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Sustainability transitions: An emerging field of research and its prospects

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ABSTRACT

Sustainability oriented innovation and technology studies have received increasing attention over the past 10–15 years. In particular, a new field dealing with "sustainability transitions" has gained ground and reached an output of 60–100 academic papers per year. In this article, we aim to identify the intellectual contours of this emerging field by conducting a review of basic conceptual frameworks, together with bibliographical analysis of 540 journal articles in the field. It is against this background that we position the six papers assembled in a special section in Research Policy. These papers pave the way for new conceptual developments and serve as stepping-stones in the maturation of sustainability transition studies, by linking with the scholarly literatures of management studies, sociology, policy studies, economic geography, and modeling.

1. Introduction

Today, we face fundamental sustainability challenges in several domains. Energy supply, for example, is confronted with a rapid depletion of natural resources, air pollution and greenhouse gas emissions, nuclear risks, uncertainties related to short- and long-term security of supply, and energy poverty (IEA, 2011). Water supply and sanitation systems have to tackle a broad range of problems related to water scarcity, insufficient access in low-income countries, extreme events (flooding, earthquakes) and micro-pollutants (Gleick, 2003). The transportation sector is challenged by congestion (especially road traffic), local air pollution, fossil fuel depletion and CO_2 emissions, and the risk of accidents (Geels et al., 2011). Other sectors (e.g., agriculture, food system) have to deal with similar challenges. While most of these challenges are related to environmental and social problems, economic problems are pressing as well. Existing infrastructure systems in many parts of the world are confronted with huge financial needs in terms of infrastructure renewal and expansion (Gil and Beckman, 2009; UNEP, 2011), which seem even more daunting in times of financial crisis and public budget overruns (IEA, 2009).

The sustainability challenges are coupled with and aggravated by the strong path-dependencies and lock-ins we observe in the existing sectors (e.g., Ahman and Nilsson, 2008; IEA, 2011; Safarzynska and van den Bergh, 2010; Unruh, 2000). Established technologies are highly intertwined with user practices and life styles, complementary technologies, business models, value chains, organizational structures, regulations, institutional structures, and even political structures (e.g., Rip and Kemp, 1998). As a consequence, established socio-technical systems undergo incremental rather than radical changes (Dosi, 1982; Frantzeskaki and Loorbach, 2010; Markard and Truffer, 2006), and such incremental changes will not suffice to cope with the prevailing sustainability challenges.

Against this background, the issue of how to promote and govern a transition toward sustainability, i.e., a fundamental transformation towards more sustainable modes of production and consumption, has received increasing attention both in the policy arena (OECD, 2011; UNEP, 2011) and in social-science research (Frantzeskaki and Loorbach, 2010; Grin et al., 2010; Smith et al., 2005). In theoretical terms, four frameworks so far have achieved quite some prominence in transition studies. These include transition management (Kern and Smith, 2008; Loorbach, 2010; Rotmans et al., 2001), strategic niche management (Kemp et al., 1998; Raven and Geels, 2010; Smith, 2007), the multi-level perspective on socio-technical transitions (Geels, 2002; Geels and Schot, 2007b; Smith et al., 2010), and technological innovation systems (Bergek et al., 2008; Jacobsson and Johnson, 2000; Hekkert et al., 2007). We will discuss these frameworks and their origins in some more detail below.

It is important to note though that there is a broad range of other relevant theoretical approaches, which have been used to study and explain the particularities of transitions. These include general theories, such as evolutionary economic theory (Nelson and Winter, 1982; van den Bergh and Gowdy, 2000) and actor network theory (Callon, 1986; Law and Hassard, 1999), as well as approaches with a more specific focus on technology, such as social construction of technology (Bijker et al., 1987), constructive

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technology assessment (Rip et al., 1995), long waves (Freeman and Louca, 2001; Perez, 2002), technology future studies (Porter et al., 2004; Truffer et al., 2008), reflexive governance (Kuhlmann et al., 2010; Voß et al., 2006), and sociology of expectations (van Lente and Rip, 1998; Borup et al., 2006). There are also related strands of research on "green issues," such as the literature on sustainability sciences (Kates et al., 2001), ecological modernization (Mol and Sonnenfeld, 2000), green management and corporate social responsibility (Rugman and Verbeke, 1998; Porter and Kramer, 2006), industrial ecology (Ehrenfeld, 2000; Socolow et al., 1996), and eco-innovation (Kemp, 2010; Rennings, 2000). We will confine our subsequent review and analysis to the four aforementioned frameworks, because they adopt systemic views of far-reaching transformation processes of socio-technical systems. This selection represents, by no means, an exhaustive coverage of relevant viewpoints on sustainability transition studies.

Today, we observe a growing international community of scholars in the field of transition studies. The field has become more and more salient through a strongly increasing number of publications. Special issues have covered topics such as long-term policy design and transition management (Voß et al., 2009), sustainability transitions in Asia (Berkhout et al., 2009, 2010), infrastructures and transitions (Loorbach et al., 2010), the transformation of the energy system (Schreuer et al., 2010), and actor strategies (Farla et al., 2012).[1]

Moreover, several institutional structures have been developed quite recently that can be expected to increase the visibility of transition studies even more: the first two international conferences on Sustainability Transitions in 2009 and 2011 have brought together more than 100 and 200 scholars, respectively. Three follow-up conferences are planned until 2014. Furthermore, a new journal titled "Environmental Innovation and Societal Transitions" was recently launched (van den Bergh et al., 2011), and the Sustainable Transitions Research Network (STRN) has been established to connect scholars and to stimulate exchange (www.transitionsnetwork.org). This institutionalization of the field signals an important new phase for the transition studies community: it creates new opportunities for more intense collaboration, contributes to the legitimization of transitions research, and might also facilitate interaction with policymakers.

At the same time, this recent growth justifies a critical reflection of sustainability transitions research in empirical and conceptual terms. Smith et al. (2010) have already made an important step in this direction, with a focus on the multi-level perspective as one of the established frameworks in transitions research. With our contribution, we want to reach out beyond existing approaches as we identify scholarly communities, such as economic geography, management studies, sociology, modeling, and political sciences, which have dealt with related issues but remained somehow disconnected from the main body of the sustainability transitions literature until now. Our ambition is to stimulate the uptake of novel concepts and lines of thought established elsewhere in order to both enrich and challenge the existing theoretical basis of sustainability transitions research. We also would like to facilitate a dialogue of established scholarly communities, and to raise interest for sustainability transitions in communities that have not yet addressed these topics and the underlying challenges in much detail. We believe such an exploration is useful, as it will contribute to broadening the field of transition studies and help it to remain reflexive and critical. As such, the second aim of this special section is to enrich the agenda for future research on sustainability transitions.

This introductory paper aims to prepare ground for the papers in the special section. Its primary goal is to identify major research fields and dynamics in sustainability transitions. To this end, we will review the origins of sustainability transition studies in the literature and conduct a quantitative literature survey. The second aim of this introduction is to introduce the special section papers and to show how they relate to each other and to a broader research agenda in the field of sustainability transitions.

