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SPECIAL FEATURE: ORIGINAL ARTICLE

Sustainability and Digitalization: A Game-Changer? Possibilities, Perils, Pathways

Theorizing stakeholders of sustainability in the digital age

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Abstract Stakeholder theory, originally introduced in 1984 by philosopher Edward Freeman, is among the most influential theories today addressing the complex interplay of societal actors. It underwent several transformations and expansions, but the original Freeman model as well as the latest approaches places the corporation at the center positioning the theory as management driven. In this article—from a sustainability science perspective—we argue that sustainability could also be considered as the center, around which societal actors are grouped, because everyone, individuals as well as stakeholders, have a stake in a 'common future' that is built on the transformative concept of sustainability. Next to this shift of perspective from corporation to sustainability at the center, we advance the concept of sustainability stakeholders with the new paradigm of the digital age we (are about to) live in: the proposed sustainability-centered stakeholder theory is developed to incorporate novel parameters as brought about by digitalization (such as big data, real-time transparency, algorithmic correlations, predictive analytics, or changing privacy standards). Hence, we classify the stakeholders of sustainability according to their roles as "big data stakeholders:" collectors, generators, and utilizers of big data. This digital sustainability stakeholder model operationalizes the complex interplay between stakeholders focused on their 'stake' in sustainability and a common future and illustrates their roles in the digital age. Thus, it offers a normative framework to analyze stakeholders' responsibility to contribute to, advance, promote, and achieve sustainability.

Keywords Digital age · Stakeholder theory · Sustainability · Big data

Introduction

Sustainability in the digital age

Multiple avenues of overconsumption of natural resources and harmful environmental and social consequences threaten the basis of our existence and that of future generations. At the same time, digitalization changes the rules of the game: disruptive technologies (Lin 2015), such as big data with its predictive potential, allow unseen possibilities to overcome this unsustainable situation (Goes 2014). Building on the so-called Brundtland definition of sustainable development, the overall aim is "our common future", incorporating the rights of future generations (WECD 1987). Hence, everyone have a stake in this pathway to sustainability. However, agents with a stake, i.e., stakeholders, have differing roles in contributing to and ultimately achieving sustainability, particularly given the game-changing parameters in the "digital age" (Schmid and Cohen 2013).

Hence, in this article, it is argued from a sustainability science perspective that sustainability could be considered at the center of a new normative stakeholder concept around which societal actors are grouped, because everyone, individuals as well as stakeholders, have a 'stake' in a common future that is built on the concept of sustainability. Thus, we

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present an update of stakeholder theory to the paradigm of the digital age we (are about to) live in based on a brief literature review of stakeholder theory and sustainability.

Stakeholder theory, originally introduced in 1984 by philosopher Edward Freeman, is among the most influential theories today addressing the complex interplay of societal actors. It has been most successful in business-related theories, such as business ethics, general management, or business and society. Stakeholder theory underwent several transformations, but the original Freeman model as well as the latest updates and refinements (Freeman et al. 2010) place the corporation at the center and group a set of primary and secondary stakeholders around this core. There have been alternative approaches, not with the company at the center, but the customer (NovoNordisk in: Freeman et al. 2007) or the government (Dahan et al. 2015), or where a complex system approach is chosen (Sachs and Maurer 2009).

To make sustainability the normative core of all relations between actors and objects, sustainability in the proposed concept is placed at the center and incorporates novel parameters as brought about by digitalization (such as big data, real-time transparency, algorithmic correlations, predictive analytics, or changing privacy standards). We base this extension on Zwitter (2014), who introduced three types of "big data stakeholders", which are merged with existing approaches of stakeholder theory.

The main contribution of this digital sustainability stakeholder model is the operationalization of the complex and dynamic interplay between stakeholders focused on their 'stake' in sustainability and their responsibility to contribute to advance, promote, and achieve sustainability (Ekbia et al. 2015). A sustainability science perspective is taken, drawing on the literature from diverse fields, such as management studies, ethics, environmental studies, political sciences, etc. Particular interest is given to the game-changing role of big data when structuring the sustainability stakeholders along their three roles in the digital age: big data collectors, big data utilizers, and big data generators (Zwitter 2014). Implications, such as stakeholder analysis, along the lines of the proposed model are discussed as well as limitations.

Literature review and research gap identification

Stakeholder theory as established in business and society and corporate sustainability research

Often depicted as a response to shareholder value thinking, stakeholder theory emerged in the 1980s as a strategic management theory (Freeman 2010) and has continued to develop as a management paradigm ever since (Clarkson 1995; Mitchell et al. 1997; Donaldson and Preston 1995; Freeman et al. 2010; Schneider and Sachs 2015) and still is considered the 'gold standard' for theorizing and managing the complex business and society relations. In the beginning heavily criticized as being 'socialist' (Philips et al. 2003), it has entered mainstream management theory (e.g., Jones 1995), business ethics research (e.g., Brown and Forster 2013), CSR and sustainability thinking (e.g., Fineman and Clarke 1996; Jamali 2008; Garvare and Johansson 2010), and other business-related disciplines (e.g., marketing: Podnar and Jancic 2006) providing the basis for a myriad of conceptual and empirical works at the intersection of business and society (for an overview, see Parmar et al. 2010).

