Transition topology – a methodological approach to map (systemic) change in transition paths

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1 Introduction

Issues of place-specificity and the long-term character of system change are increasingly emphasized in transition research. More recently, scholars also argue to acknowledge the multiplicity of transitions, understood as the variety of possible ways to reconfigure and change a socio-technical system (e.g. mobility, energy). The ways how systems are changed are shaped by place-specific institutional and governance arrangements (Hansen/Coenen 2015, Hodson et al. 2017). Despite this enhanced understanding of the place-specificity of transitions, it remains largely hidden how actors on the micro-level impact on organizational and institutional change over time, leading towards sustainability on the system level. Although the long-term character of transitions is frequently highlighted, many studies focus on the initial stage of a transition (Brown et al. 2013, Hansen/Coenen 2015) and thus do not capture the outcome of micro-dynamics at the macro-level of the transition path at later points. How and if changes are stabilized is not considered in depth.

Recently, the institutional perspective on sustainability transitions is gaining in importance, since various theoretical and empirical contributions have emphasized institutions and institutional change as a critical issue (e.g. Geels, 2004; Fuenfschilling and Truffer, 2014; Jolly and Raven, 2015, 2016; Wirth et al., 2013; Smink et al., 2015a). In line with other authors (Brown et al. 2013, Fünfschilling/Truffer 2014, Hansen/Coenen 2015, Geels et al. 2016, Hodson et al. 2017), we argue for a profounder research into (de-) institutionalization processes in sustainability transitions and the actors that drive them on the micro-level. By combining insights from sustainability transition theory, evolutionary economic geography and neo-institutional theory, we intend to contribute to the 'socio-institutional perspective of sustainability transitions' (Köhler et al 2017, Loorbach et al. 2017, Fuenfschilling/Truffer 2014). In particular, we argue that the emergence of new organizational forms is an important driver for institutional change. How institutional and organizational changes are interrelated in regional transition paths is widely underexplored. Insights into these relationships, however, have the potential to enhance the understanding of dynamics and the multiplicity of sustainability transition pathways.

Making these complex processes visible, is a major methodological challenge. Causal mechanisms over time and between multiple regimes often remain unclear in existing case study approaches. Changes in institutional and governance arrangements, which are usually gradual and only add up to more fundamental change over time, are particularly hard to capture. The research question "How can hidden organizational and institutional changes and the underlying micro-dynamics be made visible in systemic transition paths?" therefore drives our paper.

We develop the methodological approach of a transition topology (Strambach/Pflitsch 2017) to enable structured navigation (Köhler et al. 2017) between different levels of analysis. As a research heuristic the actor-centered institutionalism approach (Mayntz/Scharpf 1995,

Scharpf 2000) is used. Theoretically our methodological approach is based on neo-institutional organization theory and evolutionary economic geography. The transition topology is a directed graph which captures a system's transition path across different institutional settings over time in a multi-scalar way. The transition topology displays all important institutional and organizational changes towards sustainability in the system and the connections behind. Institutional changes are operationalized as events in time, which indicate a shift in regulative, normative or cognitive elements (Scott 2001). Organizational changes refer to the establishment of new organizations, which includes more fluid as well as more permanent organizational forms. The topology enables both the analysis of the empirical material and the communication with the scientific community (Langley et al. 2013).

The potential of the transition topology is illustrated using the example of a regional system. The Augsburg region provides a particularly suitable example as the transition process there spans different regimes. The topology shows how gradual changes at an early point in time initiate a dynamic later in time. It makes apparent that institutional settings of different regimes are closely connected and influence each other in their transition dynamic, in particular through boundary spanning actors, hybrid organizational forms and temporary events. The topology makes these "hidden dynamics" visible and it can provide a basis for systematic comparisons of cases. It can be used to establish a typology of transition paths to sustainability at a system level, based on variations in key actors, the nature of their interactions with each other and the organizational dynamics that develop over time.

