed volume of work; in Ireland, however, compensation must be paid if the number of hours worked falls below quarter-time. In other countries, a minimum working-hour threshold applies (generally between quarter-time and third-time), above which there is no guarantee of work. In other cases, such as the min-max contracts used in the Netherlands, the legislation stipulates threshold and ceiling values for working hours so that part-time work can be organised in response to fluctuating volumes (Eurofound 2015).

Whereas intermittent work is largely synonymous with seasonal work (in bars, hotels and restaurants and in the commercial, leisure and entertainment industries), on-call work is becoming increasingly widespread in sectors typified by continuous but variable demand, such as at-home care, childcare, retail, after-school activities for children, event organisation, etc. Workers with a wide range of skill levels may be affected, but most are young and female.

The working conditions associated with this form of employment include very flexible working times, extremely variable wages and high expectations in terms of availability, as well as low job security, few opportunities for moving up the pay scale and low rates of job satisfaction. Jobs of this kind are a tangible expression of the decoupling of employment contracts and working time, and force workers to juggle their lives around unpredictable schedules. Certain employers appear to be using them as a form of probation before signing a standard contract with the worker, however.

3.5 The challenges of virtual work

There can be no disputing the fact that virtual work creates new opportunities by providing access to work for people who would otherwise be excluded from the labour market, such as disabled persons, those with mobility issues or those in developing economies. It also provides consumers with access to affordable and just-in-time services, and offers new levels of flexibility in terms of work-life balance as well as promoting innovation, creativity and the development of new cultural products and new services. These advantages come at a cost which is very high and perhaps too high, however, and some undoubtedly stand to gain more than others. The emergence of these new forms of work gives rise to many different

concerns in a range of areas, and their potential impact on the labour market, the location of work and value chains (Pfeiffer 2013; Fuchs and Fischer 2015) are the topic of public and scientific debate. Working conditions are a source of hope in some respects but concern in many more, particularly in terms of pay and collective regulation. New health and safety issues which have been identified include not only technostress, technology addiction, a blurring of boundaries, information overload, burn-out, permanent exposure to electromagnetic fields and postural disorders (Popma 2013), but also cyber-bullying (D'Cruz and Noronha 2014).

The European Agency for Safety and Health at Work (EU-OSHA 2015a) has drawn up an extensive list of the health and safety risks associated with the rise in crowd working. The authors make a distinction between the physical risks attributable to online work (screen-based work, ergonomics, stress, etc.) and those linked to offline work which lacks visibility due to the fact that it is organised through platforms (taxi driving, managing aggressive clients, etc.). They also include a long list of psychosocial risk factors for which little can be done in the way of prevention.

The very nature of the work may also pose significant problems in terms of well-being. Platforms and social media operate on the principle of user participation and the production of user-generated content. Behind the scenes, countless anonymous and poorly paid workers are faced with the task of continuously sifting through images, videos, written texts and other types of content, much of which contains violence, vulgarity, sadism, pornography or paedophilia, to the detriment of their mental health (Irani 2015; Roberts 2015). The well-being of these behind-the-scenes workers is a serious cause for concern.

One of the key aspects of this type of work relates to the freedom of choice and level of autonomy of self-employed workers using digital platforms. Self-employed professionals place a high value on autonomy, independence and control over their work, but the issue is whether – and to what extent – the preconditions for autonomy of this kind are met by the platforms (fair pay, monitoring of working times, etc.). Virtual work also poses a challenge to established models of communication and HR management, as well as to professional identifies (Lehdonvirta and Mezier 2013), perceptions of group membership and opportunities for the collective organisation of workers.

All of these are familiar challenges, but something which has been observed only relatively recently is the precipitous development of a platform-based economy in which players operate in something of a legal no man's land and encounter brand new risks. To take but one example, when the Fotolia platform purchased photographs for one euro and then resold them at one thousand times their cost, eliminating any copyright claims in the process, it entered into no undertakings towards the photographers and made no investment in the equipment required or costs incurred. The working conditions of Amazon employees, which hark back to a bygone era, have been the target of widespread criticism (Malet 2013). Although operating on the basis of a platform model, Amazon requires local bases for product distribution purposes, and public authorities have welcomed the opening of Amazon warehouses in areas of high unemployment in Europe in spite of grave concerns about working conditions.

