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Return to Reintegration? Towards a Circular-Economy-Inspired Management Paradigm

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Abstract
Humanity has entered the Anthropocene, a new geological epoch marked by an unprecedented human impact upon planet Earth. In this context of "planetary emergency", questioning the effectiveness of extant management research at guiding environmentally sustainable corporate outcomes has become more relevant than ever before. Responding to the calls for management scholars to reconceive the foundations of management research, this article draws on circular economy thinking to infuse the paradigmatic assumptions of the business and natural environment research field with the logic of ecological systems and bring them back to their early systemic orientation. It also discusses which barriers and limitations can prevent the circular economy from unleashing its transformational power.

Keywords Circular economy · Paradigm · Anthropocene · Business and natural environment · Barriers · Metaphors

Introduction

Recognising the "Anthropocene", a new geological epoch wherein human activities are causing irreversible changes to resources and ecosystems services [1], stimulates urgent questions about how to build a more sustainable and resilient economy. Contemporary patterns and trajectories of global consumption and production already exceed the sustainable limits of our ecological systems and are degrading them, generating severe environmental and social risks [2]. This state of "planetary affairs" calls for large-scale, systemic adoption of significantly better environmental and social practices [3], and discourse around the circular economy (CE) has emerged as a prime source of potential solutions [4].

As Sarja et al. (2021) [5] note, CE is a relatively new and developing field which, to an unusual extent for an emerging field, has developed via a plethora of systematic literature reviews (SLRs). These include broadly focussed SLRs (e.g., [6–8]) ; SLRs devoted to CE

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and particular key management fields such as for supply chains (e.g., [9, 10]); ones on CE and particular management processes such as innovation (e.g., [11, 12]) or performance assessment (e.g., [13]); particular forms of CE such as the bioeconomy (e.g., [14]); sector studies focusing on industries such as food (e.g., [15]) or construction (e.g., [16]); and particular national or regional policy perspectives (e.g., [17]).

In combination, these reviews have generated considerable insight into CE practice and potential, particularly concerning two recurrent themes: one is identifying those factors that can act as inhibitors or promoters or CE practices [5], and the other is the multi-level nature of CE discourse [18], considering macro-level issues of policy and economics, meso-level perspectives concerning industries, supply chains and production/consumption systems, and micro-level factors influencing the behaviour of firms, managers, and consumers. The insights that have been developed via these SLRs, however, suffer from several limitations. One is a relatively techno-centric approach [19], emphasising the physical systems perspective of production and consumption systems, the material and energy flows within them, and waste management in particular [18]. This may reflect both the roots of CE in technical fields such as industrial ecology [20], and the early development of the field in journals related to environment, engineering, resources, and waste before evolving towards more business and sustainability-orientated journals from 2013 onwards as more social and economic aspects was considered [9]. A second, related limitation is an emphasis on holistic meso-level studies of supply chains, industries, and production and consumption systems and the range of stakeholders within them, and a relative lack of emphasis on the behaviour, capability, and motivation of individual organisations within those systems, even though system success will depend on the ability of individual firms to play their part. These two limitations may partly reflect the roots of CE thinking [8, 21] in the work of scholars such as Kenneth Boulding (an economist), Barry Commoner (a biologist), Amory Lovins (a physicist), and Michael Braungart (a chemist).

The upshot of these two limitations is an under-exploration within the CE literature of the importance of firms within CE systems as organisations rather than as components of wider production and consumption systems, leading to an under-appreciation of the role that organisational and management theory may play in helping or hindering progress towards CEs. This, in turn, illuminates a third limitation in a literature heavily reliant upon SLRs, which is that SLRs tend to refocus attention on those elements that are most prominent within a field of academic discourse rather than on those that are absent.

That scholarship concerning CE is not fully engaged with organisational and management theories is, perhaps, not surprising, given the existing shortcomings in management theory and practice when it comes to delivering substantive progress towards sustainability rather than merely slowing down the rate of un-sustainability of current production and consumption systems [22–25]. The scant cross-fertilisation between business/management studies and natural sciences is one cause of this [26, 27]. The social aspects of organising remain the primary concern of most management theories [28], implying that limited attention is paid to the relationship between socioeconomic and physical/natural systems, which, analogously, is observed within corporate practice (ibid.). Understanding organisational issues will be important for progressing CE initiatives, not least because progressing them creates organisational challenges [9], and organisational learning issues [12], organisational inertia [29], and limitations to organisational capabilities [30] can all act as significant barriers.

This paper presents a case that the sustainability discourse in management and organisation theory, and the CE field, each represents a source of potential progress for the other, but remain currently relatively disconnected. A pathway to future integration and progress

via a revisitation and expansion of the ecological metaphorical roots of CE is proposed as a means to open up and integrate the discourse within the two fields.

The paper proceeds as follows. The second section illustrates CE thinking and practice and synthetises some of the critiques of the CE. Subsequently, the third section offers an overview of the evolution of the business and natural environment (B&NE) field, including its more recent developments, invoking the coupling of management theorising with biophysical principles and a more systemic approach to sustainability. Next, the fourth section makes the case for a CE-inspired paradigm change and discusses the barriers and limitations that could hinder this process. Finally, the discussion and conclusion sections summarise the insights and contributions generated and offer some suggestions for the development of future lines of enquiry.

The Circular Economy

From 2012 onwards, CE thinking has generated widespread interest amongst stakeholders including policymakers, businesses and academics for several reasons. Firstly, the leadership exhibited by Dame Ellen MacArthur and her titular Ellen MacArthur Foundation—which works with businesses, policymakers and higher education institutions, providing insights and analysis and promoting initiatives and collaboration to encourage and facilitate the shift towards a CE—has been crucial to generate global engagement around a new business narrative [31]. Secondly, CE thinking involves a sound economic rationale: in a resource-constrained world, resources price and supply volatility can be mitigated through more resource-efficient industrial processes [32]. Pauli (2010) [33] argues that learning from nature's functional and material efficiency is a sound strategy to remain competitive and achieve sustainability. The emergence of CE, therefore, reflects the type of "business ecosystem" metaphor proposed by authors such as Moore (1998) [34].

