Key Technologies in the Digital Transformation:

Towards a Social Science Taxonomy of Digital Technology

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Abstract

This paper has been commissioned by FEPS and SAMAK for the report 'A Progressive Approach to Digital Tech: Taking Charge of Europe's Digital Future'. The paper aims to map the key technologies underpinning the digital transformation, and to provide a structured framework suitable to analyses of their effects in the world work, the economy, democracy and citizens' everyday life. Digital platforms, the merging of the internet and our physical environment (e.g. the 'Internet of Things'), and automated decision-making systems, more commonly known as 'artificial intelligence', are identified as particularly capable of having a significant impact. The paper concludes that under the prevailing socio-economic conditions, these digital technologies, especially when considered together, carry significant risks for the cohesion of European societies.

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INTRODUCTION

Digitalisation is associated with fundamental societal and economic changes, while simultaneously permeating our everyday lives. Analysts have been occupied with the transformative impact of information and communications technology at least since the early 1960s. Nevertheless, the social sciences are still grappling to understand the wider implications of the digitalisation of the economy. The topic is higher on the agenda than ever, with ongoing debates related to the digital economy, the future of work and the right to privacy and data ownership in a digital world – to name a few. Yet, debates and studies of digitalisation often lack a common understanding of what, precisely, is being discussed. To our knowledge, there exists no widely used and comprehensive taxonomy of digital technologies that is suitable for structured analyses of the aggregate societal outcomes or policy challenges of digitalisation. This paper aims to propose a basic framework or taxonomy suitable to distinguish key technologies spurring societal change, as well as the policy challenges arising.

Aim of the paper

This paper is meant to serve as background material and analytical support for the FEPS SAMAK report "A Progressive Approach to Digital Tech - Taking Charge of Europe's Digital Future". Addressing how digital technology permeates our everyday life as citizens, workers, consumers and voters, the FEPS SAMAK report aims to understand the economic and social impact of digitalisation, and discusses whether and how it can be reconciled with political principles such as a sustainable environment, income security, decent work, education for all and gender equality. For such an undertaking, it is necessary to have a clear understanding of what digitalisation is, as well as the key technologies involved. This paper serves as background for the mapping of the key technologies of the digital transformation found in the report. The aim of the paper is thus twofold: To provide a structured framework suitable to analyse the key technologies associated with digitalisation, and single out the political challenges they raise.

The challenge

The sheer scale and width of digitalisation make it difficult to comprehend exactly how advancements in digital technology will affect various societal and political issues. It is nigh impossible to comprehensively map and describe *all* technologies that trigger societal changes, let alone detail the mechanisms through which they do so. In social science literature on digitalisation, this problem is often circumvented either by employing an exceedingly general and often diffuse concept of "digitalisation" (or "new technologies", "ICT" etc.), or by explicitly limiting the analysis to one or a select few technologies. For analyses of societal and institutional change, as well as for political purposes, there are shortcomings with both of these approaches. An exceedingly broad definition (or lack thereof) can lead to a lack of clarity about what, exactly, is studied. Conversely, limiting the scope to one particular technology risks missing the interaction of various technologies, as well as their aggregate social impact. This is of increasing importance given the encompassing, complementary and crosscutting nature of many emerging technologies.

From digitisation to digital transformation

In the broadest sense, all activities that use digitised data are part of the digital economy: in modern European economies, that means virtually all parts of the economy. *Digitisation*, defined as the process of converting information from a physical format into a digital one, involves rationalisations such as typing on a computer instead of a typewriter. While important, digitisation is neither new nor revolutionary. *Digitalisation* is a wider term, usually referring to the process of leveraging digitisation to improve processes, change business models or restructure domains of social life around digital communication and media infrastructures. *Digital transformation* is a related concept that requires the implementation of digital technologies – i.e. computers of all shapes and sizes – to alter the very nature of a business or a social domain. The framework suggested here focuses on the technologies that enable digitalisation and that make the current digital transformation both quantitatively and qualitatively different from earlier technological change. That is, the primary focus is on new and emerging digital technologies and the more sophisticated digital technologies (e.g. AI, robotics) rather than more general applications, such as websites.

Towards a taxonomy

Due to the complexity and scope of digitalisation, a comprehensive account of all relevant technologies, their use cases and possible societal outcomes is hardly doable, nor useful. In the proposed framework, the technologies described are thus selected with the aim of the report in mind, on the basis of their potential societal impact on *work, democracy, economy* and our *daily lives* as well as the *policy challenges* that the technologies create, address or amplify. Moreover, the technologies are categorised according to their complexity and applicability, i.e. from the basic technological building blocks of digitalisation such as processing power and data storage via basic enabling technologies such as AI algorithms and big data analytics, to complex technology systems such as robots or autonomous vehicles.

Structure of the paper

The paper first briefly explores existing frameworks and taxonomies of digital technology, and the need for a more comprehensive framework fit for the purpose of social and political analysis. In the following sections, key hallmarks of digital technologies and the policy challenges they may create in various fields are discussed, before a tentative framework or taxonomy for understanding and classifying emerging digital technologies is outlined. The last section takes a closer look at AI, digital platforms, IoT and cyber-physical systems, all identified to be central to understand the societal and political outcomes of digitalisation.

1. EXISTING FRAMEWORKS: A BRIEF LITERATURE REVIEW

In order to be specific about the subject of inquiry and organise our thoughts around processes and outcomes, a broad framework of relevant technologies and the ways they influence our societies is needed. Rather surprisingly, then, very few studies concerning digitalisation attempt to construct even general analytical frameworks that treat various technologies systematically, let alone comprehensive taxonomies. Many either rely on a general concept of digitalisation, or choose to focus on a single or a few key technologies and use cases – often without explaining why the delimitations are made. This pertains not least to a large part of the expanding literature on the "future of work". Yet, in the literature focused on digitalisation within manufacturing, and specifically in reports and studies focused on the concept of *Industrie 4.0*, a number of classifications and lists of key technologies have been proposed. For example, Lorenz et al (2015) hold that nine technologies are enabling factors of Industry 4.0: Big data analytics, autonomous robots, simulation, systems integration, industrial IoT, digital security, cloud computing, additive manufacturing and augmented reality. These technologies make it possible to continuously gather and analyse data of the entire production process, enabling faster, more flexible, and more efficient production.

In a review of the literature, the RSA Future Work Centre was unable to find *any* framework in existence aimed at systematically making sense of technology's impact on the world of work (Dellot et al. 2019:21). Many reports instead select a specific technology, or a set of technologies, and extrapolate trends in order to create scenarios for future development. Lacking an overarching framework for analysing technology's impact on the world of work, Dellot et al. (2019) constructed a basic taxonomy, consisting of four ways technology can influence the quality and quantity of work: automation, brokerage, management and digitisation. This relatively simple framework aptly captures the main issues and debates in the future of work literature and is drawn upon below to illustrate policy challenges regarding work. However, it is of limited use in terms of analysing the broader societal impact beyond the world of work, e.g. in terms of impact on our personal lives, our democracies or the economy as a whole.

Philosophical approaches, such as the post-phenomenological approach and material engagement theory (e.g. Ihde 1990; Verbeek 2005), offer a compelling framework for understanding how we use technology, based on how individuals interact with technological environments and with the world through technology. Aydyin et al. (2019) uses a similar approach to highlight how digital technologies are not only devices that we explicitly *use,* but are increasingly an intrinsic part of the material environment we live in, mediating our relations with the world. These approaches do not, however, tell us much about societal or political level effects and changes.

On a more technical level, several national advisory committees on technology, including members of the European EPTA network of parliamentary technology assessment, have produced a number of reports that include analyses of a large number of specific technologies, as well as ways of classifying them. For instance, the classification proposed by the secretariat for the Norwegian government's digitalisation strategy (Digital21:2018) highlights eight 'basic technologies' (AI, algorithms, connectivity, 3D-printing, blockchain, visualisation, sensors and big data) and eight 'systems technologies' (autonomous systems, drones, 5G, digital twins, IoT, AR and VR, cloud computing and robotisation). This distinction has provided inspiration for the framework proposed below.

