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A primer

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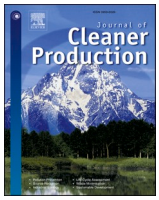

Review

Circular economy as crisis response: A primer

Kris Hartley [a], Brian Baldassarre [b,c,e], Julian Kirchherr [d,e,f,*]

[a] Department of Public and International Affairs, City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong S.A.R, China
[b] Delft University of Technology, Faculty Industrial Design Engineering, Landbergstraat 15, 2628 CE, Delft, the Netherlands
[c] Maastricht Sustainability Institute, School of Business and Economics, Maastricht University, Tapijn 11 Building D, P.O. Box 616, 6200 MD, Maastricht, the Netherlands
[d] Copernicus Institute of Sustainable Development, Utrecht University, the Netherlands
[e] Roskilde University, Department of Social Sciences and Business, Universitetsvej 1, 4000, Roskilde, Denmark
[f] Cambridge Centre for Environment, Energy and Natural Resource Governance, University of Cambridge, UK

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ABSTRACT

The early 2020s have been characterized by multiple convergent crises, including the Covid-19 pandemic and economic fallout of mitigation measures, Russia's invasion of Ukraine, and the ongoing sustainability and climate change crisis. This article discusses how the concept of the circular economy can inform responses to such crises by addressing four elements of a socio-economic system: technological innovation, supply chains and markets, public policy, and consumer behaviour. Synthesizing emerging insights from the scholarly and policymaking arenas, the article identifies the following ways that the circular economy concept can be effectively framed as crisis response: focusing on circularity in a more holistic way, adopting global value chains as the primary unit of analysis, pinpointing specific circularity aspects like drivers and barriers in value chains and business models, and extending the prevailing focus on technical aspects and material flows to often overlooked trade and geopolitical considerations. This discussion aims to articulate lessons for industry, policymakers, and scholars in leveraging a circularity approach to address the world's most pressing issues.

1. Introduction

In his article *The End of History*, Francis Fukuyama (1989) states: "In watching the flow of events over the past decade or so, it is hard to avoid the feeling that something very fundamental has happened in world history" (p. 3). These words retain their currency three decades later, with societal crises[1] that were once only emergent now manifesting themselves in immediate and measurable ways. In the 2020s so far, three principal crises have threatened global and regional stability: two abrupt (Russia's war in Ukraine and the Covid-19 pandemic) and one chronic (climate change, dissipation[2] of natural resources, and the ecological, economic, and social consequences of both).

In this article, we consider the potential for the concept of the circular economy (CE) to serve as a framing device for responses to broad-scale and multi-faceted crises. CE has already been proposed as a response, in part, to the environmental crisis (Corona et al., 2019). Until the late 1990s, legacy narratives about industrial restructuring for sustainability gestured towards the concept of process-based circularity, and since that time CE has broadened in scope to inform policy interventions and corporate strategies. The concept, however, remains focused largely on environmental questions – even as increasingly resolute policy efforts to mitigate climate change and environmental degradation have proven ineffectual in numerous measures.

Anticipating a broader conceptual reach for CE, this article discusses links among society's principal existential crises that have circular dimensions and the potential of CE to be a frame for responding to them. In

* Corresponding author
E-mail addresses: kris.hartley@cityu.edu.hk (K. Hartley), b.r.baldassarre@tudelft.nl (B. Baldassarre), juliank@ruc.dk (J. Kirchherr).

[1] We take a crisis to be defined as a situation in which "a community of people – an organization, a town, or a nation – perceives an urgent threat to core values or life-sustaining functions, which must be dealt with under conditions of uncertainty" (Boin and Hart, 2007, p. 42).

[2] According to Poncelet (2021; p. ii), "Traditionally, the depletion of mineral resources has been assessed to quantify impacts on the AoP [areas of protection of] natural resources. However, recent trends in discussion within the LCA [life cycle assessment] community suggest that dissipation of minerals may be more relevant to assess, since they represent the real loss of materials that are no longer accessible for future use, whereas the depletion of geological stocks may actually be considered to be desirable for as long as mineral resources remain accessible for further human use." Accordingly, this article uses the term 'dissipation' rather than 'depletion.'