Innovative products and business models matching CE principles are emerging, both within established corporations and small innovators, to pursue a sustained and sustainable competitive advantage through better resilience, new profit sources, reduced costs and improved legitimacy [35–37]. Governments at all levels (supranational, national, regional, city) are engaging with CE policies and strategies. The CE Action Plan is central to the European Commission Green Deal [38]; while China has ten existing and upcoming CE policies [39]. At the city level, strategies for CE are developing in capitals including Amsterdam, London, and Paris along with other major and small cities [40]. Perhaps, this is unsurprising, considering that contrary to much of gloomy environmental rhetoric, the CE fosters involvement and creativity for radically new solutions designed to do "good" rather than simply minimising "bad" [41].

Although much CE discourse has been led by non-academic stakeholders [8, 42], scientific publications on CE have grown rapidly [43]. Amongst several streams of research emerging around the CE concept, scholars have devised different definitions, with one conceptualising the CE as: "an economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy, and material loops, and facilitate sustainable development through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis), and macro (city, regions, and governments) levels" [44, p. 610]. CE thinking is clearly anchored in nature's functioning principles and, particularly, on the "waste equals food principle" in which it: "takes its insights from living systems as these have proved adaptable and resilient, and model the 'waste is food' relationship very well"

[45, p. 26]. Accordingly, in a CE, a cyclical pattern of materials use is adopted with the concept of waste being designed out by circulating materials, products, and components at their highest utility and value in both "technical" and "biological" cycles [46]. Mineral and synthetic materials, which flow in technical cycles, return to continuous cycles of production and consumption since through end-of-life material recovery strategies and appropriate design techniques (e.g., design for disassembly, remanufacturing, product durability), they preserve quality and are suitable for further use [32]. Renewable and biological materials, which flow in biological cycles, return to nature to build and restore natural capital after cascading them across other applications and extraction of bio-chemical nutrients [32].

The result of CE discourse has been to create "a holistic approach to techno-economic paradigm change deemed more operational than other concepts" [47, p. 1506], providing a viable solution to some of the most pressing sustainability concerns of this time including, but not limited to, climate change, resource scarcity, and rising unemployment [48, 49]. It represents "not the only smart and green strategy there is but, probably, the most sustainable business model, improving simultaneously ecologic, social, and economic factors" [50, p. 91].

The Circular Economy: Why Are We Not There Yet?

Given CE's potential benefits of resource and economic efficiency, and contribution to pressing carbon reduction and other sustainability goals, questions arise about why it has not become a more prevalent set of practices [51]. Part of the explanation reflects practical barriers related to organisational tensions, sunk costs, path dependencies, stakeholders' reluctance, external institutional factors and perceived risks [30, 52, 53]. Another part lies in the conceptualisation of the CE. There remains confusion around its meaning in the literature [54] with the risk that "a concept with various understandings may ultimately collapse or remain in a deadlock due to permanent conceptual contention" [55, p. 221].

Gregson et al. (2015) [56] view CE as overly vague, representing a "diverse bundle of ideas" enthusiastically championed by proponents without analysis or critical interrogation. This is not to say that CE remains unexamined, since various critiques have suggested limitations to both CE theory and practice. One set of "absolutist" critiques concerns the underlying principles of CE and draws from physics and the laws of thermodynamics in seeing activity on Earth as an inevitable march towards entropy in which efforts at circularity represent merely temporary eddies in an otherwise irreversible current of destruction [57, 58]. More prosaically, Makov and Vivanco (2018) [59] consider the impact of "rebound effects" caused by both imperfect substitution between "re-circulated" (recycled, reused, etc.) and new products, and also the "re-spending" of economic savings. Focusing on greenhouse gas emission reductions from CE initiatives in the smartphone market, their research suggests that around one third of likely savings will be lost to such rebound effects.

Another set of critiques concerns the balance of CE literature and how it is dominated by a relatively technical-fix approach concerned with efficiency and business models. The three core research themes identified in Sehnem et al.'s (2019) [8] (management-orientated) literature review are: policy instruments and approaches [60, 61]; value chains, material flows, and product-specific applications [62], and technological, organisational, and social innovation [63]. Arguably, that third theme adds some of the organisational and "human" dimensions typically missing from the field of industrial ecology as a key antecedent of CE

[20]. Despite this, there seems to be a consensus that CE literature has failed to adequately account for socio-political factors [18, 19, 64–66], although De Angelis and Ianulardo (2020) [67] argue that the social dimension, which some authors see as missing, is inherent to the rhetorical, symbolic, and cognitive dimension of the social vision that the CE model is contributing to. They view the CE as: "a cognitive framework instrumental in the emergence of a credible, shared, and persuasive imaginary of more environmentally, economically, and socially sustainable production and consumption systems by positively engaging, focusing, evoking, and planning how to achieve an integral human betterment" (p. 147).

Part of the explanation for CE literature's preoccupation with technical fixes may lie in the extent to which CE concepts are rooted in the field of industrial ecology with its focus on the technical side of industrial metabolism, and the tools making it possible to close materials and energy loops rather than the societal actors (firms, consumers, and other organisations) affecting the physical flows of matter and energy. Ehrenfeld (2000) [68] and Korhonen (2003) [69] argue that the tools of industrial ecology are only the second stage—the normal practice stage—of the paradigmatic change necessary to move substantively towards sustainability. Without the first stage, i.e., the paradigm stage (new views and values), there is no roadmap showing the direction for the tools to be applied (ibid.). Additionally, Korhonen (2005) [70] argues that: "only through affecting the agents driving the flows (…) can the flows be directed towards recycling and cascading or can we reduce our use of the flows" (p. 101). As highlighted by Bruel et al. (2019) [20]: "industrial ecology pays little attention to other aspects of the economy-society-environment interactions that can be addressed at the microeconomic level and that might help to conceptualise and operationalise the underlying IE metaphor" (p. 16).

