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Seedbeds, harbours, and battlegrounds: On the origins of favourable environments for urban experimentation with sustainability

Jonas Torrens[a,*,1], Johan Schot[a], Rob Raven[b,2], Phil Johnstone[a]

[a] Science Policy Research Unit, University of Sussex, Jubilee Building, Arts Road, Brighton, BN19SL, United Kingdom
[b] Copernicus Institute of Sustainable Development, Princetonlaan 8a, 3584 CB Utrecht, the Netherlands

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ABSTRACT

Urban experimentation (UE) is seen as crucial for enacting transformations towards sustainability. Research in this domain has flourished, but still lacks theoretical coherence. We review this emerging literature, combining methods for problematisation and critical interpretive synthesis, to address two questions: how does the extant literature conceive of the contexts in which experimentation emerge, and what dynamics are thought to be implicated in reconfiguring these contexts into favourable environments for UE? Traditionally, transition studies assume that cities may act as protective spaces for experimentation, but recent studies suggest other salient dynamics. We identify three lenses - seedbeds, harbours, and battlegrounds – which articulate the assumptions and dynamics associated with different understandings of the urban context. We argue for plural accounts of how UE thrives in particular places and offer a way 'to follow' the co-evolution between a multiplicity of experiments and their environment, through interactions between protection, connectivity, and conflict.

1. Introduction

Urban experimentation (UE) is central to recent discourses about smart, green, resilient, and liveable cities. It is seen as a means for contending with the uncertainty and ambiguity that arise when introducing innovative technologies to the city, facing wicked problems such as climate change, or bringing about wider transformations. Proponents argue that UE can facilitate learning, catalyse innovation, promote reflexive forms of governance, and widen participation. Experiments and laboratories are proliferating quickly, as new means of governing the city. Consequently, the governance of climate change and sustainability in cities is becoming experimentalist (Hoffmann, 2011, Bulkeley and Castán Broto, 2013, Bulkeley et al., 2015; McGuirk et al., 2015; Swilling and Hajer, 2017). A recent scholarship highlighted widely diverse practices, framings and expectations associated with UE (Kullman, 2013, Castán Broto and Bulkeley, 2013a,b, Evans, 2016; Evans et al., 2016). Experiments are widely varied, and so are the attempts at characterising them (c.f. Sengers et al., 2016; Kivimaa et al., 2017; Ansell and Bartenberger, 2016; Weiland et al., 2017).

Abbreviations: CIS, critical interpretive synthesis; SNM, strategic niche management; UE, urban experimentation

* Corresponding author.
E-mail addresses: j.torrens@sussex.ac.uk (J. Torrens), j.w.schot@sussex.ac.uk (J. Schot), rob.raven@monash.edu, r.p.j.m.raven@uu.nl (R. Raven), p.johnstone@sussex.ac.uk (P. Johnstone).
[1] Present address: Copernicus Institute of Sustainable Development, Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, the Netherlands.
[2] Present address: Monash Sustainable Development Institute, Monash University, 8 Scenic Blvd, Clayton VIC 3800, Australia.

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This paper aims to understand the processes involved in the formation of favourable environments for UE. Even without formally established laboratories, some places concentrate and sustain much experimentation in various domains of sustainability, infrastructure, and governance, playing a disproportional role in shaping distinct urban imaginaries (e.g. Longhurst, 2015, van den Heiligenberg et al., 2017, Raven et al., 2017; Torrens et al., 2018). Nevertheless, there is considerable fragmentation in explanations of how this happens. To foster some theoretical coherence, this study investigates two salient questions: how the extant literature conceives of the contexts in which experimentation emerge, and what dynamics are thought to be involved in reconfiguring these contexts into favourable environments for experimentation. It also discusses their analytical and governance implications.

In particular, we problematise the tendency, within transition studies, to conflate niches and the urban context for experimentation, and to assume cities behave as seedbeds which provide protection and resources to novel experiments (Geels, 2011a, 2011b, Arentsen and Bellekom, 2014), or as laboratories where protection is supplemented with formal learning processes (c.f. Nevens et al., 2013; Karvonen and van Heur, 2014; Evans and Karvonen, 2014; Voytenko et al., 2016, Bulkeley et al., 2016). Early on, experimentation had been identified as a crucial driver for promoting system innovation and socio-technical change towards sustainability (Schot et al., 1994; Verheul and Vergragt, 1995; Kemp et al., 1998; Grin et al., 2010; Markard et al., 2012; Loorbach et al., 2017, Sengers2016, forthcoming). Experimentation is seen as necessary to circumvent the obduracy of existing socio-technical systems and foster path-breaking alternatives. The strategic niche management (SNM) strand of this field has been used extensively to analyse the formation of niches, conceived as protective spaces for experimentation (Schot and Geels, 2008; Smith and Raven, 2012). Developing niches has been posited as a strategy for nourishing and scaling up radical innovations with potential sustainability gains, in both social and technological domains (Schot et al., 1994; Verheul and Vergragt, 1995; Kemp et al., 1998; Hoogma et al., 2002). Similarly, the transition management strand argued for the establishment of 'transition areas', where frontrunners and researchers could envision alternatives and initiate experiments to concretise them (c.f. Nevens et al., 2013, van den Bosch and Rotmans, 2008). However recent contributions took on place-based approaches, revealing complex journeys through which places become favourable environments for experimentation emerge and develop path-dependant styles of experimentation (Longhurst, 2015; Raven et al., 2017; van den Heiligenberg et al., 2017; Torrens et al., 2018).

We also contend that understanding urban contexts as behaving primarily as protective spaces could obscure other potentially relevant dynamics and politics (see also Bulkeley et al., 2014a, 2014b, Torrens et al., 2018). Other strands of work also suggest a more plural approach is necessary. For example, a geographical turn has been challenging the spatial assumptions of transitions studies (c.f. Hodson and Marvin, 2010; Bulkeley et al., 2011; Wolfram et al., 2016; Frantzeskaki et al., 2017; Coenen and Truffer, 2012; Raven et al., 2012), indicating that the formation of favourable environments for experimentation may be associated with dynamics arising from embeddedness in territorial, sectoral, and transnational structures (Truffer et al., 2015; Sengers et al., 2016, Wieczorek2015). Others demanded more attention to the politics of experimentation, arguing that contestation is at the core of what makes experiments transformative (Bulkeley et al., 2015; Murphy, 2015).

We therefore hypothesise that the literature already encompasses multiple conceptions of the contexts for UE, and various dynamics that influence their evolution, which are nevertheless left implicit or frequently ignored due to the lack of an encompassing framework. To redress this situation, we engage with the literature's assumptions and recurring critiques, as generative material for theoretical development (c.f. Alvesson and Sandberg, 2011). We take on this task through an iterative process of literature review and scholarly discussion.

To begin, we put forward the working definition of urban experiments that we used to orient our review and discuss the present understanding of contexts for experimentation in the transitions field. Section 3 outlines our methodology and analytical framework. Section 4 presents the results, which we articulate as three *lenses*: internally coherent set of assumptions which guide particular ways of understanding how urban contexts became favourable environments for experimentation. We label these lenses seedbeds, harbours and battlegrounds; each focus attention on plausible recurring 'contextual dynamics'. Section 5 presents a synthetic argument which brings these lenses together, and discusses our research questions, governance implications, and limitations of our work. We conclude by considering how to advance a plural understanding of UE in research and practice.

1.1. Defining urban experiments

The contemporary trend towards experimentation is a manifold and hard to delineate phenoma and so is its urban expression (c.f. Evans et al., 2016; Ansell and Bartenberger, 2016, Turnheim et al., 2018). Not surprisingly, urban experiments have been defined variably. To guide the litereture review in line with the purposes of this paper, we propose a working definition of urban experiments that combines aspects of the conceptualisations from transitions and climate governance literatures:

- as initiatives, projects, or interventions 'delivered by or in the name of an existing or imagined urban community' (Castán Broto and Bulkeley, 2013a, 2013b, pp.93)
- which embody practice-based, learning-oriented, and challenge-led approaches to addressing sustainability challenges under conditions of uncertainty and ambiguity (Sengers et al., 2016 Forthcoming)
- which involve multiple societal actors and contribute to social learning (Brown and Vergragt, 2008; Brown et al., 2003)
- and which are 'highly novel' because they differ from 'dominant, conventional ways of satisfying social needs and preferences within a specific context' (Wieczorek et al., 2015, pp.151).

In a recent review, Weiland et al (2017) highlights that these experiments are unlike classical and natural science experiments, because they take place in real-world settings which cannot be tightly controlled, involve societal actors in initiating and caring out

the experiments (necessitating co-creation or co-production, rather than only experts, see also Frantzeskaki et al., 2018), and focus on learning about what the system *ought to be* and *how to achieve* such transformation. They are best understood as attempts at developing viable socio-technical configurations, which share technological and social dimensions, 'where learning is not confined to technological learning, but includes changes in practices, services, user behaviour, institutions, ways of organising' (Wieczorek et al., 2015, pp.151). Experiments tend to emerge outside traditional channels of policy making and planning (Hoffmann, 2011), but this is changing with many cities developing specific units or laboratories to support such activities. A variety of transdisciplinary approaches has proposed tools to initiate, monitor and evaluate specific initiatives (e.g. Raven et al., 2010; Luederitz et al., 2016; Frantzeskaki et al., 2018). Other definitions emphasise experiments that aim at climate change mitigation and adaptation (Castán Broto and Bulkeley, 2013a, 2013b; Kivimaa et al., 2017). Here, we adopt a broader perspective as the proponents of such activities often contend with multiple challenges that are specific to the contexts in which they are being embedded and have to navigate non-sustainability-oriented objectives and interests (e.g. developing novel bus-rapid transit systems addressing traffic, air-pollution, climate change, and affordability of public-transportation infrastructures, c.f. Sengers and Raven, 2015). In our view, UE are not necessarily aimed at systemic impact (e.g. grassroots innovations aimed at community empowerment) but are often enlisted in narratives about potential urban transitions or transformations. In the discussion session, we discuss the caveats of having used this working definition.

