Volume 30, Issue 4

Socio-technical transition pathways and social networks: a toolkit for empirical innovation studies

Piergiuseppe Morone
*Department of Economics, Mathematics and Statistics-
The University of Foggia*

Antonio Lopolito
Faculty of Rural Studies - The University of Foggia

Abstract

In this note we investigate socio-technical transition pathways concentrating our attention on innovation niches formations. Specifically, we present a methodological conceptualization of innovation-niches and propose a preliminary protocol, based on a Social Network Analysis (SNA), aiming to capture and measure the internal status of niches. The suggested protocol provides a toolkit with insights on three SN concepts which can be used to study and measure the evolution process of technological niches. This allowed us to suggest a set of possible policy actions, which derives directly from the conceptualisation of innovation-niches propose in this paper. Although preliminary, we believe this study represents an important step in a much-needed direction, which is science-policy interface in socio-technical transition studies.

1. Introduction

The management of technological progress is a long-standing question. Historically, there are two main policy concerns in this field: first, to control the possible deleterious effects of new technologies and second, to encourage the development of technologies which bear wider social benefits (Bauer, 1995). In various periods and in various places such concerns have assumed several forms, such as social equity (Elliot and Elliot, 1976), gender equality (Wajcman, 1996), or reduced unemployment (Freeman and Soete, 1987). More recently, the concept of environment has also gained momentum among scholars and policy makers, and entered the technological change discourse (Berkhout et al., 2003).

In order to understand the process which, eventually, might lead to a technological transition some scholars have developed the so-called multi-level approach (Kemp, 1994; Schot et al., 1994; Rip and Kemp, 1998; Kemp et al., 1998; Van den Ende and Kemp, 1999; Geels and Kemp, 2000; Kemp et al., 2001). Such approach defines three levels of interaction - micro, meso and macro - through which the management of technological change is undertaken. These levels are named respectively: innovation-niche (micro), socio-technical regime (meso) and the socio-technical landscape (macro). The transition takes place when the existing socio-technical regime is replaced with a new one (Geels and Schot, 2007). The multi-level approach (MLA) helps in defining the interaction across different levels which leads to the transition. It highlights that transition take place only when some pre-conditions for change are met. First of all, changes at the landscape level (that forms the exogenous environment which is beyond the direct influence of regime actors) should create an adequate pressure upon the existing regime. Another crucial element is that an innovation-niche (that is the source of radical innovations) has sufficiently developed. Under these circumstances the emerging niche can replace the existing regime. In other words, transition occurs at the meso level and is affected by changes at the micro and macro level.

In this paper we concentrate our attention on the micro level, as we believe that in order to understand and manage the transition's trajectory, the internal conditions and the niche status need to be properly investigated. Some efforts have already been made in this direction. The Strategic niche management (SNM) is a recently developed technique that focuses on the study of success and failure of experiments with sustainable radical innovations. Such approach proved to be quite useful in providing a general theoretical framework of analysis. However, its empirical applications appear to be too concentrated on specific case studies and too descriptive in nature (Caniels and Romijn, 2008). In our view, such studies failed to analyse properly the micro level determinants of niche's mechanisms that are crucial in the transition processes.

In order to overcome this gap we propose an empirical protocol, based on a Social Network Analysis (SNA), able to capture and measure the internal status of innovation-niches. The suggested protocol, albeit preliminary, provides a toolkit with insights on three SN concepts which can be used to study technological niches, on the associated indexes as well as on the best way to gather adequate data to calculate such indexes.

The work is structured as follows: in section 2 the internal mechanisms required to promote the emergence of a new niche are explained. Section 3 focuses on the development of a set of indicators able to capture such internal mechanisms. A summing up section concludes the work.

2. Defining innovation niches

Innovation-niches can be conceived as "protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology, and (2) enhancing the further development and the rate of application of the new technology" (Kemp et al., 1998: 186). We can see niches as 'incubation rooms' for novelties because they are protected or insulated from normal market selection in the regime (Schot, 1998). Their operation relies on the provision of locations for

learning processes; the provision of spaces to build social networks which support innovations (e.g. supply chains, user-producer relationships, see Kemp et al., 1998; Geels 2002); the fostering of convergence; and the alignment of expectations (Hoogma et al., 2002).

