Paper no. 2013/39

The Geography of Sustainability Transitions: A Literature Review

Teis Hansen (Teis.Hansen@circle.lu.se)
CIRCLE, Lund University, Sweden

Lars Coenen (lars.Coenen@circle.lu.se)
CIRCLE, Lund University, Sweden

This is an early version of a paper, which, in its final form, is accepted for publication in *Environmental Innovation and Societal Transitions* with the title "The Geography of Sustainability Transitions: Review, Synthesis and Reflections on an Emergent Research Field".

This version: December 2013

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications

WP 2013/39

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ABSTRACT

This review covers the recent literature on the geography of sustainability transitions which has recently expanded considerably. The first aim of the review is to clarify the position of geographical thought in different contributions which have adopted an explicitly geographical perspective to understand key spatial issues of sustainability transitions. The second aim is to take stock with the theoretical and empirical insights which have been achieved in this literature and their internal coherence. The review synthesises insights following from both contextual analyses of particular settings in which transitions are embedded and studies of the geography of inter-organisational linkages of importance for transition processes. In this way, the review introduces researchers with an interest in the field of geography of sustainability transitions to the theoretical and empirical results obtained up to now and it highlight those areas which need further work.

JEL Code: O13, O33, Q01, Q55, R11

Keywords: Geography, sustainability transitions, space, scale, context, proximity

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Teis Hansen* & Lars Coenen

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)

Lund University

P.O. Box 117

S-22100 Lund

Sweden

Teis.Hansen@circle.lu.se / +46 462223892

Lars.Coenen@circle.lu.se / +46 462227747

* Corresponding author

1. Introduction

The last decade has seen a burgeoning academic interest in the topic of sustainability transitions (Markard et al., 2012). However, until recently, spatial dimensions of sustainability transitions have been largely ignored in this literature (Smith et al., 2010; Coenen et al., 2012). Why do transitions occur in one place and not in another? How do transitions unfold across different geographical contexts? What is the importance and role of spatial scale for transition processes? These questions, which can be seen as typical for a geographer's perspective (Scott, 2000), remained more or less below the radar in the pioneering work on sustainable transitions. While key initial contributions were made in the specific area of urban sustainability, city infrastructures and low-carbon transitions (Hodson and Marvin, 2009; Bulkeley et al., 2011), a broader, more general engagement with the geography of transition, similar to that on the geography of innovation (Asheim and Gertler, 2005), was lacking. Similarly, the focus on high-tech and service industries following from the dominant post-industrial, post-material discourse in economic geography has led to a lack of engagement with environmental issues from this side as well (Angel, 2000) even though interest seems to be picking up more recently (Economic Geography, 2011; Patchell and Hayter, 2013).

Within most recent years, however, a number of contributions have been made that outline in broad terms possible contours of a research agenda for the geography of sustainability transitions (Lawhon and Murphy, 2012; Raven et al., 2012; Truffer and Coenen, 2012; Nevens et al., 2013). Moreover, there has been a poignant interest in geographical aspects of transitions at the latest three international conferences on sustainability transitions in terms of special sessions, thematic discussions and paper contributions (Lund, Copenhagen and Zurich). In addition, numerous empirical studies have been made that in various ways explicitly dealt with and partly also theorised about transitions' spatial aspects, including special issues in European Planning Studies (2012) and this issue.

In light of this increased attention, research on the geography of sustainability transitions is developing and expanding rapidly with contributions from many fields, using different approaches. This heterogeneity has both advantages and disadvantages. On the one hand, cross fertilisation of insights from multiple traditions and disciplines avoids short-sightedness and cognitive lock-in and provides scope for analytical refinement and conceptual renewal, especially bearing in mind the interdisciplinary legacy of the transitions literature[1]. On the other hand, the importation and translation of 'external' ideas may be criticised for often resulting in rather haphazard and fuzzy conceptualisation (Lagendijk, 2006). Different approaches assign dissimilar

[1] A lot of novel theory development within the transitions literature originated at the intersection of evolutionary economics and more constructivist approach in studies of technology and science (STS).

meanings to similar terms or similar meanings to dissimilar terms. This can be illustrated by various seemingly geographical metaphors found in the MLP framework, such as 'landscapes', and the 'local-global' distinction in niche development dynamics (Geels and Raven, 2006). Though initially introduced in the transitions literature without an explicit spatial connotation, these concepts are easily mistaken for having a quite specific meaning within geography (Bridge et al., 2013).

Similarly, conceptualisations of space and place may create considerable ambiguity when imported from its origins in geographical thought into a sustainability transitions framework. Different readings of different parts of the geography literature may point to rather dissimilar meanings of key notions used to analyse and explain spatial phenomena and processes. Within economic geography, for example, we have seen quite dramatic shifts ranging from a cultural to a relational and, most recently, towards an evolutionary turn which each have treated issues such as scale, proximity and local-global rather differently. Given this internal heterogeneity it is not entirely clear what a geographical perspective on sustainability transitions implies and how it can be applied in empirical studies. Without claiming to be conclusive or definitive, there is at least a need to clarify the position of geographical thought in different contributions which have adopted an explicitly geographical perspective to understand key spatial issues of sustainability transitions.

