



What is protective space? Reconsidering niches in transitions to sustainability

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ABSTRACT

The transitions literature emphasises the role of niches, defined as a protective space for path-breaking innovations. Surprisingly, the concept of protection has not been systematically interrogated. Our analysis identifies effective protection as having three properties in wider transition processes: shielding, nurturing and empowerment. Empowerment is considered the least developed in current niche literature. It can be understood as either processes that make niche innovations competitive within *unchanged* selection environments (fit-and-conform) or as processes that contribute to *changes* in mainstream selection environments in ways favourable to a path-breaking niche innovation (stretch-and-transform). Adopting a more constructivist perspective, we subsequently argue that analysis of these properties needs to be complemented with particular attention for the politics involved in their construction. Attention to empowerment confirms the view that niche actors need to link to wider processes of social change, and suggests how this arises. The paper ends with an outlook upon two promising research avenues: (1) the reconstruction of niche development in light of the present framework; (2) analyses of the diverse (political) narratives seeking to empower niches across time and space.

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1. Introduction

Sustainability transitions research emphasises the role of niches as a source for path-breaking innovation. A defining characteristic of these niches is that they afford temporary '*protective space*' for the configuration and development of such innovations (Schot et al., 1994; Kemp et al., 1998). Initial protection is deemed essential, because path-breaking innovations fail to successfully compete within selection environments embodied in incumbent socio-technical regimes. Hence, the protective space is needed to shield the innovation against (some of) the prevailing selection pressures. Within this protective space, niche actors can nurture the path-breaking innovation so it becomes more robust through performance improvements and expansions in supportive socio-technical networks. Initial technology niches give way to more conventional market niches. As the innovation enters broader and more diverse markets, so the need for protection falls away progressively, and the innovation becomes competitive and influential in contributing to regime shifts (or transitions) towards sustainability.

That, at least, is the argument in the literature. One can think, for example, of the development of solar photovoltaic cells initially within a 'protective space' constituted by satellite programmes

in the 1960s, public research programmes in materials science, and policies for developing renewable energy since the 1970s. The protective space was widened further through international aid programmes for PV power systems in remote, off-grid development projects. Since the 1990s, sustainable energy policy in some wealthier countries has opened a market-niche for integrating or retrofitting solar power systems into buildings and selling this 'distributed generation' of electricity into the grid. Some advocates claim that (controversially) continued trends in both technology, installation, and wider energy systems and markets will lead to 'grid-parity' for solar electricity in the future (i.e. cost-competitive against conventional electricity generation).

Protective spaces are significant for such 'hopeful monstrosities' (Mokyr, 1990). It is therefore surprising that the concept of 'protection', so foundational to transition studies, has received little systematic attention in the literature. Even responses to criticism from Himmels et al. (2007); see Geels and Schot (2007), about the undesirability of protection in innovation, have not prompted serious reflection on what protection is, where protection comes from, how it is contested, who is involved in shaping protection, nor how protection is transformed and declines as transitions come about.

In this paper we argue that the limited conceptualisation of niches as protective spaces has two shortcomings. First, most of the empirical and conceptual work has focussed on processes and patterns in *shielding* and *nurturing* path-breaking innovations, despite the initial problem framing of niches as potential mechanisms in broader processes of regime shifts. This is understandable, because the foundations of niche-based approaches were

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developed during the 1990s, when sustainable innovations were still searching for or surviving in early niche markets.² Although later work, especially in the context of the multi-level perspective (Geels, 2002), has reframed the research topic and unit of analysis towards understanding transitions, ideas and conceptualisations of how path-breaking innovations escape their protective spaces and interact with wider regime change processes are still poorly developed (STRN, 2010). In this paper, we propose to unpack the notion of protective space by adding *empowerment* to the functional properties that niches have in wider transitions. In short (we will elaborate on the notion in Section 4), empowerment refers to either niche-innovations becoming competitive within unchanged selection environments or to niche-influenced changes in regime selection environments in ways favourable to the niche-innovation. This way of thinking about protective space sits firmly within the evolutionary tradition of innovation studies.

In contrast, adopting a more constructivist tradition in innovation studies emphasises a second shortcoming in the limited conceptualisation of protective spaces. While thinking of niches as being functional in evolutionary transition processes might be attractive to a more managerial 'outsider' ontology on niche development, it runs the risk of not being able to capture the 'generative forces required to initiate and then sustain' those functional processes (Garud et al., 2010, p. 761; Smith and Stirling, 2007). Therefore we later develop in the paper an 'insider' ontology that highlights the sense-making agency required in protective space dynamics.

Moreover, as support for sustainability innovations expands and becomes more mainstream, so a greater variety of advocates will be arguing for support for *their* particular innovations (Shove and Walker, 2007), but not all will enter these negotiations equally, nor address sustainability in the same ways. Indeed, some social actors will actively try to undermine niches and disrupt their space for development. Hence the second part of the paper will also address the *politics* involved in actor-networks constructing, maintaining and empowering contested protective spaces, with a particular focus on the role of *narratives*. The propositions in this part of our analysis are informed by insights from recent literature on institutional change (Phillips et al., 2004; Hardy and Maguire, 2010; Lawrence et al., 2009; Battilana et al., 2009; Garud et al., 2010, 2007; Zietsma and Lawrence, 2010; Hargrave and Van de Ven, 2006) and network governance (Kooiman, 2003; Jessop, 1998, 2003; Hajer and Wagenaar, 2003; Law and Callon, 1994)

Hence, two analytical questions guide our discussion:

- How can we understand and analyse the dynamics of protective space in sustainability transitions in a more systematic way?
- How can agency and politics in protective space dynamics be captured in such a framework?

While the paper is mainly theoretical, we use examples from solar electricity (PV) to illustrate our argument in places.

The rest of the paper is structured as follows. We first summarize the arguments for protective space in shielding (Section 2) and nurturing (Section 3). These sections elaborate existing literature on niche development and relevant insights from the technological innovation systems approach. Section 4 contributes a discussion of empowerment as a third functional property of protective space. Section 5 proposes a framework for studying agency and politics in protective space dynamics. We end the paper with conclusions and outlook in Section 6.

² We refer in particular to strategic niche management (Schot et al., 1994; Kemp et al., 1998) and the technological innovation systems approach (Carlsson and Stankiewicz, 1991; Johnson, 1998).

2. Shielding path-breaking innovations against mainstream selection pressures

Drawing upon evolutionary theory, a key feature of socio-technical regimes is the way they function as selection environments for the creation and retention of innovative variants (see Rip and Kemp, 1998; Geels, 2002; Smith et al., 2010). Socio-technical regime theory argues alignments and mutual interdependencies across multiple socio-technical dimensions also generate processes of lock-in and path-dependency. Path-breaking sustainable innovations are at a structural disadvantage within these contexts, because they are too demanding in terms of their socio-technical implications for the regime.

