Gazdaság & Társadalom / Journal of Economy & Society
17 (35) (2024) 3, 43–67. • DOI: 10.21637/GT.2024.3.03

Sustainability Transitions – Innovation Eco-Systems – Digital Solutions 2024

Conference paper on: Discourse on the influence of digitalization from an ecological perspective on ESG Transformation and sustainable development in industry

Sándor Rostás[1]

Abstract: The main focus of this study is to research the effects of the use of digital technologies in the ESG transformation (Environmental, Social, Governance) with the goal to achieve growth and climate protection goals from an economic perspective. The use of digital solutions in automated processes offers opportunities to obtain information about impending disruptions when carrying out periodic tasks, and to avoid them in the sense of ecological sustainability to protect the natural resources (primary raw materials) that still exists. The purpose of this study is to examine the general understanding of ESG transformation and the connections within industry between digitalization and sustainable development through comparative analysis and comprehensive literature research. Despite the efforts in many scientific works that are increasingly concerned with sustainable development, the public often debates the increasing destruction of natural resources due to population and economic growth only, but makes no efforts in implementing relevant changes. Laws and guidelines such as the European Union's CSRD directive as a regulatory requirement (Corporate Sus-tainability Reporting Directive) have a direct impact on economic factors such as trade intensity, economic growth and unemployment. In summary, this work will show that the use of innovative digital solutions can both conserve existing resources and generate new growth opportunities.

Keywords: *digitalization, ESG-transformation, CSRD, sustainable development*

JEL Codes: *Q01, Q56, R11, O13, O35*

[1] ROSTÁS Sándor, Ph.D. Student
University of Sopron Alexandre Lamfalussy Faculty of Economics
(Rostas.Sandor@phd.uni-sopron.hu)

Introduction

Digitalization is currently considered to be of great importance in social and economic policies, both on the level of governmental regulations and also in the sustainability policies of the companies (Brockhaus et al., 2020). There are optimistic expectations that operational digitalization will optimize processes, preserve resources and thus increase sustainability in both production planning and upstream and downstream processes (D. Koch et al., 2022). Digitalization, digital transformation, IoT (Internet of Things) and AI (artificial intelligence) are often used synonymously, as the computerization of processes or as a digitalization term for the assumption of decisions by software-supported systems (Negi et al., 2024), not taking into consideration that the scope and the necessary investments for the transformation are very different (Brockhaus et al., 2020).

Such generalized statements make the transformation process more difficult because the terms of digitalization and artificial intelligence blur fiction and reality due to their frequent use in social media and feature films (Gethmann et al., 2022). Depending on the industry sector which the companies belong to, the ESG transformation (Environmental, Social, Governance) affects almost all areas: such as the business model, corporate financing, corporate value, CO2 compensation, marketing, production and strategic planning (Neumann & Forthmann, 2024). Digitalization offers the possibility of converting analogue issues into digital ones, which then creates *digitality* in which the information can be changed and communicated (Pausits et al., 2024). The three properties mentioned above − the transfer, the change and the communication − between different Internet-enabled devices are decisive for so-called IoT-products, which can better adapt products and services to customer needs and thus optimize certain processes (Jacob, 2023).

In order to do justice to the ESG transformation and ecological sustainability, the right conditions must first be created (werk21, 2022a) because they are still largely discussed separately, the so-called green economy is coming to the fore, which is the guiding principle of an ecologically sustainable economy that combines ecology and economy and increases social prosperity (werk21, 2022b). The prerequisites for the ESG transformation are sustainability regulations such as the GCD (Green Claims Directive), CSRD (Corporate Sustainability Reporting Directive) and the CSDDD (Corporate Sustainability Due Diligence Directive), which pose major challenges for companies when implementing the requirements (Falker, 2024). A study

conducted by KPMG shows that the ESG transformation of 47% of the participating companies is a clear competitive advantage, speaks of cost savings and reputational, financial and legal risks in the event of non-compliance, if one follows the interview conducted internally by two KPMG employees (Mazar, 2023). The challenges associated with implementation, such as the necessary investments in consulting, provision of resources, higher wage costs, the additional time required and the redesign of processes, which increases complexity, were not taken into account (Michen, 2023). Even with the support of digitalization and AI, implementation remains a major challenge if companies limit themselves exclusively to purpose-oriented action (predefined by goals and means) without understanding the complexity and meaningfulness (understanding-oriented action), because AI fails here in most cases – for the time being (Maio, 2024). Consequently, the discourse that arises in the initial situation of an ESG transformation will influence the final result according to the perception of the problem and the subsequent action and will determine the success (Heinemann, 2011). In this study, we took the opportunity to use the theoretical approach for the use of digitalization to increase the efficiency of electric drives along the product life cycle.

Relevance and problem

This topic becomes very important for every company or organization because all of them develop their own corporate culture over time, which is shaped by the prevailing behaviours, norms, values and attitudes (Lippold, 2024). As a result, the dominant corporate or organizational culture (hereinafter referred to as corporate culture) must be transformed into a sustainable corporate culture by which ecological and social sustainability goals and visions are communicated (Bruhn & Hadwich, 2024a). The transformation of corporate culture within the strategic objective is carried out on the one hand via company analysis (strengths/weaknesses) and on the other hand via stakeholder/environmental analysis (opportunities/threats) (R. H. Jung et al., 2018). The decisive factor is how the reality of the company is perceived and evaluated based on the information and data available (Maio, 2024) and how this reality can be transformed into a new reality (Heinemann, 2011) in the sense of ecological and social sustainability in a constant discourse. The decisive factor is how the matter (ESG transformation) is thought about and, above all, how it is debated, because both the non-linguistic and linguistic

elements of the discourse determine how ecological and social aspects are taken into account in the further transformation process (Bruhn & Hadwich, 2024b). The real relevance of the topic lies behind the EU's (European Union's) threat of liability from the CSDDD if ESG aspects are not taken into account in corporate decisions and puts ESG on a par with the management duty to ensure the profitability and continued existence of the company (Neumann & Forthmann, 2024).

The problem is that ESG is often equated with the term "sustainable" in literature and press (Dilg, 2024), but ESG goes far beyond the concept of sustainability as a criterion for sustainable business. ESG combines ecological goals (reducing negative environmental impacts), social goals (assuming social responsibility) and economical goals (compliance with legal requirements and, with the involvement of stakeholders, increasing innovation and competitiveness) (Bruhn & Hadwich, 2024b).

The ESG transformation requires that the learning content and study programs are adapted to the requirements as early as the qualification stage (Pausits et al., 2024). The transformation requires great efforts in research and development in industry, on the one hand to develop new (more recyclable) materials and products that can be used for longer in the spirit of the circular economy (Hayil & Ibrahim, 2023), and on the other hand to redesign work processes in industry, in the further training of employees and the requalification of company management (Neumann & Forthmann, 2024).

