



Sustainability in Agri-Food Systems: Transformative Trajectories toward the Post-Anthropocene

Identification and characterization of potential change agents among agri-food producers: regime, niche and hybrid actors

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Abstract

The multi-level perspective has been criticized for being functionalistic and paying little attention to actor-based perspectives. Nevertheless, for the identification and assessment of potential change agents in a sustainability transition, a clear conceptual and methodological approach is necessary. This paper, thus, develops a multi-dimensional typology of niche, regime, and hybrid actors, which is conceptually grounded in transition studies and empirically illustrated by a cluster analysis based on a survey of pig and poultry farmers in Germany, France, and the Netherlands. Animal husbandry is chosen as a case study because a significant share of the environmental impact within the agri-food system is attributed to this sector and there is evidence for resistance to change by mainstream actors. Conceptually, the paper provides a framework of constitutive elements for different kinds of actors and contributes to an extension of the niche–regime dichotomy by adding the group of hybrid actors. The empirical results show that cluster analysis is a suitable approach to identify conceptually meaningful differences among interviewed farmers. Among pig and poultry farmers, the regime actors are by far the largest group. The smaller group of hybrid actors, however, has large potential to act as boundary spanners. A particularly interesting finding is that several larger farms are among the group of niche actors which hints at the possibility that larger farms are not necessarily resistant to change.

Keywords Multi-level perspective · Actor-based typology · Change agents · Animal husbandry · Cluster analysis

Introduction

The concept of socio-technical transformations attempts to describe and explain fundamental, systemic socio-technical change processes in society from a holistic perspective. These are often viewed from a multi-level perspective (MLP), according to which the regime and niche levels are embedded in the landscape level (Geels 2002). However, this perspective is criticized because of its functionalist character

and the neglect of actors and their actions (e.g., Berkhout et al. 2004; Geels 2011). Another frequent criticism is the difficulty of empirically distinguishing the three levels (landscape, regime, and niche). For example, there are no clear guidelines or indicators for differentiating between regime and niche actors (Berkhout et al. 2004; Fischer and Newig 2016). Nevertheless, Markard et al. (2012) point out the high relevance of actors.

The aim of this paper is to conceptually ground and empirically illustrate a multi-dimensional typology of niche, regime, and hybrid actors. Many studies show that the existence of niche and hybrid actors or change agents can be considered a prerequisite for socio-technical transformations (e.g., Geels 2002; Diaz et al. 2013; Smink et al. 2015). Constitutive characteristics attributed to regime, niche, and hybrid actors are summarized in this paper from the existing literature on socio-technical transformations and operationalized for empirical analyses.

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Animal husbandry is chosen as a sector for illustrating the concept, because of its significant environmental impact and the resistance to change by many mainstream actors in the production network (Migliore et al. 2015). In a first empirical step, a cluster analysis is applied to data from a survey of pig and poultry farmers to examine whether different types of actors can be identified empirically. The interpretation of the characteristics of the three clusters allows the conclusion that the actor dimension in the MLP can be expanded by this approach and, in particular, the dichotomy between regime and niche can be eliminated by considering hybrid actors in addition. In a second empirical step, the transformative potential within the clusters for change agency towards a more sustainable agri-food system is assessed by applying a set of additional indicators for the involvement of farmers in learning and innovation processes.

The paper is further divided into six sections. In “[Actors in socio-technical transformations and their constitutive characteristics](#)”, constitutive characteristics of the three actor levels (regime, niche, hybrid) are distinguished from each other based on literature. They are applied to pig and poultry farming in “[Pig and poultry as an illustrative case for regime, niche, and hybrid actors](#)”. “[Data and methods](#)” justifies the selection of the research method (cluster analysis) and describes the cluster variables. In the empirical part, the results of the cluster analysis are interpreted in “[Results of the cluster analysis](#)”. This is followed by the assessment of the transformative potential within the three clusters based on learning processes and innovation behavior in “[Assessment of the transformative potential within the clusters](#)”. Finally, a conclusion is drawn.

Actors in socio-technical transformations and their constitutive characteristics

Socio-technical transformations are often viewed from a MLP (Geels 2002). Socio-technical transformations are shaped by three levels in the form of an interplay between niche innovations, regime internal change (or resistance), and selection pressures exerted by the landscape (Fischer and Newig 2016). Although agency is not inherent in the three levels, actors and their actions can be associated with the regime or niche level. Fischer and Newig (2016) point out that there is a consensus in the literature that agency and actors are significant elements in socio-technical transformations. However, some empirical work shows that actors often do not merely act on one level, but on multiple levels. An overarching and generally applicable definition and structure of actors is not yet available in the literature on socio-technical transformations (Fischer and Newig 2016). Avelino and Wittmayer (2016) point to a conceptual ambiguity in the literature in this regard. Smith et al. (2005), for example, also

criticize the lack of a clear demarcation between core and non-core regime members as well as outsiders. Therefore, hybrid actors are identified in this paper as a third group that shares the characteristics of the regime and the niche.

Niches and regimes have similarities in structure, but some differences in the level of aggregation and stability: both the niche and the regime have the character of organizational fields (community of interacting groups). In the case of the regime, these communities are large and stable, while for niches they are small and unstable. Both niche and regime communities share certain rules and institutions that coordinate action. For regimes, these institutions are stable and well articulated; for niches, they are unstable and in the process of emergence (Markard and Truffer 2008). Based on the literature, regime, niche, and hybrid actors can be characterized as follows.