We structure our argument as follows: First, we shortly describe the current state of research on the spatiality of sustainability transitions. Afterwards, we will conceptually shed light on the question, how institutional change and stability is connected by applying an evolutionary perspective and taking into account more explicitly spatial and social scales. Then, we discuss the question why organizational change may be an important driver of institutional change in transition pathways by using new institutionalism and organizational theories (organizational institutionalism). In the third chapter, we will outline a methodological approach, how we propose to make the hidden organizational and institutional changes and the underlying micro-dynamics visible in systemic transition paths. Chapter four illustrates the applications possibilities and potentials of the transition topology. We conclude with an outline for further research.

2 Institutional and organizational change in regional transition paths to sustainability

2.1 Current conceptualizations of space and place in sustainability transition research

Over the last years, there has been a growing interest among sustainability transition researchers in the spatial dimension of transitions. After space had not received much attention for several years, some seminal contributions (Truffer and Coenen 2012, Coenen et al. 2012, Raven et al. 2012) pointed out the need for a closer spatial analysis, in order to explain the unequal transition dynamics across space. In the meantime, a differentiated understanding of the role of space and place in sustainability transitions exists, which is based on relational, evolutionary and institutional conceptualizations of space in economic geography (Hansen and Coenen 2015). In this way, substantial insights into the geography

of transitions have been generated. Several empirical studies highlight the place-specific and multi-scalar character of transitions (Hansen and Coenen 2015). More recently, scholars have also directed attention to the multiplicity of transitions (Hodson et al. 2017).

Meanwhile the place-specific character of transitions is broadly acknowledged. Multiple dimensions of place-specificity that result from institutional, relational or socio-economic characteristics of regions can be distinguished (Hansen and Coenen 2015). Among these different sources of place-specificity, formal and informal institutions, which shape social practices in production and/or consumption contexts, have received by far the greatest attention in the literature. Many authors have shown that specific policies and long-term visions exert a strong influence on transitions at the urban or regional scale (e.g., Bulkley 2010, Carvalho et al. 2012, Maasen 2013, Rohracher and Späth 2014). Other studies emphasized the role of local informal institutions, such as trust, culture, shared understandings (e.g., Coenen et al. 2010, Wirth et al. 2013, Ornetzeder and Rohracher 2013) or particular practices (e.g., Shove and Walker 2010, Faller and Schulz 2017).

At the same time these studies have directed attention to the interrelatedness of local institutions with institutional arrangements on other spatial scales (national, global) (Hansen and Coenen 2015). In this vein, Späth and Rohracher (2012) have shown how local transformations of regimes can function as a legitimation for transitions at a broader spatial scale. Taking the example of the UK energy system, Essletzbichler (2012) has shown how regional and national regulations co-evolve with and complement each other. Interdependencies between local, national and global regimes can however also pose clear boundaries to local regime change (Hodson et al. 2017, Hodson and Marvin 2012, Späth and Rohracher 2012).

More recently, scholars have pointed out the multiplicity of transitions, understood as the variety of ways how a socio-technical system can be reconfigured (Hodson et al. 2017). This variety differs across places, as each place offers different opportunities for system change. If these opportunities are used and which of them are selected, are strongly influenced by the existing spatially-bound institutional structures. Hodson et al. (2017) emphasize that there are a variety of different visions at the regional and supra-regional level of how a sustainable urban transition could look like. These visions impact on the selection of niche innovations through which local regimes are transformed.

Despite these advancements, many studies have modelled the place-specific institutional environment as a relatively static pre-condition for sustainability transitions (Torrens et al. 2018). Place-specific institutional environments influence the decisions of actors as to which opportunities for regime change they use. Yet, actors, by making use of the opportunities given in a specific place, reconfigure these institutional environments over time.

We suppose that for a deeper and more profound understanding of the place-specificity of transitions, the territorially-bound institutional structures and related practices by actors from multiple regimes have to be analyzed. Regions comprise a diverse range of regimes. From an evolutionary-institutional perspective, these local regimes are connected through their institutional structures, which develop in a co-evolutionary and place-specific way over time. Seeing regions as open systems, it has to be acknowledged that regional transitions to

sustainability rely on more complex mechanisms than transitions of individual regimes. The spatial institutional dynamics that affect the local dimension of multiple regimes have remained largely hidden in transition research so far.