2. Sustainability transitions: review of the literature

2.1. What are sustainability transitions?

Sectors like energy supply, water supply, or transportation can be conceptualized as *socio-technical systems*.[2] Such systems consists of (networks of) actors (individuals, firms, and other organizations, collective actors) and institutions (societal and technical norms, regulations, standards of good practice), as well as material artifacts and knowledge (Geels, 2004; Markard, 2011; Weber, 2003). The different elements of the system interact, and together they provide specific services for society. The systems concept highlights the fact that a broad variety of elements are tightly interrelated and dependent on each other (cf. Finger et al., 2005; Hughes, 1987). This has crucial implications for the dynamics the systems exhibit, and especially for system transformation (Markard, 2011).

A *socio-technical transition* is a set of processes that lead to a fundamental shift in socio-technical systems (e.g., Geels and Schot, 2010; Kemp, 1994). A transition involves far-reaching changes along different dimensions: technological, material, organizational, institutional, political, economic, and socio-cultural. Transitions involve a broad range of actors and typically unfold over considerable time-spans (e.g., 50 years and more). In the course of such a transition, new products, services, business models, and organizations emerge, partly complementing and partly substituting for existing ones. Technological and institutional structures change fundamentally, as well as the perceptions of consumers regarding what constitutes a particular service (or technology). Historical examples of socio-technical transitions include the introduction of pipe-based water supply (Geels, 2005a), the shift from cesspools to sewer systems (Geels, 2006a), and the shift from carriages to automobiles (Geels, 2005b).

Socio-technical transitions differ from technological transitions in that they include changes in user practices and institutional (e.g., regulatory and cultural) structures, in addition to the technological dimension. In addition, socio-technical transitions typically encompass a series of complementary technological and non-technical innovations (e.g., complementary infrastructures). The emergence of a transportation system with the automobile technology at its core, for example, required a complementary development of road infrastructure, fuel supply systems, traffic rules, services (e.g., maintenance, insurance), user practices, etc. In fact, socio-technical transitions do not just change the very structures of existing systems, such as transportation, but they also affect related societal domains, such as living, housing and working, production and trade, and planning and policymaking.

Sustainability transitions are long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption. One particularity of sustainability transitions is that guidance and governance often play a particular role (Smith et al., 2005). There might be long-term goals, for example, that inform the direction of the transition. In this case, a

[1] For an encompassing list of special issues, see Table 2.

[2] See also the related notion of large technical systems in this regard (e.g. Hughes, 1987; Joerges, 1998).

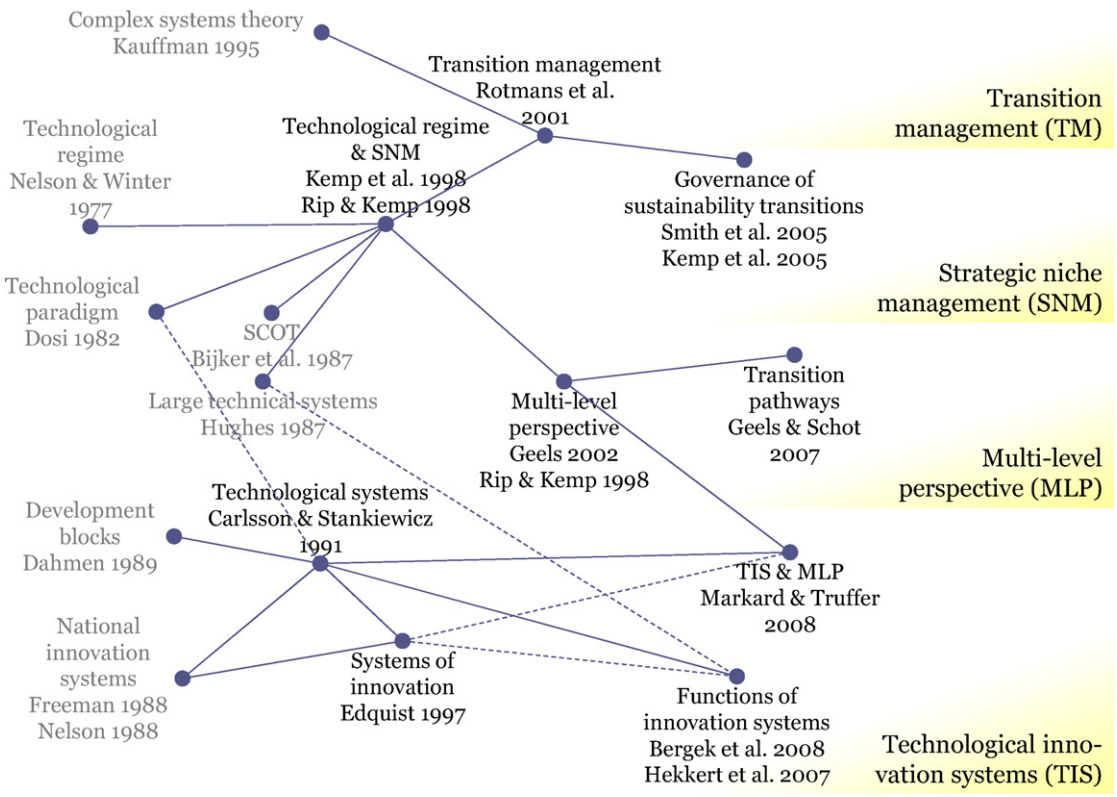

Fig. 1. Map of key contributions and core research strands in the field of sustainability transition studies.

transition is purposeful and intended, and a broad range of actors is expected to work together in a coordinated way.[3] In a guided transition, political actors, as well as regulatory and institutional support, can be expected to play a major role. Finally, we have to note that what is considered sustainable can be subject to interpretation and might change over time (Garud et al., 2010).

2.2. Conceptual approaches and their origins

Socio-technical transitions, system innovations, and the emergence of sustainable technologies have received increasing attention in the social-sciences over the past 10–15 years, and a number of conceptual frameworks have been developed for the study of these processes (Smith et al., 2010; Markard and Truffer, 2008b; Grin et al., 2010). In this section, we will discuss four approaches that are considered to be central for the theoretical framing of sustainability transitions. We will track major conceptual developments in the field[4] and identify their origins, theoretical linkages, and emerging strands of research. Our aim is to provide an introduction and general overview of the field, but not to provide an exhaustive discussion of all the richness, conceptual details, strengths and weaknesses, or similarities and differences that exist.

One of the most central concepts of transitions research is the socio-technical regime ("technological regime" in earlier work). It combines ideas and key concepts from evolutionary economics (Dosi, 1982; Nelson and Winter, 1977) with insights from the history and sociology of technology (Bijker et al., 1987; Hughes, 1987), highlighting that scientific knowledge, engineering practices, and process technologies are socially embedded—i.e., they are seamlessly intertwined with the expectations and skills of technology users, with institutional structures, and with broader infrastructures (Kemp et al., 1998). The core idea behind the regime is that it imposes a logic and direction for incremental socio-technical change along established pathways of development.

