

# Automation, digitisation and platforms: implications for work and employment Concept Paper

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## Eurofound's 'Digital Age Activity' and this concept paper

The programme of work of Eurofound is structured in activities, which are broad areas of research under which different projects are carried out over a four-year cycle. In the 2017-2020 work programme, a new activity was created under the title 'The Digital Age: Implications for Work and Employment'. Within this activity, several research projects will look at different issues such as the automation of services, the contours of the platform economy or the nature of work in digitised workplaces. Although Eurofound has a long history of research on the impact of digital technologies on work and employment, there was never a unified and consistent approach for this issue. The aim of this paper is to provide such a unified and consistent approach, and introduce the key concepts and assumptions that underlie this new activity.

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## 1. Introduction: from the Digital Revolution to the Digital Age

**The Digital Revolution can be defined as a general acceleration in the pace of technical change in the economy, driven by a massive expansion of our capacity to store, process and communicate information using electronic devices.** Although some of its key underlying technologies and scientific foundations were developed in the period 1950-1970s,<sup>1</sup> the *big bang* of innovations and applications of digital technologies was triggered by the invention of the microprocessor in the early 1970s, a general-purpose programmable electronic device capable of processing digital information. The continuous increase in performance and decrease in cost of microprocessors over the next four decades<sup>2</sup> facilitated a very rapid spread of different digital technologies such as the personal computer, the internet and mobile phones, among many others.

**The Digital Age can be defined as a historical period marked by a widespread use of digital technologies in different aspects of human activity, including the economy, politics and most forms of human interaction.** This widespread use of digital technologies implies a profound transformation of social, economic and political systems, in the same way as the steam engine or electricity transformed past societies. This paper will set out a conceptual and analytical framework to assess the implications of the Digital Age on work and employment.

In order to address the questions on how to go from the Digital Revolution to the Digital Age and why to study the implications of the Digital Age now, decades after the irruption of digital technologies, this introduction will provide some historical context and a broad interpretation of the significance of the Digital Revolution, synthesised in three main contentions that underlie the approach of the rest of this paper. These arguments derive from the work of Neo-Schumpeterian economists Chris Freeman (Freeman and Louca, 2001) and Carlota Pérez (Pérez, 2003).

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<sup>1</sup> For instance, the transistor was invented in 1947, and Claude Shannon established the basis of information theory in 1948.

<sup>2</sup> According to the so-called *Moore's Law*, this expansion follows an exponential rate, with the number of transistors in a microprocessor doubling every two years for a similar price. Astonishingly, this law remains valid after more than 40 years of exponential growth. The first of Intel microprocessors, the 4004, had 2300 transistors. The latest one (Broadwell-EP Xeon) has over 7 billion transistors. (See [https://en.wikipedia.org/w/index.php?title=Transistor\\_count&oldid=754563608](https://en.wikipedia.org/w/index.php?title=Transistor_count&oldid=754563608)).

The first contention is that changes in the methods and tools used in the economy tend to cluster around periodic ‘revolutions’, rather than following linear and incremental trends. The reasons are both technical and socio-economic. Technically: since each new technology is essentially a recombination of previous ones, the introduction of a new general-purpose key technology such as the microchip opens up a myriad of new possibilities of recombination and applications. It triggers a self-reinforcing process of fast technical change (with each new technology opening up further possibilities) until the new possibilities are depleted. Socio-economically: since production technologies are embedded in social structures, the introduction of new technologies has to struggle initially against the existing organisational forms, cultural attitudes, vested interests and institutional settings (consistent with the pre-existing production technologies); but once such resistances are overcome, the same organisational forms, interests and institutions can foster the diffusion and further development of the new technologies. These technical and socio-economic factors give technical change a syncopated rhythm similar to other (in some ways related) evolutionary processes, as Kuhn’s Scientific Revolutions or the punctuated equilibrium of biological evolution.

Thus, the Digital Revolution would be the most recent of a long sequence of periodic bursts of innovation and change in the tools and methods used in the economy. The triggering factor in this case, as already mentioned, was the invention of the microchip, a general-purpose technology with vertiginously declining costs and increasing capabilities. The microchip created a whole new set of products and industries, big investment opportunities but also socio-economic imbalances. It facilitated new forms of economic organisation that slowly spread to more and more sectors and activities, in a process which is still under way. As previous technological revolutions, it implies a paradigm change in the organisation of the economy, brings about new social structures and requires new institutions.

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#### **BOX 1: The historical significance of the Digital Revolution**

This paper roughly follows the approach of Chris Freeman and Carlota Pérez, who interpret the Digital Revolution as the fifth Technological Revolution of capitalism over the last 200 years (Freeman and Louca, 2001; Pérez, 2003). The four previous ones would be: (1) the initial Industrial Revolution starting around 1771, (2) the Steam and Railways Revolution, starting around 1829; (3) the Steel, Electricity and Heavy Engineering Revolution, starting around 1875; and (4) the Oil, Automobile and Mass Production Revolution, starting around 1908. Each of those revolutions triggered a paradigm change of the economy, and the cycle of installation-crisis-deployment-stagnation discussed in this section (for more details, see Pérez (2003)).

However, in the literature there are also very different arguments about the historical significance of the Digital Revolution. The most extreme contrarian view has been defended by the American economic historian Robert J. Gordon (2016), who interprets digital technologies as a peripheral set of innovations mostly relevant for leisure industries, but with very little effects on growth in the long run (in fact, the Digital Age would coincide with a period of secular stagnation, since the fruits of the industrial revolution have been already reaped). Others speak about a Third (Rifkin, 2011) or even a Fourth Industrial Revolution (Schwab, 2017), arguments which are closer to the Freeman-Pérez framework although more loosely constructed. The very influential MIT researchers Brynjolfsson and McAfee (2014) interpret it as ‘the Second Machine Age’, giving it a much larger historical significance, equivalent to that of the original Industrial Revolution. Finally, some scholars understand the Digital Revolution as the trigger of an evolutionary leap in humankind equivalent to the appearance of the Homo Sapiens (Kurtzweil, 2005; Harari, 2016).

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The second contention is that there is a time lag between the initial big bang of innovation provoked by a technological revolution and its full transformation of the socio-economic structure. As already mentioned, productive technologies are embedded in socio-economic structures, and their change on a large scale requires a transformation of infrastructures,

organisational practices and institutional frameworks, overcoming the explicit or implicit resistance of the existing dominant actors and industries.

A typical sequence from technological revolution to socio-economic transformation would start with the appearance of new products and industries, initially at the margins of the economy but experiencing very fast growth. This rapid growth would attract investment that provides leverage for further innovation and growth, as well as the necessary funding for the installation of new infrastructures and the development of further applications. This is the initial period of 'installation' of a technological revolution, which in the model of Freeman/Pérez generally lasts around three decades. It is a period marked by growing imbalances between the old and new industries, between the firms and workers that benefit from the new technologies and the rest. This period is often associated with a speculative frenzy that ends in a financial crisis (Pérez, 2003). In this 'installation' period, the transformational power of the new technologies remains mostly limited to the associated industries, and those most directly related (such as the building of associated infrastructures).

The financial crisis serves as a turning point and a cleansing mechanism for the excesses of the installation period, consolidating the structures of the new industries and bringing down excessive expectations. After this crisis, the new technologies are mature, the new infrastructures have been installed, and the skills and know-how associated to the new tools and methods are widespread. Then, the new technologies can spread to most other industries and activities, and their full possibilities can be realised and put in practice. This second period of the technological revolution, which generally takes another three decades after the turning point of the crisis, is what Pérez calls the 'deployment' period. Over this second period, the possibilities afforded by the technological revolution are slowly depleted, leading to a period of stagnation that prepares the ground for the next technological revolution (starting the cycle again).

