



Deposited via The University of Leeds.

White Rose Research Online URL for this paper:

<https://eprints.whiterose.ac.uk/id/eprint/144762/>

Version: Accepted Version

Article:

Huxley, R, Owen, A and Chatterton, P (2019) The role of regime-level processes in closing the gap between sustainable city visions and action. *Environmental Innovation and Societal Transitions*, 33. pp. 115-126. ISSN: 2210-4224

<https://doi.org/10.1016/j.eist.2019.04.001>

© 2019 Elsevier B.V. . Licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Reuse

This article is distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs (CC BY-NC-ND) licence. This licence only allows you to download this work and share it with others as long as you credit the authors, but you can't change the article in any way or use it commercially. More information and the full terms of the licence here: <https://creativecommons.org/licenses/>

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

The role of regime-level processes in closing the gap between sustainable city visions and action

Abstract

There is an implementation gap between cities' long-term sustainable visions and the short-term actions realised to achieve them. To accelerate sustainable urban transitions a greater understanding of the regime-level processes that enable or constrain translation between long-term visions and short-term action is required. Transition research to date has neglected regime processes, especially cultural-cognitive habits and heuristics, and the role of power and agency. To address this a novel analytical framework is proposed, with transition theory as the basis, additionally drawing on institutional and quasi-evolutionary theory. This framework is tested using Copenhagen as a case study, generating important insights; in particular that normative institutional processes are an effective means for regime actors to coordinate power, affect resource allocation, and impact selection pressures and adaptive capacity. The findings suggests that unless the institutional and quasi-evolutionary processes that drive action are re-configured in line with sustainable city visions then progress will be limited.

Keywords: sustainability transitions; sustainable cities; transition theory; regime-level processes

The role of regime-level processes in closing the gap between sustainable city visions and action

1. Introduction

It is now commonplace to state that while over 50 percent of humanity live in cities (UNDP, 2012) they consume 75 percent of global resources, over two thirds of all energy and account for 70 percent of global CO₂ emissions (IEA, 2008). This is crucial because changes in how cities operate is critical to addressing current and future sustainable development challenges (Castán Broto and Bulkeley, 2013; Ernst et al., 2016; Hodson and Marvin, 2012). Here it is important to note that city impacts, and indeed operations, are not solely within the control of local city governments. Efforts to map city powers show only 5% of emissions reduction can be taken by unilaterally by city governments, a further 46% in collaboration, leaving around half outside of city control (C40 Cities and Arup, 2016). Therefore curbing urban environmental impacts requires all scales of governance and multi-stakeholder participation (Frantzeskaki et al., 2017). Nevertheless, city governments are showing leadership in responding to the urban sustainability challenge by committing to comprehensive sustainability visions. However, whilst there are pockets of good practice, the transformations and step changes that are required are not emerging (McCormick et al., 2013). In essence, cities are struggling to work towards their long-term goals in the face of short-term pressures and constraints.

This paper attempts to understand this implementation gap between cities' long-term visions and the short-term actions realised to achieve them. In particular we focus on the processes driving decisions and action at the level of formal city actors within what the multi-level perspective (MLP) perspective calls the meso regime level (Geels, 2014, 2002; Geels and Schot, 2007; Smith et al., 2005). The MLP is a commonly used framework within transition theory which explores how transitions result from the interaction between three levels: the landscape, or macro, level at which broader political, cultural and social changes occur, shifting slowly over long time periods; the regime, or meso level, where practices, norms and regulations establish a set of 'rules' that structure, but do not determine, actions; the niche, or micro level, where (technological) innovation occurs (Foxon, 2011; Geels, 2014; Hodson et al., 2017; Rip and Kemp, 1998).

Further insights are required in terms of the relationship between long term city visions and the processes that underpin their implementation (Mendizabal et al., 2018). More fundamentally, it is unclear whether sustainability transitions are, can, or should be, vision-led (Geels and Schot, 2007; Kern, 2011; Voß et al., 2006). Cities, and socio-technical systems generally, are complex, dynamic, adaptive systems, therefore it is not possible to predict or control urban transitions (Frantzeskaki et

al., 2017; Loorbach et al., 2015). It is important to note that despite this complexity and the resulting 'bounded' rationality of actors, actions are not entirely blind. Transitions may be, and often are, purposive (Mendizabal et al., 2018; Smith et al., 2005). So whilst we cannot command and control, we can at least govern reflexively (Grin et al., 2010; van den Bergh et al., 2011). In order to do this effectively we need to understand the regime level processes that enable or constrain the translation between long-term visions and short term action (Chatterton, 2013; Cook and Swyngedouw, 2012).

Taking transition theory as our overall theoretical construct for understanding regime level processes, we highlight a number of areas of weakness that require further elaboration. First, a much greater understanding of processes and practices occurring at the regime level is needed (Geels, 2014). Transition research to date has had greater emphasis on technological innovation occurring at the niche level (Berkhout et al., 2004; Geels and Schot, 2007). Therefore, there is less work at the regime level. Though recent research has begun to address this, looking at discursive destabilisation, 'destructive' policies, institutional processes and politics of the regime (Avelino et al., 2016; Barnes et al., 2018; Bosman et al., 2014; Kivimaa and Kern, 2016), there still remains further work to be done, particularly at the urban level (Bosman et al., 2014), and Avelino et al. (2016) note the need to reconceptualise the niche-regime relationship. We join these efforts to unlock the 'black box' of the regime at an urban level, and more generally exploring the potential for change from within the regime-level itself rather than viewing regime change only as a response to niche innovations.

Second, more insight into cultural-cognitive processes is required. The emphasis on supply-side technological innovation at the niche level has also led to a gap in work on non-technical innovations (e.g. civic /social innovations) and user practices (acting as demand drivers) (Geels, 2014; Shove and Walker, 2010).

Finally, more attention to power¹ and agency² is critical (Ehnert et al., 2018; Foxon, 2011; Geels, 2014; Meadowcroft, 2011; Rauschmayer et al., 2015; Smith et al., 2005; Smith and Stirling, 2010). The assumption of largely rational actor behaviour means the role of power and agency are neglected (Geels and Schot, 2007; Smith et al., 2005). Therefore the ability of (in this case, regime) actors to adapt to and shape the system within which they are acting is often underplayed (Smith et al., 2005). Recent work has paid more attention to power and agency but there is still a need to

¹ Defined here as 'the ability to get others (through force or persuasion) to do something they might not otherwise have done' (Dahl, 1957)

² Defined here as 'the ability to take action and make a difference over a course of events' (Giddens, 1984)

understand contextual dynamics (Torrens et al., 2018), the concept of human agency (Schäpke and Rauschmayer, 2017) transformative capacity and spatio-institutional challenges (Wolfram, 2016).

Overall then, there is a need for further research on regime-level processes, especially cultural-cognitive habits and heuristics, and the role of agency and power – particularly in a city context. To address these weaknesses, this paper brings transition theory into critical dialogue with institutional and quasi-evolutionary³ theory in order to build a more holistic analytical framework that enables a deeper understanding of urban transitions. We focus on one particular case study city, Copenhagen, looking at two current and prominent initiatives: cycling and buildings retrofit, which, due to different levels of success, offer a range of critical insights. The research focuses on environmental sustainable development efforts, these include but are not limited to climate mitigation and adaptation actions. The sustainability, vs climate, focus reflects the need for holistic transformation in cities to address not just the climate crisis but sustainable development more broadly. It should also be noted that for our case study we focus on understanding the regime processes behind the implementation gap, and as a result we do not dedicate space to evidencing the implementation gap itself⁴. The first part of this paper introduces the regime and briefly summarises regime research to date, as well as presenting our analytical framework and how this expands understanding of regime processes. Next we outline our research approach and introduce the case study. Then we present the results of our analysis structured across three institutional pillars (regulative, normative and cultural-cognitive), and two quasi-evolutionary processes (selective pressures and adaptive capacities).

