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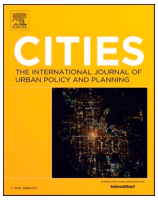

Sustainability transitions to circular cities: Experimentation between urban vitalism and mechanism

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ABSTRACT

The "circular city" is a recent addition to a string of urban sustainability concepts that call for transformative changes in the way we plan, build and (re-)shape cities. However, it is often criticised for its ambiguity. Experimentation is a prevalent mode of urban governance for realising transformative ambitions in the face of deep uncertainty and ambiguity, yet it is highly malleable for diverse (and vested) interests. This conceptual article explores the circular city as a boundary object which can have multiple translations amongst actors working toward a seemingly common goal. Based on examples of circular experimentation in the existing literature, we characterise mechanistic and vitalist worldviews of the circular city—where the former views the city as a controllable mechanical system while the latter likens the city to a living being. We identify contradictions between mechanistic and vitalist tendencies within the visions, networks and learning processes of circular experimentation. We argue that boundary objects can be a useful tool for facilitating a productive dialectic between worldviews in urban experimentation, using contradiction as a driver of change. We conclude with recommendations for facilitating a dialectical approach to experimentation and suggestions for further research.

1. Introduction

As the closest level of governance to citizens, cities play a crucial role in driving the circular economy ambitions set out in the European Commission's Green Deal. Policy programs and city networks by the OECD, European Union, ICLEI, and think tanks and consultancies such as the Ellen MacArthur Foundation, Metabolic and Circle Economy increasingly promote and support cities in transitioning to the circular economy. The circular economy is considered a system of production, distribution and consumption where the concept of waste is eliminated and replaced through reducing or alternatively reusing, recycling and recovering materials, as well as regenerating ecological systems with the aim to create environmental, social and economic sustainability (Kirchherr, Reike, & Hekkert, 2017, p. 229). Therefore, the ideal of a circular city describes a city which "embeds the principles of a circular economy across all its functions" (The Ellen MacArthur Foundation, 2017, p. 7).

Transitioning to circular urban systems will require sustainability transitions, which encompass more than just technological innovations but also far-reaching changes in markets, policies, practices and cultures toward more sustainable means of consumption and production (Markard, Raven, & Truffer, 2012). Seminal sustainability transitions frameworks such as strategic niche management (Schot & Geels, 2008; Schot, Hoogma, & Elzen, 1994) and transition management (Loorbach, 2007) have emphasized the importance of providing favourable conditions for experimentation in a protective environment that allows innovations to co-evolve with user practices, policies and markets before being exposed to the selection pressures of the established regime. Cities are thought to provide conducive environments for niche experimentation, for example through urban living labs (ULLs) or citizen-led initiatives (Bulkeley et al., 2016, 2019; Geels, 2010; Voytenko, McCormick, Evans, & Schliwa, 2016; Wolfram, 2018). Many cities have already begun experimenting with circular economy initiatives as part of their climate and environmental strategies and strive to become so-called 'circular cities' (Cuomo, Ravazzi, Savini, & Bertolini, 2020; Florez Ayala, Alberton, & Ersoy, 2022; Paiho et al., 2020; Prendeville, Cherim, & Bocken, 2018; Williams, 2019). However, there is limited evidence so far that these experiments have transformed the socio-institutional settings in which they are embedded (Williams, 2021a, p. 134).

With its popular metaphor of moving from a 'linear' to a 'circular'

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system, the circular economy engages a variety of actors from all spheres of society, albeit in different and sometimes contradictory ways (Korhonen, Nuur, Feldmann, & Birkie, 2018). Studies analysing the range of manners in which the circular economy is imagined and/or implemented at the urban scale often contrast technocentric and grassroots approaches (Bassens, Kębłowski, & Lambert, 2020; Bauwens, Hekkert, & Kirchherr, 2020; Friant, Reid, Boesler, Vermeulen, & Salomone, 2023; Genovese & Pansera, 2019; Marin & De Meulder, 2018). In the following paper, we relate these approaches to mechanistic and vitalist worldviews in urbanism, where the former understands the city as a human-engineered machine based on technical systems and routines while the latter views the city as a living being with a "soul" made up of the intangible, relational forces that constitute urban life (Adams & Tiesdell, 2007; Amati, 2021; Mehmood, 2010; Pløger, 2006; Sap, 2002). Applied to the circular city, each worldview promotes a vision of circularity that, so far, has had limited success in becoming institutionalised in its ideal form. Scalable eco-city and eco-district demonstration sites frequently struggle to attract inhabitants; grassroots experiments arise from community needs but are typically crowded out by commercial urban development (Marin & De Meulder, 2018; Williams, 2021a). Their underlying mechanistic and vitalist worldviews starkly clash in many ways, yet at the same time, each appears to possess something the other crucially lacks.

Urban experiments are often riddled with contradictions and paradox, which Castán Broto (2015) argues can either lead to paralysis or generate change. Rather than attempting to resolve contradictions by eliminating or establishing primacy of one alternative over the other, she argues for a dialectical approach to contradiction. A dialectical approach transcends the binaries of simple opposition by recognising "the mutual interdependence of opposites rather than their mutual incompatibility" (Castán Broto, 2015, p. 464). Engaging with a dialectical approach in urban sustainability transitions requires collaboration between actors with conflicting worldviews. In the following article, we propose the use of boundary objects as a dialectical tool within urban experimentation processes. Boundary objects are concepts (or ideas, physical objects, etc.) that are flexible enough to adapt to the specific contexts of different social worlds, yet structured enough to serve as a common point of reference for collaboration (Star, 2010; Star & Griesemer, 1989). Boundary objects can facilitate sustainability transitions by enabling collaboration without constraining valuable diversity (Franco-Torres, Rogers, & Ugarelli, 2020). The circular economy can be considered a boundary object; its vague, multifaceted and contested nature simultaneously enables fruitful collaboration between heterogeneous actors (Berry, Haverkamp, Isenhour, Bilec, & Lowden, 2022; Rödl, Åhlvik, Bergeå, Hallgren, & Böhm, 2022; Rosenlund, 2017). However, the broad nature of boundary objects like the circular economy can also conceal conflicts and tensions under a depoliticised heading (Niskanen, Anshelm, & McLaren, 2020). This is also evident within the prominent "win-win" framing of the circular economy (Kovacic, Strand, & Volker, 2021; Niskanen et al., 2020). Therefore, the aim of this article is to unpack the contradictions within the circular city as a boundary object. Based on a narrative review of the growing field of literature on circular cities and informed by mechanistic and vitalist worldviews of urban life, we consider the possibilities for a dialectical approach to circular urban experimentation.