The social framework conditions are experiencing a radical change in training, studies and in industry due to the rapid development of digital transformation, because new skills in dealing with and using new digital solutions are necessary in order to use new forms of learning and products (Pausits et al., 2024). In this context, transformation can be understood as the process of transferring technology or technology components and associated knowledge across the boundaries of several social units (Sarala et al., 2024). Artificial intelligence is a part of digitalization and digital transformation that is aimed at using all the potential of digitalization, which in turn is a part of automation, which allows human work to be done by machines (Gethmann et al., 2022). Only a few traditional professions in crafts and agriculture (traditional manufacturing/cultivation) can now do without digitization – all other sectors and many areas of industry are currently moving towards Industry 4.0, where many expect that investments in applications that increase quality and efficiency will reduce costs through networking in the value chain and that the range of services and products can be improved through digitalization (Jacob, 2023). With Industry 4.0, the automation of processes is changing and even

areas of life and work fields, depending on the industry, are subject to changes caused by the technical development of IoT products (networking of applications) (Gethmann et al., 2022). The networking of various IoT products is hoped to lead to more intelligent and energy-saving use, whereby networking also implies a stronger interlinking of economic activities in the sense of globalization – stronger cooperation between different companies/organizations (Jäggi, 2003). The companies that will prevail are those that can use the advantages of digitalization to efficiently use increasingly scarce resources and are thus significantly more energy efficient (Linne, 2003). Innovative business models are usually strategically geared towards growth and are either aimed at changing the type of value creation or at creating new (additional) needs in addition to existing ones (Griese & Schnitker, 2023). Since climate change is not only a scientific problem, but also a social and technical problem, which has been discussed in social science journals for more than 30 years, more and more social and political questions are being addressed (Jankó et al., 2010), meaning that such complex topics can be seen as the basis for ESG transformation at the individual and macroeconomic level (Bruhn & Hadwich, 2024b).

The transformation to a circular economy does not only involve the development of new, more recyclable materials, but also the intensification of benefits and the extension of product life spans pose major challenges for society, as these are not compatible with the growth strategies of many companies (Linne, 2003).

ESG – Challenges

Industry and society are undergoing a major transformation, which is essentially accompanied by ecological, demographical, socio-political and economical megatrends, which is one of the reasons why business environments are constantly changing, and the pressure is constantly growing (Englert & Ternès, 2019). Demographic change is a significant element of the transformation, as current forecasts predict that Germany will be short of 7 million workers or skilled workers by 2035, which will lead to a decline in economic performance and failure to achieve growth targets (Bruhn & Hadwich, 2024b). The ability to promote and invest in innovation is said to have great potential in sustainable development if these innovations are sustainable and forward-looking and are geared to the changed situation (Englert & Ternès,

2019). In the future, digitalization, sustainability and people will be inseparable from one another, as all of these areas are constantly producing new information and therefore more new knowledge must be imparted in a shorter period of time (Bruhn & Hadwich, 2024b).

For this reason, traditional business models should be constantly re-evaluated because Industry 4.0 technologies generate significant benefits from Big Data solutions that enable real-time integration of business processes (sales, production), which influences customer behaviour and product life cycles (Gläß & Leukert, 2017).

Environmental and climate crisis

The environmental and climate crises cannot be viewed in isolation because they are accompanied by health and economical crises (Wittpahl, 2020) and currently also political crises and wars in Europe and the Middle East. Many organizations, institutes, experts, researchers and churches are increasingly pointing out that all the crises mentioned above are closely related to each other (Bándi, 2024). Banks play an important role in both, in the economic crisis and also in the climate crisis because they determine what climate-friendly investments should be and how they are promoted (Schwager et al., 2022). One of the most important questions in terms of ecological sustainability is how a product can be produced in such a way that as few resources (raw materials and energy) as possible are required and how it can be operated in such a way that as few greenhouse gases as possible are released (Jacob, 2023). Not least, the high greenhouse gas emissions are attributed to the increasing need for packaging and transport for consumer goods in online retail (Harwardt, 2023) and the poor recyclability of many products, which is associated with enormous energy requirements (Griese & Schnitker, 2023).

To achieve the climate protection goals, greenhouse gas emissions must be reduced in both, in the industrial sector and in all other sectors (health care, transport, private sector) by reorganizing to CO2-neutral technologies (Schwager et al., 2022). However, the CO2-neutral technologies from wind and solar energy are not always available and weather changes have a direct impact on power supply, which makes demand-oriented supply currently still questionable (Wittpahl, 2020). The effectiveness of the objectives derived from the ESG transformation can be tested using KPIs (key performance indicators), which are determined by measuring

- the CO2 footprint,
- energy consumption (electricity, gas),
- water consumption and
- the amount of waste produced (Bruhn & Hadwich, 2024b).

Social and societal

The previously mentioned megatrends and digitalization are changing the culture of a society, which also initiates a change in values that is interrelated with selected social areas such as individualization and the drive for perfection, mobility, gender roles and diversity, demographic change and, of course, sustainability (Jacob, 2023). The changed everyday behaviours in the so-called "wealthy industrialized countries" are thus contributing significantly to the climate crisis due to the constantly growing mobility (individual transport), the need for new technologies (electronic products) and the significantly increased amounts of household waste (Schwager et al., 2022). The extraordinarily high pressure caused by the constantly new needs of the masses initially falls on the producers, who are happy to pass on all the responsibility to politicians because market share, market dominance and growth are what counts for producers first and foremost (Sigl, 2023).

The ESG transformation is an overall social transformation process affecting society as a whole, which shapes the development of society as a whole and pursues the goal of enabling a fair and good life for all now and in the future (Henkel et al., 2021). Taking digitalization into account, a contemporary theory states that digitalization is a global and social event that has already begun with the restructuring process of society and the economy (Sigl, 2023). The effectiveness of the social goals implemented in the company is also evaluated by means of KPIs, which are determined, for example, by measuring

- the degree of diversity,
- age and origin of employees, employee satisfaction, safety of working conditions
- or expenditure / donations for social projects

(Bruhn & Hadwich, 2024b). Compliance with social goals is one of the key factors in counteracting the disadvantages of digitalization such as

- high workload and lack of time,
- unfair pay,
- bureaucracy and high documentation effort,
- no social prestige of the profession, age discrimination,
- poor working conditions (Jacob, 2023).