The new forms of work in the digital economy are typified by a blurring of boundaries at several levels, each giving rise to questions in the field of collective regulation (Meil 2015):

– The problem of work-life balance is not new, but has taken on a new dimension with the rise in popularity of virtual work. How can private life be ring-fenced, and how can time be best managed?

– The lack of any clear distinction between the status of employed and self-employed workers is a particularly pressing issue in respect of the changes currently in progress, particularly for those working in the creative and journalism sectors, for example. Is there a need for a new status somewhere in between the two, or should the current rules be broadened in scope? Further to this question, what are the options for ensuring freedom to move between employment and self-employment while retaining the necessary degree of security?

– The distinction between producer and consumer is also no longer self-evident. Carrying out encrypted banking transactions, giving opinions on tourist infrastructures, uploading photos or videos, producing and distributing information – do these fall under the heading of consumption and/or production? The use of the new term 'prosumer' to describe this kind of work, as mentioned in the first section of this document, gives rise to two regulatory problems: how can we identify the party responsible for value creation, and who is authorised to claim ownership of this value? (Fuchs and Fischer 2015.)

– New models of collaborative production (co-creation, peer production, the collaborative economy) also give rise to ambiguities in terms of the status of an employee and that of a sharer. How can a distinction be made between sharing and unpaid salaried work?

– Finally, certain forms of employment such as crowdsourcing and micro-tasks which are enjoying a boom are also characterised by very fluid boundaries between the roles of employer and contractor. What basis should be used to create a legal framework for this type of contractual relationship? What approach should be taken towards unfair competition between activities organised by platforms such as Uber or AirBnB and longer established and more regulated sectors?

The changes generated by the digital economy are not gender-neutral. In the first place, many women work in intermediary roles which seem likely to be hardest hit by the digital economy's anticipated upheavals in terms of both job numbers and the nature of the work; secondly, women are still underrepresented in the IT sector and have little or no say in the development of the programs and applications which determine the work they actually do. From a more fundamental perspective, virtual work, flexibility and autonomy appear to mean different things for women and men, replicating traditional power relationships and gender segregation in the private sphere. 'Thanks to virtual technology, women can continue to multi-task – they opt in and opt out of work/family tasks, and by doing so, they can "do

it all", without challenging conventional gender roles, without threatening their marriages or the belief that they are good mothers' (Rafnsdóttir 2014).

Finally, against a backdrop of ecological transition, digital technologies also give rise to concerns in connection with the exponentially growing collateral damage they cause, including the consumption of electricity and rare metals and the production of electronic waste (Flipo *et al.* 2013).

3.6 Interim conclusion

The world of work is currently witness to the emergence or development of new forms of employment, some of which are linked to the rise of a digital economy. They include ICT-based mobile work, which is a relatively old but rapidly growing phenomenon, as well as on-call work, which again is nothing new but can now be organised through platforms using geolocation, and finally – and most spectacularly, in terms of the speed of its growth and its very nature – crowd working, which gives organisations or individuals access via online platforms to large numbers of workers willing to carry out paid tasks. These forms of work are neither entirely novel nor entirely bad news for workers, but many of the circumstances which go hand in hand with them give rise to concern, shake up social structures and call for appropriate forms of regulation.

4. Social structures and regulation

New working configurations make it necessary to broaden our analysis to include new concepts and new ways of thinking about individuals and the collective in this field. In the first part of this section, we therefore propose certain points of reference which can be used when debating the nature of the relationship between the individual and the collective in today's world of work, even though variations in the precise ratio of face-to-face and remote work mean that this relationship is very individual. In the second part, we examine the challenges currently faced by social partners and government authorities, before concluding by revisiting a number of fundamental principles concerning the meaning of work for individuals today.

4.1 Geographical distance and social bonds

The idea of an individual's relationship with the collective is based on the standards which individuals apply in a particular sphere – in this case the world of work – to their relationship with others and with groups, and the principle governing the relationship between individuals and the collective in the work sphere appears to be best described as a form of privatised sociability. A great deal of research has confirmed the value placed by individuals on the social dimension of work and the importance of a good working atmosphere and good relations with colleagues and superiors (Méda and Vendramin 2013). Yet an individual's work group – the people he sees on a day-to-day basis and with whom he actually works – appears to play a larger role in this respect than membership of a professional group or an abstract collective. This is a further consequence of the emergence of highly individual organisational models and career trajectories; changes in our relationship with work, together with a proliferation of new ways of organising employment, have led to new ways of creating an 'us' at work.

