The opportunities and risks of digitalisation for sustainable development: a systemic perspective

Digitalisation can drive the sustainable transformation of society and industry. Many of the opportunities are, however, closely linked with risks. The use of a systemic risk-benefit perspective can help with the review and categorisation of the major impacts and trade-offs regarding the ecological, economic, and social dimensions of sustainability. The dynamics and uncertainties of digitalisation are complex – to make digitalisation a sustainable success, all involved actors should be engaged in a co-design process to develop a governance structure that is in line with sustainability.

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Digitalisation is a complex and dynamic process often regarded as the fourth major innovation cycle in human history, characterised by its extraordinary power in shaping the future (Floridi 2014). There are numerous assessments of the impacts of this transformation ranging from utopian to dystopian (cf. Welzer 2016, Zuboff 2019). In contrast to many conventional technology assessments, which rely on analysing the (given) properties of technologies and delineating their influence on socio-technical systems, digital technologies are continuously engaged in processes of progression and re-design and are strongly dependent on the goals and objectives of designers and clients. This openness for design may, however, be deceiving as historian Dan Schiller (2007) claims.[1] Other authors associate more positive connotations such as liberation and self-expression with the use of cyberspace (Aksin-Sivrikaya and Bhattacharya 2017).

Regardless of how digital services are being framed or evaluated, most authors agree that a review of the impacts of digitalisation cannot start from technological properties but from the intentions and practices that constitute joint products by developers and, within the limits mentioned above, the users and other communities, for example, regulators. The opportunities and risks of digital technologies are not immanent, but typically arise as a consequence of the way in which digital applications and services are designed and regulated. This openness in terms of design has two consequences: first, risks and benefits cannot be revealed ex-post by scientific analysis but are created ex-ante in the process of developing and applying digital technologies and, second, management of benefits and risks rely on the interplay between stakeholders from science, industry, trade unions, politics, civil society, and user groups (Scholz et al. 2021). This is not to say that digital technologies are void of any immanent contingencies and technology-driven trajectories as Armin Nassehi has pointed out (Nassehi 2019) and there is an ongoing debate about the limits of how much co-design by users is possible and permitted (Abbe and Sandon 2019).

Providing a comprehensive picture of complexities and dynamics

On the condition of its immanent flexibility and plasticity, the process of digitalisation can best be assessed by a systemic risk-benefit perspective in order to provide a more comprehensive picture of the complexities and dynamics of digitalisation (Lucas et al. 2018). This perspective highlights the manifold interactions between different actors of digital transformation and focuses on the manifold interdependencies between technological innovation, economic drivers, societal and ecological impacts as well as regulatory efforts. Most importantly, it provides the necessary flexibility based on the variability of design options.

The many interdependencies give rise to unintentional emergent effects, which are perceived as positive or negative depend- >

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1 Schiller regards digital services as commercial commodities that are framed and disguised as creative building blocks for a diversity of users. In reality, these services are "conditioned and structured by the social institutions and relations in which it [information] is embedded [...] creating a specific form of capitalist organization across an unprecedented range" (Schiller 2007, pp. 15 f.).

ing on the viewpoint of the observer. This ambiguity creates particular problems and challenges for governing digitalisation. Any impact assessment of digital transformations needs to include, first, a clear normative basis from which such an assessment is made and, secondly, a conceptual framework that does justice to the relative openness for designing technological options.

Both conditions (normative framework and openness) are met when using the systemic risks perspective and applying the normative frame of sustainability. The systemic risks perspective integrates knowledge on technological flexibility, economic organisational forms, regulatory parameters, and social or individual behaviour (Renn et al. 2020). All four areas of influence are interlinked and mutually dependent (Schweizer 2019). The systemic perspective provides a conceptual approach to include complexity, uncertainty, and ambiguity into risk analysis as well as risk governance, and opens the door for flexible and adaptive management methods (Klinke and Renn 2012). It underscores the importance of flexible and responsive interventions, thus places a specific focus on the process of design (Schweizer and Renn 2019). Governance impulses can be strategically planned and executed, however, only within limits. All interventions by governance actions are processed within the respective system according to its own rules (in German "operative Geschlossenheit").

Linking a systemic risk-benefit perspective with a normative frame based on the three pillars of sustainability has the potential to facilitate the creative freedom of digital transformations and at the same time to represent the plurality of values within the normative boundaries of sustainable development.