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exploring this novel applicability of the concept, we situate CE within a socio-economic context as constitutive of four elements: technology, market, policy, and consumer behaviour. These elements collectively encompass the three major groups of societal actors (private sector, public sector, and civil society) and, fourthly, a force – technology – that both enables and guides the choices of each actor and has been foregrounded in recent sustainability discussions (Walshe et al., 2021; Yadav et al., 2020). Each element reflects differing dimensions of responses to the aforementioned crises, highlighting the opportunity to conceptually 're-balance' and 're-wire' CE (Nye, 2006; de Jesus and Mendonça, 2018; J. Kirchherr et al., 2018) in novel ways. The core question discussed is: 'Can the circular economy conceptual approach and underlying strategies (i.e., reduce, reuse, recycle) be used as a crisis-response frame beyond the goals of optimising economic and environmental performance?'

This article is structured as follows. First, we describe patterns in the conceptualization and practice of CE, and opportunities for extension. Second, we explore four fundamental shifts driven by the aforementioned crises. Finally, we reflect on ideas and directions for future CE research, focusing on how CE-informed ideas can better help policymakers and producers address emerging and synchronous crises.

2. Circular economy: evolution of a concept

CE is a contested concept characterized by multiple perspectives and differing definitions (Kirchherr et al., 2017; Nobre and Tavares, 2021; Bauwens et al., 2020; Friant et al., 2020; Kirchherr et al., 2017).[3] This article refers to CE as an 'umbrella' concept (Blomsma and Brennan, 2017) based on a set of strategies (i.e., reduce, reuse, and recycle) to decouple economic growth from resource use and associated environmental impacts (Kirchherr, 2021; Mies and Gold, 2021; Geissdoerfer et al., 2017; Kirchherr et al., 2017). The CE concept can be examined in the context of the four aforementioned socio-economic elements. First, technological innovation has the potential to accelerate CE in accordance with its frequent anti-cyclical tendencies (e.g., during crises or economic downturns; for a review of studies about pandemic-driven innovation, see Liu et al. (2022)). Second, producers are streamlining and regionalizing supply chains to increase autonomy and resilience (Panwar et al., 2022), a strategy for which CE has the potential to serve as an enabler. Third, governments are (re)emerging as major actors influencing both trends, particularly in the context of a 'green' Covid-19 economic recovery (Dai et al., 2023; Zachariadis et al., 2023). Finally, consumption of physical goods declined during Covid-19 and may continue to do so amidst the fading consumerism and economic hesitancy among some consumer groups (Basu and Swaminathan, 2023). This phenomenon often accompanies economic disruption and sluggish or drawn-out economic recovery following crises, and can works towards the kind of policy goals that CE approaches support.

The concept of CE has already begun to be applied beyond purely industrial or end-of-pipe contexts. For example, CE has been proposed as a way to address Covid-19 (Ibn-Mohammed et al., 2021), including through the stabilization of medical supply value chains (Wuyts et al., 2020). A burgeoning literature also addresses CE in the context of facilitating sustainable economic recovery post-Covid-19 (Cifuentes--Faura, 2022; Negrete-Cardoso et al., 2022; Sharma et al., 2021). Nevertheless, CE's relevance to other types of crises, while potentially strong, remains under-explored in the literature. As an example of such crises, geopolitical instability – from the diplomatic and rhetorical to the militaristic – is a recurring existential threat that modern society has not solved. As an example, the Russian invasion of Ukraine has led to catastrophic human and social consequences; secondarily and more relevant for this discussion, it has also substantially disrupted supply chains (Baldassarre et al., 2023a,b; Cui et al., 2023).[4] Moving towards a CE-based protectionist framework, Nygaard (2023) has proposed CE, along with other investment and technological approaches, as a way for countries and firms to partially sidestep if not wholly overcome interruptions to material and resource flows resulting from military conflict. Illustrating the applied potential of this perspective, a study of EU publications about CE found that economic growth and innovation, along with waste management, are dominant rationales – while supply disruptions (e.g., from military conflict) and climate crisis receive less attention (Baldassarre and Saveyn, 2023).

Policymakers appear to be embracing, on an initial level, CE-inspired thinking in policy responses to various crises. Examples are discussions and actions concerning critical raw materials (Schrijvers et al., 2020), including the 2008 proposal by the European Commission of a raw materials initiative (addressing extraction, trade, skills, and related knowledge; European Commission, 2008), the evolution of those ideas into the European Commission, 2016 CE action plan (European Commission, n.d.) and its 2020 revision (European Commission, 2020a), and the more recently introduced European Critical Raw Materials Act (European Commission, 2023) and mandatory collection targets for local recycling and reuse targets for batteries (European Parliament, 2022; European Commission, 2020a, 2020b).