In a previous study focusing on the ICT sector, we introduced the idea of cooperative nomadism to describe the relationship between the individual and the collective in very individual working environments where work is carried out both face-to-face and remotely and where project teams are constantly being reshuffled (Vendramin 2004). The relationship between an individual and the collective embodies the constant desire and need to join together with others, not only to carry out professional activities but also to further personal aims and build one's identity, but it does not signify a need for pre-existing, long-lasting or geographically present collectives. Like other types of collective, cooperative nomadism is not immune to disagreements, competition and unethical behaviour,

but it would be a mistake to regard it as being solely motivated by egotistical considerations and the functional benefits which others can provide; instead, it should be regarded as an alternative model for shaping an individual's relationship with others.

This type of relationship between an individual and the collective is a long way removed from membership of a community, since involvement in a collective rests on a compromise between the collective dimension of work and the personal dimension of the individual at work. In an updated study on models of professional identity, Renaud Sainsaulieu and his colleagues also found evidence of a decline in fused identity paradigms and a rise in models where patterns of integration are determined more by interactions at work than by rules (Osty *et al.* 2007). Individuals have high personal expectations of collectives, which are judged on the basis of the level of satisfaction and learning opportunities they provide. More complex, more diffuse and less entwined bonds of solidarity are emerging between increasingly highly skilled individuals who make clear expressive demands and have distinctive career paths, with shared activity forming the foundation for these bonds. This way of being together at work and building quasi-nomadic collectives is a good match for certain professional profiles, but also for certain periods in individual working lives rather than necessarily throughout a career.

The rise in remote working has led to a greater individualisation of relationships with work; 'It is not that the individual is more and more isolated, but that ways of belonging are more and more individual' (Rosanvallon 2007: 304). Rosanvallon makes a distinction between face-to-face collectives (linked by geography) and shared activity collectives (linked by activity). Face-to-face collectives impose socialisation, by providing a firm bedrock of solidarity and a stronger sense of belonging. They give rise to strong emotional ties, and cooperation is favoured over coordination. The opposite is true for shared activity collectives, where the collective is a more impersonal concept. The author's distinction between these two types of collective demonstrates that 'this plurality of belonging does not entirely discredit the role of "traditional" face-to-face collectives, but rather broadens our perspective on methods of integration at work. Individuals are building their working identities at the crossroads of these two distinct types of collective.' (Rosanvallon 2007: 304.)

Certain workers engaged in these new forms of work are left no opportunity for face-to-face or even shared activities, and this begs the question of how professional identities can be built and forms of collective organisation nurtured in such an unstructured environment. Lehdonvirta and Mezier (2013) analysed these issues on the basis of a survey of online workers performing micro-tasks[11], focusing on the way in which workers balanced the risky and constantly shifting nature of the work against their need for a stable identity and self-esteem. They identified three different scenarios:

11. The authors used three platforms (MTurk, MobileWorks and CloudFactory) for their empirical investigations.

– certain workers avoided the issue of professional identity by substituting a different identity linked to other professional activities or cultural categories (mother, for example);

– others constructed a positive professional identity by reinterpreting instability as freedom and setting great store by autonomy;

– yet others had joined together with other workers in order to build self-organised online structures (peer groups, online communities and networks) with a view to laying down standards and rules, making it possible to construct a socially acceptable professional identity through a group or category of similar workers.

There are, in fact, a large number of initiatives aimed at organising isolated workers, such as the German trade union platform Ver.di for freelancers[12] or the creative professionals in France who have begun to rally around a petition launched in 2014 and entitled 'Travail gratuit [Free work]', which protested against crowdsourcing and called for the government representatives to clarify their position on 'perverted crowdsourcing' or speculative work. New forms of online activism have also been employed by platform workers, for example the Canadian Kristy Milland, a former worker and task requester on MTurk, who runs the oldest community for MTurk workers[13]. There is also a trend for self-employed workers or employed remote workers to gravitate towards co-working spaces in order to recreate social bonds by means of face-to-face interactions, despite the absence of shared activity.