1.2. Contexts for urban experimentation

Within the transitions' literature, conceptualisations of the nature of experimental settings have been heavily influenced by the notion of niches and protective spaces. This literature understood niches as spaces with a distinct selection environment, which afforded temporary protection for emerging technologies, enabling learning, and technological development that deviates from the rules of a dominant socio-technical regime (Kemp et al., 1998; Hoogma et al., 2002).

Lately, with the introduction of the so called Local-Global model, there was a shift towards understanding that niches emerge from and are reinforced by learning from a sequence of experiments, in multiple localities (Geels and Raven, 2006; Smith and Raven, 2012). In this perspective, the aggregation of lessons and their articulation by intermediaries allows the development of a set of shared rules, expectations and social networks, which in turn support further initiatives; experiments and the spaces in which they thrive are linked by recursive and potentially self-reinforcing dynamics (van den Bosch and Rotmans, 2008). Accordingly, various studies approach UE from a perspective of niche formation (e.g. SNM, transition management, grassroots innovation), thus assuming that the dynamics involved in the formation of environments for experimentation and transitions in cities are best described as part of a process of niche formation at a global/trans-local scale.

However, when considering UE, we should pay specific attention to places that concentrate experiments in multiple domains and try to understand how and why these became favourable environments for UE. Individual experiments are unlike to produce major-breakthroughs in and of themselves. In urban settings, multiple socio-technical systems co-exist and intersect (Schwanen, 2015; Hodson et al., 2017) and a multiplicity of experiments have to be aligned to create sufficient momentum and arrive at robust socio-technical configurations and concrete sustainability gains. Hodson et al. (2017) for example, suggests studying how multiple socio-technical experiments, governance arrangements and social interests are being aligned in reconfiguring the context itself. Recent studies have proposed explicitly place-based approaches to understand the evolution of specific contexts in which UE flourishes (e.g. Longhurst, 2015, van den Heiligenberg et al., 2017, Raven et al., 2017; Torrens et al., 2018), highlighting dynamics which are not reducible to that of niche formation.

Instead of a priori conflating the urban contexts with niches, we argue that we should attend to the possibility that other dynamics, aside the formation of a protective space, are salient in the formation of favourable environments for UE.

There are also good reasons not to assume a priori that the primary loci of UE are found in protective spaces created purposively or formally instituted as laboratories. Emphasis on constructing protective spaces and setting up laboratories can lead to a neglect of situations in which UE emerge organically in a city, i.e. outside spaces designated, explicitly framed, and resourced to support experimentation. For example, when studying the development of a favourable environment for experimentation with civic energy activities in Bristol, Torrens et al. (2018) observed that political efforts to frame and equip the city as a 'laboratory for change' were a recent development in a longer history of engagement with UE, with constant exchanges between grassroots groups and local government. While the dynamics highlighted by SNM certainly played a role in that city's developments, others were salient but downplayed by that theory.

Moreover, placing formalised experiments or laboratories in the spot light, but neglecting unruly practices emerging from within the urban context, and the dynamics implicated in sustaining experimentation overtime, the literature is at risk of seeing experimentation happening 'on places' rather than 'in places' (Hodson et al., 2015; Coenen and Truffer, 2012). This would imply that most cities can come to accommodate a niche or a laboratory, which is sharp contrast with the very empirical domain of the literature, which has centred around places with a high concentration of UE (e.g. Bristol, Totnes, Fribourg, Gratz, Amsterdam, etc), which suggest that such spaces may be far from being evenly distributed. This pattern may also be the result of a bias towards studying frontrunners, which has not yet been adressed critically.

Thus, we place our conceptual focus on the urban context and the dynamics which may explain their development. To interrogate these processes, we expand on the idea that experiments and their contexts are linked by a recursive dynamic (van den Bosch and Rotmans, 2008). We define contextual dynamics as the recursive and potentially self-reinforcing processes through which the context in a city enables urban experimental processes, which in turn reconfigure or reinforce that context as to form a favourable environment for UE.

Table 1
Typology (adapted from Alvesson and Sandberg, 2011). We focus on the first three categories.

Type of assumptions	Characteristics	Strategy for identification
In-house	Assumptions that exist within a specific school of though	Scrutinising internal debates and the interfaces between groupings of related authors
Root metaphor	Broader images of a particular subject matter underlying existing literature	Identifying basic image or metaphors used to represent the social reality in question
Paradigm	Ontological, epistemological and methodological assumptions underlying existing literature	Requires familiarity with alternative world views and efforts to map alterative paradigms
Ideology	Political-, moral- and gender-related assumptions underlying existing literature	n/a
Field	Assumptions about a specific subject matter that are shared across different theoretical schools	n/a

In the remainder of this article, we examine how these contexts are understood and what dynamics are implicated in the formation of favourable environments for UE.

2. Methodology and analytical framework

This work builds on recent investigations of contexts with a profile of persistent grassroots mobilisation (e.g. Bristol, Totnes and Berlin, see Torrens et al., 2018; Longhurst, 2015 and Blanchet, 2015), which exposed us to distinct understandings of why conducive environments for UE emerge. At present, no coherent theoretical position accounts for the various dynamics which were involved in shaping those contexts.

To examine that emerging body of work, we identified a method for problematising the literature and another to support the synthesis, which we present below. Both allow us to work with extant literature to identify and critique different theoretical positions and contribute towards theoretical development. Acknowledging that entrenched theoretical positions may represent specific facets of a multifaceted concrete phenomena (Sayer, 1984), we argue that articulating the distinctive understandings could sensitise researchers to take on a more encompassing view of how favourable environments for UE are formed.

2.1. A method for problematising the literature

We approach the nascent literature on UE with a problematisation, which we take to be a 'dialectical interrogation of one's own familiar positions, other stances, and the domain of literature targeted for assumption challenging' (Alvesson and Sandberg, 2011, p.252). As a research method, problematisation aims on illuminating and challenging the assumptions that underpin existing theories, opening up new avenues for research. It can be applied to different kinds of assumptions (see Table 1).

In this article, we focus on the in-house, root metaphors and ontological assumptions (part of paradigmatic assumptions) for two

Table 2
Analytical framework derived by expanding on the idea of problematisation.

Category of analysis	Category in Alvesson and Sandberg (2011)	Guiding questions for the analysis of the grouping of papers	Examples of the relevance
Root-metaphors for the context	Root metaphor	What metaphor is used to describe the urban context in its relationship with experimentation?	Geels (2011a, 2011b), Arentsen and Bellekom (2014); Sekulova et al. (2017)
Commonly-used context descriptors	Root metaphor	What other metaphors are used to describe the context of experimentation?	
Commonly-used process descriptors	Root metaphor	What other are used to describe the processes associated with the development of the context?	
Conception of the urban context	Paradigmatic	What is the (explicit or implicit) assumption about the constitution of the urban context?	van den Heiligenberg et al. (2017), Longhurst (2015)
Role played by the urban context in urban transitions	Paradigmatic	What role does the development of the urban context play in sustainability transitions?	Hodson and Marvin (2010); Moloney and Horne (2015)
Contextual dynamics	In-house	Which recursive or self-reinforcing processes are thought to enable experimentation in the context and reinforce the context?	Hoogma et al. (2002); van den Bosch and Rotmans (2008)
Prevalent forms of knowledge and learning	In-house	What forms of knowledge and what processes of learning are foregrounded?	Smith et al. (2016)
Role ascribed to intermediaries	In-house	What functions are intermediaries assumed to play regarding this contextual dynamic?	Gliedt et al. (2018); Matschoss and Heiskanen (2017)
Political dimensions	In-house	What are the central concerns regarding the politics of experimentation?	Bulkeley et al. (2015)
Oversights	n/a because derived from persistent critiques	What critiques are levied against this perspective, in terms of what is left out or underplayed?	Murphy (2015); Truffer et al. (2015)

reasons. First, a focal area has emerged in recent years, and these three sets of assumptions can be seen to be in flux, and thus worthy of articulation and critical scrutiny. This is evident in how persistent emerging critiques have emerged but not been translated into full-fledged alternative theorisations. Second, because the ideology and field assumptions have been scrutinised for the wider field of sustainability transitions elsewhere (e.g. Avelino and Rotmans, 2009, Smith et al., 2010; Geels, 2011a, 2011b, Stirling, 2014).

To operationalise such problematisation, we seek to 'scrutinising internal debates and the interfaces between groupings of related authors, who use similar narratives and vocabulary', (Alvesson and Sandberg, 2011). For that, we to use a series of guiding questions, the relevance of which can be found in previous studies (Table 2). We expand particularly on in-house assumptions of different groupings of the literature, because there has been substantial debate recently about these topics. Aside from contextual dynamic, which we introduced above, the other in-house assumptions have been a staple of discussions in the field. These dimensions were then used for thematic coding using Nvivo® 11 software.

2.2. Identifying the relevant domain of the literature

A necessary step first for problematisation is identifying, sorting and delimiting a specific domain of the literature associated with our research question, and different groupings within this domain. Compared to research concerned with identifying and filling gaps, this typically involve a narrower literature coverage and more in-depth readings of key texts (Alvesson and Sandberg, 2011). In order to achieve this objective in a transparent and reflexive manner, we mobilise in this article a Critical Interpretive Synthesis (CIS) (Dixon-Woods et al., 2006a, 2006b). This is a method which adapts aspects of systematic literature reviews to applications where interpretation, synthesis and assumption challenging is required.