This long-cycle theory of technological revolutions, whose canonical case was the Fordist revolution of automobiles, oil and mass production starting in the 1910s and finishing in the early 1970s, fits surprisingly well the unfolding of the digital revolution. The invention of the microprocessor in the early 1970s facilitated the creation of many new products and markets in the margins of the economy, such as video-games and micro-computers, which experienced very fast growth and developed tools and methods that were soon applied to other fast-growing products and markets, such as the internet or mobile phones. The huge profits of the new industries attracted increasing investment and generated big expectations, leading to a speculative frenzy that ended in the dot-com crash of 2001 (perhaps extending to the financial crash of 2008). According to this cyclical model, the deployment period of the Digital Revolution would be starting now, when the new tools and methods diffuse to the entire socio-economic structure and the real economic transformation takes place.

This leads to the third contention: for a technical revolution to produce real and shared benefits to society, the institutional framework has to significantly change to deal with the broad socio-economic implications of the new forms of economic activity. Again, this is a corollary of the social embeddedness of productive technologies. The institutional framework of market economies deals with the externalities and contradictions created by economic activity (for instance, providing employment insurance or income redistribution), but also performs some important regulatory functions (employment regulation, competition policies, demand stimulation, education or R&D policies). It seems obvious that a technological revolution that implies a transformation in the tools and methods used in the economy will require also a significant change in the institutional framework that regulates and helps coordinate such an economy. Indeed, the history of previous technological revolutions shows that they have been associated with profound changes in economic regulation and state

intervention, in response to the increasing socio-economic imbalances and contradictions of the installation phase, following to the sequence previously presented.

For instance, the Keynesian welfare state and employment regulation model can be interpreted as an institutional response to the imbalances and contradictions created by the Fordist mass production system (Boyer, 1990). By regulating industrial conflict and employment relations, redistributing income and stimulating demand, the Keynesian welfare model facilitated the full deployment of the Fordist mass production system, but it also ensured that its benefits were more widely shared by the population.

The Keynesian welfare model is an example of a successful reorganisation of the institutional framework to deal with the imbalances and contradictions created by a technological revolution, in this case the Fordist mass production system. However, it is important to emphasise that a successful reorganisation of the institutional framework cannot be automatically assumed. Institutional reorganisations are the result of political processes which have their own logic (which is obviously beyond the scope of this paper). Technological revolutions tend to generate socio-economic imbalances and contradictions which the existing institutional framework (developed in and for a different context) cannot resolve. This is likely to lead to some type of political crisis, but the result is indeterminate. It can be a successful reorganisation of the institutional framework, an unsuccessful one or even no major change.

This historical argument also applies very well to the subject of this paper. The Digital Revolution has created significant imbalances and contradictions over the last few decades, as attested by increasing income inequalities as well as economic and political instability. These imbalances and contradictions are at least partly the result of an increasing incongruence between the underlying economic structure and the institutional framework. As digital technologies and the associated organisational changes (automation, digitisation and platforms, as will be discussed later) extend to more and more sectors of the economy, the contradictions are likely to become even bigger. That is why now, at this historical conjecture, it is particularly important to improve our understanding of how the Digital Revolution changes the nature of economic activity, work and employment. This knowledge should assist the democratic political process in redesigning and reorganising the institutional framework of the economy, ensuring that the Digital Age is one of human flourishing and progress for all. This is the ultimate aim of Eurofound's programme of work on the Digital Age and its implications for work and employment.

The rest of this paper is divided in five sections. Section two discusses how technology, the division of labour and institutions interact with each other as they transform socio-economic structures. Section three presents some of the key attributes of the digital economy, inferred from the observation of the industries and sectors which are at the forefront of the Digital Revolution. Section four introduces the three vectors of change that, in the author's view, are more significant for understanding the implications of the Digital Age for work and employment: automation, digitisation and platforms. Finally, section five provides some final remarks and considerations to guide a research programme based on this conceptual and analytical framework.

## 2. The foundations: technological and socio-economic change

From a material perspective, the economy can be understood as a process of combination and transformation of inputs into outputs, to produce goods and services for human needs. Thus, technology can be defined as the tools and methods used for carrying out these transformation processes.

But what is a technology? At the most basic level, a technology is a domesticated natural phenomenon: a device that allows reproducing and controlling a mechanism observed in nature. But the most important thing about technologies is that they can be combined: once a technology has been perfected, it becomes a building block that can be combined with others into more advanced technologies. Furthermore, technologies can facilitate the discovery and domestication of new natural phenomena (the way microscopes opened up the microscopical dimension, and with it a myriad of new possibilities for the life sciences and associated technologies). These two aspects of technology (combinatorial recursiveness and possibility to uncover further natural phenomena) lead some authors to describe technological change as an ‘autopoietic’ process which develops by bootstrapping (Arthur, 2009). The more technologies available, the more possibilities for recombination and discovery of new phenomena, and therefore for further technological development. The result is a self-reinforcing process of technological progress which is ultimately about the accumulation of (applied) knowledge.

It is important to note that, even from this purely technological perspective, technical change is not seen as a continuous process, but as one punctuated by periodic bursts of innovation. Technologies cluster in domains: groups of technologies that share a family of effects, a common purpose or underlying theory, and which become toolboxes for the assembly of new technologies or applications. Bursts of innovation often happen when a new domain is opened up by the discovery or domestication of a new type of natural phenomenon, and a new toolbox of technologies is made available for new recombinations and applications. Also, innovation often results from redomaining (Arthur, 2009): the application of an existing solution to a different problem allows translating the entire toolbox associated with the existing domain into a new one.

This would be, in a nutshell, a purely ‘technological’ account of technical change, which helps understand its peculiar self-reinforcing, punctuated and accelerating nature. But for the purposes of this paper, it is problematic because there is obviously something missing. The economy may be seen as a transformation process, but it still needs some agents to enact such a transformation. And those agents are human beings whose input into the production process must be coordinated. In this respect, it is useful to distinguish two types of mechanisms for the coordination of human input in production processes: technical (division of labour) and social (socio-economic institutions).

**The division of labour refers to the separation and allocation of tasks to different persons cooperating in an economic process.** It is an attribute of economic activity which is as important and universal as technology itself. On the one hand, it is a mechanism for coordinating the input of different individuals towards a common (productive) goal, which derives from the fact that humans are social animals. On the other hand, it can be considered a (organisational) technology, perhaps the most general-purpose and universal of all, which can expand enormously the efficiency of any type of cooperative production. The increase in efficiency associated to the division of labour is the result of specialisation (which increases

the dexterity of workers) and a better coordination of the labour input (which reduces time between tasks, facilitates standardisation, etc.).

Is the division of labour a technology, or a separate attribute of economic activity? Although it can be understood as a very general purpose organisational method (and therefore a technology in some ways), it is so universal and important on its own that it is better to consider it separately. A more complicated question is whether the division of labour is a technical or a social attribute of the economy. On the one hand, it is obviously social because it is a form of social coordination, as already argued. On the other hand, it can also be considered a technical attribute of economic activity: it is a form of increasing the efficiency of a productive process independently of the interests and values of the people involved. In this last sense, it can be neatly differentiated from economic institutions, which as will be discussed later, aim to coordinate workers as social beings rather than as inputs into a productive process. Thus, the division of labour is both a technical attribute of economic activity (a method that allows a better coordination and efficiency of labour input into the economic process) and a social attribute (since the division of labour is a form of social coordination that gives rise to a social structure).

The relationship between the division of labour and technology is fundamental to economic development, and works in both directions. Technological change shapes the evolution of the division of labour, by changing directly the production process and the types of labour input necessary. The introduction of a new technology into a production process that is organised in a particular way will always require some reorganisation of work: some tasks may change or become unnecessary, while some others may be created anew. The skills, positions and conditions of different workers within the process will necessarily change as a result.

But the division of labour is also a key enabler of technical change. First, the breakdown of production processes into separate tasks facilitates a better identification of problems and potential technological solutions. Second, the specialisation of workers increases their knowledge of the economic process and therefore their capacity to develop new tools and methods. In general terms, the division of labour expands human knowledge of the production process and therefore facilitates innovation and technical change.