As discussed earlier, several scholars have developed a strategic niche management approach (Kemp et al., 1998; Kemp et al., 2001; Hoogma, 2000), arguing that the niche formation process follows three fundamental mechanisms that would correspond to the willingness to act, the power to act and the knowledge to act.[1] In what follows we shall analyse these three mechanisms in detail.[2]

2.1 Mechanisms for the emergence of innovation-niches

The *willingness to act* depends upon the convergences of actors' expectations towards a common view. One of the main barriers to the adoption of a new technology is that its advantages are not clearly understood by all possible adopters as actors decide to take part in projects on the basis of their expectations. More specifically, diverging expectations can affect the way goals are defined and prioritised (Kemp et al., 1998; Van der Laak et al., 2007). This initial obstacle can be overcome only through the development of a robust and shared vision among the actors potentially involved. Such convergence provides the willingness to act that, following Raven (2005), legitimates actors to invest time and resources into a new technology that does not yet have any market value.

Once the required level of willingness to act is reached, involved actors need an adequate level of *power to act*. This issue concerns the second niche formation mechanism which involves a networking process. Considering the niche as a small network of dedicated actors (Geels and Shot, 2007: 400), it is fundamental for its formation and evolution that powerful actors join the network. Their support is crucial to gather and mobilize the resources required to guide the technical change in a desirable way.[3] Niche members can be seen as actors of a relational network, possessing those complementary resources needed to control the innovation process. The emerging predominant position within this network will most likely shape the niche features. This predominance reflects the individual power of each actor involved in the regime transformation.

The last mechanism to allow the development and implementation of the new technology is the acquisition of the necessary *knowledge to act*. Acquiring knowledge is a deeply informal process, as tacit and uncodified knowledge can only be acquired and shared by means of intensive and direct interactions. Moreover, as it has been noted, knowledge flows more intensively within a core group of firms characterised by advanced absorptive capacities (Giuliani and Bell, 2005), both the niche structure and actors' individual characteristics are key factors in assessing the intensity of knowledge flows.
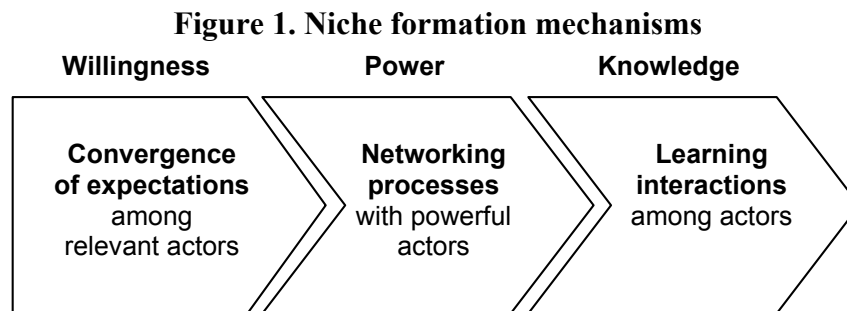
All these three mechanisms represent the pre-conditions which need to coexist for the formation of an innovation-niche (see Figure 1). Note that the logical mechanism of niche

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[1] In this paper, by mechanisms we mean the three sub-processes that characterize the niche creation process (Caniels and Romijn, 2006).

[2] We are aware that there are several other aspects that can affect the creation of an innovation-niche, such as the availability of venture capital, technology cost, and the extent that the existing regime is locked in (Geels and Shot, 2007; Van der Laak et al., 2007; Verbong and Geels, 2007). However, we decided to restrict the focus of our analysis to the three above mentioned mechanisms grounding our decision on the existing literature on strategic niche management and socio-technical transition (Smith et al. 2005; Raven 2005; Caniels and Romijn, 2006; Caniels and Romijn, 2008) which has consistently stressed the predominance of such mechanisms.