Such a review is needed in order to synthesise recent years' intensive research on the topic and to assess whether more or less coherent results can be identified, lessons can be drawn and future research can be identified. Similarly, it would be useful to identify opposite or conflicting findings that require further investigation and scope for cross-overs between different studies. A well-known weakness of many geographical analyses is that they celebrate the particular and focus on highly idiosyncratic case stories of specific regions and localities. It is therefore a challenge for spatial analyses of sustainability transitions to identify and formulate insights with theoretical purchase beyond the narrow domain of geography of transitions (Geels, 2013). The objective of this review is two-fold. First, to make explicit how in recent geographical studies of sustainability transitions space has been conceptualised and second, to take stock with the theoretical and empirical insights which have been achieved so far and their internal coherence.

The review considers papers that explicitly combine sustainability transitions analysis with a geographical perspective. The methodological outset was taken in combined keyword search[2] on ISI Web of Science, however, this only yielded a limited amount of results. Thus, most papers were identified through snowballing, i.e. by examining reference lists of already known papers as well as citing papers to some of the key contributions within the field.

[2] E.g. "sustainability transition" and "geography".

The remainder of this paper looks as follows. The next section will seek to clarify how the key concepts of space and place have been conceptualised in the economic geography literature. Further, following insights from economic geography (Gordon and McCann, 2000; Knoben, 2009), this review then distinguishes between two key aspects to understand the position of geographical thought in the sustainability transitions literature: section three is focused on the contributions' perceptions of geographical context; section four considers the different perspectives on the spatial dimension of linkages between actors (i.e. scale). This corresponds with Angel's (2000) call for considering both the territoriality of technological development and change (i.e. context), and the geography of inter-organisational linkages in order to understand economy-environment relations.

2. Dealing with space in geography: the importance of context and scale

"Trying to think clearly about space is not easy." (Dainton, 2001, p. X)

While it is impossible here to do full justice to the theoretical discussions in economic geography on the concepts of space, scale and context, the intention is to illustrate and clarify the different meanings that these terms may have taken in economic geography. The complexity of this issue is partially due to a number of "turns" that economic geography has taken over the last decades – a cultural turn, a relational turn and most recently an evolutionary turn – which has implications for the conceptualisation of, in particular, space.

Recent conceptualisations of space are often contrasted to the notion of space in traditional positivist geography, where space is considered an empty container waiting to be filled, e.g. with various forms of economic activity. As it is evident from the preceding section, the relational turn has in particular influenced contributions within the geography of sustainability transitions literature and it is therefore given specific attention here. The relational turn emphasises the social forces in arguing that space is constructed through social interactions between actors. The popularity of this perspective needs to be contextualised against an on-going globalisation background in which processes of hypermobility and time-space compression due to technological change prevail. Within economic geography, this has resulted in an increasingly vocal criticism of the emphasis by geographers on local processes, e.g. in clusters, agglomerations and industrial districts. Attention has consequently shifted to the ways that social networks influence inter-organisational partnerships and can facilitate collaboration between partners which are geographically distant (Allen, 2000; Saxenian and Hsu, 2001), and the importance of such distanciated collaboration is now frequently emphasised (Amin and Cohendet, 2004; Bell and Zaheer, 2007; Fleming et al., 2007).

Partly as a counter reaction to the overemphasis on the local scale, relational geography claims to give no *a priori* privilege to any scale (Boggs and Rantisi, 2003) and it considers space as non-existing in itself; thus, space is nothing more than a social construction depending on relations between actors (Amin, 2002), or merely an analytical perspective whereby the central objects of analysis, economic action and interaction, can be analysed (Bathelt and Glückler, 2003). Variations over space are explained by social relations, while no causal power is given to space itself (Allen et al., 1998). Thus, while it is argued that economic activities are situated in time and place, the outset continues to be relations and there is little attention to the role of geography in the formation of these relations. As stated by Bathelt and Glückler (2003, p. 129) *"relational economic geography enables a complex understanding of economic action and its localized consequences"*, thus, the core focus is connectivity and the impact in specific areas, not the impact of specific areas on establishing connectivity. As pointed out by Sunley (2008), relational geography has in this way increasingly distanciated itself from institutional perspectives that highlight the role of dense relations in geographical proximity for tacit knowledge exchange. Rather, relational geography emphasises relational proximity. However, this perspective has, in turn, been criticised for giving exaggerated prominence to global networks and understating the role of factors that constraint these flows (Jones, 2009).

In summary, relational geography takes its outset in relations rather than entities such as firms or nation-states. One important criticism is a lack of consideration of the role of geography in forming relations, as the propensity to establish relations are not equal across distance (Hansen, 2013). This is closely related to the stability of economic institutions, which is arguably underestimated in relational geography, as it disregards the entities where institutions are formed and reproduced, since it – though claiming otherwise – gives *de facto* privilege to micro scale processes (Sunley, 2008).