As a standard definition, a stakeholder is "any group or individual that can affect or be affected by the realization of an organization's purpose" (Freeman et al. 2010, p. 26). The basic assumption is that companies aim to establish functioning relationships with their stakeholders want attend to their needs to operate legitimately and successfully (Parmar et al. 2010). Adopting an instrumental lens, mutually trustful stakeholder relationships lead to a competitive advantage for companies (Jones 1995). From a normative perspective, it has been argued that such relationships are morally good from various perspectives of philosophical theory, for instance, utilitarianism (Jones and Wick 1999). Since its initiation, various models, and typologies for identifying and classifying a firm's (or more broadly, an organization's) stakeholders have been put forward.

Initially defined as a basic set of six stakeholders that are common to most companies–employees, customers, investors, suppliers, communities, and management (Freeman 1994)—Clarkson (1995) classified stakeholders into primary and secondary ones, relative to their impact on the firm. Primary stakeholders are those that have a direct effect on the company or that are directly affected by it, such as managers or suppliers, whereas secondary stakeholders affect the firm indirectly. Secondary stakeholders are, for instance, the media, government, or civil society organizations. This classification was taken over by researchers and practitioners alike (Freeman et al. 2007, 2010) because of its simplicity and descriptive power (Donaldson and Preston 1995). Mitchell et al. (1997) proposed another stakeholder identification and prioritization scheme that classified stakeholders according to the three attributes power, legitimacy, and urgency of claims, thus arriving at seven different classes to be used for the purpose of identifying relevant stakeholders, calling it a "dynamic" stakeholder theory. Even though it appears less static than the primary–secondary classification (Clarkson 1995; Freeman et al. 2010), both approaches have been criticized for being too narrowly drawn to the dyad firm-stakeholder (Rowley 1997). Focusing on the nature of the

stakeholder relations and integrating a realist theoretical approach, Friedman and Miles (2002) proposed a stakeholder typology based on the contractual nature of the relationships also accounting for conflicting relations. They developed a matrix of four different stakeholder types, which also depict how stakeholders can move between categories over time. However, the primary–secondary classification prevailed in most applications of the theory.

Overcoming the rather static and classification-based illustrations of stakeholder–firm relationships, Rowley (1997) used social network analysis to account for the multiplicity of stakeholder demands arriving at different network structures. A similar approach was taken on by Neville and Menguc (2006) who developed a framework for stakeholder multiplicity and the inherent competing demands according to their strength, direction, and synergies. From these ideas of more dynamic and interactive stakeholder relationships also emerged the understanding of dynamic responsibilities that companies face with regard to their stakeholders (Sachs and Maurer 2009) and a stronger focus on the interdependencies among the different groups (Schneider and Sachs 2015). Recently, stakeholder theorists have further pointed to a potential "overemphasis of stakeholder roles rather than relationships between stakeholders as real people with names and faces" (McVea and Freeman 2005, p. 57). In this vein, a reconceptualization of stakeholder individuals and groups and their identities according to their interdependent relationships and the perceptions thereof were proposed (Schneider and Sachs 2015).

Hence, stakeholder theory, in its more than 30 years of existence, has moved from a simple, but rather static theory focusing on stakeholder groups and their roles to more dynamic, yet more complex, relationship-focused models that incorporate interdependencies, conflicts, and intergroup perceptions.

Sustainability: a transformative approach and the peculiar role of 'future generations'

The second debate of importance here is the understanding of sustainability as a transformative approach as introduced in the literature. When paying respect to different stakeholders, sustainability becomes a complex project of many different involved parties—a vision to be developed in sustainability science (Wiek and Iwaniec 2014). As described above by stakeholder theory, this complexity becomes manageable when defined as specific stakeholder roles. Given the normative nature of the sustainability concept that aims at changing the status-quo (given that our current world still is highly unsustainable), sustainability as a concept requires transformation and development towards a more sustainable world. In this regard, a field of the literature has evolved, where, as Seyfang and Haxeltine state, the sustainability transition is constructed as what they call "multilevel perspectives" (2012, p. 383). This combination of micro- and macroperspectives naturally fits well with the multiple levels of different stakeholders engaging in dialog to reach their goals. On a more scientific level, "sustainability science" focuses on the dynamic interactions between nature and society (Clark and Dickson 2003 p. 8059) in a transformative way towards a more sustainable state of affairs (see Mader 2013, McCormick et al. 2013, or Higgins 2013). This idea of transformation traces backs to the groundbreaking publication of the club of Rome in 1972 when introducing "The limits of growth" (Meadows 1972).