In the next chapter, we therefore focus on the micro-level and how actors stimulate institutional change, which leads to transformative change at the systemic level of the regional path over time. Capturing these dynamics can substantially enrich current explanations of why regional transitions unfold so differently across regions.

2.2 The Interplay of stability and change in (Regional) Sustainability Transitions Pathways

A core issue of the different approaches in sustainability transitions is the relation between stability and change. Transitions to sustainability are defined as large-scale disruptive changes in societal systems that emerge over a longer period of decades (Loorbach et al 2017, Geels 2010). The niche-regime-landscape dynamic (MLP), is considered as the main mechanism for the emergence of radical novelty on the system level. By focusing on long-term changes in socio-technical systems, research on sustainability transitions has clearly revealed that these processes are complex, and pounced in their variety and diversity (Loorbach and Rotmans 2010; Raven, Schot, and Berkhout 2012). Moreover, these processes are strongly shaped by place specificity identified in theoretical and empirical terms by scholars with an economic geography perspective. A significant number of case studies confirmed the impact of place-specific institutional and governance arrangements on transition pathways and dynamics (Hansen/Coenen 2015, Hodson et al. 2017 Coenen and Truffer, 2012; Truffer and Coenen, 2012).

These insights have been led to the more explicit recognition of the multiplicity of transitions (Köhler et al 2017), understood as the variety of possible ways to reconfigure and change socio-technical systems (e.g. mobility, energy). What is, however, not fully explored are the sources and the mechanisms that underlay the multiplicity and the spatial shaping of sustainability transitions pathways. Particularly the complex way in which institutional stability and change are interrelated in transition pathways (in a specific space-time context) has not received much attention so far. We argue stability and change are not binary categories but instead are reciprocally intertwined and contributing in this way to the multiplicity of regional transition paths to sustainability.

Institutional stability

To understand the dialectic relationship between stability and change at the system level (Köhler 2017 et al: 5) both Transition Research and Evolutionary Economic Geography (EEG) apply the key concept of path dependency. Similar to the debates in transition studies, the socio-institutional perspective in EEG finds a more prominent role recently. Both mainly separated strands have complementarities that can enhance the understanding of institutional change and the multiplicity of transitions dynamics.

By focussing on path dependency of socio-technical regimes, transition research highlights primarily the stabilizing forces that contribute to the lock-in of unsustainable production and consumption patterns. Particularly emphasized is the path dependent co-evolution of

institutional trajectories with technologies over time leading to persistence and rigidity of socio-technical regimes (Geels 2010). Their relative stability is explained by using the concept of a dominant institutional logic underpinning the strong alignment of practices, technologies and materiality. To succeed in system change radical and disruptive change is required (Walker 2000, Köhler et al 2017).

Research in economic geography focuses path dependent development of regional systems and explain the unfolding of the place-specific institutional endowments as intended and unintended outcomes of decisions, actions and interactions in the past that constrain and enable the context of future actions. In recent research work, a more elaborate institutional analysis and differentiation of institutional arrangements find the entrance. Scholars take into account the interaction between institutional architectures at different spatial and social scales (Gertler 2010, Evenhius 2017, Wink et al. 2017). *Institutional complementarities and coherence* are recognized as important mechanisms for the stability of place-specificities by generating disincentives to radical change. Institutional complementarity, which over time links together different institutions situated at distinct spatial scales and modes of organization in a certain architecture, contributes to coherence. The complementary nature of institutional configurations within the regional socio-economic system, make some institutions more efficient through their interaction with others. Spatially bound institutional configurations entail nested institutional arrangements of distinct spatial reach and often an *institutional hierarchy*, the relative importance of one or a few institutions for the coherence and dynamic of the institutional architecture as such (Amable 2000, Morgan et al. 2010). Moreover, these institutional mechanisms have an important influence on the co-evolved intersecting multi-regime structures located in regional systems as they contribute to the maintenance of their spatially shaping.