The next section provides the theoretical background of the paper, founded in urban experimentation, boundary objects and urban vitalism. The third section applies mechanistic and vitalist worldviews to the literature on circular cities. In the fourth section, we reflect on the analysis and its implications for the visioning, networking and learning processes of urban experimentation. In the fifth and final section, we discuss the limitations of the paper and directions for further research.

2. Theoretical background

2.1. Contradictions in urban experimentation

Urban experimentation describes "inclusive, practice-based and challenge-led initiatives designed to promote system innovation through social learning under conditions of uncertainty and ambiguity" (Sengers et al., 2016). Transition scholars argue that urban experiments constitute a new form of urban governance that involves a more incremental, practically-oriented, interventionist approach than the more conventional development of urban plans and strategies (Bulkeley et al., 2016; Bulkeley & Castán Broto, 2013). Studies of urban experimentation draw on Strategic Niche Management (SNM), a central approach within the sustainability transitions literature, concerned with the creation, development and controlled phase-out of protected spaces, or 'niches', for experimenting with sustainable innovations before they enter into competition with the established regime (Kemp, Schot, & Hoogma, 1998; Schot et al., 1994).

The articulation of compelling *visions* and expectations, the creation of heterogenous *networks*, and social *learning* from multiple experiments are considered key internal processes for successful emergence of niche environments (Geels & Raven, 2006). SNM emphasises that social and technological change are co-constituted and should be integrated during experimental processes rather than focusing primarily on technological innovations. Niches can be purposively orchestrated by policy actors or arise emergently through the collective action of social groups and users (Schot & Geels, 2008). Other scholars have pointed out that the 'protective space' of niches is not neutral; niches can 'empower' sustainable innovations to either *fit-and-conform* to meet the selection pressures of the existing regime—usually at the expense of strong sustainability values—or to *stretch-and-transform* the regime by reconfiguring parts of the dominant selection environment (Smith & Raven, 2012). Furthermore, Savini and Bertolini (2019) highlight the politics of niches in an urban context, where engrained power structures can nurture, but also stifle, marginalise or assimilate emergent solutions that fundamentally challenge the current regime. Torrens, Schot, Raven, and Johnstone (2019) argue that urban contexts provide more than just a protective space for experiments to emerge. Firstly, cities are links within transnational networks for the circulation of knowledge and resources that can amplify experiments. Eco-districts, demonstration sites and development projects can provide cities with frontrunner status and attract further resources for experimentation, in a self-reinforcing pattern. At the same time, cities are political arenas where divergent interests collide through contestation, struggle and conflict, often driven by (or giving rise to) grassroots and social innovation in particular.

A fundamental question within experimentation is how to create wider transformative change beyond individual experiments. Urban experimentation can arise both from local needs as well as global processes of restructuring (Hodson, Geels, & McMeekin, 2017, p. 5; McCann, 2008; von Wirth, Fuenfschilling, Frantzeskaki, & Coenen, 2019). Thus, tensions can arise between the need to be place-specific but also to generate knowledge that is more broadly applicable as well as scalable solutions that can be implemented in other places. While universal platforms for urban services such as Airbnb and Uber can experience fast growth, their solutionist approach has shown to wipe over contextual specificities in socially harmful ways (Pfotenhauer, Laurent, Papageorgiou, & Stilgoe, and J., 2022). Grassroots innovations, on the other hand, are more connected to local realities but are less suitable for linear growth or replication (Seyfang, 2010). While they can spread to other contexts, for example through translocal networks (Loorbach, Wittmayer, Avelino, von Wirth, & Frantzeskaki, 2020), they do not necessarily aspire to do so and scaling logics can conflict with initiatives' sense of identity (Augenstein et al., 2020). Striking a balance between place specificity and wider-scale relevance is therefore a challenge, and requires thoughtful experiment design that emphasises reflexive learning (Augenstein et al., 2020; von Wirth et al., 2019). Beyond a

narrow focus on scalable outcomes, urban experimentation provides a space where a multiplicity of socio-technical arrangements, modes of governance, and understandings of sustainability can compete, co-exist or complement each other to reconfigure existing urban systems in a way that is specific a particular place (Hodson et al., 2017). Torrens and von Wirth (2021, p. 7) call this *generative multiplicity*, which is "premised on sustaining and culturing plural variations of experiments simultaneously, bringing about new forms of contestation and contradiction to stimulate higher-order learning processes and transformation of socio-material configurations". In the following, we explore how boundary objects can help to foster such generative multiplicity within experimentation processes.

Castán Broto (2015) warns that polarising approaches to contradictions within experimentation can lead to paralysis and, instead, advocates a dialectical approach. The dialectical perspective understands human reality as made up of logically and socially constructed contradictions, or "opposed yet interdependent elements which presuppose each other for their existence and meanings" (Hargrave & Van de Ven, 2017, p. 325). These elements are often referred to as the thesis and antithesis, or affirmation and negation. Castán Broto (2015) emphasises that within the Hegelian model of dialectics, contraries are intrinsically related and, thus, the negation is not simply reducible to the opposite of the affirmation. Rather, she argues, "contradiction needs to be approached from a non-bivalent perspective that looks beyond the opposition of contraries and explains, instead, how contraries are mutually constituted" by explaining the conditions that produce the contradiction (p. 465). The contradictory element arises as a product of the affirmation and its incompleteness, expressing a desire for change and action. Castán Broto (2015) relates this to the contradiction experienced when ideals of low carbon futures clash with lived urban realities.