Early regime concepts focused predominantly on socio-cognitive and market processes that influence which technological developments engineers and investors deem feasible and worth developing (Nelson and Winter, 1977; Dosi, 1982).³ Later conceptualisations broadened the notion of regimes to incorporate a wider set of sociological processes of selection operating beyond firms and research institutes, in an attempt to get to grips with their emergence and decline (van den Belt and Rip, 1987; Kemp, 1994; Rip, 1995; Rip and Kemp, 1998; Geels, 2002; Smith, 2007):

- Established *industry structures* form a selection environment through, for example, established network relations, industry platforms, strong user-producer interactions, shared routines and heuristics, existing capabilities and resource allocation procedures. Path-breaking innovations entering the market might be rejected because they do not fit with existing industry structures and decision making processes that have emerged in co-evolution with the dominant design.
- Dominant *technologies and infrastructures* form a (material) selection environment, for example, through articulated technical standards and infrastructural arrangements, which are imposed on new innovations. Path-breaking innovations require different standards and infrastructures in order to perform (technically and economically) optimally, and as a result are perceived as problematic.
- Guiding principles and socio-cognitive processes in the established *knowledge base* are geared towards incremental knowledge development rather than paradigmatic shifts. Path-breaking innovations are rejected because insufficient resources are attributed to new knowledge development, RD&D and so on, and academic and private research institutes perceive disincentives because of a lack of dedicated journals, conferences and research groups.
- *Markets and dominant user practices* form a selection environment through stabilised market institutions, supply and demand, price mechanisms, user preferences and routines. Path-breaking innovations have a hard time entering the market, for example, because external environmental costs are not represented in end-user prices, or because they require inconvenient user practices compared to accustomed habits.
- *Public policies and political power* form a selection environment through, for example, prevailing regulations, policy networks and relations with incumbent industries. Political power is exercised to maintain the status quo, in terms of jobs, tax base, and votes,

³ In the Nelson–Winter–Dosi model, heuristics are deployed which promise, but do not guarantee, solutions to problems and opportunities (Schot, 1992). This constituted an *ex ante* mechanism for selecting among 'technological paradigms' – what Dosi (1982) called the 'direction of mutation' (p. 156). Added to this is *ex post* selection between variations in markets (Dosi, 1982), broader social and economic institutions were also noted to shape innovation, but were not elaborated (Dosi, 1982; Nelson, 2008; Metcalfe, 1998).

which is a disadvantage for path-breaking innovations, because they require different policies and regulations, and even new political economies.

- The *cultural significance attached to a specific regime* forms a selection environment through, for example, its widespread symbolic representation and appreciation. Path-breaking innovations are put at a disadvantage, because they represent different cultural values and lacks widespread stabilised representations.

Hence it has been argued by various scholars in the field of evolutionary theories that path-breaking innovations tend to develop in niches that *shield* those innovations from mainstream selection pressures (Schot, 1992; Leventhal, 1998; Basalla, 1988; Mokyr, 1990; Rip and Kemp, 1998; Glynn, 2002; Raven, 2006; see Schot and Geels, 2008 for a review of this literature). Here we define shielding as those processes that hold at bay certain selection pressures from mainstream selection environments, and add to this literature that it is possible to make an analytical distinction between passive and active niche spaces.

Initial niches can be passive spaces where the selection pressures are felt less keenly for contingent rather than strategic reasons, and in a sense precede mobilisation by advocates. These could be geographical spaces, such as regions outside the reach of centralised energy grid infrastructures, for which expanding infrastructure would entail relatively high costs or even be impossible. These remote spaces find alternatives more feasible, such as solar cell applications in space in the 1960s (Oliver and Jackson, 1999). Advocates of decentralised energy technologies have mobilised these spaces as initial geographical application domains for developing and selling their products. But passive shielding could also entail institutional spaces not linked to specific path-breaking innovations. One example is the generic public support for materials research, which was mobilised by academic advocates to do research on solar cells in the 1970s (Knoppers and Verbong, 2001). Another example is an environmentalist milieu with different cultural values and whose members are willing to trade-off, say, higher cost or lower performance on conventional terms, because an innovation performs better environmentally and/or is deemed to be more socially just. In the case of sustainability, environmentalists and civil society organisations have often been proactive early adopters of a variety of sustainability innovations like solar power (Truffer, 2003; Smith, 2007). In sum, we define *passive protective spaces* as *generic spaces that pre-exist deliberate mobilisation by advocates of specific innovations, but who exploit the shielding opportunities they provide.*

A few scholars have also argued that niches can be constructed more actively through strategic niche management interventions (Kemp et al., 1998). Obviously technology policies play an important role in such interventions. These include classic supply-side measures for counter-acting cost differentials or performance characteristics (e.g. regulations, tariffs, and taxes), but also demand-side measures that try to alter preferences (e.g. quotas, public purchasing, information campaigns, market segmentation). For example, between 2008 and 2011 specific public policies provided financial investment support for Dutch households to purchase solar cells for their rooftops, as have other OECD governments.

Active shielding could also entail specific interventions originating from non-policy actors. Examples include private initiatives such as the establishment of incubator units that are allowed to reside temporarily outside the more short-term oriented decision making processes within their mother-firms, as was arguably the case with BP, Shell and other oil companies who have supported PV business development for periods in the past. But examples also extend to bottom-up, civil-society initiatives such as solar cell cooperatives like 'Wij-willen-zon' established in the Netherlands

in 2011 to bulk-buy solar cells at lower prices.⁴ Instead of searching (or waiting) for the right context conditions, active shielding is about encompassing approaches to creating spaces that hold off mainstream selection pressures. In sum, we define *active protective spaces* as those spaces that are the result of *deliberate and strategic creation* by advocates of *specific* path-breaking innovations to shield regime selection pressures.

Table 1 provides a summary of the different regime dimensions, selection pressures, the logic of the need for protection and some examples of shielding. An important point here is to note that in this conceptualisation shielding is understood as *processes* evolving over time rather than distinctive events that can be categorised as being an act of shielding, nurturing or empowerment. In fact, we expect that most events, such as a governmental decision to provide funds for a demonstration program, or a firm deciding to setup an incubator unit, or environmentalist groups deciding to adopt a particular green technology, enable shielding, nurturing and empowering at the same time. From a process perspective (and constructivist ontology), however, nurturing, shielding and empowerment are distinctively different. Take the example of governments implementing a investment support program for demonstration sites. An analyst interested in shielding would question how such a support program came into place, who had lobbied for it, how, and so on. An analyst interested in nurturing would emphasise how the program enables the further growth of the niche, such as how it enables learning, or draws in new entrants. Finally, an analyst interested in empowerment will question how the establishment of the program is used by niche advocates to argue for more enduring forms of institutionalisation; mobilise the program as 'evidence' for maturing of the niche, and so on.