4.2 Organising and regulating a world of unstructured work

Some of the developments associated with so-called virtual work ('so-called' because virtual work always involves very real work in the world beyond the screen) are concerning because they pose threats in terms of job quality and protection for workers and consumers, as well as opening the floodgates to floutings of existing regulatory frameworks, unfair competition and market distortions. The collective agreements of the industrial age will be unachievable if workers are scattered and systematically placed in competition with each other, and it is hard to see a future for traditional working relationships in a world where digital platforms act as labour market intermediaries. Possible lines of action are taking shape in the form of new trade union models, both on and offline, and alliances between workers with different statuses (Degryse 2016).

The activities organised by digital platforms such as Uber, AirBnB and MTurk represent a key regulatory challenge, and several countries are attempting to assert some kind of authority over the legal no man's land in which these entities

12. www.mediafon.net
13. www.kristymilland.com

appear to operate. As is the case for Amazon, the public authorities are embroiled in a conflict between their desire on the one hand to avoid unduly obstructing initiatives which are likely to create jobs, and on the other to protect industries (public transport, bookshops, hotels, tour operators, etc.) which themselves create jobs and would be the target of unfair competition if these established sectors and the platforms were subject to different rules.

The European Agency for Safety and Health at Work has produced a more accurate list of critical factors (EU-OSHA 2015a):

– The status of platforms needs to be clarified in order to determine whether they can be regarded as temporary work agencies and expected to comply with the same regulations.

– The ambiguity surrounding the identity of individual employers should be resolved. In cases where a platform is developed on an in-house basis to manage a company's own staff, it is readily apparent that the only protagonists are the employer and the worker. More frequently, however, there are three parties involved; a client, the online intermediary and the worker. Platforms which function as intermediaries between clients and self-employed professionals are relatively straightforward, since they fall under the heading of normal business relationships, but the situation is less clear when the work is carried out by unskilled amateurs. This issue should be clarified as a matter of urgency since it is vitally important in terms of the responsibilities incumbent upon each of the parties.

– It should be clear who is legally responsible and who should take out insurance for accidents or cases where products are not fit for purpose or become the subject of legal disputes, since the undertakings provided by the platforms in this respect frequently boil down to nothing but disclaimers.

– Methods need to be found of applying existing European directives and national legislation to work of this kind, and status-related issues must be clarified so that it falls within the scope of the relevant directives on working time, temporary work, undeclared work, fair pay, etc.

– Consumer protection and public safety also represent regulatory grey areas due to the confusion between producers (requiring employment protection) and consumers, which has ramifications for the necessary processes and control, inspection and complaint mechanisms to be implemented.

– Consideration should be given to ways of certifying the skills offered by platforms, particularly in fields such as healthcare or electrical services.

Education and training also present key challenges which must be overcome in order to reverse the persistent flow of jobs towards more highly qualified workers as a result of technical progress, and lifelong learning will remain all-important in a world of rapid technological change and increasing professional mobility (both voluntary and enforced). Although this is a long-standing challenge faced

by society, it has become even more urgent in the face of such precipitous change. We are faced with the question of how those involved in virtual work – in all its manifestations – can acquire skills, and not only ICT skills but also soft skills in terms of organising one's own work, promoting one's services, etc. Validation of prior experience is also an area which undoubtedly merits further exploration in relation to future lifelong learning models.

The future of social protection systems has also been the source of much debate, and some have suggested that the social protection model of the future should move away from the current emphasis on professional activities and instead be focused on individuals throughout their lifetime, with a view to making career trajectories more secure in a world of discontinuity. Finally, and without entering into a very different debate, those commentators who have followed in the footsteps of others before them by positing that the end is nigh for work (Rifkin 2014) or employment (Stiegler 2015) have also proposed that thought should be given to forms of payment other than earned income, such as negative income tax or an unconditional basic income.