Within the social sciences, systematic reviews have been used extensively to explore particular concepts or to identify gaps that persist despite a wide range of research on a subject (Petticrew and Roberts, 2008). They are aimed towards a comprehensive treatment of the literature, with attention to the quality of the research included, a clear and systematic approach to synthesising the data, generally following a rigorous and transparent processes (Victor, 2008). This kind of review was pioneered in medicine, where they are conventionally deployed to collect evidence and test 'what works', appraised according to a strict hierarchy of evidence that privileges randomised control trials and tended to exclude other research designs and qualitative evidence (Dixon-Woods et al., 2006a, 2006b). To that objective, conventional the method requires strictly staged protocols suited for generating an aggregative synthesis that summarises data along concepts (categories and variables) that are assumed to be 'largely pre-specified, secure and well defined' (Dixon-Woods et al., 2006b, p.36Dixon-Woods et al., 2006bDixon-Woods et al., 2006b, p.36).

In the sustainability transitions field, however, systematic reviews (e.g. Sengers et al., 2016 forthcoming, Kivimaa et al., 2017) have been used instead to explore and contrast understandings of particular concepts, to enable theoretical refinement and identify areas for further development. For that reason, scholars adopted more interactive procedures (rather than staged), combined with an interpretive stance necessary to realign the reviews with the constructivist perspective on scientific knowledge (e.g. Sengers et al., 2016 forthcoming). Within other communities, similar concerns inspired the development of various methods for the synthesis of qualitative research (cf. Weed, 2005; Barnett-Page and Thomas, 2009).

A review with emphasis on aggregative synthesis would not meet our interest in problematising this nascent literature, which is currently in flux, with concepts are not consistently labelled, defined and interpreted with multiple competing arguments over the conceptualisation of experimentation (c.f. Sengers et al., 2016 Forthcoming, Caprotti and Cowley, 2017; Kivimaa et al., 2017; Weiland et al., 2017) and equally diverse understandings over the contexts for experimentation (c.f. Longhurst, 2015, van den Heiligenberg et al., 2017, Torrens et al., 2018).

Instead, we adopt the method of critical interpretive synthesis that aims explicitly at theoretical development, circumventing some of the strictures of systematic reviews (Dixon-Woods et al., 2006a). In our understanding, CIS makes explicit the adaptations which scholars in the transitions field were already adopting. Its key processes are as follows (Dixon-Woods et al., 2006a, p.10)

- To start, a research question is formulated, but it may be revisited and refined
- Rather than a staged process, searching, sampling, and critique and analysis proceed iteratively, and are considered 'dynamic and mutually informing processes'
- Search is approached with a broadly defined strategy, rather than a strict protocol, and may include purposive selection of material known to be relevant
- Ongoing selection of potentially relevant sources is informed by the emerging theoretical framework, and may require additional searches
- Appraisal of sources privileges their relevance and theoretical contribution, rather than adherence to a strict hierarchy of evidence
- Procedures for extracting data may be useful but are not an essential feature

CIS complements well the notion of problematisation with an explicit method for handling the literature review. Its ideal output is the formulation of a synthesising argument which integrates the evidence from across the corpus of research into a 'coherent theoretical framework comprising a network of constructs and the relationships between them' (Dixon-Woods et al., 2006a, 2006b p.5). This may require the generation of 'synthetic constructs' that stem from interpreting the evidence included in the review, and which mobilise various facets of the phenomenon at hand. For that, CIS invites engagement and critique with the assumptions, research traditions and meta-narratives which lay behind research reviewed. As it relies on an interpretive approach, CIS does not lend itself to full auditability and reproducibility expected of systematic reviews. Nevertheless, CIS strives for methodological transparency, embracing the authorial dimension to the research and demanding constant reflexivity by the authors of the review.

To adapt CIS to our objectives, and focus on problematisation, we carried out a search on Scopus® database for studies concerning UE with sustainability (see Appendix A for detail on the initial searches). From this initial corpus, we identified literature reviews (n = 8), and traced their references and citations. Removing duplicates, excluding conference papers (which quality varies considerably) and screening the abstracts for relevance to our question, we limited the search to 99 entries. We then assessed the introduction of these papers, to confirm that they placed sufficient emphasis on the contexts for experimentation to justify a full-text reading. Our lead author was mainly responsible for handling the literature review, co-creating the strategy with the other co-authors and discussing intermediary results.

Finally, our interpretive synthesis was refined through dialogue with scholars in this field and feedback received in multiple conferences (Eu-SPRI 2016, IST 2017, Hamburg workshop on Urban Energy Transitions 2017, acceleration workshop in DRIFT 2018, NEST conference 2018).

3. Results

Below, we present the three lenses derived by approaching the extant literature with this combination of problematisation and CIS. The first part of Table 3 shows the root-metaphors, context and process drescriptors used for grouping the studies reviewed (see also Appendix B). The second part expands on the in-house assumptions, which we explore and articulate in the coming sections. to identified three distinctive lenses, a coherent of assumptions and understandings about the nature and processes of development of favourable environments for UE, that could potentially be used to interrogate empirical cases.

Table 3
Lenses articulating the different assumptions encountered in the literature, based on the critical integrative synthesis.

Lens	Seedbeds	Harbours	Battlegrounds
Root-metaphors for the context	Evolutionary and ecological, invoking protection, separation and growth	Maritime, travel, and communication metaphors invoking mobility, flow, connectivity, communication, and cosmopolitan sensibilities	Conflict, confrontation, and performance, invoking friction, tension, and strategic action
Commonly-used context descriptors	Niche, protective space, habitat, fertile soil, breeding space, seedbed	Alternative milieu, hub, nexus, nodes, buzz, pipelines	Arenas, fields
Commonly-used process descriptors	Protecting, embedding, seeding, shielding, nourishing, nurturing, growing, replicating, scaling up, fertilizing	Harbouring, connecting, networking, migrating, anchoring, transferring, circulating	Mobilizing, resisting, struggling, gaining traction, entrenching, challenging, empowering, mediating
Conception of the urban context	A configuration of place-specific factors and resources that creates a distinctive selective environment	A hub of connections and passages, embedded in wider networks and circulations of resource, people and knowledge, which sustains a socio-cognitive milieu	An arena of disputes between political coalitions, which act strategically to advance their objectives
Role of urban context in sustainability transitions	Protect emerging socio-technical configurations, allowing them to develop and grow despite the pressure of the incumbent regime (through shielding, nurturing and empowerment)	Facilitates encounters, anchoring and (re) discoveries of various tendencies, increasing their exposure to transnational developments while offering a socio-cognitive form of protection for sub-cultures	Act as places where confrontation between incumbent and challengers are play-out, making disputes visible and allowing for the reconfiguration of governance arrangements
Contextual dynamics emphasized	Evolutionary Emerging practices, innovations and experiments are shielded from harsh selective forces, nurturing local variation and learning-by-doing	Relational Formation of a well-connected, reputable place, which draws in resources while offering exceptional socio-cognitive opportunities and protection	Institutional/Conflictive Empowerment and encounters with structural impediments Restructuring governance arrangements
Prevalent forms of knowledge and learning	Tacit knowledge from experiments being retained locally Local ecology of knowledge	Trans-local learning Access to privileged communicative channels Migration of embodied expertise	Learning through confrontation/ contestation (critical knowledge)
Political dimensions	Negotiating protection Ensuring protection and negotiating resource allocations despite entrenched interests	Navigating connectivity Power relations enacted through translocal linkages	Strategising conflict Negotiating across incongruent interests to achieve substantial institutional reforms or dislodge dominant interest
Role of intermediaries	Framing of local projects, aggregation of learning, harnessing local resources Mediating between individuals and institutions/firms	Primarily as transfer agents, connecting to global networks, harnessing resources from afar, promoting place-reputations, translating and codifying notions	Mediating confrontation and controversies, re-framing activities, building alliances, mobilizing
Key oversights	Unrealistic 'localism' of a containerised view of urban contexts Assumes a shared vision	Tensions in bringing novelty to context Who represents the milieu?	Risk of exaggerating the role of conflict in enabling transitions

3.1. Seedbeds

The seedbed lens forgrounds configuration of place-specific factors and resources that are thought to contribute to a selective environment conducive to experimentation by affording protection for experiments, shielding them from the harsh conditions imposed by the prevalent socio-technical regime and promoting specific processes for nurturing innovation and supporting their growth and diffusion (see Smith and Raven, 2012).

Studies in this group draw primarily from the SNM literature, referring to the context with a variety of evolutionary and ecological metaphors which emphasise protection such as niches, seedbeds, habitats, and fertile soil, and to processes which allow initiatives to be replicated, grown and spread. Similar metaphors are also present in the grassroots innovation literature, which also draws from SNM (e.g. Smith and Seyfang, 2007). Conversely, these metaphors also indicate that this protection is not absolute, as the experiments are seen to be 'exposed to the elements' of real-world contexts. To encompass both meanings, but avoid conflation with the concept of niches (which has been interpreted in multiple ways), we labelled this lens as seedbeds. Fittingly, this metaphor has been used to describe the role of cities low-carbon transitions, when cities act as the initial locations for niches that go on to expand elsewhere, forming national-regimes (e.g. various niches associated with electrification), contrasted to cities not playing a part, or acting as key as agent in national level transitions (see Geels, 2011a, 2011b).