Nevertheless, the EU policymaking discourse does not explicitly conceptualize CE as a crisis response tool, and a meta-level perspective that cuts across crises types is largely absent. Furthermore, there is a gap between rhetoric and initiative. Friant et al. (2021) argue that EU policies regarding CE exhibit "a dichotomy between words and actions, with a discourse that is rather holistic, while policies focus on 'end of pipe' solutions and do not address the many socio-ecological implications of a circularity transition" (p. 337). There exist scattered conversations and grass-root projects in the policy arena about the potential of CE as a crisis response tool (e.g., its relevance for climate targets and mitigation of import dependencies for critical materials) but no consolidated positioning has emerged. Although CE has been proposed as a solution for the sustainability crisis, earlier conceptualizations failed to account for the broader social implications of industrial transformation (Geissdoerfer et al., 2017), rendering these initial proposals one-dimensional and thus potentially ineffective. A more holistic conceptualization of CE, in alignment with the manifold dimensions of sustainability action (consider the broad-reaching policy project implied by the UN Sustainable Development Goals; Hartley, 2020), would integrate perspectives about social, cultural, and political context. One avenue for reimagining CE as crisis response is through problem definitions that encompass impacts common across all crises (e.g., most core policy challenges manifest themselves in economic disruption). A CE-based crisis response approach would apply the concept not in the usual technically ring-fenced way but in a more abstract and holistic way.

3. Fundamental shifts in the socio-economic system

The Russian invasion of Ukraine, Covid-19 pandemic, and enduring sustainability crisis have, both individually and collectively, precipitated major shifts in the four elements of the socio-economic system. First, technological innovation is, in some cases, accelerating in an anti-

[3] The following definition of CE is proposed by Kirchherr et al. in an analysis of 221 CE definitions (2023; p. 7): "The circular economy is a regenerative economic system which necessitates a paradigm shift to replace the 'end of life' concept with reducing, alternatively reusing, recycling, and recovering materials throughout the supply chain, with the aim to promote value maintenance and sustainable development, creating environmental quality, economic development, and social equity, to the benefit of current and future generations. It is enabled by an alliance of stakeholders (industry, consumers, policymakers, academia) and their technological innovations and capabilities."

[4] The Versailles declaration of March 2022 states that the EU should reduce strategic dependencies in sensitive areas, including critical raw materials.

cyclical manner. Major innovations often materialize during crisis situations (e.g., renewable energy technologies, vaccinations, and process innovations borne of scarcity or uncertainty; see Kleinknecht, 2016). Second, many businesses are simplifying and regionalizing supply chains to reduce reliance on inputs from source regions seen as unpredictable or unstable. This approach is intended ostensibly to increase production sovereignty and resilience (Pla-Barber et al., 2021) and has already been politically supported through the recently introduced EU industrial strategy (European Commission, 2020d). Third, governments are re-emerging as major actors supporting the two aforementioned trends (Makin and Layton, 2021). Finally, consumption of physical goods has declined and consumerism may be entering a new era of drawdown (Loxton et al., 2020; Mehta et al., 2020). The remainder of this section discusses these four shifts.

3.1. Accelerated technological innovation

At the beginning of 20th century, Schumpeter (1912) postulated that innovation is the engine of economic development. In the past decade, concerns around the slowing pace of innovation have emerged (Michelson, 2021; Gordon, 2012; Cowen, 2011), but the current convergence of crises may reverse this trend. While Schumpeter believed that innovation generates both cyclical instability and economic growth, some scholars now argue that innovation is counter-cyclical – meaning that innovation increases and is most impactful during times of crisis and economic instability (Am et al., 2020; Woolliscroft, 2020; Kleinknecht, 2016). For example, Archibugi et al. (2013) find that while economic downturns can hamper innovation efforts, firms with certain characteristics (e.g., shrinking and younger) or adopting certain strategies (e.g., collaborating, appropriating technology, and aiming to be cost-competitive) have been found to increase innovation under such pressures. According to Filippetti and Archibugi (2011, p. 179), crises are a "fertile environment" for innovation (see also Archibugi et al. (2013) and Gross and Sampat (2020)). Examples of technological innovation addressing the sustainability crisis also abound (e.g., carbon-free aluminium smelting and clinker substitutes in cement manufacturing; see Rahman et al., 2013) while many other innovations have yet to reach the mass market (Su et al., 2020; Lin and Zhu, 2019). Further, rising production costs can give impetus to innovation. Examples are costs of carbon under the EU's Emission Trading System and the costs of raw materials and goods due to Covid-19 and the Russian war in Ukraine (Jagtap et al., 2022). Further innovations may be expected around energy generation and use, fertilizer manufacturing, and production of steel and titanium components – all factors that exhibit some degree of vulnerability resulting from production constraints and supply insecurity amidst crisis.