Contradiction is resolved once either a synthesis or transformation takes place, where transformation can be described as "the ordering of parts to form a new whole or that neither side could have produced itself" (Hargrave & Van de Ven, 2017, p. 326). This can only be achieved if the proponents of the contradictory element can build enough power to challenge the already established affirmation. In conclusion, conflict and contradiction are generative forces that awaken a desire for change and can lead to transformative action (Castán Broto, 2015; Hargrave & Van de Ven, 2017).

2.2. Boundary objects

Originating from the field of science studies, boundary objects are concepts (or things, discourses, processes, etc.) that facilitate collaboration between heterogenous actors even in absence of consensus (Star & Griesemer, 1989). Boundary objects are thought to be a useful tool that can be intentionally used in transition processes to articulate selection pressures, build cooperation amongst conflicting worldviews without constraining diversity, and concentrate resources in order to make transition possible (Franco-Torres et al., 2020, p. 35). For example, framing traditional urban systems, like cycling networks, as boundary objects can facilitate experimentation by inviting alternative interpretations of objectives, challenges and their solutions rather than defaulting to dominant logics (Fastenrath & Coenen, 2021). The circular economy (Rosenlund, 2017) and other related urban concepts have been studied as boundary objects, such as urban metabolism (Newell & Cousins, 2015), urban mining (Wallsten, 2015), green infrastructure (Garmendia, Apostolopoulou, Adams, & Bormpoudakis, 2016) and ecosystem services (Abson et al., 2014).

Boundary objects are ambiguous and ill-defined at the common level and more well-defined at the individual level, where actor groups produce their own translations of the boundary object based on their intrinsic values and worldviews. This produces a dynamic where actors move back-and-forth between ill-defined and well-defined forms of the boundary object (Star, 2010) (see Fig. 1).

Over time, certain actors (typically those with administrative agency) attempt to bring this flux between ill-structured and well-structured aspects of the boundary object under control through methods of standardization, such as the creation of rules, definitions and classifications (Bowker & Star, 1999; Star, 2010). Inevitably, such processes are wrought by power dynamics where certain actors have more influence than others over which translations become standardized. Particularly in contexts of urgency, the translations which best align with dominant logics are likely to overpower new or alternative translations associated with greater uncertainty (Fastenrath & Coenen, 2021; Franco-Torres et al., 2020; Hawkins, Pye, & Correia, 2017). This can lead to the exclusion of relevant stakeholders that feel marginalized by the dominant problem framing (Fastenrath & Coenen, 2021) and serve to reinforce boundaries between social worlds rather than bring them together (Oswick & Robertson, 2009). The broad and ambiguous nature of boundary objects can also provide a depoliticised framing concealing tensions and contestation, as demonstrated by Schutter, Hicks, Phelps, and Waterton (2021) in the case of the blue economy. According to Kovacic et al. (2021, pp. 89, 11), this is also the case in the ambiguous and depoliticised narrative of European circular economy policy, where "different, and sometimes opposing narratives, are brought together through moderation, setting the stage for 'win-win' solutions, middle ground and compromises" and inviting "an apparent consensus which makes criticism difficult to voice, and all the more necessary". It is therefore important to be attentive to power dynamics within the negotiation of boundary objects.

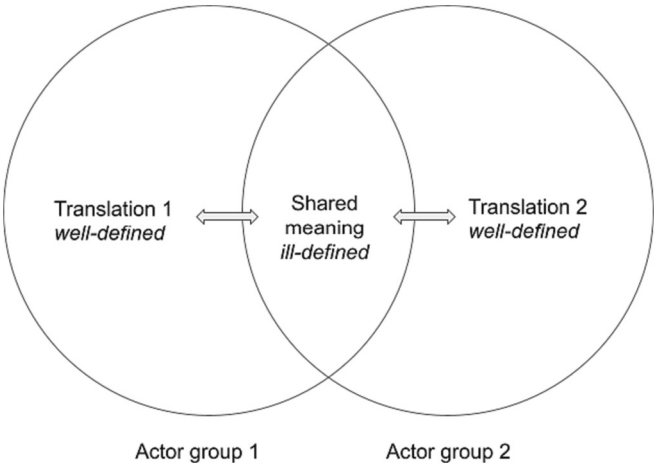

Fig. 1. Dynamics of collaboration pertaining to a boundary object (authors' own elaboration).

2.3. Urban vitalism

To unpack the contradictions between different translations of the circular city as a boundary object, we revisit the debate between mechanistic and vitalist conceptions of life that riddled experimental science in the 18th and 19th centuries. The mechanistic philosophy postulated that the phenomenon of life could be explained entirely through classical mechanics, likening living organisms to machines (Allen, 2005). Vitalism developed in opposition to the mechanistic worldview, which it argued failed to account for the unique qualities of living organisms such as self-replication, response to stimuli and self-regulation (Allen, 2005). Vitalists assigned these unexplained properties to an immeasurable life energy or 'vital force', such as a spirit or soul.

The interplay between mechanism and vitalism throughout scientific history shows that they existed in an oscillating, dialectical relationship, mutually constituted by their contradictory nature (De Klerk, 1979; Hein, 1972). Vitalism's notion of a mysterious life force was logically derived from the epistemic limitations of classical mechanics (De Klerk,

1979, p. 8; Greco, 2021). As described by Hein (1972, p. 174) "in the course of its history, mechanism like vitalism became less extreme and the two positions have drawn closer to one another, both sides having made concessions to the insights of the other, and, more important, to the complexity of the phenomena to be explained". Vitalism was scientifically refuted in the early 20th century and the mechanism-vitalism controversy was eventually transcended by systems theory and complexity science (Capra & Luisi, 2014).