The most recent turn in economic geography – the evolutionary turn – takes on board some insights from the relational turn, including the importance of non-spatial forms of proximity for the relations between actors (see Boschma, 2005). However, the starting point is fundamentally different from relational geography as the ambition of evolutionary economic geography is *"to demonstrate how geography matters in determining the nature and trajectory of evolution of the economic system"* (Boschma and Martin, 2010, p. 6). Throughout the last decade evolutionary economic geography has shed new light on the spatial conditions for innovation and economic growth, reviving an interest in the importance of historical path dependencies for future spatial development paths (Boschma and Frenken, 2006; Uyarra, 2010). According to Martin (2010, p. 3), "the combination of historical contingency and the emergence of self-reinforcing effects, steers a technology, industry or regional economy along one 'path' rather than another". In addition to spatial context, evolutionary economic geography has thus stressed the importance of the

historical context. While there is considerable debate within geography concerning the role of institutions in an evolutionary framework (compare Boschma and Frenken, 2009; MacKinnon et al., 2009), the roots of this turn in theories of path dependence are evident through a greater sensitivity to the (geographical) factors that restricts the fluidity of networks. Thus, Jones (2009, p. 487) suggests that a more evolutionary perspective offers greater chances of establishing "a moderate relationalism" which avoids treating space as either fully fixed or fully fluid. Further, considering the evolutionary roots of transition research, an evolutional perspective on space can also be expected to have considerable synergies with contributions within the mainstream sustainability transitions literature.

In sum, the conception of space is a highly complex and contested issue even without the further confusion added through the use of expressions such as niches as "protective spaces" (Geels, 2002, p. 365) in the sustainability transitions literature. However, a definitive statement of what space means for transitions is probably not the most pressing and interesting aspect of the geography of sustainability transitions literature even though greater awareness and conceptual clarification of spatial terms that are used may be sought for. Rather, one may ask what we mean by 'geographies of sustainability transitions' and why an analysis of the spatial aspects of sustainability transitions is meaningful. In this, we concur with Bridge et al. (2013). The geography of sustainability transitions captures the distribution of different transition activities across space. Transitions are constituted spatially and unpacking this configuration will allow us to understand better the underlying processes that give rise to these patterns. This requires both contextual analysis of the particular settings (spaces) in which transitions are embedded and evolve while at the same paying attention to the geographical connections and interactions (i.e. the spatial relations) between that space and other spaces. In the next section we have structured our literature review along these two themes: (1) the importance of geographical context and (2) the role of spatial linkages.

3. Sustainability transitions and geographical context

In an early contribution, Shove and Walker (2007) merely note the importance of contextual factors such as the political environment and the anticipatory knowledge of local transition managers for transition processes. Since then, geographers have called for a detailed examination of the importance of context for sustainability transitions (Lawhon and Murphy, 2012), and studies have indeed taken up this challenge. As table 1 illustrates, the importance of multiple dimensions of geographical context for sustainability transitions is now well-established. Generally, these contributions focus on the local, regional and urban levels, while considerable less attention is given to the national scale, with some exceptions examining the territorial institutional environment (Angel and Rock, 2009; Berkhout et al., 2009).

Table 1. Insights on the influence of geographical context on sustainability transitions

Themes	Authors	Insights
Urban and regional visions and policies	Bulkeley et al. (2011); Carvalho et al. (2012); Coutard and Rutherford (2010); De Laurentis (2013); Dewald and Truffer (2012); Essletzbichler (2012); Faller (2012); Hawkey (2012); Hodson and Marvin (2009; 2010; 2012); Maassen (2012); McCauley and Stephens (2012); Monstadt (2007; 2009); Quitzau et al. (2012); Rohracher and Späth (2013); Shove and Walker (2007); Smith (2007); Späth and Rohracher (2010; 2012); Truffer and Coenen (2012); Uyarra and Gee (2013)	*Generic insights:* • Urban and regional visions and policies are central to facilitate ST • Policy generally aim to combine ecological goals with economic competitiveness • Often, such policies also stimulate industrial development of cleantech industries *Specific insights:* • Policies need to encompass multiple policy areas, thus, they are contested and negotiated between multiple public, quasi-public and private territorial actors
Informal territorial institutions	Angel and Rock (2009); Berkhout et al. (2009; 2011); Binz et al. (2012); Bridge et al. (2013); Coenen et al. (2010; 2012); Dewald and Truffer (2012); Faller (2012); Maassen (2012); Murphy and Smith (2013); Ornetzeder and Rohracher (2013); Shove et al. (2013); Späth and Rohracher (2010; 2012); Truffer and Coenen (2012); Wirth et al. (2013)	*Generic insights:* • Informal territorial institutions influence sustainability transition processes • Development and diffusion of environmental innovations are conditioned by such institutions *Specific insights:* • Influence of informal territorial institutions is partly through the influence on environmental regulation • Importance of recognising differences in informal institutions even within local or urban areas
Local natural resource endowments	Bridge et al. (2013); Carvalho et al. (2012); Essletzbichler (2012); Murphy and Smith (2013); Späth and Rohracher (2010; 2012); Trutnevyte et al. (2012)	*Generic insights:* • Resource endowments influence choices between sustainable technologies *Specific insights:* • Resource scarcity stimulates investments in sustainability transitions
Local technological and industrial specialisation	Bridge et al. (2013); Carvalho et al. (2012); Coenen et al. (2010); Essletzbichler (2012); McCauley and Stephens (2012); Monstadt (2007); Ornetzeder and Rohracher (2013); Smith (2007)	*Generic insights:* • Specialisation promotes the innovations necessary for sustainability transitions *Specific insights:* • Specialisation is often the outset for regional policy agendas • In turn, such policies reinforce technological and industrial specialisations
Localised knowledge spillovers	Binz et al. (2012); Essletzbichler (2012); McCauley and Stephens (2012)	*Generic insights:* • The extent of knowledge spillovers in a region influences the ability of firms to develop environmental innovations. • Such spillovers do not happen automatically, but can be stimulated by public policy
Consumers and local market formation	Binz et al. (2012); Dewald and Truffer (2012)	*Specific insights:* • Engaged end-users are a central supplement to formal support programs in local market creation • Co-location enables producers to obtain feedback from end-users

