Sustainable AIoT: How Artificial Intelligence and the Internet of Things Affect Profit, People, and Planet

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1 Addressing the Triple Bottom Line

To achieve long-term business success, purpose for associates, and acceptance in today's societies, business leaders must keep a close eye on social and environmental dimensions in addition to the prerequisite of attaining adequate profits. This is especially true during times of major technological transformations. A fascinating breakthrough technology pushing such a transformation is artificial intelligence (AI). AI has great potential to make devices intelligent in the Internet of Things (IoT)—referred to as AIoT. In this chapter, we evaluate how a sustainable AIoT supports the three interrelated dimensions of profit, people, and planet.

Megatrends such as population growth, resource scarcity, and climate change drive and shape today's businesses and society, which is reflected by

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intensive discussions in the media and through activities of supranational organizations, such as the United Nations, e.g., Sustainability Development Goals (SDGs) and the Intergovernmental Panel on Climate Change (IPCC). Even the financial industry asset manager *BlackRock* has joined France, Germany, and other global foundations to establish the Climate Finance Partnership, a public-private effort to improve financing mechanisms for infrastructure investment. In his annual letter to investors, *BlackRock* CEO Larry Fink wrote in 2020: "[…] awareness is rapidly changing, and I believe we are on the edge of a fundamental reshaping of finance" (Fink 2020). *Bosch* with its approximately 245 manufacturing plants worldwide announced its intent to become carbon neutral (Scope 1 and 2 emissions) as the first global industrial enterprise from the year 2020 (Bosch 2019).

Another important trend is the social fragmentation of societies. The financial crisis of 2008, the US elections in 2016, and Brexit in 2020 sent shock waves through the political and financial elites within the EU and the USA. These events compelled global movements to engage leaders across business, government, and civil sectors and encourage them to practice and invest in ways that extend the opportunities and benefits of our economic system to everyone, e.g., non-governmental organization (NGO) Inclusive Capitalism, which is supported by E.L. *Rothschild LLC*, among others (NGO Inclusive Capitalism 2020).

Companies must consistently align themselves with these drivers by means of a modern accounting framework and performance reporting, which should transcend the important measures of profits, return on investments, and shareholder value to include environmental and social dimensions. During the mid-1990s, John Elkington developed such a sustainability framework called the triple bottom line (TBL), which included the interrelated dimensions of profit, people, and the planet (Elkington 1994; Slaper 2011).

The interesting and likely provocative question is whether the AIoT actually supports this TBL sustainability framework:

- **Profit**: Companies investing in digitalization do not achieve an acceptable return on investment and adequate profits similar to their traditional business, which is called the digitalization paradox (Gebauer 2020). According to a study conducted by *Cisco* in 2017, "[…] 60 percent of IoT initiatives stall at the proof of concept (PoC) stage and only 26 percent of companies have had an IoT initiative that they considered a complete success. Even worse: a third of all completed projects were not considered a success […]" (CISCO 2017).

- **People**: The impacts of AI and related automation on the future of work have been widely discussed since approx. 2011 (Arntz 2016; Frey 2017). These impacts even induced public discussions about the necessity to introduce an unconditional basic income (Die Zeit 2015).
- **Planet**: The billions of connected devices, communication infrastructures, and data centers require electricity in their usage and resources and energy for their production (Andrae 2017). The greenhouse gas emissions produced by these processes are comparable to those of air traffic today.

In the following, we reflect on the fundamental impact of the AIoT on profit, people, and planet.