The Finnish parliament's Committee for the Future, which is ambitious in scope and has developed foresight methods that have since been adopted by the OECD and the European Commission, identifies ten main technology groups in their 2016 report (p16):

1. Instrumentalisation of everything (measurement and control);
2. Artificial intelligence, (AI) and algorithmic reasoning;
3. Digitalisation of processing and information storage;
4. Traffic, mobility and logistics;
5. Production of goods and services;
6. Material technology;
7. Biotechnology and pharmacology;
8. Energy technology;
9. Digital crowdsourcing platforms;
10. Globalising technology interfaces.

In an updated analysis (2019), the Committee identifies no less than 100 "most promising technologies", 100 legislative objectives to ensure the streamlined adoption of these technologies and

200 "professions of the future" that meet the upcoming skill challenges. While both comprehensive and well structured, this approach appears both excessively detailed and too broad in nature to be employed for succinct analyses of the political issues arising from new technologies and the digital transformation of society; not least as several of the technologies and areas considered are not necessarily digital, nor new.

2. CHARACTERISTICS OF DIGITAL TECHNOLOGY

In order to narrow and sharpen the analytical scope to the technologies and policy challenges most central to the societal consequences of digitalisation, this paper highlights new digital technologies that 1) leverage the exponential growth in computing power, storage and connectivity; 2) are data driven and 3) have a cross-cutting nature that enables society-wide impact. Technologies that display all three of these traits are uniquely positioned to change our societies. A number of digital technologies share the first two traits, which in essence means that they take advantage of the rapid development in computers as well as the vast and growing amounts of data gathered in increasingly digitalised societies. While most technologies have specific fields of application, several new digital technologies can be applied for a vast variety of uses that cuts across both various scientific fields and most economic sectors. Technologies that display all these traits can potentially advance very quickly due to the combined effect of ever better computers and more data, with society-wide consequences.

Leveraging exponential growth

Growth in connectivity and computing power, at an exponential rate, is reducing the cost of information sharing and data processing. Moore's law stipulates that the capacity of integrated circuits (microchips) double every 2 years (Moore 1965). This prediction of exponential growth in computer chips has proven surprisingly accurate since its formulation in 1965. Exponential growth can also be observed in technologies such as data storage, pixel density and photonic transmission, with resulting increases in the capacity to gather, store, process and share data. This growth is driving the rapid development of current digital technologies. The exponential growth of digital technologies is a long-term trend set to cause fundamental societal change, independent of whether the latest tech buzzwords turn out to be worthy of their current hype or not.

Data driven

The digital economy runs on data, created by both human users and by physical sensors and cameras. Advances in data analytics make it increasingly easy to generate inferences from data collected in different contexts, including those in which we as individuals are not aware that we create and share information. Our personal data is constantly mined, analysed and monetised for advertising as well as optimisation of algorithms and AI. By organising data sets and "treating" them, using software, algorithms and computing power, data become useful and sellable. As the cost of data collection, storage and processing continues to decline, ever-larger volumes of data will be generated from the internet of things, smart devices, and machine-to-machine communications. Data is used to improve advertising, insurance, credit ratings, self-driving cars, retail delivery logistics, water supply management, and so on – everywhere, big data may help to understand and decide, for public purposes, for profits or for surveillance. Data itself is becoming a driver of productivity growth, prompting a recast of our thinking on infrastructure to include broadband networks, cloud computing and data capture and storage (OECD, 2015). According to Valenduc and Vendramin (2017), it is the use of Big Data, as a strategic economic resource, that distinguishes the current wave of digitalisation from previous technological progress, representing a 'quantitative and qualitative leap'. Data is an intangible asset that can be reproduced and transferred at close to zero marginal cost.

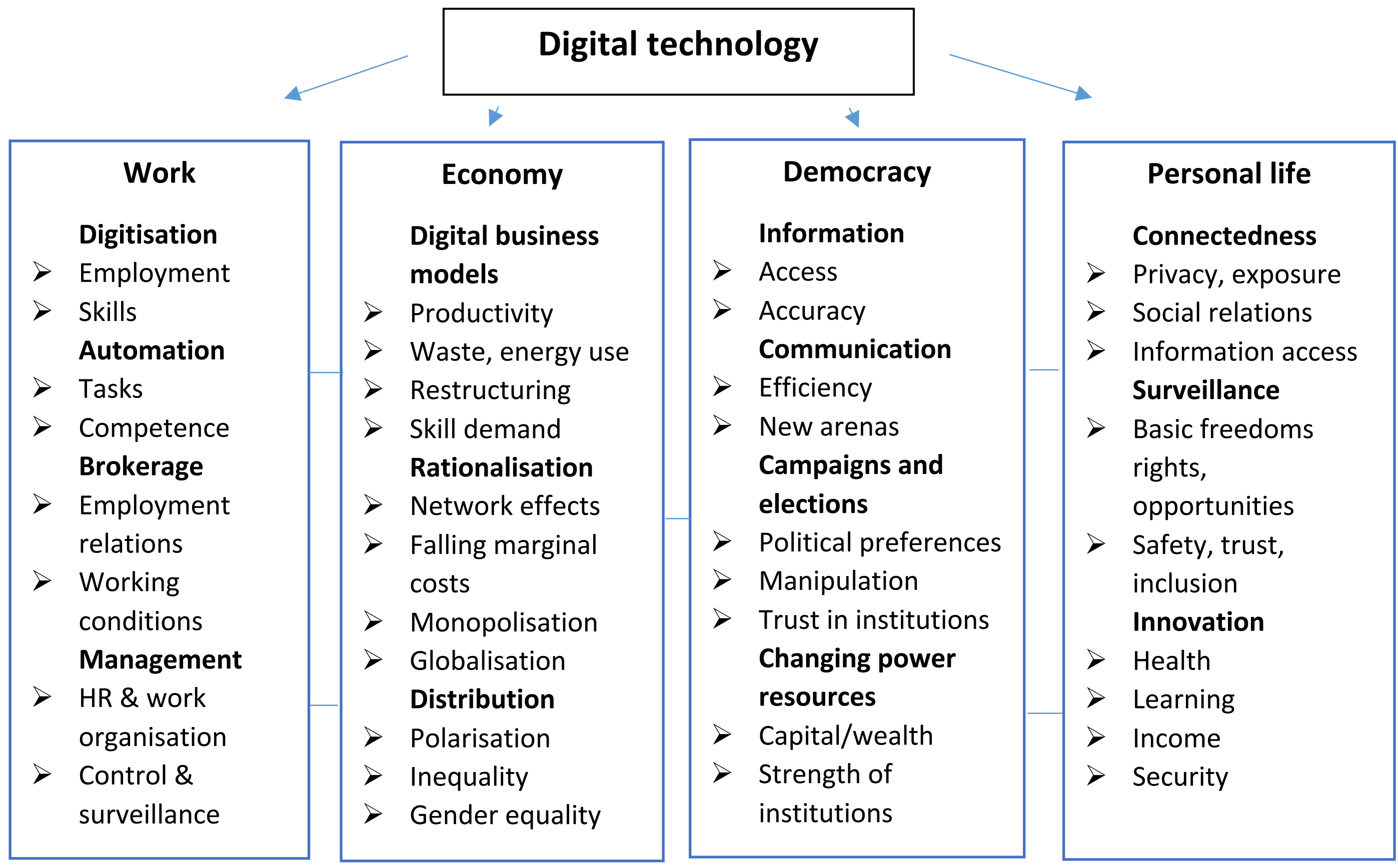
Cross-cutting and society-wide

Digital technologies are not just about our computers, smartphones and 'stuff on the internet'; they increasingly permeate everyday life and the physical world. The Internet of Things, cyber-physical systems, facial recognition and smart homes, factories and cities are examples of how the digital and physical world are converging. Thus, digitalisation is cross-cutting and influences all industries, enabling new ways of organising as well as new forms of production. The most important technologies are not limited to use cases within a single industry or practical application, but are cross-cutting in the sense that a technological advancement can be used in a variety of applications in all sectors of the economy and affect our lives in various ways. The technologies highlighted in the framework proposed below all share these traits. This cross-cutting nature enables society-wide impact, which is mediated by social and economic actors, institutions and policies in a complex interplay that varies with context. Consequently, the framework outlined below is not intended to fully capture this complexity of implications or to be universally applicable; it merely aims to be illustrative of current debates and issues in a European context.

