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Abstract

In this paper we argue that insights in the actor level of sustainability transitions are a necessary next step in the study of sustainability transitions. The paper outlines a first step towards a more systematic analysis of actor strategies in sustainability transitions by linking strategies described in the sustainable entrepreneurship literature to the technological innovation systems literature. The focus is thereby on nascent entrepreneurs and entrepreneurial incumbent firms which both play a crucial role in developing and commercializing the technologies needed in a transition to sustainability. Our analysis points to two avenues for further research: the role of legitimacy strategies in sustainability transitions and the role of cooperative versus competitive strategies in sustainability transitions.

Keywords: Technological innovation systems, functions of innovation systems, sustainable entrepreneurship, ecopreneurs.

1. Introduction

There is an increasing awareness in society of the negative environmental and social consequences of economic growth, which has led to a growing body of literature that focuses on sustainability transitions. Sustainability transitions are guided processes through which socio-technical systems shift towards a more sustainable direction. This emerging body of literature departs from evolutionary economic
principles and acknowledges that transitions involve a wide variety of actors as well as technological and institutional changes. Since the first papers in the late 1990s, (e.g., Kemp et al., 1998), several theoretical frameworks have been applied to the study of sustainability transitions which have provided insights for policymakers that seek to manage these processes. The two main approaches are the multi-level perspective on transitions with its related notions of strategic niche management and transition management and the (technological) innovation systems approach (Markard and Truffer, 2008a).

The multi-level perspective (MLP) conceptualizes the outcome of socio-technological transitions as the interplay between three different levels of developments: the niche level, where novelty is created; the regime level, which consists of the structures that represent the current practices and routines; and the landscape level which consists of long term processes of change. Landscapes form the context and the selection environment to developments at the other levels. Landscapes can change over time, although they can generally not be changed by niche or regime actors (Kemp et al., 1998; Rotmans et al. 2001; Geels, 2002). The MLP has inspired a large body of empirical research on historical transitions, has formed the basis for the energy transition programme in The Netherlands (Kern and Howlett, 2009) and, has enriched our understanding with a typology of so-called transition pathways (Geels and Schot, 2007). These pathways provide a more dynamic view of transitions by identifying the typical patterns that take place when niche developments become embedded at the regime level. Thus, the primary focus of the multi-level perspective is on understanding how transitions unfold. The related concepts of strategic niche management and transition management are more policy-oriented and provide guidelines on how to effectively influence transitions in a particular, i.e., a more sustainable, direction.

A second, complementary research stream within the sustainability transitions literature focuses on technological innovation systems (TIS) (Carlsson and Stanckiewicz, 1991; Edquist and Lundvall, 1993). A TIS is defined as “the set of (often connected) actors and institutions that influence the speed and direction of innovation” and the TIS approach seeks to understand the collective aspects of the innovation process. In this literature the level of analysis is thus the innovation system that influences the development and deployment of emergent technologies. When the TIS approach is applied to sustainability transitions researchers often use a more normative approach that is, whether the TIS structure and the processes in the TIS are conducive to the further development and deployment of a particular technology, which can potentially contribute to a sustainability transition.

The TIS approach conceptualizes a transition process as a build up process of different technological innovation systems. In recent additions to the TIS literature, the so-called functions of innovation systems
approach focuses not only on the structure of a particular TIS, but also on the key processes that take place, or should take place, in a TIS (Alkemade et al., 2007; Bergek et al., 2008a; Hekkert et al., 2007; Jacobsson and Bergek, 2004; Negro et al., 2007). This approach provides insights to policymakers by identifying systemic weaknesses that hamper the development and diffusion of sustainable technologies. For instance in 2008, the Dutch energy transition programme allocated 450 Million Euro to renewable energy technologies based on insights from TIS analyses.

The growing number of scientific articles and influence on the political debate gives evidence of how both approaches have been successful in extending the understanding of sustainability transitions. However, both approaches have also been criticized for their lack of attention to the micro level unit of analysis as well as an insufficient conceptualization of strategies at the actor level (Smith at al. 2005, Markard and Truffer 2008a). Markard and Truffer (2008a), for example, suggest that scholars must “consider more explicitly innovation processes as perceived at the micro-level of organizations (strategies, agencies)”. Exceptions are Parrish and Foxon (2009), who explicitly address the strategies used in a case study of an ongoing sustainability transition in the US energy industry, and Markard and Truffer (2008b), who analyze how actor strategies influence innovation system performance and dynamics in their case study analyses of stationary fuel cells in Germany. In light of these recent criticisms and the recent empirical investigations we argue that the strategies deployed by micro–level actors should be embedded in the theoretical approaches to the study of sustainability transitions.

Despite the insights into the different types of transitions and pathways gained by contemporary MLP research, current conceptualizations of transition processes do not explain fully why certain niches become part of the regime and why others do not. More specifically, it is difficult to explain why one of two technological alternatives embedded in the same regime and subjected to the same landscape factors becomes a success and the other does not. For example, regime and landscape influences do not explain the current dominance of battery electric vehicle technology over hydrogen technologies.

The TIS related functions of innovation systems approach does provide some insight in these processes as the functions form the link between the actor level and the meso-level dynamics. Therefore, we take the TIS approach as starting point for an actor-level analysis of sustainability transitions. Analyses using this approach have mostly considered how an innovation system facilitates or hinders individual actors in their attempts to innovate. In this paper, we consider the related, but often neglected, question of how actors are able to adapt to and/or influence the innovation system. Our focus is therefore on the entrepreneurs, which have been identified as essential in sustainability transitions research (Negro and Hekkert, 2009). While other actor types, such as governmental actors, capital providing agencies, research organizations,
and NGO’s, have been found to play a supportive role in sustainability transitions, we focus on entrepreneurial firms as this actor group is to a large extent responsible for introducing the novelty and experimentation that is required for sustainability transitions. We contribute to literature by providing key insights that improve our understanding of the determinants of internal TIS dynamics. Moreover, our insights provide practical strategic implications for actors and policymakers, whereas previous publications are mainly tailored for policymakers.