However, it seems that the turn-around towards sustainability is not yet reached, although the concept is more than 40 years, yet the indicators of unsustainability still only know one direction, particularly due to the irresponsibility of companies (Shevchenko et al. 2016). Instead, we find scientific evidence that unsustainable outcomes, such as emissions, wastewater, and lifestyles, are nevertheless on the rise (Kauffman and Arico 2014). This, in return, can be understood as a necessity and an urge to understand sustainability as being transformative. Conceptually, this urge is explained by the core focus as applied in the still noteworthy definition of sustainable development in the so-called Brundtland report (WCED 1987). It focuses on the demands and needs of future generations, as also Krysiak (2009) holds. This focus on (not-yet existing and unknown) future generations best explains the need to be transformative for the sustainability concept, as otherwise future generations will not have the same resources and chances as past and contemporary generations.

Identified research gap from the review and the role of big data

In the light of the achievements of stakeholder theory and given the necessity to regard sustainability a transformative concept, we identify the need to combine stakeholder theory with sustainability incorporating the new possibilities of big data to arrive at a more powerful, yet normative, conceptualization of sustainability and how to get there. Digital communication technologies and big data applications can help achieve sustainability and an ecological society (Gijzen 2013; Hampton et al. 2013). As Helbing has argued (2012, p. 56), the interconnectedness of the planet's social and ecological systems can lead to cascading effects, which increase the "vulnerability to random failures or external shock." He, therefore, proposes a digital "global participatory platform" that can help increase sustainability globally. Such a platform is dependent on the participation of multiple stakeholder groups. Thus, on a

conceptual level, we see an opportunity to operationalize stakeholder theory allowing for complex dialogs of those who have a 'stake' in an issue with sustainability as a transformative concept. Combined with the plentitude of data as brought about by digitalization and big data, the research gap is to combine these three to arrive at a more comprehensive and powerful concept that explains how to strengthen the transformative aspect of sustainability, by

1. taking the analytical clarity of identifying stakeholders of sustainability, combined with
2. roles in big data to arrive at a more comprehensive concept of sustainability.

In sum, the following scheme visualizes the approach taken here in Fig. 1.

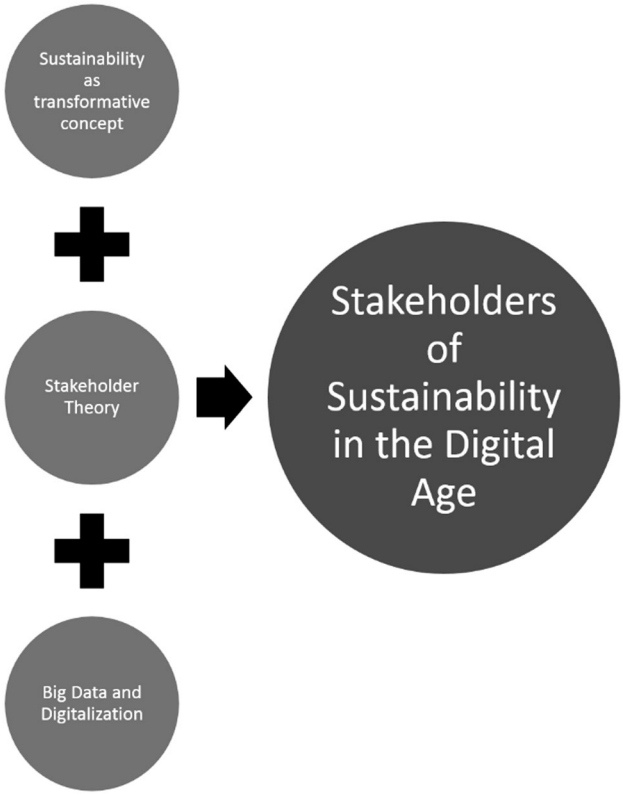

Fig. 1 Illustration of the research gap

Digital sustainability stakeholder theory: a stakeholder model of sustainability

The concept: summary and visualization

Stakeholder theory has so far been mostly applied to organizations, predominantly large corporations. As Philips et al. (2003) note, this is an "unnecessary limitation" (p. 495) of the theory. The authors referred to the array of other organizational forms, such as non-governmental organizations (NGOs), privately owned businesses, or public policy bodies that can be analyzed through this theoretical lens. Dahan et al. (2015) have just recently put forward a stakeholder model with government at the center to examine its role in protecting citizen rights. In the context of sustainability, Garvare and Johansson (2010) proposed a stakeholder model of the organization that incorporates the two views of organizational and global sustainability. While with organizational sustainability, they refer to the long-lasting success and legitimacy of an organization, such as a firm, and global sustainability refers to the Brundtland definition's notion of the term (WECD 1987). Their model does not place any concept at the center; instead, it shows two ovals of organizational and global sustainability and depicts primary and secondary stakeholders within the former.