The overarching goal of sustainable development is a guiding principle for the coherent evaluation of potential impacts generated by digitalisation processes. This goal provides the normative reference point for criteria of impact assessment. It is essential that all three dimensions of sustainability – the ecological, the economic, and the social – are taken into consideration and analysed in terms of their respective interdependencies and flexibilities. The combination of a systemic risk-benefit perspective and a normative frame based on the three pillars of sustainability has the potential to give adequate weight to the creative freedom of digital transformations and to represent the plurality of values within the normative boundaries of sustainable development.

The ecological dimension: untapped potentials

The three main objectives of *ecological sustainability* are decarbonisation, dematerialisation and renaturalisation (Dalby 2016). Decarbonisation focuses on the reduction of harmful greenhouse gases, in particular carbon dioxide. The aim here is to shift to a sustainable energy supply based on renewable energy sources. In the case of dematerialisation, the aim is to develop products and services with a minimum of material input, waste and emissions, and to use environmentally friendly materials and processes whenever new materials have to be added to the production cycle. Finally, the goal of renaturalisation refers to the conservation of biodiversity and the continued existence of natural ecosystems.

Digitalisation offers opportunities to fulfil these three ecological goals. Digital platforms can provide communications and coordination services with a smaller carbon footprint in terms of mobility, material consumption, and land use. The substitution of energy and materials with information is one of the hallmarks of the new digital age of innovation. In the digitalised production – the so-called Industry 4.0 – digital technologies can help to optimise production processes in such a way that the consumption of energy and material is minimised (Fritzsche et al. 2018). Innovative approaches to improving energy efficiency through the use of digital technologies are, for example, the systemic optimisation of the kinematic properties of large robot fleets (Riazi et al. 2017) or the flexible adaptation of industrial loads to the availability of renewable energies (Ma et al. 2020). The most prominent approach to saving materials is additive manufacturing, which can also be used to manufacture lighter products, potentially enabling further savings in the usage phase (Rinaldi et al. 2020).

However, such potential benefits are not automatically realised when digital technologies are applied. For example, there is an ongoing debate whether autonomous vehicles or distributed car sharing systems will reduce or increase the overall ecological footprint, for example, due to rebound effects (Gossart 2015). Furthermore, due to the growing number of devices and the increasing use of streaming and cloud services, the energy consumption of digital services and applications continues to rise (Andrae 2019). Studies show that while modernising production processes in accordance with Industry 4.0 is thought to lead to efficiency gains, in many cases no significant reduction in material and energy consumption can be demonstrated (Fritzsche et al. 2018). The reason lies in an increase in production in absolute terms, a tendency to focus purely on process efficiency over time, and a failure to tap into the potential of digitalisation in corporate environmental management (Beier et al. 2020).

In theory at least, the growth of digital services can be compatible with the goals of ecological sustainability. But today's reality is far-removed from that ideal. The consumption of energy and material is actually increasing as digitalisation expands. This situation will not change unless the majority of affected companies

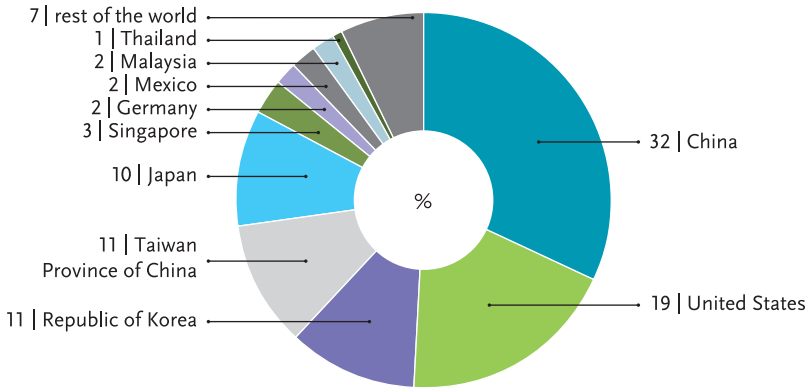

FIGURE 1: Geographic distribution of value creation (in percent) in the information and communication technology (ICT) manufacturing sector. 2017. Source: UNCTAD (2019).

adopt the three ecological objectives as binding principles. This would require a clear commitment by the providers and operators of digital services to exploit efficiency potentials and use only (ideally self-generated) non-fossil energy sources for their servers and other devices. In the transition to Industry 4.0, binding targets for saving energy and material and reducing non-recyclable waste and land use need to be set.[2]

The economic dimension: accounting for the present and the future

Three objectives are paramount regarding the economic dimensions of sustainability: fostering the circular economy, ensuring long-term, socially protected employment, and preserving an economic system that is open, innovative, and competitive (Schröder et al. 2020). A comprehensive circular economy necessitates digital services. Whenever waste from one sector is used as input material for another, complex and dynamic logistics are essential. This is where new applications in artificial intelligence, digital product identification, and compatible data standards across the entire product lifecycle can pave the way for sustainable logistics.