In sum, the literature notes how mainstream selection environments hinder path-breaking innovations. Because selection environments are multi-dimensional, path-breaking innovations require multi-dimensional forms of protection. These might be deliberately created spaces through innovation-specific public or private interventions (active) or generic spaces pre-existing mobilisation by advocates of specific innovations (passive). Whether passive or active, the function of such protective spaces in transitions to sustainability is to provide an environment where regime selection pressures are held off in a way that allows path-breaking innovations to be nurtured and further developed.

3. Nurturing path-breaking innovations in protective spaces

Whenever and wherever shields are mobilised or established, the space that becomes available provides an opportunity to nurture a path-breaking innovation. We define nurturing as processes that support the development of the path-breaking innovation. Ideas about nurturing emerging innovations in niches have been dealt with at length elsewhere in the literature. Here we provide a brief summary of two frameworks, i.e. the strategic niche management approach and the technological innovation systems approach. We summarise the TIS approach here for two reasons. First, the strategic niche management approach has until now focused on experimental projects as the main space for nurturing path-breaking innovations.⁵ The TIS approach has a more elaborate framework of processes for nurturing (Markard and Truffer, 2008).

⁴ 'We-want-sun' is a Dutch foundation established in 2010 to enable the uptake of solar energy without public support. The first 5000 solar panels have been installed in 2011. The initiative responds to cuts in government grants for solar panels.

⁵ The focus on experiments as main space for nurturing is because of the initial problem framing of strategic niche management research, which was interested in why many environmental innovations never make it to the market (Schot and Geels, 2008). Experimental projects in real-life contexts were seen to be critical in

Table 1
socio-technical selection pressures and protective space.

Regime dimension	Selection pressures	Logic of the need for protective space	Example of passive shielding	Example of active shielding
Industry structure	Organisational networks, industry platforms, user-producer networks, shared industry routines, labour force, capabilities, etc.	<i>Industrial protection:</i> path-breaking innovations do not fit into established industry structures; need for new capabilities; different user-producer relations and business models; shifts in resource allocation procedures	Solar PV firms mobilize actors outside the incumbent energy regime as initial customers, such as farmers, who are seeking to broaden their sources of income	Establishment of incubator units that are allowed to reside temporarily outside the more short-term oriented decision making processes within their mother-firms
Technologies and infrastructures	Technical standards, infrastructural requirements, etc.	<i>Technological protection:</i> prevailing technical standards and infrastructural requirements can disadvantage path-breaking innovations, which require different standards and infrastructures to technically and economically perform effectively and efficiently	Identification of places outside the current reach of existing infrastructures, like rural areas or islands, or 'developing countries'	Arguing for temporal exemptions of existing technological standards such as power quality standards
Knowledge base	Formal research programs and groups, review procedures and preferences of established journals, paradigms, etc.	<i>Socio-cognitive protection:</i> prevailing knowledge development is paradigmatic and institutionally organised in established journals, research departments and conferences, which disadvantages knowledge development for path-breaking innovations	Mobilising generic innovation support schemes for R&D like materials science research programs to work on solar PV cells	Implementing technology-specific R&D support schemes for solar PV
Users relations and markets	Market rules and institutions, user practices and preferences	<i>Market protection:</i> market rules and user routines and preferences associated with the prevailing regime disadvantages path-breaking innovations, which require different ways to organise market transactions and different user routines	Identifying environmentalists willing to pay higher prices and accept lower performance as early adopters of building-integrated solar PV.	Realizing support programs to lower investments of PV cells for households
Public policies and political power	Administrative regulations, policy goals, power relationships, policy guiding principles, etc.	<i>Political protection:</i> existing policies are optimised for the status-quo, which is enforced by political powers; regulations create a disadvantageous selection environment for path-breaking innovations	PV advocates using voids in regulatory frameworks, or re-framing PV to fit contemporary political objectives (such as jobs, economic growth)	Lobbying for explicit promises and claims about solar cells in political programs; or white papers
Cultural significance and associations of the regime	Media laws and preferences, symbolic meanings of technologies, cultural value of innovation, etc.	<i>Cultural protection:</i> widespread cultural legitimacy and symbolic representation associated with the prevailing regime disadvantages path-breaking innovations representing different values	Referring to prevailing environmental values of dedicated social groups such as environmentalists or civil society groups	Enacting new media discourses linking PV technologies with high-tech values in society

Second, as we will argue below, the framework developed here can contribute to expanding both these key frameworks in transition studies with the concept of empowerment.

The key niche nurturing processes in the strategic niche management literatures are: assisting learning processes, articulating expectations, and helping networking processes. A review of case studies (Schot and Geels, 2008) suggests that: (a) expectations contribute to successful furthering of the novelty when they are robust (shared by many actors), specific, and of high quality (substantiated by ongoing projects); (b) social networks contribute when their membership is broad (plural perspectives) and deep (substantial resource commitments by members); and (c) learning processes are broad, covering issues on a variety of socio-technical dimensions, not only accumulating facts, data and first-order lessons, but

bridging the infamous Valley of Death by bringing together actors from variation and selection environment in shared networking and learning activities.

also generating second-order learning about alternative ways of valuing and supporting the niche (Schot and Geels, 2008; Hoogma et al., 2002).

The current niche literature focuses on 'experiments' as key arenas for nurturing (Kemp et al., 1998). Experiments can be defined as 'initiatives that embody a highly novel socio-technical configuration likely to lead to substantial sustainability gains' (Berkhout et al., 2010). The path-breaking innovation is conceptualised to develop through the above relations operating across these located socio-technical experiments (Geels and Raven, 2006). Dedicated intermediating work is needed for interactive learning to take place, expectations to develop, and supportive networks to build (Raven et al., 2008; Smith, 2007). Niche theory currently claims that, in time, an innovation-specific proto-regime emerges that shields and nurtures that innovation more actively. In the current literature this process is considered to operate on two levels (Fig. 1). 'Local' relates to experimentation in specific places with local contexts, supported by local networks, and generating lessons accordingly.