We argue that reconnecting the TIS approach to the micro-level through analyses of actor strategies is both timely and necessary. With the application of the TIS approaches to sustainability transitions new questions regarding the role of actors arise, both regarding the understanding of sustainability transitions and its policy implications. Recent research has revealed that sustainability transitions differ from other socio-technological transitions in some important aspects. First, there is a preferred direction. This normative element of sustainability transitions implies that the innovations, which are developed within a transition trajectory, need to contribute to sustainability. These innovations are labeled as, eco-innovations, sustainable innovations, sustainability innovations, cleantech or innovations for sustainability (Rennings, 2000). However, the development and diffusion of these innovations may be hampered by a “double externality” problem (Oltra, 2008): In addition to R&D related market failures, entrepreneurial firms developing environmental innovations, there also exist positive externalities related to the adoption and diffusion of such environmentally friendly technologies (e.g., clean air). Due to these externalities entrepreneurial firms may not be able to appropriate all the benefits of their innovations. Second, sustainability transitions often require the substitution of large technical systems and infrastructure dependent technologies. These factors strengthen the position of incumbent firms that benefit from the status quo (Hughes, 1983; Gomez-Ibanez, 2003; Van der Vooren et al. 2011). These characteristics of sustainability transitions also have implications for strategies of entrepreneurs that (seek to) contribute to sustainability transitions by developing new business ideas, which is precisely why these actors are the subject of a recently emerging field of sustainable entrepreneurship.

With the differences from general socio-technical transitions and the rise of sustainable entrepreneurship literature in mind, we propose to link the literature on TIS and the dynamics of TIS with the sustainable entrepreneurship literature. Linking these literatures is useful for three reasons. First, insight in the potentially successful entrepreneurial strategies will increase the relevance of the sustainability transitions literature for entrepreneurial firms. Second, by understanding the behavior and strategies of entrepreneurs in the context of sustainability transitions we can better understand the micro mechanisms that influence
the speed and direction of change at the meso-level. In other words, we propose that the strategic actions of entrepreneurs have a large influence on the speed and direction of sustainability transitions. By understanding this, we are able to design better policies. Finally a theoretical outline of possible strategies can structure future case studies on the link between micro level strategies and the dynamics of sustainability transitions. The aim of this paper is thus to construct an overview of the actor strategies identified in the sustainable entrepreneurship literature and use these insights to contribute to the research agenda on sustainability transitions.

The remainder of this paper is structured as follows: Next, Section 2 and 3 describe the role of entrepreneurial firms in sustainability transitions and the role of actor strategies in TIS within a sustainability context. In section 4 we give an overview of entrepreneurial strategies as identified in the sustainable entrepreneurship literature. Finally in section 5 we conclude and derive implications for the sustainability transitions research field.

2. Entrepreneurial firms in sustainability transitions

In this section we elaborate on the role of entrepreneurial firms in sustainability transitions. Although we recognize that many other actor types are important in sustainability transitions, firms are ultimately responsible for bringing technologies to the market that are necessary for sustainability transitions to occur. In management literature, as well as in previous case studies in the domain of transition studies, this pivotal role of entrepreneurs has been identified (Schumpeter, 1934; Venkatamaran, 1997; Tilley and Parrish, 2009; Hockerts and Wüstenhagen, 2010; Alkemade et al., 2007; Hekkert et al., 2007; Markard and Truffer, 2008a; Negro and Hekkert, 2009).

The relatively young field of entrepreneurship research (Shane and Venkatamaran 2000; Ardichvili et al., 2003; Eckhardt and Shane 2003) is concerned with the discovery and exploitation of profitable opportunities. In this paper we focus on entrepreneurial firms which can be defined as firms that discover, evaluate, and exploit profitable opportunities.

In our definition entrepreneurial firms may be new entrants as well as *incumbents*. One the one hand incumbents are often regarded as playing a more defensive role in sustainability transitions especially when so-called disruptive or competence-destroying innovations are concerned. Garud (1994) describes how incumbents often reject new technologies “because of the strength and inertia built into their existing technological paradigm (Dosi, 1982)”. Reasons for this inertia are that the competences of incumbent firms developed within this existing technological paradigm are geared towards the old technology
(Penrose, 1959; Christensen, 1984; Anderson and Tushman, 1990) and that the small niche markets that help shape the new technology are often not financially attractive to large firms (Christensen 1997). On the other hand, there also exists empirical evidence that incumbent firms are able to adequately adapt to radical technological change and competence-destroying innovations (Arend, 1999; Hill and Rotheraermel, 2003; Afuah, 2001; Zahra, 1993; Parker, 2011). Cefis and Orsenigo (2001) for example find that in many industries most innovations are produced by incumbents classified as “persistent innovators”. Incumbent firms may also strive to become more innovative when threatened by new entrants or the emergence of competence-destroying technologies (Gatignon et al., 1997; Hekkert and van den Hoed, 2004). In the general entrepreneurship literature, innovative behavior by incumbent firms is described in studies on corporate venturing or intrapreneurship (Antoncic and Hisrich, 2001; Thornton, 1999) or in the context of sustainability transitions as corporate sustainable entrepreneurship activities (Hockerts and Wüstenhagen, 2010; Stenzel and Frenzel, 2004; Bansal and Roth, 2000). In the transition typology of Geels and Schot (2007) the innovative strength of regime actors is essential in regime transformations; that is, transitions in which established firms focusing on competence-enhancing innovations may contribute to a transition by making the incumbent regime more sustainable.