At a more macroeconomic level, Siderius and Zink (2022) [71] provide a detailed critique of the CE in terms of the points of incompatibility between elements of CE and its quest for technical efficiency and the market system and an emphasis on market efficiency that underpins our socio-political system. They argue that CE's attempts to pragmatically conform to market principles create perverse incentives that undermine its potential for success. This paper represents a complementary analysis that considers the apparently paradoxical disconnection between CE and the organisational and management theories concerning firms' sustainability-orientated behaviours at the more microlevel. The implication of this, and Siderius and Zink's analysis, is that the macro, meso, and microlevel initiatives seeking to promote CE are unlikely to succeed without a more foundational level change that reconsiders the dominant social paradigm and the assumptions within it.

The Evolution of the Business and Natural Environment Field

Although writing on the environmental implications of firms' activities has a long tradition, the emergence of a coherent B&NE scholarship field addressing sustainable management and organisational theory was cemented with the constitution of the Organizations and the Natural Environment division of the Academy of Management in 1994 [72]. It has since evolved through several stages:

Critical Epistemological Research

The publication of landmark articles in the 1995 *Academy of Management Review* special issue [73]—which figures amongst the most cited literature on the subject [74]—marks the beginnings of critical epistemological research as the first B&NE research stream [7,

73]. Within this, Gladwin et al. (1995) [75] warn about the flaws of the epistemological assumptions underlying management theory, arguing that: "modern management theory is constricted by a fractured epistemology, which separates humanity from nature (…). Reintegration is necessary if organisational science is to support ecologically and socially sustainable development" (p. 874). The solution, they argue, is a sustaincentric orientation since: "for a world view to be congruent with sustainable development, it must manifest inclusiveness, connectivity, equity, prudence, and security" (p. 884). Similarly, Purser et al. (1995) [76] propose replacing the prevailing anthropocentric management paradigm with an eco-centric approach, accounting for the interconnectedness between organisations and nature. These authors' lines of enquiry espouse systems thinking and view organisations as embedded within a wider macrosystem [73], which put it strongly in sympathy with CE principles.

Managerial Epistemological Research

Critical epistemological research was progressively abandoned during the late 1990s in favour of studies concentrating on the organisational level perspective of the business and nature interface, emphasising the "business case" for sustainability [22, 73]. As put by Hahn and Tampe (2021) [77]: "with the maturation of business sustainability as a research field, the concept of business sustainability has lost much of this early systems-oriented zest" (p. 458). Where the critical perspective gave B&NE theory common ground with CE concepts in offering the prospect of radical pro-sustainability change, the more managerial perspective and its emphasis on maintaining existing market structures allowed the "capture" of CE discourse, pulling it back towards "business as usual" [71].

This more managerial stream of epistemological research integrated environmental concerns into mainstream views of organisational performance, applying (instead of challenging) existing concepts and frameworks in management scholarship [77]. Pursuing environmental goals became a matter of strategic concern for enhancing competitiveness, legitimacy, and profitability: with win–win outcomes emphasising the business case for sustainability [77]. Porter and Van der Linde (1995) [78] emphasise that environmental stewardship is an opportunity leading to increased resource efficiency and, hence, competitiveness. Similarly, Hart's (1995) [79] natural-resource-based view of the firm suggests that developing new capabilities in managing the interface with the natural environment, i.e., pollution prevention, product stewardship, and sustainable development, is crucial for pursuing competitive advantage.

This "strategisation" of sustainability made it less challenging and more comfortable for many management theorists, but the resulting management theories failed to incorporate natural processes and systems understanding and were based upon a business-as-usual premise [80]. Starik and Kanashiro (2013) [26] highlight that none of these theories: "appear to have the unique features, benefits, opportunities, challenges, or orientations to assist individuals, organisations, and societies to move towards sustainability as much and as soon as it appears necessary" (p. 7). They underline that the management field had yet to embrace the "call for reintegration" and acknowledge the relevance of biophysical foundations for its theorising, a position echoed by Pogutz and Winn (2016) [81]. Yet, the scope and magnitude of sustainability challenges required: "significant transformation and radical reassessment of values, relationships, and priorities that will likely lead to broad changes in dominant theoretical paradigms" [17, p. 20].

The New Call for Reintegration: Why and How

The B&NE field clearly needs sustainability management theories that accommodate the interface and the reciprocal influence between physical and social systems, since sustainability issues cross both systems' boundaries [82, 83], requiring genuinely transdisciplinary dialogue [80]. These considerations provide a wake-up call to return to the origins of the B&NE field and its more systemic orientation. Then, the fundamental questions become: *why is it important to reconnect to, and learn from, nature?* And *how can such a connection be built?*

The deep ecologist and systems theorist, Capra (2007), [84] argues: "the outstanding characteristic of the biosphere is its inherent ability to sustain life. To be sustainable, a human community must be designed so that its ways of life, technologies, and social institutions honour, support, and cooperate with nature's ability to sustain life" (p. 10). On a similar theme, Pauli (2010) [33] maintains that a thriving economy is one that understands and applies ecosystems logic since nature always exhibits true sustainability. Analogously, Unruh (2010) [85] argues that we should take nature as a model to learn from since the Earth's biosphere is a sustainable production system. Once the principles responsible for the biosphere's sustainability are profitably incorporated into business practices, the sustainability destination may be reached (ibid.).

Moving the B&NE field beyond its prevailing paradigmatic orientation seems to require further dialogue with the natural sciences [22, 73]. Frederick (2017) [86] proposes "natural corporate management" as "a natural theory of the firm" with a central tenet that corporate and natural forces are deeply entwined since nature both promotes and threatens business survival at the same time. Natural corporate management encourages managers to pursue "economising" and "ecologising" goals simultaneously for a firm's long-term survival. Economising involves self-sustenance through the pursuit of a profit. Ecologising is concerned with the sustainable development of the organisation in relation to its ecosystem through positive relationships with other entities. Similarly, Laszlo (2019) [87] calls for "quantum thinking", which requires management research to incorporate physical and natural science theories. Under a quantum world view, humans are embedded in nature and the purpose of management becomes to do "good" by creating prosperity for all.

