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A Green Digitalized Economy?

Challenges and Opportunities for Sustainability

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Digitalization is creating new patterns of production and consumption and bringing sweeping changes across the economy. The increasing use of information and communication technology (ICT) has stirred hopes that this will create new opportunities for economic development and lead to more environmentally friendly production methods. The social and environmental impacts of this digital transformation are only beginning to be understood, and little reliable data on its environmental effects exists. However, some initial trends are already discernible. It remains unclear whether the digital transformation of the economy can be reconciled with the goals of sustainable development. This will depend to a large degree on how the digital transformation is shaped at the national and international levels.

The digitalized economy

Digital (i.e. computer-based) technologies such as robots, cloud computing, artificial intelligence (AI), the Internet of Things and digital platforms play an increasingly important role in the global economy. This is driving the emergence of new sectors and business models, and altering employment, production, and consumption patterns across a wide range of industries. While it is difficult to define the boundaries of the dynamic economic landscape shaped by digitalization, three core elements can be distinguished (see Figure 1).

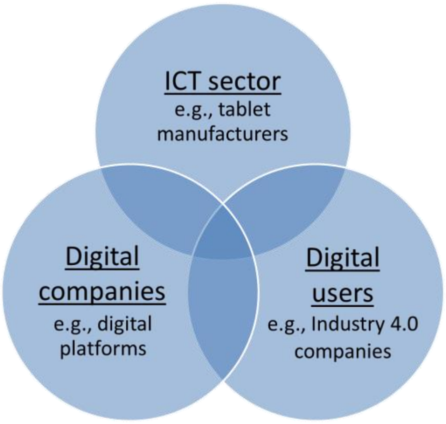

Figure 1: Three elements of the digitalized economy

A core element of the economy that has already been transformed by digitalization – or "digitalized economy" – is the information and communication technology (ICT) sector, which enables digital connectivity across the economy by providing the technological infrastructure, hardware, and software. So-called "digital companies" form the second element, encompassing all those companies whose value creation model is fundamentally rooted in the use of ICT. Prime examples include digital platform companies such as Amazon and Alibaba. The "digital users", in turn, include companies operating in sectors outside of the aforementioned, for example branches of industry such as agriculture or mechanical engineering, which use digital technologies, processes, and business models primarily as a means to supplement and further develop existing value creation models. One example of this is Google's collaboration with Volvo and Audi to develop an integrated infotainment system for the automotive sector based on their open source "Android" operating system. This example also reveals how the boundaries between the three elements of the digitalized economy are blurring as digitalization progresses.

The implications of a digitalized economy for sustainability

The digitalization of the economy is characterized by three distinctive processes of change, affecting information flows, resource flows, and value creation models respectively. The social and ecological effects of these change processes differ across industrialized, developing and newly industrialized countries, reflecting the different underlying circumstances and degrees of economic penetration. This IASS Fact Sheet explores, through the lens of these three change processes, the challenges and trade-offs that we must tackle in order to forge a more sustainable digitalized economy.

Changing information flows

Changing information flows loom large in the digitalized economy. In 2018 there were almost two and a half times as many connected devices as there were people on living on the planet – researchers predict there will be nine times as many by 2025 (Safaei et al., 2017; Cisco, 2020). A number of ICT and digital companies have successfully harnessed this trend. In 2008, the ten largest corporations worldwide included five natural gas and oil companies and just a single company from the digitalized economy; a decade later, the seven major ICT and digital companies dominate the global top ten list.

In industry, these changes in information flows are captured in the concept of "Industry 4.0", which aims to harness the intelligent networking capacities of the Internet for digital users in production. This is achieved by sharing information among actors across the production process and establishing digital networks that link producers, customers and end users, facilitating the continuous exchange of information between factories, manufacturing systems and products (see Figure 2). This interconnectivity enables companies to coordinate globally distributed production processes more efficiently and flexibly. However, little regard is given to ecological impacts and gains in the conception and interpretation of Industry 4.0 (Beier et al., 2020).

It remains to be seen whether digital interconnection will in fact help companies to comprehensively track the environmental impacts of their activities along the value chain. The digitalization of corporate sustainability management could make an important contribution in this area. The use of digital technologies could improve the quality and availability of data (e.g. mechanical material and energy consumption) at both the product and process levels. The adoption of uniform standards for data collection in the context of sustainability management could also facilitate the comparison of environmental data across sectors and countries. Improvements in the availability and quality of data would increase transparency and facilitate the calculation of ecological footprints and, as a consequence, support the development of new, more resource-efficient products (Agez et al., 2020).