Some researchers have investigated the determinants of proactive environmental strategies in existing firms as opposed to more defensive strategies. For instance, Aragón-Correa and Sharma (2003) relate the quality of the environmental strategy of the incumbent to resources, capabilities and uncertainty in the general business environment, where a more uncertain environment stimulates proactive environmental strategies. Delmas et al. (2007) relate proactive environmental strategies to the environmental sensitivity of customers and the efficiency and dependency on coal-fired electricity generation in their study of environmental differentiation in the electric utility industry. Buysse and Verbeke (2003) find that more proactive environmental strategies are associated with a broader and deeper coverage of stakeholder relations, and Aghion et al. (2009) show that in response to foreign entrants firms, that are already close to the technology frontier will innovate more whereas the performance of firms that already lag behind further decreases. This suggests that the innovation activities of the existing firms in response to radical technological change also depend on the previous level of sophistication of the industry. In summary, both incumbents and new entrants may be important change agents in sustainability transitions and we therefore include both types of actors in our discussion of entrepreneurial strategies.

With respect to new entrants, Aldrich and Ruef (2006) distinguish two types of entrepreneurs, innovators and reproducers. The majority of nascent entrepreneurs are reproducers: organizations started in an established population whose routines and capabilities vary only minimally, if at all, from those of
existing organizations. Innovators are those entrepreneurial firms started by entrepreneurs whose routines and competences vary significantly from those of existing firms which corresponds to the Schumpeterian view on the entrepreneur as an innovator (inventor-entrepreneur).

In more recent TIS research, a special type of actor has been identified who may fulfil the role of a system builder. A system builder is an actor that (consciously) seeks to contribute to TIS build up and to strengthen the key processes (functions) in a TIS (Hellsmark and Jacobsson, 2009). The goals of system building entrepreneurs are generally broader than the goals of non-system building entrepreneurs in the system as they not only seek survival, or maximum profits, for themselves but also the development of a well-functioning TIS.

A large part of the entrepreneurship literature focuses on the characteristics of entrepreneurs and their motivations for starting a new business. While this is not directly related to entrepreneurial strategies, insight into these motives might be helpful for policymakers that want to nurture the diversity required for sustainability transitions. Entrepreneurs that focus not only on economic goals (profit) but also have environmental, ecological (ecopreneurs, green entrepreneurs) or social goals (social entrepreneurship – see Short et al. (2009) for an overview) are increasingly studied. Sustainability-driven entrepreneurs are those entrepreneurs that include all three pillars of sustainable development (people, planet and profit) in their goals, i.e., the triple bottom line (Tilley and Parrish, 2009; Schlange, 2009; Hall et al., 2010). Sustainability-driven entrepreneurs (Tilley and Parrish, 2009), who do not solely emphasize economic goals, may differ with respects to their characteristics and strategies, or as Prahalad and Hamel (1994) state, “the idea of being environmentally friendly or ‘green’ will have an impact on all aspects of the business”.

Not all entrepreneurs in sustainability transitions can be classified as sustainability-driven entrepreneurs. For instance, some may be “accidentally or opportunistically green” (Walley and Taylor, 2002) but not founded on sustainability principles. This opportunistic behavior has been observed in case studies when entrepreneurs strategically label themselves or their technologies as green or sustainable in order to have access to more resources or gain legitimacy (Farla et al., 2010). The key point of departure from the traditional literature on entrepreneurship is that while entrepreneurs have contributed to the current sustainability problems, they have an important role in their solution as well (Dean and McMullen, 2007; Dyllick and Hockerts, 2002; Gibbs, 2009; Parrish and Foxon, 2009; Schaper, 2002; York and Venkatamaran, 2010). Cohen and Winn (2007) argue that entrepreneurial opportunities are generated by the same market imperfections that also cause environmental degradation, namely the inefficiency of firms, the existence of externalities, the failure of pricing mechanisms, and the fact that information is not
perfectly distributed. Entrepreneurs can directly contribute to sustainability transitions by exploiting these market failures. Sustainability-driven entrepreneurs may also indirectly contribute to sustainability transitions as they force other firms to shift their activities in a more sustainable direction (Hockerts and Wüstenhagen, 2010; Geels and Schot, 2007; Parrish and Foxon, 2009). When sustainability-driven entrepreneurs become successful they make it attractive for others to enter the emerging field (population growth) and also change the selection environment for other firms. This is a key insight in the TIS framework that states how positive externalities lead to increased entrance of new entrepreneurs and the build up of a larger innovation system.

Chandler (1962) defines strategy as “the determination of the basic long term goals and objectives and the adoption of courses of action and the allocation of resources necessary for carrying out goals.” In a dynamic environment characterized by technological change it is necessary for a firm to continuously re-align with its environment without loosing internal consistency (Miles et al., 1978). Strategies can be internally focused as well as formulated in relation to the environment and the optimal strategy may change over time during the life cycle of an industry (Mintzberg, 1978; Anderson and Zeithamel, 1984; Afuah and Utterback, 1997). For a firm actor in a particular TIS this means that the optimal strategy for this actor may depend on (1) the stage of development of this TIS, (2) the strategies and actions of other actors within this TIS, (3) the stage of development of co-evolving (possibly competing) innovation systems and the strategies of the actors within them and (4) other exogenous factors. A typology of actor strategies must be able to accommodate all these different factors. Before we provide an outline for such a classification in section 4 we first discuss the treatment of the strategies of entrepreneurial firms in the TIS literature.