[3] Following Smith et al. (2005: 1506), "one major group of resources concerns control over financial revenues or capital stocks. Others include the ability to control material artefacts, such as hardware and infrastructures, or the production of salient knowledge, through research and marketing. [… A] further type of resource is embodied in the command of legitimacy, credibility or other recognised sources of authority in making demands upon the behaviour of others. Examples here might include a competence in developing or passing legislation, or in implementing regulations".

formation requires the occurrence of these three processes in the order exposed in Figure 1.[4] In what follows we will present a general framework for investigation of niche formation processes as well as a toolkit for empirical studies.

Figure 1. Niche formation mechanisms

Willingness	Power	Knowledge
Convergence of expectations among relevant actors	**Networking processes** with powerful actors	**Learning interactions** among actors

3. Social Network Analysis – a toolkit for empirical studies

So far, some authors have used social network tools in order to investigate the niche structure (among others, see Caniels and Romijn, 2008). However, this literature focused solely on the structural dimensions of the network that represent the niche, neglecting the kind of interaction existing among actors and the cognitive content (values, beliefs, knowledge exchange, etc.) of these ties. In this work we will attempt to bridge this gap in the literature. In line with this aim, the analysis of niche mechanisms, described in some detail in section 2 above, depicts not only structural elements, but also the cognitive (as the sharing of common values, visions and knowledge) ones. In what follows we will use SNA to define a methodological conceptualization of each of the three niche mechanisms discussed above, and at the same time we will attempt to provide tools suitable for their measurement. Specifically, we will develop a 3-steps procedure for each mechanism:
Step 1 – SN concept: define the concept using social network theory;
Step 2 – SN tool: identify the best available index to measure the above-defined SN concept;
Step 3 – SN data: specify the data needed in order to calculate the above-identified SN index.

Mechanism 1 - Willingness to act: requires a strong convergence of expectations of agents on the future development of the niche as initial condition leading to the niche formation (see above).

SN concept. The SN concept that best captures the link between the development of a common view and the formation of a cohesive group is, as we believe, the so-called *social circle* (Kadushin, 1968). A social circle is not a proper network, since it does not necessarily imply social interaction, pre-existing relations nor a form of collective identification. It is, rather, a social entity with three fundamental features: (1) a certain degree of indirect interactions among the actors; (2) the sharing of similar interests; (3) an informal architecture without clearly defined leaders and rules which determine modes of interaction and membership criteria. It basically acts as a network incubator. Also in the absence of pre-established relations, the existence of a common set of interests provides chances for interactions (Grossetti, 2005) and, it therefore facilitates the emergence of a network structure. A developing niche could be seen as a social circle in which the central common interest is

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[4] However, as noted by Raven (2005), these three processes are interrelated and mutually reinforced, thus there is not always a clear causal relation among them. For instance, in the starting phase expectations may be broad and fragmented but when the learning process advances discovering new applications, "social actors themselves change their views and align their expectations about the new technology over time, under the influence of further development of the new technology, and their exposure to it" (Caniels and Romijn, 2006, p. 6). At the same time, this could foster aggregation, encouraging other actors to join-in the network.

the development of a new technology. Thus, when analysing the willingness mechanism of the niche, the presence and structure of such a social circle should be one of the primary concerns to address.

   SN tool. The measurement of the strength of the common interest represents the core of the problem. We propose a network index to measure the level of shared interest around a specific event based on the traditional network density measure (see, for instance, Wasserman and Faust, 1994): the *network density of sharing relations index*. Such index measures the level of *sharing* among the members of the group, considering a specific common interest (i.e. the potential development of the niche's sector). This sharing measure should be seen as the convergence of the attitude of several actors towards a hypothetical change in the specific context of the niche. Intensity of the sharing relation (*SR*) should be measured between every pair of actors. Once this is done, the *network density of sharing relations index (D_{sr})* could be calculated as:

$$D_{sr} = \frac{\sum_{l=1}^{z} SR_l}{n(n-1)}$$

[1]