However, privacy and data protection is a concern wherever Industry 4.0 processes require the utilization of personal as well as machine data. As global data traffic surges, the need to overcome these and other related challenges becomes ever more urgent. The growth of global Internet Protocol traffic – from 100 GB per day day in 1992 to 46,000 GB per second in 2017 (UNCTAD, 2019) – is indicative of this trend. Data volumes will continue to grow as economic processes become more connected.

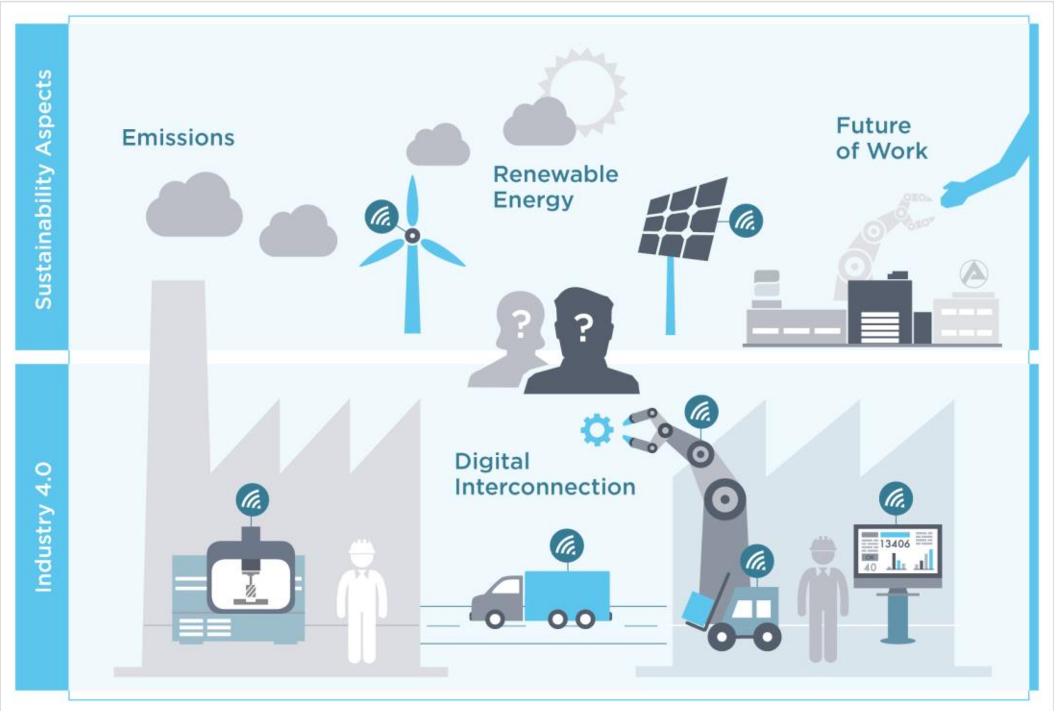

Figure 2: Industry 4.0 and selected sustainability challenges

Changing resource flows

Global demand for raw materials such as lithium, cobalt, copper, tantalum, tungsten, and rare earth metals is expected to grow, reflecting the increased uptake of ICT. The German Raw Materials Agency (DERA) anticipates that demand for metals such as lithium, dysprosium / terbium and rhenium could reach double that of the primary production in 2013. The increasing demand for such metals is driven in part by digital companies and users. The collection and analysis of data in the context of Industry 4.0 requires that manufacturing systems across the entire production chain be retrofitted with sensors, actuators, processors and communication technologies, or indeed replaced with modern systems. However, many of the raw materials utilized in these technologies cannot yet be recovered economically from decommissioned devices. And many "future technologies", such as fibre optics and RFID, have no recycling potential until 2035 (Marscheider-Weidemann et al., 2016). The raw materials utilized in ICT are primarily sourced from developing and newly industrialized countries, where their extraction frequently entails inhumane working conditions and comes at the cost of substantial environmental harms.

On the other hand, there are hopes that the digitalization of the economy – and of industrial production in particular – will promote resource-friendly business practices by increasing efficiency and closing resource cycles ("circular economy").