However, to account for the importance of sustainability in the digital age and for the future development of the planet, we take on a different perspective arguing for the normative core of sustainability as guiding principle for all actors and objects. To illustrate this key function of sustainability across actors, time, and data formats, we suggest placing sustainability at the center of this model. Sustainability as the focal concept is encircled by ten stakeholder groups, which are, on a meta-level, grouped into their roles as big data generators, utilizers, and/or collectors (Zwitter 2014).

Particularly in an age of big data, stakeholders can be seen as interrelations of groups and individuals that interact on specific topics or in specific realms. However, they also assume different roles in a digitalized world, at times simultaneously. This adds the meta-layer to the classification of stakeholders in the digital age, which we account for in the proposed model of digital sustainability stakeholders. Zwitter (2014) differentiated between three roles of big data stakeholders: generators, collectors, and utilizers. Big data generators are natural, physical, or artificial actors that generate data; big data collectors are those that store and govern the massive amounts of data; and big data utilizers refer to entities that collect and analyze data for a specific purpose. The crucial point is that some stakeholder groups or individuals take on multiple roles simultaneously, while others do not. This leads to a power imbalance between the groups. Furthermore, power is relational between these three role roles; thus, power is relative to and, therefore, depends on the other actors in the environment.

Building on the developments in the more than 30-year history of stakeholder theory, the proposal of these digital sustainability stakeholders incorporates the notions of relationships, group roles, and perceptions while aiming to

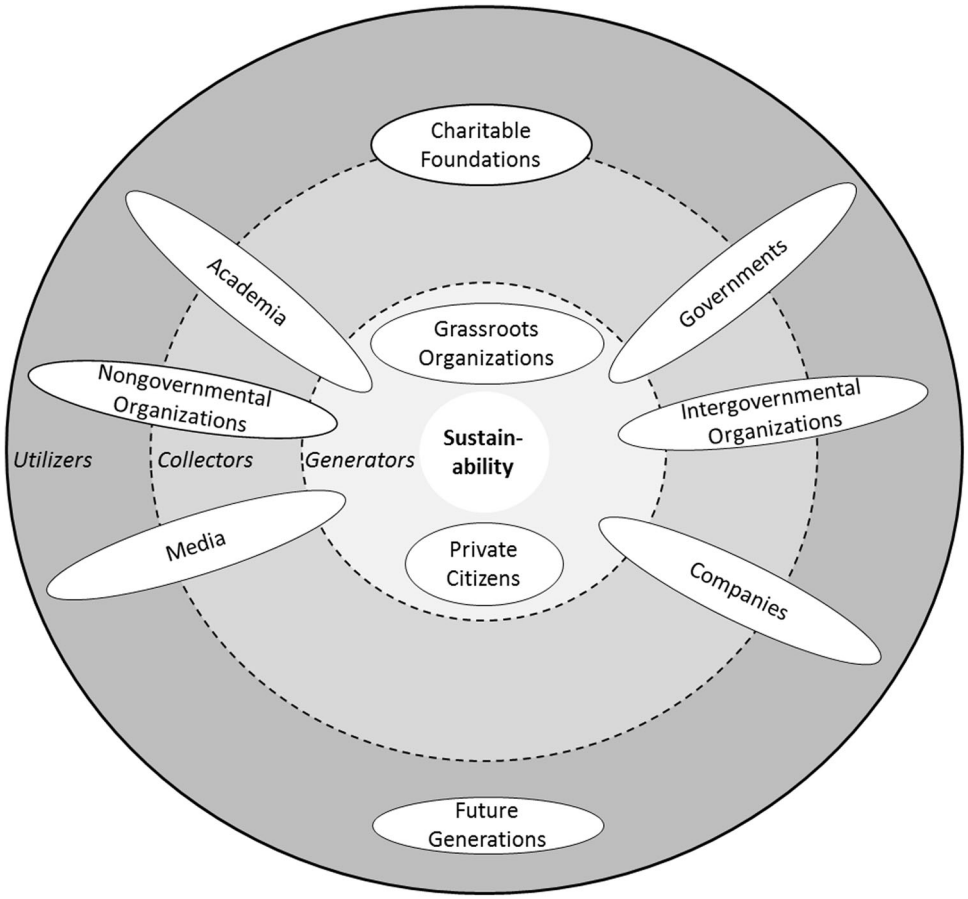

Fig. 2 Digital sustainability stakeholder model

be simple in its graphic illustration of interdependencies. Special emphasis is placed on the different roles that stakeholder groups take on simultaneously, as illustrated in Fig. 2. The ten identified stakeholders of sustainability are: governments, intergovernmental organizations, companies, media, non-governmental organizations, academia, charitable foundations, grassroots organizations, private citizens, and future generations. A description of these stakeholders is provided in the following paragraphs.