At the same time, technological innovation often disregards sustainability action principles like the 3-R framework (reduce, reuse, and recycle) and has historically been applied primarily to process efficiency and product development and enrichment. This reality underscores the importance of examining innovation not only as a quantitative phenomenon (e.g., spending, cost savings, and patents) but also as a qualitative phenomenon (e.g., type, scope, concept, and broader mission). Examining indicators in the EU, Vranjanac et al. (2023) provide evidence that CE innovation is associated with CE performance. Examples illustrating the potential of the circular economy concept to support long-term innovation are knowledge-sharing for new business models and production techniques in the 'Maker movement' (Unterfrauner et al., 2019), new opportunities to place circular transition directly in the hands of consumers, including the development of applications that help people who travel share recreational equipment and food that would otherwise be wasted (Florido et al., 2019), and adopting an integrated view of CE-focused innovation that encompasses supply chains, regional production centres, and the internal capabilities of organizations (Sehnem et al., 2022; see Suchek et al. (2021) for other examples and de Jesus et al. (2021) for a framework that illustrates pro-circular innovation strategies).

3.2. Regionalization of supply chains

Economists have for decades examined the often troublesome side-effects of globalization (Jian, 2017; Kim and Shin, 2002; Amin, 1999; Morrison et al., 1991). As the world becomes more interconnected economically and otherwise, tensions emerge on multiple levels and can be fuelled by geopolitical instability, challenging globalization through economic protectionism and regionalization or localization of supply chains. While de-globalization is not a well-defined and coordinated process, actions that contribute to it (mostly without citing the term or idea) have accelerated in some cases due to supply chain threats. One example is the EU's pursuit of 'open strategic autonomy' (Miró, 2023), an effort to reduce external dependencies in strategic areas (e.g., health care supplies) through efforts like stockpiling of resources and diversification of supply chains and production capacity. The European Commission has also endeavoured to specify and quantify resource vulnerabilities decades into the future, as well as investigating the circularity potential in this sense (see, for example, Carrara et al., 2023; Baldassarre et al., 2023a,b).

The sustainability crisis, Covid-19, and the Russian war in Ukraine may also in some ways contribute to accelerating de-globalization (Ciravegna and Michailova, 2022; Jordaan, 2022). Energy independence has been an aspiration of many Western countries for decades, given the fragile diplomatic relationship between the West and many petroleum- and gas-producing countries; this relationship is now further strained by the Russian war in Ukraine. However, solutions to this crisis often involve politically thorny trade-offs. For example, the transition to renewable energy sources can reduce demand for fossil fuels but may also deepen dependencies on critical materials, components, and technologies (e.g., rare earths for permanent magnets and photosensitive semiconductors) that are sourced largely from China (Pitron, 2021). This challenge raises the prospect of supply chain disruptions similar to those experienced in the first phase of the Covid-19 crisis, when deliveries of microchips and semiconductors from Taiwan were halted and pressure grew to adopt local production of essential health supplies (e.g., FFP2 masks and ventilators; see Pearce and Bowman, 2020). These examples exhibit the intricate connections between concurrent crises and supply chain instability. To enhance the resilience of production systems in the face of such crises, EU policymakers have called for 'open strategic autonomy' (European Commission, 2020d) and 'smart specialization' (European Commission, 2021), both of which focus on leveraging and strengthening regional supply chains.

Examples of efforts to enhance supply chain resilience are flexible and dynamic remanufacturing capabilities that accommodate differing material sizes and varying storage, testing, and packaging needs (Bag et al., 2019), supply diversity and technology-enabled substitution of inputs (Baars et al., 2021), systematic mapping of supply chain risks (Senna et al., 2023), and strengthening of data analytics capabilities to enable faster and more informed management decisions at crucial moments when supply chains are under stress (Munim et al., 2023). At the same time, regional supply chains will not necessarily become more sustainable even if inputs are sourced locally. Thus, it is essential to take a broader and integrated view of how supply chain structures interact with and fit into the larger socio-economic ecosystem, illustrating how the imperatives of one crisis do not always align with those of another.