3. DIGITALISATION AND SOCIETAL CHANGE: MAPPING KEY POLICY CHALLENGES

The framework suggested here is structured around four areas of societal change: *work, economy, democracy* and *personal life*. This corresponds to the aims of the report *A Progressive Approach to Digital Tech,* concerned with the policy challenges related to the digital technologies that permeate our everyday life as citizens, workers, consumers and voters, for which this paper serves as analytical support. In order to pinpoint and narrow down the most relevant technologies and to be able to address societal impacts in a systematic way, this section singles out a number of mechanisms through which digital technology is related to societal change in the four abovementioned areas. A simplified graphic representation is presented in figure 1. The taxonomy presented in the next section illustrates the impact of a selection of the most central cross-cutting digital technologies positioned to create policy challenges in each of these fields.

Figure 1: Effects and main policy issues associated with digital technologies



Work

The effects of new digital technologies on employment, production processes, work organisation, and labour markets are expected to be far-reaching. Digitalisation will influence the quality, quantity and nature of work, changing the types of jobs available as well as where, how, and by whom they are done. Digitalisation will have consequences for the working conditions of individual workers and for competence needs at the workplace level, and in turn for structures that regulate the relationship between employers and workers. The way digital technology does this may be summarised in four key mechanisms (Dellot et al. 2019:20): Digitisation, automation, brokerage and management.

Digitisation: Where technology turns physical goods and knowledge into data that can be captured, shared and replicated at low cost. The technologies enabling digitisation range from the personal computer (enabling digitisation of documents), the internet and digital platforms (enabling digitisation of communication, commerce and exchange of music, video, news etc. online), to the Internet of Things that enables digitisation of vast amounts of data about the physical world including buildings, machines, production processes, vehicles and workers themselves. Digitisation is changing work tasks and business models, driving restructuring, job loss and job creation, and demand for new skills and lifelong learning. This raises a number of policy challenges, not least related to the provision of lifelong learning, and facilitation of efficient, flexible and just restructuring processes.

Automation: Where technology can perform a process or procedure with minimal human assistance, completing work tasks or changing who is responsible for undertaking them. Key technologies include AI, machine learning and cyber-physical systems such as robots, autonomous vehicles, smart factories etc. Automation can have profound effects on the labour market and number of jobs, both in terms of job loss in certain companies and industries where technology can replace humans, and new opportunities elsewhere where increased demand or new tasks are created. Employment can be expected to decrease in occupations involving routine tasks that can be automated – often manual labour, but increasingly also advanced cognitive work – and to increase in occupations where human labour is complementary to technology. This increases the need for specialised skills, while decreasing the need for routine work. This changing skill demand has been linked to changes in the occupational structure, with increasing polarisation in skills and pay (Autor et al. 2006; Goos et al. 2010; Eurofound 2017).

Brokerage: Where technology mediates exchange between employers, workers and customers, sometimes replacing multiple brokers with a single platform. Work mediated by digital platforms – e.g. Uber – is often described in terms of gig- sharing- or on-demand economy. The key technologies enabling efficient digital brokerage include AI algorithms, big data processing and cloud storage used by the platforms, as well as increased connectivity including internet and smartphone usage among potential workers and customers. Digital brokerage of work raises a number of policy issues surrounding decent work, pay and working conditions, as well as the possible erosion of the wage-earner model and industrial relations central to the European social models. Platform work promises flexibility for firms, customers and workers, but also creates new insecurities while potentially transforming the traditional employer-employee relationship with significant implications for labour market policy and social dialogue, as well as working conditions (OECD 2016; Dølvik & Jesnes 2018). Work on platforms tend to be classified as independent work, linked to limited access to the rights and social benefits granted to employees, including the right to collective bargaining. The possibilities of mobilising through collective action is thus limited, affecting the power resources of workers. Platform work is also linked with a more general trend of rising atypical employment and dualisation of labour markets (Emenegger 2012; Eurofound 2017).

Management: Where technology aids the recruitment, monitoring and organisation of work processes. Key technologies include digital management tools such as customer relationship management (CRM) systems, AI-powered recruitment software and platforms, gamification of work and communication technology allowing remote work, as well as technologies that track employees physically – including AI-enabled facial recognition, video surveillance, GPS tracking, sensors etc. Policy challenges arise related to worker's right to privacy, the power relations between employers and employees, potential discrimination, the (non)transparency of algorithmic decision-making, work-life balance, psycho-social work environment and more.

Economy

Closely related to the effects on working life, technology also has obvious micro- and macroeconomic effects. At its core, new technology is a main driver of productivity growth and historically a key driver of economic growth. The latter depends, however, on whether the value added is distributed in ways that ensure sufficient growth in demand. Digital technology also has profound effects on business models, skill needs and inequality. The impact of digital technology on these fields can be explained through the mechanisms of *digitalisation of business models*, *rationalisation* and its *distributional effects*.

Digitalisation of business models denotes processes through which digital technologies change or transforms the business logic to create and capture value for consumers and businesses. The rise of digital platforms, e-commerce, social media and big data create opportunities both for reinvention of traditional business models and more radical disruption of traditional industries. The use of digital technology can reconfigure value chains, create new markets, enable sharing of under-used assets and much more. Business models enabled by new technology often take the form of *digital platforms* that harness digital connected ecosystems and the ability to efficiently gather, record and refine data, to achieve rapid scale (Srnicek, 2017). Platforms and other data-driven and online business models leverage data to improve services, provide targeted advertising, and gain market insight. This gives rise to a logic of 'surveillance capitalism' in which gathering and storing as much data as possible can increase competitiveness (Zuboff 2019). Conversely, digitalisation of business models can also entail a reconfiguration of production in the direction of re-shoring of manufacturing and local micro-production, aided by the use of robots and 3d-printing.

Policy challenges related to the digitalisation of business models arise in various fields including taxation, competition law, innovation policy and industry-specific regulations, as well industrial relations and collective bargaining. The most pressing challenges include how global tech corporations can be efficiently taxed and regulated, as well as how to best regulate emerging types of digital markets and businesses in order to strike a balance between laissez-faire deregulation and overly conservative approaches that stifle innovation.

Rationalisation, understood as the reorganisation of production processes to increase efficiency, often based on the formalisation, transformation or automation of work processes, is arguably the most important motivation that drives the introduction of digital technologies throughout the economy. Use of digital technologies can increase labour productivity and foster economic growth. Though it is a well-known paradox that "you can see the computer age everywhere but in the productivity statistics" (Solow 1987), there is growing evidence that digital technology will be crucial to uphold continued economic growth, and indeed already is. Examples include estimations that AI has the potential to double economic growth by 2035 (Daugherty & Purdy 2016), and that the use of robots in 17 countries raised labour productivity by 0.36 percentage points annually over the period 1993 to 2007 (Graetz and Michaels 2015). Several studies demonstrate that the introduction of new technologies has historically increased productivity, wealth and employment in the long term, despite short-term job loss or displacement (Crafts 2010). ICT technologies in general and AI in particular has vast potential to rationalise production of both goods and services. New productivity-enhancing technologies range from industrial robots and automated maintenance scheduling in factories to chat-bots and digital customer profiling based on big data in the service industries.