According to Greco (2021, p. 53), vitalism functioned as a "placeholder" or "marker of ignorance" tied to an expectation of future scientific developments. The vitalist philosopher Henri Bergson famously described vitalism as "a sort of label affixed to our ignorance, so as to remind us of this occasionally, while mechanism invites us to ignore that ignorance" (Greco, 2021, p. 62). Therefore, the legacy of vitalism can be seen as its problematization of "the quality of our engagement with problems and with their solutions" (Greco, 2021, p. 50).

Mechanistic and vitalist thought patterns still widely abound (Capra & Luisi, 2014; Greco, 2021). In urbanism, they are made visible by the prominent metaphors of the city as a machine or living organism (Lynch, 1984; Solesbury, 2014). The machine metaphor is often used to describe the city as a controllable, unified system composed of separable, knowable parts (Lynch, 1984; Solesbury, 2014). Historically, the mental model of the city as a machine has led to efficiency, standardization and rapid execution but also execution of power, social domination and dehumanisation (Lynch, 1984). It is also often used in reference to the reductionist, mechanical style of modernist architecture and urban planning, seeking to create the 'city of tomorrow' by developing new towns and districts from scratch, designing out social ills and breaking with the past (Fishman, 2003; Sap, 2002).

Vitalism has flourished as a metaphor for understanding what brings 'life' to a city (Adams & Tiesdell, 2007; Amati, 2021; Mehmood, 2010; Pløger, 2006). Pløger (2006) describes urban vitalism as the energetic flows of individuals' free will or "will-to-life", expressed in both mundane routines as well as interceptions of serendipity, encounter, and surprise. Urban vitalism asserts that all entities within the city can only be understood in terms of their relations to one another (Greenhough, 2010). The city is therefore not a fixed entity, but always in a state of process or *becoming,* changing in indeterminate ways that evade quantification and control. Urban vitalism views citizens as active agents in urban development, rather than passive subjects of engineered systems (Mehmood, 2010, p. 67). Furthermore, urban vitalism invites a non-anthropocentric view of agency, where all living and lively beings are valued as conscious and co-productive agents of city life (Greenhough, 2010; Houston, Hillier, MacCallum, Steele, & Byrne, 2018). Despite a 'new vitalism' or 'vitalist turn' in the social sciences, the term vitalism often lacks legitimacy due to its mystical underpinnings (Greco, 2021). It has been criticised for its ideological nature and disregard for the endurance of institutional structures in society (Greenhough, 2010). Like the mechanistic philosophy, it has in certain instances been misapplied as a rationale for dehumanisation and extremism (Klinke, 2019).

As can be seen, thinking solely in mechanistic or vitalist terms is insufficient and even harmful. In addition, a polarization of mechanistic and vitalist approaches is likely to lead to an inability to act. We argue that urban experimentation can aim to facilitate a dialectical process between mechanistic and vitalist worldviews within the circular city as a boundary object.

3. Mechanistic and vitalist worldviews within circular city experimentation

The circular economy concept has undergone multiple evolutionary phases with involvement from many different actors, representing both transformative and reformist schools of thought (Reike, Vermeulen, & Witjes, 2018). Thus, it is full of impossibilities, contradictions, and controversies, particularly the physical limitations of circularity, its compatibility with capitalism, and social justice implications (Friant, Vermeulen, & Salomone, 2020; Lehmann, Hinske, de Margerie, & Nikolova, 2023; Reike et al., 2018). These become even more apparent when applied to real urban contexts.

Spatial representations (Marin & De Meulder, 2018), future scenarios (Bauwens et al., 2020) and municipal policy discourses (Friant et al., 2023) of circular cities identify key lines of differentiation between techno-economic and socio-ecological goals, as well as centralized and decentralized ways of organizing and governance. In a similar vein, the circular economy and its application in cities is often presented as a juxtaposition between "technocratic eco-modernism" and "convivial technology for social revolution" (Genovese & Pansera, 2019) or "neoliberal urbanism" and "spaces of socio-ecological transition" (Bassens et al., 2020).

Despite (or perhaps as a result of) this ambiguity, the circular economy is an increasingly popular policy narrative for sustainable urban development around the world and municipal policymakers are enthusiastic about implementing the circular economy in their cities (Prendeville et al., 2018; Vanhuyse, Haddaway, et al., 2021).

A dialectical approach toward the contradictions between mechanistic and vitalist worldviews implies first understanding their commonalities and differences and how these are mutually constituted. We try to unpack this in the next section based on a narrative review of recent literature on circular cities, structured according to the three key processes in urban experimentation as identified in the strategic niche management approach referred to earlier in Section 2.1: visioning, networking and learning (Schot & Geels, 2008, pp. 540–541).

3.1. Visions

The articulation of expectations and visions supports the emergence of niches by providing direction to the learning processes, attracts attention, and legitimises experiments (Schot & Geels, 2008). However, the way that these visions are framed will influence the types of niche experiments that are included (and excluded). While both mechanistic and vitalist approaches to circular cities share the a common vision of transforming the linear model of production and consumption in cities to a circular one, their visions are contradictory in their rationales and envisioned solutions.

The mechanistic worldview is concerned with matter and materiality, in other words, the 'stuff' of the circular economy: engineering efficient, closed loop systems of building materials, water, waste, nutrients, etc. From this perspective, the objective of a circular city is "*fostering business models and economic behaviour which decouple resource use from economic activity by maintaining the value and utility of products, components, materials and nutrients for as long as possible in order to close material loops and minimise harmful resource use and waste generation*" as stated by the Circular Cities declaration signed by over 60 European cities (ICLEI Europe, 2020). The term 'decoupling' is based on a mechanistic logic, implying that the economy and the environment are two separable parts of a technical system. However, there is no empirical evidence that absolute decoupling of economic growth from environmental impact will ever be possible (Hickel & Kallis, 2020; Parrique et al., 2019).