Corporate governance

For companies and organizations of all kinds, ESG transformation means a constant process of change with an ever-increasing focus on reducing greenhouse gas emissions and improvement of ecological sustainability (Schwager et al., 2022). With the megatrend of digitalization and artificial intelligence, sustainability has become a success factor and possibly offers one of the most important social and economic opportunities of the present (Lippold, 2024). Megatrends can be spoken of when there is a need for change – here – in the sense of ecological sustainability, which brings about change and the pursuit of improvements that have a broad impact on society and the economy (Jacob, 2023). For this reason, investors are more likely to invest in the shares and funds of companies that invest capital in green technologies and pursue ethical principles in corporate governance and are also given advantages because they are said to have great innovation potential (Linne, 2003). Ultimately, the company's management is responsible for generating profits in order to be able to successfully implement the business model in an economically, ecologically and socially sustainable manner over a longer period of time and to influence the market accordingly (Lippold, 2024). To this end, at the beginning of an ESG transformation, it is necessary for the management to implement future leadership and strategy in a sustainability-oriented manner, in its vision, mission, corporate values and in strategy development, in planning (Bruhn & Hadwich, 2024b). The KPIs of ecological sustainability measure success based on

- the increase in profit and sales,
- the profitability of sustainable investments and
- the reduction of costs and savings in energy and raw materials

based on the implemented economic goals (Bruhn & Hadwich, 2024b).

Objectives and questions

The aim of this study is to use an example to examine the service life of an electrically driven machine (submersible motor pump) from the creation of the need, along the service life to disposal, and to map the ESG aspects and link them to the theoretical approaches of ESG. Since the climate crisis has penetrated the collective awareness, energy and resource efficiency features, which are also important for professional users (companies), have also come to the fore due to social pressure and, on the other hand, due to the Supply Chain Due Diligence Act and other requirements by the legislature (Schwager et al., 2022). The energy industry's goal for the future is the decentralized and demand-oriented provision of energy and, with the help of digitalization, only the amount necessary to carry out a specific job (such as emptying a container) should be used (Jacob, 2023). Changes are often associated with significant adjustments in production plants, including changes to the business model, and therefore offer consistency in the optimization and efficiency strategy to adapt processes to the existing conditions with the help of digitalization (Jacob, 2023).

The following example looks at a normal (everyday) process of TEG (Tsurumi (Europe) GmbH, Düsseldorf, Germany) with the support of the sales and marketing department. With a few exceptions, depending on the industry, sales structure and corporate culture, sales processes are organized very similarly, whereby they are also essentially determined by the customer decoupling point (Uhe, 2002). The customer decoupling point indicates at which point in the product creation process a customer can be assigned to the product in the supply chain (Schenk et al., 2014). This point is at the end of the process at TEG because almost all products are produced anonymously to the customer. As a result, the previously formulated goal is illustrated with the practical example of TEG. Furthermore, an attempt is made to link the ESG aspects and technical possibilities of digitalization along the product life cycle in order to identify possible opportunities and risks. The following questions can be derived from this

- In which phases of the product life cycle can digital technologies help to reduce CO2 emissions?

- In the practical example presented here, can positive effects be achieved between the ESG (Environmental Social Governance) elements, or can they only be considered in isolation from one another for the time being?
- Can possible approaches from the linear economy be found in the circular economy under the given circumstances?

The following hypothesis can be derived from the questions: digital technologies can extend the useful life of certain products, thereby conserving valuable primary raw materials and contributing to ecological sustainability.

Method

In order to answer how digitalization, the Internet of Things and artificial intelligence relate to the ESG transformation, and which limitations still exist in practice, a comprehensive and systematic literature research was chosen as the method. In order to present the theoretical aspects more transparently, supporting examples from the practice of Tsurumi (Europe) GmbH are used.

Literature research

Systematic literature research is most suitable in this work because the research question has already been defined and relevant sources have been searched for using selected search terms. Systematic literature research in selected databases is essential in order to take into account the latest state of research (Döring, 2023), but it is advisable not to consider only the latest sources in this work. The beginnings of digitalization go back to the middle of the 20th century with the ENIAC (Electronic Numerical Integrator and Computer), followed by mainframe computers in the 1960s, personal computers in the 1980s, followed by the Internet and later smartphones, up to today's AI applications, which have influenced both the economy and politics and society ever since (Jäggi, 2023). The search for specialist literature was carried out using the keywords mentioned in the abstract and other search terms as listed in *Figure 1*.

Search terms	Number of hits – Fernuniversität Hagen database	Number of hits – Database of the Technical University of Dortmund	Number of hits – Google Scholar database	Number of hits – Research Gate database
Digitalization ESG	4	45	85	121
ESG-Transformation	66	70	90	76
CSRD ESG	48	32	66	72
Sustainable development ESG	24	21	94	70
environmental crisis	28	59	49	80
climate crisis	16	33	91	50
Renewable energy	49	35	73	75
energy efficiency	69	49	68	42
Artificial intelligence	44	21	23	38

Figure 1: Overview of literature search – Search terms absolute distribution
Source: own illustration

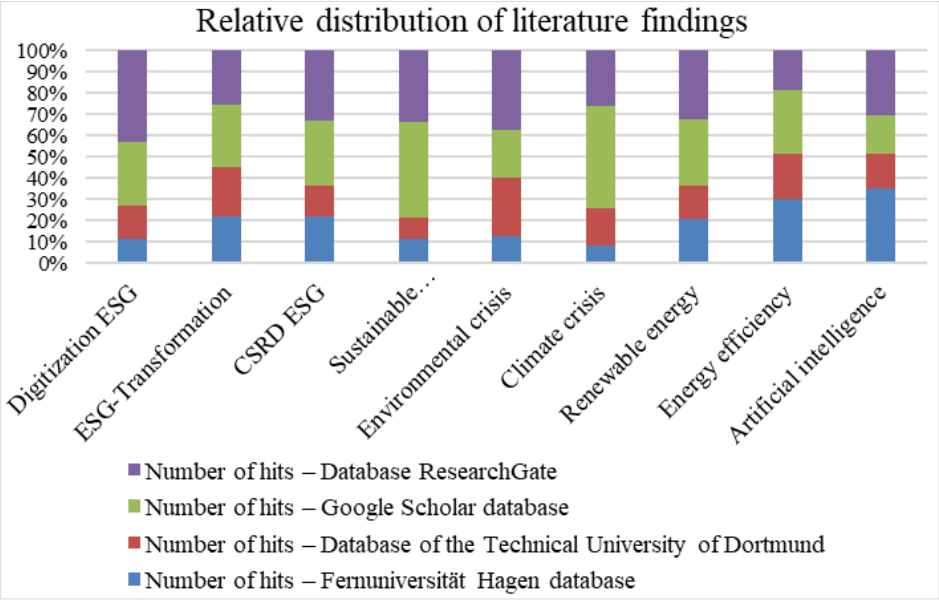

Figure 2: Overview of literature research – search terms relative distribution
Source: own illustration

The relative distribution of the search results in *Figure 2* shows that most possible sources can be found primarily via Google Scholar and secondly via ResearchGate. Some sources are often suggested to various databases and in

most cases the sources can be accessed via a download link directly from the publisher (Springer Fachmedien, Springer Gabler, Springer Berlin and Springer Vieweg). The focus of the selection of sources was on processing the current state of research (Döring, 2023), so the search was specifically for sources from 2023 and 2024. But older sources are also taken into account in this work as long as their content is still current and no newer research results are available, unless they are needed for a historical consideration of the subject of the study (Berger-Grabner, 2016). A very high number of articles were identified in this search and therefore the research was initially restricted to the established publishers mentioned. The publications were then selected based on the relevance of the title to the topic. A total of 2,004 publications were found. After removing duplicates and publications that were not available online, 154 remained. After checking the content of the abstracts, 48 remained.

