

The COVID-19 pandemic as a window of opportunity for more sustainable and circular supply chains

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ABSTRACT

The COVID-19 pandemic is a microcosm for future challenges and crises. The greatest of these challenges is the climate crisis and the potential collapse of our Earth system. However, crises may also provide opportunities to transition to more sustainable futures. In our study, we qualitatively analyze statements of a heterogeneous group of 46 experts from academia, industry, government, and organized civil society to explore inasmuch experts perceived the pandemic as a window of opportunity for more sustainable supply chains (SCs) and what they consider opportunities, challenges, and necessary actions for more sustainable circular SCs. Our study contributes to current and future studies on the opportunities in times of crisis and the actions needed to overcome SCs vulnerabilities, thereby increasing the resiliency, circularity, and sustainability of SCs.

1. Introduction

The COVID-19 pandemic is perceived as one of the worst global health and economic crises in recent decades. Governments around the world responded by implementing human containment measures, border closures, and quarantines of varying degrees to contain the spread of the virus (Ivanov & Dolgui, 2020; Belhadi et al., 2021), resulting in global restrictions on the movement of goods and services and unexpected changes in supply and demand (Belhadi et al., 2021). One of the painful lessons of the pandemic is the destructive power - and at the same time, the fragility - of many of our man-made systems. Such a system is the global supply chain (GSC) system, which refers to “the cross-border organization of the activities required to produce goods or services and bring them to consumers through inputs and various phases of development, production, and delivery” (International Labour Organization, 2016). The COVID-19 pandemic impressively showed the weaknesses of the current over-centralized GSC (Adelodun et al., 2021; Ibn-Mohammed et al., 2021; Karmaker et al., 2021; Fathollahi-Fard et al., 2022a, Fathollahi-Fard et al., 2022b). In particular, these weaknesses include GSC resilience, i.e. its ability to resist, adjust, and recover from disruptions to meet customer demand and ensure performance (Hosseini et al. 2019) and GSC sustainability.

Current SCs have been characterized by a state of lock-in to carbon-

intensive, fossil-based production and linear consumption structures for the past sixty years (Morone, 2018), and the link between COVID-19 and SC sustainability is just beginning to emerge in research (Negri et al., 2021). Many researchers warn against going back to normal (e.g., Bogner et al., 2020; Hitt et al., 2021) and highlight the urgent need for different systems that promote sustainability transitions (ST) to other patterns of production and consumption. Menke et al. (2021) suggest that implementing sustainability standards and targets from raw material sourcing to production, storage, delivery, and all transportation needs in between, cannot only help create more opportunities for partnerships, improve productivity and reduce risks, but more importantly, have a positive impact on the people and communities in and around the operations. Thus, it is imperative to simultaneously address both SC resilience and SC sustainability because it leads to issues that transcend country and company boundaries. It is, therefore, essential for all stakeholders along the SC (e.g., suppliers, manufacturers, distributors, etc.) and for all stakeholders that can influence a company’s strategy and behavior (e.g., governments, consumers).

Under this premise, circular economy (CE) principles such as product life extension, designing out waste and using regenerative resources (Guidice et al., 2020) provide potential opportunities for SC sustainability, efficiency, and resiliency (Sarkis, 2020; Nandi et al., 2020). Wuyts et al. (2020) argue that it does so by safeguarding the planet’s

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finite natural resources and converting the “take-make-waste” linear industrial system into value loops. Other academics adopt a similar position (Linder et al., 2017; Fogarassy & Finger, 2020) and argue that these loops reduce environmental pressures through practices of maintenance, repair, refurbishment, redistribution, upgrading, reselling, and waste minimization. The most prominent CE definition (Kirchherr et al., 2017, p. 226) is by the Ellen Macarthur Foundation:

[CE is] an industrial system that is restorative or regenerative by intention and design. It replaces the ‘end-of-life’ concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.

As noted by Nandi et al. (2020), sustainable SCs and CE principles may provide long-term avenues for building economic and SC resilience while contributing to the triple bottom line of economic, social, and environmental sustainability (Elkington, 1994). This study builds on these arguments and uses contributions of experts as data for the empirical analysis. As the literature mainly focuses on the perception and roles of governments and private companies, we contribute to the debate by providing a more holistic understanding by including other voices (e.g., non-governmental, intergovernmental organizations or organized civil society), as demanded by Gupta & Singh (2021). This variety of views strengthens the robustness of findings (Eisenhardt, 1989) and helps to build a comparative understanding of the topic. Thus, this empirical study aims to contribute to the literature by showing (1) inasmuch different stakeholders perceive the COVID-19 pandemic as a window of opportunity for more sustainable and circular SCs (rather than as a threat) and (2) what actions and strategies these stakeholders (as problem owners) perceive necessary. The novelty of our study consists of the holistic perspective and the data base chosen.

Our study complements previous literature (Guidice et al., 2020; Ibn-Mohammed et al., 2021; Kanda & Kivimaa, 2020; Ivanov & Dolgui, 2020; Sarkis et al., 2020; Sarkis, 2020; Nandi et al., 2020) and aims to answer the following research questions:

RQ1: Inasmuch do different stakeholders, including actors from academia, industry, government, and organized civil society, perceive the COVID-19 pandemic as a window of opportunity for more sustainable and circular SCs?

RQ2: What opportunities, challenges and actions need to be considered for using such windows of opportunity and making SCs more sustainable and circular?

In section 2, we set the scene by giving insights in the current state of the literature on SC disruptions as windows of opportunity. This is followed by an outline of the research methodology (section 3), including data collection and procedures for the qualitative study. The subsequent sections present and discuss the findings and results (sections 4 and 5). Section 6 contains the conclusion, which summarizes this study’s contribution, practical implications, limitations, and potential directions for further research.

2. COVID-19, supply chain disruptions and windows of opportunities for sustainability transitions

2.1. COVID-19 supply chain disruptions as windows of opportunities

During the pandemic, countries around the globe experienced many severe SC disruptions. Rapid changes in supply and demand fostered logistic, financial and production collapse (Gocer, 2021; Zanoletti et al., 2021). Reasons include the lock-down regulations, which led to a decreased workforce, border closures and transportation restrictions. This also resulted in market uncertainty, changing consumer lifestyles and behavior (Adelodun et al., 2021; Chhimwal et al., 2021; Gocer, 2021; Gupta & Singh, 2021; Ibn-Mohammed et al., 2021; Zanoletti et al., 2021). Moreover, the disruption of global SCs exposed the weaknesses of

the prevailing SC model, that is, the over-centralization of the SC in terms of production and supply and China’s supremacy in it (Ibn-Mohammed et al., 2021; Karmaker et al., 2021). Similarly, the pandemic also exposed the lack of SC flexibility, adaptability, and diversification in the sourcing strategies (Ibn-Mohammed et al., 2021) and the decreasing life cycles of our consumption goods (Ibn-Mohammed et al., 2021).