The *regime level* is not consistently defined in the literature. It includes a dominant rule set or system of actors, institutions, technologies, and user practices (Markard and Truffer 2008; Sutherland et al. 2015). Characteristics of a regime are: self-stabilizing, inertial, and incremental innovation (Markard and Truffer 2008). The regime is the predominant way production systems are organized in a particular industry, e.g., how conventional poultry production works in general. Regimes are usually focused on system optimization rather than radical innovations aiming for system change (Bergman et al. 2008). Due to the persistence of dominant structures, conventions, and routines, regimes can be understood as established power centers. To preserve the status quo and defend their own interests, the processes of change are often rejected (Schneidewind and Scheck 2012). Regimes are therefore characterized by path dependencies and cognitive or technological lock-ins (e.g., Klitkou et al. 2015).

The description of regime actors as inert actors who merely try to optimize an existing system suggests that rapid adoption of innovations and, in particular, incremental innovation hardly play a role. The frequent rejection of processes of change and skepticism toward innovations suggest both a low proportion of actors who rate themselves as innovators and a low proportion of actors who differ from other companies in the region, in particular, by being highly open to innovations.

The *niche level* is a protected space and to a certain extent isolated from the regime. Isolation can result from cognitive, social, and spatial distance (Geels and Schot 2007). The protected space provides a shield against pressure from the regime. Actors have more freedom to develop new routines and alternative structures than in the regime. However, their assertiveness is limited (Raven et al. 2012). According to Loorbach and Rotmans (2010), niche actors can be seen as dynamic frontrunners. Radical innovations play an important role (Bergman et al. 2008).

A contribution to the development of the niche concept is made by van de Poel (2000) with his emphasis on the important role of outsiders in the processes of technological change. He defines outsiders as actors who are not directly involved in technological development and do not share the rules and institutions of a technology. Outsiders often have less to lose than insiders in launching radical innovations. This is an important reason why radical innovations are initiated more often by outsiders than by insiders (van de Poel 2000).

Coenen et al. (2010) point out that niche activities often have a rather experimental character. The articulation of expectations represents an important resource for niche experiments, since it reduces uncertainty in innovation processes, additional resources can be mobilized more easily by pointing out future benefits, and once these expectations are accepted by the public, third parties can be influenced more easily. The articulation of collective expectations requires cognitive and social proximity between the actors.

The acquisition of a sufficiently large body of knowledge can be seen as a key mechanism for niche development (Lopolito et al. 2011). Therefore, both individual learning processes (especially learning by doing) and collective learning processes (especially learning by interacting) are relevant. Social learning, experimentation, and co-production of knowledge also serve as a tool to test visions and gain experience with new technologies (Hermans et al. 2013). Especially for niche actors, learning processes are important to discover, for example, the diversity of practices in agribusiness that can be made more sustainable (Barbier and Elzen 2012).

Boschma et al. (2017) point to the high importance of heterogeneous groups of actors for mobilizing resources to establish a new industry. According to Coenen et al. (2010), niche experiments should be supported by a set of diverse and complementary expectations that are open to adaptation. At the same time, there should be a stable basis for collaboration and coordination in the niche. For learning processes in the niche, taking a myopic perspective can lead to lock-ins. Therefore, there is a need for a balance between internal and external (local and global) learning processes. Spatial proximity can be helpful in these articulation processes, as it allows niche actors to interactively share expectations on a continual and extensive basis. Coenen et al. (2010) also find empirical evidence for this by using the example of thermal energy storage technologies in the Netherlands. The various proximity dimensions play a central role in the development of niches in their respective local contexts. Hansen and Coenen (2015) also emphasize that networks consisting of heterogeneous actors can be most easily established at the local and regional level, as spatial proximity is conducive to bridging cognitive or cultural distances between actors.

Organizational and social proximity are particularly necessary for the emergence of networks.

In addition to the established niche–regime dichotomy, various authors (e.g., Diaz et al. 2013) have introduced a third type of actor, the *hybrid actor*. McCauley and Stephens (2012) also emphasize the importance of intermediaries in linking niche activities to regime-level institutions. Niche–regime interactions are key to bottom-up transformations and this is where hybrid actors play a central role. For niche–regime interactions, there should be some compatibility between niche and regime elements to translate niche practices into mainstream regime practices. If these circumstances are met, the niche can dock with the regime. As a result, a small group of regime actors may begin to collaborate with niche actors. Through this collaboration, inconsistencies and tensions within the regime become apparent. These regime actors, who distance themselves from the regime’s mainstream practices, are called hybrid actors. They tend to be more open to innovation than regime actors and challenge the regime’s mainstream practices. Therefore, it seems promising for niche actors to convince these hybrid actors of their own niche practices (Diaz et al. 2013). Nevertheless, hybrid actors might also restructure markets in a direction that enables the survival of established companies (Kallio et al. 2020).

Hybrid actors often fulfill the function of a boundary spanner (Smink et al. 2015) or institutional entrepreneur (Diaz et al. 2013). According to Battilana (2006), an institutional entrepreneur deviates from the rules and practices of the dominant institutional logic and develops alternative rules and practices. Translating niche practices into regime practices allows for compromise and the opening of the regime to novelty (Smink et al. 2015). The hybrid actor shares some similarities with the notion of structural folds coined by Vedres and Stark (2010). Networks are inter-cohesively connected through structural fold actors; as multiple insiders (Vedres and Stark 2010) they have access to resources and contact with members of different cohesive networks.

The constitutive characteristics of regime, niche, and hybrid actors are summarized in Table 1. They are applied to the empirical case of pig and poultry farming with regard to the expected characteristics of regime, niche, and hybrid actors in this field in.