Without a doubt, digitalisation has created new value chains. According to estimates, the global information and communication technology (ICT) sector grew from US Dollar 1.3 trillion (1012) in 1992 to 3.9 trillion in 2014 and currently accounts for 4.5 percent of global gross domestic product (Selvam and Kalyanasundaram 2015). According to Eurostat over 53 million people were employed in the ICT sector worldwide in 2019. Practically all medium- and long-term forecasts for the ICT sector assume that a growing number of highly qualified and well-paid jobs will be created in future while the general trend towards polarisation in employment continues unabated (OECD 2019).

Digital services will help us to make further efficiency gains in the production and dissemination of goods and services. Other important goals, like the resilience that has become so important in the current COVID-19 pandemic, can be achieved with the help of ICT systems, especially in the area of controlling and monitoring.

However, digitalisation also entails risks for economic sustainability. In particular, the huge increase in electronic waste and the industry-supported built-in obsolescence of devices (especially smartphones) are diametrically opposed to the concept of a circular economy (Benton et al. 2015). There is no doubt that digitalisation creates new jobs and places of work. But there is also no doubt that jobs are being lost in conventional economic sectors, and entire professions are no longer needed (Dengler and Matthes 2018). Moreover, precarious forms of employment (without social security, ostensible self-employment) often arise as a side effect of teleworking (OECD 2016). Turbulence on the employment market is an inevitable corollary of innovation and technological advancement. Yet this brings an ethical responsibility to find socially acceptable solutions for those who cannot share the benefits of digitalisation.

No other economic sector has greater potential for innovation and change than the ICT sector. But this also brings on the risk of a concentration of power. In 2017, ten national economies, led by China, the United States and South Korea, accounted for 93 percent of global value creation in ICT manufacturing (UNCTAD 2019) – also see figure 1. The five top providers of cloud computing (Amazon, Microsoft, IBM, Google, and Alibaba) are responsible for more than 80 percent of global value creation (Raj-Reichert 2018).

In terms of innovation, potential efficiency gains, the creation of viable employment, and linked services and logistics in the circular economy, digital services and applications are a cornerstone of the economic dimension of sustainability. But the reality of the ICT sector still lags far behind this ideal. The quick replacement of terminal devices (particularly smartphones), poor hardware modularity, reparability and recyclability, and at least indirect encouragement of a throwaway mentality contradict the goals of circular economy that considers the long-term effects of resource depletion. Concerted efforts on the part of industry, politicians, trade unions and civil society groups are needed to manage employment market transitions from analogue to digitally assisted jobs in a socially responsible way and to create incentives for a digital provider culture, especially in Europe, that can counteract the current tendency towards a concentration of power in the hands of a few companies.

2 Behavioural economic incentives ("nudges") for more sustainable living and consumption could also be built into smart assistance systems.

The social dimension: focus on equality

Three objectives can be identified in the context of the social dimension of sustainability in the area of digital services: equivalent living conditions (intra- and intergenerational justice), sovereignty and active participation in the digitalisation process (including on a global level), as well as social and cultural identification with the transformations set in motion by digitalisation (Weingärtner and Moberg 2011).

Some opportunities of digitalisation for the social dimension should also be highlighted. Digital services are provided free of charge for most users. Search engines, navigation services, social networks, communications forums, or functional control processes are all made available by providers without financial compensation. Instead, payment is made indirectly through the provision of data, which the providers can share with advertisers for a fee. This pattern makes digital services accessible to the majority of the population, even to those with low purchasing power. The only requirements are ownership of an internet-compatible device, internet access, and the ability to navigate the internet (digital literacy).

Many digital services facilitate the direct participation of users in public activities. The COVID-19 pandemic in particular has shown the extent to which digital communications platforms have allowed us to keep in touch with colleagues and friends, hold cultural events online, and maintain key services and functions. Further options like e-government and e-democracy hold the promise of even more convenient and inclusive access to public life. Mainly due to the social media, the digital age has been instrumental in promoting universal human rights across the globe, which only direct censorship has managed to curtail. All of this enriches the process of forming individuals' identity and exposes people to diverse cultural points of reference.

Many of these opportunities are, however, closely connected with risks. Many autocratic systems have used digital means to control individual behaviour and impose rigorous surveillance methods. Digitalisation can be a powerful tool for oppression as well as liberation. There is clear evidence that certain population groups and regions are advantaged and others disadvantaged when it comes to using digital services (e. g., Yoon et al. 2018).[3]

There is a strong positive correlation between digital literacy and social status (education, income, location) (Hockly and Dudeney 2018). In addition, one could expect a major division between those who will benefit from the digitalisation in their professional and private life and those who will be left behind. Small and medium-sized enterprises are often not well equipped to cope with the digital transformation process (Kumar et al. 2020), and that puts them at a competitive disadvantage. Present regulations that govern data acquisition and processing are not sufficient to guarantee data security, let alone sovereignty (Scholz et al. 2021).