Flipping around a common theme in management research, Ergene et al. (2020) [22] pose the question: "what if we were to take socio-ecological wellbeing as our central focus and make an ecological case for business, instead of the business case for sustainability?" (p. 6). To encourage research for an ecological case for business, they counsel that four major shifts are necessary. The first shift is epistemological: B&NE research should return to the critical epistemological approach and so to scholars' engagement with questions of ecological well-being to promote new forms of organising that are restorative and life supporting. The second shift is ontological: B&NE research should embrace a relational ontology, i.e., the world viewed as a complex web of relationships of humans and nonhumans as valid stakeholders. The third shift is about transdisciplinary collaboration with the natural sciences to learn the functioning of the human-nature interface and address the unprecedented changes inflicted on the natural environment. Lastly, the fourth shift demands engaged scholarship that builds connections with society, enabling new ways of researching, organising, and living. In line with Ergene et al.'s 2020 [22] call for a systems orientation and restorative forms of organising, Hahn and Tampe (2021) [77] draw on a systems approach and propose to

reconceptualise business sustainability as regenerative business, i.e., "businesses that enhance, and thrive through, the health of social-ecological systems in a co-evolutionary process" (p. 456).

To accommodate these shifts and reintegrate biophysical realities back into the B&NE field, one obvious route would appear to be through developments in the relationship with the CE field.

The CE and B&NE Relationship as the Way Forward

For the CE field, greater integration with B&NE could allow it to move beyond its current techno-centric approach and positively engage with organisational processes and principles that frequently represent key barriers to practical progress. It would also help to extend the development of the field away from a reliance on practitioners and rebalance the emphasis on meso-level studies and technical micro-level studies by exploring the importance of firms as organisations. De Angelis (2021) [52] explores the organisational tensions and apparent paradoxes hampering the greater implementation of CE principles. We can, perhaps, add to this, with the apparently paradoxical relative disconnection between the CE and B&NE fields. CE provides exactly the type of multi-level perspective that Starik and Kanashiro (2020) [88] view as vital to developing more sustainable management theories. CE's roots in industrial ecology also mean it seems to offer a pathway for B&NE towards reintegration with a more physical systems perspective and towards more radical critiques of existing production and consumption systems and management practices.

The need for a radical paradigm shift in management thinking is recognised as crucial in achieving progress towards sustainability [75]. Reflecting upon the current state of research in the B&NE field, Hoffman and Georg (2018) [23] argue: "we are in a period of revolutionary science where the old models and theories used to explain the connection between business and the natural systems are no longer complete (…). The role of B&NE research in this period of flux is to help speed the process of paradigmatic change by conducting research that enlightens our way forward" [10, p. 56]. CE's potential as a new sustainability-orientated paradigm within our economies is a feature of the literature [18], but this is often articulated more specifically in relation to production systems or supply chains [10]. CE thinking can inform a deeper transformation of the paradigmatic roots of the B&NE field since it is consistent with the four shifts that Ergene et al. (2020) [22] identify as necessary to initiate such a transformation. Particularly: CE thinking aligns with the critical epistemological research insofar as it promotes an economy: "that is restorative and regenerative by intention and design" [32, p. 7] (shift 1); CE thinking embraces a relational ontology world view based on systems thinking, i.e., the economy is part of the wider socio-ecological system and the CE speaks of reintegration of economy within ecology [46] (shift 2); CE thinking draws significantly from nature's functioning principles [32, 45] (shift 3), and CE thinking encourages collaboration at different levels to promote a society-wide transformation [89] (shift 4).

In addition to the limitations of the CE already outlined in this paper, there may be a further limitation linked to CE's theoretical foundations that restricts its ability to deliver the paradigm shift in organisational and management theory that is required to make more substantive progress towards sustainability possible. The theoretical foundations of CE are based on translating the principles and practices that make natural systems sustainable across industrial-economic systems and hoping to replicate the material recycling and resilience of natural systems that are an outcome of many millennia of evolution. However,

that process of translation is limited by being both partial and uni-directional. It is partial in emphasising some of the elements of ecological systems that help them to be sustainable and resilient, while the application of others is limited by the boundary conditions within which the CE narrative operates. It is uni-directional in that the approach is to consider those characteristics of ecological systems that, if translated to economic systems, could enable them to become more sustainable. Yet, following Ergene et al.'s (2020) [22] flipped logic concerning the "ecological case for business" suggests the need for a reciprocal interrogation about which characteristics of our production and consumption systems tend to make them comparatively linear and unsustainable in nature.

Extending Circular Economy's Use of Ecological Principles

An early attempt to codify principles for ecological systems comes from Barry Commoner, whose pioneering work in ecology is recognised as a key precursor of CE thinking [21]. His four laws of ecology were articulated in the 1971 book *The Closing Circle* [90]. Commoner's third law: "*Nature knows best*" was intended to highlight that human interventions in ecosystems, irrespective of the scientific knowledge behind them, rarely lead to overall improvements in sustainability. For example, the indiscriminate use of antibiotics to promote growth in beef production may increase beef yields but at a wider system cost of growing antibiotic resistance and new "superbugs". The entire CE movement represents an application of the nature knows best principle. Within it, at a micro-level, firms may apply "bio-mimicry" [91] as a design process to create materials, processes, and products that mimic natural ones. At the meso-level, industries can pursue "bioeconomy" [92] strategies to harness the processes and materials provided by natural biological systems to meet industrial needs. Although authors such as D'Amato et al. (2017) [92] and D'Amato and Korhonen (2021) [93] view such bioeconomy strategies as a distinct alternative to CE as a sustainability strategy, evolving definitions of CE reflect such applications of the third law. The Ellen MacArthur Foundation's underlying model for CE combines biological cycles as the basis for material production and consumption and nutrient recycling, with technical cycles that aim to recover, restore, and recycle other materials [32]. CE's focus on resource sustainability via waste prevention [94] reflects Commoner's second law: "*Everything must go somewhere*". In other words, nature does not deal in "waste" and there is no "elsewhere" into which used materials or toxic by-products can go.

