oikos

Digital Economy and Sustainability

May 2017

oikos Associate Report
Christoph Rappitsch

Table of Contents

Table of Contents **2**

1. Introduction **3**

2. Digital Economy – An Overview **4**
2.1. Development 4
2.2. Technologies 5

3. Digital Infrastructure and Sustainability **7**

4. Digitalization and Sustainability across Markets **10**
4.1. Energy 10
4.2. Food 11
4.3. Health 13
4.4. Housing 15
4.5. Mobility 17
4.6. Finance 19

5. Conclusion **22**

Literature **26**

1. Introduction

Digitalization – the increased use of information and communication technologies (ICT) – is affecting all areas of our lives. Rapid progress in the development of hardware and software is steadily moving us towards a fully-digital society.

The ways how we learn, communicate, and consume are cases in point. Applications and devices make it "easier" (in inverted comma, because sometimes technology makes things more complicated or confusing) to do routine work or to stay in contact with each other. Many of them have already become so embedded in our daily experiences that it is hard to imagine living without them. Instant e-mail delivery, navigating with online maps, and an internet at our fingertips, available 24/7, has become second nature to us. The increased use of digital technologies to transfer money, to hail a taxi or to control energy consumption provides an illustration.

The impact of digitalization on our lives is profound. A typical day in the internet today comprises 2.3 billion GB of web traffic, 152 million Skype calls, 207 billion e-mails sent, 36 million purchases on Amazon, 8.8 billion videos watched on Youtube, and 4.2 billion Google searches.[1] The speed with which digital technologies continue to make inroads into societies is constantly on the rise. And the lines between the old economy and a new digital one are becoming increasingly blurred.

Against this background, this report explores the opportunities and risks of the digital economy for a broad sustainability agenda and thus for people, communities and the planet.[2] Bringing two vast topics as digitalization and sustainability together into a 20+-page report is a task that can only be covered in a very selective way. In this spirit, I provide an overview on key opportunities and threats of the digital economy for sustainability, and highlight examples of companies and initiatives attempting to seize the former and mitigate the latter. I am also largely focusing on advanced economies – even though I am certainly fully aware of the significant benefits and risks that digitalization may also bring along for developing countries. I hope that this important dimension can be taken up in follow-up work at oikos in the future.

The report starts with an overview on the digital economy. How is it defined? How clearly can it be distinguished from the rest of the economy? How did it develop in the past and how is it expected to evolve in the future? What are key technologies that it is based on? And which developments are lying ahead?

The subsequent sections focus on the link between the digital economy and sustainability. It starts with an exploration on key sustainability issues relating to the infrastructure that underpins it. What is the resource use of the Internet? What is the environmental impact of end devices, e.g. smartphones?

The next section continues with a closer look at the sustainability implications of digital technologies across different markets including energy, food, health, housing, mobility and finance. It also highlights examples of initiatives that are seizing the opportunities and mitigating the risks of digitization for sustainability.

The final chapter highlights key conclusions and shares an outlook on possible next steps on the topic within and outside of oikos.

[1] World Bank (2016).

[2] The definition of sustainability as reflected in this report is based on the concept of sustainable development as coined by the Brundtland Commission in 1987: "Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs." World Commission on Environment and Development (1987).

2. Digital Economy – An Overview

The term "Digital Economy" was popularized by Don Tapscott – a leading global authority on the economic and social impact of technology – in his 1994 book "The Digital Economy: Promise and Peril in the Age of Networked Intelligence." More than 20 years ago, he highlighted that "in the old economy, information flow was physical: cash, checks, invoices, bills of lading, reports, face-to-face meetings, analog telephone calls or radio and television transmissions, blueprints, maps, photographs, musical scores, and direct mail advertisements. In the new [digital] economy, information in all its forms becomes digital - reduced to bits stored in computers and racing at the speed of light across networks."[3]

For the OECD, "the Digital Economy is an umbrella term used to describe markets that focus on digital technologies [and which] typically involve the trade of information goods or services through electronic commerce."[4] According to Wikipedia, "digital economy refers to an economy that is based on digital computing technologies. The digital economy is also sometimes called the Internet Economy, the New Economy, or Web Economy."

What all these references have in common is a central role of digital information. Economic activities are increasingly based on collecting and processing data about customers, suppliers, warehouses, etc. and transforming them into useable knowledge. Data becomes a new key currency.

In the digital economy, every key aspect of a business is based on technology. Its boundary to the Old Economy is blurred and moving. Technologies are changing rapidly, and so are companies and markets.

2.1. Development

While the digital economy cannot be traced back to one single starting point, the creation of the internet and the introduction of personal computers in the early 1980s, the invention of the world-wide web in 1989 and its opening to the public in the early 1990s, as well as the release of the first smartphones in the late 1990s, were key milestones in its development. Since then we have come a long way.

Today, 7 billion people – 95% of the global population – live in an area that is covered by mobile cellular networks. Close to one out of two people in the world use the internet. The number of mobile phone subscriptions increased from 2.8 billion in 2006 to 7.4 billion 10 years later. Nearly half of all households worldwide have a personal computer.[5]

At the same time, the differences in access to digital technologies remain significant. More than 80% of the population in developed countries compared to just over 15% in least developed countries is online. Fixed broadband subscriptions per 100 inhabitants stand at 30 in developed countries, compared to 0.7 in Africa.[6] Within the OECD, the number of wireless mobile broadband connections stands at close to 140 per 100 inhabitants in Finland, and at 34 in Hungary. More than 90% of businesses use broadband in Spain compared to just below 70% in Poland.[7]

Digital divides also exist on a national level. In Switzerland, 97% of the population with a monthly income above 10.000 CHF uses the internet several times a week, compared with 55% of those with an income below 4.000 CHF. 99% of those aged 14-19 are online on multiple occasions every week, compared to just 43% of those older than 70 years.[8] Different connection speeds also abound. While more than 50 out of 100 internet subscriptions in Switzerland provide high-speed access, just over 20 offer speeds above 25 Mbs and just over 5 feature speeds above 100 Mbs.[9] The concentration of fiber

[3] Tapscott (1994), p. 6.
[4] OECD (2013), p. 5.
[5] ITU (2016a), ITU (2016b).
[6] ITU (2016b).
[7] OECD (2016a), OECD (2016b)
[8] Bundesamt für Statistik (2016a).
[9] Bundesamt für Statistik (2016b).

optic networks in Basel, Bern, Geneva, Lausanne, Winterthur, and Zurich is a further case in point in that context.[10]

Box 1: **Fiber Optic Networks**

Fiber-optic networks send impulses of light through fiber-optic cables to transmit information such as telephone and cable TV signals as well as internet data. Developed in the 1970s, they have already replaced a significant part of core copper networks in the industrialized world.

While their main application so far has been focused on long distance communication and high demand usage, rollout to consumers is gaining momentum. In the OECD, fiber now accounts for 19% of all broadband connections – with a maximum share of 73% in Japan and a low end of close to zero in Belgium, Greece, and Ireland.[11]

These differences notwithstanding, the digital economy is leaving a growing mark around the world. New companies and business models emerge, where old ones fall. Innovation and disruption are abundant. Digital photography replaced Kodak.[12] Bookstores have suffered not only from online retailing of physical books, but also from eBooks and the change in reading habits that go along with them. Uber has successfully and controversially taken away market share from established taxi companies. iTunes, Spotify and Netflix have changed how we consume music and films. Airbnb and TripAdvisor have transformed travelling. Skype, WhatsApp, and Facetime have done the same for communication. And online banking, mobile cash and crowdfunding are reshaping our use of money.

Thus, the digital economy is now estimated to account for more than 20% of GDP worldwide[13] The European Commission has called it "the single most important driver of innovation, competitiveness and growth."[14] Many expect this momentum to continue with accelerating speed and with profound implications for people and planet – both in terms of opportunities as well as risks.

The impact of the digital economy on employment is a case in point. Self-checkouts crowd out human cashiers, computers sit in for persons in call centers, and online banking reduces bank staff. In their bestselling 2014 book "The Second Machine Age", MIT's Erik Brynjolfsson and Andrew McAfee share an optimistic picture about technological progress, but also caution against the significant risk that it will put many jobs at risk as tasks that were previously thought to be uniquely human are taken over by robots and algorithms.[15]

At the same time, new jobs emerge. Apple estimates that the applications designed for its smartphones have helped create more than 600,000 new jobs.[16] The European Commission forecasts "that if all EU countries mirrored the performance of the USA or the best-performing EU countries, 400,000 to 1.5 million new jobs could be created in the EU internet economy."[17]

2.2. Technologies

The digital economy is built on a myriad of technologies and products. Key pillars include the internet, smartphones, broadband and mobile networks, Radio Frequency Identification (RFID), sensors (to detect changes in the environment), as well as a rapidly expanding universe of software.

Increasingly, these technologies are not only used by users to communicate with other users or devices, but also to enable smart devices to communicate with each other in what has been coined the "Internet of Things" (IoT). A washing machine that starts automatically after the sun provided enough energy for the house photovoltaic system, and sends a message to the homeowner that it has started and when it expects to finish is a case in point.

The rapid fall in costs for sensors, processing power and communication are key enablers of this development.

[10] See https://map.geo.admin.ch (→ "Broadband map" → "Optical Fibre")
[11] OECD (2016d).
[12] Gann (2016).
[13] Accenture (2016).
[14] European Commission (2016a).
[15] Brynjolfsson and McAfee (2014).
[16] Bloomberg (2015).
[17] European Commission (2016a).