3. Entrepreneurial strategies in the TIS literature

The first step in our analysis is to identify how entrepreneurial firms and their strategies are conceptualized by the TIS approach and to discuss these concepts in the context of sustainability transitions. The TIS literature focuses on the processes that influence the development and diffusion of a technology. From a more normative sustainability transitions perspective the assumption is that these processes are needed to form a large and well functioning innovation system which in turn is a prerequisite for successful innovation and technological transitions. Based on a review of the innovation literature and a large number of historical case studies it has become clear that seven key processes are crucial in (emerging) technological innovation systems (Hekkert and Negro, 2009; Jacobsson and Bergek,
2004; Suurs and Hekkert, 2009; Bergek et al., 2008a; Negro and Hekkert, 2008; Negro and Hekkert, 2007, 2008). These key processes are: entrepreneurial experimentation, knowledge development, knowledge exchange, guidance of the search, market formation, resources formation and counteract resistance to change.

Entrepreneurial experimentation refers to the process of technological variety creation by means of experimenting with new technology. Entrepreneurs experiment in order to test whether new technological options can be transformed into viable business opportunities. Knowledge development is necessary in the innovation system to feed entrepreneurial experimentation and to learn how technological options can be developed for successful market introduction and diffusion. This learning process often involves a variety of actors and which is captured by the knowledge exchange function. Guidance of the search is important to align the visions of different actors on the desired future of the innovation system. Such guidance reduces uncertainties and stimulates focuses efforts. Market formation is important as their may not yet exist market for new technologies and in existing markets the initial advantages of sustainable technologies tend to be small due to high costs and technological imperfections. The process of resource formation acknowledges the financial and human capital resources that are critical inputs for innovation processes. The last function counteract resistance to change refers to processes needed to increase the legitimacy of new technological trajectories in order to overcome inertia in institutional structures and resistance by actors that benefit from the status quo.

Many TIS studies explicitly focus on the early stages of a transition and consider the difficulties that arise when a technology moves from the exploratory to the growth phase. As innovation systems develop, the number of actors involved grows, the complexity of the system increases, different functions become more important and when the innovation system matures, it acquires more and more characteristics of a production system (Markard and Truffer, 2008a). Thus, we can expect actor strategies to change over time in order to adapt to this changing environment. Entrepreneurial strategies may contribute to the fulfillment of the functions of an innovation system. When entrepreneurial strategies are aligned with systems goals entrepreneurs may actively seek to contribute to the functions in a way that is beneficial to the system. However, this is not necessarily the case and even when there is such alignment many different actor strategies are possible to reach these goals. In order to create a favorable process of guidance of the search, entrepreneurs may lobby the government for supportive policy programmes or

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1 See Hekkert et al. (2007) and Markard and Truffer (2008a) for a more elaborate description of the functions of innovation systems.
seek to mobilize support through the media. Moreover, they may wish to pursue strategies by themselves or in a more collective effort. However, the TIS literature does not specify these differences in actor strategies, their attribution to specific actor types, and the relation between TIS dynamics and actor strategies. The TIS framework highlights the importance of function fulfillment and focuses less on the specific actor that contributed to a function and the strategies used by this actor. From empirical case studies it becomes clear that function fulfillment relies on a variety of actors types. Exceptions are experiments with new technologies that are generally performed by either entrepreneurs or incumbents. Another observation when carefully analyzing the empirical TIS studies is that in the early phase of development, entrepreneurs contribute to many functions whereas in later stages more specialization takes place (Alkemade et al., 2006). These dynamic effects are however not embedded in the theoretical framework.

In the TIS approach the analysis starts with a technology or new idea championed by a certain entrepreneur or a group of entrepreneurs. The TIS approach does not pay much attention to the emergence of novelty in the form of new technologies and the entrepreneurs developing these technologies but rather assume the presence of a technology or new idea as the starting point of the analysis. Policy based on the TIS approach is thus likely to focus on the protection and stimulation of a particular form of novelty rather than on stimulating the emergence in of novelty in general. Such diversity however is a prerequisite for change and the question “how much diversity should we create” is thus a relevant question in sustainability transitions (Stirling, 2010). Policymakers that seek to apply TIS insights in transition policy should therefore take this technology-specific focus of TIS studies into account.

In summary, in TIS studies the focus is on the key processes that need to take place within an innovation system but not on the actual strategies of nascent entrepreneurs and the influence of these strategies on these key processes. This leads to two shortcomings. First, current TIS studies are very good in analyzing system weaknesses and their implications for innovation. However, the explanation of these weaknesses and the role of actor strategies in creating these weaknesses remain unclear. Second, there does not exist a clear overview of the strategies that entrepreneurs have available in order to contribute to the functions in different phases of development of the TIS. This limits the options for TIS analyses to strategically advise entrepreneurs on which innovation strategy to apply. In the next section we propose a first step towards a more systematic analysis of actor strategies in sustainability systems by linking strategies described in the sustainable entrepreneurship literature to the TIS literature.
4. A typology of strategies for sustainable entrepreneurship

To construct a classification of actor strategies in TIS we build on the framework of Aldrich and Ruef (2006) who in their work propose an evolutionary framework to study organizations and populations of organizations, which fits well with the TIS perspective since they share their roots in evolutionary thinking. Furthermore, both approaches recognize the collective nature of innovation and change although Aldrich and Ruef focus on organizations (mostly firms) whereas the innovation systems approach takes a broader set of actors and institutions into account. Aldrich and Ruef (2006) distinguish four levels of strategic behavior: 1) Strategies at the organization level (within organization), 2) within-population strategies, 3) between-population strategies and 4) community level strategies. A population refers to a group of organizations that is alike, e.g., a group of nascent entrepreneurial that focus on a new technological option. A community refers to a group of dissimilar organizations. This inclusion of heterogeneous organizations aligns with innovation systems thinking where all actors that influence the innovation process are considered part of an innovation system. Populations grow by the entrance of new organizations and populations change through selection and retention where unsuccessful organizations die out and successful organizations remain in the population and grow.