Case study

The case study of Tsurumi (Europe) GmbH outlined in Chapter 5 does not represent an independent study within the framework of an empirical investigation. All information was provided by TEG's Sales and Marketing Director, Mr. Birger Schmidt, and Senior Product Manager Mr. Stefan Himmelsbach as part of the team of CSRD implementation from May 2024. The aim of applying the case study is to develop practical incentives to identify opportunities that can achieve improvements within the limits of existing processes in terms of ecological sustainability, thus shortening the learning curve for future solutions and accelerating new processes (Bruhn & Hadwich, 2024a).

The company operating in this case study is the subsidiary of the Japanese manufacturer TMC (Tsurumi Manufacturing Co., Ltd.) with headquarters in Kyoto. The European subsidiary sells its products throughout Europe with the support of five subsidiaries and a very well-organized dealer network.

The implementation of the CSRD is, on the one hand, a requirement of the parent company TMC and, on the other hand, a requirement of the CSRD standard. Since TEG, together with its subsidiaries, meets at least two of the criteria (total assets and net sales) across Europe, it will therefore be required to report as early as 2025 (Bruhn & Hadwich, 2024a).

Procedure of the case study

The approach in the case study consists of comprehensive observation of the sales process during CSRD implementation. The analysis of the TEG's business model and the strategy towards risks related to ESG aspects along the supply chain is of great importance because it poses the risk of an increased material footprint or a threat to security of supply (Has, 2022). Since the TEG also still follows the structures of the linear economy (production – use – disposal) because it can always procure resources easily and inexpensively (Hansen et al., 2021), the risks and opportunities in the phases of the product life cycle displayed in *Figure 3* must be examined and new knowledge converted into benefits for the customer (R. H. Jung et al., 2018).

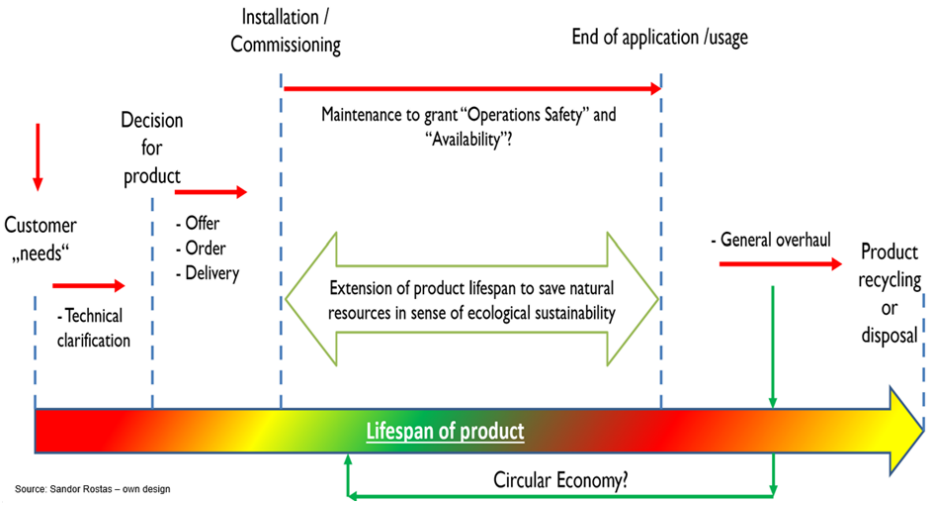

Figure 3, Product lifespan of TEG products: own illustration

For products that are essentially made from primary raw materials, the focus is on long durability and long-term usability (Linne, 2003). The key to success is, on the one hand, identifying the ESG factors for the business model (electricity consumption, water consumption, material consumption) and, on the other hand, assigning these to one of the ESG areas (environmental, social or corporate governance) and identifying the corresponding risks and opportunities and assessing them with the probability of occurrence (Neumann & Forthmann, 2024). The main ESG risks related to climate change and sustainability are divided into strategic, operational, financial and compliance

risks (Gleißner & Romeike, 2020). The present case study identifies operational risks and opportunities, which are then later reflected in the operational management phase in sustainable business models, establishment of the circular economy, novel product-service systems and sustainable innovation (Bruhn & Hadwich, 2024b).

Overview of the product life cycle phases

The following is a summary of the contents of the product life cycle phases in *Figure 3* from the discussions with B. Schmidt and S. Himmelsbach.
When needs for submersible motor pumps arise, end users are often unable to sufficiently specify the situation for which they need the equipment sufficiently, so that they either order from the product catalogues without prior technical clarification or they request offers with little or incorrect technical data. In such cases, there is a risk that the end user will receive incorrect products that are either over- or under-dimensioned. There is a risk that over-dimensioned devices will have an uncalculated energy requirement and that under-dimensioned devices will not be able to deliver the required performance. In both cases, the wrong product selection has a negative impact on the service life, energy and material consumption. An appropriate sustainability marketing concept could offer opportunities to work the relevant market, taking ecological and social aspects into account, in such a way that customer satisfaction and early detection of needs and their correct assessment are the focus (Grunwald & Schwill, 2022).

In the technical clarification phase, the risks lie in the communication skills and the respective communication policy of those involved, which determines a successful outcome. The technical clarification actually only serves the purpose of determining the right product (with the right technical properties) based on the technical conditions of the end user. Communication is considered to be very important, so it also offers an opportunity in this phase to be able to fairly serve specific needs in the various buyer segments (Grunwald & Schwill, 2022).

There must be no risks in the customer and supplier relationship during the phases of product decision, quotation processing, order processing, delivery and installation & commissioning, provided that no significant questions remained unanswered in the previous phases and interim changes and unforeseen events were communicated correctly and in a timely manner. In this phase, the supplier is primarily responsible for ensuring the process capability of its internal processes (Bullinger et al., 2009).