where $\sum SR_l$ is the sum of the intensity of the *l* (with *l=1,...,z*) generic couple of actors, *z* is the number of the all possible couples, and *n* represents the number of niche's members[5]. This index can be seen as the average value of the sharing relationship between two members of the examined group and represents, therefore, a measure of the convergence of expectations of potential niche's members. The index ranks between 0 and 1 and takes the upper-bound value if all actors express the maximum interest towards the niche technology. We shall suggest that a value equal to or greater than 0.5 (i.e. 50 percent) would indicate an adequate level of convergence of expectations. In order to calculate this index it is very important first to correctly specify the members of the group, and subsequently to collect adequate data. Such concerns will be addressed in the phase of data collection.

Differently from the traditional network density that measures the proportion of actual relations out of all possible in a network, this measure does not refer to actual relations but to pseudo-relations among actors since the convergence of their expectations does not entail a real interaction but it should rather be conceived as an opportunity: the stronger it is, the likelier it is that an actual interaction will emerge. Other possible indicators to measure the *willingness* mechanism could be the mean of the values attached by each actor to the niche option, or the proportion of actors attaching a value equal to or greater than a specific threshold. While these indicators are very simple and easy to understand, they do not entirely catch the essence of this mechanism, which envisages the actual *convergence* of expectations. Instead, the proposed index focuses exactly on this convergence process, expressing the average level of actors' agreement on the desirability of the niche option and, thus, informing us on how the network, as a whole, *converges* towards a common vision.

   SN data. Since there are no distinct criteria of membership and well-defined rules of interaction, the specification of the circle's members presents some difficulties. Following

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[5] SR could be constructed using the information drawn by means of a dedicated questionnaire (see for instance table 1 first question). Specifically, on the basis of the responses, the intensity of the sharing relation within the *l* generic couple of actors (*SR_l*), among the *z* possible couples, is calculated as $SR_l = \min(x_i; x_k)$ $\forall i, k \subseteq n$ *and* $i \neq k$ where *l=1,...,z*; x_i *and* x_k represent the values attached to the niche option respectively by the actors *i* and *k*; $\min(x_i; x_k)$ is the minimum level of agreement between actors *i* and *k* on the desirability of niche technology; *n* and *l* have the same meaning as above. SR_l varies between *0* (no sharing) and *1* (maximum sharing). Once the sharing relation is computed, D_{sr} can be calculated as above.

Kadushin (1968), one way to deal with this problem is using an open-ended sociometric chain. In this perspective, a useful approach is represented by the *name generator* technique, which is based on interviews aiming at eliciting from respondents a list of actors with whom they have ties of a specific kind. In doing so, the interviewee must specify the type of tie linking him/her to his/her acquaintance (which could be represented by communication interaction or other forms of interaction). Once the exact group configuration has been established, data on agents' attitudes could be collected. We suggest that agents' attitudes should be quantified asking group's members to indicate their potential reaction to a hypothetical progress in a niche's sector (e.g. if they would join a specific development project in this sector or not). A scoring mechanism should be applied to the various possible responses in order to make a quantifiable comparison between pairs of actors possible.

Mechanism 2 - Power to act: requires an actual networking process among actors. Power is by all means an important topic within SNA as it is a fundamental property of any social structure. This approach emphasizes that power is a relational concept: an individual does not have power in a vacuum; he/she can exert power only in relation to other actors. Thus, power arises from occupying advantageous positions in networks of relations. Furthermore, since power is a consequence of relational patterns, the amount of power in social structures varies according to the social architecture within which interactions occur.

SN concept. Centrality is an SNA conceptual and analytical tool, especially useful in analysing the individual and a network feature of power relations (Freeman, 1979). At the individual level, this concept refers to the properties of actor location in a social network which make an actor prominent or important. These properties concern, first of all, the whole pattern of ties owned by the individual actor. Intuitively, the actor endowed with a lot of connections has favourable positions since he/she can potentially access a lot of resources in the network for satisfying his/her needs. This makes him/her less dependent on other actors and, at the same time, he/she can exert influence on other actors who could be damaged if he/she decides to disconnect from them.