The policy challenges arising from technological rationalisation are related firstly to enabling the extraction of its potential economic gains. This requires leveraging and developing comparative advantages through optimal market- and innovation policies, as well as meeting new skill demands with educational systems providing a skilled workforce, the required technical expertise and opportunities for lifelong learning. Secondly, challenges arise in tackling rapid restructuring in various industries, companies, and communities, with increasing demand for retraining, employee mobility and adequate social safety nets. Thirdly, the distribution of the economic gains of productivity increases are paramount political concerns. This includes changes in the wage share, the rate of capital return, taxation etc.

Distributional effects of digital technology, related to both rationalisation effects and new business models, create a number of policy challenges. First, digital technologies may under certain conditions increase inequality. The introduction of new technologies has historically tended to most affect lower and middle-skilled workers in routine jobs that are easy to rationalise and automate. This can create occupational polarisation, referring to a growth of the number of jobs both at the high skill/wage and low skill/wage ends of the occupational distribution, relative to a decrease or stagnation of the number of jobs in the middle of the distribution. This pattern has been observed from the 1990s, in the U.S. (Autor et al. 2003; 2006) and more recently in many European countries (Goos et al. 2010; Eurofound 2017). The World Bank (2019) estimates that since 2000, the percentage of jobs involving routine skills has fallen from 42 to 32 percent in developed countries. In conjunction with a rise in atypical forms of employment and often a decrease in the wage share, technology-driven rationalisation may thus contribute to rising inequalities. Related challenges include de-skilling in certain affected professions (Braverman 1974; Susskind & Susskind 2017). Digitalisation also affects gender equality, notably through the existence of a gender divide in IT and STEM (science, technology, engineering, and mathematics) jobs, with low proportions of women in these professions contributing to the gender pay gap (EIGE 2018). Huge efforts are likely to be required in occupational training and re-skilling to prevent growing skill-mismatches, wage gaps and exclusion in the lower end of the labour market.

Digital business models also have significant distributional effects. The direct exchange of data enabled by computers, smartphones and the internet has made intermediaries in different sectors redundant as digital technology has allowed producers – e.g. of games, books, newspapers, music, film etc. – to circumvent traditional intermediaries and directly reach consumers. Such disintermediation can both increase market efficiency and significantly alter market structures and bargaining positions. As data and software can be reproduced and shared with low cost, data-driven and digital business models often create decreasing marginal costs. In combination with the strong network effects associated with digital platforms, this creates markets conducive to the formation and exertion of monopoly power, in which a handful of global corporations have grown to control much of the digital economy (Rifkin 2014; Rogoff 2018). The globalisation of markets associated with digital and online services makes it challenging to optimally tax and regulate businesses, and countries not at the forefront of these technological developments risk that the gains are extracted by multinational corporations and neither sufficiently taxed nor reinvested in national economies.

Democracy

Digital technologies are increasingly becoming an intrinsic part of political processes of vital importance to our democracies. They influence the functioning of our political systems by revolutionising the access to *information,* enabling more efficient *communication* and opening up new areas of deliberation and debate. Simultaneously, digitalisation is changing the nature of *political campaigning* and the integrity of elections, with potential for political manipulation and voter fraud. Additionally, a number of specific policy fields are being transformed.

The transformative effects of digital technologies on the **access to information** and the efficiency and nature of **communication** is changing political landscapes and the functioning of democracy. At its best, technology broadens access to information, removes barriers for political participation and creates new arenas for democratic deliberation and debate. Politics can respond more directly to citizens, and vice versa. Digitalisation can also improve the quality and coverage of public services and political participation by supporting the free flow of information and knowledge, the freedom of expression, association and assembly and hence the protection of individual liberties. Other effects also create cause for concern: Polarisation of public debates and the creation of echo chambers seems to increase on new communication platforms such as forums, comment sections, Facebook and Twitter. Personalisation and algorithmic control of newsfeeds on social media and online news outlets can contribute to polarisation, being designed mainly to capture user's attention and consequently often confirm biases or promote sensationalist content. This is illustrated not least by the notion of a 'post-truth society', where objective facts seem to be less influential in shaping public opinion than appeals to emotion and personal belief. A related concern is that these powerful means of governing communication and information are increasingly owned and controlled by a small number of private companies, potentially creating sharper divisions in terms of **power resources** to influence political processes of vital importance to democracy. These are key challenge for policymakers, the media and society as a whole.

Political campaigning is fundamentally changed by the proliferation of the internet, social media and big data. Political parties increasingly invest in social media campaigning and exploit big data to profile citizens, allocate organisational resources and target individual voters with tailored messages. Elections themselves are often conducted using digital technology, thus increasing efficiency but introducing cybersecurity as main concern. Online voter manipulation efforts and campaigns to sway elections in various ways is already a reality, exemplified by Russian interference in the U.S. presidential election. To uphold the integrity of elections and the public trust in civic institutions is thus a key policy challenge.

The digital technologies that influence the nature and functioning of democracy include the internet, with its effects on the speed and scale of information, social media platforms, search and personalisation algorithms steering public attention and debates, and not least AI which potentially can be used for advanced political manipulation. Control of such technologies can be used to 'nudge' voter behaviour to win elections. Other less debated issues include the possibility that quantum technologies can be used to decrypt vast amounts of private and classified information, while blockchain in principle can underpin more direct democracy (EPTA 2018).

Personal and everyday life

Digital tech affects each of us as workers and citizens, but also impacts us in our roles as consumers, patients, students, and social beings. The internet, the PC, the smartphone and social media have already changed the way we live our daily lives and communicate with each other. Wearable devices, biometric monitoring, and the internet of things – including smart speakers with AI driven voice assistants, sensors and cameras, are increasingly digitalising the way we interact with our physical environment as well. In short, technology can be said to affect personal lives through increased *connectedness*, the proliferation of *surveillance* and by accelerating the pace of *innovation* in fields that affect us as individuals. These effects are ambiguous, increasing opportunities but introducing new challenges as well.

The most profound change to our day-to-day lives over the past few decades is arguably the pervasive and constant **connectedness** to the internet through smartphones, computers and smart environments. The proliferation of smartphones and social media is changing the nature of social relations, moving more of our communication, entertainment consumption and even dating online. The access to information and the speed of communication is unprecedented, with the world at our fingertips. But this 'always online' society also presents formidable challenges. The average person spends 24 hours a week online and almost half look at their phone within five minutes of waking up.[1] Behavioural science is applied to increase user time on apps and social media. Simultaneously, excessive technology use is linked to depression and accidents (Elhai et al. 2017). The massive **surveillance** enabled by digital technologies is propelled by business models built around extracting as much personal data as possible, in order to better predict and ultimately influence behaviour. In addition to user data generated on PCs and smartphones, our interaction with the rest of our environments is leaving a digital trace as watches, cars, speakers, homes and even cities become increasingly connected. Users routinely give up their personal data in return for free services, with limited understanding of the terms. While sometimes individually rational, this has societal implications linked to the growing value of data and the power concentration in the mega-corporations that control the data and the flow of information provided to users. Our constant online presence thus raises fundamental political questions concerning privacy and the collection, storage and use of user data, ownership and transferability of personal data, and cybersecurity. These are not only questions of how long company X can store Y data, but pertains to the exercise and protection of basic rights and freedoms of individuals, as well as trust in social institutions and infrastructure.

As **innovation** progresses, products and services are reinvented, become more affordable or improve in quality. Access to public services can be enhanced through the use of digital technology, while computers underpin advances in various fields including healthcare, education, entertainment and retail. For consumers, e-commerce and digital technology in stores create more efficient and enjoyable shopping experiences, while digital platforms and the sharing economy create new possibilities for economic exchanges. In education, technologies ranging from tablets to augmented reality and AI-powered adaptive learning software enable new ways of learning, as well as assessing performance. For patients, the internet can provide low-cost knowledge and health information, while healthcare professionals can access patient data and information more easily. Digital technology also drives new drug discoveries and advances in biotech such as new genome editing techniques, that could revolutionise future medicine. Such innovations present policy challenges in diverse areas ranging from the regulation of CRISPR via the use of facial recognition systems in stores to the use of augmented reality in classrooms.