This lens focuses attention on how the contexts are reconfigured throught the acummulation of lessons from experiments, suggesting that particular places or cities may give rise to situated 'protective spaces' for experimentation. The formation of favourable environments for UEs is thought to be analogous to the formation of niches. For protection to emerge, different dynamics are at play that allows for variation to emerge, and for novel sociotechnical configurations to develop through sequences of experiments. Three key dynamics that have been summarised by Smith and Raven (2012) and cited by multiple works in this grouping.

First, the emergence of a protective space depends on shielding, which refers to processes involved in modulating the pressures exerted by mainstream selection environments (Smith and Raven, 2012). This is thought to passive shielding, where this is due to a contingent combination of favourable conditions which predates the strategic intent, and active shielding, where proponents of a certain innovation or experiment deliberately and strategically seek to create protective spaces (e.g. demonstration projects, urban laboratories, urban living labs). In the former, a growing literature has identified a series of place-specific conditions or 'success factors' which can contribute to the emergence of experiments (e.g. van den Heiligenberg et al., 2017, Feola and Nunes, 2014, Hansen and Coenen, 2015).

Second, the urban context may enhance nurturing, the processes that support the development of innovations: assisting learning, articulating expectations and for strengthening social networks (Schot and Geels, 2008). Local networks are implicated in such activities; the breadth and inclusivity of these networks is understood as a crucial factor for the development of the context. In line with the local-global model (Geels and Raven, 2006), intermediaries are seen to play a key role in framing local activities and aggregating/codifying the knowledge so that it finds wider applicability, and in creating further protection for new experiments.

A third dynamic has been identified, which concerns the empowerment of initiatives – the discursive processes through which actors involved in a given protective space argue for the wider applicability of those experiments (Smith and Raven, 2012). Here, actors may develop the competitiveness of niche (fit-and-conform) or by restructuring the wider selective environment (stretch-and-transform). In both cases, the very accumulation of experiments in a particular place may reconfigure the context as to favour further experimentation, thus creating a self-reinforcing dynamic (Hodson et al., 2017; Torrens et al., 2018).

In this understanding of the context, learning is primarily derived from practical activities (learning-by-doing) associated with introducing novel socio-technical configurations in a particular context. Whether knowledge is primarily situated or brought-in from other contexts seems to be an empirical question (c.f. Holm et al., 2011; Schreuer et al., 2010). According to Heiskanen et al. (2015) there has been a tendency to neglect the knowledge accumulation that happens locally, in a 'the multi-interest' context (Heiskanen et al., 2015). Along these lines, a complementary understanding can be found in studies which characterise creative cities. Cohendet et al. (2010, p.108, our emphasis), for example, suggests that a set of distinct organisations with different interests may in fact be necessary to sustain learning processes in a particular city. Based on a case of Montreal's creative milieu, they describe how a 'delicate, subtle and fragile local ecology of knowledge, where creative processes nourish themselves' can emerge from the repeated exchanges between three groups: underground (i.e. artists, activists, bohemians primarily involved in exploring and experimenting with radical ideas; the upperground, i.e. companies, multinationals, concerned primarily with exploiting commercial opportunities, and the middleground, intermediaries invested in developing the local scene.

Politically, this understanding of the context highlights contention around ensuring the viability of policies supporting protection, and the allocation of resources to nourish initiatives. Also, fit-and-conform strategies for empowerment raise concern over capture, particularly when the priorities of national or municipal governments differ (Shreurer et al. 2010), or when municipalities are seeking to support grassroots initiatives and risk overriding their priorities (c.f. Wolfram, 2018; Torrens et al., 2018).

Two oversights justify the need for other analytical lenses. First, as pointed in recent geographical critiques, it is 'problematic to assume that 'tacit knowledge transfer is confined to local milieus whereas codified knowledge may roam the globe almost frictionless' (Bathelt et al., 2004, p.31 apud Sengers and Raven, 2015). This is aggravated by neglecting other non-local relationships which co-constitute the urban context (Späth and Rohracher, 2012). Second, this lens risks 'naturalising' the mechanisms through which certain interests prevail over others, depoliticising how urban contexts are mobilised and positioning as a privileged site for experimentation with particular forms of sustainable technologies and practices (Heiskanen et al., 2015). Moreover, privileging a localised dynamic of learning and creativity and emphasising consensus building downplays the potential conflict in attempts to reconfigure the city, and masks incongruent visions of how the city ought to develop and who is to decide (Bulkeley et al., 2014a, 2014b; Hodson and Marvin, 2009, 2010).

3.2. Harbours

The harbour lens foregrounds urban contexts as hubs for connections, passages, mobilities and flows, acting as nodes in a wider network of cities and places, which foster diverse place-specific but connected subjectivities. Under this perspective, favourable environments for experimentation may form when places are able to draw in like-minded individuals, facilitate encounters, and enable anchoring and (re)discoveries of various tendencies. This lens emphasises that a particular city can develop multiple transnational links and become a privileged site for experimentation if it attracts, retains and facilitates the circulation of resources and embodied expertise (experts, activist, social entrepreneurs, etc.), while at the same time offering a receptive context for ideas and concepts (including but not restricted to technology). As Blok and Tschötschel (2016), rather than emphasising the solely the fixity of metropolis, places should be seen as 'a particular nexus of situated and transnational ideas, institutions, actors, and practices that may be variously drawn together for solving particular problems' (Ong, 2011 pp. 4). Regarding the prospects of transitions, places are understood variably as passage points to multi-locational innovation journeys (c.f. Sengers and Raven, 2015), members of wider cosmopolitan communities which share risks and jointly pursue opportunities (Blok and Tschötschel, 2016) or as enrolled in demonstrating the agenda of powerful transnational interests (Silver, 2017). In turn, experiments are seen to be particularly important means to reconfigure the flows or linkages, leading to potentially self-reinforcing dynamics.

Works appertaining to this group deploy a variety of geographically-informed conceptualisations, recognisable by their various maritime and travel and communication metaphors alluding to connectivity, circulation, flow, movement, transport, transmission and transnational links. Despite considerable theoretical diversity, this group is distinctive because of its reliance on relational conceptions of place that highlight the co-constitution of situated and translocal relationships and structures. Some of these studies draw from primarily from assemblage urbanism theories, thus inherinting both relational geographic understandings of place and flat-ontologies from actor-network theory (e.g. Blok, 2014). Implied in these accounts, is a dialectic between that which is mobile and fixed: "mobilities cannot be described without attention to the necessary spatial, infrastructural and institutional moorings that configure and enable mobilities" (Hannam et al., 2006, p.3). Thus, to label this group, we use the metaphor of harbours, which represents places of privileged connectity, which arise from both favourable geographical characteristics, insfrastructural assets and historical developments, that are enrolled in wider networks of circulation, and which develop particular cultures as a result (e.g. multicultural, tolerant to diversity, cosmopolitan, etc). This is not restricted to actual port cities, even if global port cities epithomise this framing (e.g. Blok and Tschötschel, 2016).

This lens focuses attention on how the contexts are reconfigured through their connectivity and exposure to other contexts. It opens research on how place-specific and proximal aspects are shaped by networks and processes 'beyond the local', through a variety of actor-, knowledge-, capital-, institutional-, and technological-transnational linkages and flows (Wieczorek et al., 2015). Two salient dynamics are salient in the literature.

First, Longhurst (2015) and Torrens et al. (2018) indicates a recurring dynamic involving cultural alterity, openness and experimentation in the formation of an alternative milieu, defined as a 'geographically localised concentration of countercultural practices, institutions and networks can create socio-cognitive 'niche' protection for sustainability experiments'. The (pre-) existence of non-mainstream identities and practices is thought to contribute to welcoming and sustaining other counter-hegemonic identities and practices. In turn, this cognitive protection and openness helps reinforce claims of cultural alterity. This dynamic is crucial for the emergence and renewal of positive socio-spatial imaginaries (i.e. actors assume that the context is a good one for trying novel and radical ideas). Similarly, Amin et al. (2002) discussed the importance of developing and reinforcing an outward- and forward-looking sense of place, characterised by a:

> readiness to avoid a politics of place based around an inward-looking local sense of place (e.g. a culture of 'we have always done it this way', or 'our field of engagement ends at the city boundary'). Instead, we see a politics *in* place that is not reducible to a local sense *of* place, one that draws on a wider field of connections, resources, and ideas (…) (p.121)

Second, a recursive dynamic involves experiments enabling or reinforce transnational linkages, and develop place-reputations, and vice-versa. Powerful actors and often foreign actors (e.g. donors, intermediary organisations, expert networks) are particularly drawn to iconic experiments which promise to further transnational linkages and increased pull for flows of people, capital, technology (Blok, 2014). Moreover, the reputation of local institutions (e.g. grassroots exemplars, leading universities, local think-thanks, well stablished firms) and different shades of place-reputations - 'green', 'bohemian', 'creative', 'alternative', 'entrepreneurial' - which emerge organically can become prised assets which municipal governments seek to build-on and leverage (Hodson et al., 2005, Torrens et al., 2018). They are crucial to attract migration of likeminded individuals and mobile experts, new knowledge, resources and capital. Increasingly, local stakeholders are engaged in quotidian efforts to shape, advertise and instrumentalise their reputations, for which sustainability activities are a prime substrate. Networks of consultants, journalists, city networks, prizes and international challenges are involved in locating, branding, ranking and celebrating 'best places',' best practices' and national exemplars (Hodson and Marvin, 2009; McCann, 2013; McCann, 2004; Ward, 2000). The active promotion by mayors and local authorities signals an 'extrospective' stance, with an 'explicitly stated global orientation that encourages both competition and cooperation with other cities for "greenest," most "liveable" status' (Mccann, 2013, p. 11). Furthermore, place-reputations may enable access to privileged communicative channels implicated in the circulation of knowledge. Building and maintaining these linkages and channels require dedicated efforts, expertise and resources which are unevenly distributed (Bathelt et al., 2004; Sengers and Raven, 2015).