Based on the characteristics and behaviors summarized from the existing literature, it is to be expected that niche and hybrid actors are most likely to be able to assume the function of a change agent and proactively initiate change in socio-technical transformation processes (Caldwell 2003). Van Poeck et al. (2017) mention four types of change agents. Based on their descriptions, niche agents are most likely to take on the role of the convincer. This is because the convincer emphasizes the importance of intrinsic motivation as

Table 1 Constitutive characteristics of regime, hybrid, and niche actors. Source: Own representation based on various sources

Variable	Regime	Hybrid	Niche
Proactivity	Self-stabilizing ^a Inert ^a		Fronrunner ^c Dynamic ^e
Degree of autonomy		Isolation results from cognitive, social and spatial distance ^b	Protected space, isolation from the regime ^b
Significance of innovation	Incremental innovation ^a System optimization ^c		Radical innovation ^c System change ^c
Communities of practice	Large and stable ^a		Small and unstable ^a
Institutions	Stable and clearly defined ^a	Institutional entrepreneurs ^d	In the making ^a
Position of power	Centers of power ^f	Active distancing from mainstream of the regime ^d	Little power, actors come and go ^g
Openness to innovation	Rejection of change ^f Skepticism about innovation ^{c,f}	Tend to be more open to innovation than regime actors ^d	Production has experimental character ^h
Degree of path dependency	Based on technological path dependency ^b	Multiple insiders in a structural fold ⁱ	Social learning, experimenting, co-production of knowledge → testing visions ^j

^aMarkard and Truffer (2008)

^bGeels and Schot (2007)

^cBergman et al. (2008)

^dDiaz et al. (2013)

^eLoorbach and Rotmans (2010)

^fSchneidewind and Scheck (2012)

^gRaven et al. (2012)

^hCoenen et al. (2010)

ⁱVedres and Stark (2010)

^jHermans et al. (2013)

a maxim for action. For the convincer, sustainability aspects are a matter of personal concern and commitment and are linked to personal values and principles. As a revolutionary, the convincer tries to orchestrate processes of change collectively or to initiate individual activities that can be copied by other actors (walk the talk). Hybrid actors can rather play the role of mediator change agents. The mediator fulfills the function of a mobilizer and facilitator in the sense that networks are established, actors are brought together, and an exchange of different perspectives and views among actors is promoted. Hybrid actors, due to their role as multiple insiders between regime and niche, as well as their open and pro-cooperative behavior patterns, seem to be most suitable to connect actors of different networks and to motivate other actors through communicative skills (van Poeck et al. 2017). Hybrid actors could also assume the function of convincer due to their strong doubts regarding mainstream regime practices and a stronger profile with regard to sustainability aspects. Regime actors, on the other hand, have neither a disposition to mediate collective solution strategies nor an intrinsic motivation to push for sustainability aspects and processes of change.

Pig and poultry as an illustrative case for regime, niche, and hybrid actors

Animal husbandry is chosen as a sector for illustrating the concept, because of its significant environmental impact and the resistance to change by many mainstream actors in the production network (Migliore et al. 2015). Pigs and poultry accounted for 81% of meat production in the EU-28 in 2018, the stocks of both species grew very dynamically since the 1960s, and the intensity of pig and poultry farming increased with remarkable spatial concentrations (Peyraud and MacLeod 2020). Therefore, pig and poultry farming contribute largely to the negative impact of the agri-food system on sustainability. Global climate impact through greenhouse gas emissions, either directly or indirectly via land use change for feed production, local impacts on air and water quality, effects on biodiversity and soil quality as well as animal welfare issues are among the main sustainability hotspots related to animal production (Peyraud and MacLeod 2020). A recent systematic review of the environmental impact of pig and poultry production has confirmed that feeding (including crop cultivation, feed manufacturing, and feed transportation) is the main contributor

to the environmental impact associated with pig and poultry production (Andretta et al. 2021). Therefore, the analysis of innovation adoption focusses on feed innovation among farmers.

Based on the analysis of the literature in the previous section, the expected characteristics of regime, niche, and hybrid actors are described in the remainder of this chapter.

Regime actors

For regime actors in conventional pig and poultry production, it is expected that aspects of social and environmental sustainability are rated as rather less important (Migliore et al. 2015; Silvasti 2003). Therefore, it is expected that there is only a small proportion of actors who indicate that environmental sustainability and regionality are important to them when selecting feed. Likewise, a low proportion of actors is expected to attach high importance to environmental protection and rural development as objectives, or to produce for an organic/animal welfare label.

Compared to niche actors, regime actors often include more established and larger companies (Smith 2006). Therefore, a larger proportion of actors is expected to hold an above-average number of animals. It is probably more common for entire regions to be dominated by regime actors rather than niche actors, as niches under development are often much smaller than regimes (Markard and Truffer 2008). Therefore, it is assumed that a regime actor is more likely to be understood as a typical company for the respective region. It is thus expected that an above-average share of regime actors will state ‘My company is typical for the region’ in response to the question ‘How do you differ in particular from typical companies in your region?’ and thus express that they do not deviate from the mainstream.

With regard to external sources of knowledge, due to the frequent dominance of regime actors in a region and their lower openness, a higher importance of the local or regional level for knowledge exchange can be assumed compared to the other two groups of actors. This is because spatial proximity can help build trust between actors (Hansen and Coenen 2015). Regime actors are more likely to try to optimize the existing system with incremental innovations and thus preserve the status quo. Therefore, compared to the other two groups of actors, it can be expected that there is a similarly high proportion of actors among regime actors who have already introduced incremental innovations. Regime actors, however, are not as open to innovations as niche actors. Thus, more persuasion is needed to adopt innovations. Arguments for adoption could be provided, for example, by consultants or other companies that have already gained experience with the innovation. However, this takes time. Therefore, it is assumed that only a few regime actors will quickly adopt innovations.

Niche actors

It can be expected that niche actors, as dynamic frontrunners in protected environments, can develop radical innovations more easily, adopt innovations more quickly, and rate themselves as innovators more often. High openness to innovation can be expected as a difference from other companies in the region. Niche actors challenge regime practices through their actions. This often finds expression in contrary views on social issues such as aspects of social and ecological sustainability. Therefore, mirroring the evaluation of sustainability aspects by the regime actors, it can be expected that niche actors attach a significantly higher importance to sustainability aspects.