Despite the temporal and structural persistence of socio-technical regimes, the primary interest of scholars such as Rip, Kemp, and Schot was in regime shifts (transitions) and the factors that lead to the destabilization of existing regimes and the emergence of new regimes. Much of the early work in the field was already concerned with the question of how to deliberately reorient regimes and manage transitions toward sustainability (Kemp, 1994; Kemp et al., 1998; Schot, 1992; Schot et al., 1994). Against this background, transition studies also have developed strong linkages with work in the field of constructive technology assessment (Schot and Rip, 1996; Schot, 1999).

The niche is another key concept in transition studies, due to its pivotal role in the emergence of novel technologies. Niches have been conceptualized as protected spaces, i.e., specific markets or application domains, in which radical innovations can develop without being subject to the selection pressure of the prevailing regime (Kemp et al., 1998). Through processes of social learning across multiple experiments, articulating promising expectations and heterogeneous networking, niche innovations gain momentum and can eventually compete with established technologies (Geels and Raven, 2006). Later studies have nuanced this largely bottom-up perspective by investigating how niches grow, stabilize, or decline in interaction with the dynamics of prevailing regimes (Raven, 2006) and followed niche developments over

[3] This does not imply that the transition goals are not contested: Different actors pursue different interests, e.g. opposing such a transition or advocating a different direction (Meadowcroft, 2011).

[4] The publications we depicted as nodes in Fig. 1 are key conceptual contributions corresponding to those listed in Table 1. See Section 2.3 for further details.

Table 1
Most-cited publications in the field of sustainability transitions (own assessment).

No	Title	Author(s), year, and journal	Citations (through 2011)
1	Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management	Kemp, R., Schot, J., Hoogma, R., 1998 Technology Analysis & Strategic Management	281
2	Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study	Geels, F.W., 2002 Research Policy	258
3	On the nature, function and composition of technological systems	Carlsson, B., Stankiewicz, R., 1991 Evolutionary Economics	237
4	Understanding carbon lock-in	Unruh, G.C., 2000 Energy Policy	214
5	More evolution than revolution – transition management in public policy	Rotmans, J., Kemp, R., van Asselt, M., 2001 Foresight	191
6	From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory	Geels, F.W., 2004 Research Policy	161
7	The governance of sustainable socio-technical transitions	Smith, A., Stirling, A., Berkhout, F., 2005 Research Policy	151
8	Typology of sociotechnical transition pathways	Geels, F.W., Schot, J., 2007 Research Policy	143
9	The diffusion of renewable energy technology: an analytical framework and key issues for research (*manual insertion*)	Jacobsson, S., Johnson, A., 2000 Energy Policy	133
10	Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship (*manual insertion*)	Garud, R., Karnoe, P., 2003 Research Policy	132
11	The past and future of constructive technology assessment	Schot, J., Rip, A., 1997 Technological Forecasting and Social Change	122
12	Functions of innovation systems: a new approach for analysing technological change	Hekkert, M., Suurs, R.A.A., Negro, S., Kuhlmann, S., Smits, R., 2007 Technological Forecasting and Social Change	110
13	Transforming the energy sector: the evolution of technological systems in renewable energy technology	Jacobsson, S., Bergek, A., 2004 Industrial and Corporate Change	99
14	Strategies for shifting technological systems: the case of the automobile system	Schot, J., Hoogma, R., Elzen, B., 1994 Futures	87
15	The politics and policy of energy system transformation – explaining the German diffusion of renewable energy technology (*manual insertion*)	Jacobsson, S., Lauber, V., 2006 Energy Policy	77
16	Analyzing the functional dynamics of technological innovation systems: a scheme of analysis	Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008 Research Policy	61
17	Technological innovation systems and the multi-level perspective: towards an integrated framework	Markard, J., Truffer, B., 2008 Research Policy	59
18	CAUTION! Transitions ahead: politics, practice and sustainable transition management	Shove, E., Walker, G., 2007 Environment and Planning A	53
19	Processes and patterns in transitions and system innovations: refining the co-evolutionary multi-level perspective	Geels, F.W., 2005 Technological Forecasting and Social Change	52
20	The transition in Dutch water management	van Der Brugge, R., Rotmans, J., Loorbach, D., 2005 Regional Environmental Change	51

longer periods over time (Geels and Raven, 2006; Schot and Geels, 2008; Smith, 2007). *Strategic niche management* (*SNM*), i.e., the deliberate creation and support of such niches, was suggested early on as a way forward to trigger off regime shifts (Hoogma et al., 2002; Kemp et al., 1998).

In subsequent years, further strands of research developed on the basis of these foundational concepts and ideas of transition studies. One was the study of long-term historical transitions in a broad range of empirical domains, which was particularly advanced by the work of Geels (Geels, 2002, 2005a,b, 2006a,b; van den Ende and Kemp, 1999). These studies were conceptually based on the *multi-level perspective*, which built, among others, on the work of Kemp, Rip, and Schot (Kemp et al., 2001; Rip and Kemp, 1998) and explained technological transitions by the interplay of dynamics at three different levels: niches, regimes, and landscape (Geels, 2002). Landscape factors might put pressure on existing regimes and open windows of opportunities for niches to break through and contribute to fundamental changes, or shifts, in socio-technical regimes. Depending on timing and qualitatively different niche-regime-landscape interactions, Geels and Schot (2007b) have elaborated how transitions can evolve following different types of transition pathways.

Another line of research pushed forward the ideas of active interventions and *transition management*. Transition management combines the work on technological transitions with insights from complex systems theory (e.g., Kauffman, 1995) and governance approaches (Rotmans et al., 2001; Smith et al., 2005). Transition management scholars have proposed and applied an instrumental, practice-oriented model for influencing ongoing transitions into more sustainable directions (Kemp and Loorbach, 2006; Loorbach, 2010). Guiding principles for transition management are derived from conceptualizing existing sectors as complex, adaptive societal systems and understanding management as a reflexive and evolutionary governance process (Nill and Kemp, 2009; Voß et al.,

2009). A prescriptive strategy for transition management was further developed through action research and participation in various regional and national policy projects, in which transition management has been made operational as a combination of problem structuring and envisioning in multi-stakeholder arenas, developing new coalitions, implementing agendas in experiments, and evaluating and monitoring the process (Loorbach and Rotmans, 2010). Given recent drawbacks in actual policy contexts (Kern and Smith, 2008; Kern and Howlett, 2009), the role of transition management and of related evolutionary approaches (Nill and Kemp, 2009) in national policy-making processes remains to be seen. Recently, increasing attention for transition management has been observed on regional and local levels, such as cities (Bulkeley et al., 2011).