Our findings show that the novel analytical framework generates important insights into regime processes in particular the cultural-cognitive habits and heuristics, and the role of power and agency in transitions. We find that transitions play out across all three institutional pillars, and both quasi-evolutionary processes are fundamental. In particular we find that normative institutional processes are an effective means for regime actors to coordinate power, starting a chain reaction that affects

³ Quasi-evolutionary theory should not be confused with co-evolutionary work on transitions (see e.g. (Foxon, 2011). The concept of co-evolution is used to conceptualise how technical and social aspects and sectors do not develop in isolation but are affected and affect each other (Grin et al., 2010), whereas quasi-evolution conceptualises the selection pressures and adaptive capacities shaping development.

⁴ This we briefly justify through: (1) wide acceptance that no city has yet achieved sustainability; (2) using carbon and climate as a proxy indication of sustainability shows that whilst Copenhagen is leading on reducing direct emissions (with 2.6 tCO₂e per capita against a target of 2.9 tCO₂e per capita) when considering scope 3 emissions we see leading European cities such as Copenhagen still have a large gap to overcome (European cities have between 5-23 tCO₂e per capita, two to three times more than when just consider scope 1 and 2) (C40 Cities and Arup, 2018, 2016); and (3) Copenhagen's own progress reports that demonstrate a gap between their vision and progress – their last published annual report showed impressive progress (38% decrease in emissions), but still a shortfall towards their target (286,000 tonnes of carbon) (City of Copenhagen, 2016).

resource allocation, which in turn impacts the development (or not) of adaptive capacity and shapes selection pressures.

2. Deepening regime level analysis

The concept of the regime was originally used by Nelson and Winter (1982) and Dosi (1982) to describe a technological regime and associated problem-solving activities of engineers (Kemp et al., 1998). As the notion of *socio*-technical systems and transitions developed so too did the regime definition, growing to encompass both social and technical dimensions. Here we define the regime as it is used in the MLP: the meso-level where dominant actors and institutions maintain a dynamic but relatively stable status quo. The regime has been conceptualised as the selection environment where innovations developed in a niche survive or fail (Smith et al., 2010). However, this does not account for the complexity within the regime itself where rules are constantly being reproduced and changing (Kemp et al., 1998; Shove and Walker, 2010), and where dominant regime actors actively resist change (Geels, 2014; Turnheim et al., 2015).

More recent research captures the complex and dynamic nature of regimes. Geels (2014) conceptualises the regime as ‘the locus of established practices and associated rules that enable and constrain incumbent actors in relation to existing systems’. Hodson et al (2017) define the regime as ‘the institutional structuring of tangible socio-technical systems; the intangible rules, shared cognitive routines, regulations and standards which structure but do not determine action’. Turnheim et al (2015) describe regimes as the result of ‘prevailing regulatory, normative and behavioural practices’, and emphasise that as regimes involve both rules and active resistance then transition analysis needs to account for destabilisation of incumbent regimes as well.

In order to address these gaps, and gain a better understanding of the regime, we attempt to construct a more comprehensive analytical framework based on transition theory but drawing on insights from institutional theory and quasi-evolutionary theory. This approach is supported by research recommendations to draw on different theories to construct a more comprehensive model of change (Frantzeskaki et al., 2017; Markard et al., 2012).

2.1. Institutional theory: regulatory, normative and cultural-cognitive processes

Institutional theory has been used by a number of scholars to gain deeper insights into transitions, MLP and regime change (Avelino and Wittmayer, 2016; Ehnert et al., 2018; Geels, 2004; Geels et al., 2016; Geels and Schot, 2007; Smith et al., 2005). Geels and Schot (2007) refer to the institutional ‘rules of the game’ as a useful framework for understanding system transitions. They draw on

institutional theory for a more nuanced analysis of the levels of the MLP by bringing in multi-actor arenas and the politics of transitions. Institutional theory also supports more granular analysis, going beyond aggregate explanations of alignments within and between the niche, regime, and landscape, to explanations of chains of events, and of particular events or local projects by zooming in on specific actors and (local) contexts (Geels and Schot, 2007). Thus institutional theory can be used to build a more 'local' understanding, complementing the MLP 'global' analysis of alignments (Geels et al., 2016). Importantly, institutional theory can support enhanced understanding of power (Ehnert et al., 2018). Highlighting the rules of the game enables analysis of who sets the rules and who is included or excluded from play. For example, Castán Broto (2016) looks at the role of institutional path dependency in constraining particular transition pathways from playing out and particular actors from play. Avelino and Wittmayer (2016) also use institutional theory to conceptualise shifting power relations, looking at how networked power and agency are spread across different actors.

For the purposes of our analysis, we draw on Scott's (1995) synthesis of institutional theory into three pillars: regulative, normative and cultural-cognitive processes. Regulatory processes consist of rule-setting, monitoring, and sanctioning activities (for example regulations and laws). They signal clear demands: how things *must* be done. These are hard and fast rules compared to the 'softer' normative processes which establish standards and values. Regulatory processes are formal and explicit compared to the unconscious, internalised cultural-cognitive processes. Normative processes include both values and norms, they define both the goals and the appropriate ways to achieve them (for example standards, accreditation). They set out the vision, values and standards of the sustainable city actor network – i.e. what *should* be done, and how those things *should* be done. Normative processes can be shaped by developing new knowledge, skills and evidence that redefines what best practice is. Normative values affect power coordination and resource allocation within the municipality and wider city network, impacting organisational structure and staffing capacity, and network and alliance formations. Cultural-cognitive processes are the shared conceptions that make up the nature of social reality, they act as a frame from which to create meaning (for example beliefs and customs). They shape ways of thinking and being, both in terms of thought processes and heuristics, but also practical habits and routines. These are the unconscious, unwritten rules that set out how things are and how things are done (there is no conscious thought process about how they *must* or *should* be done).

We draw on institutional theory to reconceptualise transition theory across the three institutional pillars enabling a deeper analysis into regime level processes across a continuum from formal, imposed regulations, to values-based norms, to cultural-cognitive habits and heuristics.

2.2. Quasi-evolutionary theory: selection pressures and adaptive capacity

Transition theory has long drawn on evolutionary theory to help analysis: to understand technological innovation (Dosi, 1982; Nelson and Winter, 1982); in developing the MLP as an analytical framework (Geels and Schot, 2007); for governance perspectives (Grin et al., 2010); and in better accounting for actor choice (Foxon, 2011). However, unlike biological evolution, in this context selection and adaptation are not blind (Foxon, 2011; Meadowcroft, 2009; Rip and Kemp, 1998). Rip (1995, 1992) and Schot (1998, 1992) first developed a quasi-evolutionary approach to take into account these, at least partially, directed efforts of niche actors in not only anticipating selection pressures but also in trying to shape them (e.g. through R&D programmes or demonstration projects).

Smith et al. (2005) have used the quasi-evolutionary model to analyse transitions. They see transitional change as a function of two processes: shifting selection pressures that act upon regime actors to shape, but not determine, action; and the adaptive capacity of actors to respond to and shape selection pressures. Selection pressures can be directed (e.g. anti-nuclear), general (e.g. environmental awareness) or undirected (e.g. an aging demographic). Adaptive capacity is a combination of the *availability* and *coordination* of resources to adapt to these selection pressures (Berkhout et al., 2004), and shapes the particular form and direction of regime change over the long-term.