Not only are niches rather smaller groups of actors, often the actors tend to be younger, less established companies. Therefore, a correlation with the farm size and thus a lower proportion of farms with an above-average number of animals is expected. Likewise, a low frequency is expected for the statement ‘My farm is typical for the region’.

It is expected that the high importance of co-production of knowledge and the formation of networks with different (heterogeneous) actors will find expression in a high proportion of firms carrying out co-innovation processes. In particular, cooperation with other companies in the innovation process is expected. This is because, to generate momentum for niche activities, the exchange of expectations and an understanding of a specific path or direction of developments are conducive. Radical innovations often require a very specific and extensive body of knowledge. The integration of a broad spectrum of knowledge sources and a higher openness to new developments suggests that niche actors not only search for new knowledge at the local or regional level, but also succeed in acquiring relevant knowledge at the national or international level. Therefore, a higher proportion of niche actors is expected to acquire knowledge at the national or international level. This argument is also supported by the need for a balanced relationship between local and global learning processes so as not to run the risk of falling into a lock-in situation (e.g., Bathelt et al. 2004).

Hybrid actors

According to Diaz et al. (2013), hybrid actors more closely resemble regime actors than niche actors. Often, hybrid actors have grown out of the regime. Therefore, they are thought to be somewhat more likely to be characterized by rapid adoption of innovations, openness to innovations, and self-assessment as innovators compared to regime actors. Compared to niche actors, however, a lower proportion of firms can be expected in this respect. However, similar to niche actors, questioning regime practices suggests a stronger emphasis on social and environmental sustainability

aspects. Therefore, the sustainability aspects are expected to be more distinct differentiators from the innovation variables compared to the regime actors.

The fulfillment of the function of a boundary spanning actor or multiple insiders suggests the ability to interact with other actors. It is therefore to be expected that hybrid actors cooperate more frequently than regime actors with other actors in innovation processes and have also introduced innovations more frequently together with other actors.

Data and methods

Questionnaire-based survey of farmers

The empirical analysis is based on a survey conducted among pig and poultry farmers in three European regions of intensive agriculture (Northwest Germany, South Netherlands and West France). The study regions differ not only in terms of consumption habits, but also in terms of different production networks, regional innovation systems and openness to innovation, which are important factors influencing the innovation behavior of actors (e.g., Kayser et al. 2011; Castro et al. 1997). Therefore, the results are expected to be a good representation of the variety of farming practices.

In France and Germany, paper-based surveys were conducted in 2016 at leading agricultural trade fairs for animal husbandry (SPACE and EuroTier). In addition, an online survey was designed. The URL link of the survey was distributed to farmers in Germany by various multipliers (associations, press, etc.) and in France by the market research company AgriDirect. In the Netherlands, the link to the online survey was sent to 3,103 farmers by AgriDirect. The survey focused particularly on regions with a high concentration of pig and poultry farming in the three countries (Weser-Ems and Münsterland in Germany, North Brabant and Gelderland in the Netherlands, Brittany and Pays de la Loire in France). In total, 381 usable questionnaires were returned (202 in Germany, 54 in the Netherlands, and 125 in France).

Of the 381 respondents, 68% were farm managers and 14% farm successors, which indicates that they have a good overview of the farming operations. 85% of the respondents are male. 89% are full-time farmers. 96% of the farms reported conventional production. There is quite a wide range in terms of the number of animals kept. The interviewed farmers are on average 42.5 years old and have been actively working in the industry for 20 years, which indicates a rather high work experience. A comparison of the farm sizes with the Eurostat data shows that large poultry farms are overrepresented in France and Germany, while large pig farms are overrepresented in all countries.

With regard to data quality, it has to be acknowledged that it has been particularly difficult to get in contact with farmers in the Netherlands, which resulted in a response rate of just 1.7%. In the other countries, the response rates could not be calculated because of the direct approach of farmers at trade fairs and via other multipliers. However, the structural analysis of the sample has shown convincing results with regard to validity and plausibility of the data. Nevertheless, the study remains illustrative because representativity cannot be confirmed.

Cluster analysis

On the basis of the conceptual typology of different actors, a cluster analysis is used to examine which constellations of the different types of actors are reflected in the data. Cluster analysis helps to identify groups that are homogeneous in themselves, but heterogeneous to one another. In addition, cases who cannot be assigned to any cluster because of their great dissimilarity can be identified (single-linkage procedure) and excluded as outliers from further analyses.

The different procedures of the cluster analysis are essentially constituted by the choice of the proximity measure as well as the grouping procedure. Regarding the proximity measure, the squared Euclidean distance was chosen because the classification variables are binary (Backhaus et al. 2016) and this proximity measure is frequently used in empirical studies (Eckstein 2016). As grouping methods, partitioning and hierarchical methods are distinguished from each other. Hierarchical methods are suitable for uncovering cluster structures. A hierarchical procedure is used in order not to have to determine a priori exactly how many clusters are to be created (Eckstein 2016).

The variables considered are to be equally weighted in the cluster analysis. Variables that are highly correlated with one another can lead to a distortion of the results (Backhaus et al. 2016). However, the correlation performed for all possible pairs of variables does not show a very high correlation (most correlation coefficients are below 0.2). Furthermore, before performing the average linkage procedure, the single linkage procedure was performed to identify outliers.