3.3. Strong government

The revival of government as the keystone actor shaping socio-economic systems has been long discussed in the literature and is being revisited again in the context of recent crises, both in the literature (Green, 2022; van't van't Klooster, 2022) and in policy agendas like the Green New Deal in the United States (Galvin and Healy, 2020). Calls for government to take the lead in the transition towards sustainability,

amidst inconsistent and sometimes flagging efforts from the private sector, have increased both in policy and academic discourses (Hekkert et al., 2020; Pel et al., 2020; Köhler et al., 2019). Even within the past decade, a renewed interest in government intervention has coincided with policy efforts to recover from the 2008 global financial crisis (including what Mandelkern and Oren (2022, p. 1) call 'depoliticised interventionism'). The Covid-19 crisis accelerated this shift, as demonstrated by rising public expenditures like the US' $1.9 trillion and EU's EUR 750 billion recovery funds (The Economist, 2021). Public concern about the pandemic temporarily granted political space for strongly interventionist policies (e.g., lockdowns and vaccination mandates) that would arguably have been unthinkable prior to the crisis (particularly in many Western countries). Simultaneously, Russia's invasion of Ukraine has demonstrated that governments can act in a quick, collaborative, and decisive way to defend common values and interests (Beisheim et al., 2022).

Forecasts by *The Economist (2021)* have anticipated that, by 2026, aggregate fiscal expenditures in the world's major economies will exceed the current average of 16 percent of global GDP in every major economy, due largely to net-zero emissions targets required by sustainability agreements and policy mandates. Supporting this interventionist shift is a reliance on innovation promotion in which transition tasks are outlined and coordinated by 'strong government' (Hekkert et al., 2020; Mazzucato, 2016, 2018, 2021). At the same time, strong governments do not necessarily prioritize CE (Kirchherr, 2021; van den Bergh, 2011), highlighting the need to take a more nuanced view that considers not only government capacity but also political dynamics and the influence of collateral interests.

3.4. Consumption reduction

Consumerism – the profligate and often mercurial spending patterns of the buying public – has for decades been a pressing topic in the sustainability and transitions literature. Scholars often argue that achieving sustainability depends on combating or overcoming consumerism, due to its impact on the environment through resource extraction, energy use, and waste disposal (Hobson and Lynch, 2016; Lewis, 2012; Akenji, 2014; Behr, 2010). The crises referenced in this article drove inflation in the early 2020s, as it reached its highest levels in decades in many countries and resulted in reduced consumption (Kantur and Özcan, 2021). Additionally, the increasingly visible impacts of climate change (e.g., extreme weather events, forest fires, and others) have in some cases been found to modestly impact public sentiment about government intervention (Hoffmann et al., 2022; Rosenthal, 2022; Howe et al., 2019). As weather events become more severe, social scientists have the opportunity to investigate the potential of climate impacts to foster new public ideals and behaviours that alter consumption patterns (Wallis and Loy, 2021; von Zabern and Tulloch, 2020). On the other hand, if consumption is reduced merely due to ephemeral phenomena like inflation (and thus out of financial necessity rather than ideological conviction), the trend may not be considered a systemic and durable shift towards CE thinking. Post-consumerism may also be viewed as the product of a cultural shifts and evolving personal priorities and values (Kotler, 2020; Cohen, 2013), including a trend towards "feminist and socialist moral values which may also be conjoined with a more collectivist version of care ethics" (Cochrane, 2020, p. 195). In critiquing the post-consumerism discourse, Jardim (2023) states "the (radical) core of post-consumerism resides in the notion that it is possible to exist beyond consumerism, adopting ways of subsisting that deny the pre-valent programmes of consumption based on the economic acquisition of goods that are created by exploiting natural and human resources—and the consequent exchange of semantic values that accompany those acquisitions." (p. 165).