Commoner's first law—"*Everything is connected to everything else*"—underpins an understanding of the biosphere as an ecological web in which individual changes, such as habitat or species loss, will have repercussions elsewhere that may be unpredictable. CE thinking, drawing on systems thinking, acknowledges the existence of many parts in a system, i.e., organisations are parts of interconnected economic, ecological, and social systems, and the implications this has for product and system design [89]. A product fit for a CE is one designed considering its interactions with economic and ecological systems along its entire lifecycle, and any organisation wishing to move to a CE needs to consider its wider system interactions [89]. CE, particularly at the meso-level, when considering entire industries as production and consumption systems, does take a more holistic and open systems approach to understanding the behaviour of industries and the companies within them than conventional management theory perspectives. Yet, while these systems are generally considered in a form that is abstracted from the wider socio-political systems within which they are embedded [20], and from indirect physical consequences, there will be limits in terms of what the CE is able to achieve. Partly because vehicles for CE theory,

from academic papers to policy documents, will have limits to what is considered acceptable in terms of complexity and length, it will always struggle to fully accommodate *Commoner*'s first law.

It is Commoner's pithy fourth law—"*There is no such thing as a free lunch*"—that CE arguably takes least account of. The failure of current production and consumption systems to internalise their external social and environmental costs is a fundamental cause of their unsustainability [20, 71]. The point of this law is that all human interaction with natural systems, particularly exploitation or interference, has consequences. This is not arguing that benefits from natural systems are not (financially) freely available since many millions of people still rely directly on these systems for nutrition and materials. Even those benefits are not "free" because they depend upon the maintenance of system inputs (water, energy, nutrients) and ongoing system integrity. A key implication of the fourth law for CE is that circularity's ability to contribute to sustainability will be limited while economic systems fail to reflect the full socio-environmental costs of resource extraction as emphasised in several CE publications [89, 94]. At micro and mesolevels, this will require the adoption of full-cost accounting principles to internalise costs that currently remain unmet and treated as externalities, and material flow cost, accounting practices for both the physical and monetary flows through production and consumption systems [95]. At a more macro-level, it will require the abandonment of subsidies that distort natural resource markets and encourage wasteful consumption and production practices. The scale of these subsidies was revealed in Parry et al.'s (2021) [96] analysis, demonstrating that global energy markets involve $11 M in subsidies for fossil fuel producers every minute.

Making Management Principles More Ecologically Oriented

CE is part of a long-standing tradition of using ecological concepts to understand organisations and their relationships with one another and to their environments. Ideas of ecosystems, niche occupancy, resource competition, and competitive exclusion (two entities cannot coexist within the same niche for long, eventually one outcompetes the other), symbiosis, producers and consumers, productivity, territories, predator–prey relationships, lifecycles, resource access "chains", and resilience are amongst those derived from nature and applied, literally and/or metaphorically, to organisations and industries. To use CE principles as the foundation for a theory of sustainable management research, we need to go beyond simply extending the application of ecologically-based principles to understand and manage our production and consumption systems. We also need to apply Ergene et al.'s (2020) [22] principle of "flipping" how we interrogate the relationship between ecology and economy to examine which existing management principles work against, rather than with, the four laws of ecology. Several candidate concepts emerge where reconsideration from a more ecological perspective may be beneficial:

Value

At the heart of CE's potential contribution to more sustainable business is the notion of retaining the value of resources within production and consumption systems. A shared concept between ecological and economic systems is resources having value in terms of importance, worth, or usefulness. However, most discussion of the value of natural resources and the ecosystem services they provide comes from an anthropocentric and economic perspective, prioritising human stakeholders and monetary value, and producing quasi-market

values for non-market resources [97, 98]. Siderius and Zink's [71] analysis of the incompatibilities between CE and market economies places considerable emphasis on misconceptions of value in relation to notions of scarcity and the prices attached to resources. However, the grounding of their analysis in the market economy and an anthropocentric perspective may close off the lessons about value that an ecological perspective may offer.

In ecological systems, the key resources are energy (food) and water to facilitate survival and activity, and materials that can allow organisms to build and maintain themselves and engage in beneficial activities (such as creating shelter or attracting mates) [99]. O'Connor et al. (2019) [100] argue that ecological systems depend for their survival not just only on those inputs but also on information and information networks. Biodiversity, they argue (p. 2), represents: "*…a form of information; it is information stored in genes, morphologies, traits and behaviors that reflect the ecological and evolutionary history of life on earth*". Finally, organisms may derive strategic value (improving their odds of survival and ability to reproduce) through particular locations within their environment (such as a defendable habitat), or relationships with other organisms (which could be social relationships between members of a species, or parasitic/symbiotic relationships with other species). All of these aspects of value expressed in ecological systems can find parallels within economic systems, although human socio-cultural relationships introduce a range of other value concepts such as economic value, emotional value, psychological value, and status value[1] [101]. There is an intersection between value in ecological and economic systems provided by the obvious example of natural resources and a growing interest in the concept of socio-ecological systems [102], and also in the less obvious concept of the positive environmental value of particular technologies or economic strategies, explored in a CE context by Manninen et al. (2018) [103].

Two crucial and interrelated questions concern how value is judged and from whose perspective [97]. For organisms within natural systems, benefits via energy, resources, locations and relationships that facilitate survival and activity can result directly from their choices and actions, or indirectly from the actions of other organisms (e.g., predators benefit scavengers), or from serendipitous external circumstances (such as weather events). The patterns of value that accrue to different organisms within an ecosystem are the result of the many individual (and for some species collective) strivings to survive and access valuable resources [99]. Despite this rampant individualism, ecosystems tend to establish sustainable long-term balances in the production and consumption of resources despite short-term fluctuations, such as the balances between predator and prey populations [99].

The potential to make business production and consumption more sustainable is limited by a tendency to focus on the delivery of value to a limited number of stakeholders. Although a marketing perspective frames value generation as about meeting consumer needs [104], since the late 1970s, management theory and practice have become predominantly concerned with delivering value to shareholders in the form of economic returns, despite robust critiques of this approach and its consequences for society and the environment (see, for example, Mulligan 1986 [105]). Using economic criteria to judge value is problematic in many ways, partly because it ignores social and environmental benefits that accrue outside of formal market exchanges, and also because of the treatment of some costs as externalities. The ultimate expression of the limitations of economic valuations comes at the aggregate level and the pursuit of economic growth as measured by GDP

[1] There is, however, evidence that some more complex species engage in symbolic, exchange, playful, or social behaviours with similarly indirect and/or complex benefits.