Disruptive changes, such as in the GSC, have been observed in many areas. Despite their negative sides, scholars also highlight the positive aspects (Kanda & Kivimaa, 2020). Transitions scholars, for instance, describe the current crisis as “a meta-transition event at the landscape level that permeates into multiple regimes simultaneously” (Wells et al., 2020, p. 30). Such an event offers a “unique opportunity to analyze in real-time the effects of a protracted landscape-scale perturbation on the trajectories of STs” (Kanda & Kivimaa, 2020, p. 1). As economic and social systems have been severely disrupted by the COVID-19 pandemic (Wells et al., 2020), this presents an opportunity for the organizational landscape to orchestrate long-term strategies to deal with the “new normal” (Hitt et al., 2021). If understood and used adequately, the destabilization at different levels might create a window of opportunity for novel niche innovations to establish themselves (Kanda & Kivimaa, 2020).

Already before the COVID-19 crisis, scholars argued that societies urgently need a paradigm shift towards more sustainable and resilient production and consumption, with “systems of recirculation and regeneration of resources being a recurring theme” (Weetman, 2020, p. 18). In this context, circular economy practices evolved as a recent industrial concept that has gained traction in policy-making spheres, practitioners, think tanks, and the academic discourse (Linder et al., 2017). The strategies of CE have proven to provide the SC with greater sustainability and resilience to future disasters (Wuyts et al., 2020; Alonso-Muñoz et al., 2021). Circular economy practices not only serve as a tool to mitigate climate change through material recirculation, resulting in reduced material extraction, resources consumption, and waste generation (Adelodun et al., 2021; Chhimwal et al., 2021; Gupta & Singh, 2021; Ibn-Mohammed et al., 2021; Zanoletti et al., 2021). Circular systems also minimize dependence on virgin raw materials, thereby minimizing production uncertainties (Chhimwal et al., 2021), thus promoting the generation of more efficient and resilient operations (Alonso-Muñoz et al., 2021). Additionally, there is a strong association between CE implementation, cost reduction, and long-term profitability due to reduced wasted resources and improved production processes (Chhimwal et al., 2021; Gupta & Singh, 2021; Ibn-Mohammed et al., 2021). Moreover, by focusing on local sourcing and processing within the same region, CE can foster the generation of local jobs and promotes social equality and inclusion (Ibn-Mohammed et al., 2021). This is why using circular economy practices in reconfiguring SCs is a promising path for more SC sustainability and resilience.

GSCs and actors along them showed their ability to reconfigure to changed landscapes and societal needs. SCs exhibited an unexpected level of responsiveness and agility to adapt quickly. Companies like New Balance and General Motors voluntarily provided support for personal protective equipment (PPE) and ventilators during the COVID-19 pandemic (Sarkis, 2020), and True Value Co. switched two of its production lines from paint to FDA-approved hand sanitizer within two weeks (Lee & Trimi, 2021). New production lines for medical equipment were installed in record time in several countries, which opened the conversation on the ideas of relocation and diversification of the production and supply processes (Ibn-Mohammed et al., 2021; Nandi et al., 2021). This shows that the disruptions and changes generated by the pandemic opened an opportunity for new areas of research (Zanoletti et al., 2021). What is more, the SC disruptions also shifted priorities and what is considered relevant. The pandemic had a positive effect on the company’s perception of the need for sustainability transitions (Gupta & Singh, 2021; Ibn-Mohammed et al., 2021; Karmaker et al., 2021; Nandi et al., 2021). According to Gupta & Singh (2021), due to the pandemic

disruptions, companies became more concerned about increasing the circularity of their process to expand the longevity of resources. In a similar vein, the pandemic generated a positive shift in the behavior and perception of consumers towards sustainability (Adelodun et al., 2021; Ibn-Mohammed et al., 2021; Karmaker et al., 2021).

However, the pandemic also presented several challenges for sustainability transitions that must be considered (Adelodun et al., 2021; Ibn-Mohammed et al., 2021; Karmaker et al., 2021). For instance, the use of single-use plastics to avoid contagion inflated during the pandemic, thus putting more pressure on government resources and current waste management activities. Also, with the mandatory lockdowns and the social distancing regulations, several companies entered an economic recession, which increased unemployment and intensified economic, social, and environmental challenges (Karmaker et al., 2021). To address these challenges, companies and governments are expected to embrace a post-pandemic economic recovery action plan, which might project emissions back and beyond the levels seen before the pandemic (Adelodun et al., 2021). Additionally, because the pandemic has shifted the entire focus of countries and companies to mitigate the social and economic impact caused by the pandemic, there is likely a slowdown in reaching the sustainable development goals (Ibn-Mohammed et al., 2021; Kayikci et al., 2021). Summing up, the literature sees the pandemic as a window of opportunity for more sustainable and circular SCs and a potential threat for STs, heavily dependent on how actors react to the opportunities and challenges.

2.2. Necessary actions for making use of windows of opportunities

According to the literature, there are several actions or strategies that can be implemented to foster STs after the pandemic - addressing resilience and sustainability simultaneously (Moosavi et al. 2022). Particularly, companies along the SC adopting concepts of sustainability play an important role in this . SC sustainability refers to companies' efforts to consider the environmental and human impact of their products' journey through the SC (e.g., sourcing, producing, and delivering value) while providing value for their stakeholders (Menke et al., 2021). Therefore, companies should increase their focus on implementing innovations and technologies that support and facilitate the new sustainable and more resilient SC systems (Adelodun et al., 2021; Gupta & Singh, 2021; Ibn-Mohammed et al., 2021; Karmaker et al., 2021; Nandi et al., 2021; Parashar & Hait, 2021; Zanoletti et al., 2021, Soleimani et al. 2022). Technologies such as blockchain, internet of Things (IoT), artificial intelligence, big data analytics, cloud computing, and 3D printing are widely recognized in the literature by their ability to support companies in the overcoming of transition barriers, as well as facilitating measurement processes, increasing resource efficiency, and achieving agility (Karmaker et al., 2021; Nandi et al., 2021). Equally important is organizations' cultural development to encourage research and development, managerial involvement, and commitment to sustainability, social responsibility, and agility (Adelodun et al., 2021; Gupta & Singh, 2021; Karmaker et al., 2021; Nandi et al., 2021; Saidani et al., 2021; Zanoletti et al., 2021).