SN tool. In order to measure the centrality of an actor, an important parameter which needs to be examined is represented by the number of his/her ties to other actors in the network. In the context of socio-technical transition, centrality depends mostly on the amount of resources possessed by each actor and on how relevant such resources are considered by other actors. Thus, from a structural point of view, powerful actors should be those which are extensively involved in interactions with other actors because of their ability to control crucial resources. In the same way, the niche has an adequate level of power if enough powerful actors have joined-in in order to coordinate the innovation process. Social network tools allow measuring both individual and systemic aspects of power. The simplest measure of actor centrality is the *actor degree*, which is the number of ties he/she possesses. An extension of this indicator is represented by the *in-degree* measure which focuses only on received ties. A standardized formulation for actor i is $C'_{in-D}(a_i)$:

$$C'_{in-D}(a_i) = \frac{d(a_i)}{n-1} \qquad [2]$$

where $d(a_i)$ is the sum of ties received by actor a_i and n is the number of network members. This measure is independent of n and thus can be compared across networks of different sizes. The actors' measures can be then combined to obtain a group-level measure which synthesizes the degree of centrality in the network. The general indicator used for the network centrality (C_{in-D}) has the property that the larger it is, the more likely it is that a single actor would be quite central (and thus powerful), with the remaining actors considerably less central:

$$C_{in-D} = \frac{\sum_{i=1}^{n}[C_{in-D}(a^*) - C_{in-D}(a_i)]}{(n-1)^2}$$ [3]

where $C_{in-D}(a^*)$ is the largest value observed for individual centrality and *n* has the same meaning as above. These two centrality indexes could be used to verify if the niche has reached, on the whole, an adequate level of power and who are the potentially most powerful actors, which should be involved/stimulated in order to make the networking mechanism more effective. Also in this case it is important to define a threshold value above which the level of power could be considered adequate. As mentioned, the larger is the *in-degree network centrality*, the more likely it is that a single actor would be quite central (and thus powerful), with the remaining actors considerably less central. In a powerful network we can expect that several actors occupy central positions, giving rise to a centralization index smaller than one. Hence, we would suggest that any value equal to or above 0.25 (i.e. a level of centralization equal to or greater than 25 percent of a theoretical star-network[6]) would correspond to an adequate level of power. However, we suggest combining such punctual investigation with a visual inspection of the network in order to appreciate its actual configuration.

Of course, the governance structure of a network can be measured in different ways (see for instance Storper and Harrison, 1991). However, unlike other indexes, the one here proposed focuses only on *received ties* among actors. We choose this index as we believe an actor receives a tie when he/she is perceived as powerful. Thus, this index is well-suited to provide a snapshot of the distribution of *power attribution* among actors.

SN data. Given that the niche's network is based on resources' interdependency, a variation of name generator, called *resource generator*, could be used in this case. Basically, this approach consists in asking the respondent to list his/her acquaintances that are able to control specific resources. Since the network members are not known *a priori*, a set of potential members is selected drawing on information obtained by a panel of experts or by existing documentations. The selected actors are interviewed and asked to list those acquaintances how are able to control specific resources. In turn, the listed actors are subsequently interviewed. This process is repeated until a specific criterion is matched, usually when a significant proportion of the same actors are repeatedly named. This allows the reconstruction of the group, although its boundaries are initially unknown. The borders of the social circle are the base to drawn the niche's ones.

Mechanism 3 - Knowledge to act: refers to learning interactions as it involves the acquisition of a sufficient amount of knowledge to act. This implies that the network representing the niche would be characterized by adequate knowledge flows.