A good example of how the division of labour and technical change feed each other is automation, the replacement of human by machine input for some tasks in production. Historically, a detailed division of labour (and specialisation) has been a precondition of automation: only if processes are broken down into very simple and specific tasks, those tasks could be automated. But of course, the automation of certain tasks has been in the long run a key determinant of the unfolding of the division of labour (for instance, the importance of routine manual tasks as forms of human labour has decreased drastically in modern economies since the Industrial Revolution).

Technology and the division of labour form the material foundation of the economy as a transformative process. However, the coordination of human input into production is not only a technical problem, but also a social one. Human beings have different needs, interests and values, and their input in production requires **rules, structures and mechanisms of social coordination, that is institutions. Institutions support the functioning of economic processes by providing stability and social coordination, and by dealing with their external effects.** They make the economic process socially sustainable, allowing the material process of economic transformation to function within a human society.



If institutions are necessary for the economy to function, why not understand them as a particular category of technical solutions to the problem of social coordination? For instance, could the coordination of economic activity by the mechanisms of markets and firms, anchored in institutions such as property rights, contract regulation and enforcement not be understood as organisational technologies that facilitate a more efficient coordination of economic activity? To some extent, they can: any set of codified rules and principles of behaviour is a method, an algorithm, and therefore a technology (of social coordination in this case). However, it is important to differentiate between organisational methods that explicitly aim at the social coordination of human interaction (hence institutions) and organisational methods that ostensibly aim at the technical coordination of human input into a productive process (hence division of labour or work organisation). Whereas the latter may also have social implications (for instance, generating power structures), this would be a non-intended effect (the same way that a technology can have particular social implications), whereas the whole point of an institution is its social implications.

This may seem like a pointless distinction, but it can be an important point for discussions of economic policy. **Technology and the division of labour form the material or technical sub-stratum of the socio-economic system, which can be associated with very different institutional frameworks.** This is what explains the wide institutional variations that can exist between economies whose overall use of technology and division of labour (that is, their economic development) is very similar. Perhaps the best example is that for a long time a similar underlying economic process (similar technologies and division of labour) existed in two radically different institutional forms, capitalism and state socialism. It is the institutional framework which determines most directly the distribution of life chances across the population, even if it is constrained by productive possibilities given by the underlying economic structure. **The benefits of technical change and economic development can be very differently distributed depending on the institutional framework that each society sets for itself.**

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#### **BOX 2: Implications of technical change on work and employment**

On the basis of the arguments discussed in this section, four different domains of the implications of technical change for work and employment can be differentiated:

- A. **Tasks and occupations:** This refers to the distribution of tasks in the economy and the occupational structure, which are directly and continuously changing as a result of technical change (every new technology involves some new way of carrying out a particular process, and therefore a change in the associated tasks).
- B. **The conditions of work:** This refers to the physical, psychological and environmental requirements and conditions of work, which are also directly affected by the technology used.
- C. **The conditions of employment:** This domain refers to the contractual and social conditions of the work relation, including issues such as stability, opportunities for development or pay. They mostly depend on the institutional framework and labour regulation, and the effect of technology is more indirect.
- D. **Industrial relations:** This domain refers to the more or less institutionalised ways in which workers and employers organise their relations and settle their disputes. The effect of technical change on this domain is also indirect (affecting the three previous domains, it can affect the interests, power and organisational capacity of workers and employers).

Domains A and B (tasks and occupations and conditions of work) are two aspects of the division of labour and part of the material attributes of the economy, and the effect of technical change is direct and rather immediate (it can

change directly the types of tasks needed in production and the conditions in which work takes place). Domains C and D (conditions of employment and industrial relations) are part of the social or institutional attributes of the economy, and the effect on them of technical change is indirect and more indeterminate.

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As was the case with the division of labour, the relationship between technology and economic institutions is fundamental and works both ways. Technical change and the unfolding of the division of labour are continuously changing the nature and structure of economic activity, which changes the needs, interests and values of economic agents and erodes the stabilising and coordinating role played by economic institutions. Sooner or later, economic institutions have to be reorganised and adapted to a change in the technologies used in production. This also applies to the need to reorganise the institutional framework of the economy in the Digital Age. For example, the so called ‘Internet of Things’ (the use of cheap digital sensors to digitally monitor every single object within a factory) promises a big leap in the efficiency of industrial processes, but it can also transform the factory into an all-invasive surveillance system. The existing regulation of industrial labour cannot deal with such a change because it was designed for an entirely different type of factory. This regulation has to be changed in order to ensure that industrial production is carried out in accordance to prevailing norms of privacy and personal autonomy, for instance.

But the relationship also works the other way: institutions also shape technological development. First, because human agency is the ultimate driver of technical change, and human agency is fundamentally structured by institutions. For instance, the ownership rights of market economies place most investment decisions in the hands of capital owners, which can steer technological development towards their particular interests (compared to a system in which investment decisions are democratically made, for instance). Second, institutions can also be explicitly and directly aimed at redirecting technical change, because of the (expected) effects of such change. For instance, some types of technology can be forbidden if their expected effect is contradictory with social values or norms, as happens with some types of genetic engineering.

### 3. Attributes of the digital economy

The key technology behind the digital revolution is the microprocessor. It is the quintessential general-purpose technology, since it can be applied to any type of process that involves information. Chip-based technologies and devices have been developed for all kinds of information processing, storing and communicating purposes, with exponentially growing possibilities for recombinations and new applications. The general applicability and combinatory possibilities of chip-based technologies are further leveraged by their continuous and very fast decline in cost and increase in capabilities.

In terms of its general applicability, the microchip can only be compared with epochal innovations such as steam and electricity. These historical precedents suggest that it takes a significant amount of time for economic agents to grasp the full possibilities of a new general-purpose technology, and to transform economic processes accordingly. Historically, these key innovations often start as curiosities, are then slowly applied to the most obvious and directly related industries and activities (such as artificial light in the case of electricity), and only after a significant time lag diffuse to all types of industries and activities, reaching their full transformational potential. For instance, the use of steam in industrial processes required factories to be organised around one or several central large engines. This type of organisation was retained even some time after the introduction of electricity, despite the fact that

electricity allowed the use of smaller motors and therefore a more flexible and efficient modular organisation of production. It took engineers some time to notice this possibility and reorganise factories accordingly – in fact, the debate in engineering schools about the relative benefits of one or other system lasted several decades (McAfee and Brynjolfsson, 2017).

The diffusion and application of digital technologies follows a similar process. They were first mostly significant in the ICT sector itself (although they transformed a marginal activity into a massive industry), then spread into ICT-related sectors and activities (mass media and leisure industries, telecommunications) and are currently diffusing to (and transforming) all types of economic activity (retail, manufacturing, health and education, etc.). The diffusion of digital technologies across all types of economic activity also involves a diffusion of the skills and work methods of the ICT sector. In fact, it can sometimes involve a direct colonisation of other types of economic activity by the big players of the ICT industry, as can be seen in the examples of Amazon in retail or Google and Facebook in advertising and media.

But how do digital technologies transform economic processes? How does a digital economy differ from an analogue (that is, pre-digital) economy? To a large extent, this is still an open question, since the transformative potential of digital technologies has by no means been exhausted. However, by looking at the sectors and industries where digital technologies have already had a deep impact, it might be possible to infer how digital technologies can transform economic processes. This paper will emphasise in particular four aspects of digital technologies that in the author's view have significant transformative potential for economic activity.

First, digital technologies can make production more flexible. Until recently, machines applied in any productive process tended to be relatively rigid. The functionality of the machine was physically encoded in its mechanical design: a change of function or operation required a physical change in the design of the machine. In this kind of mechanically-assisted production processes (the prototypical example being the assembly line of Fordism), human operators were the ones providing flexibility to the system, dealing with unforeseen circumstances or giving final touches to the final product, including any customisation. Instead, digitally-enabled production processes are programmed, which means that the process is not embodied in fixed mechanisms, but rather controlled by an algorithm that can be recalibrated as needed. This applies to any kind of digitally-enabled production process, whether it deals with information (for instance, administrative processes controlled with a database software) or with physical goods (for instance, an industrial arm that can be programmed to perform different types of operations).