It is important to note that companies cannot (and probably will not) act on this opportunity on their own. Participation and collaboration between all stakeholders is key for transitions. Therefore, governments and companies should focus on efforts to deepen environmental education for consumers (Adelodun et al., 2021; Gupta & Singh, 2021; Ibn-Mohammed et al., 2021; Karmaker et al., 2021; Saidani et al., 2021), as educated consumers are more willing to choose and pay higher prices for products that are produced in an eco-efficient way (Adelodun et al., 2021; Alonso-Muñoz et al., 2021; Saidani et al., 2021). Additionally, consumers have a key role to play in the application of a circular and more resilient SC, as they are the ones who reuse and return obsolete products to the production chain (Alonso-Muñoz et al., 2021). For this, strong government regulations and policies are necessary to encourage transitions to more sustainable processes and discourage the

continuation of the present linear, one-way SCs are essential to achieve post-pandemic sustainability goals (Adelodun et al., 2021; Gupta & Singh, 2021; Ibn-Mohammed et al., 2021; Karmaker et al., 2021; Zanoletti et al., 2021). For taking the window of opportunity seriously, the implementation of a sustainable recovery plan after the pandemic is going to require investment and financial support from companies and governments (Alonso-Muñoz et al., 2021; Ibn-Mohammed et al., 2021; Karmaker et al., 2021; Kayikci et al., 2021; Zanoletti et al., 2021). Adequate financial support and investment will facilitate the research, development, and implementation of new materials, technologies, and processes needed to adapt and transform to a sustainable SC (Gocer, 2021; Karmaker et al., 2021).

Summing up, the literature shows a strong focus on the role and actions of government and private companies. What is missing is the investigation of other stakeholders - such as consumers, non-governmental agencies, or intergovernmental organizations. This is in line with Gupta & Singh (2021) study limitation to incorporate more expert voices in the discussion. Therefore, we conduct a qualitative research design that allows us to cover a heterogeneous spectrum of views and to show us, inasmuch different voices have different understandings of how to foster change. This is vital to accelerate the transition to a circular and more sustainable SC.

3. Data and method

To contrast the perceptions the effect of the pandemic on SC sustainability, this study follows a qualitative research design, analyzing secondary empirical data from the early stages of the COVID-19 pandemic. We collected and analyzed recorded contributions, keynotes, interviews, and discussions at international conferences that took place from March 2020 to December 2020 (see Fig. 1 for the methodological proceeding and Appendix C for conferences overview). These recordings allowed us to gather in-depth insights from a heterogeneous group of experts in SC, CE, bioeconomy, innovation, and from relevant governmental or academic stakeholders, that would be - in a primary study using interviews - impossible to gather: Our data contains contributions from C-level experts from New Balance, Nestlé, HP, Walmart, GE Digital, Procter & Gamble, from academics from MIT, University of Virginia, UCLA, Duke University, University of Toronto, École

Data search	Data search following PRISMA framework (Moher et al., 2009).
Identification	Youtube search using: "Covid" OR *Covid-19" OR "Corona" OR "pandemic" AND "supply chain®" AND "circular economy" OR "circularity" OR "circular business models" AND "bioeconomy" OR "circular bioeconomy" AND "recovery"
Screening / Eligibility	24 conference recordings found on YouTube.
Included	Exclusion of 7 recordings and of 3 statements due to a lack of relevance or access, leading to a final sample of 17 recordings.
Data analysis	Data analysis following the six phases of thematic analysis by Braun and Clarke (2006).

Fig. 1. Methodological proceeding.

Polytechnique de Montréal or Tsinghua University, as well as contributions from governmental bodies such as the EU Commission, European Institute of Innovation and Technology, US Chamber of Commerce Foundation, Asian Infrastructure Investment Bank or the International Monetary Fund, and from non-governmental organizations (NGO) such as the Ellen MacArthur Foundation or Greenpeace.

The professional background of the experts is rather balanced (Appendix B) – from academia, government, NGOs, and from the private sector between 10 and 12 experts each – with intergovernmental organizations (IGO) constituting three experts. The geographical spread is concentrated in Europe and North America (21 and 23 experts, respectively). Asian experts are underrepresented in our sample.

We followed the six phases of thematic analysis by Braun and Clarke (2006) to conduct our analysis. To identify themes and patterns, we pursued an inductive approach, to code the data without fitting into any predetermined coding frame (Braun & Clarke, 2006; Nowell et al., 2017). See Appendix C for an example of the coding and theme formation. Guided by our research questions, we present three themes and the respective codes found in the data (see Table 1).

For our qualitative research to be useful and meaningful, we must conduct it rigorously and methodologically with research quality in mind (e.g. Nowell et al 2017). In Appendix D we summarize how we approached the quality criteria of qualitative research as reviewed in Frambach et al. (2013), where the terms in parentheses refer to the quality criteria typically employed in quantitative research: credibility (internal validity), transferability (external validity), dependability (reliability), and conformability (objectivity).

4. Findings

The objective of analyzing videos of conferences featuring a wide range of experts from academia, industry, government, and organized civil society was to get a deeper understanding of the perception of the crisis and the identified opportunities, challenges, and actions, including voices that are underrepresented in the academic discussion (e.g. organized civil society). In Fig. 2, we present the distribution of these themes and codes according to the professional affiliation of the experts.

4.1. Pandemic as a window of opportunity

From the data, we clearly see that the panelists indeed mostly perceive the pandemic as a **window of opportunity** for more

Table 1

Themes and codes identified from the data as well as the number of times the codes were found in the data.