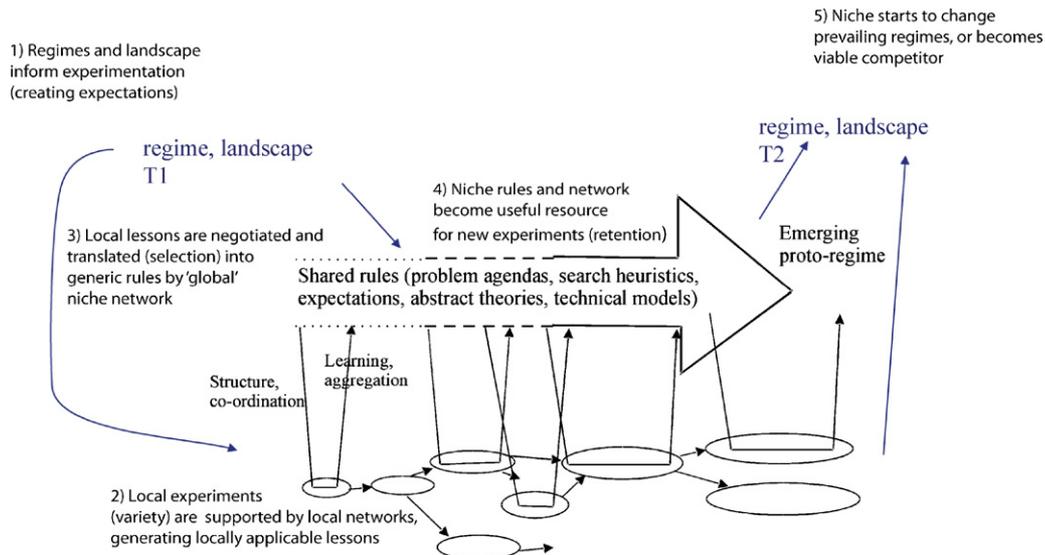


Fig. 1. Local-level and global-level niche development processes (adapted from Geels and Raven, 2006).

'Global' refers to an emerging institutional field or proto-regime supported by a network of actors that is concerned with knowledge exchange and resource flows transcending local contexts. This field is constituted by actors such as industry platforms, user-groups and other intermediary organisations and operate partly autonomous from local experiments (Grin, 2010).⁶

Recently the literature on technological innovation systems (TIS) has further increased our understanding of nurturing path-breaking innovations from a systemic perspective. A TIS analysis usually involves the identification of an emerging system in terms of its actors, networks and institutions; an analysis of the 'functions' or 'processes' occurring within that system in terms of knowledge development, resource mobilisation, market formation, influence on the direction of search, legitimisation, entrepreneurial experimentation and development of positive externalities; and on the basis of these analyses a normative assessment of the performance of the emerging system, critical inducement and blocking mechanisms, and key policy issues (Bergek et al., 2008).

The TIS approach distinguishes between two main stages of system evolution (Jacobsson and Bergek, 2004). The 'formative stage' is characterised by relatively long development periods (rarely shorter than a decade), substantial (technological and market) uncertainties, underdeveloped price/performance ratios of products, relatively small volumes of production and economic activities (compared to estimated potentials), unarticulated demand and an absence of self-reinforcing features (Bergek et al., 2008). In this phase technology-specific systemic structures (actors, networks, and institutions) need to be put in place and aligned. Dedicated knowledge creation, (early) market experimentation and formation, entry of firms and gaining wider legitimacy for the technology through the formation of advocacy coalitions are at the heart of the formative stage. This formative stage can be considered to cover a similar stage and dynamic as the emergence and stabilisation of a global niche shown in Fig. 1. The formative stage needs to be followed by a 'growth stage', in which 'the focus shifts to system expansion and large-scale technology diffusion through the formation of bridging markets and subsequently mass markets' (Bergek et al., 2008:420). The dynamics of this stage has received less

attention in the TIS literature compared to the formative stage, although progress is being made through the concepts of positive feedback loops, cumulative causation and identification of different 'motors', which are about identifying patterns in interactions between functions that set the stage for a subsequent growth stage (Jacobsson, 2008; Suurs, 2009).

While the TIS framework provides a detailed framework for understanding *nurturing* of innovations, the actual success of innovations is mainly regarded as a consequence of the performance of the innovation system itself. As such, it is 'inward looking, and does not pay much attention to the system's environment' (Markard and Truffer, 2008, p. 610). Consequently, from the perspective developed in this paper, TIS approaches arguably underplay the *shielding* of emerging innovation systems against mainstream selection pressures, and are only able to study the internal consequences of dynamics in the wider selection environment upon an emerging system. In other words, TIS tends not to highlight the interplay between the wider selection environment of an emerging system and internal system dynamics as an endogenous explanation in the emergence of that system. Similarly, despite its distinction between a formative stage and a growth stage, a TIS analysis will find it difficult to explain mass-market diffusion of path-breaking innovations, because that would inevitably involve many interactions between an emerging system and its environment. In other words, 'an innovation systems approach is myopic with regard to the explanation of technological transitions' (Markard and Truffer, 2008, p. 610).

Illustrative of this is a study by Jacobsson and Bergek (2004) into the relatively successful German PV sector. What is particularly striking is how much TIS-building was actually enabled and operated through political processes. Actors had to respond to and shape the contexts in which they were doing their system building. Regulatory frameworks had to be institutionalised so that firms would develop PV. The associated 'costs' were legitimised through arguments about realising wider social and economic values (such as jobs, energy security, addressing climate change, an alternative to nuclear power), and which would otherwise remain ineffective externalities in conventional energy markets. This involved researchers, firms, lobbyists, environmentalists and politicians turning to the state for policies that would empower their case: first research programmes, then industrial policy, and later market deployment through energy policy. Jacobsson et al. conclude (p. 24), '[N]ew technologies need to be given a 'space' in

⁶ For a more fragmented and contested view of niche development, compared to the ideal 'arrow' of development and institutionalisation implied in Fig. 1, see Smith (2007) and Jørgensen (this issue).

which a learning process can take place'. Yet their study does not really analyse the relationships between the development of these spaces and the innovation within (cf. Dewald and Truffer, 2012). The same can be said for the niche literature: it is unclear precisely how niches compete and transform incumbent regimes (Smith, 2007). Empirical studies are highlighting the importance of (institutional and political) dynamics in the *empowering* of path-breaking innovations, without critical reflection on what empowerment entails (Jacobsson and Lauber, 2006; Hellsmark, 2010; Avelino and Rotmans, 2009). It is here that both the strategic niche management and TIS literatures need to develop their theory, and where we offer an initial analytical contribution.

4. Empowering path-breaking innovations

There is currently some confusion in the niche literature regarding protective spaces, empowerment and the transformation of selection environments.

On the one hand, protective spaces are 'temporary' sites that are conditional upon improvements to the innovation being nurtured in that space. As niche innovations are nurtured into forms that become competitive under conventional, incumbent regime terms, so the protective shields become redundant and can be removed, and niche innovation is 'empowered' in the sense that its developing competitiveness enables increasingly widespread diffusion. The implication is that the niche innovation is developed in such a way that it fits into and conforms to a relatively unchanged selection environment. This, we label as *fit and conform empowerment*, and define it as processes that make niche innovations competitive within unchanged selection environments.

On the other hand, the institutionalisation of some niche practices within a reformed regime is also advocated in the strategic niche management literature. This suggests some features of the niche space are institutionalised as new norms and routines in a transformed regime. Here, the niche is empowered by enabling it to change its selection environment, rather than be subordinated by it. This, we label as *stretch and transform empowerment*, and define it as processes that re-structure mainstream selection environments in ways favourable to the niche.

We elaborate on both forms of empowerment in the next sections.