The stakeholders

Governments

Exercise social control through a set of administrative tools (Hood and Margetts 2015). They "provide infrastructures and markets, whose laws and regulations must be obeyed, and to whom taxes and other obligations may be due" (Clarkson 1995, p. 106) and can, therefore, be seen as a major driving force for sustainability (Perez-Batres et al. 2011). Governments are nodal points in social networks. This property of nodality is also most fiercely affected by the changes perpetuated by digitalization: on the one hand, governments have to fight for their nodal position because of increased competition by private players, such as Google, that are considered more powerful in the digital environment. On the other hand, governments can use the infrastructure and information provided by these actors and control them through their administrative tools (Hood and Margetts 2015): with regard to sustainability, for instance, Google Crisis Response helps governments gather and distributes information to affected people in the case of natural disasters, often more efficiently than government communications. Hence, even though governments might not be at the edge of digital innovation at all times compared to private players, digital technologies provide governments with increasing possibilities to fulfill their purpose. The digital age opens up even more possibilities for governments to exert social control, in terms of taking in information as data collectors and generators, as well as by impacting citizens utilizing these data (Hood and Margetts 2015). During the four consecutive years of drought in the State of California, for instance, the State government has been controlling communities' water use on a monthly basis to re-evaluate the necessity of the water conservation mandate issued by the Governor in April 2015 (California Water Boards 2015). Hence, government is "as a major coercive institutional force speaking for the natural

environment" (Perez-Batres et al. 2011, p. 846) and, therefore, a major stakeholder for sustainability.

Intergovernmental organizations

Are initiators, drivers, and implementers of sustainability? They are organizations founded by more than two nation states, usually through an international treaty. The United Nations, founded in 1945 to secure world peace after two world wars, is today the most powerful development agency in the world. Starting with the Brundtland report in 1987 (WECD 1987), the UN has ever since been the leading organization in sustainability. Just recently, it managed to pass 17 sustainable development goals (SDGs) in a multistakeholder effort, thereby setting the agenda for sustainable development until 2030. Under its regime, a myriad of multipartner initiatives and individual organizations have propelled to tackle different thematic fields of sustainable development, such as the Food and Agriculture Organization (FAO), the UN Global Compact, the World Health Organization (WHO), and many more. Funding for these initiatives is provided by partnering governments, public or private organizations in UN-led programs, such as the UN environment or development programs. The World Bank, too, is a major funder of sustainability actions (Bäckstrand 2006). Intergovernmental organizations are simultaneously big data generators, collectors, and utilizers. They generate data with their massive sustainable development programs, such as the FAO's climate-smart agriculture program or WHO's expanded program on immunization that has been running since the 1970s. As big data collectors, the WHO monitors and analyzes, for instance, global health trends with the Global Health Observatory, such as the rate of tuberculosis infections, or the FAO's food price index measuring the price of food commodities. For their sustainable development agenda, these data are also used to demonstrate the need for sustainability and urge nation states to take actions. Hence, the United Nations takes on all three roles as big data stakeholders for sustainability.

Companies

Business is one of the most important stakeholders for future sustainability. Companies, be they large multinational corporations or small craft businesses, are amongst the biggest sources for environmental pollution, for instance, by their water use or emissions (Perez-Batres et al. 2011). Firms are also the cause of many social problems, such as poverty, due to underpay, health, and safety issues due to bad working conditions, for instance, in the extracting industries, or worker exploitation (Elkington 1998). On the bright side, private business catalyzes economic development from the bottom of the pyramid, establishes and safeguards local communities, brings innovation in social and environmental domains, and satisfies basic and more sophisticated human needs. As an essential part of society that will employ an estimated 3.5 billion people by 2030 (McKinsey Global Institute 2012), businesses have big leverage and the necessary resources when it comes to rendering the world more sustainable (Shrivastava 1995). Particularly, large corporations today try to assume this role by setting out sustainability, CSR, or shared value programs, where they tackle social and environmental problems. Some do so out of a 'business case' motivation (Savitz 2006), where engagement in social and environmental causes is considered to foster sales and financial targets, and others do so out of ethical commitment, because it is the 'right thing to do' (Garriga and Melé 2004). Most companies are big data collectors, generators, and utilizers at the same time. Businesses generate data, for instance, regarding power use, waste, employee payment, product turnover, recycling, etc. Firms also collect the very same data to control and monitor success or resource consumption, predict market shares and sales, and for efficient planning purposes. Furthermore, companies collect data for other institutions, such as the state, for instance, when forwarding salary accounting for employee taxing or when selling products and services that are subject to VAT. At the same time, companies utilize data to gain knowledge about their customers, innovate in research and development, open new markets, predict product successes and failures, etc. Companies that have a quasi-monopoly in the digital age, such as Google or Facebook, are again a special case of this stakeholder group of data utilizers, collectors, and generators; due to the immense power, they gain through the vast amount of data and they collect and possess, which raise critical ethical questions (Boyd and Crawford 2012).