Sensor prices have dropped from 1.30 US$ to 60 cents over the last 10 years. Processing costs have come down by a factor of 60 and the cost of bandwidths has dropped by a factor of 40 in the same time. Goldman Sachs refers to the resulting "Internet of Things" as the third wave of the Internet with the first stage of fixed internet connecting 1 billion users, the second stage of mobile Internet adding another 2 billion, and the third stage having the potential to add another 28 billion "things" by 2020.[18] IoT Investments are expected to amount to 6 trillion US$ 2015-2020.[19]

While the IoT offers vast opportunities it also poses significant risks – in particular in terms of security. Many smart devices contain sensitive data, e.g. tracking information. At the same time, they are relatively simple in their construction and often have no firewall. Moreover, communication between them is often not secure. As a result, they are attractive targets for hackers who may extract sensitive information or take control of the device. A recent example was the Distributed Denial of Service (DDoS) attack on Dyn, a major DNS host (which acts like an address book in the internet). During the attack, which shut slowed down or knocked off websites such as Amazon, Netflix, Twitter and many others, smart devices were used to make so many requests to the Dyn Servers until they shut down, no longer being able to handle requests.[20]

Box 2: **RFID**

An important component of IoT technologies is "Radio-frequency identification" or RFID. The technology is based on the use of electromagnetic fields to identify and track tags attached to objects. It comprises two components – the tag, which contains electronically stored information, and the reader, which reads the information on the tag. Passive tags convert energy from a nearby RFID reader's interrogating radio waves into usable power. Active tags have a local power source such as a battery and may operate at hundreds of meters from the RFID reader. Unlike a barcode, the tag need not be within the line of sight of the reader, so it may be embedded in the tracked object. The amount of data a tag can store varies. Usually tags carry no more than 2KB of data – enough to store basic information about the object it sits on.[21]

[18] Goldman Sachs (2014).
[19] BI Intelligence (2016).
[20] Solomon and Fox-Brewster (2016).

[21] https://en.wikipedia.org/wiki/Radio-frequency_identification, http://www.makeuseof.com/tag/technology-explained-how-do-rfid-tags-work/, https://www.rfidjournal.com/faq/show?66.

3. Digital Infrastructure and Sustainability

The digital economy has significant social and environmental repercussions. In that context, IISD (2010) distinguishes between „direct effects" of the ICT sector itself, "enabling effects" through the use of ICT in e.g. smart energy grids, buildings and transportation, and "systemic effects" by "enabling the transformation of economic, social and governance structures, and supporting fundamental changes in the values, attitudes and behavior of individuals, as citizens and consumers."[22] Similarly, SCF Associates (2009) identifies the following first, second, third and fourth order effects:

1. Effects "due to the physical existence and use of ICT plus manufacturing processes involved, e.g. pollution and energy to manufacture and for disposal, etc."
2. Effects "created by the application of ICT to optimize unsustainable consuming processes, i.e. power saved by use of ICT in applications."
3. Effects "due to the aggregated effect of large numbers of people using ICT over the medium to long-term as ICTs can have substitution effects, e.g. for physical travel, saving on travel, road congestion, with knock-on effects, in road construction, etc."
4. Effects due to improvements in "society's overall decision-making capacity to implement sustainability policy, with metrics to measure impacts in real time"

A key sustainability aspect of digital infrastructure is its use of resources. Global sales of PCs, tablets, ultra-mobiles and mobile phones amounted to 2.4 billion units in 2015.[23] With all these devices comprising dozens of minerals, metals and compounds their material intensity and thus their social and environmental effects are profound.

The role of tin in smartphones provides an example. Tin is a key component in phones and other electronic gadgets. Almost one third of global tin supply is produced on the Indonesian islands of Bangka and Belitung. Several reports have highlighted the social and environmental harm caused by tin mining in the region – including injuries and fatal accidents when mines collapse, loss of forest and farmland, as well as damages to marine life.[24]

Box 3: **Fairphone – A Smartphone with Minimal Harm to People and the Planet**

Fairphone is a Dutch social enterprise that designs, produces and sells smartphones with "minimal harm to people and the planet." It aims to create positive social and environmental impact – in particular through long-lasting design and reparability, the use of fair materials, as well as the provision of good working conditions. Its modular design makes it easier to replace single parts. The longer use time that results from that reduces CO2 emissions by 30% across its life cycle.

The company started in 2010 as an awareness campaign to highlight the use of conflict minerals from the Democratic Republic of Congo in smartphone supply chains. Back then, the sole intention was to engage the Dutch public in designing the prototype of a "fair" smartphone and thus to create awareness for the role of conflict minerals in its supply chain. The launch of a functional commercial product was not on the agenda.

Nonetheless, in January 2013 the campaign became a social enterprise and by Christmas 2013 delivered its first batch of Fairphones to consumers. It launched the Fairphone 2 in December 2015 and in May 2016 crossed the mark of 100,000 Fairphones owners – an important milestone, but still a relatively small number compared to other big smartphone producers: Samsung alone shipped 72.5 million devices worldwide in Q3 2016.[25]

[22] See also Ciocoui (2011)
[23] Gartner (2016).
[24] See e.g. Friends of the Earth (2012) and Bloomberg (2015).
[25] https://www.fairphone.com, Fraunhofer (2016), Akemu and Whiteman (2015), Statista (2017a).

Energy consumption of digital infrastructure is another significant sustainability factor. The expanding use of digital technologies increases the need for reliable and secure power supply – and thus the vulnerabilities in case of failure. Electricity has been the backbone of industrialized societies for a long time. With digitalization, our dependency on power is increasing even further. The 2003 blackout in the Midwest and Northeast United States as well as Ontario, Canada, which affected 50 million people and lasted for four days for some of them, is a case in point. It also resulted in an estimated economic loss of 6 billion US$.[26]

Moreover, rising energy demand for digital technologies has important environmental repercussions. The use of energy to cool data centers as well as to adjust to air temperatures, humidity and pressure is reported to account for 2% of greenhouse gas emissions worldwide, thus putting them on par with global aviation.[27] In 2013, the energy consumption of data centers in the US was estimated to amount to 91 billion kilowatt hours of electricity – the equivalent to the yearly output of 34 large coal-fired power plants.[28] Apple's iPhone uses about 2 kWh per year if it is charged daily. An average laptop uses about 72 kWh and an average desktop computer uses 300 kWh per year.[29] Thus, the 231 million new iPhones sold in 2015 and the 277 million new laptops and desktop computers that were shipped in the same year, leave a sizable sustainability footprint – not just in terms of resource use, but also through their energy consumption.[30]

As more and more people get connected to the Internet and use smart devices energy consumption through digital infrastructure will increase. Nonetheless, the net effect in terms of energy savings may still be positive. In fact, GeSI (2015) estimates that expanded use of ICT technologies will lead to an increase in the carbon footprint of ICT infrastructure by 1.25 Gt CO2 until 2030, but during the same period to a footprint reduction of 12 Gt CO2 due to the positive enabling effects of ICT across all sectors.

Box 4: **The Carbon Footprint of Google**

Google disclosed its carbon footprint for the first time in 2011 and has since reported its CO2 emissions on an annual basis. In 2015, its total emissions of CO2 equivalent amounted to just under 3m tons – an amount that the company matches with carbon offsets to bring its net emissions down to zero.[31]

In 2016, the company sourced more than 50% of its energy from renewables. It also announced that it has become the "largest corporate buyer of renewable power, with commitments reaching 2.6 gigawatts of wind and solar energy", and that it will reach its goal of 100% renewable for its global operations by 2017.

In 2015, Greenpeace rated the company with a "B" on "Energy Transparency" as well as "Renewable Energy Commitment and Siting Policy", and with an "A" on "Renewable Energy Deployment and Advocacy". Greenpeace also offers the "Click Green Scorecard" as an add-on for the Google Chrome web browser, which shows to what extent websites are powered by clean or dirty energy.[32]

From a social perspective, access to digital infrastructure remains a key challenge. By end-2016, the number of people not using the internet stood at, 3.9 billion people – more than half of the global population. In Europe, 20% of the population is offline. In Africa that share amounts to 75%. Across the world, highlighting a divide across gender lines, 51% of the men use the internet, whereas only 45% of women are online. Fixed broadband penetration remains below 1% in Least Developed Countries (LDCs) compared to 30% in the developed world. Fixed broadband prices are five times as high in LDCs compared to the costs in developed countries. Bandwidth per inhabitant amounts to 131 kbit/s per inhabit-

[26] CRO Forum (2008), p. 8.
[27] Vaughan (2016).
[28] NRDC (2015).
[29] Helman (2013).
[30] Statista (2017b), Statista (2017c).
[31] Clark (2011), Google (2016).
[32] Google (2016a), Google (2016b), Greenpeace (2015).

ant in Europe, in stark contrast to 13 kbit/s in Asia and 6 kbit/s in Africa.[33]

Divides also persist within countries. The differences in internet usage across age and income within Switzerland mentioned earlier are a case in point. When Google started providing Fiber access in Kansas City, a survey showed just 10% of residents in low-income neighborhoods taking up the service, compared to 42% in middle and high-income areas. 21% of those who did not subscribe in the low-income neighborhoods cited costs as the reason for not subscribing.[34]

In addition to different levels of access, the digital divide also results from a gap in competencies to exploit digital technologies. In that context, the OECD reports vast differences in ICT skills and calls for more emphasis on "promoting strong levels of foundation skills, digital literacies, higher order thinking competencies as well as social and emotional skills.[35]

Box 5: **Digital Divide Data (DDD) and Impact Sourcing**

Digital Divide Data (DDD) is a social enterprise that delivers business process outsourcing services to clients worldwide. Established in 2001 in Cambodia, the firm today has staff of over 1200 across Asia, Africa and North America.

DDD offers digital content, data and research solutions such as eBook conversion, newspaper and archive digitization, data entry, and web research. Its services are provided by youth from low-income families in developing economies, as well as, since 2014, military spouses and veterans in the United States.

Its social model provides its employees with opportunities to generate income and access to higher education as well as skills development. The company has been a key driver of a broader movement coined "Impact Sourcing" to leverage global sourcing for development. In September 2016, a group of leading buyers and providers in the field launched the Global Impact Sourcing Coalition.[36]

[33] ITU (2016a).
[34] Barr (2014).
[35] OECD (2016). Also see Wischmeyer (2016) and Lobe (2016).