SN concept. A way to capture these flows is to account for the presence of all possible *communication relations* among actors which could allow knowledge to flow from one agent to another. The SNA allows classifying some communication interactions such as formal collaboration agreements and face-to-face knowledge exchange. Indeed, a niche could be understood as a network in which such communication interactions take place. At the same time, it is the measuring of knowledge flows which presents a major challenge for applied researchers (Morone and Taylor, 2009). Recently, several empirical studies have focused their attention on clusters and networks as the locus of knowledge diffusion. However, some have stigmatised "the role of fuzzy social relationships and ill-defined spillover mechanisms as the basis of knowledge flows and learning processes within territory-bounded communities" (Giuliani and Bell 2005, p. 48), and have consequently proposed more direct and reliable

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[6] Such a theoretical configuration has a central actor, connected with all others, and all other actors connected only with the central actor.

ways of defining and measuring knowledge flows (e.g. Dicken and Malmberg 2001; Malmberg and Maskell 2002; Amin and Cohendet 2004).

SN tool. A way to measure the learning diffusion within the network is to calculate the density of communication relations with knowledge content. The network density relates to the number and proportion of the ties connecting the individuals within this network. The traditional density index is calculated as the ratio of the number of all ties present within the network, to the maximum possible. In line with the objective of this paper, we propose a slight variation to this index, considering only on those ties which are communication relations with a knowledge content. Denoting these with L_k, the density of knowledge (D_k) relations is calculated as:

$$D_k = \frac{L_k}{n(n-1)/2} \quad [4]$$

where the denominator represents the maximum possible number of ties, which is determined by the number of actors, denoted with *n*. The minimum value for density is 0; that is no interactive learning process is present. The maximum value that this measure could assume is 1 and this happens when the network is fully saturated, i.e. all possible knowledge relations actually exist. However, this is just a theoretical upper-bound as in real social networks it is highly unlikely to observe values close to it, given that the number of possible relations grows exponentially with the number of actors in the network. In light of this, we would suggest a threshold value of 0.1 (i.e. 10 percent of all possible relations) as the benchmark for an adequate level of knowledge flows. Also in this case we would suggest to combine the punctual analysis with a visual inspection of the emerging knowledge network which could also allow gathering additional information, such as who are the key knowledge actors in the network and which role do they play.

SN data. Collecting adequate network data is an essential step in order to properly measure knowledge diffusion patterns. In order to do this, researchers should collect data on the number of knowledge relations each actor has (or has had in the recent past) with any other actor identified as part of the network. This information can be gathered by the *name generator* used to collect data relevant for the convergence of expectation, seeing that it only involves asking individuals to specify the nature and the contents of the reported relations.

A first application of the toolkit here proposed is currently developed within a project funded by the European Commission focused on the development of bio-refineries in rural areas in Europe.[7] In this case the innovation niche is a network of actors interested in the development of a technological solution for the production of energy and other products with a high added value from bio-mass. The potential members of the network can be identified with various means (using an open-ended sociometric chain, interviews with experts). Once this is done, the data needed in order to calculate the indexes presented can be gathered using the questions reported in table 1.

This example, drawn from the specific case of a bio-refinery niche formation, can be generalized and adapted to investigate other cases.

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[7] The full name of the project is "Developing advanced Biorefinery schemes for integration into existing oil production/transesterification plants", acronym "SUSTOIL". It is a support action project funded through the Seventh Framework Programme (Energy Theme). The project started in June 2008 and is to finish in May 2010.

Table 1. Questionnaire suggested for niche mechanisms investigation

Niche's mechanisms	Questionnaire queries	Possible response
Willingness to act	A project for bio-fuel development and use is planned in your region. The plan envisages experiments in the production of raw material for bio-diesel, the establishment of facilities for the production of bio-fuel and tax exemptions for some categories of users. Would you like to join the project? [Please indicate your level of expectation towards the project]	*5=Very high, 4=high, 3=medium, 2=low, 1=very low*
Power to act	In your opinion, in order to make this project successful, the participation of which actors is important? [Please indicate also the reason]	*The name of the important actors and the reason they are important (capacity to mobilize people; technological and knowledge resource;s capacity to coordinate the local development strategy; capacity to control financial resources; capacity to control material infrastructure; raw materials production capacity)*
Knowledge to act	Who are the actors with whom you have/had knowledge exchange on bio-refinery? [Please indicate if you: 1=receive information, 2=exchange information, 3=transmit information]	*The name of the actors with whom the respondent have/had knowledge exchange on bio-refinery*