4. Call to action

Policy documents, press coverage, and academic literature have elaborated on numerous pathways for CE transition. Framing CE in terms of crisis response reveals unexamined angles that common conceptualizations (e.g., CE as industrial structure reform) overlook. At the same time, there are opportunities to hone the CE concept for this purpose – particularly when considering the growing literature critiquing the CE (see, for example, the special issue of *Culture and Organization*; Corvellec et al., 2020). Example critiques include the proposition that CE incompletely accounts for social factors (Clube and Tennant, 2022; Ortega Alvarado et al., 2022; Vanhuyse et al., 2022), that the orientation of CE action around the concept of 'waste' is unsustainably rooted in a flawed and materialist economic growth logic (Valenzuela and Böhm, 2017), and that the concept is conceptually and theoretically unclear, unduly influenced by technical and economic factors, and suffers structural obstacles to implementation (Corvellec et al. (2022) offer a summary; see also Millar et al., 2019). The prospects of decoupling economic growth from recourse degradation (Bauwens, 2021) and embracing a degrowth perspective in CE (Schröder et al., 2019) offer some potential in overcoming such challenges. Nevertheless, prospects remain dim given embedded political interests as perpetuated, in part, through pro-growth narratives and norms (Rödl et al., 2022; Kovacic et al., 2020).

Efforts to position CE as a broader framework for crisis response should first confront and resolve these limitations. At the same time, there is promise in emergent policy debates about the potential of CE to serve as a crisis response lever. For example, the European Commission acknowledges the instrumental value of CE in achieving climate targets (DG Environment, 2020). The EU Critical Raw Materials Acts positions circularity efforts as key levers to mitigate import dependencies on critical materials (European Commission, 2023; Righetti and Rizos, 2023). Such strategies are particularly relevant in the context of technologies for renewable energy, which often require critical raw materials to be manufactured; examples are photovoltaic (solar) panels, hydrogen electrolyzers, fuel cells, and wind turbines (Axt et al., 2023; Baldassarre et al., 2023a,b; Nyffenegger et al., 2023).

While the continued revision of policies and implementation strategies may be expected, consolidated positioning remains incomplete. This situation presents an opportunity to incorporate new insights that synthesize lessons from policy action in other fields, including crisis response. Cross-sector collaboration is often highlighted as a facilitative factor in both circular economy (Köhler et al., 2022) and crisis response (Maon et al., 2009; Simo and Bies, 2007), particularly for filling capacity gaps and leveraging expertise. Pathways to strengthen collaboration between industry and government include (i) institutionalized feedback channels that regularize knowledge-exchange (e.g., conferences), (ii) participatory policymaking processes that transparently solicit and incorporate input from industries, consumer groups, and environmental and social NGOs, and (iii) blended procurement models that leverage private capital to develop hard infrastructural and soft (institutional or behavioral) interventions to foster CE transition.

To further support these types of policy interventions, more interdisciplinary academic research is needed, particularly for interventions that require data and scientific inputs. There is growing recognition that CE transition is a fundamental cultural and societal shift, rather than simply a new way of designing products, processes, and business models. As technology evolves, there is a seemingly incessant flow of novel ways to optimize ring-fenced aspects of production in the interest of circularity. However, this progress need not excuse society from deeper contemplation about structural or systemic (i.e., cultural and political) determinants of unsustainability. Evolving policy challenges mandate further investigation that pushes the concept of CE out of its epistemic

box and towards more holistic thinking. Interdisciplinary research is needed for this purpose. Going beyond descriptive analyses of individual cases, conceptual approaches to analyzing CE have recently gained more popularity (Kirchherr and van Santen, 2019), with scholars contemplating definitional nuances and the relevance of allied concepts like sustainable development, sharing economy, and green economy (D'Amato and Korhonen, 2021; Henry et al., 2021; Geissdoerfer et al., 2017). At the same time, the CE literature boasts an extended history of applied research based on empirical observations of practical experiences, including case studies of eco-industrial parks (Abu-Qdais and Kurbatova, 2022; Gómez et al., 2018; Mathews and Tan, 2011; Wenbo, 2011) and a more recent focus on circular business models (Geissdoerfer et al., 2020; Henry et al., 2020; Nuβholz, 2017; Lewandowski, 2016). Relatedly, Baldassarre et al. (2020a,b) issue a call for translating intangible sustainable innovation and design ideas into concrete business practices, in response to a demonstrated need for more empirical research to bridge the theory-praxis gap. Moreover, given the current convergence of policy crises, the EU's focus on strategic technologies and industrial ecosystems holds potential for lesson-drawing (European Commission, 2020b, 2020d), and policymakers focused on science-related issues have already identified focus areas (Table 1). As suggested by Mhatre et al. (2021) in a review of the EU's CE initiatives, a range of actions can be taken to further promote CE transition, including more supportive policies, infrastructure, supply chain collaboration, and encouragement of collaboration and awareness.