[36] www.digitaldividedata.com, gisc.bsr.org/.

4. Digitalization and Sustainability across Markets

While digital infrastructure has significant sustainability implications, digitalization also brings along vast sustainability opportunities and risks through new products, services and business models. Against this background, the following chapter focuses on the key role the digital economy plays in six key markets: Energy, Food, Health, Housing, Mobility, and Finance. It offers a short introduction into digital developments in each of these realms, explores the opportunities and risks of digitalization, and presents solutions to harness digital technologies for sustainable development.

4.1. Energy

Our modern society needs sustainable, reliable and secure energy supply, which not only provides and stores green energy (i.e. hydroelectricity, solar, wind, etc.), but is also able to integrate these power forms from various sources, e.g. private solar panels. One of the biggest challenges to integrate renewable energy into the grid is the fact that it does not steadily produce energy. This leads to fluctuation in the grid with peaks and lows in supply.

Smart grids play a growing role to balance power generation with demand and increase efficiency. Compared to a traditional grid, which is designed to take power from central generators and carry it to several customers, smart grids are able to use two-way flows of electricity and information. This allows them to create an intelligent and automated energy delivery network.[37] It also allows producers to monitor consumer behavior to the effect that the system can adapt quickly to peaks in consumption.

Digital technologies are at the heart of smart grids. Smart meters that allow real-time tracking of power consumption by end-users are a case in point. Smart household appliances that communicate with the grid and react to signals from energy providers to reduce energy consumption during times of peak demand are further key components. Data collection, management and analysis are additional key pillars.

Box 6: **DEPsys – Monitoring the Smart Grid**

Switzerland-based DEPsys was founded in 2012 to create a real-time management tool for a stable feed-in of renewable energy into the grid. The company's vision is based on the belief that "the world should be powered entirely by renewable energy".

Against this background, its core product "GridEye" provides a smart grid platform to measure, monitor and control the low-voltage grid for an efficient integration of renewable energy sources at decentralized injection points. The hardware components of the platform are used to measure and control data and to communicate with each other. The data is then analyzed to optimize grid performance by reducing peak loads, efficient use of all decentralized energy sources and adaptions to customer needs. The server provides visualization, configuration and data management applications and is accessible through a web browser. It can also be used as a database and backup system.

In 2014, Bilan selected DEPsys as one of the 50 best Swiss start-ups to invest in. In 2015, the company was ranked among the best 100 start-ups in Switzerland. In 2016, the company received 3 million CHF of financing from Statkraft Ventures, VNT Management and ONE CREATION.[38]

Smart grids also provide the infrastructure for the growing role of "prosumers" – consumers that produce power themselves for their own use and to feed it into the network. Decentralized electricity generation accounts for an increasing share of global power production. In 2015, Europe had more than 2'800 energy cooper-

[37] Fang et al. (2012)

[38] http://www.depsys.ch.

atives. In Germany, the number of renewable energy cooperatives increased from 67 in 2008 to 772 by 2014. Nearly half of the renewable energy capacity in Germany is owned by private households and farmers. Decreasing costs of distributed power generation and energy storage are key drivers of this development.[39]

As a result, utilities face a growing need to move towards new business models and strategies that account for the increasing share of distributed power generation. Using their capabilities to manage the supply and demand balance in distributed energy networks, and offering contracting services to increase energy efficiency in residential and commercial buildings, are possible pathways to pursue in this context.[40]

Box 7: **Eturnity AG – Advisory Platform for Solar Panels**

Established in 2012, Eturnity provides online platform for electric utilities and solar power installers to provide "competent, speedy and cost-efficient advisory" and to automate the sales process for solar power systems.

The platform, called LEA, determines the specifications for an optimal solar power system based on data such as location, building properties, electricity supplier and consumption, and generates a quotation that can then be sent to the end customer. The company also offers a Smart Meter to collect data for buildings without a consumption profile.[41]

4.2. Food

The agricultural sector must face major challenges in the future. Food demand is projected to increase by at least 60 percent until 2050 compared to a 2006 baseline. Climate change and resource scarcity pose growing obstacles to meet this requirement. Against this background, the most recent annual report of the Food and Agricultural Organization highlights the need for "a profound transformation of food and agricultural systems worldwide".[42]

Digital technologies can play a key role in addressing these challenges. Precision farming is a case in point. Bringing together various components such as sensors, cameras, and GPS it allows farmers to apply precise amounts of water, pesticides and fertilizer at the right time to their crops – and thus to reduce the amount of inputs while at the same time increasing yields. Data collection and analysis on weather, soil and air quality stand at the core of this approach.[43] The Global e-Sustainability Initiative and Accenture estimate that by 2030 the increased use of digital technologies in agriculture can raise average global crop yields by 30%, reduce food waste by 20%, lower annual CO2 emissions by 2 Gigatons, and create 2 billion US Dollars in additional revenues in the sector.[44]

Box 8: **CombaGroup – The Smart Lettuce**

CombaGroup was started in Switzerland in 2011. The company works together with salad packagers and sets up greenhouses to grow salad right next to the packaging fabrics. Its innovative use of aeroponics – the growing of plants in an air or mist environment without the usage of soil – consumes 90% less water, 90% less space and reduces the carbon footprint by 20% compared to traditional ways of growing.

IT controls the temperature and air moisture. It also provides the right mix of water and minerals for an irrigation robot to spray on the salad roots in controlled intervals. The resources, which are not used by the plants, are recovered and recycled. The result is locally-produced salad without the use of pesticides and herbicides all year-round and significantly lower environmental impact.[45]

Increasing crop yields are an important, but not a sufficient step towards global food security. The eradication of hunger will depend largely on an increase in purchasing power in

[39] Ren 21 (2016)
[40] See e.g. Hannes and Abbott (2013), PwC (2013).
[41] www.eturnity.ch.
[42] FAO (2016).
[43] IBM Research (2017).
[44] GeSI and Accenture (2015).
[45] www.combagroup.com.

developing countries. In that context, digital technologies can play an equally important role – also regarding agricultural incomes and safety nets. The use of RFID technology in livestock insurance (see below) and the offering of weather insurance through cell phones, as provided for example through ACRE Africa[46], are cases in point.

Box 9: **RFID in Livestock Insurance**

In spite of three decades of government support, livestock insurance in India had remained out of reach for many farmers. A significant prevalence of false claims had kept premiums high and thus affordable insurance coverage limited. In 2009, IFFCO-Tokio General Insurance – a joint venture between the Indian Farmers Fertilizer Cooperative (IFFCO), formed by more than 40,000 farmers' cooperatives, and Tokio Marine and Nichido Fire of Japan – launched a cattle insurance scheme for 25'000 farmers. The scheme is based on tagging insured animals with RFID chips. The use of RFID greatly reduces scope for fraud and as a result has led to a significant reduction in premiums and an expansion of coverage. Two years after introduction, the scheme had insured more than 28'000 cattle for 16'800 beneficiaries.[47]

In parallel to the expanding use of digital technologies in food production, digitalization is also making growing inroads into its distribution. The increasing role of online shopping provides an illustration. A 2015 online survey of 30'000 respondents across 60 countries, found one quarter to be already shopping groceries online for home delivery and 55% being willing to do so in the future. A smaller number of consumers are using "click and collect" models where they order online and pick up goods themselves at a store or different location.[48] Similarly, a 2013 survey by A.T. Kearney of 617 people in Switzerland reports that 30% had already bought groceries via the internet at least once. The three main reasons why people did not buy online were: (1) satisfaction with the traditional shopping facilities, (2) no possibility to feel/taste the food, and (3) insecurity about the quality of the product. At the same time 58% say they have a general willingness to buy food online. People were also asked what would need to change for them to buy more online. Their most common answers were: (1) the possibility to control goods at delivery, (2) the guarantee that food was packed on the same day, (3) the possibility to choose from identical delivered products, and (4) the availability of a picture of the actual product.[49]

In the context of this development, new (online) participants and technologies enter the market. In 2007, Amazon started an online supermarket (AmazonFresh) in the US for grocery deliveries and in June 2016 added London as the first metropolitan area outside of the US to this offering.[50] In Switzerland, the launch of dedicated online grocery shops for organic products, like farmy.ch, bio-online-shop.ch or green-shop.ch, provide further examples.

Box 10: **farmy.ch – The Online Portal for Organic and Regional Products**

Farmy.ch was founded in 2014 as Switzerland's first online platform for regional and organic products. Nearly the entire offering comes from farmers in Switzerland. A few products such as coffee and bananas are sourced from producers abroad based on criteria that meet the company's philosophy. To be more than just an online shop for regional products, farmy.ch also offers recipes for regional meals with pre-set product baskets. Orders are delivered within two days. In Zurich, deliveries are either made by environmentally friendly E-Bikes or can be picked up at one of 6 pick-up stations.[51]

In addition to online purchases – either from online-only shops or from brick-and-mortar stores with an online presence – digital technologies are also gaining traction in other applications. The use of Quick-Response (QR) Codes is a case in point. QR-Codes are optical labels that provide information

[46] acreafrica.com.
[47] Impact Insurance (2012).
[48] Nielsen (2015).
[49] A.T. Kearney (2013)
[50] Simpson (2016).
[51] https://www.farmy.ch.

about the products they relate to and which can be read by different devices such as a smartphone. In 2012, Walmart and P&G launched shopping trucks with QR-Codes on their sides in Chicago and New York. Customers could scan these codes to purchase the items displayed and have them delivered to their homes.[52] A year earlier, Homeplus, a discounter in South Korea, opened the first virtual supermarket in the subway of Seoul where it displayed food and drinks with their respective QR-Codes on the subway station billboards. Customers could scan and buy these items to be delivered to them on the same day.[53]