[106]. Such an entirely quantitative measure treats all economic activity as "valuable" so that wars, epidemics, and natural disasters are placed on an equal footing with socially and environmentally constructive activities as sources of "value".

Hearn and Pace (2006) [107] argue for adopting an ecologically-inspired approach to understanding business systems as "value ecologies" instead of value chains to better capture the holistic and dynamic nature of business systems; to move concepts of value beyond a focus on products and consumption; to capture the complexities of relationships that can be both cooperative and competitive; and because it: "opens the door to evolutionary metaphors to analyse change and development of the context of businesses" (p. 55). Although they saw these benefits in relation to conventional notions of competitiveness, they are equally relevant to the pursuit of business sustainability.

Principle of Indirect Equivalence (in Value) Rather than Direct Equivalence (in Function)

In nature, there can be direct functional equivalence between ecosystem components so that one carnivorous predator may consume a calorific equivalent alternative species instead of its usual prey if it is unavailable [99]. It will not be able to switch to a vegetarian diet with the same calorific value as an indirect equivalent, or trade a water supply for a food supply. Business systems work on the basis of indirect equivalence through the use of monetary valuations that allow the worth of resources, products, ideas, organisations, and environmental damages to be calculated and compared as a basis for exchange. Hornborg (2017) [108] argues that "general purpose" money created a notion of "generalised interchangeability" that has been central to industrialisation and the rise of neoliberal economic theory, leading to growing wealth inequality and to the systemic ecological degradation linked to our behaviours, policies, and institutions. Such interchangeability is a key component of "soft" sustainability concepts in which interchanges between natural, social, and economic capital are acceptable in order to sustain our economic systems' productivity, even if that is at the expense of some forms of natural capital [106].

Time, Space, and Energy

Webster (2021) [21] sees CE's contribution to sustainability as inherently linked to its role in orientating the economy towards the long term, a theme echoed by Masi et al.'s (2017) [9] view of long-time horizons as crucial to a shift to circular supply chains, and Kok et al.'s (2013) [109] identification of short-termism as a barrier to the changes in organisational structures and cultures that CE requires. Time is, however, not a simple or isolated phenomenon, and as Einstein's special theory of relativity stresses, it is intertwined with the physics of energy, matter, and space. Good and Thorpe (2020) [110] stress the importance to sustainable business theory of understanding the temporal and spatial dimensions of both natural and organisational phenomena. The difference between the two types of phenomena, however, is that, while natural organisms are bound by natural temporal and spatial barriers, organisations can transcend them.

Energy, as a common denominator of both ecological and industrial systems, has interested energy economists and others since Odum (1973) [111] introduced energy accounting and the solar emjoule as a common basic unit of energy. For management scientists, who tend to consider organisations as abstract rather than physical entities, there may be a temptation to view money as the metaphorical energy on which commercial production

and consumption systems run. However, the abstract nature of money and its instrumental rather than intrinsic value [98], combined with its role in interchangeability and value exchanges of indirect equivalence, allows economic systems to transcend the limitations of time and space that ecological systems are subject to. Ecological systems operate through a spatially and temporally direct network of connections (as per Commoner's first law). Whales may be able to hear each other at a distance of thousands of kilometres, and a seed from a Siberian silene stenophylla successfully germinated after 32,000 years, but such examples stretch the direct constraints of time and space rather than transcending them. Human constructs of money and culture allow cause and effect to transcend direct and continuous temporal and spatial relationships so that an individual could arrange for a tree to be planted after their death in a country they had never visited.

Although time is a commonality between ecological and economic systems, it is not simply a shared system property. The conventional chronological perspective rooted in physics measures time as a property, but, more subjective, social perspectives consider how we experience events in terms of sequencing and the "rhythms" of life. This distinction between the concepts of "duration" and "succession" [112] is framed in a business context by Halinen et al. (2012) [113], contrasting "clock time" and "event time". Ecological systems reflect time passing through seasons and day/night or lunar cycles, and frequently depend on timing and sequencing. However, they are typically not subject to precise timing but, rather, to the confluence of a variety of environmental factors. For example, the mass coordinated reproductive event of coral spawning can be predicted to occur at sunset, on a day shortly after the full moon in October or November, but which month and which day will be influenced by temperature, weather, and current conditions [114].

Human timekeeping depends on harnessing natural phenomena with regular periods of oscillation and has evolved towards increasing precision from an initial dependency on planetary orbits to measuring the energy properties of caesium atoms. Technology and culture have allowed human systems to become increasingly synchronised and precisely timed. Where once sundials created local time for every town, the growth of railways and electric telegraph time signals prompted a standardisation around "railway time" and a timetable. This allowed railway operation, and the businesses relying upon it, to become increasingly precise, synchronised, and efficient. These principles found their ultimate expression in just-in-time logistics systems, which are associated with both economic and ecological efficiency and the potential to reduce waste [115]. However, they also have a vulnerability to risks. In ecology, systems tend to evolve towards a balance between efficiency and resilience [99]. Therefore, hunting animals will marginally compromise their speed by carrying some reserves of fat to improve their overall chances of survival (the exception being cheetahs, and, although this has encouraged their use as metaphors for "lean" enterprises, it also represents an "over-specialisation" that increases the species' risk of extinction, as observed by Wildavsky (2017) [116]. Likewise, effectiveness, qualified as the interplay between efficiency and resilience [117], is where CE thinking stands [118, 119].

The spatial elements of the supply chains underpinning our production and consumption systems also have sustainability implications. Global supply chains can concentrate production in particular localities in ways that overcome natural system constraints of time and place through the application of technology and money—for example, to make strawberries available in supermarkets all year around. This concentration of supply is in marked contrast to ecological systems that tend to draw productive capacity, strength and resilience from geographical diversity [120]. The globalised scope of production and consumption systems poses a particular challenge for CE initiatives whereby the material benefits for

sustainability of remanufacturing or recycling products are likely to be lost to the carbon costs involved in transporting them multiple times around the globe. For that reason, there is increasing interest in localised or regionalised CE initiatives, for example, based around consumption and production within a city or region [50].