2 The AIoT Profit Opportunity

The AIoT offers opportunities that arise from creating new business models, building deeper customer relationships, improving the value proposition, and therefore increasing revenues and profits. Adequate profits are a necessity for sustainable companies to finance growth, to make important investments, or to have the leeway to raise wages. Here, we emphasize service business and product-as-a-service (PaaS), which is the principal concept of selling the outcomes a product can provide rather than the product and related services itself. Generally speaking, customers no longer purchase products and services and maintain product ownership. Instead, customers avoid initial investments and only pay for the actual use and performance of a product. The AIoT is one key driver of PaaS. Intelligence and connectivity enable an entirely new set of product functions and capabilities (Porter and Heppelmann 2014): monitoring, control, optimization, including updates over-the-air, and autonomy. A company that offers connected products has transparency about how the customer uses the product and what the condition of the product is, e.g., operating hours, performance, and malfunctions.

2.1 Product-as-a-Service as a Business Model

Companies embracing PaaS indicate that it is the foundation for stable and more predictable revenues and hence for more sustainable and resilient business models (Tzuo 2018). Prominent examples in the B2C context are the very popular subscription-based business models introduced by *Spotify*, *Netflix*, and *Apple*. Rather than purchasing DVDs, approximately 2/3 of households in the

USA stream movies via the Internet (ibid.). For manufacturing companies, PaaS is thought to be the holy grail of monetizing IoT data, with a current market size of US$ 21.6 billion (2019), which is expected to grow with a CAGR of 35% until 2025 (NGO Inclusive Capitalism 2020).

PaaS has been conceptualized through notions including pay-per-use, service-oriented business models, use-oriented and result-oriented product-service systems, outcome-based services, substituting services, and so on. The topic itself originated as early as 1920, when *Michelin* tires introduced the idea of being paid for every kilometer a tire accrued instead of selling tires. *Xerox* disrupted the entire plain-paper copier industry by charging per copy instead of selling the copier.

PaaS has recently gained a lot of momentum through digital technologies, given that product connectivity allows product providers to gain deep insights regarding customers' financial requests, the entire product life cycle, customers' daily operations, and risk mitigation requirements. Thus, an increasing number of PaaS approaches have been launched recently and are currently scaled up. Some examples include printing as a service, machine tools as a service, compressed air as a service, jet engine as a service, farming equipment as a service, commercial garage lift as a service, vacuum handling equipment as a service, robot uptime as a service, earth-moving equipment as a service, and compressor as a service.

2.2 Creating Sustainable Growth with Product-as-a-Service

PaaS not only offers various benefits for customers and product providers but also supports environmental sustainability:

- *Customers* can become financially flexible and relieve their balance sheet by having operational expenses (OPEX) instead of capital expenditures (CAPEX). Furthermore, customers benefit from aligned incentives between them and the manufacturer in addition to the possibility of minimized risks. For example, the risk of equipment breaking down and not running at the optimal performance level can be transferred to the manufacturer through a PaaS business model.
- For *product providers***,** PaaS represents a recurring source of revenue that is less volatile than the economic and investment cycles of products. In the current COVID-19 crisis, business opportunities have opened up, as customers have had to stretch their financial budgets. PaaS will continue to

have strategic benefits for product providers even in a post-COVID-19 world. In addition to being a recurring source of revenue, PaaS allows a manufacturer to secure or win back service revenues from third-party providers.
- Furthermore, PaaS is assumed to improve *environmental sustainability* (the planet dimension). Some reasons for this are highlighted in Gebauer et al. (2017): PaaS encourages sensible consumption and leads to product designs, which maximize resource efficiency. PaaS also incentivizes resource-efficient product usage. In addition, PaaS leads to more preventative maintenance activities, resulting in longer lasting products and easier remanufacturing (e.g., a photocopier company lets customers pay per copy, later refurbishes a used copier, and then provides it to new customers to offer pay-per-copy). This last example shows that PaaS is an opportunity to reduce environmental impact by shifting away from the linear take-make-waste economy toward a circular system.

As a leading manufacturing company, *Bosch* established PaaS business models. In the following, two prominent examples are explained:

- Homeowners often hesitate to modernize or install a state-of-the-art heating system due to the high initial costs. The *Bosch Heating+* service eases this decision by allowing customers to benefit from a new heating system without a major initial investment.
- Coin-operated communal washing machines are the past. *WeWash* (WeWash 2021) offers everything from installation in lieu of maintenance and repairs to a cashless billing process, which reduces the costs associated with providing a laundry room in serviced apartments and hotels for the operator.