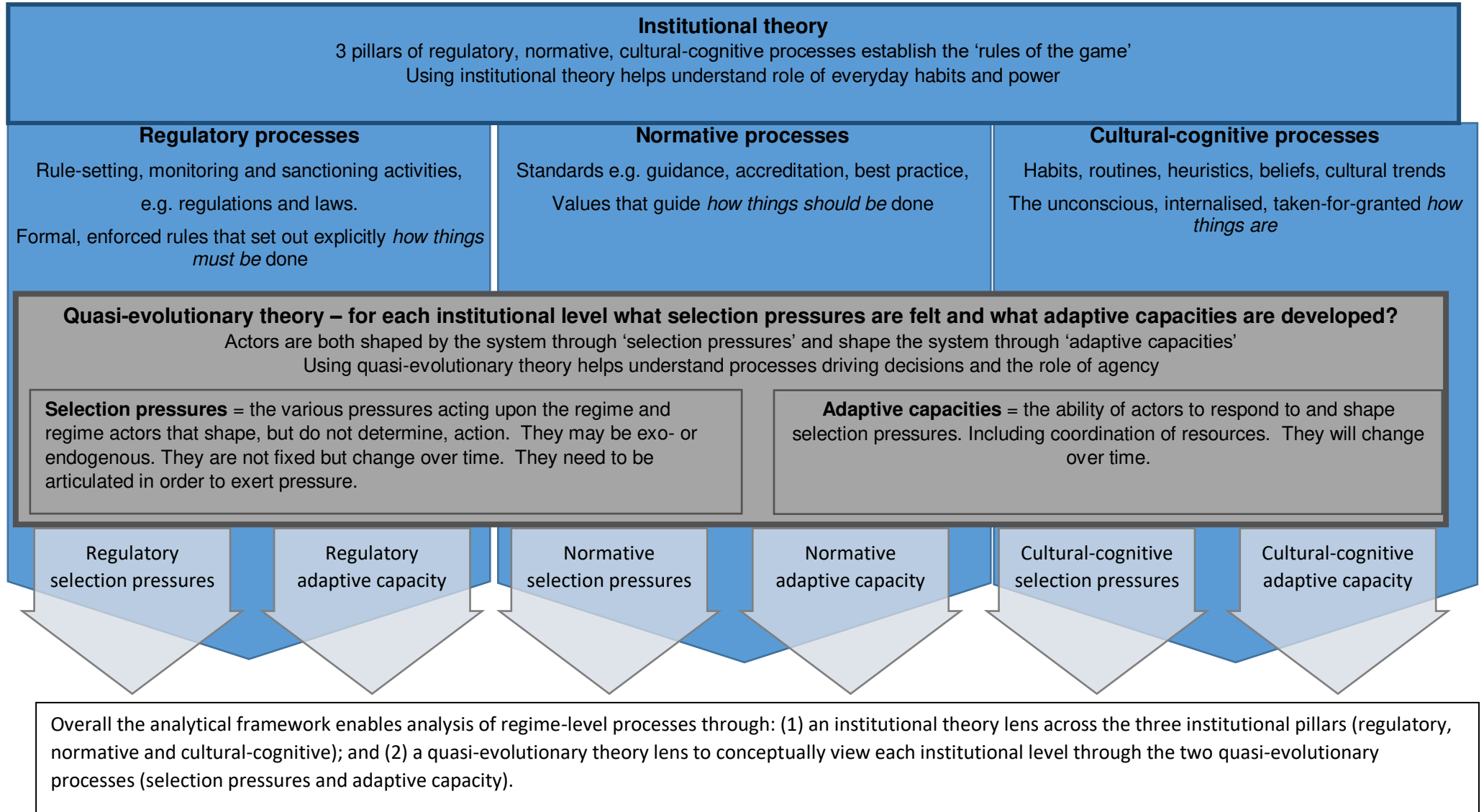
We draw on quasi-evolutionary theory to conceptualise each institutional level as a duality of selection pressures and adaptive capacity, enabling exploration of the power to shape selection pressures and the agency to adapt to them.

2.3. Analytical framework

In summary our analytical framework takes transition theory as the overall theoretical construct to explore and explain sustainable city transitions. We then draw on additional conceptual 'lenses' to address weaknesses in transition theory. Firstly, we use an institutional theory lens to understand regime level processes across the three institutional pillars (regulatory, normative and cultural-cognitive). This provides a greater depth of analysis and addresses research gaps by incorporating habits and heuristics through the cultural-cognitive level. Secondly, we use a quasi-evolutionary theory lens to conceptually view each institutional level through the two quasi-evolutionary

processes of selection pressures and adaptive capacities. This provides greater depth of analysis and addresses research gaps by foregrounding power and agency. This results in our final analytical framework; data is analysed by institutional pillar, and for each pillar further analysed by selection pressure and adaptive capacity. The boundary for our analysis is the urban regime. Figure 1 summarises the institutional and quasi-evolutionary framework elements.

Figure 1: Summary of the analytical framework



3. Methodology

A case study approach enabled understanding of complex situations and contemporary, real-world settings where the boundary between what is being studied and the context is not always clear. The underlying research driver is in understanding and overcoming the implementation gap for sustainable city visions, therefore an existing vision is a pre-requisite. A leading city was chosen to enable: (1) research of processes beyond individual and organisational execution capacity to system processes; and (2) investigation of enablers as well as barriers.

Our case study city, Copenhagen, was selected based on its well-recognised, strong commitment to a long-term sustainable vision and demonstration of best practice in urban sustainable development. Our focus, the municipality of the City of Copenhagen, Københavns Kommune, is the largest of four municipalities that make up Copenhagen with a total population of 616,098 (Danmarks Statistik, 2018). Copenhagen is a world leader in green growth (Sharpe et al., 2012) and has a history of environmental and sustainable goals: in 2008 it set out an Eco-Metropolis vision; in 2009 the City Council unanimously committed that Copenhagen will become the world's first carbon neutral capital by 2025; and in 2014 Copenhagen was European Green Capital. The City of Copenhagen has a 'Co-create' vision⁵ with sustainable development as an underlying principle throughout, it has a Climate Plan Copenhagen 2025 and a Climate Adaptation Plan. Progress towards these visions and plans is reported annually to the Technical and Environment committee, as well as publically.

Two initiatives, cycling and buildings retrofit, were explored in order to achieve the ambition of a city-wide, cross-sector research approach but still enable depth of research. These initiatives were selected through three key informant interviews which identified examples of a more successful and more challenging initiatives; cycling and buildings retrofit respectively. There is a long history of cycling in Copenhagen going back to the turn of last century and Copenhagen is widely recognised as a successful 'cycling city.' Building retrofit is part of the Carbon Neutral Plan for Copenhagen. Although emissions from buildings only account for 8 per cent of total carbon emissions, energy efficiency needs to be improved to mitigate the increased costs of a transition to lower carbon energy generation. Buildings retrofit progress has been slow in Copenhagen, largely for the same reasons that any city finds it difficult; a lack of strong incentives or imperatives.