A quite large number of studies examine the central role of **urban and regional visions and policies** for sustainability transition processes (the edited volume by Bulkeley et al., 2011, takes a prominent position in this literature). While these contributions have a main focus on the urban and regional levels, the importance of connections to other policy levels is evident, with some authors taking an explicitly multi-level governance perspective (Hodson and Marvin, 2010; 2012; Späth and Rohracher, 2010; 2012; Uyarra and Gee, 2013). For instance, Hodson and Marvin (2009) highlight that the visions promoted by urban government may be developed by exogenous actors, which deliberately search for specific urban contexts to test them in real life. Importantly, interaction between different policy levels is not merely a top-down process, and Faller (2012) notes that urban strategic discourses can also inform policies at higher levels, thus, the relation between policy levels should be understood as a two-way influence.

The importance of urban and regional visions and policies reflects the necessity to mobilise the heterogeneous group of local actors of relevance for sustainability transitions (Essletzbichler, 2012). Local planners are in particular centrally placed actors in the process of establishing sustainability priorities and engaging local stakeholders, even though the formation of local stakeholder networks is highly influenced by existing relations (Hawkey, 2012; Quitzau et al., 2012). As policies need to encompass multiple policy areas, they are contested and negotiated between multiple public, quasi-public and private territorial actors (Monstadt, 2007; Coutard and Rutherford, 2010). Contributing to the heterogeneous mix of actors is the close connection between sustainability transitions and physical infrastructure which in many cases have been privatised, thus, governance of sustainability transitions becomes a collaborative effort involving public and private actors with varied interests and incentives. This results in highly complex processes (Monstadt, 2007; Faller, 2012) with direct competition between different visions, which may not only disagree in terms of technologies and level of ambition, but also include struggles over the right geographical scale to develop initiatives promoting sustainability transitions (Hodson and Marvin, 2012). Strong actor coalitions may lead to exclusion of otherwise central aspects from urban and regional visions and strategies (Späth and Rohracher, 2010). Disagreements may also lead to alliances across different levels of government, as Coutard and Rutherford (2010) describe in the Île-de-France region where the agendas of local and national authorities align, leading to a united front against the regional authorities. This highlights the fundamental political nature of sustainability transition processes, echoing the suggestion by Shove and Walker (2007, p. 766) that *"there is a politics to transition management, a playing out of power of when and how to decide and when and how to intervene"*.

A further characteristic of urban and regional sustainability transition policies is that they are typically aimed at combining ecological goals with economic competitiveness (Hodson and Marvin, 2009; Späth and

Rohracher, 2010). A main way in which this dual focus materialises is through policies aimed at stimulating industrial development of cleantech industries (Carvalho et al., 2012; McCauley and Stephens, 2012). As noted by Smith (2007), this is a policy area where the regional level actually has leverage to act, by mapping and supporting cleantech clusters through e.g. research and development support, training programmes and assistance with funding applications. This mirrors the suggestion in the literature on regional innovation policy (e.g. Asheim et al., 2011) that regional actors are better able to design successful policies than national actors, due to their knowledge on the specific context and their ability to fine-tune policies.

While governmental policies can be considered a main component of a location's institution environment, **informal territorial institutions**, understood as territorially bound norms, habits and values, are an equally important factor for sustainability transitions. Naturally, the relation between the two is close, as noted by multiple authors in analyses ranging from the national to the regional and local levels (Angel and Rock, 2009; Faller, 2012; Späth and Rohracher, 2012). To exemplify, Angel and Rock (2009) note the importance of discourses, commitment to environmental improvement and citizen pressure for differences in changes to formal regulation among East Asian countries. As noted by Maassen (2012), government regulators may also – at least – envision the reverse influence, however, changing deeply embedded norms through formal regulation is a difficult and long-term project.