4. MAIN TECHNOLOGIES: TOWARDS A TAXONOMY

Digital technology is a vast field of partly interrelated basic technologies, technology systems and use cases, often described using buzzwords. It is nigh impossible to comprehensively map and describe *all* technologies that influence societal changes, let alone detail the mechanisms through which they do so. However, analyses of digitalisation always rely on assumptions about what technologies are of importance, even when such assumptions are not made explicit.

In this section, two complementary ways of identifying and categorising the relevant technologies are presented: The first approach categorises technologies based on complexity and the specificity of their application: from underlying technological *drivers* such as computing power, storage and connectivity that underpin almost all digital tech, via *basic technologies* that are almost universally applicable such as artificial intelligence and digital platforms, to *technology systems* such as the internet of things and cyber-physical systems. The second approach links these technologies to the areas of societal change

[1] UK survey data. Source: ofcom.org.uk/about-ofcom/latest/features-and-news/decade-of-digital-dependency

and the policy challenges they create, in line with the analytical model presented in the previous section.

A specificity approach: From technological drivers to specific use cases

As emphasised above, the scope and pace of change induced by digital technology is driven by the simultaneous advances in hardware, software and connectivity, and the society-wide deployment of the technologies this enables. Some are relatively basic, general-purpose technologies such as sensors, networks and connectivity technologies that make up the internet. Advanced but general-purpose software technologies such as big data analytics, blockchain and AI algorithms are also included in this category. These basic technologies provide the foundation and building blocks for many new services, applications and business models. When combined in various ways to create more complex systems, they enable sophisticated yet general-purpose applications that can be labelled 'technology systems' (digital21 2018), using a set of interconnected components designed to fulfil a particular function without further human design input. Such complex systems include digital platforms, as well as the internet of things and cyber-physical systems such as robots and smart factories, in which physical things and software components are deeply intertwined and interactive. Last, these technologies can be leveraged or combined in a multitude of different use cases, creating products and applications in which the technology is applied to solve a specific problem or create a new service, often in a single industry. E-commerce platforms, self-driving cars and dating apps are examples of products and applications that can have significant impact in certain areas, but lack the cross-cutting and society-wide nature of the more general tech.

This approach to categorising technologies is illustrated in figure 2 (below). The selection of technologies is not exhaustive but intended to highlight key technologies of each type, selected on the basis of their importance in relation to the policy challenges described in the previous section.

Figure 2: Technological hierarchy, by level of specificity

Specificity of application	Technologies (not exhaustive)				
Products and applications	E-commerce	Self-driving cars	AR glasses	Deep fakes	Mobility as a service
	Workplace automation	Manufacturing robots	AI decision support	Smart voice assistants	3d-printing
	Platform work	Dating apps	Smart utility grids	Camera surveillance	Fitness trackers
	Cryptocurrency	Social media	Predictive maintenance	Facial recognition	+++
Technology systems	**Platforms** (Amazon, Facebook, Google, Uber++)		**Internet of things (IoT)** (Connected devices, sensors, cameras, machines ++)		**Cyber-physical systems** (robotics, autonomous vehicles, smart factories, smart cities++)
Basic technologies	**AI** (Machine learning algorithms, natural language processing++)		**Big data analytics** (Internet and smartphone user data, cameras, sensors ++)		**Internet** (WWW, LAN, WiFi, cellular, 5G++)
Drivers	**Data processing**		**Data storage**		**Connectivity**

For a comprehensive analysis of the consequences of digitalisation in a given policy field or industry, technological advancement on each of the levels described should be considered. While the direct consequences of specific use cases that are already widespread will often be readily apparent, the full potential and impact will often be premised on advances in more general technology. Consider for instance the impact of digital surveillance cameras in retail: At its most basic, this use case enables cheaper and better coverage of stores, improving security at the cost of customer privacy. However, advances in data storage and connectivity may render it cost effective to connect all cameras in a network, store all footage in high definition in the cloud and make the files searchable. Further, facial recognition and AI algorithms may use the footage to identify and track individual customers, register what they browse or buy, and – if given access – connect this data with the individuals online shopping history, profiles on social media etc. in order to tailor promotions, provide personalised service – or to single out likely shoplifters. This obviously has wider implications in terms of privacy, security, business models, work organisation etc., and in terms of political regulations needed to protect public and citizen interests.

A topical approach: Areas of societal change

For the purposes of this paper, the selection of technologies to take under consideration should as far as possible be grounded in the type of social change we want to explain or anticipate, as opposed to an a priori selection based e.g. on metrics such as prevalence, adoption, investment or novelty. The technologies highlighted here are thus selected on the basis of their potential societal impact. More precisely, they are selected on the basis of the policy challenges that the technologies create, address or amplify in the four areas of societal change identified in the previous section (work, economy, democracy and personal life).

Figure 3 illustrates the linkages between these areas and a selection of digital technologies likely to spur societal change: The internet, artificial intelligence (AI), cloud storage and -computing, big data analytics, digital platforms, 5G cellular networks, the internet of things (IoT) and cyber-physical systems such as robots, connected factories and autonomous vehicles. The technologies selected[2] all figure prominently in the scientific literature on the social consequences of digitalisation *and* display a cross-cutting nature by spurring societal change in all of the four areas considered. The technologies, along the y-axis, are arranged from the basic, general-application technologies to the more complex technology systems that they enable, following the approach outlined in figure 2.

Figure 3: Digital technologies with cross-cutting societal effects

Policy fields/areas of societal change

		Work	**Economy**	**Democracy**	**Personal life**
	Internet	+	+	+	+
	AI	+	+	+	+
	Cloud	+	+	+	+
Digital technologies	Big data	+	+	+	+
	5G	+	+	+	+
	Platforms	+	+	+	+
	Internet of things (IoT)	+	+	+	+
	Cyber-physical systems	+	+	+	+

Principally, this framework illustrates that each of these digital technologies affect *all* of the selected policy fields. Each cell in the grid contains salient processes of social change and its own set of policy challenges. Consider for instance, artificial intelligence. As outlined above, AI has obvious and far-reaching consequences for the world of work, as well as the economy. There is already a large body of literature considering AI's impact in terms of workplace automation, algorithmic management, decision support, economic growth and so on. Less intuitive, perhaps, is its impact on democracy: AI

[2] The technologies selected represent a limited number of the most central cross-cutting technologies, based on current research literature, and is far from exhaustive. Blockchain, AR&VR, drones, 3d-printing, digital twins etc. are other technologies referenced extensively in the literature which could be included, but to some extent lack clear cross-cutting properties.

powered systems are increasingly filtering and personalising information flows in online- and social media, changing the access to knowledge and the nature of democratic deliberation and debate. A related concern is that AI powered systems could increasingly be able to control what we know, what we think and how we act through various sophisticated manipulation technologies and techniques, as "the trend goes from programming computers to programming people" (EPTA 2018:3).

An analyst or politician considering the grid space in figure 2 may thus use it as a starting point for analysing how of each of these evolving digital technologies (as well as their current or future applications) can affect each policy field, e.g. to reveal policy challenges or identify research gaps. For a more fine-grained approach, each policy field can be expanded into the sub-categories and issues as outlined in figure 1, creating a larger matrix.