⁵ 'Co-create Copenhagen' is a vision for 2025 to create 'A Liveable City', 'A Bold City' and 'A Responsible City' <https://urbandevdevelopmentcph.kk.dk/artikel/co-create-copenhagen>

Data collection involved a series of interviews with sustainable city initiative actors; eight and nine interviews were undertaken for retrofit and cycling respectively. Interviewee selection was through snow-ball sampling based on recommendation from local actors whilst ensuring a mix of public, private, civic sector actors. Our starting point for interviews were the three key informant interviews with central actors in senior roles leading sustainability work in the city government. We then interviewed a range of actors across both cycling and building retrofit in a variety of roles from policy making to project management, and academics to architects (see table 1 for further details). The snow-balling method was purposefully designed to generate a sample from within the sustainable city actor network as our unit of analysis, as well as more practical resource restrictions preventing us from interviewing a greater sample. So it should be noted that most, if not all, of our interviewees had a sustainability bias, and furthermore that this limits our ability to explore and understand wider regime perspectives. However, interviewees were aware of and frequently cited wider, often competing aspects of the regime. The interviews were semi-structured covering the sustainable city vision, the ‘story’ of the cycling or retrofit initiative (as understood and experienced by the interviewee) and aimed to draw out what was driving decision-making and action-taking. Interviews were undertaken between May – July 2017, usually undertaken at the place of work and generally lasting for around an hour. All interviews were recorded and then transcribed. Secondary data from key policy documents was also drawn on to support interview evidence.

Data analysis was undertaken using NVivo software. Interviews were coded by institutional pillars and then by selection pressure or adaptive capacity to explore how regime actors operated across regulatory, normative and cultural-cognitive pillars, what selection pressures were operating and what adaptive capacities were available in the sustainable city actor network.

Finally, this paper emerges from an applied PhD exploring the processes and practices of sustainable cities through academic-practitioner informed research, drawing on the researcher’s practical experience of working with cities and supported by C40 Cities Leadership Group⁶.

Table 1: interviewees by interview type, role and organisation type and sector

Interviewee number	Interview type	Role or organisation type	Sector
C0	Key informant	Policy	Public

⁶ It should be noted that whilst C40 are supportive of the research and the lead author works for C40 this research is independent academic research, affiliated with the University of Leeds.

C1	Key informant	Climate change	Public
C2	Key informant	Climate change	Public
C3	Retrofit	Manager	Public
C4	Cycling	Political	Public / Civic
C5	Retrofit	Operations	Private
C6	Cycling	Cycling specialist	Public / Private
C7	Retrofit	Manager	Private
C8	Cycling	Cycling specialist	Public
C9	Cycling	Planner	Public
C10	Cycling	Architect	Public / Private
C11	Cycling	Environment	Public
C12	Cycling	Academic	Public
C13	Retrofit	Housing association	Civic
C14	Retrofit	Architect	Private
C15	Cycling	Academic	Public
C16	Cycling	Planning	Public
C17	Retrofit	Architect	Private
C18	Retrofit	Construction association	Civic
C19	Retrofit	Policy	Public

4. Exploring Copenhagen's regime processes

We now turn to our findings organised by institutional the three pillars (cultural-cognitive, normative, then regulatory), and then for each institutional pillar by the two quasi-evolutionary processes (selection pressures and adaptive capacity).

4.1. The cultural cognitive pillar

Overall, cultural-cognitive processes shape ways of thinking, practical habits and routines.

4.1.1. Cultural-cognitive selection pressures

Starting with selection pressures, the ways of thinking, or heuristics, act as selection pressures in terms of what problems are regarded as priorities and what solutions are most desirable.

Interestingly a strong example of this sort of selection pressure is related to the 1970's oil crisis. Its affects were widespread and generated broad concern around fossil fuel dependency. This is still embedded in Copenhagen's cultural-cognitive selection pressures today, as a deep-seated emotional logic for sustainable energy and mobility. Such heuristics are extremely important, so much so that going against them inhibits action as one interviewee commented:

"is it legitimate to be against it [the sustainable city vision], and I would say no it is not, it is not legitimate for politicians to say I don't think Copenhagen should be a green city, there is no way you would get anywhere with that... if it is against it you are uphill already" (interview C11⁷)

However, whilst there is broad support for long-term sustainable visions, it is important to note that these goals are competing with other priorities and unsustainable cultural-cognitive selection pressures around e.g. economic growth and car culture:

"of course we are fighting every year for the budget and have to compete with schools and elderly" (interview C1)

"...this old and very locked in, or path dependent idea that more cars give more growth... is so firmly rooted in people... that the car gives freedom, and that is a freedom that for many people are seen as a basic right" (interview C12)

Interestingly, though economic growth is often in competition with sustainability visions, it is also a key part of Copenhagen's sustainability aspirations:

"... teaching from what we have been doing here in Copenhagen and trying to also connect Danish companies with other cities like New York in order also to promote the green growth agenda which is also part of the whole sustainability agenda" (interview C2)

Cultural-cognitive processes such as habits and behaviours also exert strong selection pressure. Cycling is a good example of this. People cycle because it is the most efficient, convenient option, not because it is sustainable:

⁷ See appendix for table summarising interviewees by interview type, organisation/role type and sector.

“when we... ask why people they are biking, it is not because of environmental issues, it is only 2% who say that, it is because it is the fastest and most convenient way to get about the city, that is more than 80% that answer that” (interview C1)

In contrast, with regards to retrofit, people want the cheapest and easiest option and the upfront costs and inconvenience of retrofit create cultural-cognitive selection pressures against this – especially with cheap energy available in Denmark.

4.1.2. Cultural-cognitive adaptive capacity

Turning to cultural-cognitive adaptive capacities and the ability of regime actors to respond to and shape selection pressures, we found multiple examples of how storytelling and symbols were effectively used to shape cultural-cognitive beliefs and thinking. For example the bike is widely used as a symbol for Copenhagen, not only by the municipality but a range of NGOs and businesses. Many interviewees talked about the power of this symbol for Copenhageners and hence the use of it by city actors to support a pro-bike culture. Several interviewees also cited that the bike became a symbol for the environment movement in general:

“...it is not just a symbol of a man and a wheel to get around, it is a symbol of many other things, take the whole story of Copenhagen, you can put many things under that umbrella and say the bike is the symbol of the green city, the green city unfolds itself with the way we treat our water, the way we clean our waste and so on, so it has many things underneath, to be green is many things, so sometimes you need a very strong symbol” (interview C11).

Similarly one retrofit interviewee talked about Samsø energy island, a Danish project to create an exemplar sustainable energy community. Here the creation of a strong brand successfully influenced people’s behaviour, generating selection pressure to support the new ‘renewable energy island’ identity.

As well as using adaptive capacities to shape and change selection pressures, actors also used adaptive capacities to modify sustainable city initiatives to better fit with existing selection pressures. For example investment in infrastructure to make cycling the easiest option (to better meet selection pressures around the most convenient form of transport) has been a major part of cycling promotion including building cycling lanes: working on key connections to speed up the network; introducing faster ‘greenway’ traffic light systems; and investment in pedestrian and cyclist bridges that make cycling significantly faster than going by car.

4.2. The normative level

Normative processes set the broader parameters for the vision, values and standards for regime actors. They are important as they affect how power is coordinated and resources allocated, through e.g. organisational structure and network formation, and staffing and budgeting.

4.2.1. Normative selection pressures

Normative selection pressures manifest themselves through strong buy in to city visions and values. For example interviewees frequently referenced the Co-create Vision for Copenhagen which sets out the values that are important such as “better everyday life in urban spaces” and stressing that neighbourhoods must be “attractive and organised in a way that supports both the individual choice and the emergence of new communities” (City of Copenhagen, 2015, pp. 6, 10). Equally, the ambition to be the world’s best city for cyclists is a clear normative value that creates a strong selection pressure for regime actors. Rather than a measurable, quantifiable regulatory process, it is a qualitative statement of intent.

We also identified normative processes that set out standards and best practice as a further set of effective selection pressures. These can be set out in accreditation and guidance or best practice benchmarking against professional peers or other cities. For example, company specific building guides and voluntary green building codes (such as building guides for Scandinavian hotel chains or the Norwegian Green Building Council’s 10 recommended measures for buildings⁸) were mentioned by interviewees as affecting how they undertook retrofit work.