Risks arise in the usage phase when the operating conditions change, which also changes the intended use. Further risks arise in this phase when preventive maintenance work has either not been planned or has not been planned appropriately for the level of difficulty of the application. As already mentioned above, from an ecological and economic point of view, the usage phase should be as long as possible, although these efforts run counter to the growth targets of the suppliers (Kreipl, 2020).

At the end of the usage phase, the options are to overhaul a device or to recycle the device and dispose of the remaining parts that cannot be recycled. There is a risk that due to a lack of capacity, a lack of knowledge or because it is simply uneconomical, devices will be disposed of too quickly without checking whether these devices can be reintroduced into the usage process after a general overhaul in the spirit of the circular economy (Hansen et al., 2021).

Results

The impact of digitalization on ESG transformation is currently still difficult to determine for all areas of the industrial sector. It is important to recognize the differences between digitalization, the Internet of Things and artificial intelligence, because these are important with regard to the implementation and handling of new technologies and the acceptance of change (Henkel, 2023).

Digitalization will make sustainability reporting more transparent for stakeholders and their measures to reduce greenhouse gas emissions more comparable, as digital tools will offer the possibility of automatically providing assessments based on defined criteria to interested parties in the future (Herzner & Schmidpeter, 2022). In this context, sustainability reporting is an essential topic for companies that themselves or whose customers are subject to the CSRD, because not only the legislator, but also investors, banks, customers, business partners and other stakeholders can increasingly demand reporting (Has, 2022).

Elements of sustainability reporting such as GHG accounting (Scope 1-3) according to the GHG Protocol (Greenhouse Gas) and LCA (Life Cycle Assessment) have become increasingly important (Bruhn & Hadwich, 2024a). As already discussed in the example case above, the LCA perspective plays an important role with the double materiality assessment, in which

companies assess both their impacts on society and the environment (materiality of impacts) and the impacts of society and the environment on the company (financial materiality) (Has, 2022). GHG accounting (Scope 1-3) assesses the organizational and corporate level

- Scope 1 direct GHG emissions from own company processes,
- Scope 2 indirect emissions from purchased energy and
- Scope 3 from upstream activities (primary and secondary resources) and downstream activities (sales and use) and despite different objects of investigation, LCA or Scope 1-3, environmental or climate impacts are recorded that go far beyond the pure impacts within the company; the entire life cycle of the product or the company is taken into account (Eisele, 2021).

In the above case study, both the different perspectives of life cycle assessment and the aspects of GHG accounting can be illustrated. In practice, however, accounting in both areas still has to contend with major hurdles. The electrical devices from the manufacturer TMC are delivered to Europe ready for use and can be made available directly on the market. Calculating the product-related CO2 footprint is difficult due to information gaps in the supply chain and the fact that many assumptions have to be made in the calculation. Therefore, the upstream activities cannot therefore be controlled by the European subsidiary. Where it can exert influence, however, are the downstream activities of sales and use. An appropriate marketing strategy and measures to extend the product lifespan could help to improve the ecological footprint. This would not least be the case if measures were established to reintegrate devices into the usage process after their useful life has expired due to wear and tear. This would be the first step towards a circular economy, but it would also change the way production is carried out, the supply chain would have to be adapted, which at the same time requires a change in the business model (Kadner et al., 2021).

The establishment of appropriate measures based on reliable eco- and GHG accounting would ensure that the ecological limits are maintained and respected by those involved (Bruhn & Hadwich, 2024b). The necessary changes are fundamentally linked to the problems of changing, designing, managing and controlling processes, because the individual behaviour of the people involved is often not taken into account – but these people decide whether the changes are accepted or boycotted (Bruhn & Hadwich, 2024a).

This group of people primarily includes the people involved (so-called decision-makers) who are characterized by aggressive growth strategies and are less concerned with ecological sustainability and primarily with increasing sales (Jäggi, 2023).

Discussion

A good opportunity to spark a debate is the question of what opportunities and risks arise from the interaction between digitalization and the ESG transformation. Here, too, supporters and opponents of digitalization, IoT and AI face each other, clearly expressing that while they have advantages, they also pose considerable risks (Jäggi, 2023). A challenge for management is to identify corresponding demands from the relevant market and to transform them into a competitive advantage with the necessary speed (Meffert et al., 2024). Digitalization offers considerable advantages, which are based on the fact that physical objects, digital objects and people can be networked with one another (IoT) in order to establish chains of effects and to accelerate the exchange of information (Joisten, 2022).

However, the high transformation costs have a disadvantageous effect on SMEs because there is always the impression that the costs are not proportionate to the benefits and the transformation process is more often characterized by negative future prospects due to political uncertainty and there are still obstacles to digitalization due to a lack of IT knowledge among employees (Brockhaus et al., 2020). From a democratic perspective, challenges in the digital divide are discussed because inequality is justified by the phenomenon of capitalism and technological change, in which the problems of social inequality are spread through digital instruments (Chen, 2024). The ESG criteria Environment (GRI300), Social (GRI400) and Governance (GRI100) are synonymous with sustainable action in the economy for the presentation and evaluation of sustainability The three criteria are used without taking into account the usual KPIs and without calculation methods as a basis for the presentation of some of the opportunities and risks in *Figure 4* that arise from the TEG case study along the product life cycle in Figure 3.

	Chances	Risks
Environmental	• Saving primary materials • Saving secondary materials • Use of recycled materials	• Outdated management method • Inefficient communication with potential customers
Social	• Emergence of new work areas • Emergence of new professional fields • Better Work Life Balance	• Extinction of traditional professions • High effort required to cope with the flood of information • Age discrimination
Governance	• Efficient management methods can be used • More efficient communication tools	• Research and development suffer due to standardized decision-making processes • High effort for the documentation of processes

Figure 4, ESG opportunities and risks in the TEG context
Source: own illustration

TEG has no influence on the production processes at TMC in Kyoto and therefore there is no possibility of discussing concepts for reducing the need for primary and secondary materials and promoting increased use of recycled materials. There is currently a real opportunity for TEG to extend the life of devices by determining the right device and taking measures to extend the life span of the product. Risks in the environmental area arise from outdated management methods in sales, where no attempt is made to serve the relevant markets in a needs-oriented manner. Outdated communication models can lead to these becoming even more prone to errors due to demographic changes, because the methods and types of communication are constantly evolving (Bruhn & Hadwich, 2024b).

In the social sector, digitalization, IoT and AI are creating opportunities for completely new professions and fields of activity, as well as a new attitude to life through an improved work-life balance, which has also been facilitated created by the possibilities of mobile work (free location and time management). On the other hand, there are risks that traditional professions may be completely forgotten and die out. Some people also still have to learn how to handle the large amounts of data that digitalization creates. Otherwise, employees' risk being overworked and having higher levels of sick leave. Another risk factor is age discrimination, because it is assumed that older

employees are no longer capable and cannot handle the new technology (Sigl, 2023).