The programmability and algorithmic control of production processes makes them intrinsically much more flexible than previous methods of mechanically-controlled devices. But how far can this flexibility go? Ultimately, it depends on the processing power available to the algorithms. Since the processing power has been exponentially growing in the last few decades, the degree of programmability and flexibility inherent in digitally controlled processes has also grown exponentially. Artificial intelligence and deep learning algorithms, for instance, can directly observe their environment, learn and perform whatever tasks they are assigned with minimal human intervention. Theoretically, an algorithm could be as flexible and adaptable as a human being (in fact, it could be more, even if it is impossible for us to imagine how).

This is why the digital revolution could take the automation of labour input in production to the extreme, making human labour redundant. Algorithms that can do anything that a human being can do make human labour unnecessary.

Second, digital technologies boost the accessibility of information at all levels and points of the economic process. This reduces transaction costs and facilitates much more complex organisational structures of all kinds. It also expands markets and makes location increasingly irrelevant.

Many years ago, Ronald Coase argued that firms exist because some types of transactions are too costly to coordinate by markets (Coase, 1937). Most of the costs of those internalised transactions are, in fact, associated to limited or imperfect information. The increasing accessibility and ubiquity of information associated with digital technologies, therefore, predictably leads to a significant increase in the outsourcing of specific tasks and functions to other companies, even outside the national boundaries. This has deepened and expanded markets in unprecedented ways, significantly contributing to globalisation. The global value chains of multinational corporations would not be possible without the information and communication capabilities of digital technologies.

Lately, the combination of instant and massive information availability with the principle of algorithmic control discussed in the previous point has given rise to an even more radical challenge to the classical argument of Coase on the boundaries between markets and firms. Digital platforms such as Uber perform some of the functions of markets (providing a space where suppliers and consumers of certain services can meet), but also some of the functions of firms (coordinating, monitoring and disciplining the supply of services via algorithms). In fact, it is probably correct to say that platforms transcend both markets and firms, since they do not only provide functions of both, but can actually do even more (they facilitate economic transactions that neither markets nor firms could coordinate). Defying the distinction between firms and markets, platforms also defy existing forms of labour and market regulations, as attested by some recent court cases around Europe. As argued in previous sections, platforms are a new form of economic activity that probably requires new regulations and institutions.

Another important effect of the massive expansion and deepening of markets enabled by digital technologies is the creation of ‘long tail’ markets. In massively big markets with near perfect information, there is economic value in the provision of even extremely rare goods or services. This is reinforced by the customisation possibilities of digitally-enabled production process previously mentioned. The contrast with the mass production technologies of the 20<sup>th</sup> century is stark: instead of homogeneous national markets for mass-produced goods, digital technologies enable very specialised long-tail markets at a global scale.

But the same effect also tends to create ‘winner-takes all’ markets, in which a single provider of a particular type of good or service tends to concentrate the vast majority of economic activity. The much better information on the quality of goods and services available in digital markets removes one of the key traditional advantages of local markets, which was the trust provided by short-range transactions. If a global online retailer provides detailed and reliable information on a product (including other buyers’ reviews), secures the transaction and provides fast and real-time tracked delivery, why buy it in the local store at a higher price? Furthermore, the long-tail effect ensures that big online providers will have a massively bigger range of products to choose from. Thus, big online global providers are likely to take a very significant share of the market, with potentially troubling effects in terms of market competition and inequality.

The third important effect concerns digital goods rather than digital technologies directly. Digital goods can be simply defined as strings of bits (digital information) that have economic value. The generalised use of digital technologies in production tends to make digital goods

more central for the economy. And a very important attribute of digital goods is that they tend to have very low or even zero marginal costs.

In economics, the marginal cost is the increase in total costs associated to the production of an additional unit of good or service. In a textbook competitive market, prices would tend to equal marginal costs (above marginal costs, producers would increase the supply of the good, bringing down the price; below marginal costs, it is not profitable to produce). Digital goods tend to have zero marginal costs because they are non-rival and infinitely expandable. They are non-rival because their use by someone does not make them less useful for anyone else (a piece of music does not lose value if someone listens to it, whereas a sandwich loses all its value if someone eats it). They are infinitely expandable because they can be infinitely reproduced at (virtually) no cost (a digitised piece of music can be freely copied infinite times). In a competitive market, non-rival and infinitely expandable goods would have zero marginal costs and therefore a price of zero.

But although the use and reproduction of a digital good has no cost, its production (creation) does. This generates an incentive problem in an economy where production is driven by profit: nobody would produce goods which are costly to produce but can generate no revenue, even if there is a demand for them. In market economies, different institutions have been created to deal with this incentive problem, which applies not only to digital but to any kind of informational good (including ideas, many forms of art or communication). The most important of these institutions is Intellectual Property Rights (IPR).

Essentially, IPR give the creators of informational goods monopoly rights over their use and reproduction, for a given number of years, backed and enforced by the state. The two most important types of IPR are patents (for inventions with industrial applicability) and copyright (for creative, intellectual or artistic works). Most digital goods would be protected by copyright, although patents can also play an important role. For instance, in the case of software, patents are often used to restrict the use of generic ideas or procedures (such as a 'progress bar' for displaying how much of a task has been completed; Stallman, 2005), while copyright is used for the particular form in which such ideas are expressed in a commercialised piece of software.

It is important to note that despite their similar name, IPR differ significantly from Ordinary Property Rights (OPR, the socially-enforced rules that determine the use and ownership of goods which are rival and not infinitely expandable), for at least the following two reasons.

First, OPR defends the (rights of the) owner of a good, whereas IPR defends the (rights of the) producer of the good. While OPR primarily restrict the capacity of third persons to use a good they do not rightfully own, IPR primarily restrict the capacity of the rightful owner of a good to make certain uses of it (for instance, sharing or reproducing it). An (unintended) effect of this is that the enforcement of IPR requires a much more intrusive surveillance, since its focus is on the private use of goods by their rightful owners. In the case of digital goods, cheap and pervasive computers and online tools such as P2P make the sharing of intellectual property extremely easy, which has led to increasingly intrusive measures of tracking and monitoring the private use of digital goods (see for instance the controversial issue of Digital Rights Management systems for e-books scanning the entire library of users and sending the information to corporate producers; McSherry, 2014).

Second, while OPR does not in itself restrict the potential benefits derived from the use of a good, IPR does. Since digital goods are non-rival and infinitely expandable, their potential use is infinite (a piece of digital music can be shared any number of times, and each new use

is as good as the first one): therefore, IPR reduces *infinitely* the potential use of a good (that is, from infinite to one). This contrasts with OPR, which only concerns who is entitled to use the good, but it does not limit its use otherwise (as long as someone eats a sandwich, all its potential benefits are realised). This effect is particularly problematic in the case of patents, which concern inventions with industrial applicability: the restriction of potential uses of an idea is also restricting many potential recombinations and further possible applications of that idea. Patents may incentivise creation, but drastically limit recombination, which is actually one of the most important mechanisms of innovation, as previously discussed.

So, IPR systems solve the incentive problem of zero marginal costs for digital goods, but at the expense of creating two perhaps bigger problems: the need for intrusive enforcement and the drastic limitation of the potential uses (including combinatorial innovation) of digital goods. A third, institutional troubling effect can be added. Because IPR are essentially government-sanctioned monopolies, they immediately create a big incentive for producers to lobby the government in order to strengthen and expand IPR rights, which results in further suboptimal outcomes (some of the benefits of innovation are spent in the intrinsically unproductive activity of lobbying, and to the extent they are successful, they simply expand rents without any benefit to society; for an example, see Depoorter, 2004).

IPR is not the only institution used for solving the incentive problem of informational goods. Historically, alternative methods such as procurement and patronage have been used as well. The main characteristic of these alternatives is that they ‘divorce the ex-ante incentive of an innovator from the ex post stream of rents generated by the innovation’ (Quah, 2002, p. 27). In other words, they incentivise innovation/creation directly, by establishing grants or awards for innovators/creators, which means that the resulting digital goods or works can generally be in the public domain (ensuring their potential benefits are fulfilled), even if authorship is fully recognised. These are the systems most widely used for academic, space, military and basic research and development, which underlie most of the key innovations of the digital revolution (Mazzucato, 2015).