In addition to such use of QR Codes to order purchases, they also play a growing role in increasing transparency on products. With smart devices (phones, tablets, etc.) it is easy for customers nowadays to scan products and do research on them, even while in a store. The application fTRACE is an example. Its provider works together with different food producers to include a tracking code on the packaging of their products, which can be scanned to retrieve key information about the product, e.g. its origin, where and when it was processed, as well as data about its quality.[54]

4.3. Health

Digital technologies already play a significant role in healthcare today and are expected to have an even profounder impact on the sector moving forward. ICT adoption in healthcare has followed a similar pathway as in other industries since the 1950s and led to the use of IT in standardized tasks such as accounting and payroll, as well as the processing of vast amounts of data and supply chain management. Fast forward to the 2010s, and the picture becomes much more diverse with a convergence of health technology, genomics and ICT providing an expanded digital healthcare offering.[55]

Components of digital healthcare range from electronic medical records, mobile health apps, telemedicine to wearables. Digital patient records such as the "My Health Record" in Australia, the EU-funded "MyHealthAvatar" app, online platforms for medical consultations such as "DrEd", as well as wearables such as "Fitbit" which track steps, distance and calories burnt, are examples in this context.[56] Wearables are smart devices, which are worn on the body of the user, e.g. smart watches or fitness trackers. These devices can monitor body functions and encourage the wearer to be more active. A current project in this field is the development of a smart lens by Verily Life Sciences, a sister company of Google, and Alcon, a subsidiary of Novartis. The prototype, which was introduced in 2014, has sensors and a radio antenna thinner than a human hair and is able to measure glucose levels in tears – thereby allowing diabetes patients to control their blood sugar.[57]

Box 11: **Visolino by obvita**

As more and more schools use iPads in classrooms, doors are opened for the inclusion of visually handicapped persons with such features as a zoom function or "Voice-Over". But often this is not enough to follow the lesson. Visolino by obvita was started to address this challenge.

obvita is a Swiss non-profit association with the aim to help and improve the life of visually handicapped individuals through different projects, courses, and activities. One of its projects is their app called Visolino for iOS. It is designed to help visually handicapped students to participate in reading, writing and mathematics and to cover further their special needs. It allows user to

- change the contrast of the window of each learning content to fit the need of each student
- change the size of fields, texts and numbers
- use an external keyboard, so that the monitor only contains necessary information
- use the app with a braille terminal

The project was started in 2015 and devel-

[52] City Wire (2012).
[53] Strother (2011).
[54] www.ftrace.com.
[55] Deloitte (2015).
[56] myhealthrecord.gov.au, www.myhealthavatar.eu/, https://www.dred.com.
[57] https://verily.com/.

oped by the obvita association in cooperation with teachers, students as well as internal and external IT-specialists. The app was funded by obvita and other charitable organizations and released in April 2016.[58]

Health applications of artificial intelligence and virtual reality are also making a growing imprint upon the sector. The use of IBM Watson in healthcare provides an illustration. Watson uses similar steps as a human to make decisions, observe, interpret, evaluate and finally decide. It is supplied with big data (books, research papers, articles, etc.) from a certain field (e.g. health care), then tries to understand each sentence and what the real intent of the sentence is, and thus learns the language, the jargon and the mode of thought in this area. Based on this, Watson comes up with answers to questions. It learns and gets more precise by ongoing Q&A with human experts from the field. The technology became famous for competing and winning on the US quiz show "Jeopardy" in 2011.[59] In 2013, its first commercial application was in a cancer treatment center in New York City, where Watson assisted doctors in finding the right treatment for patients.[60] In 2015, IBM launched Watson Health to expand its consulting towards other hospitals and doctors. Final decisions are taken by doctors.[61]

Digitalization also brings new possibilities when it comes to educating young doctors. In April 2016, a cancer surgery was live-streamed using virtual reality and 360-degree video technology. This live stream could be watched using either a smartphone or VR-glasses in hospital universities around the world. It was even possible for medical students to type questions, which the surgeon would answer during the operation.[62] Similarly, the UK Royal College of Surgeons announced that it plans to explore the use of mixed reality headsets (e.g. Microsoft HoloLens) to replace traditional cadaver-based training with the use of holograms for training purposes.[63]

Box 12: **MindMaze**

MindMaze was founded in 2011 as a spin-off from the Swiss Federal Institute of Technology Lausanne (EPFL). The company builds human-machine interfaces to help people with neurological disabilities, mostly stroke victims, to recover by retraining their brain based on virtual reality, computer graphics, and brain imaging.

Their key product, called MindPlayPRO, is designed to trick the brain to think, that the side affected by a post-stroke paralysis is moving while in reality the healthy side does all the actions. This triggers new neural connections and thereby a rewiring that helps patients learn to move their paralyzed side again. The newest version of the product integrates the use of VR-glasses.[64]

The increasing move towards e-health can make healthcare more efficient, transparent and raise the quality. In tests, "Watson's successful diagnosis rate of lung cancer is 90 percent, compared to 50 percent for human doctors"[65], which leads to a quicker treatment and thereby increases survival chances of the patient. Also, if more and more doctors and hospitals are connected via the Internet, they can easily share patient data and consult each other, thus making the whole system more effective. Wearables are able to provide health data 24/7, which makes it easier for doctors to diagnose the patient. They can also inform the wearer, if body signals are unusual, e.g. of the imminent risk of a heart attack. Such applications could transform the health sector from a system which has its focus on the past (what has happened, how can this be treated, etc.) to a system, which focuses on the future (how will the health of the patient develop, are there any risks soon for the patient, etc.). Furthermore, more medical students can get a lifelike experience of surgeries and learn from the best surgeons around the world. With mixed reality headsets, it is much easier for colleges and universities to simulate complicated surgeries for many students without the need for real human bodies or parts. Therefore, spatial distance

[58] www.obvita.ch.
[59] Markoff (2011).
[60] Upbin (2013).
[61] Lorenzetti (2016).
[62] Quinn (2016).
[63] Davis (2016).
[64] www.mindmaze.ch.
[65] Steadman (2013).

will become less and less important and increase the skill level of aspiring doctors.

To move further in this direction, state assistance is needed. A successful transformation of the health sector needs a good combination of innovation from the private sector as well as reforms in the public sector. Switzerland's eHealth strategy provides an example. Formulated in 2007, it became an integral part of the federal "Health 2020" strategy in 2013. Its aim is to establish nationwide electronic patient dossiers and to provide doctors and patients with an internet portal, where individuals can inform themselves about current treatments and gain relevant information. The strategy also highlights the benefits of telemedicine and telemonitoring (diagnosis and treatment, as well as monitoring, of patients from afar).[66]

At the same time, and despite all the benefits from ehealth, one should not overlook the risks of digitalization in the health sector – especially regarding privacy. In this context, as in other parts of this report, the biggest questions are: (1) how easily can our data be hacked; and (2) are we giving up too much privacy for too little benefit? The connection between hospitals and doctors is good for efficient examinations of patients. But putting patient records into the cloud potentially allows hackers to access and misuse sensitive data. Similarly, wearables share the same weakness as all IoT devices: default passwords (which are often never changed); no security functions (such as firewalls); and vulnerability to attacks (e.g. DDoS). Furthermore, the wearables' GPS function, tracking the movement of the wearer, can be used as a surveillance tool. Against this background, and in view of the sensitivity of health information, data security will be key to further digitalization of the sector.

4.4. Housing

Digital technologies are also becoming more and more important in our homes. Smart household devices increasingly communicate with and control each other. They automatically turn off for energy preservation while smart meters meticulously collect client data and let energy producers optimize their supply. Users can program radiators to heat up at 7 a.m., half an hour before they wake up, and lights to switch off, when they leave the house. Air conditions and security systems can be controlled by smartphones. And indoor positioning systems allow for real-time tracking of people and objects.

Within the last few years, a lot of companies have moved into this space. Amazon and its "Echo" system provide an illustration. It is a speaker, which is activated and controlled by the user's voice and automatically connects to the Alexa Voice Service, an artificial intelligence/personal assistance. The service can control lights, play music, share weather updates, give reminders about appointments, etc.[67] Similar systems are offered by Google (Google Home), Apple (Apple HomeKit) and other smaller companies from all over the world. A big question for the future is, if these systems will be able to control and manage all the different smart applications in our homes or whether their services will be limited to certain brands and applications.

All these applications can be used for the purpose of reducing energy consumption. In that context, one of the biggest savings potential lies in the heating systems. With time-controlled thermostats and automatic opening of windows households can reduce their consumption of heating energy by 10-30%.[68] Users of Nest, a US company that was acquired for 3.2 billion US$ by Google in early 2014, were reported to have saved 1.4bn kilowatt-hours of electricity between 2011 and its acquisition, equaling enough electricity to power 135,000 US homes for a year.[69] Similarly, Advanced Power Strips (APS) – designed to turn off every electronic device that is not used – reduce energy waste in the form of "vampire loads" (electronic devices, which use energy in standby-mode) and save up to 12% of the annual electricity consumption in a household.[70]

These great benefits notwithstanding, the drawbacks of smart homes should not be overlooked: privacy issues and

[66] BAG (2016).

[67] Wikipedia (2017).
[68] Diermann (2014).
[69] LaMonica (2014).
[70] US Department of Energy (2016).

data security risks. Since the disclosures of Edward Snowden, society started paying more attention to privacy and data security. Despite the development of new tools, nobody can be fully sure, whether a conversation is private or if one's location is tracked. Samsung, for example, warns customers not to discuss personal information in front of their TVs, with the voice activation feature on. The TV set will "'listen' to what is said and may share this information with Samsung or third parties".[71] It is also possible for hackers to take control of smart devices and use these either to get ransom money from the owner or use the devices for other hack attacks. The attack on Dyn referred to in section 2.2 provides an illustration. Recently Pen Test Partners, a British IT security firm, demonstrated how easy it is to hack into a smart thermostat and take control of it. They could even send messages like: "Give us money or this winter is going to be very cold". The company also said, this hack could have been easily prevented, if the system had some basic security controls, which was not the case.[72] Obviously, making the IoT more secure should rank high on our agendas. People must also start thinking about how many smart devices they really need.