A sustainability transition requires the growth of different technological innovation systems to replace (parts of) the current socio-technical system and during this growth process a TIS draws in new actors. According to the TIS approach such a build up of a well functioning innovation system occurs when certain key processes (the functions of innovation systems) take place within the TIS. The Aldrich and Ruef framework allows us to systematically analyze the strategies actors have available in such a context as a first step to a description of the relation between actor strategies on the one hand and system build-up and functioning on the other hand. The framework explicitly enables the analysis of strategy in a changing context (e.g., either due to entry of new firms or due to a changing selection environment). In addition to the four levels of strategy identified by Aldrich and Ruef, we also distinguish between competitive and cooperative strategies. Several authors have indicated that especially cooperative strategies are important in sustainability transitions and that entrepreneurs should run in packs (Van de Ven et al. 2008).

We use these levels and types of strategic behavior to structure our survey of the literature in the following way: The entrepreneurial firm seeking to develop and commercialize a new technology, which is a (partial) substitute for an existing technology, or that opens up an entirely new market must act strategically on several levels to achieve its goals. First, internal strategies, aimed at developing the technology and establishing the entrepreneurial firm, are important. Following Aldrich and Ruef (2006)
we will label strategies of this type as *within-organization* strategies. As the TIS framework focuses on outcomes of the system level and takes strategies into account only when they contribute to this system level, *within-organization* strategies are only taken into account in a TIS analysis when they contribute to the functions. However as these strategies can sometimes determine the fate of the entrepreneurial firm (as opposed to exogenous or system influences) these strategies should be considered in an actor level analysis especially in relation to innovation system build-up.

The other levels of strategic behavior (within-population-, between-population- and community-level) regard the relationship between the entrepreneur and the environment. The entrepreneur can choose competitive or more cooperative strategies to structure these interactions in order to achieve his long term goals (Garud, 1994). Sources of competition and opportunities for cooperation first of all arise from the incumbents that have invested in and have competences regarding the existing technology. Sartorius and Zundel (2005) label this competition as *new-old* competition. An example of *new-old competition* is the competition between electric vehicles from new entrants like THINK and Tesla and the current dominant design, the internal combustion engine. An example of *new-old cooperation* is the cooperation between battery producers and incumbent automotive firms leading to the development of electric vehicles like the Nissan Leaf and the Mitsubishi i MiEV.

An entrepreneur also faces competition from other entrepreneurs (both incumbents and new entrants alike) experimenting with the same new technological option. An example of such *new-new* competition is the competition between different battery technologies for electric vehicles. Moreover an entrepreneur may face competition from other entrepreneurs developing new technologies that are partial substitutes i.e., different technological options aimed at the same application context, e.g., the competition between electric vehicles and biofuel cars. This constitutes a second form of new-new competition. The distinction between technical and service characteristics is helpful to describe the two types of new-new competition (Saviotti and Metcalfe 1984, Saviotti and Pyka 2004). The first type of new-new competition described above focuses mainly on technological characteristics where firms try to achieve the highest level of performance on certain technological characteristics. This type of new-new competition is currently visible in the mobility domain where different producers of battery technology compete on, e.g. driving range of electric batteries or battery recharging time. The second type of new-new competition focuses on service characteristics, where different technological options compete to provide a similar service. An example from the same mobility domain is the competition between electric vehicles, hybrid vehicles, and alternative fuel vehicles to provide low carbon mobility solutions.
The influences of these different levels of competition are taken into account on an aggregate level in TIS analyses. Cooperative strategies pursued by other TIS actors (new-new cooperation) may, for example, be analyzed as a positive contribution to functions such as entrepreneurial experimentation, knowledge development and knowledge exchange. Competitive strategies and strategies pursued by non-TIS actors will be classified as negative contributions to either resistance to change or guidance of the search.

When considering the different level of strategic behavior, it is important to note that population boundaries are not static and may evolve as the technologies evolve or due to mergers and take-overs (Afuah, 2001; Saviotti and Pyka, 2004). These population boundaries themselves may be the subject of strategic behavior as entrepreneurs establish their organizational identity by specifying their product market niche and the width of the chosen niche influences the competitive responses from rivals. Dependent upon the stage of development of a particular innovation system and strategic choices made in the past rival firms may be considered as belonging to the same (within-population) or to a different (between-population) population.

Lastly, Aldrich and Ruef (2006) distinguish community level strategies which are strategies directed at other non-rival actors. Most community level strategies have a cooperative character as other non-rival actors are necessary to build a community that succeeds in developing and applying the new technology. In order to come to an overview of actor strategies we survey the literature for strategies that are relevant for entrepreneurs in sustainability transitions. We structure our overview using the classification described above. Following reviews of the field by Ireland and Webb (2007) and Busenitz et al. (2003) we survey both the main management journals and the dedicated entrepreneurship journals to identify these strategies. Our survey also includes three journals dedicated to sustainability-driven entrepreneurship. In these journals we have searched fairly broadly for relevant articles.