4. Implications and concluding remarks

Analyzing the status of readiness of innovation-niches is crucial in order to understand and manage in a desirable way a technological transition. Insights on niche formation can be obtained investigating the social interaction occurring among actors composing the niche. In order to do so, in this paper we combined a social network approach with the strategic niche management theory, developing a set of specific tools able to capture and investigate the potential readiness for niche formation. This objective first led us to a methodological conceptualization of three key niche formation methods – i.e. willingness to act, power to act and knowledge to act. Subsequently, we developed three specific indexes able to provide a quantitative measurement of such methods. Lastly, we have introduced specific survey methods to detect data on the three mechanisms.

The result of this work is providing researchers with a toolkit which can be used to assess the actual status of the niche and, eventually, assist policy makers in planning suitable actions to foster technological transition patterns. Specifically, the combined use of the three proposed indexes leads to the characterization of four scenarios corresponding to different levels of niche readiness. Table 2 summarises such scenarios.

First scenario: the analysis reveals the absence or a negligible presence of the fundamental mechanisms of niche formation, thus, the niche itself is completely inexistent. This scenario requires what Kemp et al. (1998) call a socio-technical alignment policy, focussing on specific interventions for aggregation and enabling actors. First of all, the lacking of vision and expectations regarding the new technology should be addressed. This means stimulating interest and attention of potential stakeholders - developers, investors, regulators, producers and users - through the development and the spreading of a clear vision about the new

technology. This should include a suitable communication plan encouraging others actors to develop their visions and expectations.

Second scenario: only a minor level of convergence of expectations is detected. There is the basis for the formation of a group sharing the same vision about a specific innovation technology which could act as an incubator for an actual niche. Under these circumstances there is a need for networking. The attention should be focussed on the relevant actors identified, by means of a resource generator survey. The interventions could envisage regular meetings and discussions orientated to users, scientists, societal organizations as well as to producers. A dedicated network specialist could be employed in order to build and maintain such a network.

Third scenario: the convergence is realized and a networking process begins. In this case we have what we could call 'a proto-niche', that is a network of actors with a clear vision. A certain power to act is already mobilized, but there is still a need to build a stable communication strategy. Possibilities to share new knowledge can be created through interaction platforms, regular meetings and conferences. A monitoring activity could be implemented using information technology solutions.

Forth scenario: all the three mechanisms have took place and the niche is at a good level of development. Specific efforts should be dedicated to reinforce and encourage niche's mechanisms, maintaining the level of activities, and by using the above mentioned policy interventions with economic protection such as subsidies or tax exemption, or ensuring R&D funding commitments by private actors participating in the experiment (Caniels and Romijn, 2006).

Table 2. Niche status and policy indications

Scenarios	Willingness to act	Power to act	Knowledge to act	Niche status	Policy indication
First	Absent	Absent	Absent	Absence	Develop a clear vision spreading it through a suitable communication plan
Second	*Present*	Absent	Absent	Embryonic	Develop a broad network planning, engage in regular meetings and discussions with stakeholders
Third	*Present*	*Present*	Absent	Proto-niche	Create possibilities to share new knowledge (platforms, meetings, conferences)
Forth	*Present*	*Present*	*Present*	Full	Maintain and encourage niche's mechanisms through economic and social protection

These are four possible scenarios we envisage and which could be easily detected implementing the SN methodology developed in this paper. To each scenario is associate a specific policy action which derives directly from the conceptualisation of innovation niche provided in this paper – i.e. the three mechanisms through which the niche builds the internal momentum to become an effective alternative to the dominant regime. Although not exhaustive, we believe this study represents an important step in a much-needed direction, which is science-policy interface in socio-technical transition studies: the issue is not whether

science should determine policy but how science can be part of a more holistic analysis and how it can provide effective guidelines to policy action.

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