A main – and not too surprising – conclusion drawn from these contributions is that informal territorial institutions are important explanatory factors for spatial differences in terms of sustainability transition processes (Coenen et al., 2012; Truffer and Coenen, 2012). In other words, localised norms and values have important influences on the uneven spatial landscape of sustainability transitions. Empirically, this is among others highlighted by Späth and Rohracher's (2010; 2012) analysis of the transition process in the Austrian district of Murau which is based on values embedded at different geographical levels: from the significance given by Austrians in general to self-reliance on energy, to the local importance given to the use of biomass in the area. Similarly, Wirth et al. (2013) convincingly show the influence of geographical differences in professional cultures among Austrian farmers on regional differences in the extent and character of biogas technology diffusion. In this way, informal institutions condition the potential for different sociotechnical configurations.

Informal institutions are found to play a key role for both the development and diffusion of environmental innovations. Firstly, environmental innovation activities, including grassroots innovations, are situated in specific local institutional contexts (Berkhout et al., 2011; Ornetzeder and Rohracher, 2013). Thus, localised institutional framework, including norms and values such as e.g. specific local cooperation cultures, should be analysed in order to comprehend the background and potential of individual sustainability experiments

(Coenen et al., 2010; Truffer and Coenen, 2012). Exemplifying this, Coenen et al. (2012) argue that it is central to acknowledge the importance of specific territorial institutional advantages such as a collaborative culture and attitude towards knowledge sharing in order to understand the success and innovativeness of the Danish wind turbine industry.

Secondly, as noted by Bridge et al. (2013, p. 336), *"the spatial diffusion of energy technologies is culturally contingent: how new energy technologies spread across space often depends on how these technologies (and the natural resources upon which they are deployed) are embedded in (national) systems of signification and cultural routines."* Thus, it follows that norms around consumption have important influence on the potential for upscaling of niche technologies and, we would add, also the spread of unsustainable technologies. On the former, Bridge et al. (2013) mention expectations concerning cost and reliability of energy supply, and social practices associated with energy consumption as examples. Along similar lines, in an empirical analysis, Binz et al. (2012) highlight the importance of the attitude to risk for the (lack of) diffusion of onsite small-scale membrane bioreactor wastewater treatment plants in China. On the latter, Shove et al. (2013) demonstrate that local practices and their development over time are central to understand the geographical diffusion of air conditioning.

Finally, the important role of territorial informal institutions for sustainability transitions should not lead scholars to disregard the potential considerable heterogeneity in norms and values within a given area. As an example, Maassen (2012) points to the differences in practices between architects, developers and planners collaborating on the deployment of photovoltaics technology in three European cities. This highlights that even though many informal institutions are localised, they are not necessarily pervasive across the territory, and this may delay or even hinder transition processes.

Relatively few contributions deal explicitly with the importance of **local natural resource endowments** for sustainability transitions, perhaps since the central role is simply too self-evident: the potential of tidal power is larger in coastal areas with large tides, of solar power in areas with many hours of sunshine, etc. Still, transition strategies do often not take local natural resource endowments sufficiently into consideration (Trutnevyte et al., 2012). The influence of natural resources is stressed by Carvalho et al. (2012) who explain how the large regional production of soya crops influenced the decision to focus on biodiesel (rather than e.g. biogas or hydrogen) in Curitiba, Brazil, while Späth and Rohracher (2010; 2012) describe the importance of the abundance of local wooden biomass for the transition process in Murau.

The potential importance of local natural resource endowments for sustainability transitions is however mediated by various factors. Within renewable energy, many forms of natural resources are concentrated

in peripheral areas, where insufficient infrastructure is a significant barrier (Murphy and Smith, 2013). Further, while Bridge et al. (2013) stress the influence of natural landscape features, they also highlight how social attachments may prevent the transformations of these landscapes with are necessary for sustainability transitions.

In addition to favourable natural conditions for renewable energy generation, resource scarcity within traditional resources (e.g. fossil fuels) may also stimulate investments in sustainability transitions, as exemplified by Essletzbichler (2012) in the case of the Spanish region of Navarra. In essence, this highlights that a selective factor disadvantage can stimulate a quick transition towards innovative practices, thus, regions with little or no fossil resources have greater incentive to support sustainability transitions.

A number of studies point to the importance of **local technological and industrial specialisation** for sustainability transitions. One main argument is that geographical clusters promote the innovations necessary for sustainability transitions (McCauley and Stephens, 2012; Bridge et al., 2013). Similar to other technologies, the development, demonstration and implementation of green innovations is stimulated by agglomeration economies such as access to a pool of skilled labour, supporting intermediary organisations, research institutes and universities (McCauley and Stephens, 2012). Specifically regarding universities, Stephens et al. (2008) provide a detailed description of the various roles they may have in sustainability transition processes and how these roles vary depending on the national and regional context. Universities may for instance take key roles in addressing regional-specific sustainability challenges.