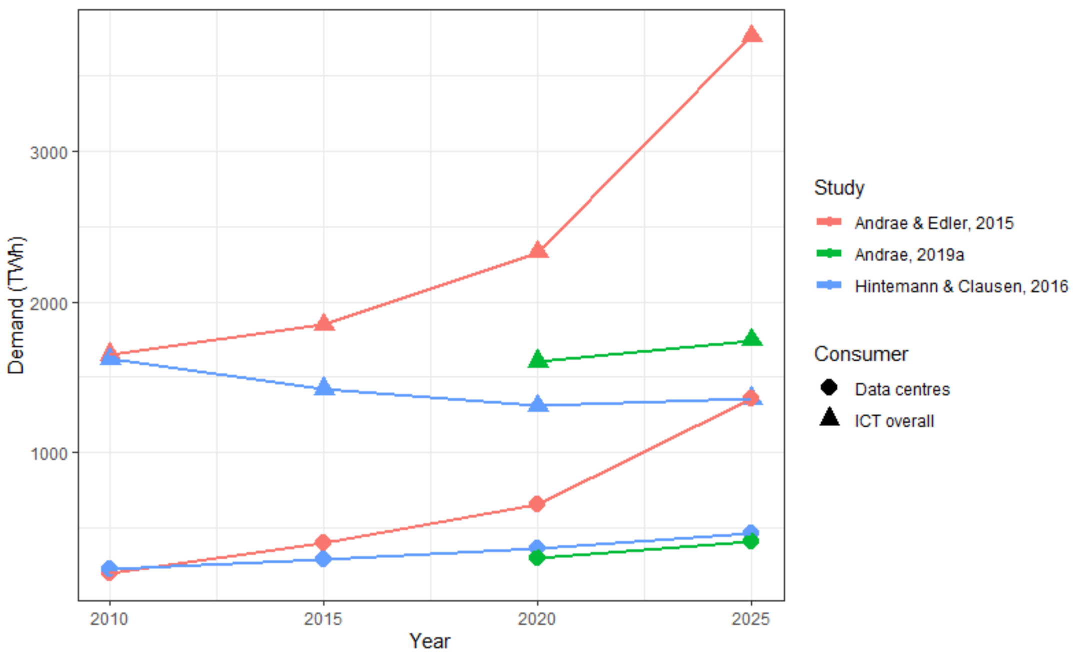

Figure 3: Total electricity demand from ICT and data centres

Whether this will result in a net positive balance for the environment remains uncertain, however.

An increasingly digitalized economy will consume not only raw materials, but also a lot of energy. Artificial intelligence (AI) systems, which are becoming increasingly widespread in the digitalized economy, are particularly energy-intensive. The carbon footprint of training a single AI system can be as much as 284 tons of CO_2e – or five times the lifetime emissions of an average car (Strubell, Ganesh, & McCallum, 2019).

The forecast energy requirements for global ICT use through to 2030 vary, but most studies anticipate a slight to strong increase (see Figure 3). A majority of studies assume that the energy requirements of ICT devices will stagnate or decrease as a result of efficiency gains (Andrae & Edler, 2015; Hintemann & Clausen, 2016; Stobbe et al., 2015). On the other hand, studies also assume that the energy demands of data centres and network infrastructure will increase due to the growing volume of data and the outsourcing of processes to the cloud (Andrae, 2019a; Richard et al., 2017).

However, recent forecasts suggest that growth in energy demand from data centres will fail to reach the levels anticipated in projections from 2015 as a result of developments in technology (such as hyperscaling) which have delivered large gains in efficiency (Mesanet et al., 2020). The ability of efficiency gains in data transmission and storage to offset growing volumes of data traffic will be critical to the evolution of ICT energy consumption (Andrae, 2019b; IEA, 2017). Energy demand forecasts for this sector are characterized by numerous uncertainties relating to potential technological innovations (e.g. quantum computing) and the future uptake of ICT in the countries of the Global South.

Pledges by major ICT and digital companies such as Apple, Google and Microsoft to power their operations using 100 percent renewable energy could help to limit the environmental impacts of the sector's growing energy demand – particularly if companies achieve this goal by increasing their own energy generation capacities. Digitalization can also help to optimize energy efficiency and consumption in production processes. In the field of robotics, for example, researchers have experimented with programming robots to perform tasks as quickly as necessary, rather than as quickly as possible. In one study, the adoption of this approach delivered energy savings of up to 30 percent (Riazi et al., 2016). The digitalization of the economy also holds opportunities to facilitate ecological industrial symbiosis (van Capelleveen, Amrit, & Yazan, 2018). For example, the flexibility provided by Industry 4.0 solutions could help manufacturers to cope more easily with the volatility of intermittent renewable energy generation (Scharl & Praktiknjo, 2019). This would enable production processes to be scheduled in such a way that they track with peaks in renewable energy generation, allowing producers to source energy at favourable prices. Achieving this requires digital technologies with the capacity to provide for the seamless flow of information between the energy sector and digitalized economy in real time.