4.1. Empowering to fit and conform

Fit and conform empowerment makes the niche innovation competitive with mainstream socio-technical practices in otherwise unchanged selection environments. An innovation that is originally perceived as potentially path-breaking becomes incremental in terms of its broader socio-technical implications. This is not a problem on narrow socio-economic terms, because the cumulative economic impact of incremental innovations is considered large, if not larger than more disrupting forms of innovation (Lundvall, 1992; Fagerberg, 2006). From the perspective of transitions to sustainability, however, there are at least two challenges related to fit and conform empowerment.

First, ironically, the processes in protective spaces that empower innovations to become more competitive in conventional regime terms, such as improved alignment with existing industrial norms or structures, can actually by quite *disempowering* in terms of *sustainability*. There is always pressure for sustainable innovations to become competitive on the more narrow economic, technological, organisational and other criteria of existing markets, compared to the broader sustainability values that might originally have motivated the innovative effort. Moreover, even if cost reductions are realised while maintaining sustainability performance

improvements, aggregate rebound effects and economic growth can counteract these relative performance improvements in the long run (Sorrell, 2009; van den Bergh, 2011; Jackson, 2009). As such the sustainability of the innovation itself is reduced through this pressure to fit and conform.

Second, providers of protective shields might find it challenging to govern the performance improvements that allow protections to be removed. This is most vividly illustrated in the infant industry literature (Chang, 2002; Bell, 2006; Cimoli et al., 2009; Gallagher, 2006; Jacobsson and Alam, 1994; Bastos and Cooper, 1995), whose concern for protective spaces are shared with niche-based approaches to sustainability (Caniëls and Romijn, 2008).⁷ A complementary to fit and conform empowerment in the context of sustainability transitions is, therefore, the development of (1) institutional reforms that transform incumbent regimes; and (2) political capacity to avoid protective space becoming captured by sectional interests, and to ensure protection stimulates the dynamic accumulation of innovative capabilities for sustainable development (Wade, 1990; Nill and Kemp, 2009).

4.2. Empowering to stretch and transform

The above implies a second form of empowering, i.e. stretch and transform. In this case, empowering innovations aims to undermine incumbent regimes and transmit niche-derived institutional reforms into re-structured regimes. Niches influence their selection environments and thereby favourably affect the subsequent evolution of sustainable niche-derived innovations.⁸

The process and content of stretching and transforming will not be entirely internal to the niche, but will rely upon other processes of change within the regime and in the broader society and economy. Important considerations here are the general influence that sustainability advocates have in the institutionalisation of environmental values and social justice in society and in their influence over political economy (Lang and Hines, 1994). Empowered niches play a role in those politics as emblems for more sustainable alternatives, and as such they can inform processes of institutional reforms, even if they rarely drive those processes (Smith et al., 2005). Niche advocates have to come to present a realistic resolution to instabilities, conflicts and tensions experienced by actors within regimes; such that institutionalising niche practices, rather than continuing with the routines in socio-technical regimes, becomes accepted by a sufficiently powerful coalition capable of bringing the changes about.

It is possible to observe this process as niches mature and become more established. Solar PV advocates have been able to tap into wider social movements for low carbon energy, anti-nuclear sentiments, and policy elite interest in ecological modernisation and the development of green economies and jobs. A well known example is the German feed-in tariff, which 'may well be seen as the first sign of a breach into an old structure' (Jacobsson and

⁷ In this literature, the nurturing of infant industries to maturity involves their initial protection with a view to accumulating innovation capabilities that allow the (subsequently unprotected) sector to compete internationally. The more disappointing experiences with import-substituting industrialisation, however, show that protected industries might be captured by those interested in perpetuating the rents accruing to under-performing firms in that space, without further improving the capability for competitive innovation. Historical experience indicates how difficult it can be for governments to credibly compel protected firms to learn and acquire new innovative capabilities, and that even well-intended governments can find it hard to independently withdraw public protection from infant industries that are not improving (Schrank, 1997). This might be because those industries have become politically significant constituencies for them to be abandoned (e.g. important for the labour and/or capital interests upon whom government elites are dependent).

⁸ Evolutionary biologists and ecosystems ecologists note similarly conscious phenomena in the natural world (Day et al., 2003).

Lauber, 2006, p. 272), and is the outcome of networks of (industrial, administrative and grassroots) advocates accumulating the political power to overcome the defensive strategies of the established network of German utilities, the Ministry of Economic Affairs and DG Competition (Dewald and Truffer, 2012). Success is not guaranteed, however, as critical debates about reversals in policy towards PV in Germany and elsewhere illustrate.

'Stretch-and-transform niches' will create capabilities and attract resources that empower participation in political debates over the future shape of institutions and regime selection pressures. Such institutionalisation of niche practices is advocated in the strategic niche management and TIS literature, but the processes of institutionalisation have not been systematically interrogated (Smith and Stirling, 2010). Stretch and transform empowerment will include 'control' policies such as environmental regulations, fiscal measures or quotas, which incline (regime) actors more favourably towards investment in niche solutions. Reforming institutions or creating new institutions requires power, expressed through the mobilisation of material and nonmaterial resources, and collective action capable of shaping norms, standards and routines in transformed regimes (Rhodes and Marsh, 1992; Smith et al., 2005; Avelino and Rotmans, 2009).

At this point, it is important to recognise that niche empowerment can be problematic when, rather than removing redundant protections or institutionalising productive 'protection', it actually results in *protectionism*. Protective measures can be captured by actors who are neither interested in making the niche more competitive nor empowering it to be part of a wider regime transformation. Rather, niche actors seek to retain the benefits of protective measures such as price supports unconditionally.⁹

It is this risk of protective space becoming an institution that shields poor innovation that underpins the critique of niche approaches made by Hommels et al. (2007). The relations between protective space dynamics, niche innovation, and regime transformation are neither linear nor unproblematic. The extent to which certain social actors capture these processes for sectional interests – whether as incumbents (as discussed above) or proponents of alternatives – depends upon the power relations between the different actors and the way a wider politics of the public good holds them to account. We turn to this politics, and the possibilities and limits for sustainability niches to exercise such agency in the next section.

5. Agency, politics and narratives in protective space dynamics

So far, we have identified three properties of protective space – shielding, nurturing and empowering. Seeing protective space as something functional to the evolutionary imperatives of niche development, and that ought to shield, nurture and empower in

certain ways for sustainability transitions, appears reasonable from a managerial perspective or outsider ontology that is confident in 'objective' measures of sustainability, niche performance, and regime status (Garud et al., 2010; Smith and Stirling, 2007).