Box 13: **Loxone and eSmart – Managing Smart Homes**

Loxone was established in 2009 and is headquartered in Austria. The company's green
miniserver offers an integrated platform to manage energy use across the entire home. Features include optimal use of the sun, e.g. by automatically opening the shutters in the morning to use sunshine for heating, coordination with off-grid photovoltaic energy production, e.g. by only turning the washing machine on when the home-owned PV system produces electricity, and a stand-by killer that shuts down all electronic devices in standby mode. The server also provides home owners with detailed statistical information about their energy use and thus the data to reduce energy consumption.

eSMART was established in 2011 as a spin-off of the Swiss Federal Institute of Technology (EPFL) in Lausanne, Switzerland. The core of the company's smart home management system is "a distributed automation system made of modules the size of three cubes of sugar that are plugged directly into the home's existing electric grid and connected to a touch-screen, smart phones and computers". It allows for remote and automatic control of smart homes and supports users to reduce energy consumption. Among other features, the system offers wall-mounted touch screens for home control, room-by-room temperature regulation, video phone for checking identities at the door, as well as the collection and analysis of energy consumption data.[73]

In addition to their impact within homes, digital technologies are also a driving force for new business models in the housing market. Airbnb and Couchsurfing – two online platforms that allow travelers to find accommodation in places they travel to – are cases in point. Airbnb involves payments from guests to hosts. Couchsurfing involves no monetary exchange between its users. Both offerings are examples of the Sharing Economy – "an economic system in which assets or services are shared between private individuals, either free or for a fee, typically by means of the Internet."[74]

Box 14: **Airbnb – The Bright Side and the Pitfalls of the Sharing Economy**

Airbnb is an online rental service that allows owners to rent out their homes and apartments to short-term tenants. It was founded in 2008, is active in over 191 countries and has over 2 million listings worldwide. The company generates revenues by receiving a percentage of the rent.

Airbnb is a prime example, if not the poster child, of the Sharing Economy. Its proponents argue that it fosters a more efficient use of existing homes and makes travel more sustainable.

[71] BBC (2015).
[72] Tierney (2016).
[73] www.loxone.com, www.myesmart.com, www.startup.ch/esmart.
[74] https://en.oxforddictionaries.com/definition/sharing_economy.

At the same time, critics point to the fact that Airbnb creates unfair competition for hotels as the homeowners who are renting out their places via this platform do not need to meet the same regulatory standards. Furthermore, the growing number of apartments offered through Airbnb has already been reported to reduce the availability of affordable housing for permanent residents in a city. Against this background, the city of Berlin passed a law – the "Zweckentfremdungsverbot" – in 2014 that came into effect after a two-year transition period last May, and which restricts non-licensed lending via platforms such as Airbnb, Wimdu and 9flats to rooms only and prohibits renting out entire apartments or houses without a permit. Fines for non-compliance can go up as high as 100.000 euros. City authorities have indicated that they would reject 95% of requests for permits for popular districts.[75]

4.5. Mobility

I want to start this section with a quote from my father, who worked as a mechanic for almost 30 years, from ten years ago: "The future of our mobility lies not in the fact, what we drive, but who drives it. In 15 to 20 years we will have self-driving cars and relax during our road trips." It seems as if his prophecy will turn out to be true.

Self-driving cars are going to be one of the biggest changes digitalization is going to bring for our society. These cars, also called autonomous vehicles, "are vehicles that are capable of sensing its environment and navigating without human input".[76] They offer the possibility to connect with other cars and reduce accidents. Furthermore, if these cars are electric, they can be integrated into the grid and function as energy storages.

Every big car manufacturer and IT companies such as Google and Apple are working on this topic. Google started its autonomous car driving project in 2009 and renamed it into Waymo in 2016. By then, its self-driven fleet had collected 2 million miles. Audi, BMW and Daimler formed the "5G Automotive Association" together with Ericsson, Huawei, Nokia, Intel, and Qualcomm in September 2016 to use 5G technology to better connect vehicles with each other. Tesla introduced its semi-autonomous "Autopilot" feature in late 2015, which enables hands-free control for highway and freeway driving. Apple launched its self-driving cars in December 2016.[77]

Autonomous cars offer several benefits in terms of sustainability. They could reduce the number of accidents significantly.[78] In 2013, according to the WHO, 1.25 million people died in road accidents worldwide.[79] Reducing this number would not only decrease personal tragedies, but also lower the costs for hospitals and insurances. To make this possible, technology is required to let cars communicate and warn each other of obstacles on the road. The same technology could be used to find parking spaces quicker and optimize routes, thereby saving time and fuel. Furthermore, autonomous cars could increase the mobility of elderly or disabled people, as they can now use a car without driving it by themselves or with the help of others. There is also an opportunity for autonomous cars to boost car sharing, if automotive and/or IT companies provide cities with autonomous car sharing fleets and a well-organized system to use them. This could provide significant relief to city infrastructure (e.g. through reduced traffic and lower demand for parking spaces)

But autonomous cars and their interconnectedness also pose risks. The potential for technology abuse raises particular concerns. In that context, one of the worst-case scenarios is that hackers would take control over autonomous cars and only give it back in return for money. Moreover, possibly wide-ranging effects of technological failures give reason for caution. Sensor systems may not be able to fully capture the surroundings, which could lead to accidents. A deadly example is the crash of a Tesla in autopilot mode in mid-2016, which was not able to "distinguish a large white 18-wheel

[75] www.airbnb.ch, Oltermann (2016).
[76] https://en.wikipedia.org/wiki/Autonomous_car.
[77] www.waymo.com, Der Standard (2016), Wired (2016), Economic Times (2016).
[78] Bertoncello and Wee (2015).
[79] WHO (2017).

truck and trailer [against a bright spring sky]."[80] There is also the possibility that people use autonomous vehicles more often as the time during travels can be used for productive work, thereby increasing the use of energy and pollution. Another important point to mention here is, that as autonomous cars are more convenient to drive, more people may buy one, thereby raising resource and energy use, increasing traffic, and thus placing a higher burden on cities' infrastructure.

Moreover, self-driving cars will have significant effects on employment – in particular on the jobs of truck and taxi drivers. Self-driving trucks hit the road in the US state of Nevada in May 2015. A year later, a self-driving convoy crossed Europe to reach the port of Rotterdam. In September 2016, UBER introduced self-driving cars into its fleet in Pittsburgh. Shortly thereafter it expanded this offering to San Francisco. Governments need to prepare for the impact of this development. The fact that the US alone has 3.5 million truck drivers offers an indication for the scale of the challenges disruption in this sector may pose.[81]

For autonomous cars to reach the mainstream, there are still many obstacles to overcome. While many projects seem promising, the technology still has to be perfected. Additionally, the legal situation is still unclear. Bringing light into this legal grey zone, policy makers not only have to consider physical safety and damage, but also privacy and cybersecurity issues – in particular with regard to the questions what happens with collected data and who can access it?[82] One step into right direction would be if cyber security experts, self-driving car manufactures and policy makers work together and try to come up with solutions for these complex difficulties.

Box 15: **BestMile – Cloud Platform for Autonomous Vehicles**

BestMile is a Lausanne-based startup and another spin-off from the Swiss Federal Institute of Technology. Founded in 2014, the firm offers a platform to optimize and operate autonomous vehicle fleets. Its services are cloud-based and cover tasks such as real-time dispatching, route optimization, charging management as well as providing travel information to users.

The software of the company is compatible with all available vehicles, including human driven cars. It currently has three reference projects, where they manage autonomous public vehicles: the "Smartshuttle" in Sion, "Olli Intro" in Washington, as well as "CityMobil2" in Lausanne.

While autonomous cars and ICT-based traffic systems are an important aspect of digitalization in mobility, they are not the only one. As in other sectors, increasing inroads of digital technologies also have disruptive effects on business models relating to mobility.

Carsharing is a case in point. Firms in this field provide cars which can be reserved online or via an app, enabling the customer to open the reserved car with a card or smartphone. To use the service, customers pay a monthly/annual fee and/or a fee for the kilometers driven. The sharing company covers insurance up to a certain amount. The biggest carsharing company in Switzerland, Mobility, offers about 2,900 cars at 1,460 stations throughout Switzerland. It also employs 190 people, serves more than 127,000 customers and in 2015 generated 71 million CHF in revenues.[83]

The effects of carsharing on sustainability appear to be positive. Research on the US market reports that 25% of the users of carsharing have sold a vehicle due to carsharing, and another 25% have postponed buying a car, thereby leading to the conclusion that one vehicle shared replaces about 9-13 privately owned ones. The analysis also estimates that 0.58-0.84 metric tons or 34%-41% of GHG emissions are saved by one household due to carsharing per year.[84]

Cars are not the only thing in the sector of mobility which can be shared. There are also possibilities to share bikes and taxis as well as to pool rides. Digital technologies are key to making

[80] Yadron and Tynon (2016).
[81] Solon (2016)., Sorge (2016).
[82] Goodman (2016).
[83] https://www.mobility.ch/en/private-customers/.
[84] Shaheen and Chan (2015).

this happen. The biggest bike sharing company in Switzerland, Publibike, offers 95 stations with 800 bikes and ebikes throughout Switzerland. Carvelo2go provides a sharing platform for cargo bikes and e-cargo bikes. Nextbike is present in 23 countries with 35,000 bikes – all of them equipped with onboard computers and GPS systems. And Blablacar makes it possible to share rides.

Box 16: **EletricFeel – Makes Electric Bike Sharing Easy**

Zurich-based EletricFeel, founded in 2012, provides – among other offerings – a management solution for electric bike sharing companies. The software allows these mobility operators to run their business more reliably and efficiently.