Media

Are multipliers of information and, therefore, take on an important role as a stakeholder for sustainability? For a society to develop sustainably, societal members must be fed with knowledge, which usually happens via the media, be it mass media, such as television, social media, such as weblogs, or trade and academic journals that distribute information to specific target audiences. The increasing fragmentation of media sources in the digital age, however, rather leads to more opportunities of information for societal members, than to a weaker role of media in society (Smith 2005). Be it in the form of mass media or targeted trade press, the role of media as an information distributor is crucial to overcome the centralization of knowledge that comes with technological innovation (Sumi 2007).

Viewing media as embedded in a "'tangled web' of communication and debate between sources, media, and publics" (Smith 2005 p. 1471), in the digital age it serves as a big data collector and utilizer. Media collect and process data to distribute them to interested audiences and to do so it uses data from other sources in the 'tangled web.' Companies, for instance, rely on media to communicate their activities on sustainability in various forms, be it via social media or more traditional outlets, such as newspapers (Seele and Lock 2015). Thus, media also serve as a big data generator by matching data with a story and by being itself a source of information for other stakeholders, such as academics or politicians. In the debate on climate change, news media were found to mediate the associated dangers of climate change (Smith 2005); this holds true for the entire debate on sustainability. Hence, media serve as important mediators of sustainability risks and opportunities in public debate. Hence, they are a crucial stakeholder for the achievement of sustainability in the digital age.

Non-governmental organizations (NGOs)

Are "channels" of sustainable development? Contrary to grassroots organizations, they occur at any level and are "categorized according to some concept of sector" (Uphoff 1993, p. 619). Thus, some NGOs specialize on workers' or human rights, such as Human Rights Watch, and others advocate for the environment (e.g., Greenpeace) or fair trade (e.g., Fair Trade Association), or serve as watchdogs of politicians (e.g., Lobbycontrol) or business and market capitalism (e.g., Attac). Often, large NGOs, such as Greenpeace, operate at a global level to address sustainability issues and are powerful players in global governance systems, thereby blurring the lines between political, economic, and social spheres (den Hond et al. 2015). NGOs are motivated by a common cause and claim to represent generally accepted values and the public interest. Often, they represent marginalized groups "who lack the necessary financial, technological, and educational resources to make themselves heard" (Baur and Palazzo 2011, p. 583). In this vein, NGOs can be seen as a "normative force" (Perez-Batres et al. 2011, p. 846), not only for business, but also for sustainability in general. Hence, NGOs are an influential stakeholder group, especially for sustainability, as they attract public attention to specific causes (Devine 2003) and influence public opinion (Egels-Zanden and Wahlqvist 2007). In the era of big data, NGOs are big data generators, collectors, and utilizers at the same time. They generate data by, for instance, taking water samples from contaminated rivers and making them available to the general public, or they monitor climate change parameters, such as global warming (e.g., Al Gore's Climate Reality Project) as big data collectors. These data are then utilized to substantiate the NGO's specific claims and causes, for instance, to further the rescue of endangered species, such as the polar bear (e.g., Polar Bears International). Thus, NGOs take on all three roles of big data stakeholders.

Academia

Higher education is an important stakeholder for sustainability, permeating in at least three ways. First, academia serves to educate young people in topics, such as sustainable development, which strengthens the transition towards sustainability (Barth 2016). Second, it conducts and publishes research adding to the body of knowledge around sustainability topics while at the same time being itself sustainable (Bachmann 2016). Third, it publishes and engages in public discourse on the importance of sustainability and thereby puts the topic on public agendas. Perez-Batres et al. (2011) found evidence that the pressure from academia on organizations to adopt sustainability policies is great and even more effective than the pressure exerted by governments and NGOs. They hold that "the future direction for successful sustainability policy initiatives should be pursued through the university system" (Perez-Batres et al. 2011, p. 850). Academia takes the roles of big data generator, collector, and utilizer. Through their research and education practices, scientists generate new data, for instance, by conducting experiments or surveys, which they subsequently collect and analyze to make empirical claims about sustainability topics. Furthermore, in their role as participants in the sustainability discourse, researchers utilize their own but also secondary data to advocate for the related issues.