4.1 Within organization strategies

For nascent entrepreneurs Aldrich and Ruef (2006) focus on learning as the most important organizational (within organization) strategy. In the functions of innovation systems approach the

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3 By searching in Scopus (and on journal website for journals not in Scopus) for articles that contained (Entrepreneur*, strateg*, environment*, sustainab*,transition) in their title abstract or keywords. From these articles a selection was then made by hand. All articles included in our survey are given in the reference section of this paper.
aggregate effects of these learning activities are described by the function knowledge development. Nascent entrepreneurs learn in order to create a technological knowledge base, come to a working prototype or bring a well-functioning product on the market. A typical learning strategy for innovative entrepreneurs in the early phases of the industry life cycle is to strive for technological superiority (Abernathy and Utterback 1985, Klepper 1997, Garud and Karnøe 2003). As the entrepreneurial firm grows, other organizational strategies, such as acquisition of human and financial capital as well as coordination and management of the firm, gain importance. In TIS analyses strategies focused on resource acquisition contribute to the function resources formation.

In addition to learning strategies, within firm legitimacy for the new technology is especially important for existing firms seeking to develop a new technology. Successful strategies for incumbent firms to facilitate innovative activities within the firm, i.e., making the incumbent firm more entrepreneurial, are discussed in the intrapreneurship literature (Ireland et al. 2003), access to R&D is an important part of this strategy (Iansiti, 2000).

4.2 Within population strategies

Learning strategies are not necessarily a within-organization strategy but can also include other firms. The possibilities of appropriating the benefits of learning efforts influence the tendency for the entrepreneurial firm to cooperate with other firms as part of its learning strategy. More competitive behavior is observed in industries with high appropriability whereas low appropriability is associated with more cooperative learning strategies. An example of a competitive strategy that is not considered desirable from a sustainability transitions perspective is the use of defensive patenting in order to hinder or discourage the innovation activities of rival firms (Jaffe, 2000). In this case the firm uses financial and technological resources to build a patent portfolio in emerging technological fields without the ambition to actually exploit the opportunities of this emerging technology.

Santos and Eisenhardt (2009) emphasize the competitive elements of within-population strategies when they propose that a successful entrepreneurial strategy is based on establishing a (temporary) monopoly position through innovation. In order to achieve this, entrepreneurs should claim a market niche and signal market leadership in this niche. Strategic behavior to defend this niche are setting and negotiating boundaries with established firms (through strategic alliances or agreements with incumbents and rivals) and by eliminating rivals entering the niche through acquisition. This strategy advocates very competitive within population behavior (new-new) while allowing for limited forms of cooperation (or boundary agreements) with incumbents.
More cooperative *within-population* strategies occur when entrepreneurs “run in packs”, that is when entrepreneurs simultaneously compete with rivals for technological superiority and at the same time cooperate with these rivals to influence their institutional environment and in standard setting activities (Van de Ven, 1993; Aldrich and Ruef, 2006). This mix of cooperative and competitive behavior can be observed in some cases of new-new competition. Other forms of cooperative within population strategies are the erection of barriers to deter further entry, market sharing through product differentiation and agreements to limit competition and collaborative R&D. Finally cooperative *within-population* strategies are important for the creation of legitimacy for new entrants and new technological options especially in the case where the new entrants face strong and organized resistance to change from incumbent firms. In the functions of innovation systems approach these incumbent influences are described by the function *guidance of the search* on an aggregate level.

Empirical case studies have found that competitive behaviors are more often found to dominate, at least initially, the *within-population* interactions. In the case of first and second generation biofuels, for example, proponents of each technology vigorously competed with each other to become the most promising technology through public discourses instead of jointly targeting the incumbent technology (Suurs and Hekkert, 2009). This struggle contributed to the uncertainty surrounding both technologies and the field experienced serious legitimacy problems concerning the sustainability of the technology. Currently entrepreneurs are following a much more cooperative strategy, exercising restraint in talking to the media and cooperating to create a set of accepted standards for biofuels. In the case of salinity gradient power (blue energy), a field where two technological options compete (PRO and RED) and where there is also competition within the RED cluster, we observed that the fierce competition to develop the best technology lead to a lack of trust among entrepreneurs. Due to this lack of trust entrepreneurs did not cooperate in influencing institutions. The incumbent electricity firms that were involved in a blue energy pilot project used more cooperative strategies, motivated by the fact that they were unable “to make a viable business case on their own”.

### 4.3 Between-population strategies

With respect to *between population strategies*, Shankar (1999) proposes that new firms adapt their strategies (in this case their marketing spending) based on the expected response from incumbents (i.e., *new-old* competition). In his model, Shankar that new entrants thereby usually do not take into account small incumbents but rather focus on those service characteristics in which their product differs from the products of the large incumbents. Klein Woolthuis (2010) distinguishes system building and system following entrepreneurs. The former type aims to build a new system to challenge the old one, whereas
the latter rather makes use of existing structures to build a business. She concludes that firms following both strategies can be successful. Furthermore, these findings correspond with the distinction made in the sustainability transitions literature on transition pathways where the different transition types allow for different roles by incumbents and new entrants (Geels and Schot, 2007). Cooperative between-population strategies have also been discussed in the literature on the liability of size and age (Aldrich and Auster, 1986; Bruderl and Schussler, 1990; Freeman et al., 1983). For nascent entrepreneurs, for example, strategic alliances with other organizations can provide access to resources whereas for existing firms such alliances can provide access to new technologies. Nooteboom (1999) suggest that different patterns of alliance formation may be beneficial in different stages of the innovation process indicating that strategies for network formation may change over time but the exact nature of the relationship needs further empirical investigation. Such alliance formation strategies contribute to the TIS function of knowledge exchange although here the focus is on the outcome of the alliance. Other way for existing firms to gain access to new technologies is by in-house R&D or by launching corporate venture capital funds (Rotheaermel, 2001; Hill and Rotheaermel, 2003).