However, cluster analysis also has limitations. For example, Jain et al. (1999) emphasize that cluster algorithms always find clusters in the data. This means the cluster results either represent a random product (clusters subsuming randomly similar cases) or correct clusters have been discovered whose structure fits well with the available data. Another disadvantage of cluster analysis can be seen in the rather coarse nature of the results. Thus, theoretically, two cases of different clusters may have a higher similarity with respect to a specific cluster variable than two cases that are part of the same cluster. Therefore, it is possible that certain correlations in the data and specific

similarities and differences of cases with respect to individual cluster variables remain undetected.

Based on the literature review above (Table 1 for a summary), three different sets of variables were selected for clustering: innovation/adoption behavior, importance of sustainability aspects, and structural variables (Table 2). Four variables for innovation/adoption behavior and five sustainability variables were selected so that these two aspects would receive roughly equal weight in the clustering.

Innovativeness

The significance of innovations was measured in the survey by a differentiation between new-to-the-market (radical) and new-to-the-firm innovation (incremental). These terms are easily understandable by the respondents, even though it has to be acknowledged that new-to-the-market innovation does not cover all aspects attributed to radical innovation. It is expected that niche actors have introduced innovations that are new-to-the-market more frequently. In contrast, a lower share of firms with new-to-the-market innovations argues for a classification as a regime or hybrid cluster. The prospective and dynamic behavior of actors is mapped by the question ‘How soon after market introduction are feed innovations used in your own farm?’ This type of innovation was chosen, because the need for protein-rich feed is a main source of environmental concern in meat production (Andretta et al. 2021). A rapid adoption (in the first year after market introduction of the innovation) of feed innovations can be an indication of a dynamic frontrunner. It can be assumed that there is a higher proportion of actors in the niche than in the regime or hybrid cluster who adopt new innovations very quickly.

Regime actors are often skeptical of innovations and reject processes of change. Therefore, it is expected that these actors are also significantly less likely to differentiate themselves from typical companies in their region by being highly open to innovation. Likewise, for the self-assessment as an innovator, a lower proportion is expected for regime actors than for hybrid or niche actors. In a comparison of these four cluster variables, the lowest share of new-to-the-market innovation is expected among regime actors. Instead, new-to-the-firm innovation that optimizes the existing system is expected in the regime. This means that regime actors might see themselves as innovators and open to innovation, but with a lower proportion of new-to-the-market innovations.

Sustainability

Environmental compatibility, environmental protection, regional production, and rural development were selected to represent ecological as well as social sustainability. The question of whether production is carried out for an ecological/animal welfare label refers to both ecological and social sustainability. As already mentioned, social and ecological sustainability aspects are expected to be rated as less important by the mainstream producers. Production for an organic/animal welfare label is also uncommon for the mainstream of conventional pork and poultry production. Niche actors are trying to create an alternative to the regime, which is likely reflected in higher social and environmental sustainability ratings. For hybrid actors, it is precisely the low attribution of importance to social and environmental sustainability aspects by regime actors that could represent reasons for distancing themselves from the regime mainstream. With regard to these five variables, a lower share in a cluster therefore speaks for an attribution as regime, a high share for hybrid actors and a very high share for niche actors.

Company level

As mentioned earlier, regime actors are often more established and have larger farms. Farm size is to be represented by the number of animals kept. The mean value for the number of sows, pigs and poultry was calculated for each of the farms. If a farm has at least one value that is higher than the respective mean, the farm is counted as above-average in terms of animals kept. A high proportion of farms in a cluster with an above-average number of livestock indicates that the farm is classified as a regime or hybrid cluster. On the other hand, a low proportion indicates that the cluster is a niche cluster. Due to their size, regimes are more characteristic for an entire region than niches can be. Therefore, a high share of regime and hybrid actors is expected to state ‘My company is typical for the region’.

Results of the cluster analysis

Selection of the best cluster solution

The single-linkage method was applied to all 381 cases. 21 cases were identified as outliers and excluded. The average-linkage procedure was then performed for 360 cases. Different solutions ranging from 2 to 5 clusters were tested. The 5-cluster and 4-cluster solution each have a very small cluster with only 3 cases (Table 3). This would be useless for further statistical analysis. The 3-cluster solution has a large, a medium and a small cluster. The 2-cluster solution has a large and a medium cluster. For interpretation and further

Table 2 Variables for the cluster analysis. Source: Own representation

Variable	Question	Response options
Innovativeness	Have any product or process innovations been introduced in the last 3 years that were new to the market?	Yes, no [yes → 1]
	How soon after market launch are feed innovations used on your own farm?	First, second, third year or later, no use [first year → 1]
	To which type of innovator do you assign your company?	Laggard (1) ← 2-3-4 → frontrunner (5) [4, 5 → 1]
	What makes you particularly different from typical companies in your region?	Low production costs; high level of environmental sustainability or animal welfare in production; high openness to innovation, other specificity; my farm is, by and large, typical for the region [high openness to innovation → 1]
Sustainability	How important are the following criteria to you when selecting feed?	Environmental compatibility: not important, rather unimportant, neither nor, rather important, very important [rather important, very important → 1]
		Regional production: not important, rather unimportant, neither nor, rather important, very important [rather important, very important → 1]
	How important are the following goals for your operation?	Environmental protection: not important, rather unimportant, neither nor, rather important, very important [rather important, very important → 1]
		Rural development: not important, rather unimportant, neither nor, rather important, very important [rather important, very important → 1]
Farm characteristics	Are your products sold under organic or animal welfare labels or are your products part of such labeled products?	Yes, no [yes → 1]
	How many animals does the farm keep? (sows, fattening pigs and fattening poultry)	Number [farm with numbers above the respective mean value → 1]
	What makes you particularly different from typical companies in your region?	Items see above [My business is, on the whole, typical of the region → 1]

Table 3 Solutions with two to five clusters. Source: Own data and calculations

5 cluster solution			4 cluster solution			3 cluster solution			2 cluster solution		
Cluster	<i>n</i>	%	Cluster	<i>n</i>	%	Cluster	<i>n</i>	%	Cluster	<i>n</i>	%
1	167	46	1	233	65	1	233	65	1	233	65
2	66	18	2	97	27	2	97	27	2	127	35
3	97	27	3	27	8	3	30	8	Total	360	100
4	27	8	4	3	1	Total	360	100			
5	3	1	Total	360	100						
Total	360	100									

analysis, the 3-cluster solution seems to be most appropriate. To check for an optimal number of clusters, the Elbow criterion was tested with an ablation of the error sum of squares against the number of clusters (Backhaus et al. 2016).