Nevertheless, more is needed in both research and practice. One pathway is to incorporate higher-level circular perspectives rather than continuing to narrow down and optimize spot-level and plug-in solutions through, for example, better technology. According to Hartley et al. (2019; p. 177), "if the public policy discipline ignores the elephant-in-the-room – the intractability of global systemic crises like climate change and the failure of existing policy paradigms to provide more than incremental and middling responses – it does so at disservice to scholarly interdisciplinarity and at peril to policy practice and humanity itself." Accordingly, we call for more specific empirical analysis about how the cross-cutting paradigm of circularity is applied in crisis response. Empirical understandings about broad-scale and integrated CE action are largely missing from the literature, and would give stronger effect to a CE-based crisis response paradigm. Expressing the understanding about CE that currently prevails in the literature, Blomsma and Brennan (2017) argue for application of the concept as an overarching framing device to develop new perspectives on sustainability transition. While their approach frames CE as prolonging resource use and ours focuses on crisis response, both share an emphasis on integration and symbiosis among individual efforts and policies as catalysts for change.

Table 1
Areas of science for policy focus related to CE research as crisis response, based on publications by the European Commision (2022; 2021b, 2020a, 2020b, 2020c, 2020d, 2016).

	Focus areas
Materials and substances	• Critical raw materials • Semiconductors • Permanent magnets • Hydrogen • Pharmaceutical ingredients
Strategic technologies	• Batteries • Fuel cells • Wind turbines • PV panels • Traction motors • Robotics • Aircrafts/drones • Spacecrafts/satellites • 3D printing • Additive manufacturing • Chips • Data centres • Blockchain • Artificial intelligence
Industrial ecosystems	• Renewable energy • Energy intensive industries • Electronics and digital • Health • Aerospace and defence • Mobility

We conclude by building on the focus areas in Table 1 to highlight additional opportunities for research. First, an open question concerns which unit of analysis to adopt when engaging with CE in these focus areas. Most studies focus on raw materials (European Commission, 2018), limiting opportunities to recognize alternatives beyond recycling – including reduction, reuse, and behavioral factors higher in the waste hierarchy (European Commision, 2020; Ellen MacArthur Foundation, 2013). Consistent with emerging research on this topic, we propose as a unit of analysis a broad conceptualization of the value chain that includes the four aforementioned elements of a socio-economic system: technological innovation, supply chains and markets, public policy, and consumer behaviour. Taking a broader perspective on units of analysis, research should focus not only on resource dissipation but also on environmental change in its manifold social, political, and economic dimensions. Additional research should thus consider how ideas about CE transition can be combined with analytical perspectives like systems-thinking (Robinson, 2022; Iacovidou et al., 2021) and symbiotic networks (Chopra and Khanna, 2014) to further illuminate CE's crisis-response dimensions. Second, current research focuses primarily on the technical aspects of material flows, often overlooking relevant trade and geopolitical considerations. CE research should more deeply explore complementary trade and geopolitical issues (Pitron, 2021; Buesa et al., 2023) at the nexus of consumer choice, investor and producer behavior, and public policy. A more thorough accounting of these factors can deepen scholarly understandings about issues that impact CE transition, including supply chain resilience and the vagaries of global trade practices. Finally, recent research has only begun to pinpoint drivers and barriers to circularity within regional and global value chains (Axt et al., 2023; Baldassarre et al., 2022; Baldassarre and Calabretta, 2023; Kirchherr et al., 2018), a topic deserving additional research given increasing policy interest in various forms of resource sovereignty. Policymaking structures and political dynamics are shifting in response to global threats, including institutional and multi-lateral action on climate change, deepening integration of economies through more interventionist roles for regional trading bodies (e.g., the ASEAN (Association of Southeast Asian Nations) Economic Community), and more starkly defined diplomatic affinity clusters (ally groups) in response to growing geopolitical polarization and breaches of territorial sovereignty. The current era is an opportune time for the CE concept to prove its broader applicability, and we hope this discussion will inspire scholars and policymakers to embark on new agendas in research and practice.

CRediT authorship contribution statement

Kris Hartley: Conceptualization, Formal analysis, Writing – review & editing, Supervision. **Brian Baldassarre:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. **Julian Kirchherr:** Conceptualization, Investigation, Methodology, Writing – original draft.

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

No data was used for the research described in the article.

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