Often a new technology is not only in competition with the old technology but also with different alternative new technologies (Anderson and Tushman, 1990) and a mix of cooperative and competitive between population strategies can be used. An important issue here is the establishment of a dominant design. While it is in the interest of all entrepreneurs that a dominant design is converged upon as this increases legitimacy, it is most advantageous for each individual entrepreneurial firm when its own technology becomes that dominant design. Before a dominant design is established the expectations regarding competing technologies are an important part in this competition (Abernathy and Clark 1985, Rosenberg 1976). Discourse strategies that seek to influence these expectations thus play an important role in the early stages of development of a technological innovation system (Alkemade et al., 2006; Hillman and Hit, 1999; Hillman et al. 2004; Reinstaller, 2005) as favorable expectations create legitimacy and facilitate the allocation of resources to the new technology. Favorable expectations contribute to the TIS function guidance of the search.

4.4 Community strategies

Aldrich and Ruef (2006) focus on two key processes that need to take place to build a community: learning and legitimacy creation. Both key processes require a cooperative relationship with other community actors. Legitimacy is a key process in all emerging technological trajectories but is likely to be especially important for innovations that aim to discern themselves from other products by being more sustainable. The value that is attributed by consumers to the sustainable characteristics is mainly
determined by the importance of sustainability on the societal agenda. Raising the legitimacy of sustainable products is only possible by a collective effort of many actors. The TIS literature therefore highlights legitimacy creation as one of the most important key processes in TIS build up (Bergek et al. 2008b).

For sustainable technologies legitimacy does not only arise through the establishment of a dominant design but often comes from exogenous forces (landscape pressures in the MLP, guidance of the search in TIS). Managing the relation to actors that may influence legitimacy for the entrepreneurs is one of the entrepreneur’s key strategic objectives. Such strategies are labeled as community-level strategies.

In community level strategies of the entrepreneur, the cooperative ties an entrepreneur forms to other actors are described in the areas of institutional entrepreneurship and stakeholder management strategies. More competitive community-level strategies are observed when entrepreneurs compete for legitimacy and resources. Schlange (2009) argues that stakeholder management is more difficult for sustainability-driven entrepreneurs due to the triple bottom line nature of their ventures. When compared to the situation of entrepreneurs that focus on economic goals, sustainably driven entrepreneurs have to engage with a more diverse set of stakeholders. Moreover, the perceived sustainability of the activities of the entrepreneur is critical to the legitimacy of the company and it is therefore vital to negotiate stakeholders’ perceived sustainability. Stakeholder perspectives reflect this importance as they stress that social network formation leading to resources (both physical and in the form of social capital) are a key activity for entrepreneurs (Garud and Karnøe, 2003). Another reason for the importance of stakeholder strategies in sustainability transitions is that stakeholder activities are often an important driver for the emergence of sustainable technologies (Sharma and Henriques, 2005). These stakeholder relationships are likely to change over time as the firm grows and different resources are necessary and Stuart and Sorenson recommend that it should be more systematically studied how actors seek to form these alliances taking into account the strategic efforts of others (Stuart and Sorenson, 2008).

Again, an example of the importance of these stakeholder perceptions can be seen in the competition between first and second generation biofuels. Alkemade et al. (2006) illustrates how questions about the sustainability of first generation biofuels led to serious legitimacy and (consequently resource) problems for this technology. This legitimacy crisis resulted in a phase of (re)negotiation of new standards, and stakeholder groups, such as environmental protection groups, where very influential in this standard setting process.

Van de Ven (1993) stresses the role of a favorable institutional environment for the entrepreneurs in facilitating their innovative activity. Institutional entrepreneurship, which is defined as “the activities of
actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones” (Maguire et al., 2004), studies the strategic actions that entrepreneurs take in order to influence their institutional environment. As a technological paradigm coevolves with the technology, entrepreneurs that sponsor a particular technology have strong incentives to shape their selection environments (Dosi, 1982; Levy and Scully, 2007; Dorado, 2005; Garud et al. 2007, 2002). Negotiating these institutions is especially challenging for sustainable technologies as heterogeneous interests are involved. Strategies often take the form of discourse strategies suggesting that discourse analysis together with network analysis of the pattern of links between actors may be helpful to analyze institutional entrepreneurship strategies.

In conclusion, the literature conceptualizing the strategies of sustainable entrepreneurs identifies four main areas of strategic behavior: learning, resources, legitimacy, and appropriation. Following Aldrich and Ruef (2006), in studying transitions we find it very useful to distinguish between different levels of strategic behavior and the competitive or cooperative nature of the strategic interactions. Importantly, learning as a strategy is essential in order to build competences regarding the new or improved technology whereas legitimacy is necessary in order to obtain sufficient resources (i.e. basic scientific or technological research, financing mechanisms and the pool of competent human resources) (Van de Ven, 2008). This leads to the importance of distinguishing between new entrants and incumbent firms, as the availability of these resources are likely to be different. For instance, the current resources available to the entrepreneur may constrain the strategic options. Strategies to obtain legitimacy, in this sense, are considered pivotal in the success of entrepreneurial firms as start-ups often face a lack legitimacy (Clegg et al. 2006, Aldrich and Ruef 2006). Relatedly, in sustainability transitions literature, legitimacy problems for the incumbent firms often create niches for the entrepreneurs. Finally, our literature overview illustrates the different cooperative and competitive strategies entrepreneurs and incumbents have available when interacting with their environment.