Research on *technological innovation systems* (TIS) has emerged as a fourth major line of inquiry in the field of transition studies. It is concerned with the emergence of novel technologies and the institutional and organizational changes that have to go hand in hand with technology development. The TIS concept can be traced back to the seminal paper of Carlsson and Stankiewicz (1991), which highlighted the systemic interplay of firms and other actors under a particular institutional infrastructure as the essential driver behind the generation, diffusion, and utilization of technological innovation.[5] The authors relate their concept primarily to Dahmén's work on development blocks, which are constantly evolving systems centered on a generic technology (Dahmen, 1988; Enflo et al., 2008). There are also linkages to the concept of national innovation systems (Freeman, 1988; Nelson, 1988), to sectoral innovation systems (Malerba, 2002; Oltra and Maider, 2009), and the innovation systems approach formulated by scholars at Lund University (e.g., Edquist, 1997). Since these early days, the framework saw several conceptual refinements (Carlsson et al., 2002), one of the most influential being the identification of key processes, so-called functions, which need to run smoothly for the system to perform well (Bergek et al., 2008; Hekkert et al., 2007). Recent TIS studies have also developed a much stronger focus on specific technologies (Hekkert et al., 2007), which is different from prior studies with rather generic technologies at the core of the analysis. This shift in focus is accompanied with greater attention to radical (and often more sustainable) innovations in an early stage of development with a potential to challenge established socio-technical systems. In other words, the analytical interest has shifted from technological innovation contributing to the economic growth of countries to new technologies as nuclei for fundamental socio-technical transitions.

From their beginning, many analyses of technological innovation systems were intended to inform policy making, which is why the identification of drivers and barriers to innovation is a typical task performed in TIS studies (Bergek and Jacobsson, 2003; Jacobsson and Bergek, 2004; Jacobsson and Lauber, 2006; Negro and Hekkert, 2008). In fact, one of the major contributions of the innovation systems perspective is that it has left behind the narrow concept of market failures and replaced it with a broader set of system failures, including poorly working networks, institutional failures, infrastructure failures, etc. (Bergek et al., 2008; Jacobsson and Johnson, 2000; Klein Woolthuis et al., 2005; Kuhlmann et al., 2010; Weber and Rohracher, 2012). Combined with the aforementioned shift toward technology-specific innovation systems, this has paved the way for suggesting technology-specific policies on the basis of TIS analyses (Jacobsson and Bergek, 2011; Sandén and Azar, 2005). By now, TIS studies have established a strong foothold in research on sustainability transitions. This requires a thoughtful reflection (and adaptation) of the existing concepts, as well as an explication of how the different frameworks relate to each other (e.g., Markard and Truffer, 2008b; Weber and Rohracher, 2012).

Our review shows the growing interest in sustainability transitions and the progress made in this field. Researchers also have addressed an increasingly broad range of topics, thereby applying different perspectives. At the same time, many issues are still unresolved, and scholars are just beginning to challenge existing frameworks or to compare the insights generated by different frameworks. Moreover, there is still much to learn from theories and approaches established in other scientific disciplines, including, for example, sociology, management studies, economic geography, and political sciences. We will return to this in the final section of this paper. Next is a quantitative literature review.

2.3. Quantitative survey of papers

2.3.1. Method

The identification and delineation of an emerging strand of scientific inquiry by searching literature databases by keywords is challenging, because results depend crucially on the selection criteria used. To counter this, we provide full transparency about the choices we made, including the following issues: How to define the core of the field and the starting point for the analysis, on which elements to focus (e.g., scholars, research groups, or publications), how to implement the search, and which sources to use.

The analysis is based on the assumption that a scientific field is centered on a particular cognitive problem with some level of consensus and shared knowledge (Cole, 1983). We apply the following definition:

> Research on "sustainability transitions" comprises all scientific articles that are concerned with the analysis of the institutional, organizational, technical, social, and political aspects of far-reaching changes in existing socio-technical systems (e.g., transportation and energy supply), which are related to more sustainable or environmentally friendly modes of production and consumption. Sustainability transitions research includes empirical studies, as well as conceptual and methodological contributions.

In the subsequent review, we limited the articles to *peer-reviewed journal articles* that are reported in the Scopus database (www.scopus.com). Scopus covers quite a broad range of social science journals, which we expect to be of particular importance for sustainability transition studies.[6] We realize that, with the decision to exclude books and book chapters, we miss out on some of the original contributions in the field (e.g., Hoogma et al., 2002; Rip and Kemp, 1998; Voß et al., 2006).

The starting point of the analysis is a set of 20 papers, which we assume to be core publications in the field (cf. Table 1). The list is based on a rather general Scopus search of all articles referring to the four frameworks (cf. Section 2.2), from which we took the most cited ones.[7] Several sensitivity checks were carried out that did not

[5] Note that the term "technological system" was used in much of the earlier work and that TIS was only introduced recently (Bergek et al., 2008; Markard and Truffer, 2008b).

[6] As of 2011, Scopus covered a total of 18,500 peer-reviewed journals compared to the Web of Science, with about 12,000. For a comparison, see also Gavel and Iselid (2008).

[7] The search string was Title-Abs-Key ("strategic niche management" OR "technological innovation system" OR "technological system" OR "multi level perspective" OR "transition management"). As of February 14, 2012, this resulted in a list of 1950 documents. Based on our expert knowledge and the information provided in the titles and abstracts, we deselected 28 papers from the top 50 that use the keywords in a different context. Furthermore, three papers (Garud and Karnoe, 2003; Jacobsson

Table 2
Special issues in the field through 2011.

Title	Editor(s)	Year and journal
Environmental innovation and societal transitions: introduction and overview	Van den Berg, J., Truffer, B., Kallis, G.	2011, Environmental Innovation and Societal Transitions
Innovation studies and sustainability transitions: the allure of the multi-level perspective and its challenges	Smith, A., Voß, J.P., Grin, J.	2010, Research Policy
Sustainability experiments in Asia: innovations shaping alternative development pathways?	Berkhout, F., Verbong, G., Wieczorek, A.J., Raven, R., Lebel, L., Bai, X.	2010, Environmental Science & Policy
Introduction to the special section: infrastructures and transitions	Loorbach, D., Frantzeskaki, N., & Thissen, W.	2010, Technological Forecasting and Social Change
Transforming the energy system: the role of institutions, interests and ideas	Schreuer, A., Rohracher, H., Späth, P.	2010, Technology Analysis & Strategic Management
Designing long-term policy: rethinking transition management	Voß, J.-P., Smith, A., Grin, J.	2009, Policy Sciences
Sustainability transitions in developing Asia: are alternative development pathways likely?	Berkhout, F., Angel, D., Wieczorek, A.J.	2009, Technological Forecasting and Social Change
The dynamics of sustainable innovation journeys	Geels, F.W., Hekkert, M.P., Jacobsson, S.	2008, Technology Analysis & Strategic Management
Transitions to sustainable energy systems	Haas, R., Watson, J., & Eichhammer, W.	2008, Energy Policy
Governance for sustainable development in the face of ambivalence, uncertainty and distributed power	Newig, J., Voß, J. P., & Monstadt, J.	2007, Journal of Environmental Policy and Planning
Transitions towards sustainability through system innovation	Elzen, B., & Wieczorek, A.	2005, Technological Forecasting and Social Change

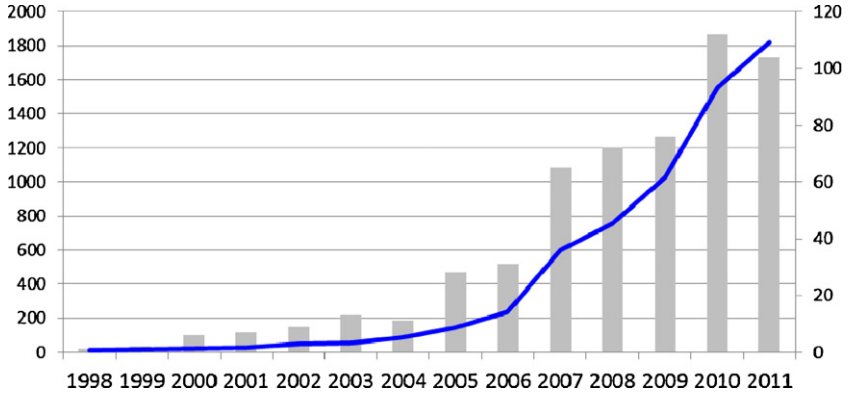

Fig. 2. Number of citations (line, left scale) and journal articles (columns, right scale) per year.

show any major effects with regard to the essence of our results as reported in the following section.