4.3 Revisiting the meaning of work

As a counterbalance to the transformation of work and the emergence of virtual work, it is useful to focus on the real meaning of work today, which is not affected by the growing importance of digital technologies. Work plays a central role within our societies and underpins their very workings, not only providing economic security but also helping to construct personal identities and locate individuals on a scale of social prestige, and European values surveys and a substantial body of research (Méda and Vendramin 2013) amply corroborate the importance attached to it. Our expectations of work can be fall into three different categories, namely income and security, high-quality interpersonal relationships and opportunities for personal development, fulfilment and self-expression at work, and work must meet these three types of expectation (instrumental, social and expressive) whether it is real or 'virtual' and face-to-face or remote. One development observed in connection with the new forms of employment is the gravitation of self-employed workers towards co-working spaces in search of social bonds and a group experience. Platform workers engaged in micro-tasks (transcription of image indexing) have formed virtual communities in order to recreate these social bonds and establish standards, and designer-creators and journalists have also started to organise themselves by creating associations, sharing information and client blacklists and setting benchmark prices.

There is still a strong expectation that work should provide a decent income, secure employment, meaningful activity and social bonds, and the only question is the extent to which the new forms of employment and work in the digital economy will be up to this task.

5. Conclusion

The rise of the digital economy can be regarded as another product of the drivers for change which have played a leading role in successive developments such as the information society, the network society and the knowledge-based society. Digitised information, which is available in ever vaster quantities and which can be leveraged using ever more sophisticated tools, represents an economic resource whose strategic importance is growing by the day. The current trends for customised production, networked industrial capacities and changes to the structure of value chains at global level, which underpin the production model of smart industry (Industry 4.0), are being strengthened and accelerated by the new avenues of exploration opened up by communicating objects, autonomous robots and learning machines. However, a glance back over the past 30 years shows us that the process through which technological innovations permeate through the economic system and are adopted by companies is a complex and long-winded one, involving interplaying factors such as economic return, work organisation and skills management. The relationship between technological performance and productivity gains is never straightforward, since it is always interposed by managerial strategies, social connections and collective agreements. This is why the relationship between computerisation and jobs is and will remain complex and resistant to reductionist analysis.

Trends which look likely to be amplified by the digital economy include the emergence of a wide variety of flexible and non-standard forms of work, since digital technologies – and particularly the combination of big data modelling with human or object geolocation – will continue to facilitate and speed up the introduction of flexible working arrangements. Finally, digitisation will not give rise to any changes in respect of the central role played by work in the construction of individual and collective identity or the social recognition associated with work, but it will sweep away some of its fundamental tenets, in particular the bonds of social contact which are forged and the landmarks in space and time which provide it with a unique position in social life.

The rise of the digital economy will also revolutionise certain aspects of our attitude towards economic development and the future of work, since digitisation promotes radically new business models such as two-sided markets using online platforms or goods and services with a quasi-zero marginal production cost. Particular attention should be paid to the opportunities and limits of a generation of new new technologies, in particular big data mining and analytics, the virtual storage of intangible digital assets in the cloud, the Internet of Things and learning and mobile robots. Although these innovations still have a long way to go before

reaching full market penetration, they have already resulted in a shift in the ever more fluid boundary between human and machine capacities. At every level of the economy and society, choices will need to be made between a technocratic and pessimistic discourse which predicts the increasing replacement of human labour by robots (whether mechanical devices or virtual entities) and a more positive and inclusive vision which suggests that our focus should be on the co-existence and complementarity of workers and robots.

Other disruptive trends include hitherto unseen developments such as crowd working which have become possible only thanks to very recent technological breakthroughs. Although the real scale of these phenomena is still difficult to judge, their consequences in terms of payment structures, job quality and working conditions represent a major departure from a social model built on jobs. The virtual work carried out by ICT-based mobile workers is undoubtedly an offshoot of remote work, but it is now a feature of increasingly intangible and globalised environments which are not rooted in time or space and where the boundaries between work and home, between employment and self-employment and between producers and consumers of digitised information are blurred. On-call work has long been a familiar fixture of the employment landscape in certain countries in the form of zero-hour contracts, but it has now assumed new dimensions as a result of the task assignment platforms which combine geolocation with big data processing. The rebuilding of social links in increasingly unstructured work situations represents both a challenge and an urgent necessity.

'Little by little, then all at once.' By repeating this aphorism by Brynjolfsson and McAfee, we hope to make it clear that the challenges likely to be posed by the transformation of work in the digital economy should rank highly on political and trade union agendas.

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