However, empirical research demonstrates how challenging it is to develop these measures and properties in practice: ideas for how protective space *ought* to operate soon encounter confounding and conflicted realities (Lovell, 2007; Voss et al., 2009). An empirical focus on niche actors, and 'the melee of real-life dynamics, interactions, and of everyday practice' (Leach et al., 2007, p. 24; Hughes, 1983), soon indicates why any protections secured often tend to be incomplete or insufficient, from the perspective of niche advocates and strategic managers, and as a result have consequences for the development of socio-technical alternatives that fall short of their ideal (Smith, 2007; Romijn et al., 2010). Analysing and theorising the dynamics of niche-based approaches to sustainability transitions has to be complemented with an insider ontology that emphasises the embedded agency of actors involved in both niche construction and regime reproduction (Garud et al., 2010; Zietsma and Lawrence, 2010; Smith and Stirling, 2007).

Moreover, such a perspective also has to be politically informed because, ultimately, niche agency results from sense-making advocates with uneven access to resources who try to influence powerful actors in different institutional positions and who often frame sustainability challenges and innovative solutions very differently. As such, niche protection is about power and antagonisms, and it is this that makes it political (Mouffe, 1996).

So, in this section we explore how agency and politics play out in protective spaces. We see agency as the result of a collective and embedded capacity and hence developed and reproduced through actor networks. We explore what this means for the politics of niche protection, in which collective industrial and public policy support is secured for niches in the context of historically powerful incumbent regimes. Following recent literature on institutional change and network governance we will focus on narratives as a key political strategy to argue for empowering institutional reforms. Hence, this section involves thinking in a more networked and discursively argued way compared to our more evolutionary representations of protective space in the preceding sections. We will focus here on empowerment, as this is the least developed element of protective space processes.

5.1. Local-global agency and empowerment of protective spaces

Actor-oriented perspectives on niche development have tended to focus on relations between 'local' networks of socio-technical experimentation in specific project locations, and 'global' networks for converting that experience into more generic, mobile processes and norms, and which make subsequent projects relatively easier to re-apply in a growing variety of locations (Geels and Deuten, 2006; Geels and Raven, 2006; Law and Callon, 1994; see Fig. 1). Locally, networks of actors negotiate the design and outcomes of specific projects and produce and make sense of locally applicable lessons. Global actor-networks support the exchange and interpretation of specific lessons and experiences across local projects, negotiating the codification and standardisation of that knowledge; negotiating and contesting which are the most appropriate evaluative criteria in markets, firms, policy arenas, R&D departments and so on.

We add that especially in the case of empowerment global networks have an additional role to play if these processes are to persist, which is to secure the flow of resources that underpin these local-global processes. This requires commitments from actors in the wider social world. So in addition to *inward-oriented* network activities aimed at the practical development of a socio-technical configuration, global networks are also engaged in

⁹ The same is true for regime actors. Regimes benefit from accumulated privileges that actually act as a form of 'protection'. Current fossil energy regimes, for example, have protective subsidies and other advantages institutionalised within them. Although estimations differ widely, energy regimes have been reported to benefit from various direct and active protection in the form of subsidies and other public policies (Steenblik, 1995). Recently, the International Energy Agency estimated that global fossil fuel consumption subsidies amounted to \$312 billion in 2009 compared to \$57 billion for renewable energy. Research funding for fossil fuels over the past 10 years has mounted to \$22 billion, compared to \$17 billion for renewable energy and energy efficiency and \$56 billion for nuclear energy research (IEA, 2011). More generally it has been estimated that between 1994 and 1998 over US\$ 1 trillion was spent worldwide on subsidies that potentially harm the natural environment (van Beers and van den Bergh, 2009). Though perhaps originally institutionalised for good reasons at the time (e.g. cheap fossil fuels as a way to further economic development and social welfare), these regime privileges effectively disadvantage development of alternatives, like solar PV.

outward-oriented activities of representing, promoting and enrolling support for that development.

Global networks enacting empowerment processes might, for example, try to shape expectations about what constitutes 'good' or 'promising' performance for the purposes of continuing socio-technical development. Thus advocates of solar PV repeatedly argue that static, narrowly framed cost-benefit comparisons of their technology with conventional electricity generating technologies overlooks a host of more dynamic social and economic benefits. So, for example, advocates argue PV is advantageous because it provides energy security, diverts payments to distant generators, keeps wealth in local economies, and addresses a host of environmental issues.

Under this view, protective space is constructed through a form of boundary work, in which global networks develop a repertoire of narratives involving socio-technical representations to key, resourceful audiences in the wider social world, and rendered credible (or not) by drawing upon local network experiences (Law and Callon, 1994; Gieryn, 1983; Star, 2010). The niche literature views that wider social world as involving relatively more institutionalised regimes, compared to the more inchoate socio-technical configurations developing through local-global networks in niche protective spaces. The question becomes one of how that boundary between niche context and content is negotiated and transformed productively over time, such that a weakly institutionalised niche socio-technical development exerts influence over much more institutionalised socio-technical regimes.

In practice, the possibilities to enact empowerment processes will be distributed unevenly within and beyond global networks advocating certain niche innovations. Moreover, there will be disagreements over which institutional reforms should be prioritised. There can be disputes amongst advocates within a particular niche network over how best to advance future niche development, and what forms that development should take in order that the innovation will flourish. There are also contests between different niches over which should receive greater and more targeted support. All this is taking place within the context of a historically privileged regime, which holds the authority to arbitrate and the power to provide protective support. To this we turn in the next section and elaborate the politics of protection as a discursive process.

5.2. The politics of empowerment as a discursive process

Empowerment is a political process, because it is characterised by the outcomes of multiple interdependencies operating within and beyond the global networks identified above (Wilks and Wright, 1987; Smith et al., 2005; Kooiman, 2003). Each actor participates in, responds to or counteracts an emerging global network in different ways and with different purposes, holding different interpretations and interests in the situations across which the niche develops, and offering or withholding resources of varying significance to the future directions of niche development. Not all actors enter into these negotiations equally: some are able to exercise greater influence owing to their resource attributes, experience, institutional positions, and connections with other influential actors, all relative to the task in hand; but neither does any single actor, such as an industrial lobby, or a government department, have sufficient power to force through decisions, strategies, and implementation activities unilaterally (Stoker, 1998; Rhodes, 1997). These politics will be most prominent in processes of stretch and transform empowerment, because here global networks are trying to realise institutional reforms from a position where privilege and power resides beyond the niche itself.

To understand these processes, we note how recent literature in institutional change emphasises the significance of discursive strategies and narratives. That literature addresses a challenge of

embedded agency similar to the one concerning us here: one in which change agents are trying to influence a situation in which actors' thoughts and actions are constrained by incumbent institutions (or, in our case, regimes) (Zietsma and Lawrence, 2010). Discursive processes are considered important in this literature, because they underpin both the durability and change of institutions (Phillips et al., 2004).¹⁰ It locates important change processes as resting in actors strategically re-telling the past to make new sense of the present and envision alternative futures (Hardy and Maguire, 2010; Garud et al., 2010, this issue). Actors develop *narratives* in an attempt to reshape perspectives and patterns of social action and enable institutional reforms.