In a next step, we searched for all the papers that cited one or more of the 20 core papers. The resulting list of more than 1400 articles was filtered with a set of criteria (keywords) to identify publications (about 480) with a focus on sustainability transitions.[8] The suitability of these keywords was tested with a subsample of all manually selected papers on sustainability transitions published in Research Policy to date.

As a complementary approach to identify papers in the field, we took all 102 articles that appeared in ten special issues or special sections on sustainability transitions through 2011 (cf. Table 2). Again, the selection of these special issues was based on our expert knowledge. Through this step, we added another 50 articles. In a final step, we crosschecked the results with our initial list of 20 papers and, from this list, we added nine that had not shown up in the search. This led to the final sample of 540 articles.[9]

2.3.2. Results

Ever since the first papers were published at the end of the 1990s, the number of publications on sustainability transition has grown considerably, to a current total of more than 500, with a remarkable upturn in yearly output since 2005 (Fig. 2). In 2010 and

and Johnson, 2000; Jacobsson and Lauber, 2006) that made original contributions to the field but did not show up in the automatic search were added manually.

[8] TITLE-ABS-KEY ((sustainab* OR environmental* OR bio* OR renewable OR socio-technical) AND (transition OR transform* OR "system innovation" OR "radical innovation" OR shift OR change)). The first part of this string is intended to refer to sustainability-related characteristics, while the second part should refer to the fundamental nature of the change.

[9] The search was run on February 14, 2012, but we chose 2011 as a cut-off date; i.e., articles and citations from 2012 were not included.

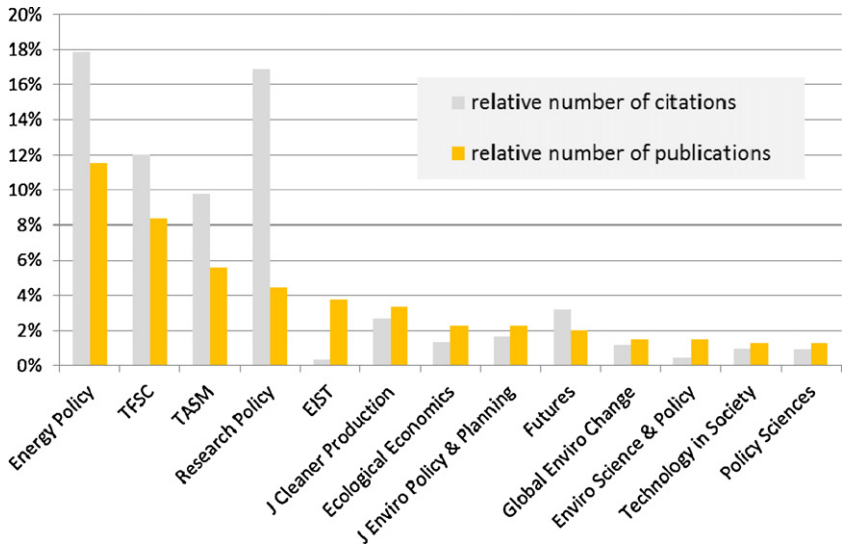

Fig. 3. Most important journals in the field.[11].

2011, more than 100 articles appeared in the field. Special issues dealing with the topic have increased as well, regularly covering 20–30% of the papers. As of the end of 2011, the articles had received more than 6000 citations. In fact, over the last five years, the yearly citations have increased steeply, from 235 (2006) to 1815 (2011), which underlines the high dynamic of the field.

Four journals, including Energy Policy, Technological Forecasting and Social Change (TFSC), Technology Analysis and Strategic Management (TASM), and Research Policy, have emerged as leading outlets, followed by Environmental Innovation and Societal Change (EIST) and the Journal of Cleaner Production (Fig. 3). The top four journals account for 30% of the articles, with an above-average citation rate, as they receive 57% of the citations in the field. Articles in Research Policy have received, by far, the most citations (on average, 45 cites per article), followed by TASM (21), Futures (19), Energy Policy (18), and TFSC (17). The key journals also provide a first indication of the broader scholarly communities in which transition studies are currently embedded or to which they are related. These include innovation studies, technology assessment and foresight, environmental policy studies, sociology of technology and, to a lesser extent, ecological economics.

If we change the perspective by asking how much attention articles on sustainability transition receive in comparison to other articles in the same journal, we find that the emerging field has already left some marks. Of the four top journals, Research Policy is the one in which the new field is most prominent. Since the first article on the topic appeared in 2002, sustainability transition papers regularly rank among the top ten cited papers of each year. From 2002 to 2010, four articles are on the first rank[10] (Geels, 2004; Smith et al., 2005; Geels and Schot, 2007b; Bergek et al., 2008), another four on the second (Geels, 2002, 2010; Markard and Truffer, 2008b; Nill and Kemp, 2009), and one on the third (Smith et al., 2010). In TASM, TFSC, and Energy Policy, sustainability transition studies are also among the top ten cited papers, although less often than in Research Policy.

We also analyzed which empirical topics and sectors have received attention so far. It turns out that the sustainability challenges in the energy sector and the large variety of new technologies that have emerged here in recent years (e.g., renewable energy sources such as solar, wind, and biomass) represent by far the most dominant topic (36% of all papers), followed by studies on transportation (8%), water and sanitation (7%), and food (3%). In geographical terms, many studies in the field cover developments in the Netherlands and in the UK (9% of the papers and 8%, respectively), followed by the US (6%) and Germany (5%). As such, we clearly see a kind of "European bias" in the current state of the field, which is to be expected, given the provenience of the researchers. Another particularity that emerges is that most studies apply a national focus, while global, regional, and urban analyses are much less frequent (Fig. 4). With the increasing geographical expansion of transition studies, this is certainly another issue to address in the future development of the field.