2.3 Implementing and Adopting Product-as-a-Service

In addition to these benefits, various requisite management actions make PaaS a success beyond a handful of PaaS pilots with a few selected customers. Managers often phrase this as "the PaaS pilot never fails, but PaaS never scales":

- Products for which PaaS has a provable positive effect on easy-to-measure performance metrics are particularly suitable. Management should be aware of this and target these products accordingly.

- To transfer PaaS from a few success pilots at the periphery of a company into their core offerings, companies have to ensure the commitment of top management to obtain the necessary human and financial resources.
- Top management needs to be aware that PaaS might challenge the existing product-dominated culture. Companies should therefore begin with lighthouse projects to validate the PaaS approach and obtain the necessary momentum.
- Once lighthouse projects have been proven successful, companies should invest in a broader PaaS enablement structure (small teams, use cases, competence development).
- Often, the switch to a PaaS business model leads to a revenue drop, as small recurring payments replace large initial revenue. Simultaneously, costs increase due to the necessarily large pre-investments. Management needs to be aware of this period in which costs exceed revenues to prepare stakeholders accordingly.

3 The AIoT People Opportunity

It is undeniable that digital technologies create fascinating benefits for individual people and societies. This has become particularly clear over the course of the COVID-19 crisis. The pandemic has demonstrated how online marketplaces have become part of society's critical infrastructure as the success of companies like *Amazon* has shown. Digital technologies also drive the AIoT. The result is a virtuous cycle of value improvement between both areas: Growing IoT—growing volume of data—improved AI algorithms—growing IoT. The benefits of this are that IoT devices with AI can even act autonomously, e.g., logistics robots that transport goods in complex environments, such as hospitals. *Bosch*, as a leading automotive supplier, is applying AI, e.g., in safety systems for cars and trucks pursuing the Vision Zero with the aim of achieving no fatalities or serious injuries involving road traffic. In healthcare, AI expert systems support medical professionals in making diagnoses that are more accurate and suggest better therapies. These examples prove that the AIoT improves the overall quality of life of people and thus has a positive impact on the people dimension.

Nevertheless, as the breakthroughs in AI were shared in recent years with the public (e.g. *AlphaGo*, *IBM Watson*), there has been a debate about its impact on employment: will the resulting automation destroy working capital and therefore the social performance of companies, e.g., will it lead to a massive reduction of the total number of associates or apprentices? The starting

point was a study by Frey and Osborne from Oxford University published online in 2013. This study suggested that 47% of jobs in the USA were at a high risk of being automated (Frey and Osborne 2013) and triggered further examinations of the expected impact of AI-driven automation on the economy, e.g., the Whitehouse report of the executive office of the US president (2016) or the comprehensive study by the *McKinsey* Global Institute (McKinsey Global Institute 2017). The following subchapter is based on these studies.

3.1 Future of Work with AI

Historically, societies have already experienced significant transformations driven through technological and scientific progress, e.g., automation in agriculture and the industrial revolution in the nineteenth century based on the steam engine. Such technological progress drove complex adaptions within societies. From a long-term perspective, it created more jobs and prosperity. There are three primary reasons why productivity and job growth mainly complemented each other in the past:

- *Cost savings and higher wages*: Productivity gains reduce the prices of products and services (e.g. the telecommunication industry in the past). Companies can afford higher wages when their workers are more efficient. Both drive higher or new consumption. In addition, efficiency gains are a source of larger profits, which can be reinvested.
- *Increased value and quality of outputs boosts demand*: Productivity growth is also about increasing the value and quality of outputs for any given input. For example, the automotive industry has massively improved the value of cars for their customers by implementing new comfort and safety features. At the same time, supplier and car manufacturers have managed to maintain or even improve quality.
- *Sustaining global competitiveness requires ongoing productivity gains*: Innovations and the related productivity gains sustain or even increase local jobs.