Theme	Codes	#
Window of opportunity	Opportunities for circular economy	25
	SC heterogeneity	4
Opportunities	Adaptation to current needs	16
	Green recovery	16
	Responsibility of consumers	16
	Responsibility of companies (suppliers, manufacturers, retailers)	5
Challenges	Centralized production	10
	Lack of SC risk planning	6
	Health and safety concerns	5
	Fragility of supply chains	3
Actions	Localization	22
	Necessity for a system restart	20
	Importance of government action	20
	Innovative product design	20
	Collaborative symbiosis	19
	Green recovery	16
	Adaptation to current needs	16
	Responsibility of consumers	16
	Supply chain management	74
	Redesign of supply chains	4

sustainable and circular SCs. Especially government panelists express this view. Experts mention that the COVID-19 crisis has exposed the vulnerability of the current economic system and highlighted the need to accelerate the transition to a more resilient economic model, moving away from economic practices based solely on efficiency of scale. An Executive Lead at the Ellen MacArthur Foundation stated:

As the pandemic exposes some of the weaknesses in the current system, why would we step back and look to repair those weaknesses versus stepping up and accelerating forward with the transition with significant momentum behind it leading in? (2e)

Several speakers mentioned that a change in our economic system began already before the COVID-19 crisis with the goal of reducing greenhouse gases through “divestment from fossil fuels and innovation in resilient solutions” (15a). A representative of the European Commission argued that these transformations from synthetic materials to the use of renewable materials have “accelerated with the COVID-19 crisis” (7b). Furthermore, the pandemic has accelerated ST and the launch of “mission-oriented portfolio innovations” (5d), benefiting businesses, customers, and the planet. Along the same lines, a majority of experts from the private and non-governmental sector, stressed the need to incorporate CE practices and use them to set new priorities that promote sustainability, resiliency, and inclusive policies. Also, CE was perceived as a tool to combat long-term challenges like the climate crisis, pollution, and biodiversity loss. Using resources responsibly was described as particularly important. CE also offers new business opportunities as “circular business models can transform burdens into different value streams” (6a), promising “new innovation opportunities and the creation of new jobs” (2c). Additionally, if implemented in rural areas, CE was highlighted to support farmers in primary production. At the same time, cities were considered to provide a good way into CE strategies because of the “interconnectedness of city systems” (1a). The speakers shed light on how CE may address SC vulnerabilities, as CE uses secondary raw materials as a substitute for scarce raw resources, which in turn helps avoid critical dependencies. Lastly, highlighted the need to prepare for “the next shock” (2c) and “by being more distributed, diverse, inclusive, and more locally oriented where it makes sense, the CE also enhances resilience” (2c). Still, some panelists from academia also point to the fact that it is difficult to assess whether or not the pandemic is such a window, as there is a huge **SC heterogeneity** and it might not be an opportunity for every of these SCs.

The speakers focus on four different **opportunities** for exploiting the perceived window: **Adaptation to current needs, green recovery, power of companies (suppliers, manufacturers, retailers), and responsibility of consumers**. Panelists from academia particularly emphasized the fact that many SCs were able to **adapt quickly to current needs** during the pandemic (localization, change in production, focus on products that are really needed). This shows them that SC might also be able to adapt to more sustainable and circular processes rapidly. Another opportunity are the different **green recovery** action plans. Especially governmental actors express hope when talking about recovery plans. “That’s the beauty of all these strategies is that they are conducive to a low carbon economy as well. [...] (They do not) prioritize COVID recovery at the expense of the fight against climate change. It’s a double win.” (1a). Another perceived opportunity is the changed understanding and perception of the **power of companies and responsibility of consumers**. However, the panelists also point to some **challenges**, such as the **centralized production processes** created over the last decades, the general **fragility of SCs, health and safety concerns** of consumers towards more circular production and especially the use of waste streams and the **lack of SC risk planning**. Moreover, the panelists agree that the identified opportunities can only be used as such if the **right action** is taken.

Professional affiliation	Window of opportunity		Opportunities				Challenges				Actions									
Academia		3	7	2			3	4	1	10	3	5	1	2						
Government	14		3	10	4		3	1	1	4	1	11	4	10	4	1				
Intergovernmental organ.		1					2					1								
Non-governmental organ.	6		4	2	6	3	2	1	1	6	12	7	3	4	2	6				3
Private Sector	5		1	2	6	2		4		2	4	12		10	2	6	10			2
Sum	25	4	16	16	16	5	10	6	5	3	22	20	20	20	19	16	16	11		5
	Opportunities for CE	SC heterogeneity	Adaptation to current needs	Green recovery	Responsibility of consumers	Power of companies	Centralized production	Lack of SC risk planning	Health and safety concerns	Fragility of SC	Localization	Necessity for a system restart	Innovative product design	Importance of governm. Action	Collaborative symbiosis	Green recovery	Responsibility of consumers	SC redesign & management	Power of companies	

Fig. 2. Distribution of themes and codes depending on the experts' affiliation.

4.2. Actions for using the window of opportunity: Localization, system restart and the role of stakeholders

After the major disruptions caused by the COVID-19 pandemic, there is consensus among the experts on the panels that the economy needs to be rebuilt. But the question arises of how to build back. In our data, we find nine different **actions** considered necessary. In particular, experts from academia and non-governmental organizations define the **localization** of production as imperative. Panelists argue that if products could be taken apart, refurbished, recovered, repurposed, and/or upgraded where the actual users are, the risks associated with GSC could be cut to ensure SC resilience. One panellist from the European Commission argued that to achieve the green transition established by the EU Economy Action Plan, it [the green transition] “needs to take place based on local resources responding to local needs and involving primary producers (6c).” Panelists highlighted that after the COVID-19 pandemic, there would probably be a reassessment of what can be globalized and what needs to be locally produced. For instance, one of the speakers attributed the resilience shown by the agri-food sector to having shorter SCs than manufactured goods. NGOs also believe that using the window of opportunity is only possible with a complete **system restart**. This system restart entails the need for **innovative product design**. Panelists, especially from the private sector, identified product design strategies to respond to the system challenges posed by the pandemic. Designing in a way that allows multiple usages and the use of waste in resource creation was highlighted as it will enable to displace the need for new virgin materials and reduce the risks associated with SCs. Additionally, one panellist emphasized that thinking about a design where one can achieve material optimization is part of the needed system change, and “investing in R&D because the CE needs circular compatible materials as well” (1a) becomes a crucial piece in innovating for the new green economy.

Especially the private sector, but also government and NGOs, emphasize the importance of a **collaborative symbiosis** of all stakeholders. The most important stakeholders are companies as suppliers, manufacturers and retailers, but also customers and governments. An SC becomes resilient when there is coordination, collaboration, and cooperation among different actors in the SC. CE practices were perceived among panelists of the private sector as an industry-led transformation. Thus, working together via exchanging resources, and data, and communicating cohesively is critical for industrial symbiosis and scaled-up adoption of CE practices.