In summary, the literature review shows that, despite its high growth in recent years, research on sustainability transition is still a field that is narrow in some regards: it precipitates in selected innovation and policy journals, but is less visible in the established journals on management studies, economics, economic geography, and political science. The research has focused primarily on energy issues but has paid less attention to water, food, and other domains. Furthermore, in geographical terms, further expansion seems to

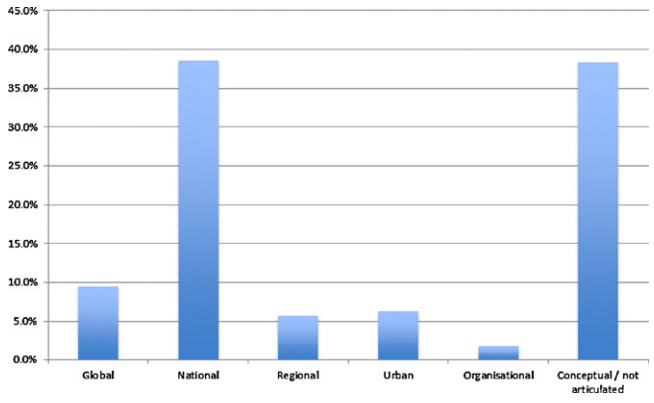

Fig. 4. Analytical focus of the articles in our sample (exclusive categories).

[10] Note that Fig. 3 only covers journals with seven or more publications on sustainability transition. In total, 49% of the publications in the field are depicted.

[11] For each year, we reviewed the top ten cited articles and listed those related to sustainability transition. Relative citation rank indicates how the specific article compares with the other top ten articles in the corresponding year.

be worthwhile. Sustainability transition studies relating to North America, Japan, China, and India, for example, are still very much underrepresented. Against this background, our effort to open up the field and connect to existing strands of research in other disciplines seems to be well justified.

3. Potential lines of future research and contribution of the papers in this special issue

3.1. Major lines of future inquiry in transition studies

This section discusses four broader lines of potential future research on sustainability transition studies, which we distilled from the literature review above, including several special issues, e.g., Smith et al. (2010) and van den Bergh et al. (2011), and the manifest of the STRN network (STRN, 2010).

First, there is a definite need to elaborate and specify the conceptual frameworks and methodological underpinnings for understanding both historical and ongoing transitions. This includes challenging the existing conceptual approaches in terms of where and how they can be applied, what their limitations are, upon what ontological assumptions they are based, etc. There has been some recent debate on the merits and shortcomings of the multi-level perspective (Genus and Coles, 2008; Geels, 2011; Markard and Truffer, 2008b), which not only helps to make the framework more precise, but may also contribute to a more rigorous application in empirical studies. Closely related to challenging and improving the existing concepts is exploring complementarities among the different frameworks (e.g., Markard and Truffer, 2008b) and complementarities with complex modeling (e.g., Faber and Frenken, 2009; Zeppini and van Den Bergh, 2011) and governance-oriented approaches (Voß et al., 2009). One core issue is whether an overarching scheme should be developed, a grand theory of transition in which the different approaches appear as more specific subsets, or whether the existing frameworks should be seen as largely complementary if not incompatible (Geels, 2010; Stirling, 2011). Furthermore, we think that there is much to learn from established concepts and frameworks in other fields, which can be used in a complementary way and to support competing explanations. Examples include neo-institutional theory, actor-network theory, resource- and capability-based approaches, complex systems theory, institutional and relational economic geography, political and policy sciences and many more. Advances in the theoretical frameworks will have implications for the methodological styles that will be prevalent in transition research as well—i.e., how different kinds of quantitative and qualitative datasets could be related to each other, what types of explanation are accepted in different conceptual frameworks, and the role that should be attributed to formalized modeling compared to intensive case study approaches.

Second, building on the very early uptake of transition-based policy concepts, such as strategic niche management or transition management, there is a pressing need to improve the understanding of the politics and policies of sustainability transitions. At a more conceptual level, issues of power and politics had originally been somewhat neglected (Lovell, 2007; Meadowcroft, 2009; Scrase and Smith, 2009; Shove and Walker, 2007). Only recently have these issues been taken up; meanwhile, they represent quite an important line of research activity in transition research (Voß et al., 2009; Avelino, 2011). Key questions pertain to issues such as, where (with whom) does power reside in transition processes? How are power and agencies performed in transition processes? Whose voices and narratives remain unheard? Which transitions are legitimate and how can this be assessed? At a more instrumental level, further research is needed to better understand the long-term impacts of specific policies on sustainable transitions; the balance between technology-neutral and technology-specific policies (Azar and Sandén, 2010) and between protection versus open innovation (Hommels et al., 2007; Geels and Schot, 2007a; Smith and Raven, 2012); the evaluation of ongoing attempts of SNM and TM (Kern and Smith, 2008); and the development and implementation of new policy frameworks to render transition initiatives pursued at local, regional, national, and international levels more effective.

A third realm where further research seems to be very promising relates to the understanding of the agency of different actor groups in the context of transition processes (e.g., Garud and Karnoe, 2003; Raven et al., 2011). Strategies of firms and other actors or the role of strategic alliances within industries did not receive much attention in the existing body of literature on socio-technical transitions (Farla et al., 2012; Markard and Truffer, 2008a). Although green innovation is one of the core drivers for fundamental shifts in industry structures, transition research has mostly focused on meso-level contexts, such as innovation systems and socio-technical regimes. Therefore, the field might benefit from more in-depth studies on how system and regime structures are created and changed through the strategic interplay of different types of actors (Musiolik and Markard, 2011). This might create linkages to existing approaches in management studies (e.g., Musiolik et al., 2012) and even result in conclusions for innovation management at the organizational level. Besides firms, consumer-related processes and the role of everyday practices in consumptive acts also warrant further scrutiny (Shove and Walker, 2007, 2010). The same holds for the role of civil society and cultural movements in transition processes (Penna and Geels, 2012; Seyfang and Smith, 2007).

Finally, there has been quite some interest over the past few years in conceptualizing more explicitly the geographical dimension of historical and emerging transition processes (Coenen and Truffer, 2012; Cooke, 2010). This has implications on a conceptual level, namely addressing the differentiation of regime, niche, and innovation system structures in specific regions of the world. It also has strong empirical implications in that transition processes happening in non-OECD countries have so far not received enough attention in the literature, and their inclusion might necessitate additional conceptual work. Finally, the geographical perspective also supports a stronger normative orientation in transition processes, as it forces analysts to ask who is profiting and who is bearing the costs of specific transformation trajectories (Lawhon and Murphy, in press). Addressing these issues more explicitly would ultimately enable the analysis of transition management in a truly "global" perspective, which is what many of the global environmental change problems, such as climate change or biodiversity management, ultimately will require (Truffer and Coenen, 2012).

The papers in this special section can be viewed against the background of these different lines of research. All papers contribute to improving the conceptual frameworks by making connections between different strands of literature. In the following section, we will introduce the papers and discuss the lines of research to which they contribute.

3.2. Papers in this special section

3.2.1. Spatial contexts

Thus far, the spatial and institutional contexts in which socio-technical transitions unfold have not received much attention in the literature. Many studies on technological innovation systems, for example, depart from national system boundaries without making explicit why these boundaries were chosen and how they affect the findings and the generalizability of the results (e.g., Jacobsson and Lauber, 2006; Negro et al., 2007). Analyses based on the multi-level perspective have equally failed to analyze the spatial particularities of transitions in a more systematic way (Smith et al., 2010). What is

the relation of local networks and the global development and diffusion of new socio-technical configurations? To what extent are innovative technologies adapted to specific regional and institutional contexts? How can the multi-scalar dimension of transitions be integrated into the conceptual frameworks we use in transition studies?