An important question now arises: Will AI also create prosperity and jobs in the future? There is no simple answer because there are too many influencing factors in a complex modern economy. The following four questions support a balanced analysis of the impact of AI and the respective time horizon:

- *What are the limitations of AI systems and technological barriers?*
  AI systems are currently optimized for narrow-specific tasks. These systems are programmed with little innate knowledge and possess no common sense about the world or human psychology. Generalizing these systems to other tasks with different contexts is not possible at present. In addition, important AI systems are black boxes whose outputs cannot be explained, even if the algorithms are known. On the other hand, there is a great demand from customers to understand the decisions of AI systems, e.g., if a financial AI system of a bank declines a customer's mortgage application. Finally, verifying and validating AI systems for safety critical applications needs to be solved (e.g., for fully autonomous driving).
- *In which areas and markets are AI system cost competitive (lower marginal costs)?*
  AI-driven automation is implemented through economic reasoning. There are higher incentives to automate in advanced economies than in developing economies because of the higher wage rates in the former. Installed conventional systems are typically not replaced until they are depreciated. Investments in infrastructure typically have particularly long time horizons. Therefore, even if AI systems offer new functionalities and higher productivity, decision-makers may postpone their introduction.
- *How long is the adaption time for people and institutions?*
  The speed and extension of software-based innovations throughout the globalized world connected by the Internet far surpasses that of steam engines during the industrial revolution. AI-driven automation has a direct impact on repetitive and administrative tasks. Even highly paid academics are affected. For example, one repetitive task of a radiologist is to analyze MRI images. There is no clear answer as to whether entire occupations will go extinct or whether AI systems will only assist with certain tasks. In the example given, this would mean that an expert system detecting tumors in MRI images would not replace a radiologist but would rather increase their productivity and diagnostic quality.
- *What is the reaction of governments in a time with inequality in societies with populists forcing national shielding?*
  This new wave of automation comes at a time when we are already discussing other economic effects, such as globalization and the outsourcing of jobs. New governmental regulations could slow the penetration of AI-driven automation, especially if inequality in societies is expected to increase.

Hypothesis: A significant share of working activities have the potential to be automated. However, the proportion of work actually replaced will be

much lower due to technical, economic, and social factors, and, as history demonstrates, completely new occupations will emerge. Investments in infrastructure, healthcare, and energy in response to megatrends also generate further demand for work. Many countries are also faced with the fact that their population is aging disproportionately, e.g., aging societies such as China and Germany. In the interim, there is a risk that frictional unemployment will increase as downward pressure lowers wages because of the fast technological evolution. Income polarization could continue in advanced economies, e.g., stagnating middle-class wages in the USA due to declining middle-wage occupations. In the long term, associates will need to adapt as their occupations evolve alongside increasingly capable AI systems. Processing data, collecting data, and other repetitive and predictable physical tasks will be increasingly automated, and a large proportion of associates are expected to switch occupational categories. There will continue to be a high demand for jobs that require social and emotional skills, creativity, and advanced cognitive skills. Educational institutions such as schools and universities should be prepared. Training and re-education of the existing workforce within companies will be necessary.

3.2 The Strategic Imperative of AI

AI is a strategic imperative for leaders. *Bosch*, for example, intends that all of its products either will contain AI or will be developed or manufactured with its help by 2025. To achieve this objective, *Bosch* founded the *Bosch* Center for AI in 2017 (Bosch 2021). Therefore, how can an enterprise become a robust AI company? The popular AI Transformation Playbook from Andrew Ng offers five steps as clear guidance (Ng 2018):

1. *Execute pilot projects to gain momentum*: The first AI projects chosen should succeed in increasing faith in the new capabilities of AI. This momentum is more important than choosing the most valuable project from a business perspective.
2. *Build an in-house AI team*: Such a centralized AI team should execute an initial sequence of cross-functional projects to support different product groups/divisions/business units with AI competence. An in-house AI team helps to build a unique competitive advantage, e.g., applying specific domain knowledge of the company.
3. *Provide broad AI training*: AI talent is hard to find. In addition, executives and leaders of the company need to understand what AI can do for their

enterprise. With the availability of digital content such as online courses (e.g., Coursera), training large numbers of associates in new AI skills is very cost-efficient today.