Best practice benchmarking was also referenced frequently, often in relation to other cities.

Amsterdam was noted as a global competitor in terms of cycling, and a key spur for Copenhagen to set the ambition to be the world’s best cycling city. Other cities’ progress creates the ambitious targets and standards as one person commented:

“now they are finally talking about forbidding big trucks in the city centre, which has been done in the German cities for the last 20 years or so” (interview C15)

4.2.2. Normative adaptive capacity

Turning to normative adaptive capacities, the first observation to note is there were more references to adaptive capacities than selection pressures for the normative level, in contrast to the cultural-cognitive and regulatory pillars where selection pressures dominated interview material.

⁸ See <https://translate.google.co.uk/translate?hl=en&sl=no&u=http://www.norskeiendom.org/eiendomssektorens-veikart-mot-2050-2/&prev=search>

The second observation to note is that adaptive capacities are directly impacted by the coordination of power and allocation of resources. One clear example is the establishment of the new bicycle secretariat. Bringing in an expert team, giving them decision making powers and doubling the budget available increased adaptive capacity and enabled a much greater level of cycling activity and progress:

“all this financial support from the city council made a lot of things easy, and also easy to suggest the next step and being more and more ambitious and saying why don't we go from increasing the cycle share from 30 to 50%” (interview C9)

Though here it should be noted that resources for cycling were still much smaller than for other transport:

“...we have more trips by bicycle than by cars, or by buses, or by Metro, or by train, but when you look at how many people work with the underground system or the train system or the car system then it is difficult to compare” (interview C8)

Here we can see how the coordination of power around a sustainable city initiative influences decision making and the allocation of resources, affecting adaptive capacity (which in turn then shapes selection pressures).

Moving on to the nature of this adaptive capacity, what we found was that regime actors effectively framed city visions to align them with citizen or political priorities. For example the Carbon Neutral vision states that “In 2025, Copenhagen will be the world's first carbon neutral capital city. As well as being an important milestone in the fight against climate change, this will have other positive effects, in the form of less noise, cleaner air, healthier citizens and more green jobs” (City of Copenhagen, 2015, p. 14). One interviewee commented that:

“the plan is not only about CO2 emissions any more, now it is a broader plan, a broader vision, and it is about liveability and all sorts of other social sustainability issues” (interview C17)

Adaptive capacities were also deployed in developing and demonstrating new and better practice through redefining and raising the bar of what ‘good’ looks like. The development of professional standards and the “seriousification” of cycling is a clear example of this (interview C8). Expected standards have been created over time through discussions, journal articles and conferences. These are then set out in guidance, specifications and training and educational material;

“so there was a need to work in a bit different way, you can call it different or you can call it professionalise, but there was a need to do a bit differently to standardise procedures and so on” (interview C8)

Competitions and pilots also create effective adaptive capacity supporting the development of better practice; *“launching a lot of different pilot projects and initiatives that really gained new knowledge and new methodologies and new types of data”* (interview C8). They demonstrate new approaches and at the same time can legitimise those new approaches through the prestige that the competition brings. For example, one retrofit interviewee commented:

“we won a large, high profile competition about sustainable social housing... and it was quite an important project for the office too, not economically but in terms of how you are defined (as)... experts in sustainability” (interview C14)

4.3. The regulatory level

Regulatory processes refer to the hard and fast rules in contrast to the ‘softer’ normative processes which establish standards and values, and the unconscious, internalised cultural-cognitive processes.

4.3.1. Regulatory selection pressures

When or if the normative sustainable city vision is translated into measurable and time-bound targets then those targets act as regulatory selection pressures. For example Copenhagen’s Carbon Neutral vision has been translated into a roadmap with specific targets for carbon emissions reductions from each source, with both overall and four year targets and annual milestones. One retrofit interviewee commented on the impact of this on retrofit efforts:

“...it all connects to the roadmap and to the climate plan because in the climate plan there is a goal saying that we should reduce energy consumption in all buildings in the whole of Copenhagen” (interview C3)

Regulations and legislation also act as selection pressures, for example planning regulations set by the City of Copenhagen for density of new developments or energy efficiency of new housing. Retrofit interviewees also referenced national and international regulations, for example EU procurement regulations or national regulations promoting investments in wind energy.

Additionally, the market also creates a set of selection pressures. There were frequent references throughout all the interviews, but particularly retrofit interviews, to the influence of the market and financial dis-incentives. Retrofit is challenging because in a relatively low cost energy environment it is hard to make a strong financial case. Furthermore costs often sit with one party (a building owner or landlord) whilst savings are enjoyed elsewhere (by the tenant in lower bills). Tenants demand low rent, and energy costs are not significant enough to be a priority when selecting an office or house so there is no way of recouping investments in retrofit.

“It is very difficult to get owners of large buildings to do some kind of retrofit, it is even more difficult to get private, one family home owners to do anything, because they have also other priorities. I mean, if you ask them what is the most important to you is it the money or is it the environment, is it the climate and so on, it will always be the money. If they are true in their answer it would be money” (interview C18)

However there were also examples of where market selection pressures incentivised cycling and retrofit initiatives, for example: cycling as the cheapest form of transport for individuals and the most cost-effective investment for government; high car tax as an appealing source of revenue for government; and low-cost building design and materials as the most sustainable and energy efficient.

4.3.2. Regulatory adaptive capacity

Regulatory adaptive capacities are used by regime actors to translate a vision into ‘hard’ targets (and, as above, these then act as effective selection pressures). For example Copenhagen municipality undertook significant planning efforts to develop a detailed roadmap for how to deliver the Carbon Neutral vision, including interim targets, clear responsibility and reporting mechanisms: *“the climate plan are organised that we have for work streams... and we have a project group with the people that are responsible for the four areas... with milestones and key performance indicators and so on and reporting on that twice a year” (interview C1)*

Interviewees frequently reference Copenhagen’s Roadmap and annual reviews against progress as evidence of this translation of the vision into hard targets. These documents demonstrate the efficacy of such adaptive efforts as the annual reviews show good progress across most initiatives and an overall decrease of 38% carbon emissions (though as previously referenced it should be noted that whilst this shows Copenhagen’s leading efforts, there is still an implementation gap in achieving their vision) (City of Copenhagen, 2016).

As well as utilising adaptive capacities to create new selection pressures (through translating visions into ‘hard’ targets), they are also used to lobby for changes in regulatory selection pressures, e.g. regulation and legislation. For example one interviewee referenced efforts by more progressive construction sector companies to improve regulation;

“some of the suppliers to the building industry that also are to the forefront globally, they really push for stronger [more sustainable] commitments, regulation” (interview C1)

Finally actors can take an alternative approach to efforts to create or modify regulatory selection pressures - instead using adaptive capacity to attempt to modify sustainability initiatives to better fit

with existing selection pressures. For example making retrofit cheaper to fit better with the strong selection pressure for the most financially cost-effective option, or introducing new mechanisms for financing retrofits that work with the existing market selection pressures, e.g. green leases that shares the costs and benefits of retrofit work between owner and tenant. The ability to ‘work around’ existing selection pressures (rather than change them) was referenced a number of times as critical to success. For example finding ‘creative’ approaches to navigating existing financial, legal or policy constraints:

“there was a very visionary and creative economist in one of the large housing corporations, and he managed to construct a financial system, he found his way through so it was possible to make tenders for these affordable housing developments, and it has succeeded” (interview C14)

Another example was given of navigating around political selection pressures by using strategies to keep the sustainable city vision non-party political and thus less vulnerable to partisan political selection pressures:

“...clean air, why can’t you be nationalistic or right wing and still think that clean air is a good thing, so I think what Copenhagen has succeeded compared to a lot of other cities is not making environmental policies into a right-wing, left-wing thing” (interview C4)

5. Discussion

By way of discussion we want to pose two main questions. First, does our analytical framework yield additional insights, and second, what do these insights tell us about achieving sustainable city visions and effectively implementing transitions?