Charitable foundations

Are usually non-profit organizations that have a specific mission or purpose that benefits the public? Anheier (2001) defines foundations as assets that are non-membership based, private, self-governing, and non-profit entities that serve a public purpose. They are either owned by private individuals, such as the Clinton Foundation, or belong to a corporation. Among the top 10 US foundations (according to total giving amounts, Foundation Center 2016) is only one non-corporate organization, but at the same time the largest, the Bill and Melinda Gates Foundation, which engages in health, poverty, and educational causes. By addressing social and environmental issues that range from local to global scope and given their at times vast monetary resources, charitable foundation is one important stakeholder for securing the needs of future generations. Corporate foundations are part of a firm's philanthropic activities (von Schnurbein et al. 2016) and thereby help

companies to fulfill their role as good corporate citizens in society (Westhues and Einwiller 2006). With regard to the challenges of the digital age, charitable foundations are big data collectors and utilizers. On the one hand, they collect digital data, for instance, in an effort to facilitate access to microfinance products via mobile devices to poorer communities by the use of information and communication technology (Consultative Group to Assist the Poor 2016). On the other hand, foundations also utilize digital data for the solution of issues, such as in the case of vaccination and infection rates monitoring, for instance, regarding the polio disease (Bill and Melinda Gates Foundation 2016).

Grassroots organizations

Are considered bottom–up local community-based organizations for social change that pertain to the "third sector" of society, collective action (Uphoff 1993)? They come in various forms, such as cooperatives, associations, or social enterprises (Seyfang and Smith 2007) as environmentally focused social economy enterprises (Davies and Mullin 2011). In the context of sustainable development, grassroot organizations have been considered as innovative forces or change agents, with "people acting from the bottom–up [that] change their own actions, seek to influence others around them and seek to change the social structures that they inhabit" (Middlemiss and Parrish 2010, p. 7559). Hence, civil actors are motivated to engage in grassroots organizations by unsatisfied social issues or ideological commitment (Seyfang and Smith 2007). By "developing transformative sustainability ideas and practices" (Monaghan 2009, p. 1027), they contribute to sustainable societies in various contexts; grassroots organizations have been found to impact low-carbon communities (Middlemiss and Parrish 2010) and lead to sustainable alternatives of body disposal (Monaghan 2009), waste recycling regimes in Irish communities (Davies 2009), or sustainable innovations in dryland agriculture (Leach et al. 2012). Despite their limited resources, power, and influence capacity, grassroot organizations "are striving hard to generate sustainable solutions" (Hargreaves et al. 2013, p. 12). Various initiatives have proven their innovative potential for sustainable development (Stevens and Morris 2001) by developing new ideas, experimenting with new practices, promoting alternative values, and leading to tangible improvements (Seyfang and Haxeltine 2012). In the digital age, grassroot organizations are even facilitated through low-cost communication technologies that allow for quick and low-threshold organizing. Grassroots organizations can be classified as big data generators. They generate, for instance, environmental data, such as carbon emissions of local communities, and make them comparable to other local communities in the region or country to help create more low-carbon communities (Middlemiss and Parrish 2010). That is way, grassroot organizations help achieve sustainable development (Stevens and Morris 2001).

Private citizens

Are crucial stakeholders for sustainability in their roles as environmental citizens, political consumers, and individual moral agents (Spaargaren and Oosterveer 2010)? As individuals in an unsustainable world, private citizens can work as a "corrective" through their sustainable actions. As Barry (2006, p. 39) notes: "green states are made by green citizens gathered within civil society forcing states to change. This "sustainability citizenship" can take on various forms, from mandatory service cleaning polluted areas, such as beaches (Barry 2006) to voluntary sustainable behavior of the individual, for instance, in recycling or waste minimization (Barr 2003), or sustainable consumption practices, where their individual behaviors have the chance to influence the system as a whole (Parker 2015). Private citizens also play an important role in the planning and implementation of sustainability programs at the local level, because they give input to the debate and at the same time gain knowledge from these processes (Hawkins and Wang 2012). By that, citizens and governments become collaborators and partners, which render the top–down approach of governments obsolete in the case of sustainability (Barr 2003). Hence, "participation by residents is an essential element in the successful pursuit of sustainability and environmental protection" (Hawkins and Wang 2012, p. 13). In the era of big data, private citizens are primarily big data generators. They generate data, for instance, through their consumption behaviors, as data points themselves, or as participants of governmental sustainability programs. For instance, regarding the protection of biodiversity, Beumer and Martens (2015) find that private citizens, using their home gardens, help generate environmental data that are sensitive to local climates and ecosystems.