New opportunities are emerging for company management through modern methods and communication tools that allow them to prepare and distribute information more quickly. Information acquisition is also easier with the help of digitalization, which means that market changes can be registered more quickly. The disadvantage is that digitalization is expected to lead to greater standardization, which can be at the expense of creativity in development. Another disadvantage that is foreseeable is that the documentation efforts will increase. This will certainly be done digitally, but the system must still be kept up to date. The basis of sustainable company management is the circular economy with the primary goal of drastically reducing of waste volumes and minimizing the need for primary and secondary raw materials and reducing GHG emissions by producing energy-efficient devices (Lippold, 2024).

Opportunities of digitalization

Digitalization is changing the world of work, and each professional group is currently affected by the change in different ways and each group learns (Pluzhnikova, 2024) and experiences the opportunities that arise from it differently (Jäggi, 2023). In industry, digitalization is leading to it becoming an independent production factor and ensuring transparency by linking the physical and virtual worlds (Gläß & Leukert, 2017). It is also a fact that digitalization is endangering jobs and professions (jobs in sales, banking, warehousing, etc.) through innovations, but it is not clear whether jobs with a high proportion of women or men are more at risk (Jäggi, 2023). In addition to the negative effects, there are also positive signals from science that the changed working conditions of employees have a positive impact on their health and satisfaction (Gethmann et al., 2022). The Baden-Württemberg Minister for Economic Affairs sees digitalization as a great opportunity to increase resource efficiency and climate protection in the manufacturing industry and, together with AI, it is assigned a key role in climate protection and sustainability (D. Koch et al., 2022).

The automation of functions and machines is also common practice at TEG, but automation is reduced to a few variables without the system being able to meet higher requirements. The term automation stands for the replacement of manual work steps, which is being raised to the level of Industry 4.0

with digitalization, where the focus is on the intelligent networking of processes and machines (Jacob, 2023). In the above case study, an intelligent system can, as a service life-extending measure with appropriate monitoring, warn early on of failures due to wear and tear in a networked system. This would be an advantage in every respect, but it is questionable whether customers are already prepared to invest in the infrastructure for communication.

Conclusion

The question of in which phases of the product life cycle digital technologies can help to reduce CO2 emissions cannot yet be conclusively answered because the product life cycle and the type of product application are different. Digitalization can help to reduce CO2 emissions in every phase of the product life cycle if appropriate digital technologies are procured and implemented for the relevant company functions. However, it is questionable what the relationship is between the investments and the hoped-for benefits. In addition to costs, another key aspect for success is the lived corporate culture, whether the organization is characterized by an open, innovation-friendly culture or whether it relies on resistance across the board (M. Jung & Von Garrel, 2021). For example, traffic systems can be optimized with the use of IoT and AI by equipping them with intelligent emergency systems and a charging infrastructure for electric cars from renewable energy sources with connection the public network systems (Singh et al., 2021).

The second question, whether positive effects can be achieved between the ESG (Environmental Social Governance) elements in the practical example presented here, or whether they can only be considered in isolation from one another for the time being, cannot be easily answered based on the example. It must be checked whether a logical connection can be made between KPIs of the ESG criteria, but it primarily depends on which KPIs are selected by the company management for the evaluations (Erchinger, 2022). In the case study, it would be conceivable that the environmental KPI waste quantity & recycled share could be interrelated with the social KPI expenditure on training and education and the corporate governance KPI ethics & compliance.

The third question, whether possible approaches from the linear economy can be found in the circular economy under the given circumstances, can be easily answered based on the knowledge gained here. For the case study, there are two approaches for establishing the circular economy. The

first approach arises at the end of the useful life due to wear and tear. A refurbished device can be returned to the cycle, which some manufacturers (Apple, Dell) already do. The second approach arises at the spare parts level. If a device has been damaged and cannot be repaired, then there is still the possibility of returning the well-preserved spare parts to the cycle.

The hypothesis derived from the above questions, that digital technologies can extend the service life of certain products so that valuable primary raw materials are conserved and thus contribute to ecological sustainability, can be confirmed based on the new findings. In the automotive industry, comparable systems already exist that have proven themselves in practice and enjoy significant competitive advantages in their market segment.

References

Bándi, G. (2024, Oktober 10). Iustum Aequum Salutare. *A jövő nemzedék védelmé-nek egyes jogi eszközei*, XX. 2024/1., 33–50.

Berger-Grabner, D. (2016). *Wissenschaftliches Arbeiten in den Wirtschafts- und Sozialwissenschaften: Hilfreiche Tipps und praktische Beispiele* (3. Aufl. 2016). Springer Gabler. https://doi.org/10.1007/978-3-658-13078-7

Brockhaus, C. P., Bischoff, T. S., Haverkamp, K., Proeger, T., & Thonipara, A. (with Ifh Göttingen). (2020). Digitalisierung von kleinen und mittleren Unterneh-men in Deutschland – Ein Forschungsüberblick [PDF]. In *Göttinger Beiträge zur Handwerksforschung,* 46 (S. 31 Seiten). Göttingen : ifh, Volkswirtschaft-liches Institut für Mittelstand und Handwerk an der Universität Göttingen. https://doi.org/10.3249/2364-3897-GBH-46

Bruhn, M., & Hadwich, K. (Hrsg.). (2024a). *Sustainable Service Management: Band 1: Nachhaltigkeit aus Sicht von Kunden und Mitarbeitern*. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-45148-6

Bruhn, M., & Hadwich, K. (Hrsg.). (2024b). *Sustainable Service Management: Band 2: Strategien und Umsetzung der Nachhaltigkeit.* Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-45146-2

Bullinger, H.-J., Spath, D., Warnecke, H.-J., & Westkämper, E. (Hrsg.). (2009). *Handbuch Unternehmensorganisation: Strategien, Planung, Umsetzung* (3. Aufl. 2009). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-87595-6

Chen, K.-W. (2024). *Digitalisierung und Demokratie: Repräsentation, digitale Partizipation und ihre rechtliche Architektur* (1st ed. 2024). Springer Fach-medien Wiesbaden. https://doi.org/10.1007/978-3-658-46263-5

Dilg, M. (2024). *Verantwortlich in Nachhaltigkeit Investieren: Eine Pragmatische Aufbereitung Kontroverser Ansichten* (1st ed). Springer Vieweg. in Springer Fachmedien Wiesbaden GmbH. https://doi.org/10.1007/978-3-658-14359-6

Döring, N. (2023). *Forschungsmethoden und Evaluation in den Sozial- und Hu-manwissenschaften* (6. Aufl. 2022). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-64762-2