Institutional change

Even so stabilizing institutional mechanisms such as institutional complementarity and coherence are in place, the composition of institutional configurations is not static, but rather simultaneously providing a flexible scope for both change and stability. Taking into consideration the institutional complementarity and hierarchy, the change of institutions within institutional configurations must not necessarily destabilize the coherence of a whole architecture. That explains why diverse regional systems with place-specific institutional endowments, even in the same national institutional system, may exist and absorb institutional change. But on the other hand, institutional change in one sphere can increase pressure and have a snowball effect on complementary institutions to change gradually. Moreover, related to the mechanism of institutional hierarchy, change at lower level has the potential to contribute to institutional change at higher levels.

In summary, EEG with the focus on regional systems, calls into question the polarized conceptualization of institutional change in the arguments about path dependence. Institutional change is considered as either being incremental, leading to inertia and to negative lock-ins over time or as being disruptive, triggered mainly by exogenous events or intended regulatory push from political actors (Martin/Sunley 2006, Boschma/Martin 2010). Such a dichotomous conceptualization does not take into account the multidimensional

character of institutions and the nested institutional environments in their multi-scalarity and place specificity (Strambach/Halkier 2013, Murphy 2015). Based on the rationale that not only radical or disruptive institutional change may lead to system transformation over time, scholars in EEG address more explicitly the plasticity of well-established institutional settings of paths and the institutional dynamics. The concept of path plasticity focus on the interrelationship of stability and change within paths by exploring processes on the micro level causing gradual cumulative institutional changes. Mainly transferred from historical institutionalism (THELEN 2002, STREECK/THELEN 2005; MAHONEY/THELEN 2010) forms of institutional change such as displacement, layering, drift, conversion and exhaustion, as well as, bricolage and translation known in sociology (Campbell 2011) are explored in theoretical and empirical terms contributing to gradual and transformative change of regional systems in the long-run. Agency and forms of path development in the broader transformation processes of regional systems gained a more prominent role in economic geography. The path dependency of institutional change is becoming understood in a more dynamic way. Centred mainly on innovation and technological changes of regional systems, different forms of path development besides path creation such as path upgrading, path renewal or path importation are outlined (Isaksen et al. 2016, Grillitisch /Trippl 2016).

Similar in transition research, over time, a more differentiated conceptualization of transition dynamics has occurred within the perspective of MLP approach. Geels and Shot (2007) distinguished four different types of transition paths by taking into account the timing of changes at the niche and landscape levels and their relationship to each other (cooperatively or competitively), as well as by recognizing the different dynamics within the socio-technical regime. They identified the substitution path, the transformation path, the reorientation path, and the reconfiguration path (Geels/Shot 2007, Geels et al. 2017). In the recent debate on the conceptual elaborations and challenges of socio-technical systems and system reconfiguration, Geels (2018) emphasizes that addressing system reconfiguration may also require some reconceptualization of the MLP. Shortcomings of the analytical focus on ‘singular disruption’ and the necessity to pay more attention to different kinds of change mechanisms are acknowledged. To understand institutional change in system reconfiguration Geels (2018) refers conceptually also to the gradual change mechanisms from Thelen (2002). Moreover, the interactions between multiple systems are also considered as an important issue for new insights into the reconfiguration processes.

2.3 The emergence of new organizational forms as driver for institutional change

3 The Transition Topology – a methodological approach to analyze and map organizational and institutional changes in sustainability transition paths

3.1 Methodological foundations of the transition topology

The 'transition topology' aims to make the hidden processes of organizational and institutional changes over time visible. The target of such a topology is to identify the processes through which these changes are generated by focusing on the timing and sequencing of events and the interconnections between processes over time. In this regard, the topology should enable to capture in particular the outcomes of the underlying micro-dynamics at the macro-level of the transition path at later points.