5.1. Is the analytical framework effective in yielding greater insights?

The analytical framework has yielded a number of insights that can deepen analysis of sustainability transitions:

First, using institutional theory helps to understand transitions by balancing the relative importance given to ‘harder’ regulatory processes and more visible normative processes with the ‘softer’, less visible cultural-cognitive processes.

Second, taking a quasi-evolutionary approach helps understand transitions, particularly the dynamics of regime change; the power to shape selection pressures and the agency of regime actors through their adaptive capacity. Analysing selection pressures high-lights the competing power dynamics shaping the city context. Analysing adaptive capacities high-lights the multiple ways in

which actors attempt to shape selection pressures, and where this isn't possible the ways actors can work around them. Fundamental to this is the insight that regime-level processes are 'agnostic' in that they can both enable or inhibit change. What we found, for example, is that cultural-cognitive symbols and stories can support and align with the sustainable vision, as with the bicycle, or they can block it, as with the car. Therefore, the success of any sustainable city initiative depends on the alignment of selection pressures and adaptive capacities with the vision, as well as the absence of counter-acting or mis-aligned processes. In other words how power and agency play out to determine who wins in the contested and competitive regime environment.

Overall, the framework provides an in-depth, detailed analysis of which processes are more or less relevant for sustainable city visions (and furthermore for initiatives within this vision) for a specific place and time. The framework can be used to 'map the contextual dynamics' enabling city actors to better understand their urban setting and determine a place- and issue-specific strategy to best drive forward their vision (Torrens et al., 2018) This addresses one of the challenges for sustainable city transitions of how solutions can be shared between different cities and their 'unique' contexts. The institutional and quasi-evolutionary processes used in the framework are common to any sustainable city effort. Using the framework helps understand the configuration of processes relevant to any given purpose, place and time. This awareness of the differences in the processes at play enables actors to better introduce a solution into their particular context. For example strong cultural-cognitive habits, normative professional standards and networks, and regulatory targets were all critical in the success of cycling in Copenhagen. For another city to achieve the same results they would likely need a similar configuration of processes. The framework can highlight similar configurations, and therefore greater likelihood for successful transfer of solutions. It can also flag gaps, such as the lack of hard targets or professional networks, which cities could work to address in order to achieve the successful import of a solution from elsewhere.

5.2. What do these insights tell us about achieving sustainable city visions and effectively implementing transitions?

Results from Copenhagen suggest that the normative level is the entry point for sustainable city network actors. This is where the greatest prevalence of adaptive capacities existed, and the examples from interviews indicate it is where regime-level actors have greatest potential to influence selection pressures, as opposed to the more embedded and less locally determined regulatory and cultural-cognitive selection pressures.

Furthermore, results suggest the normative pillar is where actors can purposively intervene through creating a sustainable city vision and values to define and drive transition. Whilst visions were repeatedly mentioned across all three institutional pillars, we found that normative adaptive capacities were most prevalent in vision setting, again suggesting this is where actors have the most adaptive capacity, enabling them to establish a strong vision that then acts as an effective selection pressure.

These normative visioning processes are supported by cultural-cognitive beliefs providing an underlying legitimacy and imperative for action. For example climate change is an accepted and acknowledged issue that needs to be tackled. Interestingly in Copenhagen actors reinforced and built upon supportive cultural-cognitive beliefs, e.g. effectively using stories and symbols to strengthen an already favourable bike culture.

Normative visioning processes are also supported by regulatory selection pressures created when visions are translated into 'hard' targets. Without this translation of the vision, city actors will struggle to achieve their ambition and risk visions becoming empty promises. With this translation, long-term outcomes can be effectively converted into short-term processes that drive the decisions and action required to fulfil the vision as seen through Copenhagen's Roadmap and annual reviews.

In addition, normative selection pressures and adaptive capacities around vision and values influence, and in turn are influenced by, power configurations. Power operates in different ways at different institutional pillars. In the Copenhagen case study, regulatory rules are often imposed through external political and market systems, normative values are often promoted by city-level coalitions, and cultural-cognitive beliefs primarily emerge from embedded social hierarchies. However, whilst we found that power configurations are at play in significant ways across all three pillars, it is the normative level where power is most effectively mobilised by our sustainable city actors. Regulatory and cultural-cognitive aspects are less open to adaptation by regime actors given they have little agency over supra-city political and market forces and deeply embedded cultural hierarchies. Instead we see in our case study that city actors have to 'work around' regulatory and cultural-cognitive selection pressures, or use their agency and adaptive capacity to modify sustainability initiatives to better fit with powerful selection pressures that they cannot change. An example of this is framing sustainability as a non-political issue, which, despite the label, is a highly political strategy to work around political selection pressures that actors cannot change (short-term political cycles).

We also observed that power configurations have a significant influence on, and are influenced by, adaptive capacities; power configurations impact the allocation of resources which in turn impacts

on the adaptive capacity of regime actors. For example the decision to double the cycling budget and allocate a team of staff to a cycling secretariat created huge capacity for adapting to and shaping selection pressures.

Once successfully established the new, or reformed, power configurations can become embedded. This represents a powerful tool for cities in creating change. When stakeholders and resources are brought together they have greater collective capacity and agency and, assuming power configurations are strong enough, these can endure beyond the people or processes that initiated change.

Through these power configurations and resource allocation, and the resulting increased adaptive capacity, regime-actors have greater ability to shape the selection pressures acting on them. Again we see greatest agency at the normative level, here actors can create new and shape existing selection pressures around visions, standards and benchmarking. Whereas in responding to regulatory and cultural-cognitive selection pressures, adaptive capacity is used more to work around existing selection pressures rather than to create or modify them. However, there are still examples that point to the ability of actors to shape regulatory and cultural-cognitive selection pressures. In particular through the translation of a normative vision into regulatory hard targets, or to strengthen cultural-cognitive beliefs. For example normative adaptive capacities around professionalization of cycling influenced the development of hard targets for cycling (e.g. km travelled or percentage of mode share, or cycling related local planning requirements), and through stories and symbols reinforced cycling culture within Copenhagen.

Finally, through analysing two different initiatives we see that whilst they are many similarities there are some significant differences. For example for cycling cultural-cognitive rules are by far the most dominant influence, whereas for retrofit regulatory processes dominate. This is an extremely important point; processes will play out differently for different initiatives, at different times, and in different places.

6. Conclusion

Our analytical framework has enabled a more comprehensive analysis of regime-level processes, including those neglected by the MLP approach to date. This suggests that the framework is a useful tool, and that the approach of drawing on institutional and quasi-evolutionary theory works to unlock the black box of the regime and gain deeper insight into the processes that enable and constrain sustainable city visions. Specifically the framework helps to understand: (1) the importance

of cultural-cognitive habits and heuristics – the institutional lens gives insights across the continuum from formal, regulatory process, through values-based normative processes, to cultural-cognitive processes, high-lighting the role of processes at all levels, including cultural-cognitive habits and heuristics; (2) power and agency – the quasi-evolutionary lens high-lights both power dynamics through competing selection pressures and agency through the multiple ways actors use their adaptive capacity to attempt to shape, or adjust to their, selective environment. Furthermore, with regards to power and agency the institutional lens shows at what institutional levels cities have power and agency – for Copenhagen it is the normative pillar where most power lies and actors have agency to shape selection pressures, for regulatory and cultural-cognitive pillars city actors have limited powers, and instead have to use agency to work around and/or fit with selection pressures.