Interpretation of the results of the cluster analysis

In the following, the three clusters are described based on the different cluster variables (Table 4). The percentages are to be understood as the share of those farms in a cluster that agreed with the question or statement on which the cluster variable is based. The percentages are highlighted in dark grey if the proportion of establishments in a cluster is significantly higher than the proportions of the other clusters in relation to the respective variable. Similarly, those shares are shaded in light grey which represent the significantly lowest proportion of establishments among the three clusters.

The first cluster (characterized as regime) has the lowest shares of farms agreeing with the respective question for all innovation and sustainability variables. The differences to

the other two clusters are significant for all variables (except for ‘regional production’ and ‘production for organic/animal welfare label’). In terms of innovativeness and sustainability, this cluster performs poorly overall. In addition, ‘My business is typical for the region’ was stated most often. This also speaks in favor of describing this cluster as the regime cluster. The frequent rejection of processes of change and skepticism about innovation by regime actors finds expression in low proportions of actors who see themselves as innovators and are open to innovation.

The second cluster (characterized as hybrid) shows a significantly higher proportion of supporters for four of the five sustainability variables if compared to the regime cluster. In terms of innovativeness, however, it does not differ strongly from the regime. This is congruent with the description of hybrid actors in the literature: hybrid actors doubt the mainstream practices (here in the form of a significantly different valuation of sustainability), but still do not show the necessary dynamism and the same prospective innovation behavior as niche actors. Hybrid actors, however, tend to

Table 4 Cluster profiles. Source: Own data and calculations

	variables	regime	hybrid	niche	total
innovativeness	new-to-Market Innovation ***	7%	16%	50%	13%
	rapid adoption (first year) of feed innovation ***	34%	36%	87%	39%
	self-assessment as an innovator ***	19%	43%	90%	31%
	high openness to innovations ***	6%	19%	63%	14%
sustainability	environmental compatibility (very) important ***	19%	97%	53%	43%
	regional production (very) important ***	18%	87%	17%	36%
	environmental protection (very) important ***	59%	98%	87%	72%
	rural development (very) important ***	49%	96%	90%	65%
	production for eco/animal welfare label **	29%	32%	53%	32%
farm	above average number of animals kept ***	21%	35%	97%	31%
	my company is typical for the region ***	33%	12%	0%	25%
	total	233 65%	97 27%	30 8%	360 100%
Chi ² -test, significance levels: * 10%-level, ** 5%-level, *** 1%-level					

be more open to innovation. This is expressed by a higher openness to innovation. They also describe themselves more often as innovators.

The third cluster (characterized as niche) is a comparatively small cluster with only 30 cases. This also fits with the literature which says that niche actors are outnumbered by regime actors at least in early stages of a transformation. The niche has the highest values for most variables in terms of both innovation behavior and sustainability aspects. Niche actors adopt feed innovations most often already in the first year after market launch. Openness to innovation is also more often a differentiating factor.

The only argument against the description of the three clusters as regime, hybrid, and niche is that, contrary to expectations, the significantly highest proportion of farms with an above average number of animals kept is present in the niche. According to descriptions in the literature, regime actors tend to be associated with larger farm sizes than niche actors. Niche actors can often also be described as being dynamic and prospective because they tend to be smaller. The survey results challenge this perspective and pose the question whether larger establishments may also be change agents. Some studies show that farm size has a positive influence on innovation capacity in agriculture (Leis et al. 2011; Batterink et al. 2006). In addition, regulation in the agri-food industry is likely to make it more costly to bring forth innovations. Small farms often have too limited financial resources or lack the ability of securing a loan (Fritsch et al. 2006, p. 287).

Assessment of the transformative potential within the clusters

In this section, the significance of differences among the three clusters with regard to transformative potential is further assessed by indicators for knowledge generation and learning processes as well as innovation behavior. According to the literature, the distribution of knowledge within the company and a regular internal and external exchange of knowledge are important to avoid different kinds of lock-ins and remain adaptive (Boschma et al. 2017). With regard to geography, integrating knowledge from different regions also helps to avoid lock-ins (Bathelt et al. 2004). In addition to knowledge exchange, complementary innovation indicators to those used in the cluster analysis are shown with a focus on co-innovation, the significance of innovation, and the adoption of two other kinds of innovation (see Appendix for detailed information on the additional questions used in this chapter). At the end of the chapter, implications for a sustainability transformation are discussed.