4. *Develop an AI strategy*: After obtaining momentum (see steps 1–3), identify the areas in which AI can create the largest impact and value. Focus restricted resources on those areas. A company will most likely not be able to develop a professional AI strategy without basic experience with AI. Create an advantage with AI specific to the companies' industry sector/s. Given that data function as a key asset for AI, develop a sophisticated data strategy.
5. *Develop internal and external communication*: The public debates the opportunities and risks of AI, e.g., artificial general intelligence has been overhyped in the media. In addition, AI has the potential to affect significantly an enterprise. Accordingly, communication should be developed to ensure alignment with the key stakeholders: investors (clear value creation thesis), the government (building trust and goodwill), customers (appropriate marketing of new benefits), external AI talent (employer branding to attract and retain talent), and associates (explain AI to address associates' concerns).

4 The AIoT Planet Opportunity

Digital technologies have the potential to support sustainability by reducing resource consumption, energy consumption, and emissions. For example, the AIoT is an imperative to manage energy supply and demand in a world with decentralized producers of renewable energy, such as photovoltaics (Meeuw et al. 2020). On the other hand, it is undeniable that digital devices and the Internet infrastructure require energy to operate. A public debate has emerged since Bitcoin mining and video streaming provoked controversy regarding the significant amount of electricity they consume. An important question is whether the economic growth induced by digital technologies is associated with an increase in energy consumption and greenhouse gas (GHG) emissions, as has been the case in the past.

There are no studies specific to the AIoT to date. Therefore, we present the results of an analysis aggregating the impact of all information and communication technologies (ICTs). It is important to note that ICTs affect the environment in two ways. *Direct effects* lead exclusively to an increase in energy consumption, GHG emissions and resource consumption caused by the

production, and the use and disposal of ICT hardware (e.g., devices, data servers). *Indirect effects* arise from the fact that the use of ICTs leads to induced changes in consumption and production patterns.

4.1 Direct Effects: Information Processing Requires Energy

Each operation of a single bit in a computer needs an absolute minimum amount of energy of 2.75 zepto joules at room temperature, which is called the Landauer limit (Landauer 1961). Erasing a single bit creates waste heat. The physics behind this limit is the fundamental second law of thermodynamics. In addition, digital devices, communication networks, and data centers have to be produced, which also requires energy and resources. According to scenarios developed in 2015 from Andrae and Edler (2015), ICTs will expand from 8 to 21% of worldwide total electricity demand by 2030 (Jones 2018). Andrae takes into account the production and use of digital devices, communication networks, and data centers holistically. Regardless of the chosen scenario, power consumption in the usage phase decreases for digital devices over the next decade and increases for networks and data centers (Andrae and Edler 2015).

A meta-study by *bitkom* (see Table 1) shows the amount of greenhouse gas emissions caused by ICTs (Bitkom 2020). With 1.8–3.2% of global GHG emissions for 2020, the ICT sector is comparable to air traffic (Graver et al. 2019). The principal reason for the generation of these GHGs is the large number of digital devices. It can be assumed that GHG emissions will increase significantly over the next decade due to the continued growth of digital infrastructures and the increasing number of households and companies equipped with digital devices.