The distinct feature which differentiates the transition topology from the already well-known network topologies is two points: the causal reconstruction and the process analysis. A network topology is usually a systematic description of a set of actors or nodes along with a set of a specified type of ties that link them together. The pattern of ties in a network yields a particular structure, and nodes occupy positions within this structure (Borgatti 2011, Scott, John 2013 Knoke, D. Yang 2008, Wassermann/Faust 1994). The reproduction of network structures is explained by the properties of networks themselves reflected in the topology. However, the causal processes which generate the structural properties remain largely underexplored (Guliani /Krädtke). The transition typology seeks to go beyond acknowledged drawbacks by taking into account the social characteristics of actors, their institutional embeddedness and the agency involved in change processes.

Furthermore, the causal reconstruction strives to explain a given social phenomenon (a given event, structure, or development) by identifying the processes through which it is generated. It does not look for statistical relationships among variables, like the quantitative social network analysis, but provide instead mechanisms or theoretical account for the existence of certain linkages (Rueschemeyer/Stephen 1997, Thelen 2002). Causal reconstruction may lead to a (more or less complex) historical narrative, however, in its theoretically more ambitious version, causal reconstruction aims at generalizations involving processes, not correlations (Mayntz 2002: 2). The methodology of the transition topology seeks to contribute to the latter.

As a research heuristic, the actor-centered institutionalism approach is used originally developed in order to analyze problems of governance and self-organization processes of social systems (Mayntz/Scharpf 1995). Given that the concept is not an object-related theory, but a heuristic for detecting and order empirical facts (cf. Mayntz/Scharpf 1995; Scharpf 2000), the approach has proved fruitful for the analysis of regional paths to sustainability.

The key features of the actor-centered institutionalism approach enable to explore empirically the connection between actors and systems and the reconstruction of causal processes. The basic assumptions is that social phenomena are the results of interaction of intentional acting actors. These interactions are structured by enduring institutional settings in which they take place. Theoretically our methodological approach is based on neo-institutional organization theory. From the institutional perspective we focus on embedded agency and institutional

work (the purposive action of individuals and organizations aimed at creating, maintaining and disrupting institutions Lawrence and Suddaby 2006, p. 215). Grounded in the structuration theory and the duality of structures (Giddens 1984), it is assumed that results of interactions in turn have impacts on institutional settings by contributing to gradual institutional changes over time. The central analytical categories of this approach are actor constellations, the action orientations and outcomes of interaction processes in time.

3.2 Establishment of the transition topology

The topology enables to explore empirically the connections between agency and changes at the system level of the path. The topology is a directed graph that maps the most important institutional and organizational changes in the path across different institutional fields and spatial scales. Organizational and institutional changes are captured in form of concrete events in time, which can be interpreted as outcomes of interaction processes at the micro-level.

The topology relies on a qualitative longitudinal case study, which involves a mix of different methods for data collection. As shown in figure 1, these methods were used throughout the process in a recursive way. In the center of the approach are narrative and problem-centered interviews with actors from different organizations that were deeply involved in the transition process. A mix of narrative and more problem-focused interview techniques is necessary in order 1) reconstruct the evolution of the transition process and then 2) investigate specific details in the process. Document analyses (of e.g. strategic papers, annual reports, websites, newsletters, etc.) are important to identify interview partners and to investigate specific details in the process. Participatory observations (e.g., during workshops, project meetings, fairs, conferences) enable to gain context knowledge and are therefore important for the interpretation of the data. The triangulation of different methods and data sources is not only necessary in order to reconstruct the transition process, but also to cross-validate the findings. As pointed out in the previous sub-chapter, the causal reconstruction of processes is a very ambitious goal that must be based on rich, varied and longitudinal data. This often affords a prolonged involvement of the researchers in the process (Langley et al. 2013.).