In order to demonstrate scalable technologies and closed-loop infrastructures that can be scaled and replicated in other cities, newly built eco-districts and eco-cities are a common pathway for circular urban development (Williams, 2021a). In their analysis of spatial representations of circular cities, Marin and De Meulder (2018) name the famous example of Masdar City near Abu Dhabi, a brand new desert eco-city complex which was intended as the first zero-carbon, zero-waste sustainable city and a "greenprint" for sustainable urban development. The development of the city began in 2008 and was driven by commercial R&D projects, where companies could rent parts of the city to install their own buildings and embed their technologies there, while their staff became the city's citizens (Cugurullo, 2013). Rather than the world's first zero-carbon city, Masdar City has been labelled as the first "green

ghost town", with only 300 residents, all of which are students at the on-site Madar Institute for Science and Technology (Goldenberg, 2016). A further example is Hammarby Sjöstad in Stockholm, Sweden—a world-renowned eco-district that has significantly reduced non-renewable energy use, water consumption and landfilled waste. However, a lack of involvement of residents during the design process meant that it was difficult to achieve some of the envisioned behavioural changes intended by certain technologies, such as correct use of the vacuum waste system, despite ex-post educational programmes (Williams, 2021a). Schoonschip, a floating eco-neighbourhood in Amsterdam, was co-produced with future residents and has exhibited impressive environmental performance from a combination of high-tech and low-tech circular technologies. However, it is detached from the economic realities of the local neighbourhood and has contributed to increasing land prices (Hubmann, 2022). Although these projects often deliver significant economic and environmental benefits, they lack involvement for citizens, which can make them unattractive places to live, reduce their sustainability potential, or make them only accessible to a small "green elite".

A vitalist worldview offers a relational perspective of circularity which considers it impossible to isolate the economy from its ecological context through decoupling. The circular economy is therefore perceived as a transformation pathway to bring the economy in better harmony with planetary systems, primarily through less materialistically-driven lifestyles, equitable distribution of resources, and ecological regeneration (Schröder et al., 2019). Vitalist circular city initiatives therefore privilege social, ecological, and cultural dimensions, considering economic factors and technological innovation as merely a means to achieving those goals rather than as ultimate goals themselves (Marin & De Meulder, 2018). Vitalist circular city approaches are driven by an emotional attachment to and an appreciation of the intrinsic value of the history, cultural heritage and ecology of a place (Girard, Nocca, & Gravagnuolo, 2019). They therefore engage with social and cultural dimensions from within existing urban fabrics, a form of 'retrofitting' rather than establishing newly built environments. They often take the form of small-scale initiatives experimenting with low-impact lifestyles such as Transition Towns, repair cafes and community gardens (Visconti, 2021). A vitalist approach seeks to reconceive human relationships with their 'stuff', with each other, with other species and with the places they live in. Circular practices of refusing, reusing, repairing, redesigning, and recycling often take place in "generative spaces" that encourage learning, serendipity and encounter, such as flea markets, repair cafes, makerspaces, clothing swaps, bicycle kitchens, food banks and urban gardens (Hobson, 2016). Examples such as Brixton Transition Town and R-Urban in France created multiple circular activities within the neighbourhood, such as an eco-construction hub, an upcycling shop, a café reusing food waste, urban farming, makerspaces, an eco-housing cooperative and community-based renewable energy production (Petcou & Petrescu, 2015; Williams, 2021a). These practices of solidarity, frugality, conviviality and care strengthen communities, build skills and knowledge and foster human-nature connection (Bradley & Persson, 2022; Genovese & Pansera, 2019; Moreau, Sahakian, van Griethuysen, & Vuille, 2017; Petrescu, Petcou, & Baibarac, 2016; Williams, 2021b). These experiments are typically political in nature, "a dialectic between the existing and the needed" (Marin & De Meulder, 2018, p. 13). Unfortunately, these projects struggle to find a permanent place within the dominant institutions of urban development and therefore often remain temporary (Williams, 2021a). Marin and De Meulder (2018) give the example of R-Urban, an activist project for resilient urban regeneration based on circular principles, which was piloted in Colombes, near Paris, in 2011. Although the municipality initially supported the initiative, it was forced to close by a change of government in 2014. A year later, R-Urban's urban agriculture site was replaced with a temporary car park while the new administration planned to build a 4000 m2 privately owned vertical farm elsewhere in Colombes (Petrescu et al., 2016). Kębłowski, Lambert, and Bassens (2020) have highlighted a variety of socially embedded circular practices in Brussels such as food banks, peer-to-peer car sharing platforms and bicycle kitchens that are missing from the municipal circular city strategy, although they generate social sustainability through reciprocity, solidarity, social justice and collective action. Cities like Paris, Lisbon and Berlin have been credited for more holistic approaches emphasizing social and environmental dimensions alongside economic goals (Fratini, Georg, & Jørgensen, 2019; Williams, 2021a).

Underlying these differences in vision is a core tension between beliefs about the degree of radical change required for the circular economy to enable transitions to more sustainable cities. The examples indicate that neither of these approaches to experimentation is able to sustain itself on its own in the long-term. A dialectical approach would imply fostering and sustaining plural variations of experiments simultaneously and generating learning experiences from the contradictions between them (Torrens & von Wirth, 2021). However, it is also important to recognize that experiments are embedded within existing institutional structures that may be more favourable to initiatives that do not require radical change. A vitalist mindset reveals that "potentially disruptive social practices emerge *everywhere* and at *every moment* in cities, but (…) only some gain the ability to change contexts" through the legitimacy granted to them by urban experiments (Savini & Bertolini, 2019, p. 832). Therefore, it is important that cities genuinely aiming for transformative change aim to level out the playing field so that a multiplicity of experiments can thrive and interact on fair grounds. In some cities, long-term lease contracts for non-commercial circular initiatives have shown positive results (Williams, 2021a).

3.2. Networks

Schot and Geels (2008) highlight the importance of building social networks to gather support for the experiment, facilitate interactions between relevant stakeholders and secure resources in the form of money, people and expertise. However, the kinds of stakeholders that are included and the roles that are assigned to them influence how those resources are distributed. While both mechanistic and vitalist approaches to the circular city emphasise the need for new forms of collaboration, they differ in their conceptions of who are relevant stakeholders and how networks should be organized.