Diversity in and competition between narratives is likely to exist, because in the case of emerging protective spaces institutions are weak or institutional voids might exist (Hajer and Wagenaar, 2003). In such situations, different global networks are producing narratives on the basis of different niche experiences, with different purposes, and for different audiences in different contexts. Actors produce, exchange, consume and negotiate these narratives in a variety of locations, such as trade shows, academic and professional conferences, governmental hearings, user group sessions, online-forums, the media, and other potentially influential events, where some might come to dominate, constituting institutionalisation (Lampel and Meyer, 2008; Hardy and Maguire, 2010).

In short, narratives are key political devices used by global actors to argue for niche-derived (yet contested) institutional reforms or claim present-day competitiveness within unchanged selection environments. In the next section we hypothesise on some of the characteristics of political narratives we expect to find in empowerment processes (Section 5.3), and contrast fit-and-conform narratives with stretch-and-transform narratives (Section 5.4).

5.3. Narratives of empowerment

Within the diversity and fluidity of actor-networks generating and enacting multiple narratives, and considering empirical studies in the niche literature, we expect three over-arching themes to be central to the plurality of narratives negotiating and contending empowerment.

First, *positive expectations* about the future as a justification of the niche are a central element in the narratives employed by global networks seeking empowerment (Brown et al., 2000; Basalla, 1988; Battilana et al., 2009). Expectations and lessons about the niche are argued and mobilised in a socio-political sense, rather than only in a socio-technical sense, in order to expand, adapt or withdraw protective/institutional concessions from key actors (Konrad, 2006).

Second, narratives will also include claims for present-day niche friendly *institutional reforms* (stretch and transform) or *competitiveness claims* within unchanged selection environments (fit and conform). Discursive strategies for institutional reforms are more

¹⁰ When actors engage in social action, their behaviour might be observed, interpreted and mimicked by others. This results in the 'enduring social patterns' (Zietsma and Lawrence, 2010, p. 189) that constitute institutions (i.e. as more and more actors mimic and converge their actions, i.e. when actors accept a shared definition of social reality, and mechanisms of conformity come into place). Obviously, direct observations 'do not easily allow for the multiple readings by multiple individuals' necessary for widely diffused social action and hence institutions (Phillips et al., 2004, p. 638). 'Texts' such as written documents and other kinds of reports of social action accessible to others (including talk, artwork, pictures, movies, etc.) allow for a far broader diffusion. As actors produce, distribute and consume texts, they enable social action to transcend the situated character of social processes and cut across separated and diverse local settings and times. In short, social action leaves traces in texts, which enable the repetitive and shared behaviours to spread across space and time, and therefore institutionalisation.

likely to involve broader issues and problem frames, and relating (simplified) representations of the innovation in relation to them, as a part of a solution to broader social, environmental and economic challenges. That means niche actors inserting the niche into broader policy discourses about institutional reforms for sustainability. Such activity takes on a variety of practical forms, including the lobbying of politicians, participation in government task forces, media promotion and other opinion forming activities (Hajer and Wagenaar, 2003). Arguments about green jobs and growth through ecological modernisation discourses are increasingly harnessed to elaborate positive expectations for many sustainability niches (UNEP, 2011), but alternative discourses concerning new sustainability economics and politics are also available and used (Raskin et al., 2002; Jackson, 2009).

Third, narratives are deployed that *challenge the regime*, emphasise contradictions within regime socio-technical dimensions, and emphasise opportunities arising from alternatives. The fossil-fuel regime is re-framed away from historic associations with cheap, plentiful and convenient energy (for the final consumer, at least), for instance, in such a way that emphasises climate change, emissions reduction requirements, energy security, and so on, and tailored to the concerns of, say, insurers and investors about new risks and reduced profitability in the future. Simultaneously, renewable energy niche actors, such as PV advocates, re-cast their niches as promising opportunities under the new context of mitigating climate change and addressing energy security. Such narratives present the niche-innovation in a favourable, problem-solving light, and serve the purpose of elaborating why it merits support from resourceful actors.

In sum, negotiating protective spaces involves the inter-related contention of narratives over (a) positive expectations about the future that justify the niche to wider audiences; (b) explicit claims for present-day niche friendly institutional reforms (or claims of present-day competitiveness within unchained selection environments); and (c) statements that re-frame the past to challenge the prevailing regime in ways that emphasise future opportunities for the innovation (and statements that defend regimes). In the final sub-section we illustrate how the constructivist perspective above can be brought into correspondence with the more evolutionary perspective earlier. Whilst these two approaches are rooted in contrasting ontologies, we do think that the consequences of actor-networks and their narratives can be interpreted helpfully in the light of the fit-and-conform and stretch-and-transform patterns discussed in Section 4 (cf. Geels, 2010).

5.4. Fit and conform versus stretch and transform narratives

The different forms of niche empowerment introduced in section four – fitting and conforming cf. stretching and transforming – imply two different patterns of political narratives for niche actor-networks, exercised in contrasting arenas, with potentially very different outcomes in terms of form and function of the emerging socio-technical system, who holds control and what sustainability criteria are maintained.

The objective in *fitting and conforming* is to convince the wider social world that the niche can become competitive on conventional, regime criteria. That is, it will perform profitably in existing markets, and does not require *radical* changes to institutions, infrastructures, skills and knowledge bases, user relations, etc. As such, the outward oriented strategic work of actors constituting the global niche is to codify and represent promising improvements in performance. Shielding measures will be represented as temporary, and nurturing processes will value lessons that direct development towards enhancing competitiveness. The audiences for this work will predominantly be related to existing industrial bodies, sponsoring government ministries, institutional investors committed

to the regime, standards institutes, and so forth. The political arenas would therefore be those normal industrial and policy-making networks dedicated to the reproduction of the regime, and the representations of the niche would seek to standardise and extrapolate developments on terms familiar to those arenas. The conditions attached to increased resource flows into the niche for its further development would be along regime lines.

The objective in the *stretching and transforming* form of niche empowerment is to convince the wider social world that the rules of the game need to be changed. The selection pressures constituted by prevailing regimes need to be transformed in order that niche-derived forms of sustainable solutions may flourish. Of course, the promise of the niche has to have considerable appeal in order to instil confidence and commitment to the broader sustainability vision which it embodies, but niche performance and legitimacy will be judged against sustainability criteria rather than the status quo. As such, the outward oriented political work of niche actors is to argue for institutional reforms and suggest the niche could realistically make the new institutions operational and effective. Shielding measures will be represented as manifesting widely desired sustainability criteria and requiring institutionalisation, and nurturing processes will value lessons that direct development towards improving sustainability. The audiences for this work are more likely to be civil society organisations, political parties, opinion formers in the media and education, trade unions, institutional investors, sectors that might benefit in an opening and re-configuring of the regime, and so forth. The political arenas would therefore be discourse coalitions and political formations that debate and mobilise around societal changes like sustainability that are lobbying for institutional reforms already, and that can see the appeal in material and practical (niche) expressions of their vision. The conditions attached to increased resource flows to the niche would be that it can make more manifest and credible the reforms being called for.