As noted above, urban and regional transition policies frequently focus on stimulating industrial development of cleantech industries. Thus, existing technological and industrial concentrations and strongholds are often the outset for policy agendas. In England, targets and activities in the various regional renewable energy plans were significantly influenced by and focusing on areas which matched the regional industrial compositions (Smith, 2007). Likewise, the strong research milieu within the field of solar research was an important precondition for the policy focus on this industry in Berlin (Monstadt, 2007). Similarly, in a comparative case study analysis, Carvalho et al. (2012) stress the role of local technological and industrial specialisation on the choice between various green urban transport technologies in Curitiba, Gothenburg and Hamburg. However, they go one step further than the influence of specialisation on the selection of technologies, and highlight the subsequent co-evolution of industries and policies in the urban contexts, as the policies also strengthen the development of the local platforms for knowledge creation and learning. In other words, policy and industrial specialisation are mutually reinforcing, with transition policies having a significant impact on *"the specialized pool of spatially rooted engineering qualifications and capability evolution over time"* (p. 388).

Closely related to the previous point, a few contributions specifically address the role of **localised knowledge spillovers**. Fundamentally, the argument is that intra- and inter-industry knowledge spillovers are positively influenced by geographical proximity, and that the extent of such spillovers among cleantech firms located in a region will impact their ability to develop innovations that can support a transition process. However, as exemplified by the study of Binz et al. (2012), such knowledge spillovers are likely to be absent in the formative stages of innovation systems around new technologies. Thus, Essletzbichler (2012) therefore argues that regional sustainability transition policies should specifically address this point and make firms able to take advantage of spillover effects by e.g. strengthening regional informal networks. Further, in line with this, McCauley and Stephens (2012) suggest that cleantech cluster policies should give more attention to social and cultural elements.

Finally, the role of **consumers and local market formation** is only sporadically considered in studies on the geography of sustainability transitions, reflecting the general insufficient attention to this topic in the wider sustainability transitions literature (Shove and Walker, 2007). Notable exceptions are Binz et al. (2012) and in particular Dewald and Truffer (2012). While the former note the central role of regulatory institutional arrangements for market development, the latter argue that engaged end-users are a central supplement to the formal support programs in local market creation. Co-location enables producers to obtain feedback from end-users which is particularly important in the early stage of market formation.

In summary, this survey of studies of the influence of geographical context on sustainability transitions points to a number of important future research areas. Firstly, some topics such as the role of consumers and local market formation have only been analysed sporadically and need a much more thorough examination. Secondly, we will argue that there is a need for a more detailed understanding of when and under which conditions the different contextual dimensions are important, as all contextual factors are not equally important in all analyses of sustainability transitions. To exemplify, despite the considerable research interest in the role of urban policies and multi-level governance processes, we still know relatively little about the extent to which differential policy contexts influence transitions governance and its scope for reform. Similarly, Truffer (2008) argues that institutions are crucial for stabilising, transmitting and containing tacit knowledge, but does that imply that the institutional environment is of particular importance when analysing sustainability transitions building on engineering-based technological developments where tacit knowledge is of main importance (contrary to science-based technological developments dominated by codified knowledge, see also Asheim (2007))? Thus, there is a strong need for going beyond the rather broad conclusions reached concerning the role of informal institutions to better understand which informal institutions matter in which contexts and how. Paraphrasing Gertler (2003) on

the role of culture in production, it is necessary to move beyond informal institutions as a residual category and establish a deeper engagement with their role in sustainability transitions, as recently exemplified by Wirth et al. (2013). In our view, these are the question and issues that are important to consider in order to improve our understanding of the influence of geographical context on sustainability transitions. Thirdly, specifically regarding policies, an important research topic is the changing role of the urban and regional levels. On the one hand, the main argument in favour of the considerable focus on these levels is that they are closer to the actors involved in sustainability transitions and more attuned to local conditions (e.g. Coutard and Rutherford, 2010). On the other hand, Monstadt (2007; 2009) argues that the increasing complexity of the governance of sustainability transitions implies that the ability of urban and regional authorities to control these processes are diminishing and that central regulatory functions have been transferred to the national and European policy levels. Further, in the case of England, Smith (2007) points out that the lack of direct control of the regional energy infrastructure and the absence of sufficient funds at the regional level for initiatives lead to a weak regional autonomy. Thus, the future roles of the urban and regional policy levels in sustainability transitions are worth further attention.

4. Sustainability transitions and scale in inter-organisational linkages

Inter-organisational linkages are of central importance for innovation processes and, thus, also for sustainability transitions. A number of different perspectives on the spatial dimension of linkages between actors are found in the literature on the geography of sustainability transitions. Contributions increasingly highlight that relations on different scales are important for the development processes that make sustainability transitions possible (e.g. Binz and Truffer, 2011; Truffer and Coenen, 2012), following the general development within economic geography (e.g. Bunnell and Coe, 2001; Bathelt et al., 2004).

Reflecting the various conceptualisations of space and scale in geography, considered in section 2, different comprehensions are also evident in the geography of sustainability transitions literature. Generally, a distinction can be made between studies that take a perspective in line with more traditional approaches in economic geography, stressing the positive influence of geographical proximity in stimulating network formation (e.g. Coenen et al., 2010), and studies that draw heavily on the relational approach, highlighting that space is socially defined (e.g. Raven et al., 2012).