Here, learning is conceptualised as happening primarily across multiple localities, and through a combination of cosmopolitan and situated ideas, designs, and interests. This highlights the process of de-embedding, translation and re-embedding of lessons and experiences across places and scales, for which there is considerable conceptual (see Geels and Raven, 2006; Sengers and Raven, 2015; Blok, 2014). It is consensual that these processes are neither automatic nor neutral politically, in the sense that what is

mobilised is inflected by the interests of the actors involved in the transfer, e.g. consultants, traveling bureaucrats, mobile knowledge workers, and 'experts-cum-advocates' (Blok, 2014; Wieczorek et al., 2015; Sengers and Raven, 2015). Elsewhere, the importance of the capacity of cities to 'anchor' more global policy change has been noted (Carvalho et al., 2012).

Politically, a variety of issues ensue. Centrally, power relationships are enacted through transnational linkages, mobilities and flows, and therefore research should attend to "the ways in which these re-configure (or reinforce) local structures in receiving geographical contexts and how they shape the design and outcome of socio-technical trajectories" (Wieczorek et al., 2015, pp. 154). Illustrates that this may entail a 'partial dislocation of urban authority' face new mobile urban policy elites. Blok (2014) illustrates how models of eco-urbanism tend to be constituted through dominant strategic and commercial interests, and to be dominated by global cities 'able to exert control over critical resources in competition with more ordinary cities'. Similarly, the dynamics described entail 'new moral geographies of inclusion and exclusion (…) as certain world cities emerge as hubs in new 'green' flows of technical and policy expertise on urban sustainability', forming 'cosmopolitan risk communities' (Blok and Tschötschel, 2016). For cities at the margins, experiments are often initiated from 'top-down' with tightly prescribed priorities and guidelines from funding agencies and international donors, e.g. privileging private service delivery over community ownership, and thus prematurely shut down alternative progressive or inclusive pathways (Silver, 2017). In each of these cases, studies flag that experimentation is not without contestation and conflict, which may open new spaces for politicization at the city level.

Two oversights are evident here. First, although this perspective is critical of power asymmetries associated with transnational linkages, but less explicit about other forms of contention that arise with experimentation. Also, an emphasis on connectivity and exposure as avenues for developing favourable environments for UE places much hope for transitions on cities that are already in a privileged position and which for that reason may be those most strongly aligned with incumbent interests.

3.3. Battlegrounds

Finally, the battleground lens forgrounds urban contexts as arenas or fields where political contestation, struggle, cooperation are staged. This lens highlights the controversies, crisis and tensions between divergent interests, around which coalitions and social movements organise, which may or not escalate into overt conflict. It focuses attention on particular situations and events which create openings for change, rather than on the long-term development of stable structures. While still concerned with experiments, this perspective opens up the analysis to episodic contentious and unruly politics, demanding an examination of the processes implicated in the reconfiguring infrastructures or governance arrangements and how they can expedite or hinder sociotechnical change. This includes how social movements and political movements organise to resist particular developments, and clashes between distinct coalitions and alliances around particular policy decisions, e.g. between local and central governments, political parties or environmental movement and polluting industries.

This lens draws from studies that use conflict, confrontation and performance metaphors. Context are often described as either arenas or fields. Arenas tend to be used in conceptualisations drawing from Actor Network Theory (e.g. Jørgensen, 2012), while fields are used in conceptualisations emphasising institutional understandings (e.g. Fligstein and McAdam, 2011). These descriptors highlight an understanding of social ordering marked by a temporary, situational and actor-dependent character, with moving boundaries and new entrants, in which apparently stable situations may be destabilised by crises or surprises. Conflict is seen as generative of change, highlighting processes of building coalitions, alliances or mediation. In some cases, those metaphors convey a sense of performance (e.g. in tactical urbanism or gerrila gardening), that capture how actors (especially social movements) may use tactics such as protests, occupations, and media campaigns to draw attention to their struggles (e.g. Jørgensen, 2012). For all these reasons, we summarise this group under the label battlegrounds.

A variety of theoretical positions are salient here. Works associated with this lens tend to dispense with the levels proposed in the multi-level perspective, favouring instead actor-centric accounts which foreground constellations of actors and their efforts for collective sense making and placemaking (e.g. Jørgensen, 2012, Murphy, 2015, Håkanson 2018). This focuses attention on how apparently powerless actors may be liberated from entrenched institutional or cognitive frames, opening up for alternative visions, interpretations, contestation and thus different courses of strategic action. Accounts of the struggles faced by grassroots and local energy initiatives (Fuchs and Hinderer, 2014; Blanchet, 2015), for example, adopt theorisations of 'strategic action fields' (Fligstein and McAdam, 2011). This conceptualisation highlights interdependence and competition between actors embedded in a 'socially constructed arenas within which actors with varying resource endowments vie for advantage' (Fligstein and McAdam, 2012, p. 3). Periods of episodic contention between actors can give way to 'settlements', periods of relative stability which re-establish collaboration and orderliness in which a dominant frame of what is at stake and what are acceptable forms of intervention become entrenched (Fligstein and McAdam, 2011).

Conflicts are thought to be both caused by and potentially generative of UE and grassroots initiatives (Blanchet, 2015, Håkanson 2018). For example, Jørgensen (2012) highlights an instance where squatters organised a series of protests to resist the construction of a highway in Copenhagen, drawing on alliances with other sectors of the city, and ultimately derailing the plans while creating space for deliberation around alternatives to automobility. Along these lines, Murphy (2015, p.84), for example, has called for:

> analyses of the competing place-frames associated with sustainability initiatives and the networks and actor- or institution-specific positionalities that stabilize, obstruct, and/or promote development visions.

One contextual dynamic regards how restructuring governance arrangements open or foreclose the possibility of experimentation in particular directions, and vice versa. Torrens et al. (2018), for example, draws from Ward (2000) and Fligstein and McAdam (2011) to study settlements - 'periods with stable constellations of actors and prevailing framings of what is at stake, resulting (…) different patterns of experimentation (…) and modes of governing this activity' (p.7). Such settlements are thought to arise from

temporary standoffs between distinct coalitions of actors or between different local and national government. In contexts with multiple experiments, this may create selectivity, supporting some initiatives but curtaining others. Settlements may become entrenched through institutionalisation or might unravel that conflicts and controversies external to a CUE may (see Fligstein and McAdam, 2011). One example of such a dynamic is found in Mclean et al. (2016), who argue:

> the 'opening up' of cities as experimental nodes is contributing to a restructuring in socio-technical urban governance, with the creation of new spaces for targeted private investment and the responsibilities of conservation efforts delegated down to an environmentally conscious citizenry.'

Another contextual dynamic regards how actors participating in conflict and confrontation may develop the capacities to act politically and increase their ability to carry out UE. This dynamic overlaps with the 'stretch-and-transform' empowerment described in the SNM literature (Smith and Raven, 2012). This concerns processes that 'create capabilities and attract resources that empower participation in political debates over the future shape of institutions and regime selection pressures' (Smith and Raven, 2012, p. 1032). For example, when grassroots initiatives may encounter structural impediments to their objectives; being confronted with institutional misfits, economic and social structures and incumbent interests, lacking infrastructures, these actors may develop critical knowledge and political acumen about the wider structures which constrain their activities (Smith et al., 2014). Similarly, disputes over how sustainability issues are being framed (issue-frames) intractable controversies around narratives, visions or imaginaries of what a place can or ought to be (place-frames) advanced by it, may lead to the sort of societal learning often attributed to experiments themselves, challenging fundamental assumptions and spurring the search for other visions and narratives about change. Actors involved in such disputes may develop 'social skill', the ability of individual or collective actors 'for reading people and environments, framing lines of action, and mobilizing people in the service of these action 'frames'' (Fligstein and McAdam, 2011, p. 7). Skilled actors are better equipped for advancing their interests by mediating and convincing others and forming coalitions and alliances. Works in this vein challenge assumption of gradual aggregation of learning locally.

This lens places the politics of urban transitions front and centre, highlighting the struggles over the future development and questioning how experiments are enrolled in restructuring wider socio-technical governance of cities, emphasising the ambivalent character of experiments 'both as a means through which to orchestrate potentially progressive and effective socio-technical change and as a means through [which] existing interests can contain the challenges of 'low-carbon' urbanism' (Bulkeley et al., 2014a,b, pp.1472). Thus, the outcomes and objectives of experiments are treated as ambiguous rather than progressive. Various works highlight contestations around supposedly green urban experiments which enact neoliberal framings (e.g. Silver, 2017), or further gentrification (Håkansson, 2018). Bulkeley et al. (2014a, 2014b) proposed that it is paramount to investigate how notions of justice are articulated, practiced and contested through experiments. Without such considerations, there is a risk that incumbents may use experimentation primarily as means of socio-spatial and socio-technical control over the development of the city and the systems that compose it. Even when this is the case, however, actors involved in setting up experiments may well be aware of these dynamics and act strategically to reposition and continue to challenge incumbent structures. For example, Gopakumar (2014) highlight how experiments advancing the marketisation of water supply inadvertently help coalescing oppositional networks of activists, which go on to set up counter-experiments that embody other logics and visions.