Both forms of narrative are evident in the case of solar PV, where different global networks are pursuing fit-and-conform and stretch-and-transform strategies with consequences for the kinds of socio-technical configuration that would result. In the case of fit-and-conform, solar advocates are arguing that large solar arrays, especially in locations with high-solar incidence, are providing scale economies that will result in grid-parity with conventional electricity generating technologies. Utilities, institutional investors, and energy policy-makers are being targeted and encouraged to back the expansion of this centralised form of PV socio-technical configuration providing large (MW) electrical capacity to grids at competitive prices.

In contrast, a stretch-and-transform narrative argues small solar PV units (kW capacity) across hundreds of thousands of buildings can facilitate a transition to much more decentralised electricity systems. This form of socio-technical configuration involves households, community groups, new energy companies, as well as utilities with new business models, all becoming producer-consumers in this new energy system. At the more politically radical end of this narrative, solar PV is seen as an important component in sustainable energy citizenship over democratically controlled energy systems (a narrative that has a long pedigree in energy politics – Lovins, 1977). Advocates target this stretch-and-transform narrative towards actors who might help build a social movement for new energy institutions, infrastructures, and markets that would make their decentralised vision viable. This audience includes civil society groups, businesses, co-operative societies, politicians, energy ministries, local governments, households, neighbourhood associations, and investors.

Of course, as the preceding sections emphasise, solar PV niche actors will continue to debate and develop these different narratives and strategies. Different coalitions may pursue one or

the other, or both, and the innovation of solar PV will fragment along conforming and transforming pathways (cf. Smith, 2007). These developments need not be antagonistic, in the sense that some socio-technical elements common to both will benefit either way. Each actor participates in, responds to or counteracts these narratives in different ways and with different purposes, holding different interpretations and interests in the situations across which the niche develops, and offering or withholding resources of varying significance to the future directions of niche development.

6. Conclusions and outlook

The aim of this paper was, first, to understand and analyse the dynamics of protection in sustainability transitions in a more systematic way, and, second, to propose how agency and politics might be captured in this framework. Only in-depth empirical work will reveal just how helpful our conceptual discussion is about the constitution and consequences of protective spaces in sustainability transitions, and the proposal for analysis to move between insider and outsider ontologies.

In our framework, protective space dynamics exhibit three functional properties in relation to wider transition processes: shielding, nurturing and empowerment. Shielding involves processes that hold off selection pressures in the context of multi-dimensional selection environments (industry structures, technologies and infrastructures, knowledge base, markets and dominant user practices, public policies and political power, cultural significance). Nurturing involves processes that support the development of path-breaking innovation within passive and active shielded spaces through the development of shared, positive expectations, social learning and actor network building (SNM) or the development of system structures and functions (TIS). Empowering involves processes that make niche innovations competitive within unchanged selection environments (fit and conform) or processes that change mainstream selection environments favourable to the path-breaking innovation (stretch-and-transform). Relationships between shielding, nurturing and empowerment can be understood as an iterative process: initial, passive protection enables early nurturing of the innovation, whose promise (if successful) empowers niche advocates to obtain more active protective measures, that assist in further nurturing, greater empowering, and eventually the institutionalisation of the innovation within a transformed selection environment.

Taking an 'outsider ontology', that views the niche as an object to be developed, a managerial perspective would seek to govern protective space through 'improving' the above kind of processes.

Adopting an insider ontology, by contrast, the analyst considers these processes as *potentially* emerging through the agency of advocates of a 'niche' socio-technical configuration. The politics of trying to construct shielding, nurturing and empowering through multi-actor relationships indicates the task will be far from an orderly, singularly rational management task. Diverse claims on the forms, focus and application of protections are likely. We identified narratives as key to the politics of protective space. We proposed that narratives for empowerment will show a number of characteristics: (a) positive expectations about the future that justify the niche to wider audiences; (b) explicit claims for present-day niche friendly institutional reforms; and (c) statements that re-frame the past to criticise the prevailing regime in ways that emphasise future opportunities for the innovation. Depending on whether niche actors are seeking a fit-and-conform pattern or a stretch-and-transform pattern this will entail different political narratives for different audiences.

Our systematic conceptualisation of protective space plus our propositions concerning the roles played by actor-networks

and narratives in constructing actual spaces underscores several avenues for empirical and theoretical research. First, more systematic attention can be given to understanding how niche advocates mobilise existing or create new shields against mainstream selection pressures. In the context of dynamic and multi-dimensional selection environments, future research could explore niche development by analysing advocates of path-breaking innovations and the strategies they deploy for mobilising passive spaces and creating active protective spaces through time. A 'linear' view would be one where advocates are first able to mobilize and shape shielded spaces in R&D environments, then move to mobilise and industrial protective space, followed by more regular market niche spaces and finally are able to mobilise and shape spaces in relation to infrastructural requirements, public policies and political power and the cultural significance and associations of the regime. However, we think more diverse and non-linear developments should be expected, depending on the ability of niche advocates to mobilise whatever spaces are at hand and on success and failure rates of nurturing the innovation within those spaces (cf. Geels and Raven, 2006). Such research would move beyond narrowly defined diffusion processes (through market niches) as well as broaden the scope of the niche development literature.

Second, new research might study in detail the process of empowerment in different cases, including cases in which actors seek to fit-and-conform as well as cases where actors seek to stretch-and-transform prevailing selection environments. While earlier niche literature identified a fit-and-stretch pattern as an important dynamic of regime shifts (Hoogma et al., 2002), a more detailed analysis of the underlying actor networks and their political and narrative strategies is needed. Moreover, while the two broad patterns are analytically attractive, we expect in empirical work to find a more messy and dynamic reality, in which different actor networks debate different adaptations to niche innovation under different regime circumstances (cf. Smith, 2007). It is here where a more sophisticated analysis of political narratives becomes helpful by providing an agency-based and politics-informed framework for understanding shifts in the resource interdependencies that drive niche development.

Finally, dynamic relationships between variation, selection environments and the emergence of new technological regimes are relevant to evolutionary perspectives in innovation studies generally. A recent review of research concluded little progress in understanding the emergence of new technological regimes (Von Tunzelmann et al., 2008). Whilst innovation studies is generally more interested in markets than sustainability, it nevertheless involves debates about marketing strategies, patterns for accumulating capabilities (and profits), negotiating collaborative and competitive networks, and so on. Perhaps in forms less obvious than for sustainability, and often on narrower technological grounds, these are normative debates about which kinds of innovation are desirable and the direction of future selection environments. The arguments in this paper might consequently stimulate debate about protective spaces in the transformation of selection environments more generally.

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