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### **BOX 3: The Open Source alternative**

A more radical alternative to the Intellectual Property Rights system, whose origins go back to the very beginnings of the Digital Revolution (in the hacking culture of the first software programmers), is the Open Source model. It is a model of decentralised production of digital goods (originally software, although it has been extended to many other types of digital goods), where authorship (or rather, contribution) is recognised but there are explicitly no limitations with respect to the use, reproduction or modification of the good in question. The incentive to contribute is reputation rather than money, although that reputation can lead to monetary gains eventually, for instance via better employment chances (Fernández-Macías, 2002).

In the Open Source model, the creation of digital goods does not generate any direct monetary benefits to producers. In this sense, it is a model that on its own cannot entirely replace the IPR system in a market economy. However, it can be easily combined with a patronage system to make it perfectly sustainable, solving the incentive problem. In fact, that is how the Open Source model has been operating in practice since its origins. As already mentioned, contribution to Open Source projects generates reputation that can be later monetised by accessing better jobs: it could be therefore argued that the companies hiring respected Open Source programmers are subsidising (providing patronage to) Open Source development. Many software companies go further, and explicitly allow their employees to spend part of their working time in Open Source projects. Open Source development is also widely subsidised by public money, since a significant proportion of developers work in universities or publicly funded research centres.

What is clear from several decades of Open Source development in software is that it can be a very powerful system of innovation and work organisation. Despite being entirely voluntary, decentralised and with no (direct) monetary compensation, it has overtaken commercial software for many types of applications, from operating systems to web servers. The Open Source model is extremely interesting for any discussion of the wider socio-

economic implications of digital technologies, because it shows their enormous transformative potential if they have a favourable institutional framework. With instant and pervasive communication, a digitally skilled user-base, and the advantages of decentralised algorithmic coordination, the possibilities for recombination and innovation can grow in a truly exponential way without generating troubling distributional effects.

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The fourth effect of digital technologies in economic processes is that they tend to create demand-side economies of scale, or network effects. This means that the value for consumers of many types of digital goods and services increases with the number of users. This effect is typical of communication-related goods and services, the classical example being the telephone (the more users in the network, the more people can be called and therefore the more value the service has for the users). Of course, the typical example in the digital economy today would be social networks, but network effects also apply to many other digital goods, services and technologies: software systems and tools, digital industrial applications (such as the Internet of Things) and standards.

Network effects lead to increasing returns in economic activity, and therefore, they favour market concentration. But it is important to note that this effect is much stronger than in traditional supply-side economies of scale typical of Fordist systems, in which costs tend to decrease with more output because high fixed costs are more spread. Whereas supply-side economies of scale generally have limits after which additional production implies diminishing returns, the limits of demand-side economies of scale are much larger or even non-existent (for instance, in the case of peer-to-peer systems, which are used even in large commercial social networks such as Facebook). But perhaps most importantly, network effects tend to cause lock-in, because the cost of switching product or service also grows with the size of the network, to the extent that can effectively make customers entirely dependent on a particular vendor. For instance, it is nearly impossible to use the type of social networking service provided by Facebook without using Facebook itself, simply because everyone uses it. Switching to another provider would require all of our contacts to move simultaneously, which would require their contacts to move as well.. Other examples of the lock-in resulting from network effects is the dominance of Microsoft in the market for desktop operating systems: again, since the value of an operating system also depends on the number of people using it (because we want to be able to collaborate and share information.), switching to a different one involves not only very high costs in terms of learning, but would require many other people to do the same in order to maintain the functionality. This is why the dominance of Microsoft only ended with the appearance of other computing devices beyond the desktop (in particular the smartphone), in which vendors other than Microsoft achieved lock-in (mostly, Google with the Android operating system, and to a lesser extent Apple).

The very strong concentration effect of demand-side economies of scale tends to create large monopolies, and is a cause for concern. On top of anti-trust and competition policies, solutions such as the use of open standards and interoperability have been proposed. It should be noted that this is in fact linked with the problems of IPR previously discussed: large digital companies often resist or try to control open standards and interoperability claiming that they challenge their profitability and their intellectual property rights. The Open Source and Peer to Peer systems discussed in Box 3 can also provide a viable alternative in this respect.

This section discussed four key attributes of the digital economy, namely: productive flexibility, fast and pervasive information availability, zero marginal costs and strong network effects. These attributes can be already observed in the sectors and industries where the digital transformation is more advanced: first of all, in the IT sector itself; secondly, in the broader communication and leisure industries. We are entering the period in which these attributes

will be observed also in manufacturing, retail and social services, as digital technologies become widespread in those sectors and slowly transform their economic processes too. Of course, these sectors have their own specificities and will probably not be entirely reshaped in the image of the IT industry: the digitisation of manufacturing, retail and public services will have their own characteristics, which are not yet obvious. However, it seems more than plausible that many of the discussed attributes of the digital economy will also apply, although to different extents and in different forms, to non-ICT industries as more and more parts of their production processes become digitised.

## 4. Implications for work and employment: three vectors of change

How can the Digital Revolution transform work and employment? As in the previous section, discussing this subject inevitably requires some speculation because the process is still unfolding. However, potential developments can be explored on the basis of how things are already changing in some particular sectors and industries where the use of digital technologies is more advanced. On the basis of a review of the literature on this area,<sup>3</sup> this section discusses three vectors of change which correspond to three different broad categories of combined applications of digital technologies in economic processes, with different implications for work and employment:

- A) **The automation of work, which refers to the replacement of (human) labour input by (digitally-enabled) machine input for some types of tasks within production and distribution processes.** Although machine automation predates even the Industrial Revolution, the use of digital technologies allows the algorithmic control of machinery and therefore many more possibilities for automation. With digitally enabled machines and artificial intelligence, all kinds of tasks can be potentially automated.
- B) **The digitisation of processes, which refers to the use of sensors and rendering devices to translate (parts of) the physical production process into digital information (and vice versa), and thus take advantage of the massively enhanced possibilities of processing, storage and communication of digital information.** This is the main way in which the attributes of the digital economy discussed in the previous section spreads to sectors and industries beyond ICT.
- C) **Coordination by platforms, which refers to the use of digital networks to coordinate economic transactions in an algorithmic way.**

These three vectors of change rely on digital infrastructures, technologies and skills already widely available in the economy. In that sense, they are clearly attributes of the deployment rather than the installation phase of the Digital Revolution, according to the scheme of Freeman/Pérez presented in the first section of this paper. They presuppose a certain degree of maturity and diffusion of digital technologies, and involve the kind of profound transformation of socio-economic structures that characterises the second phase of technological revolutions.

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<sup>3</sup> For more details, see the three separate literature reviews carried out by Eurofound in parallel to this concept paper: Peruffo, 2017; Peruffo and Schmidlechner, 2017; Schmidlechner and Peruffo, 2017



Each of these three vectors of change has the potential to fundamentally transform work and employment, both in a technical and a social way. However, each of these vectors has particularly strong effects in one of the domains of work and employment introduced in Box 2. Automation has particularly strong implications for the evolution of the types of task input necessary for the production process, and therefore the structure of employment by occupation and sector, as well as skill levels. However, it also has implications for working conditions (since the automation of certain tasks eliminates some types of work and creates others), and indirectly also for employment conditions and industrial relations (for instance, it can alter the balance of power within workplaces). The effect of digitisation is most direct and clear on working conditions, since it involves a change of the environment and nature of work processes, but for the same reasons it also involves changes in tasks and occupations, and again indirectly, on employment conditions and industrial relations. Finally, platforms are most directly a change of the social organisation of production, since they are themselves a new type of economic institution: therefore, their most obvious and direct impact is in terms of the conditions and regulation of employment, even if they can also change the division of labour (for instance, they can allow a much more detailed breakdown of tasks) or industrial relations.