A mechanistic approach to circular cities seeks to rapidly apply best practices and ready-made policies circulated through global knowledge networks and consultancies (McCann & Ward, 2010, p. 175). While such networks are highly ambitious and provide a clear starting point and accessible knowledge base for cities facing the ambiguity of the circular economy, it can also reproduce structural biases such as an over-emphasis on waste management and recycling (Jones & Comfort, 2018). Furthermore, a mechanistic approach applies the typical stakeholder roles to urban experiments. This is clearly spelled out in Amsterdam's circular city strategy (Gemeente Amsterdam, 2020, p. 22) where the municipality's task, next to regulation and applying circular principles within its own organisation and public infrastructures, is to stimulate innovation within companies by fixing market failures and to 'nudge' citizens to adopt more sustainable lifestyles; the role of the private sector is to generate profitable and scalable eco-innovations and new circular business models; while citizens are asked to follow rules and regulations and to consume circular goods and services—despite the fact that circular lifestyles are often difficult to adopt within existing socio-institutional settings (Hobson, 2020a; Lofthouse & Prendeville, 2018; Ortega Alvarado & Pettersen, 2023). Funding for circular urban experiments stems from public or private investments such as R&D funding, venture capital funds, investment programs, public procurement, or they are incentivised through fiscal policies such as tax reforms (OECD, 2020). These forms of governance and funding are shaped by vested interests and so maintain profitable and competitive conditions for the circular economy without necessarily requiring institutional transformation (Bauwens et al., 2020; Moreau et al., 2017).

Urban vitalism is rooted in a deep connection to place, where networks are determined by proximity, culture and landscape. From this perspective, circular economies are governed at the scale of bioregions, i.e. territories definable in ecological and cultural terms rather than political or economic borders (Luthe, Fitzpatrick, & Wahl, 2022; Marin & De Meulder, 2018; Savini, 2023). Bioregionalism provides "a spatial framework in which people live as rooted, active, participating members of a reasonably scaled, naturally bounded, ecologically defined territory, or life-place" (Thackara, 2019, p. 6). A vitalist perspective also invites non-human dwellers as co-productive agents in the development of circular futures, whom are typically ignored or viewed as "resources" or "service providers" in circular city strategies so far (Rask, 2022; Wuyts & Marin, 2022). Vitalist projects utilise community-based and collaborative forms of governing urban circularity. For example, the activist project R-Urban is founded in commons-based collective governance and exclusively utilises non-profit, social enterprise and cooperative organisational forms (Marin & De Meulder, 2018; Petcou & Petrescu, 2015). According to the action researchers involved in the project, R-Urban empowered citizens to transform themselves *"from users to stakeholders and from relatively passive inhabitants to initiators of collective resilience practices and economies"* (Petrescu et al., 2016, p. 732). However, the project struggled to get active involvement from the municipality, who took a passive and managing role and eventually shut down the project. Another example, the Circular Buiksloterham district in Amsterdam, a highly polluted post-industrial site which is now being regenerated through experimental circular activities is governed by a community manifesto outlining informal goals and rules (Metabolic, 2019). However, accountability has proven to be a challenge amongst the twenty-five signatories. Driven by social and ecological goals rather than economic profit, these experiments are rarely economically viable in the long-term and rely on public subsidisation, temporary land-use permissions and volunteer work (Petrescu et al., 2016; Williams, 2021b). They can therefore be challenging to sustain in the long-term without top-down support. External funds often come with limited timeframes and no guarantee of renewal and require that initiatives demonstrate self-sufficiency from an early stage (Hadfield & Coenen, 2022). This limits the ability of voluntary, non-profit and grassroots initiatives to gain access to such funding and privileges marketable business models (Torrens & von Wirth, 2021). They therefore attempt to create a protective space for themselves where they can avoid market pressures by seeking funding through institutional grants, public and civic events, self-funding, crowdfunding and cooperative management structures (Petcou & Petrescu, 2015; Williams, 2021a). Another strategy is establishing alternative economies based on gifting, bartering, swapping, time banking and local currencies. Examples of the latter include the Brixton Pound by Transition Town Brixton or the 'Jouliette' by the De Ceuvel community in Amsterdam's Buiksloterham living lab district (both connected to community energy programs).

Several studies note a tendency for policymakers to acknowledge community engagement as an important factor for circular city strategies, while actual policy measures focus primarily on the role of the public and private sector (Böhme et al., 2019; Fratini et al., 2019; Friant et al., 2023; Prendeville et al., 2018). A dialectical approach would recognize the role and agency of citizens in experiments as twofold: 1) citizens are experts of their own unreflexive, mundane, day-to-day routines and 2) equally, citizens are capable of questioning those routines and purposively experimenting with radical, intrinsically-driven behaviour change (Brons et al., 2022). Furthermore, there is a need for researchers and practitioners to connect circular cities to more-than-human approaches within urban planning and policymaking (Houston et al., 2018; Rask, 2022).

3.3. Learning

According to Schot and Geels (2008), effective learning processes should encompass multiple dimensions, spanning technical, market, cultural, infrastructural, industrial, regulatory, societal and environmental effects. Motivations for adopting circular economy strategies in Amsterdam, London, Paris, Stockholm, Lisbon and Berlin range from techno-economic goals like city-marketing and export of urban innovations, business development, job creation, reindustrialisation and resource security; environmental objectives like tackling climate change and waste reduction; and social justice rationales like social solidarity and redistribution of resources (Williams, 2021a, p. 17). However, these goals are often imbalanced in practice and therefore limit the types of learning accessible through circular urban experiments.