Demand for this software stems from the fact that it is very hard to predict the usage of shared e-bikes throughout a whole city. This can lead to empty or overflowing stations, when people want to rent or return bikes and could decrease the demand for e-bikes.

The software gives the operator a full management solution to monitor customer behavior and keep track of CO2 savings, while the self-learning algorithm predicts the optimal redistribution of bikes over the whole city. It also keeps track of the battery situation of the e-bikes and provides recommendations for replacing empty batteries.[85]

Box 17: **UBER**

Uber offers cab rides by private persons, linking self-employed drivers with commuters at a considerably lower rate than normal taxis. Payments are processed through the service's app after the ride via PayPal or credit card. Uber generates revenues with the commission it receives per trip.

Since its launch in 2010, Uber was met with massive protest, especially from licensed taxi drivers. Their protest focuses on the fact that Uber drivers do not need to provide the same certifications for their driving service as taxi drivers as well as Uber's low-cost strategy. The fact that Uber does not pay any social benefits to its drivers, since they are not employed by Uber, has also triggered concerns.[86]

The protests and legal uncertainty have led to a (partial) ban of Uber in different countries around the world. In Switzerland, they recently also led to a ruling that would oblige Uber to pay social security contributions for its drivers moving forward.[87]

4.6. Finance

Digital technologies have played a growing role in finance for a long time. The use of ICT in payments systems, the withdrawal of cash from ATMs, and the integration of vast amounts of data into investment processes has been around for decades.

Today, digitalization is making inroads into the sector with accelerating speed. Under the headline of "Fintech" innovative digital technologies are becoming an ever more important and disruptive factor. Paying by smartphone, raising capital through crowdfunding, investment analysis from roboadvisors and new currencies like Bitcoin are cases in point.

While the impact of these developments on customers and financial services providers is being analyzed in-depth, a solid debate on the broader implications of Fintech for society is yet to start. The disruptive power of Fintech can lead to cut in costs and improve the quality of financial services. Lower interest rates for loans, better algorithms for assessing risk, and smaller fees for money transfers are examples in this context. Efficiency gains through Fintech may also offer opportunities to make finance more inclusive and expand services at a lower scale – in particular also for SMEs that may benefit from more tailored solutions.[88]

Innovations in payment systems stand at the core of this development. New

[85] www.electricfeel.com.

[86] Stalder (2016).
[87] Tagesanzeiger (2017).
[88] Economist (2015a), Australian Treasury (2017).

payment services range from new offerings by banks, established non-bank players (e.g. Facebook and Apple), and start-ups. "Mobile wallets" allow users to make retail payments through their smartphones, and new cross-border platforms allow individuals to transfer money abroad at significantly lower costs.[89] In view of the high fees that are currently charged by incumbents (e.g. Western Union), the reduction of transaction costs for the 600 billion US$ in annual international remittances would play an important role in increasing the flows to migrants' friends and families and thus supporting development.[90]

Crowdfunding and peer-to-peer lending are further fintech developments to watch – also from a sustainability perspective. Crowdfunding can take different forms. Some projects take grants or offer non-monetary rewards to their funders (donation and reward-based), others provide shares in their ventures (equity-based), and a third category takes out loans (debt-based, peer-to-peer (P2P) lending).[91] Total crowdfunding volumes in 2015 were estimated at 34 billion US$ - with P2P lending accounting for 25 billion US$, reward and donation crowdfunding for 5.5 billion US$, and equity crowdfunding for 2.5 billion US$.[92] Crowdfunding is increasingly also used to fund sustainability initiatives. In that context, Solar Plaza estimated in 2015 that 165 million Euro hade so far been raised through crowdfunding for renewable energy projects.[93]

Box 18: **bettervest – Crowdfunding for Energy Efficiency**

Germany-based bettervest was founded in 2013 as a crowdfunding platform for energy efficiency investments. The platform enables individual investors to fund energy efficiency projects by companies, NGOs, and governments across the world. The minimum investment is 50 Euro. Funders receive a fixed interest rate that is paid out of the energy savings.The company reports that it has so far supported 49 projects and thus contributed to a reduction in CO2 emissions of 4,700 tons.[94]

Box 19: **splendit.ch – Online Platform for Student Loans**

splendit.ch was founded in 2011 as a peer-to-peer lending platform for student loans to offer students fair conditions and provide investors with a sustainable and alternative investment opportunity.

The platform allows students are above the age of 18 to open a credit request by stating the amount they need, the maximum interest rate they'd be prepared to pay, their motivation for education and their plans after studies. There is also information required about their enrolment at a university and an ID/passport. After successful review of the data, the request is published on the website as an auction for investors.

Investors can browse through the different auctions and place a bid with their preferred amount and interest rate. The bid with the lowest interest rate wins. The minimum sum an investor must invest in each project is 1/20 of the total loan requested. This also means that a maximum of 20 investors can lend money to one student.

Splendit aims to mitigate risks by checking the enrolment into a university, controlling the transactions and reminding the students if they have not made their payments. Nonetheless, risk assessment and the determination of the interest rate to be applied remains within the responsibility of the the investor. If a student is no longer able to pay the loan back, splendit brings together the investors and the student to negotiate new terms. As a last resort, after all other activities failed, a collecting agency is hired to collect the debt.

For the services provided, splendit charges investors a one-time 2% upfront fee of the invested amount. Students have to pay a monthly fee of 10 CHF.[95]

[89] BNY Mellon (2015).
[90] Federal Reserve Bank of San Francisco (2016).
[91] Strictly speaking there is a difference between the two as P2P loans can also be provided by one single investor rather than a crowd. The terms, however, are nonetheless often used interchangeably.
[92] Crowdexpert.com (2017).
[93] Versteeg (2015).
[94] www.bettervest.com.
[95] www.splendit.ch. prisma (2016).

Moreover, robo-advisors and cryptocurrencies are increasingly hitting headlines. Robo-advisors offer financial advice based on algorithms that reflect individual investment and risk preferences. Earlier versions of robo-advisors provided investment suggestions and left their implementation to the client. More recent offerings in the space cover everything from advice to execution. Some have also started to integrate environmental and social criteria into the investment advice they give.[96]

Cryptocurrencies are digital currencies that use cryptography to validate financial transactions and to control the creation of additional units of the currency. The first decentralized version of a cryptocurrency was Bitcoin. Launched in 2008, market observers estimated the number of retailers accepting Bitcoin to have crossed the threshold of 100,000 merchants by 2015.[97] The system is based on open-source software and uses a decentralized ledger called Blockchain to record transactions. Transfers take place directly between users without an intermediary and are validated by communicating nodes running Bitcoin software. The debate around pros and cons as well as long-term impact of Bitcoin and other cryptocurrencies is an intensive one. In that context, in terms of environmental sustainability, commentators have repeatedly pointed to the high energy use of Bitcoin – with The Economist estimating that the combined electricity consumption of the system amounts to 1.46 terawatt-hours per year, the equivalent of the consumption of 135,000 American households.

Box 20: **Blockchain**

"Blockchain" is a decentralized peer-to-peer database that contains a growing list of records called blocks. While the technology initially hit headlines in relation to its use for Bitcoin and other cryptocurrencies, its potential applications cover a much broader array of use cases including the management of medical records, supply chain management, voting, and the trading of emission rights.

The main idea behind Blockchain is that people, who do not know each other can make transactions without the need for a trusted centralized third party. The technology enables its users to record transactions on all the computers in the network and to jointly validate new transactions. Every transaction must be verified by the majority of the nodes in the peer-to-peer network. So if a hacker wants to manipulate the data, he or she has to control not just one node, but more than half of the computing power of the network. Such a "51% attack" appears to be prohibitively expensive: in 2015, the Bitcoin network was already reported to account for 13,000 times as much computing power as the largest 500 supercomputers combined.[98]

The energy consumption to maintain that computing power has led various commentators to raise concerns about the environmental effects of blockchain and its applications. The above-mentioned estimate that Bitcoin was consuming as much energy as 135,000 US households is a case in point. Whether new developments – such as moving from "proof-of-work" to "proof-of-stake" validation – can address these concerns without creating significant other challenges remains to be seen.

[96] See e.g. https://3rd-eyes.com.
[97] Patterson (2015).
[98] The Economist (2015b).

5. Conclusion

The sustainability effects of an increasingly digitalized economy are significant. And while a 20+-page study can only scratch the surface of the topic; I hope this report provides readers with a starting point to further explore the potential benefits and drawbacks of the digital economy for sustainability.

Much remains to be explored. Digitalization affects almost every aspect of our lives. The change is happening right now. And nobody fully knows the direction it will take us to.

Digitalization offers great benefits not only for our personal lives, but also to pursue sustainability objectives. It can play an important role in addressing climate change. It allows farmers to be more productive and use fewer resources. It opens new pathways to healthcare. Self-driving cars could significantly decrease the number of accidents and make our whole traffic system more efficient. And fintech provides innovative platforms to bring funding to sustainability initiatives.

But digitalization also has a dark side. Many materials required for ICT are either dangerous to the environment, mined under hazardous conditions or both. Intelligence agencies use personal smart devices for mass surveillance. The IoT, with its low security standards, can easily be transformed to a botnet and be used for hacker attacks. Moreover, digital disruption can create social problems: What will happen to people whose jobs are taken by machines or robots? Who is going to take care of them?

In addition, digitalization brings along significant risks of "rebound effects", i.e. reductions in efficiency gains because of a counterbalancing increase in demand. Autonomous cars may make current traffic flows more fuel efficient. But they may also be used more often and for longer distances, thereby undermining the positive effect (e.g. less fuel used) and increasing the negative impact (e.g. more pollution). Smartphones may make life easier and increase efficiency in certain tasks. But they also lead to more products being bought, more resources needed in production as well as more waste and emissions. We may save energy and time with our new devices and applications, but these savings could be easily offset if we buy too much and use them too often.

To draw a conclusion, I think the future can be bright and that the positive effects of digitalization can predominate its negative implications – if we make the right choices and if policy makers, business, customers and NGOs work together and adopt new technologies in a responsible and sustainable way.