Knowledge generation and learning processes

The expectation that niche actors carry out co-innovation processes with other partners is supported in Table 5. There is also a higher share of hybrid actors with co-innovation compared to regime actors. Hybrid and niche actors collaborate significantly more frequently with other actors in

Table 5 Description of the clusters based on knowledge and learning processes. Source: Own data and calculations

	Variable	Regime (%)	Hybrid (%)	Niche (%)	Total (%)
Internal knowledge exchange	Written documentation	49	57	47	51
	In-house workshops/training	11	12	23	13
	Regular exchange of experience***	41	59	63	48
	Experienced employees as a source	42	52	50	45
	Concentration of knowledge at the farm manager	30	30	37	31
External knowledge exchange	Co-innovation**	81	91	97	85
	Co-innovators: other companies***	61	73	87	66
	Co-innovators: agricultural/corporate consultants	64	75	67	68
	Co-innovators: consultants of associations	43	53	53	46
	Co-innovators: (chambers of) agriculture	49	59	60	53
	Co-innovators: scientists	14	21	20	16
	Co-innovation at local level	39	43	33	40
	Co-innovation at regional level***	68	85	83	74
	Co-innovation at national level	42	43	53	43
	Co-innovation on an international level	17	25	30	20
	Knowledge sources: direct neighborhood/local level very important	15	20	14	16
	Knowledge sources: regional level very important*	15	22	31	18
	Knowledge sources: national level very important	12	20	17	15
Knowledge sources: international level very important**	10	17	17	12	

Chi²-test, significance levels: *10%-level, **5%-level, ***1%-level

general in the innovation process than regime actors. Niche actors collaborate significantly more frequently with other companies than regime actors. Regime, hybrid, and niche actors collaborate similarly often with consultants, chambers, and scientists in the innovation process.

The expectation that regime actors, due to their own dominance in a region and their lower openness, assign a higher importance to the local or regional level for co-innovation processes than hybrid and niche actors is not confirmed. Co-innovation processes on a national or international level are of similar importance for regime, hybrid, and niche actors, with the national level being more important than the international. Regime actors are, however, less likely to collaborate at the regional level in innovation processes with other actors than hybrid and niche actors.

Overall, the various spatial levels are of similar importance for the three clusters for the acquisition of new knowledge. An exception is the very high share of niche actors which attributes importance to the regional level. In addition, a significantly higher proportion of hybrid and niche actors attribute a very high importance to the international level compared to regime actors which partially confirms the theoretical expectations.

Innovation behavior

A significantly higher proportion of innovators from the niche stated that they developed innovations with other companies compared to innovators from the hybrid cluster or the regime cluster (Table 6). This confirms the assumption that hybrid actors have introduced innovations together with other actors more frequently than regime actors.

While there are hardly any differences with regard to the frequency of new- to-the-firm innovations, there are clear differences with regard to new-to-the-market innovations. Innovations from the niche are more often also new-to-the-market than innovations from the hybrid or regime cluster. The higher importance of new-to-the-market innovations expected for niche actors is, thus, confirmed. It is also apparent that hybrid actors tend to be more open to innovations than regime actors.

Feed innovations are adopted more quickly by farms in the niche cluster than by farms in the hybrid and regime cluster. This confirms the expectation. The fact that there is a smaller proportion of regime actors who adopt innovations quickly was also expected. There is also a large difference between hybrid and niche actors for adoption of feed innovation.

Implications for a sustainability transformation

The high levels of interaction among hybrid and niche actors is expected to be conducive to the exchange and diffusion of niche practices. This is because a stable basis for collaboration in the niche is essential, so that resources can be mobilized more easily and expectations can be exchanged and adjusted between niche actors (Boschma et al. 2017; Coenen et al. 2010). This could also simplify the mutual understanding among actors with regard to which technological development path to follow and result in niche innovations to accumulate and gain momentum. It could also help to gain attention, legitimacy, and financial support. The ability to interact can also enable network formation and involvement of a wider circle of stakeholders (Geels 2011). However,

Table 6 Description of the clusters with regard to innovation behavior. Source: Own data and calculations

	Regime (%)	Hybrid (%)	Niche (%)	Total (%)
Type				
Product innovation introduced in the last 3 years***	24	38	63	31
Process innovation introduced in the last 3 years***	33	41	77	39
Co-innovation				
My operation alone**	9	14	23	12
My operation together with other companies***	9	19	53	16
My operation, through adoption or modification of processes**	12	13	30	14
Other companies or organizations	20	24	17	21
Novelty level				
New-to-the-firm product or process innovation	42	53	47	45
New-to-the-market product or process innovation***	7	16	50	13
Adoption				
Rapid adoption (first year) of feed innovations***	34	36	87	39
Rapid adoption (first year) of technology innovations**	14	21	30	17
Rapid adoption (first year) of management innovations	27	28	33	28

Chi²-test, significance levels: *10%-level, **5%-level, ***1%-level

regime actors are also cooperating externally and there is, thus, a potential for interaction with hybrid or niche actors.

For collaboration in the innovation process, the spatial levels have a similarly high significance for regime, hybrid, and niche actors. Only at the regional level, hybrid and niche actors cooperate more with partners in the innovation process than regime actors. Insofar as spatial proximity promotes the establishment of trusting relationships and constant knowledge exchange (Boschma and Weterings 2005), hybrid and niche actors potentially benefit from their embeddedness in the regional context. Niche actors also attach greater importance to the regional level for the acquisition of new knowledge. The spatial proximity could promote the exchange of experience and feedback, the integration of larger groups of experts, and the coverage of a broad spectrum of expertise. These factors are regarded as key mechanisms for the development of niches in the literature (Lopolito et al. 2011; Scholz et al. 2009).

The niche cluster (and to a limited degree also the hybrid cluster) is a likely source of new-to-the-market innovations. Product innovations were introduced significantly more often by hybrid and niche actors than by regime actors, while niche actors are introducing process innovations most frequently. The results show that innovations that are new-to-the-market originate most often from niche actors. However, about one-third of regime actors have also introduced an innovation. This shows that innovations do not originate exclusively from the niche or hybrid cluster.

Compared to regime actors, hybrid actors have a higher share of innovators who have already developed an innovation together with another company and a very high share of companies that collaborate in innovation processes with other companies. This shows that hybrid actors are quite capable of entering into interactions. This is another indication that hybrid actors can potentially fulfill the function of boundary spanning actors between niche and regime. This is likely to be conducive to fundamental change processes, as niche–regime interactions are often the basis for socio-technical transformations (Diaz et al. 2013). In this context, the description of hybrid actors as change agents seems to be appropriate.