Table 1 Approximate energy demand and greenhouse gas emissions (GHG) for 2020, Bitkom (2020)

	Data centers		Communication networks		End devices *incl. desktops, notebooks, tablets, smartphones, TVs*	
Category	Best-case	Worst-case	Best-case	Worst-case	Best-case	Worst-case
Energy (TWh)	200	1000	200	500	–	–
GHG (Mt CO_{2e})	100	500	140	300	720	1200

4.2 Indirect Effects: Changing Consumption and Production Patterns

ICTs cause changes in consumption and production patterns and therefore affect greenhouse gas emissions and energy demand indirectly. The resulting effects can have positive or negative characteristics from an environmental point of view. For example, a modern video chat application, such as MS-Teams, can support working at home—eliminating daily commutes to a company's office building. On the other hand, by intensifying competition, flight booking platforms have contributed to the emergence of the low-cost flight sector and thus to an increase in air travel and the associated GHG emissions (Bitkom 2020).

Positive Characteristics

As discussed above, the AIoT enables PaaS, which is assumed to improve environmental sustainability. There are of course further opportunities of the AIoT to generate value in the dimension of the planet. Examples from four industry sectors are given below:

- *Energy and building*: Decarbonizing the energy sector by improving grid efficiency, integrating renewables, and enabling decentralized energy trading; making smart buildings; and avoiding unnecessary energy consumption through automated monitoring and control of heating systems and air conditioning.
- *Mobility and logistics*: Enabling the home-office by video chat apps, which reduces commuting to workspaces. Video conferencing helps to avoid business trips. Apps on smartphones enable intermodal travel and car sharing in a world with rapid growth in urbanization. Connected trucks and logistic platforms help to avoid empty runs and detours of trucks and will likely improve intermodal global supply chains (e.g., transfer of loads from trucks to trains).
- *Manufacturing*: Industry 4.0 supports the creation of high-performance plants that are fully optimized in their consumption of all the used resources, comprising productive components, such as raw materials, and basic resources, such as energy and water.
- *Agriculture*: Smart agriculture reduces the need for herbicides/pesticides/fertilizers and simultaneously increases the yields of agricultural land.

Negative Characteristics

As explained above, ICTs can cause changes in consumption and production patterns. Flight booking platforms have contributed to the emergence of the low-cost flight sector and thus to an increase in air travel and the associated greenhouse gas emissions. In the previous section, we also provided examples concerning efficiency-enhancing measures within four industry sectors. Implementing such measures can also cause unintended negative effects—called rebound effects. Rebound effects can lead to an increase in demand/consumption so that the absolute savings of an input factor such as energy demand or greenhouse gas emissions fall short of expectations. If, for example, energy-saving lamps replace conventional light bulbs and customers install more of them or leave them burning longer, then the saving effects of the new lamps are less than expected. Such rebound effects can even exceed 100%, in which case they are called backfire effects. In our example of bulbs, a backfire effect would occur if more energy is collectively used after the transition from conventional bulbs to energy-saving lamps.

4.3 Overall Impact on Environmental Sustainability

As shown, ICTs have high potential to support environmental sustainability (indirect effects with positive characteristics). At the same time, ICTs create a significant footprint (direct effects plus indirect effects with negative characteristics). Hence, the following question arises: will ICTs have an overall positive or negative impact on environmental sustainability and thus in the planet dimension by 2030?

Clearly, this question is difficult to assess across all concerns. However, there are useful estimates of greenhouse gas emissions in 2030. According to a meta-study from bitkom (Bitkom 2020) the enablement factor (EA) expresses the relationship between the potential to reduce greenhouse gas emissions and the GHG footprint of ICTs:

- *Best Case Scenario* (EA = 16.3): The potential to reduce GHG emissions is 16.3 times larger than the GHG footprint.
- *Worst Case Scenario* (EA = 0.3): The GHG footprint is three times larger than the potential to reduce GHG emissions.