A mechanistic approach disassembles the city into its core functions such as the built environment, mobility, energy, food, and production, which are monitored, optimised and circulated in terms of stocks and flows of building materials, goods, people, water, nutrients, fuel, electricity, and waste. They are quantitatively measured and visualised in 'city scans' utilising socioeconomic data, material and energy flow analysis, life cycle assessments and other data-driven tools (Prendeville et al., 2018). This provides a codified, standardized and easily commercialised approach which can be applied to any city. This perspective of urban circularity emphasises technical knowledge, rendering circularity as primarily the domain of planners, engineers and technicians who have traditionally shaped the 'hard structures' of the city (Kampelmann, 2018). In addition, data engineers and analysts are central for ensuring that the circular city is also 'smart' (Prendeville et al., 2018). These types of information, knowledge and tools are essential and crucial for realising the circularity of cities and have enabled the circular city concept to spread across the world. However, it is still underresearched how these standardized approaches mesh with the social and institutional settings in different geographical contexts (Fratini et al., 2019). Furthermore, an emphasis on explicit knowledge alone overlooks and, possibly even delegitimises, the knowledge and lived realities of the individuals who use these infrastructures on a daily basis, rendering them as passive subjects rather than providing them with an active role (Kampelmann, 2018).

An urban vitalist approach is concerned with the intangible energies that bring the circular city to life. These are captured in the "small stories of closing loops" (Hobson, 2020b) or subjective experiences of circularity such as the extraordinary taste of a homegrown tomato, a sense of accomplishment after repairing one's own bicycle or the feeling of deep connection to a place. It is these forms of tacit knowledge that inform and motivate the daily choices and actions of people and can be decisive for the functioning of technological solutions for delivering circularity. For example, Kampelmann (2018) has shown how a community composting initiative in Catalonia produced far higher quality soil than a modern industrial biogas plant in the same region with an expensive pretreatment technology, because participants took a more proactive and caring role toward sorting. Furthermore, urban vitalism values circularity knowledge typically delegitimised by the mechanistic perspective, such as indigenous, frugal, spiritual and religious knowledge (Beamer et al., 2023; Ezeudu, Agunwamba, Ugochukwu, & Oraelosi, 2022; Friant et al., 2020; Lestar & Böhm, 2020; Mohamad, Idris, & Mamat, 2012; Wuyts & Marin, 2022). A broader appreciation of different ways of knowing and experiencing circularity could help to address the lack of research on the qualitative effects of circular city transitions on culture, health, wellbeing, fears and aspirations (Vanhuyse, Fejzić, et al., 2021). The contextual, complex and often highly subjective nature of the social effects of circularity is difficult to capture and requires participatory and qualitative methods, which can be resource-intensive (Pitkänen et al., 2023; Vanhuyse, Fejzić, et al., 2021). However, this level of granularity is particularly important for learning and decision-making at the local scale (Pitkänen et al., 2020). For example, the Finnish city of Turku has integrated social equity into its circular economy roadmap, with a focus on access, participation and equal opportunity, alongside a social risk assessment of its planned circularity interventions (Circular Turku & Turku Åbo, 2022). Friant et al. (2023) have noted that while Amsterdam's current circular economy strategy lacks tangible social targets, the

city is working to develop a modelling system for social wellbeing and prosperity under the Thriving City Initiative's City Portrait framework for the Doughnut Economy (Fanning et al., 2020).

An emphasis on successful implementation, quantifiable outcomes and risk reduction within project-based experimentation means that marketable technological solutions are often favoured over grassroots initiatives (Torrens & von Wirth, 2021). This bias influences which urban development pathways are pursued and may reinforce existing institutional paradigms instead of opening up for more radical transformative efforts and opportunities for learning. A dialectical approach could be employed within "small wins" governance framework (Termeer and Metze, 2019) which recognises the collective contribution of multiple small-scale circular economy initiatives with concrete results of moderate importance that result in second-order learning, overcome resistance and barriers, and connect technical and societal change.

Balancing the economic, ecological and social benefits and impacts of the circular economy within urban contexts is a complex task which involves trade-offs and risks of unintended side effects. Circular economy policies with a narrow focus on economic and environmental gains can result in "social rebound effects", such as occupational hazards, inequity and polarization (Chen, 2021). Williams (2021b) has shown instances in London and Paris where social circular initiatives have revitalised neighbourhoods both culturally and economically, thereby increasing land values and eventually being driven out themselves by investor interests or unaffordable rents. The benefits of new blue-green infrastructures or other circular experiments are often unevenly distributed and lead to gentrification in many cases (Hubmann, 2022; Lavanga & Drosner, 2020; Williams, 2021b). At the same time, anthropocentric and utilitarian approaches to nature-based solutions can have short term benefits for humans but disrupt local ecosystems (Maller, 2021). More holistic evaluation approaches are needed in order to ensure that social and ecological benefits of circular initiatives are balanced with economic rationales in urban development decisions (Fusco Girard & Nocca, 2019; Marin, Alaerts, & Van Acker, 2020; Williams, 2021b). Learning should be informed not only by discrete measurements or indicators but seek to explore new forms of data that can reflect the multiple interrelationships within and between urban systems and make trade-offs more explicit, also known as "warm data" (Bateson, 2017).

A summary of these insights is presented in Table 1 below.

4. Discussion

Boundary objects like the circular city can house clashing worldviews with the potential to lead to either depoliticization, polarization or transformation. Above, we have constructed and contrasted ideal types of mechanistic and vitalist approaches to illustrate the conflicting ways in which boundary objects like the circular city can be interpreted. As urban metaphors, mechanism and vitalism provide alternative—but partial and imperfect—frames of reference for understanding cities (Solesbury, 2014). No single city aiming to become circular will neatly fit into either of these categories, but cities are likely to have a unique blend of these approaches. Intentionally and explicitly engaging with the contradictions between these worldviews through a dialectical approach to experimentation could lead to more transformative outcomes. In the next paragraphs, we reflect on practical implications of the use of boundary objects, a dialectical approach and mechanistic and vitalist metaphors for the visioning, networking and learning processes of niche experimentation.

Table 1
Summary of mechanistic and vitalist approaches to experimentation and possible dialectic strategies.