The former of these positions emphasises the importance of relations at the local and regional scales. The fundamental argument is that geographical proximity allows continuous face-to-face interaction which facilitates the creation of social ties and thereby network formation (Coenen et al., 2010; Dewald and Truffer, 2012; Ornetzeder and Rohracher, 2013). Similarly, work on the role of industrial clusters in

sustainability transition processes also highlights positive proximity effects on inter-organisational linkages concerned with e.g., collaborative innovation projects, arising from co-location (Essletzbichler, 2009; McCauley and Stephens, 2012). Beyond intra-industry linkages, it is also argued that networks of heterogeneous actors are most easily established at the local and regional scale (Späth and Rohracher, 2010; 2012). Often, local inter-organisational network creation is furthermore shaped by intermediaries with a specific spatial focus (Hodson and Marvin, 2009; 2010).

While these contributions identify crucial aspects of the geography of sustainability processes, it has been argued that it is equally important to recognise both the potential negative consequences of inter-organisational linkages in geographical proximity on sustainability processes, and the importance of extra-local relations. On the first point, Smith (2007, p. 6273) notes the tendency for decision-making networks to be populated by *"the usual suspects"*. This highlights the inertia in such networks, which is not necessarily conducive to transition processes. On the second point, the study by Carvalho et al. (2012), exemplifies that a sensitivity to localised collaborations does not necessitate a full preoccupation with this scale, but can be combined with an acknowledgement of the importance of international and global linkages. Their study of sustainable transport technologies shows that geographical proximity stimulates formation of localised inter-organisational networks, which again facilitate development of external (national and global) linkages.

Attention to the non-local scale is also evident in contributions with an explicit focus on global linkages between developed and developing countries through e.g. global production networks or donor interventions, and their ability to influence transition processes in the receiving countries (Angel and Rock, 2009; Berkhout et al., 2009; 2011; Hansen and Nygaard, 2013; Schmidt and Dabur, 2013). Alternatively, a fully relational perspective can be adopted, exemplified by Binz and Truffer (2011) which highlight that innovation cooperation takes place at multiple scales, and considers that geography follows the social networks of actors. Similar suggestions are found in a number of key contributions to the geography of sustainability transitions literature (Coenen et al., 2012; Raven et al., 2012; Truffer and Coenen, 2012). While these papers all accept the local embeddedness of relations and the existence of geographical proximity effects, they also draw considerably on relational geography in arguing that geography is socially constructed through networks of actors and that *"a spatial perspective should adopt a relational perspective emphasizing networks that are enacted and structured across different levels of spatial scale"* (Raven et al., 2012, p. 69). What is lacking in these contributions is a discussion of the compatibility between a relational perspective and the simultaneous acceptance of the local embeddedness of relations.

Consequently, a first important topic of future research is to further explore the role of relations at various scales for transition processes. One suggested way forward in understanding the importance of geography

for inter-organisational relations, is to distinguish between two mechanisms (following Hansen, 2012): firstly, *the substitution mechanism*, where non-spatial forms of proximity (e.g. social proximity) substitute for geographical proximity. This acknowledges that geographical proximity is not a necessity in inter-organisational relations, thus, avoiding an overemphasis on the local scale. Secondly, *the overlap mechanism*, where geographical proximity facilitates non-spatial forms of proximity. This recognises the important facilitating effect of geographical proximity on other forms of proximity, thus, accounting for the local embeddedness of networks. Together, this allows an understanding of the influence of geography on the collaboration processes that make sustainability transitions possible which is neither over-, nor, under-socialised. This is important in order to comprehensively understand in which situations and for which purposes relations at different scales matter.

A second topic of specific relevance to sustainability transitions is the importance of geographical proximity for linkages between agents at different levels in the multilevel framework. While the economic geography literature highlights that geographical proximity stimulates social network formation and allows continuous interaction *in general*, contributions within the geography of sustainability transitions literature (e.g. Truffer and Coenen, 2012) argue that geographical proximity between agents is particularly important in the development of niches – *"[n]iches do not emerge out of nowhere"* (Raven et al., 2012, p. 71). This latter position is in line with the suggestion that clusters are particularly important in the case of emerging eco-industries, thus, *"synergies and interdependencies exist between cluster development and sustainability"* (Martin and Mayer, 2008, p. 275). It is proposed that the complexity of sustainability demands necessitates particularly close collaboration between actors (Allen and Potiowsky, 2008; Johnson and Silveira, 2013) and that local buzz, i.e. non-deliberate knowledge and information exchange through e.g. rumours, impressions and recommendations, may be especially important in sustainable energy clusters due to the need for cultural and behavioural change (McCauley and Stephens, 2012). However, evidence also points to the importance of localisation economies within mature, polluting industries. In fact, the oil production equipment industry is pointed out as a textbook example of an industry with a high propensity to clustering due to a very fragmented value chain, the importance of highly distinct but complementary competences, and the significance of collaborative innovation (Steinle and Schiele, 2002). This is exemplified by the oil industry in Houston which has a significant concentration of large and small oil companies, research facilities, geological firms, drilling contractors, supply companies, law firms, as well as other firms related to the oil industry. This cluster has played a crucial role for technological development within the regime. Importantly, these technologies are not just used for extracting oil in the Gulf of Mexico, but Houston-developed oil field machinery is used throughout the world, from the North Sea to the Middle East, thus, becoming a main Houstonian export (Feagin, 1985). In summary, it appears that there continues to be a

limited understanding of the differences between the importance of geographical proximity for linkages between agents at different levels in the multilevel framework. Thus, as empirical evidence is missing on this topic, further research is needed.[3]