Research has yet to confirm whether such approaches can in fact compensate for the additional demand for raw materials and energy required for the manufacturing and operation of digital technologies. The realization of potentials and prevention of negative rebound effects will also depend on the creation of adequate incentives and regulatory environments and the backing of political actors.

Changing value creation models

The digitalization of the economy is fuelling the emergence of new value creation models that are based on the interconnection of market participants and the utilization of large amounts of data to optimize economic processes. These economic sectors are often referred to as platform or data economics.

The environmental impact of digital value creation models depends to a large extent on the energy and resource intensity of the technologies they utilize and the underlying energy mix. Studies also indicate that, with their wide range of products and services, affordable pricing and payment processing solutions, digital platforms could be drivers of increasing consumption (Kahlenborn et al., 2018). This could in turn encourage the growth of unsustainable consumption patterns. However, platforms that either specialize in sustainably produced products, encourage their customers to consume consciously, or that use their profits to support sustainable projects and foster new perspectives on growth and development have also become well established in recent years. The search engine "Ecosia", which allocates a portion of its income to climate mitigation tree-planting projects, is one example of this sustainability-focussed digital business model. These business models still occupy a relatively small niche in the broader market.

But even where an explicit sustainability agenda is lacking, some business models in the digitalized economy are interesting in terms of their possible environmental effects. One example of this is the emergence of "sharing" in the mobility sector, i.e. sharing cars, bicycles or other vehicles via digital platforms. Studies have shown that the number of privately used cars decreased in cities where car-sharing services were available (Martin & Shaheen, 2016; Giesel & Nobis 2016). Some studies have also traced net savings in climate-harmful emissions to the growth of car sharing (Martin & Shaheen 2011). In general, however, the environment effects of sharing are ambivalent, with users of sharing services frequently ditching public transport in favour of making journeys by car.

The sustainability challenges presented by the digitalized economy are by no means limited to the area of ecology. Employees and contractors at digital companies such as social media platforms, online retailers and delivery services as well as platforms that place orders for services and "micro-tasks" often face poor working conditions.

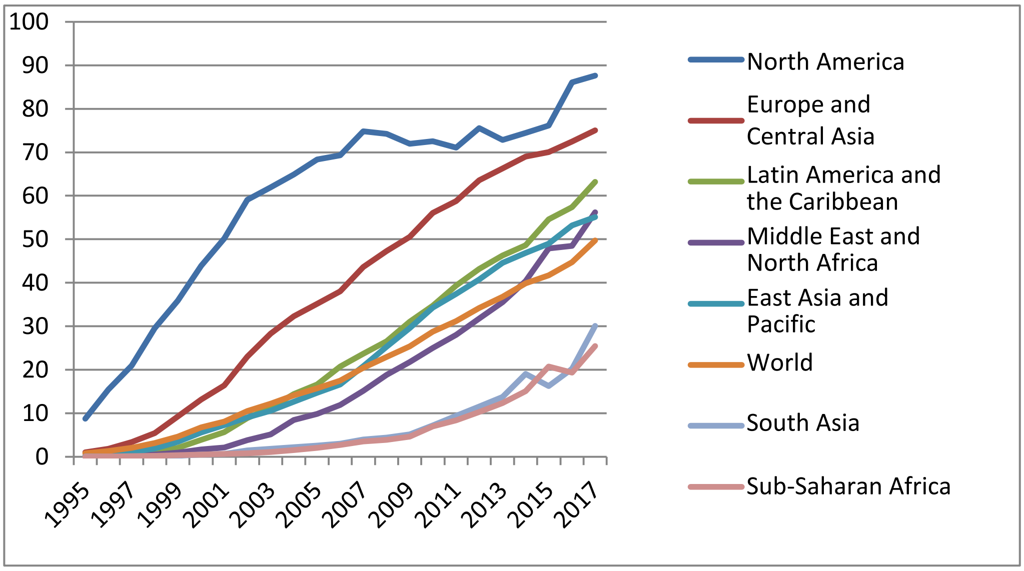

Figure 4: Share of the population using the Internet by region (in %).
Data source: World Development Indicators / International Telecommunication Union, World Telecommunication/ ICT Development Report and database.