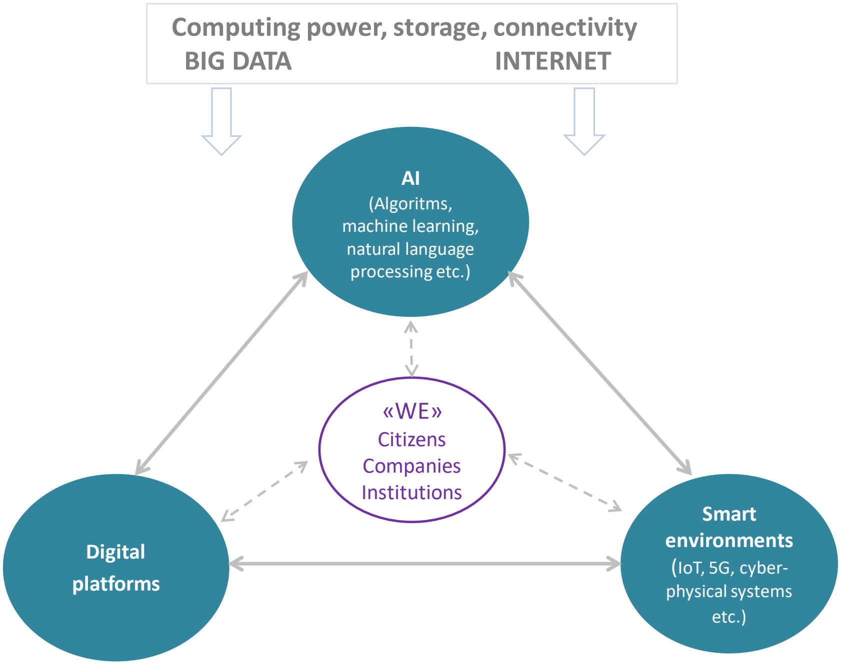
Moreover, the table illustrates that each policy area is not only affected by one or a few technologies, but by all of them and, not least, by their combination and interactions. For instance, we cannot fully grasp the impact of 5G cellular networks on the economy without considering how it enables the expansion of the internet of things, the collection of big data or low-latency communication in cyber-physical systems, e.g. between autonomous vehicles.

5. THE NEW DIGITAL SOCIETY: KEY TECHNOLOGIES

This section aims to provide a basic description of three technologies that display exceptional potential to shape the societies of tomorrow: 1) digital platforms, 2) artificial intelligence and 3) 'smart environments', including the internet of things (IoT) and cyber-physical systems. These technologies exemplify the novel and transformative nature of digital technologies driving ongoing societal changes. Digital platforms are changing information access, our social interactions and – increasingly – our economic transactions, representing a distinctly digital business model. AI is arguably the most transformative and rapidly developing basic technology at present, while smart environments are making digital technologies an increasingly integrated part of the material world we interact with.

Further, on the basis of the issue-specific taxonomy presented in figure 3, this section singles out some of the main societal changes and policy challenges raised by these technologies. A birds-eye view of this reasoning is presented in figure 4. It illustrates how digital platforms, artificial intelligence and the 'smart everything' of cyber-physical systems and the internet of things is increasingly permeating society and transforming the way we – i.e. companies, citizens, workers, consumers, voters, and institutions – act, interact, and shape our everyday lives and societies.

Figure 4: Digitalisation is permeating and framing our lives and society



Note that the figure does not specify or aim to explain the diverse ways in which the various drivers, basic technologies, technology systems, and emerging markets associated with digitalisation interact in shaping current changes. The argument is rather simply that "We", as economic, social, and political actors, are becoming increasingly embedded in digitally mediated processes and transactions. As such, society itself, and its ongoing de- and re-construction, is becoming ever more digitalised. Emerging as a dominant "force of production" in our economies, digital technologies contribute to transformation of the social relations of production and society in similar ways as Marx argued the new manufacturing technologies did during the 18th century industrial revolution. Although the internet was a result of state-initiated R&D projects, the transformative processes flowing from digitalisation have so far predominantly been shaped by international market forces. As elaborated in the report from the FEPS-project this paper is part of (Nogarede & Støstad 2020), the looming question for Europe is what kind of political-democratic action and governance is needed to ensure that the innovative and emancipatory potential of digitalisation is used for the benefit of society and us all, and not only in the interests of the mega-corporations currently controlling the new digital means of production. The purpose of the ensuing section is to illustrate the diverse ways the basic digital technologies and systems are already affecting fundamental pillars and mechanisms of our societies, and single out what kind of political-democratic challenges must be solved to make digitalisation work for all.

Platforms

Digital platforms refer to a type of emerging business models that harness digital connected ecosystems to achieve rapid scale. A business model of interactive networks more than a technology in itself, platforms are still enabled by cutting edge technology; notably connectivity, big data and artificial intelligence. The ability to efficiently gather, record and refine data is the foundation for these new business models (Srnicek, 2017). The leading platforms use large physical data centres and AI algorithms to process huge amounts of data, crucial to improving the platform and attracting users.

Platform companies – including but not limited to the likes of Facebook, Amazon, Google and Uber – create infrastructures that enable consumers and producers to connect and interact with each other in a way that was not previously possible. Platforms disrupt industries and create value by using software to facilitate efficient social and business interactions. Platforms can thus be defined by their ability to "leverage and orchestrate global connected digital ecosystems in a way that disrupt or reorganise traditional industries" (Choudary 2015).

Platform companies are technically software companies insofar that they make apps, Application Programming Interfaces (APIs), websites etc., but it is their ability to use this software to structure social interactions, work, commerce etc. that enable them to scale rapidly and disrupt industries. This fundamentally changes business models, from the traditional pipe-like value chains from producer to consumer, to a platform model where the platforms take on the role of providing and governing an open, plug-and-play infrastructure for social and economic interaction (Choudary 2015:24). The mechanisms of value creation are thus different. Content creators on YouTube, Uber drivers or eBay sellers create value, while the platform merely enables its creation and distribution to users by providing an ecosystem for the exchange. This does not require vast physical resources, but rather to leverage data to best orchestrate the physical and digital resources across their ecosystem. Physical resources are often owned by users and not the platform, like Uber drivers own their cars and Airbnb hosts their house. Platforms instead create value by algorithmically matching resources (capital, labour, media content etc.) of producers with the consumers on the platform that need the resources (Choudary 2015:27).

The *economic* impact of digital platforms is already evident, with many of the most valuable and most rapidly growing companies worldwide being platforms. Platforms enable more effective matching between producers and consumers, eliminate transaction costs and expand markets, often globally. Digital platforms are characterised by *network effects*, implying that the benefits and value associated with the platforms increase with the number of users (Eurofound 2018). For instance, social networks have limited value without a certain number of users. For an individual user, there will be benefits in migrating to the largest platform. Producers will be able to reach a bigger market or audience, consumers will gain more options and so on. This effect is easily observed in social media, dominated by a small number of global platforms, but is also at work in other types of platforms. Additionally, the digital nature of platforms allows for *scale without mass*, insofar that new users can be added at virtually no additional cost and enables a business to vastly expand its customer base without a proportional physical expansion of factories, offices, employees etc. These effects combine to enable economies of scale and markets with high barriers to entry and winner-take-all dynamics, conducive the formation of monopoly power. The five largest publicly traded companies in the world by market capitalisation – Microsoft, Apple, Amazon, Alphabet and Facebook – all have digital platforms and ecosystems as cornerstones of their business models. Today's major platform companies create value by collecting and analysing our personal data, and they are expanding aggressively both inside the technology sector and into traditional industries. Monopolisation and the resulting concentration of wealth and power is a key policy challenge, with traditional anti-trust and competition legislation proving inadequate. A related issue is how the global technology corporations in general and platform companies in particular can be fairly and effectively taxed.

The platform economy also has potential to change the way we *work*. Work mediated by digital platforms represents a new and innovative form of flexible employment. In economic and statistical terms, platform work is still relatively marginal in most European countries. The potential for growth and consequent societal change is nevertheless substantial. Digital platforms mediating labour promise reduced transaction costs and greater flexibility to firms, consumers and potentially to workers. At the same time, this innovation challenges the wage-earner model European economies are built around (Dølvik & Jesnes 2018). Often denying employer responsibility and using algorithms and data to match demand and supply of short-term work (gigs), digital platforms challenge the existing legal and institutional framework built around the relation between workers and employers. Simultaneously, digital platforms can enable circumvention of established regulation on working conditions, working time and social protection.