This lens redresses important oversights of the previous lenses, but it is equally partial in focusing primarily on framing disputes and empowerment. One should avoid the pitfall of assuming binary conflicts between coalitions of local actors and non-local actors, or niche-actors and incumbents (c.f. Blanchet, 2015). Instead, the richness of this lens lies in considering how actors mobilise alliances to advance particular framings or visions. Considering whether these alliances form stable settlements avoids over-emphasising conflict where there is evidence substantial collaboration and interdependence.

4. Synthesis and discussion

With our methodology, we sought to develop a synthetic and pluralistic approach that can support studies of the formation of favourable environments for UE. We had to balance the trade-off between two efforts: expanding our literature searches beyond the familiar remit of SNM to counter the bias towards protection, and analysing the corpus to produce a meaningful problematisation. We started with ample search parameters, carried out two rounds of triage, and grouped the articles with similar root-metaphors and apparent framings, before interpreting the different assumptions held in each of these groupings with the basis of our analytical framework (Table 2). This led us to outline three lenses associated with a coherent set of in-house assumptions. Taken individually, different papers rely on some of these assumptions but not others. Taken collectively, the different groupings gave as a clearer sense of the salient arguments and critiques reoccurring in the literature. These lenses could also be understood as different framings or perspectives, but that would imply they are mutually exclusive. By refering to them as lenses we hope to stress that they may be justaposed or combined in studying a particular context. This pluralistic approach may help researchers to be more reflexive about their implicit assumptions, and to expand the suit of dynamics they consider when studying UE.

4.1. How does the extant literature conceive of the favourable environments for urban experimentation?

Our results confirm the initial hypothesis that there are very distinct understanding of the urban context and the dynamics of formation of favourable environments for UE. Despite the importance of UE in current discussions about urban transformations, and numerous examples of how a multiplicity of experiments is involved in bring about such processes, few articles dealt directly with the evolution of the settings in which such experimentation occurs. The ones that did, considered place-based accounts which expanded

on the notion of niches (e.g. Longhurst, 2015; Torrens et al., 2018). Nevertheless, many articles allude to the contexts for experimentation, or to theoretical concepts about these contexts, which we sought to scrutinise.

The works that informed the seedbed lens were relatively cohesive, drawing from similar sources and using a shared set of concepts that are well established in the SNM literature, an evolutionary understanding of the contextual dynamics. Many individual studies have sought to expand on SNM, suggesting conceptualising urban contexts as situated protective spaces for experimentation. We noticed a risk of overly expanding what is understood as protection, encompassing everything that is good for experimentation. We concur with a more specific understanding of protection as in relationship to a dominant socio-technical regime (e.g. Smith and Raven, 2012) but go on to suggest that other facets of urban context also play a role in modulating the emergence of UE. We therefore argued in favour of clearly distinguishing different understandings of the context.

Both the harbours and battlegrounds lenses rely on work that is more recent, and so no singular theoretical perspective predominates (see Appendix B). Overall, works associated with the harbour lens aimed at more spatially and mobility attuned accounts of UE and drew primarily from geographical traditions. Those associated with the battleground lens foregrounded actor-centred and conflict-aware accounts of UE and drew from theories such as political ecology and social movement theories. Such concerns have been addressed by a variety of social science schools, so the conceptual diversity is not surprising. Our objective here was not to reconcile such drastically different conceptions, but to make evident the different assumptions which they carry.

These lenses have distinct strengths when paired with the appropriate contexts. The seedbed lens seems appropriate in cities where UE is being driven actors embedded locally which tap into shared or at least popular visions, and where policy action to support experiments is not particularly controversial (e.g. pilot projects for electric buses developed by local consortiums and supported by local governments, local food networks founded by grassroots organisations and supported by other stakeholders).

The harbour lens is more appropriate in contexts where experimentation is driven through the mobilisation of interests, visions, and resources from elsewhere, or aimed at, for example, iconic eco-housing buildings aimed at international notoriety, eco-district developments in world port cities, development projects financed through foreign aid.

The battleground lens highlights the role of conflict, controversy and struggle in resisting or opposing particular developments, which may in turn spur experimentation, such as protests against highway constructions followed by experiments in cycle mobility, struggles against evictions stimulating alternative visions of social housing provision.

These are obviously stylised examples which fit ‘neatly’ into a lens - reality is much messier. So rather than applying a lens, we suggest that analysts would benefit from interrogating situations from various angles. These lenses do not substitute theories, but nevertheless highlight certain features of a context, guiding the analysis in different directions and helping scholars problematise their own positions (Alvesson and Sandberg, 2011) or to scope different options for theoretical triangulation (Sovacool and Hess, 2017).

4.2. Contextual dynamics

Our analysis identified a variety of contextual dynamics associated with the development of favourable environments for experimentation, broadly associated with evolutionary, relational and institutional or conflictive understandings of how change comes about. Our approach highlights the potentially self-reinforcing characteristic of these processes. This seems pertinent given that the literature has only began to explain why particular places come to concentrate and sustain UE over extended periods.

Framing this discussion around contextual dynamics forces us to consider that contexts are constantly evolving. It draws us away from the notion of success factors which is generally static: either places have or not such factors at a given time, with little no clarity on how factors arise. Instead, our approach centred on asking how experiments co-constitute their environments, which we see as promising for research on urban transformations. It may be worthy enquire whether certain success factors are good indicators a given dynamic is in place and develop tools for assessing the development of the context.

Other dynamics might be of relevance, so we would welcome other studies exploring this space.

4.3. Analytical implications

For those concerned with understanding the uneven development of UE, these three lenses may form the basis for an analytical framework. Each lens identifies plausible self-reinforcing dynamics that have a strong association with particular forms of learning, intermediation and politics. This could help analysts examining why certain forms of experimentation thrive in certain places but falter in others, or why distinct patterns of experimentaiton are prevalent in certain periods, leading to path-dependant styles of experimentation. It would be fruitful to inquire about the effect different dynamics have on development of different kinds of experiments, and whether particular experiments require certain dynamics to thrive, or are more likely to fail under certain conditions. Our contribution is a small step towards a systematic assessment of such selectivities.

Tentatively, we suggest that places in which seedbed-like dynamics are prevalent may be conducive to experiments requiring intense practice-based learning (e.g. demanding user involvelment) and adaptation to highly localised practices and preferences (e.g. eco-housing, see Holm et al., 2011) or dependent of high-degrees of trust and collaboration (e.g. energy cooperatives, community gardens). Places in which harbour-like dynamics are salient, marked by high connectivity and exposure, seem conducive to experiments that assemble multiple elements of various emerging transnational technological trajectories and which are driven by widely circulated imaginaries, such as in the case of Smart Cities (see Raven et al., 2017). Alternatively, places with exacerbated battleground-like dynamics, with entrenched political divisions and controverted visions, may be conducive to radical social innovation but less so for technological development of the sort privildeged in the seedbed-like contexts.

However, we caution against using these lenses as a typology of places, with a one-to-one correspondance between dynamics and

experiments. Several of the articles reviewed highlight dynamics appertaining more than one lens, suggesting context-specific interactions. Analysts may encounter places with multiple co-occurring dynamics. For example, Longhurst (2015) and Torrens et al. (2018) showed that inward migration associated with the growing reputation of an alternative milieu could exacerbate the socio-cognitive protection in a given city and further diversify experimentation. Capturing all possible interactions is an elusive task for which to date there are no systematic study. Instead, we invite analysts to remain attentive to the place speficic expressions of these dynamics. We concur with Smith et al.'s (2016) take on different perspectives on grassroots innovation, that different perspectives and the processes they identify need to be 'in dynamic relations with one another' (p.22). When considering specific cases, it may be useful to consider whether these processes occur in sequence or simultaneously, and whether they reinforce or disrupt one another.

Whether all places can develop these dynamics, and which dynamics are most conducive to distinct patterns of experimentation seem generative questions for future studies, which could be pursued via case-studies or participatory processes.

4.4. Governance implications

Given the complexity of the processes involved in the formation of favourable environments for experimentation, our approach may be of help to actors involved in governing experiments in three different ways. We assume that an actor's implicit understanding of the context, and the metaphors they use when referring to it, are likely to shape particular governance responses.

Firstly, for someone involved in initiating experiments, it is important to assess what dynamics have been at play in a given context (see above), and the extent to which proposed experiments are in a good 'fit' or intentionally 'go against the grain' of organic patterns of experimentation. For example, experiments proposed from the top-down, in a context with a history of controversy may reignite conflict in a resistive way, rather than create the conditions for societal learning. We encourage those designing experiments or proposing experimental spaces to consider which forms of learning, intermediation, and politics they are seeking to stimulate. In certain circunstances, challenging established patterns of experimentation may be useful, but this is likely to require sofisticated intermediation and careful reflexive practice.

Following from that, intermediaries and different governance actors may find this framework useful to reflect on what roles they are likely to play. It may be hard to identify when certain activities might be necessary, and what forms of learning to support, so interrogating the context with different lenses may be useful as part of a reflexive practice. This may give raise to distinctive strategies, which complement the known tools of SNM with activities targeted at developing exposure and connectivity, and for finding constructive tactics to navigate conflict, for which transdisciplinary research is needed.

Thirdly, for those involved in supporting experimentation, it may be useful to consider different avenues through which experiments may have an influence in a process of urban transformation. Not all experiments evolve into full-fledged systems which challenge existing regimes, nor into innovations that circulate widely, or new institutional arrangements. Having a plural understanding of experimentation and its relation to the context should inform forms of evaluation that are commensurate with distinct kinds of experiments and contexts.