Low pay and intense, sometimes international, competition for orders, coupled with a lack of social security and physical and psychological impairments are just a few of the challenges that employees must grapple with in parts of the digitalized economy.

At the same time, the opportunities presented by the digitalized economy are distributed very unevenly worldwide. This is due in part to the lack of access to the Internet and other digital technologies in many countries of the Global South. In Sub-Saharan Africa and South Asia, Internet users accounted for just 25 percent of the total population on average in 2017 – this figure is far below the global average of around 50 percent (see Figure 4). Positive economic network effects do not occur until Internet usage reaches 30 percent (Gillwald 2017). In addition, few online service providers tailor their products to meet the needs of users located in the Global South, stifling uptake.

Network effects often result in a “winner-takes-it-all” effect, i.e. an individual or a handful of providers of digital services dominate the market to such an extent that it becomes costly and unattractive for users to even trial alternative services. When this occurs, new companies find it difficult to establish a foothold in the market unless they are able to offer significant improvements on existing platforms or address new target groups.

This partly explains the geographic polarization that can be observed in relation to companies in the platform economy, with China and the United States – two countries that played a leading role in the ICT sector and digital business from an early stage – accounting for 90 percent of the market capitalization of the world's 70 largest digital platforms (UNCTAD, 2019). Europe, on the other hand, accounts for just four percent of market capitalization – and Africa and Latin America combined for just one percent (UNCTAD, 2019). Against this backdrop, the question arises as to whether and how developing countries can share fairly in the opportunities created by digitalization. Increasingly these market imbalances are also leading to conflicts over the ownership of data collected from platform users. Many developing and emerging countries take the position that data generated by their citizens should be stored onshore and should benefit digital value creation in country.

Conclusion

The challenge of creating a sustainable digitalized economy extends beyond addressing social and ecological concerns in the development of infrastructures, technologies and business models. Rather, we must aim to create a globally just, socio-ecological system for the development of digital economies, in which all countries and populations can benefit from the opportunities of digitalization. The potential to achieve net energy and material savings exists, but it is down to companies and regulators to take up the challenge of pursuing this goal in policy and practice.

The challenge of creating a sustainable digitalized economy

- *In its current form the digitalized economy perpetuates an economic system that prioritizes output growth and in which social and ecological sustainability play only subordinate roles.*

  Putting the digitalized economy on a pathway towards sustainability is a difficult balancing act. Wherever digitalization delivers positive socio-economic impacts, we can expect to find adverse environmental effects, such as increasing resource consumption. Efficiency gains that could have a positive effect on the environment are often cancelled out by growth in overall demand and consumption. This dilemma is well documented: despite efficiency gains, growing standards of production and consumption as a result of economic development have led to higher absolute environmental burdens (e.g. CO_2 emissions) in every country. It is questionable whether digitalization can help to reverse this trend. A more in-depth scientific analysis of the opportunities and risks for the sustainability of the digitalized economy in specific country contexts (Beier, Niehoff, Ziems, & Xue, 2017) and improved communication between science, practice and policymaking, e.g. through transdisciplinary research approaches, can help to better understand the challenges (Fritzsche, Niehoff, & Beier, 2018). **The well-being of people and planet should take centre-stage in national and international debates and digitalization policy should be consistently aligned with the UN Sustainable Development Goals in order to guide the digitalized economy towards sustainability.**

- *Developing a more sustainable digitalized economy calls for global thinking.*

  Economic opportunities created by the digitalized economy are distributed unevenly to the disadvantage of developing and newly industrialized countries. In the context of today’s globally interconnected goods and services industries, the digitalized economy in industrialized nations affects both economies and societies in developing and newly industrialized countries. This development is increasingly laying bare unequal power relations between industrialized, developing and newly industrialized countries. Occupying a privileged role, dominant players from the USA and China in particular are able to create critical digital infrastructures, distribute their products in developing and newly industrialized countries as market leaders, and regulate access to data and information. This leads to new conflicts, for example around the regulation of digital commerce and the creation of value from data. **In light of this, discussion around the digitalized economy must increasingly turn to the question of how developing and newly industrialized countries can share in its opportunities.**

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