The rise of the digital platforms can also have tangible effects on *democracy.* Social media platforms can contribute to democratise access to information, support knowledge exchange and provide new arenas for democratic deliberation and debate. Conversely, the spread of mis- and disinformation ('fake news'), the Cambridge Analytica scandal and online campaigns to influence voter behaviour clearly demonstrate how social media platforms can be exploited. The creation of digital echo chambers that contribute to the fragmentation and polarisation of political debates and the cultivation of extremism further demonstrate the subversive potential of the technology. Digital platforms are also becoming so large that they increasingly take on roles of regulation and governance previously held by authorities. Consider, for instance, the effect of social media for the freedom of expression, assembly and free speech in authoritarian countries, or the practical importance of Facebook's terms of service for the limits of these freedoms in Western democracies.

Finally, the impact of digital platforms on our personal and social lives is already undeniable. From e-commerce platforms like Amazon changing the way we shop for goods and services, YouTube, Netflix and Spotify changing the way we consume entertainment to Facebook, Twitter, Instagram and Snapchat mediating our social relations and Tinder potentially changing our choice of life partner, digital platforms increasingly shape our daily lives. As a result, these platforms also collect, analyse and control immense amounts of our personal data.

Smart environments: The Internet of Things and cyber-physical systems

Digital technologies are not only embedded in devices that we use, but increasingly become an intrinsic part of the material environment in which we live. Technologies like the Internet of Things (IoT) and the proliferation of cyber-physical systems (CPS) – machines that sense their environment, collect, analyse and act on data; and collaborate with each other and with humans – equip the material world around us with sensors and communication devices that both detect and respond to us, and with which we can interact (Aydin et al 2019). The internet of things, coupled with AI and powerful computing, is enabling our physical surroundings and environments to become 'smart'. Smart devices, smart homes, smart cities, smart factories etc. – sometimes labelled smart environments (SmE) – promise to improve different aspects of our daily lives, from logistics and energy consumption to security, as well as boosting the economy and changing the way we work. IoT and cyber-physical systems are also central to the idea of industry 4.0, with connected and automated smart factories. IoT and CPS are related concepts that partly overlap with each other, in the sense that some use cases can be described as utilising both (e.g. a smart, AI-powered factory). Taken together, they signify the incorporation of computer technology and artificial intelligence in all kinds of objects and our physical environment.

The Internet of Things (IoT) describes the massive interconnection between all our smart devices, that transmit real time data over the internet. Although with enormous consequences, conceptually IoT is simple. Due to technological advances in cameras and sensors, making them far cheaper and smaller, and faster networks, and the increasing demand for data, it is now more and more economically feasible to connect things with each other. IoT describes networks of things – physical devices including cameras, machines, vehicles, lights, doors, home appliances, wearables etc., equipped with electronics, software, sensors, actuators and transmitters that enable them to connect to the internet and exchange data. IoT, applications already span a wide range of policy domains, including health, education, agriculture, transportation, manufacturing, electric grids and many others. This development is set to accelerate when 5G cellular network technology is rolled out in the years to come – opening up for real-time data of "everything" – indoors and outdoors, with minimal latency. This enables 'smart' cities, factories, homes etc., as well as the collection of vast amounts of data that can be harnessed on digital platforms, used to train AI and to create 'digital twins' of both physical structures and human beings. The technology is augmented by speech- and facial recognition, creating both immense innovation opportunities and privacy issues.

Cyber-physical systems (CPS) represent the next generation embedded intelligent ICT systems, in which physical things and software components are deeply intertwined and interact with each other in ways that change with context. One example is smart industrial robots operating in connected factories, which may be able to handle and move delicate products, adopt to unpredictable environments and collaborate with humans. Other examples include smart grids, self-driving cars and automatic pilot avionics. These systems are interconnected, interdependent, collaborative, autonomous and provide computing and communication, as well monitoring and control of physical processes.

CPS can be found in areas as diverse as aerospace, vehicles, civil infrastructure, energy, healthcare, manufacturing, transportation, entertainment and consumer appliances. CPS can be labour saving and increase productivity, e.g. in automated factories, or enable new services and business models, such as 'mobility as a service' leveraging self-driving vehicles or automated last-mile delivery using drones. Effects on productivity and distribution are likely to be substantial. The total value derived from the IoT has been estimated to 4-11 trillion USD (Manyika et al 2015:71), while cyber-physical systems stand to transform industrial sectors from manufacturing (e.g. Industrie 4.0) and energy to agriculture, which together account for nearly two-thirds of global gross domestic product (WEF 2015).

IoT and CPS raises policy challenges related to maintaining high levels of safety, ensure trust based on enhanced levels of digital security and privacy, improve energy and resource efficiency, and to address emerging social and organisational challenges.

Artificial Intelligence

Artificial intelligence (AI) is expected by many observers to be a transformative technology. It does not only promise new and better services, but has the potential to exert massive societal change. In its current form, AI is a main enabler of workplace automation, as well as improved digital applications. In the long run, AI will likely be able to substitute, supplement and/or amplify many mental tasks. AI is not one particular tool or technology, but a large field of computer science. AI represents the third era of computing, after tabulating (very early computers) and programmable systems, its main effect being a dramatic enhancement of the capabilities of computers in performing complex tasks.

In its most basic form, AI can be defined as a *system that makes autonomous decisions*. It refers to an area of computer science that enables a device to perceive its environment and take actions that maximise its chance of achieving set goals – thus appearing 'intelligent'. A more thorough definition is offered by the OECDs (2019:15) AI Experts Group, stating that AI is a

> "machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments. It uses machine and/or human-based inputs to perceive real and/or virtual environments; abstract such perceptions into models (in an automated manner e.g. with ML [machine learning] or manually); and use model inference to formulate options for information or aviation. AI systems are designed to operate with varying levels of autonomy".

Despite the term being a moving target to some extent, often used as an umbrella term for a computer program doing something smart, capabilities normally classified as AI include successfully understanding human speech, translating between languages, competing at the highest level in strategic game systems (e.g. chess, Go, poker), autonomously operating vehicles, and intelligent routing in networks and simulations. Current AI is very, very far from reaching human level in all fields (Artificial General Intelligence, AGI). However, AI is very capable in narrower fields, often outperforming humans.

Almost all AI is based on algorithms - a process or set of rules to be followed in calculations or other problem-solving operations, usually by a computer. Conventional algorithms are hardly intelligent and have to be programmed in a step by step process where a programmer details how the algorithm is to react to any given input in order to reach an objective. Much of the recent improvement in AI capacity is due to machine learning, which refers to algorithms that enable software to "learn" from structured data and update itself based on previous outcomes without the need for programmer intervention. That is, a human engineer does not need to code for each and every possible action or reaction, but can instead train an algorithm with structured data which the algorithm can learn from. Advances in machine learning, particularly deep learning using neural networks – simply put, computers that mimic how humans learn – is increasingly enabling computers to learn from experience, adjust to new inputs and perform human-like tasks.

Current AI based on machine learning enables machines to perform specific, routine tasks at or above human level. AI algorithms are powering a broad range of services and devices we use daily, from internet search engine optimisation, targeted online ads, mobile photography processing and personalisation of social media feeds to intelligently controlling power grids. AI is changing work by enabling workplace automation, algorithmic management and by providing decision support, and is expected to be a major driver of economic growth in the coming decades. It enables autonomous vehicles, it can help discover new medicines and detect disease outbreaks early, or it can be used in profiling of criminals or to efficiently direct police resources. More ominously, AI may be used to profile and potentially manipulate voters and has a variety of military applications that could trigger arms races.