4.5. Limitations of this study

Despite our efforts to adopt an expanded working definition of UE, we do not claim to be comprehensive. Our corpus focused on literature that discussed explicitly the relationship between experimentation in the urban context or that had informed directly such discussions (albeit with diverse terminologies). In hindsight, our searches found few examples on grassroots innovations, even though similar arguments are being held in that community (e.g. Smith et al., 2014). The intersections between the urban and grassroots domains deserves further attention (c.f. Håkansson, 2018, Wolfram, 2018).

Our corpus also downplayed the specific practices involved in performing experimentation, such as the transition management's emphasis on co-creation and co-production (e.g. Frantzeskaki et al., 2018), debates within the sustainbility science about transdisciplinarity and experimentation (e.g. Caniglia et al., 2017; Schäpke et al., 2018). Mapping which methods of facilitation, co-creation and co-production are most appropriate to navigate the various contextual dynamics is an interesting avenue for future research.

Moreover, as the terminology in this domain of the literature is not fixed nor subject to strict convention, searches on databases are necessarily biased by the search terms used. We tried to circumvent that problem by combining different search terms and including articles citing and cited by other literature reviews (Appendix A). Still, it is possible that we missed other references covering the topic of interest. However, given that we have also inspected the references of the articles that were included in triage, and included then when relevant (see CIS) we believe that missing references would have little effect on our interpretation.

Grouping different works by using their metaphors proved to be useful but not trivial. Some articles use metaphors explicitly and reflectively, while others use them interchangeably. In the case of the seedbed's metaphor, for example, Geels (2011a, 2011b) proposed the term when studing how cities can contribute to urban transitions, which was then adopted by various authors deploying and expanding on that idea. However, when we use the metaphor in our tables, they are derived from the grouping of papers, and not from a single study; we also used them as handles to summarise a broader set of assumptions which have a degree of internal coherence and which represent at least partially how that grouping treats UE.

Each of these groupings are not homogeneous or easily separated from the others, as the individual works that compose them draw from diverse influences and interpret core concepts from different angles (Appendix B). In various cases, articles show a degree of overlap between different dynamics and framings. We sought to move beyond discussing differences in terminology to highlight the key differences between distinct perspectives that co-exist in the literature. These are substantial because they derive from paradigmatic understandings of the nature of the urban context and its change, and many in-house assumptions that risk being taken for granted by practitioners and scholars alike. By

problematising these assumptions without attempting to provide a single synthetic approach, we hope to foster more constructive and plural understanding and debate about the formation of favourable environments for UE.

Our searches and method also downplayed the importance of the socio-material context for urban sustainability transitions, in both infrastructural (e.g. Hodson and Marvin, 2010; Rutherford and Coutard, 2014) and socio-ecological sense (e.g. Ernstson et al., 2010). It has been argued experiments require a continual remaking (e.g. Castán Broto and Bulkeley, 2013a, 2013b; Bulkeley et al., 2015). Our approach does not substitute those discussions, but hopefully helps to pluralise them in ways that support studies on the long-term evolution of the environments in which UE takes place. When considering infrastructures or socio-ecological systems, there a risk of a priori assuming which factor is determinant in enabling or constraining experimentation. For example, a city with obdurate infrastructure may still develop a context conducive to experimentation with other domains (e.g. novel business models for energy distribution, c.f. Blanchet, 2015).

When interpreting the Harbours lens, we struggled with the fact that most of those works take on a distinct unit of analysis, focusing on transnational and cosmopolitan contexts processes, such as with multi-location trajectories and networks. We believe that dedicated studies observing how particular places are crisscrossed by multiple such trajectories would be a fruitful addition to the literature. We tried to transpose their conceptualisations and what they mean to a particular place, but that is likely to require further conceptualisation.

Moreover, any representation such as ours misses the granularity of the individual works. Each of the in-house assumptions we discussed is subject to entire strands of the literature dedicate to them, as for example, studies concerning the role of intermediaries (c.f. Hodson and Marvin, 2009; Hodson et al., 2013; Hargreaves et al., 2013; Gliedt et al., 2018). We therefore do not presume to have a heuristic that substitutes the underlying literature. Nevertheless, when discussing this work in various conferences, we found that articulating these lenses instigated other researchers to consider alternative framings and emerging conceptualisations, and to attend to the radically diverse ways favourable environments can emerge.

5. Conclusions and research agenda

Our study contributes to pluralising the present debate on UE in two ways. First, we articulated different lines of argument hitherto obscured by considerable theoretical fragmentation in this domain. Second, we highlight the emerging place-based accounts of how situated experimental settings emerge organically. By focusing on the urban context, problematising the assumptions of the literature, and trying to articulate distinct lenses, our work highlights various facets of the contexts in which UE emerge, and identifies the dynamics that may explain their evolution.

The recent interest in UE has produced a growing fragmentation on the theoretical, empirical and methodological approaches, which may hinder the practical application of concepts and the critical engagement with the actually-existing forms of experimentation. By charting different lenses, we hope to facilitate theoretical advancement by clarifying the lines of argument and opening up a debate about which contextual dynamics actually shape the contexts for experimentation in particular cities.

When engaging with urban experiments, which are uncertain and sometimes risky endeavours, actors have to believe that their place is a favourable environment for experimentation or a special place worthy of their efforts (Longhurst, 2015). Understanding what motivates these practices and the different forms of learning involved should be of greater concern for the literature. It should not assume that urban experiments are being initiated over homogenous concerns over climate change, global sustainability, low-carbon transitions, or renewable energy, but instead inquire into how different worldviews and visions of sustainability are invoked in conjuring experiments, arguing for their relevance and making them possible (Blok, 2014, Hodson et al., 2018). Which dynamics matter in a given city is both place and issue specific.

Early on, we identified the risk of overemphasising the creation of designated spaces for experimentation, either as laboratories or as strategic niches, and thus focused our efforts on exploring the dynamics involved in the organic development of experimental settings. Space being limited, we could not treat that former strand in detail. It may be fruitful to explore the discourse around laboratories and contrast their assumptions with three lenses we presented, using a similar analytical approach.

Further research should explore the applicability of the seedbeds, harbour, and battleground lenses to case-study research, empirically refining the characterisation of contextual dynamics and explore their practical consequences (c.f. Smith et al., 2014, 2016). This could involve, for example, recasting the notion of embeddedness in dynamic terms, by considering which dynamics are manifest in a context and which experiments are more likely to succeed when aligned in those situations. Understanding these different selectivities could help explain the emergence of path-dependant styles of experimentation (c.f. van den Heiligenberg et al., 2017, Raven et al., 2017), and the challenges faced by grassroots innovations in different contexts (c.f. Wolfram, 2018).

Our approach may be useful for those studying UE and for those involved in initiating, steering and evaluating urban experiments, pluralising their understanding of the relationship between experimentation and the urban context. Without critical reflection, current UE research may be at risk of repeating the predicament of early SNM scholars who, according to Hoogma et al. (2002), had been 'over-optimistic' about the potential of that tool to foster transitions, noting that

> the positive circles of feedback by which a technology comes into its own and escapes a technological niche are far weaker than expected and appear to take longer than expected […] the contribution of the projects to niche development appear to be small (pp. 195)

To avoid that predicament, future research in sustainability transitions could develop strategies to map and enhance the contextual dynamics that are salient in particular socio-spatial contexts. For example, using participatory methods to discuss the history of a context and assess its evolution through different lenses could support transdisciplinary approaches aimed at harnessing UE to build urban transformative capacity.

If research on experimentation is to play a part in urban transformations towards sustainability, is paramount 'to follow' the development of the contexts in which it happens and take seriously the generative effects of interactions between protection, connectivity and conflict.

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Competing interests

The authors have no competing interests to declare.

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Appendix A. Details of the search procedure

(See Fig. A1)

The figure above represents the procedure we followed for our research. We began the effort to identify a suitable corpus for analysis with a search on the Scopus database, by combining searches for different terms referring to experimentation, and a search regarding terms associated with sustainability and climate change. Each time, we focused on the title, abstract and keywords of