While shares of farms adopting innovations in the first year after market introduction are mostly below 50% in all three clusters, the share of quick adopters of feed innovation is very high among niche actors. This could be seen as a positive indication because protein sources are among the hotspots of environmental concern in livestock production.

The high proportion of new-to-the-firm innovators among regime actors, which is comparable to that of hybrid and niche actors, shows that regime actors can also innovate, albeit at a lower level. This is likely to corroborate the description that regime actors try to optimize an existing system by means of incremental innovation (Markard and

Truffer 2006). At the same time, however, the probability of radical innovation, which is often causal for system transformations, is higher for the niche. Accordingly, fundamental innovation dynamics are more likely to come from niche actors. The description of niche actors as dynamic frontrunners (Loorbach and Rotmans 2010) seems to be justified by the data. Existing innovation capabilities in the regime cluster offer, nevertheless, a potential for adoption of niche innovations by regime actors. This could be relevant for transformation processes in a scenario in which niche actors do not succeed in replacing the regime themselves as in the reconfiguration pathway described by Geels and Schot (2007).

Summary and conclusion

Differences among groups of actors are important for understanding socio-technical transformations, but they are rarely the subject of explicit empirical identification. In the literature, three different types of actors are distinguished. Niche actors are the source of innovation dynamics, whereas regime actors try to maintain the status quo and are skeptical of innovations and processes of change (Geels 2002; Schneidewind and Scheck 2012). Hybrid actors often emerge from the regime, but distance themselves from the mainstream. As institutional entrepreneurs or boundary spanning actors, they often assume the function of translating logics between regime and niche and therefore form the basis for niche–regime interactions (Diaz et al. 2013; McCauley and Stephens 2012; Smink et al. 2015).

Based on the results of a survey among pig and poultry farmers in Germany, the Netherlands, and France, a cluster analysis was used to identify the three types of actors. The largest cluster, identified as the regime, has the lowest approval rates for all cluster variables with regard to innovativeness and sustainability. At the same time, it has the highest proportion of businesses that describe their operations as typical for the region. The second largest cluster, identified as hybrid, is differentiated from the regime by a high proportion of companies that attach great importance to sustainability aspects. The third cluster, identified as niche, has the highest shares for most variables of innovativeness and sustainability.

The results show that cluster profiles differ in terms of knowledge, learning and innovation as well as the evaluation of sustainability. While there are hardly any differences with regard to internal knowledge sources or knowledge exchange processes, there are differences in the importance of external knowledge sources and co-innovation. Thus, it is supported by the data that hybrid and niche actors cooperate with other actors in the innovation process significantly more often than

regime actors and tend to be more open to interactions with external actors.

The high interaction capacity of niche and hybrid actors is potentially conducive for the diffusion of niche practices. A stable basis for cooperation in the niche is essential for mobilizing resources more easily and for exchanging and adjusting expectations between niche actors. It could also support the initiation of niche–regime interactions if hybrid actors can assume the function of boundary spanning actors by bridging the logics of regime and niche. In this context, niche and hybrid actors seem to be able to fulfill the role of a change agent.

The regional level is particularly important for the acquisition of knowledge among hybrid and niche actors. Spatial proximity between actors is potentially conducive to building trusting relationships and constant exchange (Boschma 2005). Niche actors should be able to benefit from their focus on regional interactions by facilitating collective learning processes and by further joint actions such as legitimation strategies.

When assessing the validity of the results, it should be noted that three different clusters were formed by the cluster analysis, whose cluster elements are as homogeneous as possible within the individual clusters and as heterogeneous as possible between the clusters. Thus, the cluster analysis provides an optimal solution in which the cases, however, may still have a very different fit to the respective cluster. The results of the cluster analysis attribute each individual actor to belong to exactly one cluster. The observation of Jørgensen (2012) that actors often do not merely act on one level but on several levels can, therefore, not be taken into account. Furthermore, it should be considered that especially with regard to sustainability aspects, a dissonance between assessment and action can often be observed (Revell et al. 2010). The sustainability variables used for the cluster analysis exclusively represent self-assessments. Thus, it has to be kept in mind that the analysis presented in this paper is only able to assess intentions and potentials among the different groups of actors, but not their real actions.

Overall, the application of the cluster analysis and the interpretation of its results with regard to the constitutive characteristics of regime, niche, and hybrid actors based on the literature has shown that it is possible to identify different groups of actors with this method. The characteristics of the clusters seem to be meaningful with regard to the criteria derived from the literature. The introduction of a distinct group of hybrid actors has proven to be useful to better understand the complexities among change agents in transition processes. However, it has to be pointed out that farmers represent only one group of actors within the agri-food system. Transitions toward sustainability also depend on upstream and downstream parts of the value chain which were not the focus of this paper.

Appendix: Additional survey questions used in Tables 5 and 6

Variable	Question	Response options
Internal knowledge exchange	How is knowledge exchange organized in your company?	Multiple answers possible
Co-innovation	Who has developed your product/process innovations?	My business alone, my business together with other partners, if other partners, please specify
Co-innovation, partners	Who do you work with in the development or introduction of new products or processes in your company?	Multiple answers possible
Co-innovation, spatial level	At which spatial level are these partners located?	Multiple answers possible
Knowledge sources	How significant are the different spatial levels for the acquisition of new knowledge?	Likert scale from 1 'not important' to 5 'very important', combined share of 4 and 5 displayed
Origin of pressure to innovate	Where do pressures for the introduction of new products or processes come from?	Multiple answers possible
Type of innovation	Did your company introduce new or improved products/processes in the last 3 years?	Yes/no, separately for product and processes

Source: Own representation

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