4.4 Environmental Sustainability with the AIoT

This result clearly shows the uncertainty in such estimates. There is great potential but without certainty that everything will turn out well ("no free lunch"). Accordingly, it is recommended to consider the following measures when implementing new AIoT solutions:

- *Business models*: Develop AIoT solutions specifically improving sustainability. Instead of selling products (hardware) maintain ownership and offer customer pay-per-use.
- *Processes*: Implement footprint/lifecycle assessments. Enable circular economy with digital technologies.
- *Technology*: Follow the trend toward hyperscale data center and operate them with renewable energy. Minimize data bandwidth. Foster new computing and communication hardware with improved energy efficiency.

5 Conclusion

The sustainable IoT with artificial intelligence (AIoT) can strongly support the triple bottom line with the three interrelated dimensions of profit, people, and planet. Addressing all the dimensions simultaneously certainly creates complexity and tensions. However, entrepreneurial responsibility has to reconcile the three dimensions and has to take these tensions. According to the *Bosch* CEO Volkmar Denner "[…] it is not problem solving that is the primary management task, but increasingly the resolution of dilemmas" (Bosch 2021). Business leaders that successfully manage the three dimensions generate purpose inside companies, lend companies legitimacy in modern societies, and support business success. Generating value in all three dimensions is often straightforward.

A prerequisite to being profitable is an economically viable business model. Connected products can increase customer satisfaction and enable new service businesses. PaaS is one major option to increase revenues and margins while reducing the environmental footprint of a company and its customers. In addition, business models based on PaaS are typically more robust in economic crises, such as the financial crisis in 2008 or the current COVID-19 pandemic, which gives associates peace of mind.

Improving environmental sustainability often goes hand in hand with profit. For example, a reduction in electricity demand also means lower energy costs. Moreover, customers are willing to pay higher prices for environmentally friendly products, which increases margins.

The basis of a successful company is a loyal and highly motivated workforce. People are the key to success. High profits provide leeway for higher salaries. Investing in new apprenticeships and training for the existing workforce increases loyalty and strengthens the competencies within the company. Environmental sustainability also tends to be meaningful for associates. Overall, this supports employer branding and therefore attracts and retains talent, e.g., specialists who are in very high demand in the labor market. On the other hand, negative reviews of employers on social networks have a wide reach and discourage job applicants.

Well-known companies prove that it is possible to manage the triple bottom line successfully: *Apple* is powered by 100% renewable energy worldwide and is one of the most successful enterprises (Apple 2018). *BASF* has already adapted its balance sheet by addressing performance indicators in addition to classic economic KPI, such as social performance, e.g., numbers of associates and apprentices (BASF 2019). *Bühler* contributes to "[…] safely feeding the worlds and is doing its part to protect the climate [...]" (The Bühler Group 2021). *Bosch*, with its slogan "Invented for Life," is a privately owned company. Through the charitable foundation Robert Bosch Stiftung, profits are used to benefit society, the environment, and future generations (Bosch 2021). *Bosch* also has a dedicated sustainability strategy: "*Bosch* strongly believes that a social and ecological balance is needed to do business successfully in the long term. For this reason, the company aims to secure its business success in a way that preserves resources for current and future generations" (Bosch 2021).

Lessons Learned from the AIoT

- The convergence of the IoT and AI (AIoT), i.e., smart connected products and the AI-based exploitation of their data, offers great potential to improve the triple bottom line: profit, people, and planet.
- Profit: The AIoT is an enabler of product-as-a-service business models that foster stable, recurring, and thereby sustainable revenues.
- People: The AIoT will generate significant benefits for people, e.g., with respect to health, safety, and comfort. Therefore, it is an important driver of future prosperity.
- Planet: The AIoT and the continuous adoption of information and communication technologies (ICTs) lead to a direct increase in energy consumption (direct effects). However, the AIoT and ICTs have the potential to help massively to reduce green-house-gas emissions across multiple domains (indirect effects). As of today, most research is optimistic that ICTs, including the AIoT, will have a net positive impact on the environment.
- Companies have to manage the triple bottom line and carefully balance the trade-offs between profit, people, and planet. The AIoT is one means to push existing trade-offs beyond current boundaries.

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