One thing that COVID-19 has taught us is the need to recognize the systemic, interconnected nature of the challenges we face and the critical importance of acting together and bringing together collaborative efforts

across boundaries and across sectors and disciplines to act in more systematic ways (5d).

The **importance of government action** is perceived as very high. The CEO of a global circular shopping platform sees the need for political decisions to set the direction for a green post-COVID-19 recovery by “incentivizing shifts away from destructive practices to support things that are better for us” (13c). Besides a financial aspect, governments need to form partnerships and foster collaboration to, on the one hand, “facilitate access to private and public funding” (5c) and, on the other hand “, to encourage companies to [...] make SCs more secure in the future” (9a). This focus on actors in necessary actions is also visible in demand for the **responsibility of consumers**, e.g., in their purchasing decisions. Panelists of the private sector highlighted that the acceptance among their customers is vital in fulfilling the transition towards recyclable or reusable packaging. With their purchase decisions, consumers have the power to drive change towards innovations in CE, as a Senior Director for Global Climate and SC Sustainability at Procter & Gamble highlights. In addition, another important **action** is making use of the **power of companies**, e.g. in their strategic production decisions. According to the Ellen MacArthur Foundation Learning Programmes Lead, the pandemic highlighted a “need to reassess the actual place of companies in society” (1a). Corporations might rethink their contributions by starting to question their product designs, practices, and impacts and avoiding critical dependencies of one supplier in one given country, for instance, by “increasing supply domestically or using circularity concepts for the supply of secondary raw material as a substitute of scarce raw materials” (7b). The private sector also highlights the need for SC redesign & management to create more localized, sustainable, resilient and circular SCs.

5. Discussion

This study aimed to provide insights into the perceived impact of COVID-19 on SC disruptions and potential opportunities for more circular, sustainable and resilient SCs. The data gathered revealed a consensus in the literature and among experts that the destabilization of the prevailing system and the dominant regime through the pandemic created windows of opportunity. However, self-accountability to reach the much-needed green economic recovery is still missing. Even though all stakeholders seem to be in line with what needs to be done e.g., allocating resources to green recovery measures, having “better” policies, educating consumers, concrete transformative actionplans are absent. Considering this, being ready to co-design and co-create a new economic model based on CE principles in a participatory way will help remove barriers and improve action coherence.

In line with Fennemann et al. (2018), our results indicate that CE

innovations demand the synergy and coordinated action of three stakeholders: companies (including suppliers, manufacturers and retailers), consumers, and governments. The findings highlight the importance of collaborative symbiosis and cooperation across stakeholders in SCs, for instance, searching for suitable suppliers to support their localization or near-shoring plans or easily finding suitable suppliers when disruptions occur. The symbiosis of those stakeholders is relevant to making the identified action happen (see the concept map in Fig. 3).

First, as the COVID-19 pandemic has greatly affected SC operations, our findings suggest that SCs and their members are induced to re-evaluate their role in society and the environment. In doing so, these companies try to achieve the triple bottom line of environmental, social, and economic goals in their strategies. According to the experts, some are ready to take on this role. This newly perceived role greatly influences innovations in CE: On the one hand, companies (e.g., suppliers, manufacturers, retailers, etc.) have the power to bring innovations to the market, for instance, products with novel designs based on CE principles. On the other hand, these companies need to educate their customers and facilitate the acceptance of new CE innovations. In times of a potential collapse of our earth system, experts have seen the companies' needs to face the fact that they might have to change their business models – from economic growth to prosperity (Jackson, 2017). By doing so businesses increase the chances of their survival.

This leads to the second group of stakeholders identified by the experts. Consumers play a critical role in implementing CE strategies. Our findings imply that consumers started to reassess their priorities and to re-think their consumption behavior due to the pandemic. This development is essential for implementing innovations in CE because it is also the responsibility of consumers to adopt new consumption habits or change conventional patterns of consumption (Wilke et al., 2021). Consumers can use their purchasing power to drive innovations in CE. At the same time, the development facilitates the education processes of companies because consumers have already undergone a psychological change and are open to more sustainable consumption. These effects of the COVID-19 pandemic are supported by recent studies (Deloitte, 2020; Guidice et al., 2020), where participants reassessed their priorities for health, environmental and economic decisions, resulting in higher demands for locally manufactured products and retail stores. Some panelists in our data adhered to “the consumer is always right” argument. However, simply shifting the responsibility from companies to consumers fails to recognize the shared responsibility in the system and will hinder the desired ST, which undoubtedly needs a dedicated systemic effort (Schlaile et al., 2018). Curiously, there is a lack of representation and engagement of consumers in the discussions and literature we analyzed. Thus, if consumers shall change their consumption habits and

take responsibility, consumers' voices in the shared solution-finding process must be included.

The third group of stakeholders comprises of governments. As governments around the world introduce stimulus packages to soften economic hardship and to aid economic recovery, policies encouraging the adoption of sustainable practices are critical (Ibn-Mohammed et al., 2021; Parashar & Hait, 2021). Our findings support that governments are uniquely positioned to pave the way towards STs by implementing useful regulatory frameworks, providing financial support, forming partnerships, and fostering collaboration between private and public institutions. The literature proposes additional governmental interventions to enable transitions towards CE practices, such as fiscal and regulatory frameworks, including strategies for waste management, as well as regulation of products (including design), an extension of warranties, and product passports (Ibn-Mohammed et al., 2021). Also, the integration of CE principles in society through education, information, and awareness to guide consumers' consumption towards sustainable choices and push innovations in CE after the COVID-19 pandemic (Ibn-Mohammed et al., 2021). In addition, CE best practices should be promoted between nations to be effective for the whole SC. For instance, the Netherlands is seen as the frontrunner in CE implementation (Kirchherr et al., 2017), and the Dutch government has set out to be completely circular by 2050. At the same time, those countries with a more powerful position in the SCs can use regulatory tools and/or transparency requirements on producers and demand the transition towards a more circular and sustainable SC from all actors engaged. While the literature highlights the importance of governmental long-term recovery efforts towards a sustainable CE instead of short-term, incremental improvements during the crisis (Ibn-Mohammed et al., 2021; OECD, 2020), panelists did not make this distinction. Against this background, Sarkis et al. (2020) fear that it will be easier for policymakers to move back to the comfortable and familiar pre-pandemic state of affairs instead of taking a new path that is riskier, yet more sustainable and resilient.