Before discussing each of these three vectors of change separately, it must be acknowledged that the distinction between them is to some extent more analytical than real. Very often, digitisation, automation and platforms will be implemented simultaneously, because in fact there are very strong synergies between them. For instance, the use of advanced robots both requires and generates a massive amount of digital data on their environment: in other words, they both require and foster the digitisation of production. Platforms also require and generate vast amounts of data of the economic processes they coordinate, and they can facilitate automation by breaking up economic processes into ever smaller tasks. However, it is useful to distinguish these three vectors of change because they are distinct processes and have different potential implications. There can certainly be digitisation of production without any automation (if every process is transformed into bits, but all labour input is still performed by humans: an example could be the provision of psychological services in a virtual reality environment, with a real psychologist and a real customer behind digital avatars), as well as automation without platforms.

## A) Automation of work

This paper understands automation as the replacement of labour input by machine input for some types of tasks within production and distribution processes. The focus on tasks in this definition emphasises the link between automation and the unfolding of the division of labour. Automation presupposes a relatively advanced division of labour into highly differentiated tasks, since it is those detailed tasks which can be encoded and implemented by machines. And by replacing labour by machine input in certain tasks, it directly alters the division of labour. A significant part of recent research about the implications of automation has focused precisely on how automation has altered the structure of employment in terms of different categories of tasks and workers, and how it will do it in the future.

It is also important to emphasise that, following the above definition, what can be automated is a task rather than an occupation or a job. In human labour, tasks very rarely appear in isolation, but bundled into occupations or jobs. Consequently, all occupations or jobs involve many different types of tasks (Fernández-Macías and Bisello, 2016). Until human-level artificial intelligence exists, automation will be always focused on the replacement of particular tasks (or a set of related tasks): a technology will never be able to replace all the

tasks involved in a particular occupation. Successive rounds of automation may indeed eliminate the entire bundle of tasks associated with a particular occupation, although historically this has been relatively rare. In most cases, automation changes the task content of occupations and perhaps the relative importance of some occupations with respect to others, but it rarely eliminates occupations entirely (for a very interesting example of how the occupation of bank teller changed with the introduction of ATMs, see Bessen 2015).

Defined in general terms, automation is as old as the use of machinery in production. In the sectors of agriculture and manufacturing, automation has been very significant over the last 200 years, which is why these two sectors account nowadays for a fraction of the employment they used to account for, and yet produce many times more output. **What is new about automation in the digital age is that the use of algorithmic control of machinery and digital sensors, with ever-increasing computing power, expands enormously the range of tasks that machines can carry out.**

The tasks framework proposed in Fernández-Macías and Bisello (2016) is useful to differentiate what kinds of tasks are more or less *automatable* using digital technologies. Routine tasks (repetitive and standardised, generally as a result of a particular work organisation strategy and a detailed division of labour) are relatively easy to automate. In fact, *physical routine tasks* had already been automated to a large extent in advanced market economies before the Digital Revolution (and are today just a marginal category of aggregate labour input; see Fernández-Macías and Bisello, 2016: Figure 2). The automation of *intellectual routine tasks* (which grew with the bureaucratisation of the economy in the first half of the 20<sup>th</sup> century) is a much more recent phenomenon that has been directly enabled by the digital revolution. Although it still has some way to go, it seems inexorable (since digital technologies are much more efficient than human labour at routine intellectual tasks, and at a much lower cost). It is the decline of these two categories of labour input (routine physical and routine intellectual tasks) that is associated with job polarisation according to some authors (Autor, 2010), although others have argued that is neither the main driver nor necessarily linked to a decline of mid-skilled jobs (Fernández-Macías and Hurley, 2016).

Other types of tasks are still relatively spared from automation, although digital technologies are making strikingly fast progress in recent years. *Physical non-routine tasks* (requiring mostly hand-eye coordination and manual dexterity, typical of many service activities such as cleaning, serving and driving) seemed until very recently nearly impossible to automate, but recent advances in machine learning, sensors and big data are making it increasingly feasible. Soon, the limits of automation for this kind of tasks are more likely to be determined by social norms and economic considerations (including regulation, safety concerns and human labour costs) than technological feasibility.

*Intellectual non-routine tasks* (involving creativity, problem-solving and pattern recognition) are often considered as the most advanced expression of human activity, but they seem also increasingly accessible to automation. Deep learning techniques such as artificial neural networks are allowing computers to perform creative, problem-solving or pattern-recognition tasks, producing results that are often impossible to distinguish from those created by humans. Whether those computer models are creative in the same way as humans is a complicated philosophical discussion which is obviously beyond the scope of this paper. But the important point is that they could eventually be similar enough as to replace human labour in this kind of tasks too.

Non-routine physical and intellectual tasks account for a very significant share of total labour input in advanced market economies, and therefore their automation would significantly

affect the employment structure. Compared to routine physical and intellectual tasks, they are more likely to be in the bottom (physical non-routine) and top (intellectual non-routine) of the skills distribution, so their automation may have a centripetal rather than polarising effect on occupational structures.

There is one big category of tasks which has not been discussed yet, which object is human interaction itself (such as education, health, many kinds of leisure and social services). That is precisely why this category of *social tasks*, whether they are routine or not, are intrinsically more difficult to automate. To the extent that human interaction is what a task is about, by definition machines cannot do it unless they become indistinguishable from humans, which is still very far away even in the more radical forecasts. In fact, the moment in which machines become indistinguishable from humans would probably be of such evolutionary significance, that its potential effects on employment would be irrelevant (the problem for humans would be existential, not economic). Following this line of argument, it seems plausible that social (routine or non-routine) tasks would be the residual category towards which all the employment displaced by automation could end up. The image of a future in which robots carry out all physical and intellectual work, while human beings occupy themselves in entertaining and looking after each other does not look so bad after all. However, recent advances in human-robot interaction (for instance, for some types of social assistance or companionship) suggest that even if they are far from fully human, social robots may be able to fulfil human needs for some basic types of social interaction and companionship (Breazeal, 2017).

It is important to note that although the automation of social tasks seems unlikely for the foreseeable future, digital technologies can still have a significant effect on the demand for this kind of tasks by increasing very significantly the productivity of labour. An example in the field of education is the increasing availability of Massive Open Online Courses (MOOCs), which are free or very cheap courses available on the internet for anyone to enrol, and which use online videos and texts together with interactive exercises and algorithmic monitoring of progress to provide an alternative to face to face education. In this case, there is no automation, since the provision of the educational service is still done by a human being (the professor whose lessons have been recorded and who designed the course), and yet this model can obviously reduce very significantly the demand for human labour in education.

This latter point, in fact, reveals a fundamental problem in the very idea of automation. In the understanding of automation as the replacement of human by machine input for certain tasks, what does ‘replacement’ actually mean? Even the most advanced industrial robot requires the operation of humans to function: they have to be designed and maintained by someone, and when something unexpected happens (not encoded in the control algorithms), a human operator has to take control. In other words, **human labour can never be completely replaced by machines for the performance of any task, at least until human-level artificial intelligence is developed.** What is the difference then between a robot and any other tool that increases the productivity of workers? Is it not wrong to speak about automation at all? Should we not simply speak about technical changes that increase the productivity of some workers, and therefore reduce the amount of labour input which is necessary for some other types of tasks?

This section on automation cannot be finished without some words about the future. In the recent literature on this subject, there have been several attempts at forecasting how many jobs will disappear, and how fast. These forecasts have generated a lot of attention and anxiety. Is that anxiety justified? Assuming that the current round of automation is not fundamentally different from previous periods of productivity-enhancing technical change, perhaps history can provide some answers. Previous technological revolutions did reduce the

demand for some types of labour, which in some cases created a lot of trouble for the workers displaced (perhaps the most dramatic example is the populations literally displaced by the agricultural revolution and the enclosures that preceded the Industrial Revolution in the UK; see Polanyi, 1957). However, in the long run this surplus labour was always absorbed by the expansion of demand in other types of jobs and activities, as a result of growing income levels. That is why almost nobody works in agriculture nowadays, very few people in industry, and most in services, whereas 200 years ago it was the other way round.