5. Discussion: towards a research agenda

In this paper we argue that a necessary next step in the study of sustainability transitions is the study of strategies at the micro level. We thereby focused on the strategies of entrepreneurial firms as they are ultimately responsible for bringing to the market the technologies needed in sustainability transitions. We have connected the literature on sustainability transitions to the body of literature on sustainable entrepreneurship. We started our analysis from the technological innovation systems approach. As a first
step we have analyzed how strategies are conceptualized in this approach especially in cases where the
approach was applied in the context of sustainability transitions.

We have made an overview of strategies discussed in the sustainable entrepreneurship literature. The
strategies can be classified by the level of the strategy, i.e., the actor at which the strategy is aimed
(\textit{within-population, between-population} and \textit{community strategies}) and the type of the strategy
(\textit{cooperative} versus \textit{competitive}). The main goals of the strategies that were identified correspond well
with the key processes that are necessary for the build up and functioning of an innovation system.
Strategies related to learning, legitimacy, appropriation and resources correspond directly to knowledge
creation and exchange, counteract resistance to change, guidance of the search, entrepreneurial
experimentation, and formation of resources respectively. We did not however identify strategies that
would contribute to the \textit{market creation} function. One the one hand, this absence of market creation
strategies could indicate that this key process is best fulfilled by other actors such as the government. On
the other hand market creation strategies are identified in the more general strategy literature when firms
use for example marketing to create a demand for new products. The role of such strategies in
sustainability transitions needs more attention.

When considering the specific strategies that are discussed in the sustainable entrepreneurship we identify
two elements that should be part of the future sustainability research agenda: (1) the importance of
legitimacy strategies, and (2) the importance of cooperative strategies.

First our analysis suggests that strategies aiming to increase legitimacy may need specific attention in
future sustainability transitions research. However successful legitimacy strategies may also be more
complicated in sustainability transitions. As sustainability requires the balancing of goals in different
sometimes orthogonal domains the management of stakeholder networks and institutional
entrepreneurship strategies may be challenging. For a future research agenda an analysis of the strategies
actors use to obtain legitimacy thus seems an important requirement for a micro-foundation of
sustainability transitions. We hypothesize that differences in power (Arts and Tattenhove, 2004) and
resources between incumbents and entrepreneurs are important determinants for the outcome of
legitimacy discourses but this relation needs to be addressed in future research.

Second our analysis indicates that there may exist a discrepancy between the strategies described in the
sustainable entrepreneurship literature and earlier empirical case studies. The literature suggests that
although entrepreneurs should compete in the arena of technology development, cooperation in other
arenas is beneficial. Where incumbents generally are very good at cooperating when this is to their advantage we often do not observe this behavior in nascent entrepreneurs in sustainability transitions. First regarding expectations many nascent entrepreneurs express expectation of a transition pathway in which their technology completely replaces the incumbent technology (Alkemade et al 2006). Only after difficulties in this transition path are encountered do entrepreneurs select more cooperative strategies. An explanation for this deviation from more cooperative strategies described in the literature may be related to the perceived boundaries of the system. Sometimes system boundaries are determined endogenously when entrepreneurs choose whom to cooperate with and which markets to target. In other cases however, system boundaries are determined exogenously when technologies have to compete for government subsidies against other entrepreneurs in the same or related industries. Large incumbent firms are often capable of simultaneously maintaining multiple cooperative and competitive links. Case studies show however that in an emerging innovation system specialization and division of roles has not yet taken place: new entrepreneurial firms are often dominated by a single inventor-entrepreneur. A hypothesis is that once such inventor-entrepreneurs have entered a competitive relation with other actors (competition for a dominant design, competition for public funding) it becomes difficult to simultaneously form cooperative links with these actors as well. This discrepancy also raises the question is whether sustainability transitions are best served by cooperative or competitive strategies. More insight in the role of these strategies in sustainability transitions has important strategic implications for both firms and policymakers.

From the perspective of the policymaker the key question here is what type of strategies contribute to the build up of innovation systems. Empirical case studies can help to analyze on how different entrepreneurial strategies influence the success or failure of technological transitions, or more precisely, whether different strategies are required in different phases of the transition process. Discerning the strategies actors use to gain legitimacy, resources and to learn might contribute to a better interpretation of the patterns of activity observed in sustainability transitions and provide opportunities for steering and supporting entrepreneurial activities.
References
Abernathy W. J., Clark K. B. Innovation: mapping the winds of creative destruction, Research Policy, 14: 3-22, 1985


Arend, R.J. Emergence of entrepreneurs following exogenous technological change. Strategic Management Journal 20:31-47, 1999


23
Christensen 1997 The Innovator's Dilemma When New Technologies Cause Great Firms to Fail


Hekkert, M., van de Hoed, R. Competing technologies and the struggle towards a new dominant design: The emergence of the hybrid vehicle at the expense of the fuel cell vehicle? *Greener Management International* 47:29-43, 2004


Oltra, V. Environmental innovation and industrial dynamics: the contributions of evolutionary economics. *DIME Working paper* No. 7, 2008


Rosenberg Perspectives on technology. Cambridge University Press, 1976


Sartorius, C., Zundel, S. (Eds.). Time Strategies, Innovation and Environmental Policy. Edward Elgar, Cheltenham, 2005


Schaltegger, S. A framework for entrepreneurship: Leading bioneers and environmental managers to ecopreneurship. *Greener Management International* 38:45-58, 2002