6. Summary and conclusion

The COVID pandemic has shown us the “need to recognize the systemic, interconnected nature of the challenges we face, the critical importance of acting together and bringing together collaborative efforts across boundaries across sectors and disciplines to act more systematically ways” (5d). The pandemic showed us a microcosm for future challenges and crises emanating from endogenous and exogenous risks like pandemics, extreme weather events, wars and financial crises. However, if the opportunities and challenges are understood properly and the right actions are taken, crises may also provide opportunities for transitions to more sustainable futures and better prepare us for

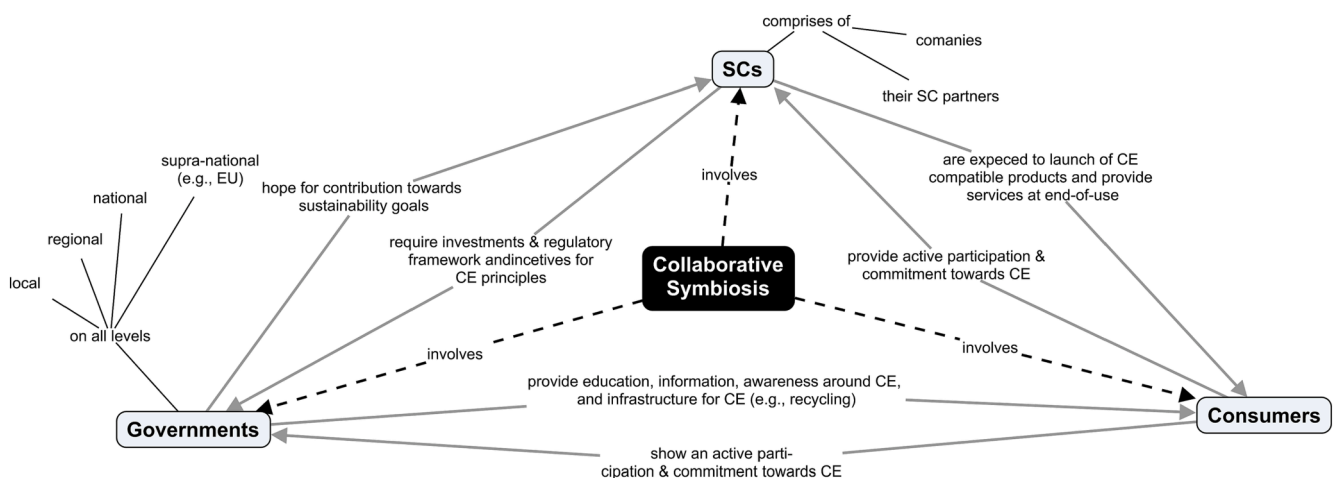


Fig. 3. Overview of the interdependence of relevant stakeholders according to our empirical findings.

upcoming crises. In this study, we aim to show inasmuch the COVID-19 pandemic is perceived as a potential window of opportunity for a more sustainable and resilient economy in terms of more sustainable, resilient and circular SCs and which actions are identified for using this window. Globally, the pandemic is not over, yet, and the (scientific) knowledge base is relatively small.

Therefore, this study bridges the knowledge gap and answers the research questions through a qualitative analysis of the statements of a heterogeneous group of 46 GSC experts from different organizations.

We found that different stakeholders from academia, industry, government, and organized civil society perceive the COVID-19 pandemic as a window of opportunity for more resilient and sustainable SCs and that a paradigm shift has already started. There seems to be a common understanding of the need to adequately using this window and the risks of simply going back to normal. The different stakeholders agree on the opportunities (for the environment, the resilience of SCs and new business opportunities) and on the actions needed (better product design, collaboration, the responsibility of producers and consumers, governmental action and regulation, investments, etc.). There is consensus that a recovery plan dedicated to SC sustainability (and not to short-term action) is needed. Almost all stakeholders identify the consumers as extremely relevant and responsible for making the SC transition happen (which is also why e.g., Milios (2022) explicitly demands ‘transcending the passive consumer role’).

Our study contributes to the discussion by confirming the need for more sustainable production methods, not only demanded by sustainability researchers but also by a diverse set of stakeholders. Moreover, we can also confirm the argument that COVID-19 is perceived as a window of opportunity in the face of a landscape shock (Kanda & Kivimaa, 2020). But only if the right actions are taken. As the literature mainly focuses on the perception and roles of governments and private companies, we believe that our study adds to a more holistic understanding by including other voices (such as non-governmental or intergovernmental organizations or organized civil society) (as suggested, for example, by Gupta & Singh (2021)).

A limitation of this study stems from the fact that the COVID-19 pandemic is still ongoing, and the impact on the long-term economy cannot yet be fully assessed. Furthermore, windows of opportunity opened by the pandemic cannot be generalized to all sectors of the economy. This research mainly focused on those sectors that depended heavily on GSC and went through disruptions. Moreover, our study has focused on information provided by SC, CE experts, and stakeholders from governmental or academic institutions. It is also necessary to provide consumer insights to understand the psychological aspects of new products and processes that help to achieve or deter an ST through circular innovations. Furthermore, given a keyword in the search terms for video conferences was “circular”, participants might already have a previous understanding and interest in CE practices and might not reflect the overall industry sentiment.

Incorporating CE principles into key business areas will impact SC management, environmental management, logistics, research, and development, among others. It, therefore, requires major sensitization along the SCs to have integrated visions and action plans. Thus, despite CE and ST being established scholarly fields, this intersection of concepts faces numerous challenges in practice. Finally, our exploratory study provides insights related to the opportunities for CE arising from current SC disruptions, lays the groundwork for future research, and encourages other researchers to examine further the practical impact of the COVID-19 pandemic on GSC and its effects on ST using CE principles. Future research should focus on conducting primary qualitative data analysis and/or case studies addressing different SC actors in particular industries (e.g., food, plastics, fashion). We also strongly demand for more transformative transdisciplinary research in this context (including consumers) (Bogner & Dahlke, 2022), to not only produce scientifically valid but actionable socially robust knowledge on desired future states and possible ways of getting there (Wittmayer et al., 2021).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.clscn.2023.100101>.