Discounting/Depreciation

The concepts of value and time combine within accountancy in ways that can work against sustainability. Discounting is used to translate an assumed future cost into a current monetary value but is compromised by the uncertainties that surround future costs and the distorting and over-amplifying nature of compounding effects [98]. By opting to utilise a relatively high discounting rate and/or a long time frame, strategies capable of generating significant short-term profits, but sizeable long-term environmental costs, can appear attractive. Depreciation is applied to judge how asset values change over time. This can involve straight-line depreciation whereby an asset depreciates the same amount annually till it has zero value. An asset expected to last 5 years would, therefore, depreciate by one-fifth of its cost each year. Diminishing value depreciation involves an asset losing a higher proportion of its value in the first few years, and certain assets are depreciated by use over time rather than time itself. A vehicle might be depreciated according to the number of miles driven, or a packaging machine according to the number of products boxed up. Any of these methods can result in a fully functional asset, such as a piece of machinery, being accorded zero value in a company's accounts. This focus on a hypothetical monetary value instead of functional value may artificially shorten equipment lifespans, disincentivise life-extending maintenance, and lead to environmentally sub-optimal decisions by companies [121].

Ownership and Control

Many of the socio-cultural concepts of value are entwined with the idea of ownership and society's emphasis on the importance and rights attached to private property, which are core tenets of market economies but problematic for a transition to CE [71]. Possession of resources is widely observed within ecology as organisms seek to access, defend, and hoard resources in order to access their energy, material, or other strategic survival benefits (such as shelter, camouflage, or mate attraction). The legal construct of ownership creates an abstract equivalent to the physical notion of possession that allows organisations and individuals to maintain their (legal) possession of, and right of access to, resources even when they are physically distanced from them. The perceived psychological benefits of owning products, as opposed to being simply able to access their benefits through renting or product/service systems, are one of the barriers that proponents of CE initiatives need to overcome [122].

Business supply chains depend upon being able to identify and agree who has a legally justified claim of ownership of resources, and on processes to change that ownership by agreement. This is typically through the payment of an agreed monetary price, reflecting a written or verbal contract [123]. Such exchanges of ownership lead to a transfer of the rights to exploit a resource, and also of the responsibilities relating to that resource. Extended producer responsibility legislation has added to the conventional responsibilities of liability for any environmental or social damage associated with a product (or the resources behind it). These additional responsibilities can include mandatory economic

responsibilities for used product collection and recycling, and responsibilities to inform customers about products' environmental properties [124].

The linear nature of conventional production and consumption systems creates ownership-based market failures in two ways. At the start of a linear supply chain, natural resources are treated as "freely" available (beyond extraction costs) to those owning the land they are located on, and also to those able to access common resources (like wild fish) without identifiable owners, leading to "tragedy of the commons" effects [125]. The creation of waste and pollution within supply chains also creates materials perceived to lack ownership, and whose residual value may risk being lost [78]. CE initiatives partly seek to avoid this loss of value in economic systems by avoiding the production of pollution and waste. However, one challenge involved in increasing resource longevity through circularity and improving material efficiency through servitisation and modular design is that of creating effective contracts that can cope with the complex issues of ownership, value, responsibility, and risk that are generated [126].

Connected to ownership is the concept of control. Controlling the use and ultimate destiny of resources may be linked to physical possession rather than legal ownership. The use, maintenance, and survival of a leased car as a physical asset will depend on the leaseholder's behaviour more than that of the legal owners. Similarly, CE systems based around reclaiming post-use purchased products will depend on the customer's willingness and ability to return the used product into the production and consumption system regardless of the producer's extended responsibility obligations. As Siderius and Zink (2022) [71] discuss in detail, a transition to the CE will require a shift from considering resources in terms of ownership and control to a vision based on access and stewardship.

Roles

Within both ecological and economic systems, different entities play different roles and fulfil particular functions. In conventional, linear economic systems, the boundaries between entities and their roles are very clearly defined. Porter's (1985) [127] "Value Chain" and "Five Forces" models are two of the best-known examples of such clearly defined roles within linear systems. An important effect of CE is to blur such roles, with what was once an "end customer" now becoming a re-supplier of value to producers through the return of used products, with implications in terms of power and responsibilities [128]. A more ecologically orientated view of relationships and roles within production and consumption systems has the potential to better capture the potential of complex and ambiguous interactions [71] such as the emergence of "co-optition" among players within a market, or the potential for sustainable value co-creation amongst different types of stakeholder [107].

Discussion

Overall, the existing dominant linear systems business paradigm is based on: abstract monetary notions of value and the interchangeability of resources this allows; contractually bound transactional relationships between discrete entities within production-consumption systems in which ownership of and responsibilities for resources are transferred at a specific time and with a specific monetary valuation; and excluding from such valuations certain socio-environmental costs that are treated as externalities. The CE can act as a bridge between the abstract world of the "econocentric" paradigm and the physically orientated

world of the "ecocentric" paradigm to contribute to the type of new "sustainacentric" paradigm envisaged by Gladwin et al. (1995) [75]. Econocentrism requires precision relating to value (monetary), ownership, production/consumption roles, boundaries, and time (with a focus on clock/calendar/contractual time). Sustaincentrism needs to allow for ambiguity/fuzziness relating to value (functional), ownership, production/consumption roles, boundaries, and time (with a focus on cyclical, sequential time). As Rogers and Bardenhagen (2013) [97] discuss in relation to attempts to economically value natural resources, this is impossible to do accurately within ecosystems by considering and valuing resources individually, since it is the complex interactions and co-dependencies between resources that generate the overall system's value. A similarly holistic approach to understanding production and consumption systems, and the value they produce, is required, going beyond the reductionist principles that have underpinned the evolution of management science.