5. Conclusion

This paper has reviewed recent studies in the emerging field dealing with the geography of sustainability transitions. The majority of studies within this field have focused on the importance of place-specific contextual factors for transition processes. A number of cross-cutting themes can be identified such as urban and regional visions and policies, informal territorial institutions, local natural resource endowments, local technological and industrial specialisation, localised knowledge spillovers and consumers and local market formation. An important empirical and theoretical insight that has been gained through these studies is that various localisation effects seem to matter in transitions, which have been neglected in much of the earlier work which was primarily concerned with transition processes at the national level. Many of the findings concerning the importance of local context overlap with general insights from the literature on local and regional innovation (e.g. localised technological and industrial specialisation, informal territorial institutions). However, some of the studies also point to particularities found in innovations processes connected to transitions, such as the lack of knowledge spillovers in formative stages of new technology and industry and the importance of proximity to end-users in early stages of industry and market formation. This focus on early, formative stages in technology and industry development, also explains why many studies have emphasised the need for support from public policy. Here, urban and regional policy is given premium as these levels of policy-making are considered better equipped to deal with and respond to the context-sensitivity and specific challenges and needs of firms and actors. This again resonates with often-heard arguments in regional innovation policy against one-size-fits-all approaches and the need for tailored policy that takes stock with the particular challenges of a region. Even though urban and regional policy is emphasised, and in connection to that localisation advantages due to proximity effects, various studies also acknowledge the presence and importance of non-local relations and supra-local scales of policy and governance. However, compared to the emphasis given to the role of context for transition processes, it seems that the issue of multi-scalarity has received less attention in recent studies on the geography of sustainability transitions.

[3] The industrial ecology literature highlights another form of proximity advantage of importance for sustainability transitions, namely the possibility for physical transactions in eco-industrial parks and industrial symbioses. However, while physical flows between co-located firms may be envisioned by planners, they are generally found to be of very limited importance for the functioning of these sites (Deutz and Gibbs, 2008).

When asking the 'bigger' question why transitions unfold unevenly across space, it becomes obvious that further empirical and theoretical research is needed. Reflexive about a geographical perspective the review also identifies that most studies are typically single case studies that in many ways emphasise the particularities of spatial context. As a result, the consensus is still *that* context and scale matters while there is still little generalizable knowledge and insight about *how* context and scale matters for transitions. Moreover, most studies on the geography of transitions seem to have been mainly layered on top of existing theory in the transitions literature, relying heavily on concepts and frameworks such as MLP, TIS and SNM. Very few studies in the geography of transitions field suggest alternative frameworks to study sustainability transitions and thus challenge current theorisations of transitions and its geographies.

Given these observations, future research on the geography of transitions is needed that investigates more systematically how context and scale influence transitions processes. Methodologically this would argue in favour of using comparative methods more frequently to identify similarities and differences across a range of contexts and scales. Moreover, past studies seem to have focused primarily on the geography of niche developments and formative phases in technological innovation systems. While the review has shown that recent studies emphasise the presence of localisation advantages for niche technologies and practices, these do not really specify what these advantages consist of and/or whether there are any regularities whether different kinds of proximities (social, institutional, cognitive) underpin these advantages. Less attention has also been paid to the spatial dimensions of regimes. A more systematic analysis of how regimes influence the geography of transitions could be achieved by doing comparative analyses of transitions across different varieties of capitalism, i.e. territorially differentiated socio-economic regimes. Finally, more research is needed to substantiate multi-scalarity in transitions. While it has become generally accepted that transitions unfold across different scales, it still remains unclear what factors and processes are most effectively governed at a local, national and international level and how these different levels of coordination interact and relate to each other.

Theories within sustainability transitions were initially developed in and applied to developed, Western European economies (Lawhon and Murphy, 2012). The fact that the recent attention to the geography of sustainability transitions coincides with the increasing usage of the framework in developing and emerging economies is probably not coincidental, as the challenges and opportunities for sustainability transitions are significantly different in emerging economies (Tukker, 2005; Johnson and Silveira, 2013). Application of theories in new geographical contexts generally implies that the theories need to be revised and further developed in a direction that is more sensitive to geography. Thus, the increasing spread of the

sustainability transitions literature to new parts of the world is likely to stimulate a further interest in the geography of sustainability transitions.

Acknowledgements

This paper benefitted from comments by Heather Lovell and other participants at the workshop "Constructing and contesting spaces for low-carbon energy innovation" at the Eindhoven University of Technology, and at the 4th International Conference on Sustainability Transitions in Zürich, Switzerland. The authors acknowledge financial support from the Swedish Research Council (Linnaeus Grant No. 349200680) and the Swedish Governmental Agency for Innovation Systems (Grant agreement 2010-07370).

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