Eisele, O. (2021). *Nachhaltigkeitsmanagement – Handbuch für die Unternehmen-spraxis: Gestaltung und Umsetzung von Nachhaltigkeit in kleinen und mit-tleren Betrieben* (Institut für Angewandte Arbeitswissenschaft, Hrsg.). Springer Vieweg. https://doi.org/10.1007/978-3-662-63012-9

Englert, M., & Ternès, A. (Hrsg.). (2019). *Nachhaltiges Management: Nachhal-tigkeit als exzellenten Managementansatz entwickeln* (1. Aufl. 2019). Spring-er Berlin Heidelberg. https://doi.org/10.1007/978-3-662-57693-9

Erchinger, R. (with Koch, R., & Schlemminger, R. B.). (2022). *ESG(e)-Kriterien – Die Schlüssel Zum Aufbau Einer Nachhaltigen Unternehmensführung: Eine Eignungsanalyse Ausgewählter Standardkriterien* (1st ed). Springer Vieweg. in Springer Fachmedien Wiesbaden GmbH. https://doi.org/10.1007/978-3-658-37877-6

Falker, G.-M. (2024). Handel schlägt Alarm zu ESG-Regeln. *Lebensmittel Zeitung*, 76(30), 15–15. https://doi.org/10.51202/0947-7527-2024-30-015-1

Gethmann, C. F., Buxmann, P., Distelrath, J., Humm, B. G., Lingner, S., Nitsch, V., Schmidt, J. C., & Spiecker Genannt Döhmann, I. (2022). Künstliche Intelli-genz in der Forschung. In C. F. Gethmann, P. Buxmann, J. Distelrath, B. G. Humm, S. Lingner, V. Nitsch, J. C. Schmidt, & I. Spiecker Genannt Döhmann, *Künstliche Intelligenz in der Forschung: Neue Möglichkeiten und Herausforderungen für die Wissenschaft* (Bd. 48, S. 1–11). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-63449-3_1

Gläß, R., & Leukert, B. (Hrsg.). (2017). *Handel 4.0: Die Digitalisierung des Han-dels – Strategien, Technologien, Transformation*. Springer Gabler. https://doi.org/10.1007/978-3-662-53332-1

Gleißner, W., & Romeike, F. (2020). ESG-Risiken und ihre Quantifizierung. In O. Everling (Hrsg.), *Social Credit Rating* (S. 391–433). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-29653-7_21

Griese, K.-M., & Schnitker, K. (Hrsg.). (2023). *Nachhaltigkeitsmarketing: Eine fallstudienbasierte Einführung* (2., vollständig überarbeitete Auflage). Springer Gabler. https://doi.org/10.1007/978-3-658-38521-7

Grunwald, G., & Schwill, J. (2022). *Nachhaltigkeitsmarketing: Grundlagen – Ge-staltungsoptionen – Umsetzung* (1. Auflage). Schäffer-Poeschel Verlag. https://doi.org/10.34156/9783791049274

Hansen, E. G., Wiedemann, P., Klaus, F., Lüdeke-Freund, F., Jaeger-Erben, M., Schomerus, T., Alcayaga, A., Blomsma, F., Tischner, U., Ahle, U., Büchle, D., Denker, A.-K., Fiolka, K., Fröhling, M., Häge, A., Hoffmann, V., Kohl, H., Nitz, T., Schiller, C., … Kadner, S. (2021). *Zirkuläre Geschäftsmodelle: Bar-rieren überwinden, Potenziale freisetzen* (S. 170 pages) [Applica-tion/pdf,pdf,print]. acatech – Deutsche Akademie der Technikwissenschaften. https://doi.org/10.48669/CEID_2021-8

Harwardt, M. (2023). Ansatzpunkte der ökologischen Nachhaltigkeit im E-Commerce. In M. Harwardt (Hrsg.), *Ökologische Nachhaltigkeit im E-Commerce: Grundlagen, Ansätze und Handlungsempfehlungen* (S. 39–99). Springer Fachmedien. https://doi.org/10.1007/978-3-658-40261-7_4

Has, M. (2022). Sustainable Products: *Life Cycle Assessment, Risk Management, Supply Chains, Eco-Design* (1st ed). Walter de Gruyter GmbH. https://doi.org/10.1515/9783110767308

Hayil, M. A. H., & Ibrahim, A. A. (2023). Implementing an Internet of Things (IoT) system to sort recyclable materials based on color and track the quantity of each color-coded

piece. *2023 7th International Symposium on Innovative Approaches in Smart Technologies (ISAS)*, 1–4. https://doi.org/10.1109/ISAS60782.2023.10391744

Heinemann, W. (2011, Dezember 9). Tekst i dyskurs | Text und diskurs. *Diskursanalyse in der Kontroverse*, 4, 31–67.

Henkel, A. (2023). Nachhaltige Digitalisierung. Gesellschaftliche Transformation, autonome Materialität und der Fall des Digital Farming. Berliner *Journal für Soziologie*, 33(3), 289–318. https://doi.org/10.1007/s11609-023-00500-5

Henkel, A., Wendt, B., Shove, E., Scheer, D., Ametowobla, D., Arnold, N., & Besio, C. (2021). *Soziologie der Nachhaltigkeit* (N. S. der N. SONA, Hrsg.). Tran-script. https://doi.org/10.1515/9783839451991-002

Herzner, A., & Schmidpeter, R. (Hrsg.). (2022). *CSR in Süddeutschland: Un-ternehmerischer Erfolg und Nachhaltigkeit im Einklang*. Springer Berlin Hei-delberg. https://doi.org/10.1007/978-3-662-61959-9

Jacob, M. (2023). *Digitalisierung der Arbeitswelt: Gegenwart und Zukunft* (1st ed). Springer Vieweg. in Springer Fachmedien Wiesbaden GmbH. https://doi.org/10.1007/978-3-658-40603-5_1

Jäggi, C. J. (2023). *Digitalisierung in Wirtschaft und Gesellschaft: Ökonomische, Soziale und ökologische Auswirkungen, Fragen und Perspektiven* (1st ed). Springer Vieweg. in Springer Fachmedien Wiesbaden GmbH. https://doi.org/10.1007/978-3-658-42206-6

Jankó, F., Móricz, N., & Pappné Vancsó, J. (2010). Földrajzi közlemények. *Climate Change: Controversies in Science and the Objectives of Human Geography* (Patr One), 4. pp.(134), 405–418.