For CE to help deliver sustaincentrism, it will need to embrace these elements of holism and ambiguity/fuzziness; for example, Nygaard (2022) [129] argues that the CE increases performance ambiguity, and potentially resolving a range of associated paradoxes [52]. There are already promising moves in this direction, for example, Kokkinos et al.'s (2020) [130] use of Fuzzy Cognitive Map modeling to cope with the complexities of understanding sustainability performance with circular systems. Lahti et al. (2018) [53] highlight problems in developing suitably detailed contracts as a key problem to be solved in successfully developing CE initiatives. In practice, such contracts may need to be superseded by more flexible "agreements" of the sort used in managing waste-based resources [131] to reflect unknowns in terms of the speed at which resources will circulate, and the value they are accorded during multiple future different cycles. This will be a very different challenge to creating the type of event-specific transactional contracts that have typified conventional linear supply chains. It is a challenge already being confronted by the accounting field, for whom CE principles pose considerable issues relating to valuations and tax liabilities, which they are seeking to address, for example, through the Financial Accounting in the Circular Economy report [132]. In many ways, this will parallel a paradigm shift away from the transactional, and towards the relational, that is reminiscent of the switch to a service-dominant logic in the marketing field. The difference being instead of relating to a metaphorical service ecosystem [133], it will help to protect more literal ecosystem services.

Since Gladwin et al.'s (1995) [75] early call for a paradigm shift in management research involving the reintegration of economy within ecology, little progress has been accomplished in enriching the foundations of management theory with ecological thinking [26, 81], leaving management research still struggling for more relevance in the face of the challenges posed by the Anthropocene. George et al. (2015) [134] call upon management scholars: "to take up grand challenges to provide strategic and managerial insights in conversations and debates that have so far been held by policymakers, economists, natural scientists, and engineers" (p. 1596). Similarly, Hoffman and Georg (2018) [23] argue that it is time for business and natural environment scholars to engage in an intellectual effort to accelerate paradigmatic change since theories and frames currently in use are no longer suitable to model the business and natural environment interface.

To move beyond incremental but inadequate progress towards substantially more sustainable business practice and management theory, and beyond a dependence on "business-as-usual" responses, we need more conceptual research that challenges the existing paradigm. Unfortunately, it is often the case that empirical research is preferred to conceptual research in organisation and management studies, leading to "conceptual blindness" [135, p. 161], and, in the CE field, there are some, like Kirchherr and van Santen (2019) [43],

who see the practical challenges faced by those trying to promote CE initiatives as requiring further empirical research rather than deeper theoretical discussions. Conceptual work, however, is necessary to reduce complexity, to take stock of the available knowledge and to enable more systematic theorising [136, 137]. This is not to disparage or discourage empirical work, which will also be vital, for example, to investigate under what circumstances frame-breaking industrial paradigms are likely to emerge. Will it be down to personality traits, internally developed resources and capabilities or wider policy interventions or institutional arrangements?

In response, this article has made a case for a CE-inspired paradigm revolution in the B&NE field. Our line of enquiry is consistent with Landrum and Ohsowski's (2018) [25] and Hofstetter et al.'s (2021) [138] (in this journal) calls for expanding the frames through which sustainability is understood in the business context by grounding it in environmental science to make a valuable contribution to the B&NE literature, which has yet to be fully infused with ecological principles [81, 139].

The apparent sympathy between CE and the B&NE literature that seemed obvious during its critical epistemological period has since lapsed into a relative disconnect between the two that seems paradoxical. Using CE perspectives to encourage a reconsideration within B&NE theory offers up the possibility of transforming that relationship into something (to use another ecological metaphor) that is more symbiotic and mutually reinforcing. This, however, will depend upon identifying and addressing those "unnatural" elements within current management principles that act as barriers to more circular and sustainable practices. This, in turn, may depend upon a return to CE's ecological roots in the search for insights that will allow circular systems to become organisationally as well as technically feasible.

Conclusion

Practical and empirical studies of CE will be important to its future but may be of little consequence unless the foundational and theoretical ideas behind the CE are also debated and developed. Siderius and Zink (2022) [71] opened up an important discussion about how fundamental incompatibilities between the ambitions of CE and the underlying macro-level principles of the market economy as part of the dominant social paradigm has left CE stuck between its potential for systemic change and a reality of reinforcing the status quo. Our analysis began from a different starting point, that CE was also held back by the paradoxical disconnection between CE principles and sustainability-orientated management theories, explaining the behaviour of the firms through which CE progress would need to be delivered. Perhaps, unsurprisingly, we arrived at some similar conclusions to Siderius and Zink (2022) [71], particularly regarding the need to rethink conceptions of value, how we approach ownership and control of resources, and the roles and relationships that underpin our production and consumption systems. These factors resonate at the macro-level of our economic systems and dominant social paradigms and at the micro-level of firm behaviour. Even Siderius and Zink's [71] conclusion that new wisdom about harmonising human development and nature may be found in the indigenous knowledge of peoples whose cultures predate the industrial era also has an organisational-level precursor in the proposal of Peattie (2005) [140] that indigenous codes of conduct may offer an alternative and more sustainable template for organisational leadership.

Our analysis also shares with that of Siderius and Zink's [71] the inevitable limitation that attempting to bring to an analysis of the potential of CE numerous complex themes introduced from several other disciplines risks the coverage of each only being superficial. Our exploration of the different frames required to understand how CE can make both a practical contribution to sustainability transitions and enhance sustainability management theory has gone beyond environmental science to draw ideas from ecological economics, the sociology of time, legal constructs related to ownership, business-to-business relationships, and the application of ecological metaphors. Each of these represents a substantial field of scholarship that is difficult to encapsulate within a handful of paragraphs, but each can be regarded as an opportunity for further detailed research into their relevance for the future development of CE practice and theory. In fact, one of the merits of this paper is to point to the importance of aiming for transdisciplinarity in our research endeavours, in line with Shrivastava et al.'s (2013) [141] who argue that "there is no single discipline or perspective that can offer complete answers to sustainability challenges" (p. 236). Our contribution may also span the academic field to reach management practice wherein overcoming the separation mindset is crucial to foster the development of business strategies that respond to the challenges posed by the Anthropocene.

Data Availability Not applicable.

Materials Availability Not applicable.

Code Availability Not applicable.

Declarations

Conflict of Interest The authors declare no competing interests.

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