But although history suggests that in the long run the employment effects of automation will probably be absorbed by the economy (although in unpredictable ways), it also shows that the large-scale processes of economic restructuring that go along with technological revolutions can be in the short and medium run socially and politically catastrophic. The terrible conditions of the working class in England during the Industrial Revolution, or the terrifying political consequences of the crisis that followed the Fordist Revolution in the 1930s, testify that. Going back to the argument presented in the introduction of this paper, this highlights the need to redesign economic institutions to deal with the social and political tensions that will very probably result from the Digital Revolution.

## B) Digitisation of processes

This paper's definition of digitisation refers to the use of sensors and rendering devices to translate parts of the physical production process into digital information (strings of bits), and vice versa. Sensors are machines that translate analogue into digital information, for instance a scanner or a digital camera. Rendering devices do the opposite, translating digital into analogue information, as for example a printer. The key advantage of this operation is that the processing, storage and communication of digital information is orders of magnitude more efficient and cheap (and thanks to Moore's Law, ever more so). By digitising a process, one can understand, control and manipulate it much better.

To understand better this idea, three of the key technologies that are bringing forward the digitisation of economic processes will be briefly discussed: the Internet of Things, 3D printing, and Virtual/Augmented Reality. **The Internet of Things** attaches sensors to outputs, inputs, components, materials or tools used in production. These sensors feed a real-time digital model of the entire process which can be analysed, monitored and controlled using algorithms, to an extent that it would be impossible in the physical world. **3D printers** literally create physical objects from three-dimensional digital models, generally by laying down successive layers of material. Although nowadays they are mostly used for prototyping and very specialised applications, 3D printers have the potential of transforming all industrial production into a digital process, from beginning to end. As in Plato's cave, all the value would reside in the ideas (digital models), while their material representations (the actual goods) would be mere shadows. Finally, **virtual reality** can move entire economic processes to the digital realm (for instance, the provision of some types of face-to-face services), while **augmented reality** can blend the digital and physical worlds by superimposing digital information over our perception of physical reality.

By digitising economic processes, these technologies expand the attributes of the digital economy previously discussed (in section 3) into potentially all the sectors of the economy: productive flexibility, fast and pervasive information availability, zero marginal costs and strong network effects. But what are the potential implications for work and employment?

1. In terms of the **tasks and occupations**, the increased efficiency of digitised process management and control is likely to be associated with labour-saving productivity growth, especially in areas such as logistics, quality control and administration. Digitisation facilitates the algorithmic automation of many of those tasks, although as previously discussed the distinction between automation and labour-saving productivity growth is a bit artificial. Another crucial effect of digitisation in terms of the division of labour is the increasing irrelevance of the physical location of labour input into production, which can contribute to a further (final?) round of globalisation. Richard Baldwin (2016), for instance, has argued that telepresence and virtual/augmented reality can facilitate the provision of face-to-face services from any distance, breaking the final boundary that protected many service activities (and jobs) from globalisation.

2. In terms of **working conditions**, the digitisation of economic processes raises some serious concern for the autonomy and privacy of workers. If every single object in the workplace is a sensor that feeds real-time information to a centralised management algorithm, the workers may legitimately feel that their autonomy and privacy are fundamentally constrained. The workplace of the future could become a *digital panopticon*. On the other hand, improved intelligence and information on work processes can also reduce risks and accidents, and remove the need to do certain alienating repetitive tasks (for instance, quality control is largely about checking a million times that something is up to standard, which a sensor can easily monitor in real time). Digitisation is also likely to spread work methods and skills of ICT into other sectors of the economy, such as manufacturing, retail or other services.

3. In terms of **employment conditions and industrial relations**, digitisation makes possible more complex organisational forms of production, and may facilitate the breakdown and subcontracting of an increasing amount of tasks even in traditional production processes. Subcontracting and outsourcing (even crowdsourcing) can imply worse conditions of employment for workers (in terms of stability, income and working hours), and make collective representation more difficult by blurring company boundaries and breaking solidarities. On the other hand, the digitisation of all types of economic processes open them up for alternative methods of collaborative decentralised production such as those discussed in Box 3. An example is the “makers” movement of some 3D printing enthusiasts and ‘artisan-hackers’, which use Open Source licences for digital designs and hardware, and defend a socio-economic model of cooperative, non-hierarchical and sustainable production (Anderson, 2012).

### C) Coordination by platforms

Platforms are digital networks that coordinate transactions in an algorithmic way. There are two important elements in this definition. The network is a structured digital ‘space’ where goods or services can be offered or demanded. These online spaces systematically collect, organise and store large amounts of data about the platform users and transactions. Some of these data are fed back into the users as records of successful transactions or evaluations, which serve both the purpose of facilitating trust between users and incentivising good behaviour. The second key element of platforms is a set of algorithms for matching and coordinating transactions in an automated way. The algorithms provide a governance structure to the platforms, incorporating encoded rules as well as automated monitoring and enforcement mechanisms.

Platforms are hybrids of markets and firms: the network and algorithmic components of platforms perform the functions of each of those basic economic institutions. Whereas the structured online space (network) provided by platforms makes them similar to markets (as spaces where supply and demand can meet), the governing algorithms make them similar to firms (as structures of command). The algorithms of platforms are essentially automated forms of management.

What distinguishes platforms from the other two vectors of change previously discussed (automation and digitisation) is that **platforms are at least as much a form of institutional as a form of productive innovation**. There is in fact some debate about the extent to which platforms really enable a more efficient organisation of production or simply facilitate the exploitation of labour and competitors. From a purely technical perspective, platforms enable a very efficient and transparent distribution of information over large numbers of users, and algorithmic matching and coordination is very cost effective relative to human coordination. It has been shown that they enable a better use of capacity and resources (Cramer and Krueger, 2016), and facilitate transactions of low economic value that were not previously viable. But on the other hand, at least part of the success of some well-known platforms can probably be attributed to their capacity to circumvent regulation in the markets they operate (exploiting competitors) and to the weakened position of workers compared to traditional firms (exploiting workers).

In this sense, the key policy question with platforms may be how to benefit from their superior coordinating efficiency while avoiding their potentially negative social outcomes, a question which necessarily revolves around their institutional design and regulation. Platforms are to a large extent a new form of economic activity that does not fit very well in the existing regulatory frameworks. To ensure that these regulatory frameworks continue to fulfil their social coordination and protection functions, they may have to be changed. But more innovative policy approaches could be tried also, such as promoting the expansion of alternative forms of platform governance with more desirable social outcomes. For instance, open source algorithms (with rules and enforcement mechanisms democratically agreed by the users) in peer-to-peer networks can in principle be at least as technically efficient as proprietary commercial models, while necessarily generating fairer distributional outcomes and a more even ground for exchange.

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#### **BOX 4: Classifying platforms**

There are many different types of platforms, so it is useful to classify them in some way. First, it is important to note that this paper's definition refers to the coordination of economic transactions (involving exchange of goods and services), and therefore it excludes online spaces that are sometimes considered as platforms too, most importantly social networks.

Different authors use different classification criteria, among which the following can be highlighted (with some examples):

1. **Platform ownership:** The main distinction here would be between privately owned platforms, generally for-profit businesses (Uber or Airbnb), and platforms which are commonly owned by their users (Blockchain). In most cases, private platforms generate revenue by charging a fee or percentage of the value of each transaction; but in some cases (especially if transactions are not commercial) they can charge entry fees or generate revenue by displaying ads.

2. **Economic nature of transactions:** There are commercial and non-commercial transactions (if the services contracted are paid or not) facilitated through platforms. The category of platforms for non-commercial transactions corresponds most directly with the original idea of the 'sharing economy', where goods and services are 'shared' or 'exchanged' rather than 'bought'. If the goods are simply shared, with no expectation of reciprocity

(beyond recognition), it is a pure gift economy (as Couchsurfing); if the goods are exchanged but with no money involved, it is a barter economy (as Simbi). It should be noted that even if the transactions are non-commercial, the platforms themselves can be for profit businesses, generally generating revenue by subscription fees or advertisement (as Couchsurfing).