To make this best-case scenario come true policy makers should pass clear laws, thereby eliminating grey zones, restrict the power of intelligence agencies, create social plans for workers, whose jobs are taken by machines and offer incentives to invest in green and sustainable technologies. Business should commit to green digital technologies and be a role model in adopting them. Customers should use available technologies to inform themselves more about what and from whom they are buying things and use this information to increase the number of sustainable products offered. They should also install smart devices and applications to live more sustainably. Furthermore, private persons should give thorough thought how to protect their data, how many smart devices they really need and how much personal data they want to disclose in the Internet.

Universities must play a key role in this process. In that context, I also hope that this report allows oikos to expand its activities on the topic and that the following conclusion box provides a helpful input for future initiatives. I look forward to remaining engaged in that.

Box 21: **Digitalization and Sustainability – Opportunities, Risks, Players and Strategic Directions**

	Opportunities	*Risks*	*Players (Examples)*	*Strategic Directions*
Infrastructure	▪ Leapfrogging in infrastructure expansion – in particular in developing countries	▪ Increasing resource and energy use ▪ Growing vulnerability in case of system failure ▪ Expanding digital divide	▪ Fairphone ▪ Google	▪ Integrate sustainability criteria along the entire supply chain for digital hardware ▪ Reduce energy footprint of servers ▪ Drive political initiatives to reduce digital gap
Energy	▪ Using smart grids to increase energy efficiency ▪ Monitoring, analyzing and providing data to consumers to drive behavioral change ▪ Integrating "prosumers" into the grid	▪ Increasing risk of hacker attacks on power plants and grids	▪ DEPsys ▪ Eturnity AG	▪ Design and adopt solutions for the whole energy sector, not just for parts of it. Seize opportunities for the combination of digital solutions with other (e.g. institutional) changes ▪ Make consumers aware of their energy behavior ▪ Build business models to integrate prosumers into energy system
Food	▪ Increasing crop yields with precision farming ▪ Using digital technologies to provide insurance to farmers ▪ Raising transparency along the food value chain with tracking codes	▪ Reduced efficiency in distribution due to online shopping ▪ Job loss in agriculture	▪ CombaGroup ▪ farmy.ch ▪ fTRACE	▪ Expand use of precision farming ▪ Leverage digital technologies to monitor sustainability along the food value chain ▪ Pursue strategies against hunger that do not only focus on production, but equally on distribution and raising purchasing power ▪ Establish social plans for workers whose jobs are at risk
Health	▪ Improving di-	▪ Growing po-	▪ IBM Watson	▪ Establish clear pri-

	agnostic capacity based on big data and computing power ▪ Constant monitoring of health with wearables ▪ Using electronic medical records for rapid and comprehensive provision of patient information ▪ Expanding offer for medical training online	tential for privacy breaches ▪ Shutdown of healthcare infrastructure, e.g. via DDoS	▪ Visolino by obvita ▪ MindMaze	vacy rules. ▪ Ensure secure digital infrastructure in healthcare ▪ Foster cooperation between public and private sector for healthcare innovation
Housing	▪ Using smart technologies for lower energy consumption and higher convenience ▪ Producing renewable energy for own consumption and integration into the grid ▪ Sharing homes	▪ Constant surveillance ▪ Hacker attacks ▪ Fewer affordable houses	▪ Loxone ▪ eSmart ▪ AirBnB ▪ Couchsurfing	▪ Provide consumers with comprehensive information on advantages and disadvantages of smart home products ▪ Increase compatibility of different smart home devices ▪ Ensure IT security ▪ Establish legislation to address risks of home sharing for housing markets
Mobility	▪ Fewer accidents ▪ More efficient traffic and more efficient use of traffic infrastructure ▪ Increasing mobility of elderly and disabled people through autonomous cars ▪ Improving use of car fleet through car sharing	▪ Increased use of cars for more and longer trips due to the possibility to use time in autonomous cars more productively ▪ Growing vulnerability to hackers ▪ Job loss due to new products, services and business models	▪ BestMile ▪ ElectricFeel ▪ Uber ▪ Tesla	▪ Seize advantages of digitalization and mobility for public transport ▪ Complement introduction of autonomous cars with incentives to reduce car use to avoid rebound effect ▪ Strengthen social policies to account for job losses in the transportation sector

Finance	▪ Improved quality of financial services and lower costs ▪ Reduced fees to send money between countries ▪ Easier access to funding ▪ Financial inclusion	▪ High energy use ▪ Hacker attacks	▪ bettervest ▪ splendit.ch	▪ Raise understanding of fintech opportunities and risks among consumers ▪ Review and improve energy efficiency of fintech technologies ▪ Ensure adequate regulation of fintech companies

Literature

Accenture (2016): Digital disruption. The growth multiplier, https://www.accenture.com/us-en/insight-digital-disruption-growth-multiplier.

A.T. Kearney (2013): Online-Food-Retailing: Ein Markt im Aufschwung http://www.atkearney.de/documents/856314/1214982/2013.10_Online+Food+Retailing+im+Aufschwung_secured.pdf/6db0f2cf-6cf8-409b-bff5-d84d58d79111?version=1.0.

Australian Treasury (2017): Economic Benefits of Fintech, http://fintech.treasury.gov.au/economic-benefits-of-fintech/, retrieved on 18 February 2017.

Barr, Alistair (2014): Google Fiber Leaves a Digital Divide, Wall Street Journal, 2 October 2014, http://www.wsj.com/articles/google-fails-to-close-kansas-citys-digital-divide-1412276753.

BI Intelligence (2016): Here's how the Internet of Things will explode by 2020, uk.businessinsider.com/iot-ecosystem-internet-of-things-forecasts-and-business-opportunities-2016-2.

BBC (2015): Not in front of the telly: Warning over 'listening' TV, http://www.bbc.com/news/technology-31296188.

Bertoncello, Michele and Dominik Wee (2015): Ten ways autonomous driving could redefine the automotive world, http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world.

Brynjolfsson, Erik, and Andrew McAfee. The second machine age: Work, progress, and prosperity in a time of brilliant technologies. WW Norton & Company, 2014.

Bloomberg (2015): Apple Touts U.S. Job Creation, Says App Store Sales Rose 50%, https://www.bloomberg.com/news/articles/2015-01-08/apple-touts-u-s-job-creation-says-app-store-sales-rose-50-.

BNY Mellon (2015): Innovation in Payments. The Future is Fintech, https://www.bnymellon.com/_global-assets/pdf/our-thinking/innovation-in-payments-the-future-is-fintech.pdf.

Bundesamt für Gesundheit (2016): Strategie eHealth Schweiz, https://www.bag.admin.ch/bag/de/home/themen/strategien-politik/nationale-gesundheitsstrategien/strategie-ehealth-schweiz.html.

Bundesamt für Statistik (BFS) (2016a): Internetnutzung in der Schweiz, https://www.bfs.admin.ch/bfs/de/home/statistiken/kultur-medien-informationsgesellschaft-sport/informationsgesellschaft/gesamtindikatoren/haushalte-bevoelkerung/internetnutzung.assetdetail.276757.html.

_____ (2016b): Hochgeschwindigkeits-Internet, https://www.bfs.admin.ch/bfs/de/home/statistiken/kultur-medien-informationsgesellschaft-sport/informationsgesellschaft/gesamtindikatoren/infrastrukturen/hochgeschwindigkeitsinternet.assetdetail.1680916.html.

Ciocoiu, Carmen Nadia (2011): Integrating Digital Economy and Green Economy: Opportunities for Sustainable Development, Theoretical and Empirical Researches in Urban Management 6/1, pp. 33.

City Wire (2012): Walmart and Proctor [sic] & Gamble launch shopping trucks, http://talkbusiness.net/2012/06/walmart-and-proctor-gamble-launch-shopping-trucks/.

CRO Forum (2011): Power Blackout Risks, https://www.allianz.com/v_1339677769000/media/responsibility/documents/position_paper_power_blackout_risks.pdf.

Crowdexpert.com (2017): Crowdfunding Industry Statistics 2015 2016, http://crowdexpert.com/crowdfunding-industry-statistics/, retrieved on 18 February 2017.

Davis, Nicola (2016): Holograms replacing cadavers in training for doctors, https://www.theguardian.com/society/2016/nov/17/medical-trainers-look-to-virtual-reality-tech.

Deloitte (2015): Connected health. How digital technology is transforming health and social care, https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/life-sciences-health-care/deloitte-uk-connected-health.pdf.

Der Standard (2016): Autobauer gründen Allianz für vernetzte Autos, http://derstandard.at/2000045004845/Autobauer-gruenden-Allianz-fuer-vernetzte-Autos.

Diermann, Ralph (2014): Wie Smart Home beim Energiesparen helfen kann, http://www.faz.net/asv/smart-home/wie-ein-smart-home-system-beim-energiesparen-helfen-kann-13283848.html.

Economic Times (2016): After Tesla and Google, now Apple to launch self-driving car, http://economictimes.indiatimes.com/magazines/panache/after-tesla-and-google-now-apple-to-launch-self-driving-car/articleshow/55790869.cms.

European Commission (2016a): The importance of the digital economy, https://ec.europa.eu/growth/sectors/digital-economy/importance_de.

_____ (2016b): mHealth, https://ec.europa.eu/digital-single-market/en/mhealth.

Fang, Xi, et al. (2012): Smart grid—The new and improved power grid: A survey, IEEE communications surveys & tutorials 14.4 (2012): 944-980.

Federal Reserve Bank of San Francisco (2016): Reducing Remittance Fees can Boost Asian Economies, http://www.frbsf.org/banking/asia-program/pacific-exchange-blog/reducing-remittance-fees-can-boost-asian-economies/.

Food and Agriculture Organization (2016): The State of Food and Agriculture 2016, http://www.fao.org/3/a-i6030e.pdf.