The paper by **Lars Coenen, Paul Benneworth, and Bernhard Truffer** introduces a "*geography of transitions*" perspective to account for a more explicit and systematic analysis of the spatial and institutional contexts of transition processes. The authors argue that both the technological innovation systems approach and the multi-level perspective lack "territorial sensitivity" in their analysis of technological transitions. The multi-level perspective, for example, tends to suffer from the fact that spatial differences at the regime and landscape levels are not accounted for. Instead, conceptual and territorial levels (to which the authors refer as "scale") are often conflated, in the sense that the niche represents the local scale, the regime the national scale, and the landscape the global scale. Against this background, the authors mobilize the conceptual apparatus from economic and institutional geography to start exploring the potential advantages of taking an explicit geographical focus. They recommend that spatial transition contexts be addressed much more explicitly in future studies. Such a scalar differentiation is expected to lead to a much broader variety of transition pathways, compared to what is acknowledged in the literature today (Geels and Schot, 2007b).

Moreover, in order to improve our understanding of the institutional embedding of transitions, it is suggested that the concepts of comparative institutional advantage and institutional thickness are integrated into existing frameworks and taken up in empirical analyses. Finally, the authors point to the potential value of analyzing the interplay of global networks and local nodes for transition studies. This also entails a better understanding of factors that enable and impede the emergence of transitions; a more nuanced and detailed view of aggregation processes (i.e., how local nodes in transition processes interact with translocal networks); and a new (geographical) perspective that unpacks the spatial boundaries often inherent in transition case studies, thus opening up possibilities for the transnational research necessary in a globalizing world. Coenen et al. (2012) provide a very valuable basis for this emerging strand of transitions research, but they also point out that we are just beginning to understand the geography of transitions. A next step forward is to invite geography scholars to the research field of sustainability transitions (Truffer and Coenen, 2012).

3.2.2. Ontological inroads to account for actor strategies

Another challenge of the emerging field is that sustainability is a multidimensional concept and subject to ongoing definition and debate. As one consequence, there are multiple theoretical grounds on which sustainability policy, strategy and research might rest. **Raghu Garud and Joel Gehman** compare how the issue of sustainability journeys can be conceptualized in the light of three different perspectives, showing how different a priori assumptions about what is involved in the journey to sustainability can result in surprisingly different conclusions. Instead of considering agency as path-dependent and selection environments as objective conditions, the relational perspective emphasizes the many ways in which actors are likely to shape the (selection) environment in which they are operating. For instance, policymakers are not regarded as independent and external selectors, but as an integral part of the overall journey to sustainability. The durational perspective goes a step further by highlighting the inter-temporal challenges involved in any journey that attempts to reconcile the "needs of the present" with the "needs of the future." From this point of view, sustainability journeys are not to be regarded as pre-definable regime shifts, but as an ongoing process that constantly is "in exchange" with past experiences and potential futures. As a result, the problem of sustainability may require that we "go back to the future." For transition studies, such a perspective certainly represents very novel terrain for research, with many open issues still to be explored. The authors illustrate each of the perspectives with anecdotal evidence from the historic and still ongoing struggle of electric vehicles to become a sustainable alternative in the transport sector.

The paper by Garud and Gehman also establishes a valuable link between transition studies and management studies. The authors repeatedly point to the role of different firms in transition processes and connect insights from organizational studies with the particularities of sustainability journeys. Given the three perspectives, firms can be conceived of as entities adapting to fundamental changes in their industry (evolutionary), drawing on their networks to influence ongoing regime shifts actively (relational), or constantly re-framing their identities and capabilities (durational). The roles of the different actors in transitions and the underlying conceptualization of agency is certainly one of the crucial topics to be explored in our field, and further input from organizational and sociology scholars is very welcome here.

3.2.3. Flat ontologies for analyzing transitions

The concepts of niche, regime, and landscape have become important tools for transition analysis and governance recommendations. The associated multi-level perspective has been used as a productive framework to describe and analyze a substantial number of historical transitions. A key element of this framework is that it organizes socio-technical processes in a hierarchal way.

The paper by **Ulrik Jørgensen** contributes by suggesting a flat approach to studying sustainability transitions. The author reviews the multi-level perspective, criticisms it has received, and adaptations that have been made to it, and he addresses three issues that require further attention. The first one is the need for recognizing the importance of actor conflicts as important conditions for transitions. Although conflicts are not completely ignored in previous transition analyses, there is also emphasis on alignment and convergence of, for example, future visions and expectations. Jørgensen asks whether we should take conflicts and multiple ways of viewing socio-technical systems as a starting point for change rather than alignment and convergence. The second one states that actors engage at all levels in society through, for example, vision building, institution building, and technological innovation. Actors do not necessarily recognize or act upon a three-level view of the world, made up of niches, regimes, and landscape. This observation, in particular, challenges the landscape concept, which, in the multi-level perspective, is seen as a collection of exogenous factors and processes that cannot be influenced. The last issue concerns the position of transition researchers themselves and the role of their academic theories, models, and advice regarding transition governance processes. How can and should we reflect upon the positions and viewpoints of these rationalized accounts of transition processes that themselves become objects in transition governance processes?

Instead of proposing adaptations to existing hierarchal accounts of transition processes, Jørgensen develops a flat approach inspired by actor-network theory. His "arena of development" approach is built around the notion of arenas: spaces in which socio-material activities are located. Arenas are temporary constructs and their boundaries may expand or shrink, depending on actor performances. Actors are not restricted to a single arena, and arenas can overlap, be coupled, and conflict, leading to social tensions and the process of reconfiguration. The paper is a first attempt to develop such an alternative framework for studying transition processes, and it illustrates the contours of the approach with three short case

studies on renewable energy, city planning, and system complexities in reconfiguring energy markets.

3.2.4. Modeling transitions

Transition research has mostly drawn on historical and current-day case studies and, therefore, applied a qualitative style of empirical analysis. Explicit modeling of core mechanisms of technology evolution has been undertaken repeatedly (Faber and Frenken, 2009), but so far remained mostly disconnected from the core empirical and conceptual developments of transition research.

The paper of **Karolina Safarzynska, Koen Frenken, and Jeroen van den Bergh** takes stock of this situation and proposes a more active engagement, with evolutionary thinking and modeling, in order to inspire transition studies and provide them with more systematic and rigorous tools for conceptual development and empirical inquiry. The authors identify four core mechanisms where transition studies could gain from a more explicit formalization: multi-level mechanisms, multi-phase dynamics, co-evolutionary development, and social learning. Multi-level mechanisms describe emerging properties from the interaction of specific actors and the sedimentation of resulting routines in societal structures and institutions. Multi-phase dynamics relates to the problem of lock-in and timing of transformation pathways. Co-evolutionary development addresses the mutual co-determination of user preferences and strategies of firms that may give rise to specific socio-technical trajectories. On a conceptual level, they distinguish co-evolutionary dynamics from merely cross influences among subsystems, and therefore can illustrate, very specifically, where shortcomings in the current conceptual frameworks may be located. And finally, social learning relates to a dynamic questioning of the core structures on which the specific trajectories build. In each of these fields, they show how existing evolutionary models or modeling approaches can support the analysis of crucial mechanisms in transition processes.