Practices that violate the protection of privacy, reduce transparency regarding data usage, and foster an illegitimate use of data constitute considerable risks that contribute to a feeling of powerlessness and "being at the mercy" of digital providers. In a survey on the opportunities and risks of digitalisation conducted by acatech and Körber-Stiftung (2019), 65 percent of the respondents agreed with the statement that technological progress could not be halted. Such an attitude is hardly compatible with the aspiration to actively shape the digital transformation.

In order to reduce risks and to promote opportunities for sustainable development, new societal initiatives are needed to help shape the contextual conditions under which digital technologies and services can and should be designed.

Additionally, the emerging internet culture propagates certain attitudes, beliefs, and worldviews that are completely at odds with the original idea of the internet as a "haven of diversity". At the same time, the anonymity of social media is increasingly blurring the boundaries between objective criticism, personal insults, and outright threats. The atmosphere of online debate is becoming more aggressive, echo chambers are becoming more attractive, and the culture of fair debate is being replaced with insinuations, malice, and polarisation (Hendricks and Vestergaard 2018). In the long run, these developments challenge social cohesion and deliberative democratic processes, but may also contribute to the resilience of democracies as they bring hidden conflicts to the attention of the public discourse.

Conclusions

A systemic risk perspective illustrates the many interconnections and cross-sectoral dependencies between digital applications and the three dimensions of sustainability. Due to the flexibility in service design, digital technologies provide multiple options but also path dependencies that are difficult to reverse. Opportunities and risks are closely intertwined and require informed and deliberate management decisions in order to be effective and favour sustainable development. Digital innovations will not per default increase sustainable practice; rather a professional technology assessment, a clear commitment to sustainability goals as expressed in the UN *Sustainable Development Goals,* and an inclusive decision-making style are required to promote sustainability within all three dimen-

3 Inequities start with a lack of access to fast internet connections and ends with insufficient digital literacy.

sions of sustainability. Improving digital literacy in all sections of the population, ensuring free internet access, assisting small- and medium-sized enterprises with digital modernisation, making digital services available to all who need them and designing digital products that reduce energy and material demand are major objectives for designing a sustainable digital future. Above all, it is crucial to establish clear rules for data security and data sovereignty. If these challenges are not adequately addressed acceptance of digital innovations is likely to erode and efforts towards a sustainable digitalisation process may be jeopardised.

In order to avoid or reduce these risks and promote opportunities for sustainable development, new societal initiatives are needed to help shape the contextual conditions under which digital technologies and services can and should be designed. Such initiatives should bring all relevant actors together in discourses in order to address the systemic risks, ensure a fair representation of developers, users and regulators and promote the opportunities that are associated with the digital potential (Renn and Schweizer 2020). Furthermore, conflicts and dilemmas are likely to arise between the ecological, economic and social dimensions of sustainability that will require painful trade-offs and compromises (Scholz et al. 2020, p. 37). Yet, many of these conflicts and limitations can be addressed and partially resolved if all the actors are willing to engage in a mutual process of co-designing objectives, rules and regulations for a governance structure in line with the normative goals of sustainability. Such an attempt should be based on scientifically sound evidence and oriented towards the common good as determined and specified in a deliberative and interdisciplinary discourse among all relevant actors. Of course, these actors have different levels of power to design the conditions of the digital world. However, when taking the three dimensions of sustainability as evaluation criteria, it becomes clear that digitalisation has enormous potential to support a sustainable transformation of society and industry if all powerful actors are willing to pursue this path. We are convinced that, in spite of commercial interests and governmental tendencies for more control, providers, regulators and users have much to gain (and little to lose) if they jointly pursue an ambitious program to make digitalisation more sustainable. A recent attempt to produce such a joint effort has been the project *DiDaT (Digitale Daten als Gegenstand eines transdisziplinären Prozesses)*[4] that developed guidelines in a transdisciplinary discourse bringing together representatives of science, providers, and users (Scholz et al. 2021). It is now the time to create and iterate such discourses with the clear mandate to shape the digital transformation towards a more sustainable society. Creating more space for co-creative discourses that promote sustainable development in the digital world might also provide an opportunity for Europe to mediate between the US approach of commercialisation and the Chinese approach of governmental oversight (Scholz et al. 2020, p. 38).

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