Fraunhofer (2016): Life Cycle Assessment of the Fairphone 2, https://www.fairphone.com/wp-content/uploads/2016/11/Fairphone_2_LCA_Final_20161122.pdf.

Gann, David (2016): Kodak invented the digital camera - then killed it. Why innovation often fails, https://www.weforum.org/agenda/2016/06/leading-innovation-through-the-chicanes/.

GeSI and Accenture (2015): "SMARTer2030 – ICT Solutions for 21st Century Challenges, http://smarter2030.gesi.org/downloads/Full_report.pdf.

Goldman Sachs (2014): The Internet of Things. Making sense of the next mega-trend, http://www.goldmansachs.com/our-thinking/outlook/internet-of-things/iot-report.pdf.

Goodman, Ellen (2016): Self-driving cars: overlooking data privacy is a car crash waiting to happen, https://www.theguardian.com/technology/2016/jun/08/self-driving-car-legislation-drones-data-security.

Google (2016a): Environmental Report, https://environment.google/projects/environmental-report-2016/.

_____ (2016b): 100% renewable is just the beginning, https://environment.google/projects/announcement-100/.

Greenpeace (2015): Clicking Green. A Guide to Building the Green Internet, http://www.greenpeace.org/usa/wp-content/uploads/legacy/Global/usa/planet3/PDFs/2015ClickingClean.pdf.

Hannes, Berthold and Matt Abbott (2013): Distributed energy. Disrupting the utility business model, http://www.bain.com/publications/articles/distributed-energy-disrupting-the-utility-business-model.aspx.

Helman, Christopher (2013): How Much Electricity Do Your Gadgets Really Use?, www.forbes.com/sites/christopherhelman/2013/09/07/how-much-energy-does-your-iphone-and-other-devices-use-and-what-to-do-about-it.

IBM Research (2017): Precision agriculture, http://www.research.ibm.com/articles/preci

sion_agriculture.shtml, retrieved on 11 February 2017.

Impact Insurance (2012): Cattle insurance through electronic identification chip technology -- IFFCO-Tokio, http://www.impactinsurance.org/projects/lessons/cattle-insurance-through-electronic-identification-chip.

ITU (2016a): ICT Facts and Figures 2016 http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf.

_____ (2016b): Key ICT indicators for developed and developing countries and the world (totals and penetration rates) http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2016/ITU_Key_2005-2016_ICT_data.xls.

LaMonica, Martin (2014): Will smart home technology systems make consumers more energy efficient?, https://www.theguardian.com/sustainable-business/smart-home-technology-energy-nest-automation.

Lobe, Adrian (2016): Weshalb uns das Internet ungleicher macht, Neue Zürcher Zeitung, 7. Juni 2016, https://www.nzz.ch/feuilleton/digitale-ungleichheit-die-neue-kluft-ld.87117.

Lorenzetti, Laura (2016): Here's How IBM Watson Health Is Transforming the Health Care Industry, http://fortune.com/ibm-watson-health-business-strategy/.

Markoff, John (2011): Computer Wins on 'Jeopardy!': Trivial, It's Not, http://www.nytimes.com/2011/02/17/science/17jeopardy-watson.html.

Miorandi, Daniele, et al. "Internet of things: Vision, applications and research challenges. "Ad Hoc Networks 10.7 (2012): 1497-1516.

Nielsen (2015): The Future of Grocery. E-Commerce, Digital Technology and Changing Shopping Preferences Around the World, https://www.nielsen.com/content/dam/nielsenglobal/vn/docs/Reports/2015/Nielsen%20Global%20E%2DCommerce%20and%20The%20New%20Retail%20Report%20APRIL%202015%20(Digital).pdf.

OECD (2013): The Digital Economy http://www.oecd.org/daf/competition/The-Digital-Economy-2012.pdf.

_____ (2016a): Wireless mobile broadband subscriptions, https://data.oecd.org/broadband/wireless-mobile-broadband-subscriptions.htm.

_____ (2016b): Business use of broadband https://data.oecd.org/broadband/business-use-of-broadband.htm.

_____ (2016c): Skills for a Digital World, OECD Background Paper, http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/IIS(2015)10/FINAL&docLanguage=En.

_____ (2016d): OECD Broadband Statistics, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm.

Patterson, Julia (2015): Bitcoin. A New Global Economy, https://blog.bitpay.com/bitcoin-a-new-global-economy/.

Prisma (2016): prisma empfiehlt: splendit.ch, http://www.prisma-hsg.ch/articles/prisma-empfiehlt-splendit-ch/.

PwC (2013): Energy transformation. The impact on the power sector business model, https://www.pwc.com/ua/en/industry/energy-and-utilities/assets/pwc-global-survey-new.pdf.

Qi, Daniel (2015): Digital AGRO, https://www.allianzre.com/v_1451285256000/media/Digital_AGRO_AIR_December_Edition.pdf.

Quinn, Ben (2016): UK cancer surgery to be live-streamed via virtual reality technology, https://www.theguardian.com/society/2016/mar/25/uk-cancer-surgery-live-streamed-virtual-reality.

REN21 (2016): Renewables 2016. Global Status Report, http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report_REN21.pdf.

SCF Associates (2009): A Green Knowledge Society – An ICT Policy Agenda to 2015 for Europe's Future Knowledge Society (2009).

Shaheen, Susan and Nelson Chan (2015): Mobility and the Sharing Economy: Impacts Synopsis, http://tsrc.berkeley.edu/node/850.

Simpson, Emma (2016): Amazon launches full online supermarket service in the UK, http://www.bbc.com/news/business-36485318.

Solomon, B., Fox-Brewster, T. (2016): Hacked Cameras Were Behind Friday's Massive Web Outage, www.forbes.com/sites/briansolomon/2016/10/21/hacked-cameras-cyber-attack-hacking-ddos-dyn-twitter-netflix.

Solon, Olivia (2016): Self-driving trucks: what's the future for America's 3.5 million truckers?, https://www.theguardian.com/technology/2016/jun/17/self-driving-trucks-impact-on-drivers-jobs-us.

Sorge, Nils-Viktor (2016): In zehn Jahren werden keine Lkw-Fahrer mehr benötigt, http://www.spiegel.de/wirtschaft/unternehmen/autonome-lkw-in-zehn-jahren-werden-keine-fahrer-mehr-benoetigt-a-1112566.html.

Stalder, Helmut (2016): Taxifahrer fordern Verbot von Uber, https://www.nzz.ch/schweiz/aktuelle-themen/protestfahrten-taxifahrer-fordern-verbot-von-uber-ld.82994.

Statista (2017a): Smartphone unit shipments of Samsung worldwide by quarter from 2010 to 2016, https://www.statista.com/statistics/299144/samsung-smartphone-shipments-worldwide/.

_____ (2017b): Global Apple iPhone sales from 3rd quarter 2007 to 4th quarter 2016, https://www.statista.com/statistics/263401/global-apple-iphone-sales-since-3rd-quarter-2007/

_____ (2017c): Shipment forecast of laptops, desktop PCs and tablets worldwide from 2010 to 2020, https://www.statista.com/statistics/272595/global-shipments-forecast-for-tablets-laptops-and-desktop-pcs/.

Steadman, Ian (2013): IBM's Watson is better at diagnosing cancer than human doctors, http://www.wired.co.uk/article/ibm-watson-medical-doctor.

Strother, Jason (2011): Shopping by phone at South Korea's virtual grocery, http://www.bbc.com/news/business-15341910.

Tagesanzeiger (2017): Muss Uber bald AHV-Beiträge bezahlen?, http://www.tagesanzeiger.ch/wirtschaft/standard/Muss-Uber-bald-AHVBeitraege-bezahlen/story/25409002.

Tapscott, Don (1994): The Digital Economy: Promise and Peril in the Age of Networked Intelligence. Vol. 1. New York: McGraw-Hill, 1996.

Economist (2015a): The Fintech Revolution, http://www.economist.com/news/leaders/21650546-wave-startups-changing-financefor-better-fintech-revolution.

_____ (2015b): How bitcoin mining works, http://www.economist.com/blogs/economist-explains/2015/01/economist-explains-11.

Tierney, Andrew (2016): Thermostat Ransomware: a lesson in IoT security, https://www.pentestpartners.com/blog/thermostat-ransomware-a-lesson-in-iot-security/.

Upbin, Bruce (2013): IBM's Watson Gets Its First Piece Of Business In Healthcare, http://www.forbes.com/sites/bruceupbin/2013/02/08/ibms-watson-gets-its-first-piece-of-business-in-healthcare.

US Department of Energy (2016): How Much Can You REALLY Save with Energy Efficient Improvements?, https://www.energy.gov/energysaver/articles/how-much-can-you-really-save-energy-efficient-improvements.

Versteeg, Kristiaan (2015): Tracking Renewable Energy Crowdfunding, http://www.solarplaza.com/channels/finance/11417/tracking-renewable-energy-crowdfunding/.

Wikipedia (2017): Amazon Echo, https://en.wikipedia.org/wiki/Amazon_Echo, retrieved on 16 February 2017.

Wired (2016): A Brief History of Autonomous Vehicle Technology, https://www.wired.com/brandlab/2016/03/a-brief-history-of-autonomous-vehicle-technology/.

Wischmeyer, Nils (2016): Wer Internet kann, ist privilegiert, Süddeutsche Zeitung,

21. Dezember 2016, http://www.sueddeutsche.de/wirtschaft/digitalisierung-der-gesellschaft-wer-internet-kann-ist-privilegiert-1.3305353.

World Health Organization (WHO) (2017): Number of Road Traffic Deaths, http://www.who.int/gho/road_safety/mortality/traffic_deaths_number/en/, retrieved on 17 February 2017.

Yadron, Danny and Dan Tynon (2016): Tesla driver dies in first fatal crash while using autopilot mode, https://www.theguardian.com/technology/2016/jun/30/tesla-autopilot-death-self-driving-car-elon-musk.