Using this novel analytical framework highlights several broader insights from the Copenhagen case study that might help accelerate city sustainability transitions more generally (though we note the limitations of extrapolating from one case study):

- The normative pillar as the entry point for intervention via visions and values:
City actors have a high level of power and agency in setting visions and they need to use this to set clear, time-bound resourced visions, translating the vision into hard targets that act as the new rules for more sustainable development. Additionally city actors can develop new standards that drive decisions through generating a new set of professional selection pressures. These can be used to challenge and change values, for example the supremacy of car over cycle or grey over green infrastructure. This is critical in giving a clear steer for the direction of transformational change.
- The role of cultural-cognitive beliefs in legitimising and driving action:
City governments need an underlying mandate from voters. City actors need an understanding of where this exists and where it is lacking. This is harder to influence, especially at a city scale, but city actors have some agency to shape cultural-cognitive beliefs, in particular building on where there is already support. Mapping cultural-cognitive processes can help understand where the best support for change lies, and where support could be bolstered.
- The influence of selection pressures and adaptive capacity on power configurations, and in turn the impact power configurations and resource allocation then has in increasing the adaptive capacity and shaping selection pressures:
Cities need to coordinate power around sustainable city visions, including decision-making powers and resource allocation. All too often visions are set without any change in city

network formations or municipality structure, or without any real authority or dedicated resources. If city actors are serious about transformational change then they need to make these organisational changes and resource allocations. Here it is important to again acknowledge that cities do not have power over all areas; where selection pressures cannot be influenced by city level governance adaptive efforts should be focused on working around or better fitting sustainability initiatives to these selection pressures.

Overall then in reflecting on the implementation gap between cities' long-term visions and the short-term actions realised to achieve them, our evidence suggests that the mis-alignment of processes with outcomes is behind this gap. Furthermore unless the institutional and quasi-evolutionary processes that drive decisions and action are re-configured to be in line with sustainable city visions then progress will be limited.

Several recommendations for further research emerge from our work. First, additional case studies should be analysed to explore the different patterns of processes at play in different city and initiative contexts. Such work will help to further refine and develop this framework approach. Second, longitudinal case studies in cities would explore how processes and the interplay between them change over time. This might also allow for new actors' views to be brought into the analysis, specifically the non-sustainability actors excluded in this preliminary research. Third, further research on sub-system approaches (e.g. energy system, agricultural system) would help to test and develop the model, as well as gain insights into regime-level processes at play in key sub-systems. Further analysis of adaptive capacities could reveal (1) how the adaptive capacities of regime actors actively seek to change selection pressures or work around them, (2) how adaptive capacities become misaligned between 'opposing' stakeholders leading to 'active resistance' amongst regime actors. We encourage transition scholars and practitioners to use and adapt our framework to generate further insights and practical applications for accelerating urgently needed city sustainability transitions.

Acknowledgements

The PhD research on which this paper is based has been enabled through funding from the Economic and Social Research Council. This funding is gratefully acknowledged. We would like to thank the two anonymous reviewers, C40 Cities Climate Leadership Group and all the interviewees for their time and support.

References

- Avelino, F., Grin, J., Pel, B., Jhagroe, S., 2016. The politics of sustainability transitions. *J. Environ. Policy Plan.* 18, 557–567. <https://doi.org/10.1080/1523908X.2016.1216782>
- Avelino, F., Wittmayer, J.M., 2016. Shifting Power Relations in Sustainability Transitions: A Multi-actor Perspective. *J. Environ. Policy Plan.* 18, 628–649. <https://doi.org/10.1080/1523908X.2015.1112259>
- Barnes, J., Durrant, R., Kern, F., MacKerron, G., 2018. The institutionalisation of sustainable practices in cities: how initiatives shape local selection environments. *Environ. Innov. Soc. Transitions* 29, 68–80. <https://doi.org/10.1016/j.eist.2018.04.003>
- Berkhout, F., Smith, A., Stirling, A., 2004. Socio-technological regimes and transition contexts. *Syst. Innov. Transit. to Sustain. theory, Evid. policy.* Edward Elgar, Cheltenham 48–75.
- Bosman, R., Loorbach, D., Frantzeskaki, N., Pistorius, T., 2014. Discursive regime dynamics in the Dutch energy transition. *Environ. Innov. Soc. Transitions* 13, 45–59. <https://doi.org/10.1016/j.eist.2014.07.003>
- C40 Cities, Arup, 2018. Consumption-based GHG emissions of C40 cities.
- C40 Cities, Arup, 2016. Deadline 2020: How Cities Will Get the Job Done.
- Castán Broto, V., 2016. Innovation Territories and Energy Transitions: Energy, Water and Modernity in Spain, 1939–1975. *J. Environ. Policy Plan.* 18, 712–729. <https://doi.org/10.1080/1523908X.2015.1075195>
- Castán Broto, V., Bulkeley, H., 2013. A survey of urban climate change experiments in 100 cities. *Glob. Environ. Chang.* 23, 92–102. <https://doi.org/10.1016/J.GLOENVCHA.2012.07.005>
- Chatterton, P., 2013. Towards an Agenda for Post-carbon Cities: Lessons from Lilac, the UK's First Ecological, Affordable Cohousing Community. *Int. J. Urban Reg. Res.* 37, 1654–1674. <https://doi.org/10.1111/1468-2427.12009>

- City of Copenhagen, 2016. Copenhagen Climate Projects Annual Report 2016.
- City of Copenhagen, 2015. Co-Create Copenhagen.
- Cook, I.R., Swyngedouw, E., 2012. Cities, Social Cohesion and the Environment: Towards a Future Research Agenda. *Urban Stud.* 49, 1959–1979. <https://doi.org/10.1177/0042098012444887>
- Dahl, R.A., 1957. The concept of power. *Behav. Sci.* 2, 201–215.
- Danmarks Statistik, 2018. Find statistik - Danmarks Statistik [WWW Document]. URL <https://www.dst.dk/da/Statistik> (accessed 10.25.18).
- Dosi, G., 1982. Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. *Res. Policy* 11, 147–162.
- Ehnert, F., Kern, F., Borgström, S., Gorissen, L., Maschmeyer, S., Egermann, M., 2018. Urban sustainability transitions in a context of multi-level governance: A comparison of four European states. *Environ. Innov. Soc. Transitions* 26, 101–116. <https://doi.org/10.1016/j.eist.2017.05.002>
- Ernst, L., de Graaf-Van Dinther, R.E., Peek, G.J., Loorbach, D.A., 2016. Sustainable urban transformation and sustainability transitions; conceptual framework and case study. *J. Clean. Prod.* 112, 2988–2999. <https://doi.org/http://dx.doi.org/10.1016/j.jclepro.2015.10.136>
- Foxon, T.J., 2011. A coevolutionary framework for analysing a transition to a sustainable low carbon economy. *Ecol. Econ.* 70, 2258–2267. <https://doi.org/10.1016/j.ecolecon.2011.07.014>
- Frantzeskaki, N., Broto, V.C., Coenen, L., Loorbach, D., 2017. *Urban Sustainability Transitions, Routledge Studies in Sustainability Transitions.* Taylor & Francis.
- Geels, F.W., 2014. Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Cult. Soc.* <https://doi.org/10.1177/0263276414531627>
- Geels, F.W., 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Res. Policy* 33, 897–920. <https://doi.org/http://dx.doi.org/10.1016/j.respol.2004.01.015>
- Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Res. Policy* 31, 1257–1274. [https://doi.org/http://dx.doi.org/10.1016/S0048-7333\(02\)00062-8](https://doi.org/http://dx.doi.org/10.1016/S0048-7333(02)00062-8)
- Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., Neukirch, M., Wassermann, S., 2016. The enactment of socio-technical transition pathways: A reformulated typology and a

- comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014). *Res. Policy* 45, 896–913.
<https://doi.org/http://dx.doi.org/10.1016/j.respol.2016.01.015>
- Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. *Res. Policy* 36, 399–417.
<https://doi.org/http://dx.doi.org/10.1016/j.respol.2007.01.003>
- Giddens, A., 1984. *The constitution of society: Outline of the theory of structure*. Berkeley.
- Grin, J., Rotmans, J., Schot, J., 2010. *Transitions to sustainable development: new directions in the study of long term transformative change*. Routledge.
- Hodson, M., Geels, F., McMeekin, A., 2017. Reconfiguring Urban Sustainability Transitions, Analysing Multiplicity. *Sustainability* 9, 299.
- Hodson, M., Marvin, S., 2012. Mediating Low-Carbon Urban Transitions? Forms of Organization, Knowledge and Action. *Eur. Plan. Stud.* 20, 421–439.
<https://doi.org/10.1080/09654313.2012.651804>
- IEA, 2008. *International Energy Agency World Energy Outlook 2008*. Paris.
- Kemp, R., Schot, J., Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technol. Anal. Strateg. Manag.* 10, 175–198. <https://doi.org/10.1080/09537329808524310>
- Kern, F., 2011. Ideas, institutions, and interests: explaining policy divergence in fostering ‘system innovations’ towards sustainability. *Environ. Planning-Part C* 29, 1117.
- Kivimaa, P., Kern, F., 2016. Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. *Res. Policy* 45, 205–217. <https://doi.org/10.1016/j.respol.2015.09.008>
- Loorbach, D., Frantzeskaki, N., Huffenreuter, R.L., 2015. Transition Management: Taking Stock from Governance Experimentation. *J. Corp. Citizsh.* 48–66.
- Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: An emerging field of research and its prospects. *Res. Policy* 41, 955–967.
<https://doi.org/http://dx.doi.org/10.1016/j.respol.2012.02.013>
- McCormick, K., Anderberg, S., Coenen, L., Neij, L., 2013. Advancing sustainable urban transformation. *J. Clean. Prod.* 50, 1–11. <https://doi.org/10.1016/j.jclepro.2013.01.003>
- Meadowcroft, J., 2011. Engaging with the politics of sustainability transitions. *Environ. Innov. Soc. Transitions* 1, 70–75. <https://doi.org/http://dx.doi.org/10.1016/j.eist.2011.02.003>

- Meadowcroft, J., 2009. What about the politics? Sustainable development, transition management, and long term energy transitions. *Policy Sci.* 42, 323–340. <https://doi.org/10.1007/s11077-009-9097-z>
- Mendizabal, M., Heidrich, O., Feliu, E., García-Blanco, G., Mendizabal, A., 2018. Stimulating urban transition and transformation to achieve sustainable and resilient cities. *Renew. Sustain. Energy Rev.* 94, 410–418. <https://doi.org/10.1016/J.RSER.2018.06.003>
- Nelson, R., Winter, S., 1982. *An evolutionary theory of technical change*. Cambridge, Ma, Belknap Harvard.
- Rauschmayer, F., Bauler, T., Schöpke, N., 2015. Towards a thick understanding of sustainability transitions — Linking transition management, capabilities and social practices. *Ecol. Econ.* 109, 211–221. <https://doi.org/http://dx.doi.org/10.1016/j.ecolecon.2014.11.018>
- Rip, A., 1995. Introduction of new technology: making use of recent insights from sociology and economics of technology. *Technol. Anal. Strateg. Manag.* 7, 417–432. <https://doi.org/10.1080/09537329508524223>
- Rip, A., 1992. A quasi-evolutionary model of technological development and a cognitive approach to technology policy. *RISEST. Riv. di Stud. Epistemol. e Soc. sulla Sci. e la Technol.* 1992, 69–102.
- Rip, A., Kemp, R., 1998. Technological change, in: Rayner, S., Malone, E.L. (Eds.), *Human Choices and Climate Change*. Battelle Press, Columbus, pp. 327–399.
- Schöpke, N., Rauschmayer, F., 2017. Going beyond efficiency: including altruistic motives in behavioral models for sustainability transitions to address sufficiency. <https://doi.org/10.1080/15487733.2014.11908123>
- Schot, J., 1998. The usefulness of evolutionary models for explaining innovation. The case of the Netherlands in the nineteenth century. *Hist. Technol.* 14, 173–200. <https://doi.org/10.1080/07341519808581928>
- Schot, J., 1992. The policy relevance of the quasi-evolutionary model: the case of stimulating clean technologies. *Technol. Chang. Co. Strateg. Econ. Sociol. Perspect. Acad. Press. London* 185–200.
- Scott, W.R., 1995. *Institutions and organizations. Foundations for organizational science*. London A Sage Publ. Ser.
- Sharpe, S., Andersen, M.M., Genoff, R., Hanton, A., Kristiansen, K.R., Bek, K., Rasmussen, T.B., Johansen, M., 2012. *Measuring the Potential of Local Green Growth—An Analysis of Greater Copenhagen: Highlights*.

- Shove, E., Walker, G., 2010. Governing transitions in the sustainability of everyday life. *Res. Policy* 39, 471–476. <https://doi.org/http://dx.doi.org/10.1016/j.respol.2010.01.019>
- Smith, A., Stirling, A., 2010. The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecol. Soc.* 15, 11.
- Smith, A., Stirling, A., Berkhout, F., 2005. The governance of sustainable socio-technical transitions. *Res. Policy* 34, 1491–1510. <https://doi.org/http://dx.doi.org/10.1016/j.respol.2005.07.005>
- Smith, A., Voß, J.-P., Grin, J., 2010. Innovation studies and sustainability transitions: the allure of the multi-level perspective and its challenges. *Res. Policy* 39, 435–448.
- Torrens, J., Schot, J., Raven, R., Johnstone, P., 2018. Seedbeds, harbours, and battlegrounds: On the origins of favourable environments for urban experimentation with sustainability. *Environ. Innov. Soc. Transitions*. <https://doi.org/10.1016/J.EIST.2018.11.003>
- Turnheim, B., Berkhout, F., Geels, F., Hof, A., McMeekin, A., Nykvist, B., van Vuuren, D., 2015. Evaluating sustainability transitions pathways: Bridging analytical approaches to address governance challenges. *Glob. Environ. Chang.* 35, 239–253. <https://doi.org/http://dx.doi.org/10.1016/j.gloenvcha.2015.08.010>
- UNDP, 2012. World urbanization prospects: the 2011 revision, United Nations, Department of Economic and Social Affairs (DESA), Population Division, Population Estimates and Projections Section, New York. United Nations.
- van den Bergh, J.C.J.M., Truffer, B., Kallis, G., 2011. Environmental innovation and societal transitions: Introduction and overview. *Environ. Innov. Soc. Transitions* 1, 1–23. <https://doi.org/https://doi.org/10.1016/j.eist.2011.04.010>
- Voß, J.-P., Bauknecht, D., Kemp, R., 2006. Reflexive governance for sustainable development. Edward Elgar Publishing.
- Wolfram, M., 2016. The Role of Cities in Sustainability Transitions: New Perspectives for Science and Policy. Springer, Singapore, pp. 3–22. https://doi.org/10.1007/978-981-10-0300-4_1