Experimentation Processes	Mechanistic	Vitalist	Possible dialectic strategies
Visioning	Techno-economic	Socio-ecological	Fostering a generative multiplicity of experiments
Networking	Top-down	Bottom-up	Empowering citizens and creating more-than-human networks
Learning	Quantitative	Qualitative	Generating second-order learning through small wins and warm data

4.1. Visioning

Within visioning processes, there is often an underlying assumption that the best goals are unambiguous and consensual (Torrens & von Wirth, 2021). The use of boundary objects provides an open framing for visioning processes, allowing multiple visions to exist alongside each other and engage in a dialectical process, rather than insisting on a shared but depoliticised vision. Castán Broto (2015) underscores that contradictions do not point to a prescribed pathway, but to an overall direction, albeit provisional and unstable. The use of boundary objects thus shifts the focus of experimentation from a pre-defined end goal toward the goal of long-term learning from the interactions between different visions. Furthermore, the use of metaphoric boundary objects, like the circular economy, can be useful for expressing and legitimising tacit forms of knowledge in innovation processes, which are otherwise often difficult to express through formal language (Koskinen, 2005). Similarly, the mechanistic and vitalist lenses, and their corresponding metaphors of the city as a machine or living being, could be applied together as a practical exercise within the visioning process to explore the scope of the boundary object and the possibilities, risks and challenges associated with different futures of circularity. This could also facilitate a discussion of how those futures relate to each other, articulating the contradictions and trade-offs that may arise. It is important to emphasise here that the two lenses are mutually constituted, and it would be counterproductive to use them in isolation.

4.2. Networking

The use of boundary objects could facilitate networking amongst stakeholders who do not necessarily share the same vision and worldviews. The mechanistic perspective emphasises the formal agency of authoritative actors for governing urban transitions; a vitalist perspective seeks to empower those actors formally excluded from planning processes or rendered as a passive, homogenous category of 'users', 'residents' or 'nature'. More nuanced approaches are necessary which acknowledge the structuration of citizens daily lives, but also their reflexive agency and ability to break out from mundane routines and shape new ways of life in the city (Brons et al., 2022). Applying the lenses of mechanism and vitalism could help to interrogate who has been included and who has been excluded within the experimentation process and extend networks to reflect the diversity and intersectionality of all forms of urban life (Rask, 2022; Wuyts & Marin, 2022).

4.3. Learning

Learning is most effective when it is not only directed as the accumulation of facts and data (first-order learning) but also helps to change cognitive frames and assumptions (second-order learning) (Schot & Geels, 2008, p. 541). This requires shift from ex-post, summative evaluation directed toward the attainment of pre-defined outcomes, to formative evaluation that is iterative, process-oriented and reflexive (Rohracher et al., 2023). The use of boundary objects and contradiction frames experimentation as a long-term, processual learning process, since 'solving' a contradiction merely creates new ones (Castán Broto, 2015, p. 472). Enabled by the essential technical and quantitative data that makes flows within the city visible and tangible, a vitalist approach places experiential knowledge at the heart of circularity. Perhaps most

importantly, urban vitalism invites a humble approach to knowledge generation that includes failure as part of the learning process and exists as a constant reminder of all that is (yet) unknown or cannot be known. Applying the mechanistic and vitalist perspectives iteratively at specific milestones of the experiment could help to assess underlying assumptions along the way and bring more reflexivity to the learning process. The metaphors of mechanistic and vitalist circular experimentation could also be used to guide more diverse forms of data collection to inform the learning process. Learning should be informed not only by discrete measurements or indicators but also include qualitative data about the contextual factors driving flows as well as tacit knowledge expressed through artistic methods, for example.

5. Conclusion

The potential of 'circular cities' to deliver urban sustainability has been both celebrated and interrogated, particularly due to their ambiguity. The concept is therefore ridden with conflict and contradiction between different translations by heterogeneous actors. Understanding the circular city and related urban sustainability concepts as boundary objects can provide a tool for addressing conflict and contestation from the perspective of the inherent interrelatedness of contradicting worldviews rather than opposition. This could lead to new practices of visioning, networking, and learning to facilitate more transformative outcomes.

Our approach adds a new perspective on paradigms within the circular economy and urban sustainability transitions literature, based on the historical but persistent controversy between mechanistic and vitalist philosophies of (urban) life. It also makes a contribution to the 'vitalist turn' within the social sciences and humanities, as referred to by Greco (2021, p. 49) and Greenhough (2010). In addition, this paper supports the growing interest within the sustainability transitions literature regarding boundary objects as tools for experimentation, by further operationalising the concept through a dialectical approach to experimentation.

Vitalism and mechanism are far-from-perfect analogies for the urban context and previous misapplications teach us that they should be used with caution (e.g. Klinke, 2019). Of course, alternative interpretations are possible which can produce very different readings than those we present in our framework. While we draw on a broad review of recent circular city literature, the articles were selected on a narrative basis and therefore may contain a subjective bias. We therefore invite other researchers to challenge or further develop the insights presented in this conceptual paper, ideally based on empirical case-studies. This would help to generate a deeper discussion of the usefulness of boundary objects as a dialectical tool as well as the metaphors of mechanism and vitalism for urban experimentation. It would be interesting to compare mechanistic and vitalist perspectives applied to a single case study or two geographically contrasting cases. Future studies could also explore the applicability of a dialectical approach to boundary objects in other contexts beyond urban experimentation, for example policymaking or business strategy. Practitioners may also find studies helpful that suggest concrete process facilitation tools or guidelines for productively engaging with contradiction in experimentation processes.

The contradictions between mechanistic and vitalist approaches reflect a recurring dilemma for urban sustainability transitions, between the need "to find a balance between reflecting urban complexity accurately and developing ideas that can be made operative in policy making, planning, and design processes" (Castán Broto, Allen, & Rapoport, 2012, p. 857). The use of boundary objects helps to draw our analytical focus on these matters of contradiction and—perhaps more importantly—to strategies that help to negotiate, synthesize, or even transcend such tensions.

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None.

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