References

- Adelodun, B., Kareem, K.Y., Kumar, P., Kumar, V., Choi, K.S., Yadav, K.K., Yadav, A., El-Denglawey, A., Cabral-Pinto, M., Son, C.T., Krishnan, S., Khan, N.A., 2021. Understanding the impacts of the COVID-19 pandemic on sustainable agri-food system and agroecosystem decarbonization nexus: a review. *J. Clean. Prod.* 318, 128451 <https://doi.org/10.1016/j.jclepro.2021.128451>.
- Alonso-Muñoz, S., González-Sánchez, R., Siligardi, C., García-Muiña, F.E., 2021. New circular networks in resilient supply chains: an external capital perspective. *Sustainability* 13 (11), 6130. <https://doi.org/10.3390/su13116130>.
- Belhadi, A., Kamble, S., Jabbour, C.J.C., Gunasekaran, A., Ndubisi, N.O., Venkatesh, M., 2021. Manufacturing and service supply chain resilience to the COVID-19 outbreak: lessons learned from the automobile and airline industries. *Technol. Forecast. Soc. Chang.* 163, 120447 <https://doi.org/10.1016/j.techfore.2020.120447>.
- Bogner, K., Dahlke, J., 2022. Born to transform? German bioeconomy policy and research projects for transformations towards sustainability. *Ecol. Econ.* 195, 107366.
- Bogner, K., Mueller, M., Pyka, A., Schlaile, M.P., Urmetzer, S. (2020). *Why we can't go back to "normal": 5 appeals for a sustainable post-pandemic economy | LSE Business Review*. <https://blogs.lse.ac.uk/businessreview/2020/04/29/why-we-cant-go-back-to-normal-5-appeals-for-a-sustainable-post-pandemic-economy/>.
- Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3 (2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>.
- Chhimwal, M., Agrawal, S., Kumar, G., 2021. Measuring circular supply chain risk: a Bayesian network methodology. *Sustainability* 13 (15), 8448. <https://doi.org/10.3390/su13158448>.
- Deloitte. (2020). *Impact of the COVID-19 crisis on short- and medium-term consumer behavior. Will the COVID-19 crisis have lasting effect on consumption?* Monitor Deloitte. <https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-business/Impact%20of%20the%20COVID-19%20crisis%20on%20consumer%20behavior.pdf>.
- Eisenhardt, K.M., 1989. Building theories from case study research. *Acad. Manag. Rev.* 14 (4), 532–550. <https://doi.org/10.5465/amr.1989.4308385>.
- Elkington, J., 1994. Towards the sustainable corporation: win-win-win business strategies for sustainable development. *California Manage. Rev.* 36 (2), 90–100. <https://doi.org/10.2307/41165746>.
- Fathollahi-Fard, A.M., Ahmadi, A., Karimi, B., 2022a. Sustainable and robust home healthcare logistics: a response to the COVID-19 pandemic. *Symmetry* 14 (2), 1–33. <https://doi.org/10.3390/sym14020193>.
- Fathollahi-Fard, A.M., Dulebenets, M.A., Tian, G., Hajiaghayi-Keshteli, M., 2022b. Sustainable supply chain network design. *Environ. Sci. Pollut. Res.* 2–4. <https://doi.org/10.1007/s11356-022-18956-y>.
- Fennemann, V., Hohaus, C., Jan-Philip Kopka. (2018). *Moving in circles: Logistics as key enabler for a circular economy*. Fraunhofer IML. 10.24406/IML-N-502288.
- Fogarassy, C., Finger, D., 2020. Theoretical and practical approaches of circular economy for business models and technological solutions. *Resources* 9 (6), 76. <https://doi.org/10.3390/resources9060076>.
- Frambach, J.M., van der Vleuten, C.P.M., Durning, S.J., 2013. *Quality criteria in qualitative and quantitative research*. *Acad. Med.* 88 (4), 552.
- Gocer, F., 2021. A novel interval value extension of picture fuzzy sets into group decision making: an approach to support supply chain sustainability in catastrophic disruptions. *IEEE Access* 9, 117080–117096. <https://doi.org/10.1109/ACCESS.2021.3105734>.
- Guidice, F., Caferra, R., Morone, P., 2020. COVID-19, the food system and the circular economy: challenges and opportunities. *Sustainability* 12 (19), 7939. <https://doi.org/10.3390/su12197939>.
- Gupta, A., Singh, R.K., 2021. Applications of emerging technologies in logistics sector for achieving circular economy goals during COVID 19 pandemic: Analysis of critical success factors. *Int. J. Log Res. Appl.* 1–22 <https://doi.org/10.1080/13675567.2021.1985095>.
- Hitt, M.A., Arellage, J., Holmes, R.M., 2021. Strategic management theory in a post-pandemic and non-ergodic world. *J. Manag. Stud.* 58 (1), 259–264. <https://doi.org/10.1111/joms.12646>.
- Hosseini, S., Ivanov, D., Dolgui, A., 2019. Review of quantitative methods for supply chain resilience analysis. *Transp. Res. Part E: Log. Transp. Rev.* 125, 285–307. <https://doi.org/10.1016/j.tre.2019.03.001>.