The paper represents a welcome call for a broader set of methodological tools to use in transition studies. This goes along with an increasingly perceived need to develop more rigorous empirical methods and improve the comparability of empirical research across different approaches. Ultimately, this may also help to improve cross-fertilization between transition studies and more quantitatively oriented innovation studies.

3.2.5. Politics and governance of niche processes

The niche is one of the central concepts in sustainability transition research (cf. Section 2.2). Despite this importance, theorizing about niches and niche protection is still at an early stage of development. One of the open issues concerns niche up-scaling, i.e. what happens when niche innovation grows beyond the initially protected space and challenges the existing regime. **Adrian Smith and Rob Raven** address this gap by conceptually exploring the different functions of niche protection for far-reaching transitions. They differentiate shielding, nurturing, and empowering as three types of processes. Shielding refers to the processes that hold at bay certain selection pressures from mainstream selection environments. Nurturing refers to processes such as learning, networking, and expectation formation, which support the development of an innovation. Empowering refers to processes that make niche innovations competitive within unchained selection environments (fit-and-conform) and processes that restructure mainstream selection environments in ways favorable to the niche (stretch-and-transform). The first two functions are part of the typical repertoire of niche analyses, and they exhibit parallels to the processes studied within the technological innovation systems framework. Interestingly, the latter function, empowering, has received far less attention, even though it is of key importance for sustainability transitions: through processes of stretch-and-transform empowering, niche actors actively reconfigure the existing selection environment at the regime level. It is in these battles that the role of agency and conflicting interests becomes most apparent. Smith and Raven suggest that our understanding of these struggles will crucially benefit as we study the narratives advocated by niche actors as well as incumbent players. Through their work, the authors link up with recent work in the fields of institutional theory and network governance (Lawrence et al., 2009; Phillips et al., 2004; Kooiman, 2003).

3.2.6. Transition policy rationales

Sustainability transitions require decisive interventions from state and non-state actors, because prevailing socio-technical systems are characterized by inertia and lock-in (Markard, 2011; Unruh, 2000). However, there is little experience with policies oriented at fundamental, system-wide changes (Voß et al., 2009). While strategic niche management and especially transition management (cf. Section 2.2) are specifically designed to address this need for "game changing" policy interventions, actual policy rationales still rely primarily on advice from neoclassical economics, or from innovation system thinking at best (Sharif, 2006; Jacobsson and Bergek, 2011).

The paper by **Matthias Weber and Harald Rohracher** makes a contribution here, as it suggests extending the existing market and system failure approaches to address the policy needs of sustainability transitions. The authors compare innovation system perspectives and multi-level perspectives with regard to whether they can serve as a basis for formulating transition-oriented policies. It is argued that both frameworks have strengths and weaknesses that can be overcome if combined. The innovation systems perspective has acquired a high degree of legitimacy for policymaking but, so far, it has failed to incorporate the particularities of transformative changes. The multi-level perspective has concentrated on the latter, but it is less compelling in devising transparent rationales for policymaking. Through the combination of the two approaches, Weber and Rohracher develop a framework of system failures that includes four structural and four transformational failures. While the former are already established in the literature (Bergek et al., 2008; Klein Woolthuis et al., 2005), the latter are new and address the challenges of sustainability transitions. Transformational failures include a so-called directionality failure, indicating missing guidance or goal-orientation, a demand articulation failure pointing to insufficiently developed markets, a policy coordination failure that emphasizes the need for coordinated policies in different domains, and a reflexivity failure that occurs when socio-technical systems are inflexible and maladaptive during a transition. It is on these grounds that policies that stimulate and sustain socio-technical transitions can be formulated.

In our view, the contribution of Weber and Rohracher is integrative in two ways. First, it highlights the complementarity of the TIS and MLP perspectives with regard to formulating transition oriented policies, and second, it builds a bridge between transition thinking and more established innovation policy approaches (e.g., Sharif, 2006; OECD, 2005).

To summarize, the papers in this special section cover many of the topics of the research agenda introduced above. Several papers contribute to the development of the conceptual frameworks. The most radical reform is proposed by Jörgensen on developing transition theories departing from the ontological assumption that no hierarchical relationships can be identified. Somewhat more moderately, Garud and Gehman point to the implications that ontological positions have on the conceptualization of agency, and Smith and Raven propose a conceptual refinement of niche maturation processes. Coenen, Benneworth and Truffer show that a spatially decontextualized understanding of the core concepts leads to a very limited understanding of the conditions for successful

transition pathways. Safarzynka, Frenken and van den Bergh suggest modeling as a way toward improving rigor and conceptual coherence in transitions research. Policy and politics of transitions play a prominent role in the paper of Weber and Rohracher who show that transitions thinking can also make substantial contributions to innovation and technology policymaking. Smith and Raven refer to the need to explicitly consider power relationships and conflicts into the analysis of transition processes, a claim that is also supported by Jörgensen and Garud and Gehman. The third realm, actor strategies, is addressed most explicitly by Garud and Gehman but also by Jörgensen and Smith and Raven. Finally, open issues related to the geography of transitions are taken up by the paper of Coenen, Benneworth and Truffer. The present selection of papers therefore represents a good coverage of the core agenda topics in transitions research but is by no means exhaustive, of course.

4. Concluding remarks

Sustainability transition studies constitute a field of research that is of high societal relevance, given the magnitude and pervasiveness of sustainability challenges we are facing today. It has developed quite impressively in recent years, with a steep rise in the number of papers published, special issues on a variety of subtopics, and the emergence of institutional structures, such as the STRN network, supporting the formation of a research community. At the same time, sustainability transition is a field of high complexities, due to the large number and variety of actors and interests involved in transformation processes. We are just beginning to understand the analytical and practical implications of fundamental shifts in established socio-technical systems.

In this special section, we have brought together a series of papers that can help to develop the field further. It is an attempt to build bridges to established strands of research outside the "traditional" core of sustainability transition studies. These include: economic geography, with its focus on the spatial and institutional contexts of innovation; philosophy of science, concerned with the ontological basics of theoretical frameworks; management studies, which pay attention to the role of organizational strategies and capabilities; sociology, which highlights that transition contexts do not exist per se, but are constantly reconstructed by the broad variety of actors involved; modeling, concerned with the development of computational models to simulate transitions; policy studies, which point to the role of power struggles; and policy advice, which has to transform itself to accept a broader range of rationales for intervention.

Building bridges and improving conceptual and methodological approaches is one important issue on the research agenda, but providing further empirical insight is certainly another. We expect to gain valuable insights as scholars extend the geographical reach of transition studies beyond the current focus on European countries, or take onboard sustainability issues in such fields as social security and health care (Broers and Bunders, 2010), which are different from the "classic" clean-tech topics in energy supply and transportation. Moreover, we think transition studies can benefit from greater attention to comparative studies, across different transition processes as well as across different conceptual and methodological approaches. It is especially the latter that can contribute to improving the rigor of sustainability transition studies and the quality of the frameworks applied. Our special section is just another step on this journey.

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