3. **Content of transactions:** The main difference here is between platforms for the exchange of goods (including Ebay or Amazon Marketplace) and platforms for the exchange of services (Uber, Airbnb, Taskrabbit). The focus of this paper is in the second type (service platforms). Service platforms can be further differentiated:

a) **Online vs. local:** Commercial service online platforms correspond to the widely used concept of **crowd work** (Mechanical Turk), whereas commercial platforms providing personal local services are often referred to as the gig economy (Taskrabbit).

b) **Types of tasks involved:** physical (Taskrabbit), intellectual (Mechanical Turk), social (Bubble). Another differentiation can be between routine (repetitive and standardised, as usual in Mechanical Turk) and non-routine tasks (which are more complex and/or require creative skills), or between micro tasks (again the best example would be Mechanical Turk) and larger tasks/projects (such as the freelance services exchanged in Freelancer) and therewith related required skills of the worker (low, medium, high).

The heterogeneity of platforms is increasing as they spread across different sectors and activities, which implies that more criteria are necessary for a comprehensive classification. Eurofound is currently working on such a detailed classification specifically aimed at crowd employment (paid work organised through online platforms).

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What are the potential implications of platforms for work and employment? The most immediate and direct implications of platforms are in terms of employment conditions, since they are a new form of economic organisation that does not fit clearly in existing categories of dependent employment and self-employment. There is a legitimate concern that some platform workers could combine the worst of both worlds: the more limited social and contractual protection of self-employed workers with the dependence and lack of autonomy of employees. However, the very diverse nature of platforms can be associated to very different situations in terms of employment conditions.

The same ambiguity in the classification of platform workers as independent contractors suggests difficulties for collective representation and participation. As independent contractors, they are not entitled to collective bargaining vis-à-vis their platforms (or clients); and although unions do represent self-employed workers in some countries, they tend to play a marginal role. Furthermore, the very nature of work activity in platforms makes collective organisation less likely than in traditional companies. The manager is an algorithm, co-workers are competing independent contractors (and potentially geographically dispersed) with whom there is hardly ever any personal contact, and the work is often carried out in isolation (or in contact with the client). However, there have been some recent examples of mobilisation of platform workers (Tassinari and Maccarrone, 2017), especially in the category of commercial platforms providing personal local services ('gig economy'). Incipient forms of online collective organisation are also emerging for crowd workers, for instance through the use of internet boards and platforms such as Turker Nation (Martin et al, 2014). These mobilisations may become more frequent as platforms grow, perhaps giving rise to new forms of industrial relations.

The impact of platforms for the division of labour is less obvious, but it can also be important. The organisational efficiency of platforms allows an extremely detailed division of labour into very small tasks, which can make them tedious and repetitive; platform work is also often carried out in conditions of isolation. These are certainly not ideal psychosocial conditions for work, and can be associated to alienation. At the same time, some categories of platform work can provide autonomy and flexibility, allowing people to participate in employment that may otherwise find it very difficult. The different categories of platform work are very

heterogeneous, and can have very different implications in terms of employment and working conditions.

## 5. Final remarks

Embarking on a new programme of work for social research is very exciting but inherently risky. Especially if the subject is as broad and ambitious as the implications for work and employment of a technological revolution which is still unfolding. It is easy to be overtaken by the utopian transformative potential of the new technologies, even if they may never be realised. Or to fall on the opposite mistake assuming always the worst possible uses for new technologies, or even attributing humanlike motivations and effects to them ('will robots steal your job?'). It is easy to overgeneralise, to be inconsistent, to focus on trivialities while missing important underlying trends. Because the subject itself is fascinating (new technologies give us glimpses of possible futures), even that kind of research may generate some interest. But it is unlikely to be of much use for assisting the democratic process in the design of better policies, which is the ultimate aim of this work.

The main aim of this paper was to minimise those risks as much as possible, and initiate Eurofound's programme of work on the digital age on grounds which are as solid as possible. For that purpose, it has tried to provide clear demarcations for the key concepts in this area, and make explicit the assumptions that underlie this programme from its inception. Of course, the different research strands that will be carried out within this programme over the years will necessarily imply some readjustment of these concepts and assumptions. After all, that is the whole point of research, to continuously update our knowledge about the world on the basis of new evidence. But interpreting new evidence requires clear concepts and analytical tools, and this paper has tried to provide that to the extent that is possible for a subject which is still very much in flux.



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## Glossary

**3D printers:** machines that literally create physical objects from three-dimensional digital models, generally by laying down successive layers of material.

**Algorithm:** a set of precisely defined steps and rules to accomplish a task.

**Automation of work:** the replacement of (human) labour input by machine input for some types of tasks within production and distribution processes. What is new about automation in the digital age is that the use of algorithmic control of machinery and digital sensors, with ever-increasing computing power, expands enormously the range of tasks that machines can carry out.

**Coordination by platforms:** use of digital networks to coordinate economic transactions in an algorithmic way.

**Digital age:** a historical period marked by a widespread use of digital technologies in different aspects of human activity, including the economy, politics and most forms of human interaction

**Digital goods:** strings of bits (digital information) that have economic value. The generalised use of digital technologies in production tends to make digital goods more central for the economy.

**Digital Revolution:** a general acceleration in the pace of technical change in the economy, driven by a massive expansion of our capacity to store, process and communicate information using electronic devices

**Digitisation of processes:** use of sensors and rendering devices to translate (parts of) the physical production process into digital information (and vice versa), and thus take advantage of the massively enhanced possibilities of processing, storage and communication of digital information.

**Division of labour:** the separation and allocation of tasks to different persons cooperating in an economic process. The division of labour is both a technical attribute of economic activity (a method that allows a better coordination and efficiency of labour input into the economic process) and a social attribute (since the division of labour is a form of social coordination that gives rise to a social structure).

**Economic institutions:** rules, structures and mechanisms of social coordination of the economic process. They provide stability and social coordination, and deal with some of the external effects of economic activity.

**Employment conditions:** contractual and statutory conditions of the work relation that have an impact on the well-being of the worker.

**Industrial relations:** the more or less institutionalised ways in which workers and employers organise their relations and settle their disputes.

**Intellectual property rights:** monopoly rights given to the creators of informational goods over their use and reproduction, for a given number of years, backed and enforced by the state. The two most important types of IPR are patents (for inventions with industrial applicability) and copyright (for creative, intellectual or artistic works).

**Long-tail markets:** massively big markets with near perfect information, where there is economic value in the provision of even extremely rare goods or services.

**Massive Open Online Courses (MOOCs):** free or very cheap courses available on the internet for anyone to enrol, and which use online videos and texts together with interactive exercises and algorithmic monitoring of progress to provide an alternative to face to face education.

**Network effects** (also **demand-side economies of scale**): situation in which the value for consumers of a particular type of good increases with the number of users. Network effects tend to cause lock-in, because the cost of switching product or service also grows with the size of the network, to the extent that can effectively make customers entirely dependent on a particular vendor.

**Occupations:** coherent bundles of tasks that require specific skills, corresponding to different positions within the division of labour in society.

**Tasks:** units of work activity that produce output, and which are coherently bundled into occupations.

**Technology:** in a general sense, tools and methods used for carrying out the economic transformation process. In a more specific sense, *a technology* is a domesticated natural phenomenon: a device that allows to reproduce and control a mechanism observed in nature. Technologies can be combined, and can facilitate the discovery and domestication of new natural phenomena.

**The Internet of Things:** sensors attached to outputs, inputs, components, materials or tools used in production. These sensors feed a real-time digital model of the entire process which can be analysed, monitored and controlled using algorithms, to an extent that it would be impossible in the physical world.

**Winner-takes all markets:** markets in which a single provider of a particular type of good or service tends to concentrate the vast majority of economic activity.

**Working conditions:** physical and psychological requirements and attributes of work and its environment that have an impact on the well-being of workers.

**Zero marginal costs** (as applied to digital goods): since digital goods are non-rival and infinitely expandable, they imply no marginal costs and would thus tend towards a price of zero in competitive markets.

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