- Ibn-Mohammed, T., Mustapha, K.B., Godsell, J., Adamu, Z., Babatunde, K.A., Akintade, D.D., Acquaye, A., Fujii, H., Ndiaye, M.M., Yamoah, F.A., Koh, S.C.L., 2021. A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies. *Resour. Conserv. Recycl.* 164, 105169 <https://doi.org/10.1016/j.resconrec.2020.105169>.
- International Labour Organization (2016), <https://www.ilo.org/global/topics/dw4sd/themes/supply-chains/lang-en/index.htm>.
- Ivanov, D., Dolgui, A., 2020. Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *Int. J. Prod. Res.* 58 (10), 2904–2915. <https://doi.org/10.1080/00207543.2020.1750727>.
- Jackson, T. (2017). *Prosperity without Growth: Foundations for the Economy of Tomorrow* (2nd edition). Routledge.
- Kanda, W., Kivimaa, P., 2020. What opportunities could the COVID-19 outbreak offer for sustainability transitions research on electricity and mobility? *Energy Res. Soc. Sci.* 68, 101666 <https://doi.org/10.1016/j.erss.2020.101666>.
- Karmaker, C.L., Ahmed, T., Ahmed, S., Ali, S.M., Mokatdir, M.A., Kabir, G., 2021. Improving supply chain sustainability in the context of COVID-19 pandemic in an emerging economy: exploring drivers using an integrated model. *Sustain. Prod. Consumpt.* 26, 411–427. <https://doi.org/10.1016/j.spc.2020.09.019>.
- Kayikci, Y., Kazancoglu, Y., Lafci, C., Gozacan-Chase, N., Mangla, S.K., 2021. Smart circular supply chains to achieving SDGs for post-pandemic preparedness. *J. Enterprise Inf. Manage.* <https://doi.org/10.1108/JEIM-06-2021-0271>.
- Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: an analysis of 114 definitions. *Resour. Conserv. Recycl.* 127, 221–232. <https://doi.org/10.1016/j.resconrec.2017.09.005>.
- Lee, S.M., Trimi, S., 2021. Convergence innovation in the digital age and in the COVID-19 pandemic crisis. *J. Bus. Res.* 123, 14–22. <https://doi.org/10.1016/j.jbusres.2020.09.041>.
- Linder, M., Sarasini, S., van Loon, P., 2017. A metric for quantifying product-level circularity: product-level circularity metric. *J. Ind. Ecol.* 21 (3), 545–558. <https://doi.org/10.1111/jiec.12552>.
- Menke, C., Hüsemann, M., Siems, E., 2021. Stakeholder influence on sustainable supply chain management: a case study of a German apparel frontrunner. *Front. Sustain.* 2.
- Milios, L., 2022. Engaging the citizen in the circular economy: transcending the passive consumer role. *Front. Sustain.* 94.
- Moosavi, J., Fathollahi-Fard, A.M., Dulebenets, M.A., 2022. Supply chain disruption during the COVID-19 pandemic: recognizing potential disruption management strategies. *Int. J. Disaster Risk Reduction* 75 (September 2021), 102983. <https://doi.org/10.1016/j.ijdrr.2022.102983>.
- Morone, P., 2018. Sustainability transition towards a biobased economy: defining, measuring and assessing. *Sustainability* 10 (8), 2631. <https://doi.org/10.3390/su10082631>.
- Nandi, S., Sarkis, J., Hervani, A., Helms, M., 2020. Do blockchain and circular economy practices improve post COVID-19 supply chains? A resource-based and resource dependence perspective. *Ind. Manag. Data Syst.* 121 (2), 333–363. <https://doi.org/10.1108/IMDS-09-2020-0560>.
- Nandi, S., Sarkis, J., Hervani, A.A., Helms, M.M., 2021. Redesigning supply chains using blockchain-enabled circular economy and COVID-19 experiences. *Sustain. Prod. Consumpt.* 27, 10–22. <https://doi.org/10.1016/j.spc.2020.10.019>.
- Negri, M., Cagno, E., Colicchia, C., Sarkis, J., 2021. Integrating sustainability and resilience in the supply chain: a systematic literature review and a research agenda. *Bus. Strategy Environ.* <https://doi.org/10.1002/bse.2776>.
- Nowell, L.S., Norris, J.M., White, D.E., Moules, N.J., 2017. Thematic analysis: striving to meet the trustworthiness criteria. *Int. J. Qualit. Methods* 16 (1). <https://doi.org/10.1177/1609406917733847>.
- OECD. (2020). *OECD Economic Outlook, Volume 2020 Issue 1: Preliminary version*. OECD. 10.1787/0d1d1e2e-en.
- Parashar, N., Hait, S., 2021. Plastics in the time of COVID-19 pandemic: protector or polluter? *Sci. Total Environ.* 759, 144274 <https://doi.org/10.1016/j.scitotenv.2020.144274>.
- Saidani, M., Cluzel, F., Yannou, B., Kim, H., 2021. Circular economy as a key for industrial value chain resilience in a post-COVID world: what do future engineers think? *Procedia CIRP* 103, 26–31. <https://doi.org/10.1016/j.procir.2021.10.003>.
- Sarkis, J., 2020. Supply chain sustainability: learning from the COVID-19 pandemic. *Int. J. Oper. Prod. Manag.* 41 (1), 63–73. <https://doi.org/10.1108/IJOPM-08-2020-0568>.
- Sarkis, J., Cohen, M.J., Dewick, P., Schröder, P., 2020. A brave new world: lessons from the COVID-19 pandemic for transitioning to sustainable supply and production. *Resour. Conserv. Recycl.* 159, 104894 <https://doi.org/10.1016/j.resconrec.2020.104894>.
- Schlaile, M.P., Klein, K., Böck, W., 2018. From bounded morality to consumer social responsibility: A transdisciplinary approach to socially responsible consumption and its obstacles. *J. Bus. Ethics* 149, 561–588.
- Soleimani, H., Chhetri, P., Fathollahi-Fard, A.M., Mirzapour Al-e-Hashem, S.M.J., Shahparvari, S., 2022. Sustainable closed-loop supply chain with energy efficiency: Lagrangian relaxation, reformulations and heuristics. *Ann. Oper. Res.* <https://doi.org/10.1007/s10479-022-04661-z>.
- Weetman, C. (2020). *A circular economy handbook* (2nd ed.).
- Wells, P., Abouarghoub, W., Pettit, S., Beresford, A., 2020. A socio-technical transitions perspective for assessing future sustainability following the COVID-19 pandemic. *Sustainability: Science, Practice and Policy* 16 (1), 29–36. <https://doi.org/10.1080/15487733.2020.1763002>.
- Wilke, U., Schlaile, M.P., Urmetzer, S., Mueller, M., Bogner, K., Pyka, A., 2021. Time to say 'good buy' to the passive consumer? A conceptual review of the consumer in the bioeconomy. *J. Agric. Environ. Ethics* 34 (4), 20. <https://doi.org/10.1007/s10806-021-09861-4>.
- Wittmayer, J., Loorbach, D., Bogner, K., Hendlin, Y., Hölscher, K., Lavanga, M., ... & de Wal, M. (2021). Transformative Research: Knowledge and action for just sustainability transitions. DIT working papers, (1).
- Wuyts, W., Marin, J., Brusselselaers, J., Vrancken, K., 2020. Circular economy as a COVID-19 cure? *Resour. Conserv. Recycl.* 162, 105016 <https://doi.org/10.1016/j.resconrec.2020.105016>.
- Zanoletti, A., Cornelio, A., Bontempi, E., 2021. A post-pandemic sustainable scenario: what actions can be pursued to increase the raw materials availability? *Environ. Res.* 202, 111681 <https://doi.org/10.1016/j.envres.2021.111681>.