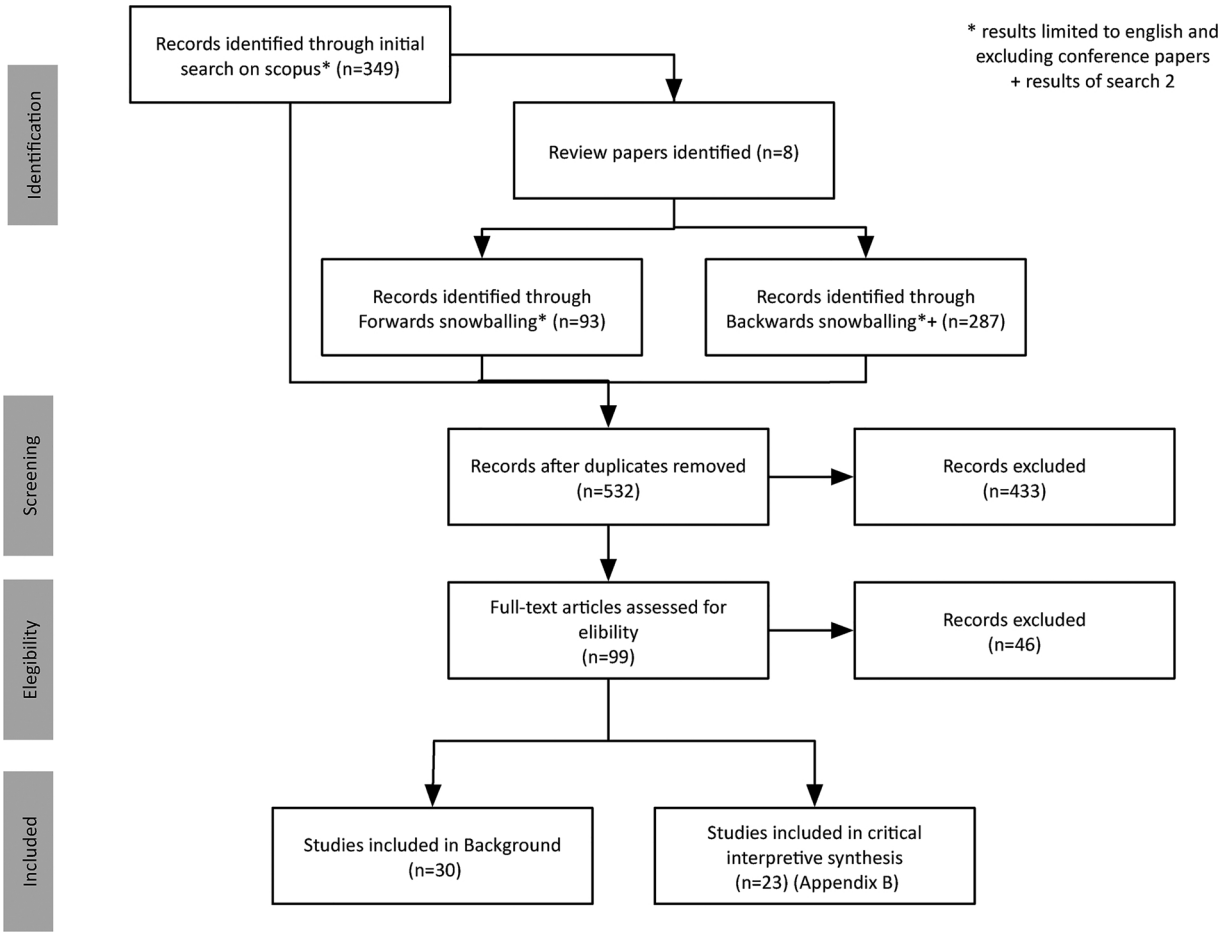

Fig. A1. Workflow of the literature review.

Box A1
Search string used in Scopus for the initial search.

TITLE-ABS-KEY (((urban* OR local* OR socio-technical OR sociotechnical OR niche* OR govern* OR grassroot*) W/3 (experiment*)) AND (sustainability OR "sustainable development" OR "climate change")) AND (LIMIT-TO(LANGUAGE,"English")) AND (EXCLUDE(DOCTYPE,"cp"))
*Scopus' wildcard for 'any number of characters'

Box A2
Search string used to refine results of the backward snowballing.

TITLE-ABS-KEY(nich* OR experiment* OR lab OR labs OR laborator*)
* Scopus' wildcard for 'any number of characters'

documents (TITLE-ABS-KEY command). The search command W/3 (within three words) was used to ensure that variations and permutations of the search terms were found, such as urban sustainability experiment or urban climate change experiments. The combined search string also limited results to English documents only and excluded conference papers (See Box A1).

The bibliographical information of these results was exported to MS Excel®, where a table was created to handle the results. We then examined the abstracts and identified 8 relevant literature reviews.

On the second and third stage, we proceeded with a search of all the articles citing those reviews (forward snowballing), and all the articles cited by those reviews (backwards snowballing). For the backwards search, we refined the results by searching for terms related to experimentation (string on Box A2). The results were added to the same table and the duplicates removed (using the MS Excel® function). When possible, missing abstracts were completed with the help of extra searches.

Screening of the abstracts led us to disregard entries which were not associated with our topic. We excluded, for example, irrelevant entries focused on experiments used primarily as a method of enquiry in environmental and sustainability sciences, and geography (e.g. fieldwork). After the screening, 99 records were considered for a second triage. Initially, we read the introduction of the and conclusions of the articles, selecting those studies which foregrounded the relationship between the urban context and experimentation. Regarding articles dealing with niche construction, for example, we included studies that made clear questions of embeddedness, the influence of place-specific factors, and institutional settings, but excluded studies focusing primarily on niche-regime interactions that were not specific to the urban context. This led to 23 studies concerning the development of favourable environments for experimentation (included in the CIS, see Appendix B) and 30 articles which informed the background.

Appendix B. The tables below summarise the key points, theoretical underpinning (aside interest in experimentation) and methodologies of the papers considered in each of the groupings

The tables below summarise the key points, theoretical underpinning (aside interest in experimentation) and methodologies of the papers considered in each of the groupings (See Table B1–B3).

In a few instances, we included references to works which were not included in the initial searches, but which illustrated the lenses very clearly (Table below) (Table B4).

Table B1
Grouping of papers which informed Seedbed lens.

Reference	Main concern	Theoretical underpinning	Method	Overlaps with another lens
Coenen et al. (2010)	Argues proximity advantages could help explain local niche experimentation	SNM Geography of innovation (proximity)	Case study of aquifer thermal storage in the Netherlands	Harbour
Holm et al. (2011)	How experiments in sustainable housing in Denmark became situated transition arenas and what role did municipalities play	SNM	Four cases of situated niches of eco-construction in Denmark	
Schreuer et al. (2010)	Issues arising when embedding experiments in cities	Constructive Technology Assessment, SNM	Case study in fuel-cell technology in the city of Graz	
van den Heiligenberg et al. (2017)	Assessment of the success factors for experimentation, and typology of habitats for experimentation	Transition Management, SNM, Regional Innovation Systems	Survey of 56 experiments in Europe.	
Wolfram (2018)	Role cities play in emergence and formation of grassroots niches	SNM, grassroots innovations, urban social innovations	Case study of Seoul efforts to support grassroots initiatives	

Table B2
Grouping of papers which informed Harbour lens.

Reference	Main concern	Theoretical underpinning	Method	Overlaps with another lens
Blok (2014)	Suggests an alternative vocabulary and method with which to study and compare eco-housing experiments	Assemblage Urbanism, Worlding Cities, Cosmopolitics	Multi-site ethnography of eco-housing experiments in Kyoto, Copenhagen and Surat	
Blok, Tschötschel (2016)	Argues that Asian and European world port cities are forming a	Cosmopolitan risk communities	Survey of experiments in 16 world port cities and analysis of experiment databases	
Longhurst (2015)	Highlights the role of alternative milieu in creating socio-cognitive protection for sustainability experiments	Geography of sustainability transitions; Territorial innovation models	In-depth case study of alternative milieu in Totnes	Seedbeds
Sengers and Raven (2015)	Development of a spatial perspective on niche-formation	Geography of sustainability transitions Buss-Pipelines Global Production Networks Policy mobilities	Case-study of BRT systems in multiple Thailand cities considering web data, interviews and ethnographic work	Seedbeds
Silver (2017)	How global actors are increasingly involved in local-carbon restructuring, using places at the margins to experiment and dominate governing, sparking contestation	Urban Political Economy	Case-study of waste-management experiment in Mbale, Uganda	Battlegrounds
Wieczorek et al. (2015)	Development of a typology for transnational linkages	Geography of sustainability transitions	Analysis of 200 solar PV projects in India	Harbours

Table B3
Grouping of papers which informed the battleground lens.

Reference	Main concern	Theoretical underpinning	Method	Overlaps with another lens
Bulkeley et al. (2014a, 2014b)	Proposes a typology to examine how justice is articulated, practiced and contested in climate change experiments	Climate justice Climate Change Experiments	5 case-studies of experiments in Bangalore, Monterrey, Hong Kong, Philadelphia and Berlin	
Fuchs and Hinderer (2014)	New approach to analyse emergent forms of governance brought about by local energy initiatives	Strategic Action Fields	Comparative Case-studies in 4 German regions	
Gopakumar (2014)	Emergence of public-private partnerships as laboratories for marketisation of water supply	Science and Technology Studies Political Ecology	Case study of a water-supply partnership in Bengaluru (India)	
Håkansson (2018)	How do grassroots initiatives take shape in particular contexts	Place making Gentrification	Ethnographic case study in Peckan (South London, UK).	Seedbeds
Jørgensen (2012)	Proposes Arenas of Development as an alternative understanding of	Arenas of Development Actor-Network Theory Sense Making	Three illustrative cases including city resistance to highway development in Copenhagen	
Mclean et al. (2016)	Explore the use and consequences of UE in restructuring governance and opening up new spaces for private investment	Climate Change Experiments	In-depth case study of a smart energy grid project in Austin, Texas	Seedbeds

Table B4
Relevant empirical studies included in the analysis, that were not found in the searches but were cited by works in the corpus.

Reference	Main concern	Theoretical underpinning	Method	Associated lens
Cohendet et al. (2010)	Understanding how a creative milieu emerges	Creative Cities	Two Case studies in the city of Montreal	Seedbeds
Torrens et al. (2018)	Unpacking the formation of a favourable environment for experimentation with civic energy alternatives	SNM, Contextual reconfiguration	In-depth case study in Bristol	Seedbeds, Harbours
Amin et al. (2002)	Understanding the uneven distribution of the social economy	Relational urban geography	Four case studies in UK cities concentrating multiple initiatives in social economy	Harbours
Carvalho et al. (2012)	Understanding the mobility of green urban transport policies	Economic geography and innovation studies	Case studies in Curitiba, Göteborg and Hamburg	Harbours
Blanchet (2015)	Why do grassroots initiatives emerge around energy distribution in cities, and how do they influence the governance of urban energy systems?	Strategic Action Fields Grassroots Innovations	Case study of conflicts around ownership of Berlin's electric grid	Battlegrounds
Murphy (2015)	Explores the promise of human geography to complement transition studies	Relational place making	Illustrative case-study of conflicts surrounding smart growth initiatives in Boston Metropolitan Regions	Battlegrounds

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