AI is in itself neither good nor bad, but creates difficult policy challenges as it is increasingly used to automate decisions in both private and public sectors. Current AI algorithms are largely non-transparent, and imperfect algorithms or training data may lead to algorithmic decisions that are biased, discriminatory or inaccurate. In applications like recruitment, taxation, policing or weapons, such shortcomings can be disastrous. The need to ensure trustworthy, unbiased and transparent AI systems is thus paramount.

Interaction and convergence

An important lesson from this attempt to sort out what digitalisation is about, and how its different elements and functions can be categorised, is that technologies do not develop in a vacuum. Advances in one technology can spur developments in other fields, and digital technologies can be combined in ways that enable a vast variety of use cases in all sectors of the economy and society. Many new devices and technologies are the results of existing knowledge applied in new ways, or together. New products and applications of digital technologies are enabled by scientific progress, while digital technology in turn is enabling scientific advances in fields far beyond the realm of ICT. Already in 2005, the Policy Department on Economic and Scientific Policy at the European Parliament recognised the convergence of key technologies as an overarching meta-trend, insofar that the "nano, bio, info, and cogno sciences" are converging and rapidly evolving, all based on an exponential increase in computing power (European Parliament 2005). The convergence of digital technologies and their increasing influence on other fields of science and technology is associated with accelerating differentiation of the processes and products where digital technologies are used. The Future Today Institute identifies 315 tech trends in their latest report (FTI 2019). At the same time, these trends interact and reinforce each other. Integration of new and emerging technologies, including those associated with platforms, IoT, artificial intelligence and robotics, creates encompassing technological environments in which we live and work. Taken together, these technologies exert significant impact on working life, the economy, democracy, and our daily lives – virtually everywhere.

6. TOWARDS A EUROPEAN MODEL OF DIGITALISATION?

As in former industrial revolutions, such periods of paradigmatic technological change tend to alter the prevailing modes of production, patterns of work, terms of competition, and the ways markets are functioning, thereby also changing the very basis on which our daily lives, social institutions, political economies, and systems of democratic-political governance are built. As a result, growing incongruences - or mismatches - tend to open up between the sweeping changes in technology and patterns of production, on the one hand, and the social relations, institutions, and political structures shaped by past modes of production, on the other (Perez & Freeman 1988). At such junctures, where society's political and social institutions are lagging behind the changes in the economy, they tend to become increasingly inadequate in handling the economic and social challenges arising. The tension and gaps between the institutionalised forms of governance, *inter alia* class- and power relations, and the emerging modes of production, also implies that society falls short in reaping the potential for social innovation and progress entailed in the latter. Such instances have in the past often served as incubation phases for major institutional and political reforms of our capitalist market economies, as perhaps most saliently demonstrated by the historical compromises enabling development of the encompassing welfare states and labour regimes – the so-called European social model – based on the rise of industrial mass production in the postwar era (Adnett & Hardy 2005). A salient feature of the digital transformation has thus far been the dominance of market forces and private corporations in shaping developments – hence also appropriating the wealth and profits arising from it – and the relative absence of political-democratic intervention aimed to secure that application of the new technologies benefit the interests of society and the public good.

As pointed out in this paper, digital technologies entail huge potential for innovation and societal progress at the same time as the patterns of digitalisation hitherto evolving tend to challenge basic features of the European model of society. This fundamental ambiguity reflects the discrepancy between, on the one hand, the powerful corporate, market-driven dynamics that thus far have shaped the course of digitalisation, emanating from Silicon Valley, now increasingly challenged, on the other hand, by the state-driven, autocratically controlled course of digitalisation emerging from China, and the lack of European political strategies aimed to steer the development, application, and distributive effects of digitalisation in directions servicing the interests of society as a whole. The paper has pointed out a number of ways in which digitalisation can challenge or disrupt the basic foundation of the European societal model:

- In the sphere of *production and working life*, digital technologies seem to spur growth in high-skilled and high-paid jobs (occupational upgrading) combined with stagnation in the middle and oscillating growth in the lower ends, entailing the risk of growing polarisation of work, skilsl mismatches, and job insecurity especially in the lower ends. Propelled by the likely spread of platform work, the latter tends to erode the wage earner relationship on which the institutions governing work and welfare in Europe are based, and may, together with the rise in the top, lead to changes in the job- and class structures associated with more inequality in income, power-relations, power resources, and voice opportunities at work.

- In the *economic sphere* and market competition, the dominance of the global mega-corporations owning and controlling the main means of digitalisation, including the huge data banks it generates, along with the "winner takes all" logic of consumer markets with close to zero marginal costs and significant network effects, spurs strong monopolising tendencies in global markets that threatens to undermine the concept of a level playing field on which the regimes of international trade and the European single market are built. Further, the tendency towards oligopolistic competition and concentration of wealth, power, and ownership control over data, copyrights and technologies in a few mega-corporations with relatively few employees, tend not only to reduce the rate of investment in job-creating production but also to circumvent the taxation capacity of national states. Combined, these tendencies aggravate the risk that the rising productivity and value added enabled by digitalisation is accompanied with decreasing employment growth, more uneven distribution of incomes from capital and labour, shrinking funding of social security, and thereby also a weakening of the macro-economic policy tools that in the past have contributed to development of increased employment in the European welfare states.

- In the realm of *our personal lives and basic individual rights and freedoms*, the surveillance of public space and constant gathering of personal information from our online presence raise fundamental political questions concerning privacy and the collection, storage and application of user data, ownership and transferability of personal data, and cybersecurity. Taking also into account the rising, state-controlled mode of Chinese digitalisation and the fuzzy boundaries between tech-giants and Western secret services, these are not only questions of how long company X can store data Y, but accentuate questions regarding the protection of basic human rights and citizens' trust in social institutions and infrastructure, which is an indispensable glue in democratic societies.

- When it comes to *political-democratic governance and participation* – considered a cornerstone of the European model of society – the ambiguous impact of digitalisation is evident. While the weakening or circumvention of the institutions for collective representation reduces the scope for voice and democratic participation in working life, the new digital means of information sharing do indeed widen the opportunities for public debate, deliberation, and mobilisation -- not least among groups that formerly have had limited access to arenas for democratic voice. At the same time the tendencies towards fragmentation and polarisation of public debate, along with enhanced opportunities for powerful groups to target or manipulate information flows, threaten the very notion of a public space where democratic deliberation – ideally – can unfold free from hierarchical biases, and politicians, governments and other power-holders can be held accountable (Habermas 1988).

In sum, the above points all to the risk that digitalisation will drive us towards a more divided society. According to Nobel Prize laureate Joseph Stiglitz, the proliferating use of artificial intelligence and robotics in working life is likely to contribute to “greater wage inequality, greater income and wealth inequality and probably more unemployment and a more divided society,“ yet “none of this is inevitable” if politicians change the rules of the game (Stiglitz, Guardian 12.9.2018). Thus, to uphold and further develop the European model of society, there is a clearly a need for forceful political action. As elaborated in the FEPS/SAMAK-report (Nogarede & Støstad 2020), such a response requires European development of political strategies to make digitalisation work for all – through taxation, regulative measures, and strengthening of democratic controls and deliberation.

In order to counter the risk of rising social divisions in terms of work, incomes/wealth, skills, social security, privacy, and political-democratic opportunities and power resources to influence societal developments, it seems that Europe has to use familiar levers of political governance in inventive ways: While new patterns of regulation are requested to offset the tendencies towards polarisation of working life, monopolisation of market competition, and compromising of privacy and individual freedoms, new, international means of taxation are needed to ensure a distribution of the productivity gains of digitalisation that fosters employment and social security. Along with other political means to develop European production of digital technologies and the skills and infrastructure people needs to master the new digitalised reality, the overarching principle of such a strategy must be that it enhances the conditions for democratic participation, transparency and enable people to held politicians and corporations accountable.

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