Future generations

Are, since the seminal Brundtland definition of sustainability (WECD, 1987), regarded a major stakeholder of sustainable development? As (Krysiak 2009, p. 483) holds, "at the core of sustainability lies futurity." However, with the future also come uncertainty and risk; hence, from a risk management perspective, Krysiak defines "sustainability as the obligation to limit the risk of harming future individuals" (ibid.). This element of uncertainty and complexity is undisputed amongst scholars when it comes to sustainability (Swart et al. 2004). The problem that

arises with this perspective is that it is almost impossible to account for future uncertainty, let alone the wishes and attitudes of future generations. Economists incorporate these risks with discounting of future interests, which, however, does not include intergenerational externalities (Sumaila and Walters 2005, p. 136): "future generations do not participate in decisions that will affect them. They cannot defend their interests in the current decision making, even though present decisions can have irreversible impacts on their welfare." In addition, attitudes and preferences of future generations cannot be known today and, therefore, hardly be accounted for entirely. Thus, sustainability has to be seen as a concept of intergenerational fairness (Krysiak and Krysiak 2006). As Norgaard (1992, p. 3) holds, "sustainability itself can be treated as a minimum criterion of intergenerational equity." Hence, just as the natural environment as a stakeholder for sustainable development, can future generations be seen as voice- and vote-less, yet crucial stakeholders for sustainability, whose preferences and goals have to be expressed by other stakeholders of sustainability on their behalf (Perez-Batres et al. 2011). As such, future generations can only be regarded as utilizers of big data generated in the future. They are passive stakeholders that are, however, directly and indirectly affected by decisions of other stakeholders of sustainability today. These decisions can be guided by the normative claim made by Krysiak and Krysiak (2006, p. 9): "a development is sustainable if no future generation will prefer to live at the present."

Stakeholder analysis and dialog

The proposed concept is not only meant to better understand the new possibilities of advancing sustainability in the digital era, but also to offer guidance in advancing and managing sustainability using digital technology. In traditional stakeholder theory, the starting point for operationalization is stakeholder analysis aiming to identify all relevant actors and objects to engage in a dialog. Given the multiplying effect of big data and the normative core of the proposed concept, sustainability's stakeholder analysis is a bit more complex and abstract compared to a firm-centered stakeholder analysis from a management perspective. The underlying normative core of the proposed concept that makes sustainability the key objective and center of the stakeholder analysis instead requires a common vision of all stakeholders involved to engage in the advancement towards sustainability and to aim for transformation of the state of affairs, possibly including one's own role.

To address these concerns and to develop a roadmap for stakeholder analysis and dialog, we suggest to opt for a flexible and context-dependent setting for stakeholder analysis. Guidance can also be offered by the criteria for envisioning sustainability offered by Wiek and Iwaniec (2014) who distinguish between 'normative quality', 'construct validity' and 'transformational validity'. Regarding the role of big data stakeholders, the production, collection, and utilization of data are recommended to be organized and scrutinized in terms of their potential to help advance sustainability. The overall aim is to advance dialog as a means of deliberation and openness, such as in the "global participatory platform" (Helbing 2012). The outcome of the proposed stakeholder analysis and subsequent dialog may be used to guide a big-data-driven learning algorithm targeted towards sustainability, as proposed, for example, in the concept of the 'digital sustainability panopticon' building on the habit-changing power of surveillance to advance sustainability (Seele 2016). In this regard, stakeholder analysis and dialog become the safeguard for democratic legitimacy of advancing sustainability, a necessary condition in our view given the also manipulative power of big data and digital 'nudging'. However, if applied and managed properly, big data stakeholders of sustainability become a powerful instrument of creating a strong sustainability vision and planning and managing the necessary steps ahead, leveraging on the game-changing power of digital technology and algorithmic learning.

Outlook

With the proposal of a sustainability-centered stakeholder theory that uses the new opportunities of big data and digitalization, several new avenues for research emerge—as well as practical limitations. In the following, we summarize the most prominent and promising ones for future research and practical application:

- When integrating big data and digitalization into a stakeholder-driven concept of sustainability, a plausible next step is integrating the recently issued 17 UN Sustainable Development Goals. Here, the role of indicators and metrics opens up new ways of controlling, reporting, and monitoring performance, also bearing the possibility of intervention on usage and consumption by public authorities. The data standard XBRL as used in corporate reporting to measure and disclosure data of performance may be seen as a promising tool for such a big data-driven environment.
- Our contribution of developing stakeholder theory with sustainability at the center may invite more research to highlight the potential of stakeholder theory when not centered around corporations. Other adaptations that put the government at the center (Dahan et al. 2015) or that offer a center-less complex system approach

(Sachs und Maurer 2009) may inspire new avenues for stakeholder theory. Particularly, the big data stakeholders (Zwitter 2014) used here could be combined to reach new levels in conceptualizing and advancing both stakeholder theory as well as sustainability. At the same time, one limitation of the proposed concept becomes obvious: placing sustainability as a concept at the center also means a loss in practicability compared to traditional firm-centered stakeholder theory. A form may manage and organize a dialog, whereas a concept would first need to be identified as relevant in guiding an analysis and process.

- A third avenue more focused on digitalization is to investigate the power relations among the different big data stakeholders. Here, the interdependencies between stakeholder groups and the power games at various levels are interesting subjects to study further.

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