Joisten, K. (2022). *Ethik in den Wissenschaften: Einblicke und Ausblicke.* J.B. Metzler, ein Teil von Springer Nature. https://doi.org/10.1007/978-3-662-63878-1

Jung, M., & Von Garrel, J. (2021). Mitarbeiterfreundliche Implementierung von KI -Systemen im Hinblick auf Akzeptanz und Vertrauen: Erarbeitung eines For-schungsmodells auf Basis einer qualitativen Analyse. *TATuP - Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis*, 30(3), 37–43. https://doi.org/10.14512/tatup.30.3.37

Jung, R. H., Heinzen, M., Quarg, S., & Kleine, M. (with Franken, R., Franken, S., Mühlencoert, T., Rank, S., Simon, C., & Weissenberger-Eibl, M. A.). (2018). *Allgemeine Managementlehre: Lehrbuch für die angewandte Unternehmens- und Personalführung* (7., neu bearbeitete Auflage). Erich Schmidt Verlag.

Kadner, S., Kobus, J., Hansen, E. G., Akinci, S., Elsner, P., Hagelüken, C., Jaeger-Erben, M., Kick, M., Kwade, A., Müller-Kirschbaum, T., Kühl, C., Obeth, D., Schweitzer, K., Stuchtey, M., Vahle, T., Weber, T., Wiedemann, P., Wilts, H., & von Wittken, R. (2021). *Circular Economy Roadmap für Deutschland* (S. 106 pages) [Application/pdf,print,pdf]. acatech – Deutsche Akademie der Technikwissenschaften. https://doi.org/10.48669/CEID_2021-3

Koch, D., Lentes, J., Schuseil, F., & Waltersmann, L. (2022). *Nachhaltigkeit durch KI*. Fraunhofer-Gesellschaft. https://doi.org/10.24406/PUBLICA-301

Kreipl, C. (2020). *Verantwortungsvolle Unternehmensführung: Corporate Gov-ernance, Compliance Management und Corporate Social Responsibility*. Im-print: Springer Gabler. https://doi.org/10.1007/978-3-658-28140-3

Linne, G. (with Schwarz, M.). (2003). *Handbuch Nachhaltige Entwicklung: Wie Ist Nachhaltiges Wirtschaften Machbar?* VS Verlag fur Sozialwissenschaften GmbH. https://doi.org/10.1007/978-3-663-10272-4

Lippold, D. (2024). *Unternehmensführung und Nachhaltigkeit: Nachhaltigkeit Als Erfolgsfaktor Für Unternehmerisches Handeln* (1st ed). Walter de Gruyter GmbH. https://doi.org/10.1515/9783111504728

Maio, G. (2024). Ethik der künstlichen Intelligenz in der Medizin. *DMW – Deutsche Medizinische Wochenschrift,* 149(14), 846–853. https://doi.org/10.1055/a-2302-8919

Mazar, G. (2023, Oktober 10). *Interview: Große ESG-Umfrage liefert über-raschende Ergebnisse*. KPMG Klardenker. https://klardenker.kpmg.de/esg-herausforderungen-in-deutschen-unternehmen/

Meffert, H., Burmann, C., Kirchgeorg, M., & Eisenbeiß, M. (2024). *Marketing: Grundlagen marktorientierter Unternehmensführung: Konzepte – Instrumente – Praxisbeispiele* (14., überarbeitete und erweiterte Auflage). Springer Gabler. https://doi.org/10.1007/978-3-658-41755-0

Michen, B. (2023). *Nachhaltigkeit in KMU im Kanton Zürich: Herausforderungen und Lösungsansätze bei der Implementierung*. https://doi.org/10.13140/RG.2.2.19075.72483

Negi, G. S., Singh, R., Gehlot, A., Malik, P., Sharma, R., Obaid, A. J., Alferaidi, A., Alharbi, Y., & Kumar, S. (2024). Microgrids 4.0: Digitalization of microgrid with IoT and recent technology interventions. *IET Communications*, cmu2.12864. https://doi.org/10.1049/cmu2.12864

Neumann, M., & Forthmann, J. (2024). *ESG-Reporting in der Unternehmenskom-munikation: Was die EU-Regulierung für die Unternehmensberichterstattung bedeutet.* Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-44204-0

Pausits, A., Schlögl, P., & Kil, M. (2024). *Beiträge wissenschaftlicher Weiterbild-ung zur Hochschulentwicklung* (1. Auflage). BoD – Books on Demand.

Pluzhnikova, N. N. (2024). Digitalization of Education and Information Technologies as a Factor of Digital Economic Development. *Journal of information and organizational sciences*, 48(1), 183–190. https://doi.org/10.31341/jios.48.1.10

Sarala, R. M., Tarba, S. Y., Zahoor, N., Khan, H., Cooper, S. C. L., & Arslan, A. (2024). The impact of digitalization and virtualization on technology transfer in strategic collaborative partnerships. *The Journal of Technology Transfer*. https://doi.org/10.1007/s10961-024-10158-7

Schenk, M., Müller, E., & Wirth, S. (2014). *Fabrikplanung und Fabrikbetrieb: Methoden für die wandlungsfähige, vernetzte und ressourceneffiziente Fabrik* (2., vollst. überarb. und erw. Aufl). Springer Vieweg. https://doi.org/10.1007/978-3-642-05459-4

Schwager, B., Hövel, A., Wendenburg, H., Kleinfeld, A., Kaminski-Nissen, M., & Bongwald, S. (2022). *CSR und Nachhaltigkeitsstandards: Normung und Standards im Nachhaltigkeitskontext*. Springer Gabler. https://doi.org/10.1007/978-3-662-64913-8

Sigl, K. (Hrsg.). (2023). *Nachhaltigkeit und Digitalisierung – (k)ein unternehmer-isches Dilemma: Zukunftsbilder und Impulsberichte*. Springer Berlin Heidel-berg. https://doi.org/10.1007/978-3-662-66815-3

Singh, R., Sharma, R., Vaseem Akram, S., Gehlot, A., Buddhi, D., Malik, P. K., & Arya, R. (2021). Highway 4.0: Digitalization of highways for vulnerable road safety development with intelligent IoT sensors and machine learning. *Safety Science*, 143, 105407. https://doi.org/10.1016/j.ssci.2021.105407

Uhe, G. (2002). *Operatives Marketing: Gezielter Einsatz des Marketing-Instrumentariums* (1. Aufl., 1. Dr). Cornelsen.

werk21, R. (2022a, August 19). *Digitale Nachhaltigkeit* [Text]. Umweltbun-desamt_1; Umweltbundesamt. https://tinyurl.com/2fwjh7cm

werk21, R. (2022b, August 19). *Digitalisierung als Transformationsmotor für eine Green Economy* [Text]. Umweltbundesamt_2; Umweltbundesamt. https://tinyurl.com/cs8azud2

Wittpahl, V. (Hrsg.). (2020). *Klima: Politik & Green Deal | Technologie & Digital-isierung | Gesellschaft & Wirtschaft*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-62195-0