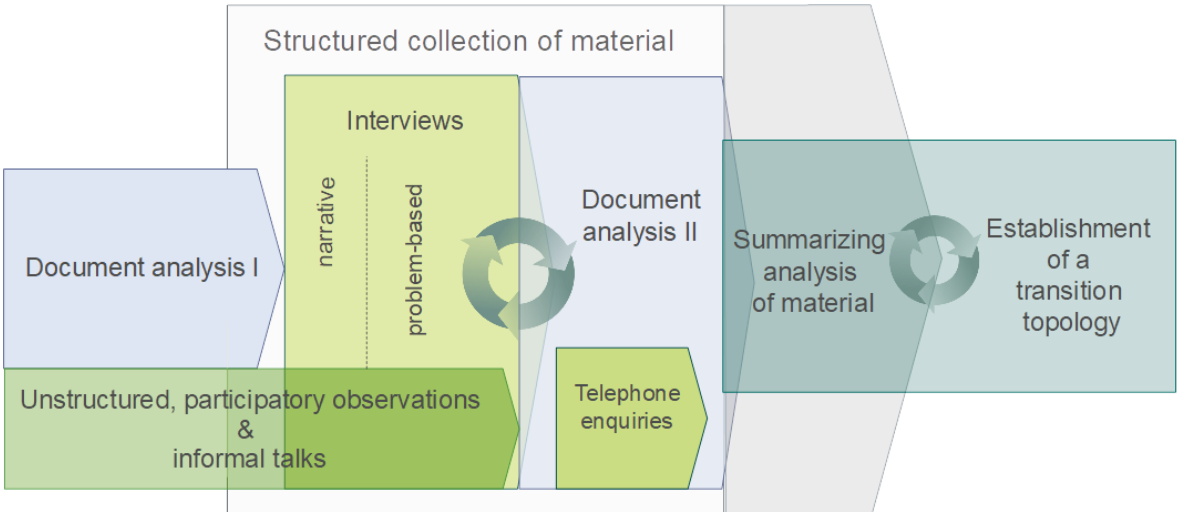

Figure 1: Establishment of the transition topology

With a mix of inductive and deductive categories, the most important institutional and organizational changes need to be identified. Institutional changes are operationalized as events that indicate a shift in regulative, normative, or cognitive elements. Organizational changes are further differentiated (according to our elaborations in chapter 2.3) in events that indicate 1) the establishment of a new organization, which includes new independent organizations as well as new departments in existing organizations, 2) networks and 3) institutionalized temporary events. In a next step, different forms of connections between events can be included in the topology, e.g. impulses from one event to another event that has been vital for the latter's establishment. These impulse can be of a material (e.g., financial support) or non-material nature (e.g., founding idea, transfer of personnel).

4 Illustrating the potentials of the transition topology

In this chapter, the application possibilities and potentials of the transition topology are illustrated. The chapter is subdivided into four different topics, which exemplify the range of application possibilities of the approach. The first three sections draw on an in-depth case study of the sustainability transition of the Augsburg region (Germany). The latter has been increasingly recognized for its frontrunner role in the transition towards sustainability, e.g. through the German sustainability prize in 2013. The Augsburg region provides a particularly suitable example as the transition process there spans different regimes, including technology-based regimes (e.g. mobility, energy, housing) as well as regimes from the social infrastructure sector (e.g. health, education, food). The fourth section illustrates the application of the topology to analyze the role of a specific actor type in regional sustainability transitions. It draws on a comparative case study about the involvement of the universities of Augsburg and Linz (Austria) in the transition process to sustainability of their surrounding regions. Although the Linz case is in many respects comparable to that of Augsburg (population size, industrial history, student numbers, study program), the approach towards sustainability of both regions differed substantially.

4.1 The nature of organizational and institutional change in different transition phases

The topology (see figure 1) makes apparent that Augsburg's transition process is characterized by a dynamic institutional and organizational change. Through the analysis of the empirical material, three different phases in the transition process were identified. These phases already become visible by studying the pattern of the topology: In figure 1 these phases can be distinguished by the varying quantity of events in the different time periods. A closer examination shows that the three phases also differ regarding the nature of organizational and institutional changes.

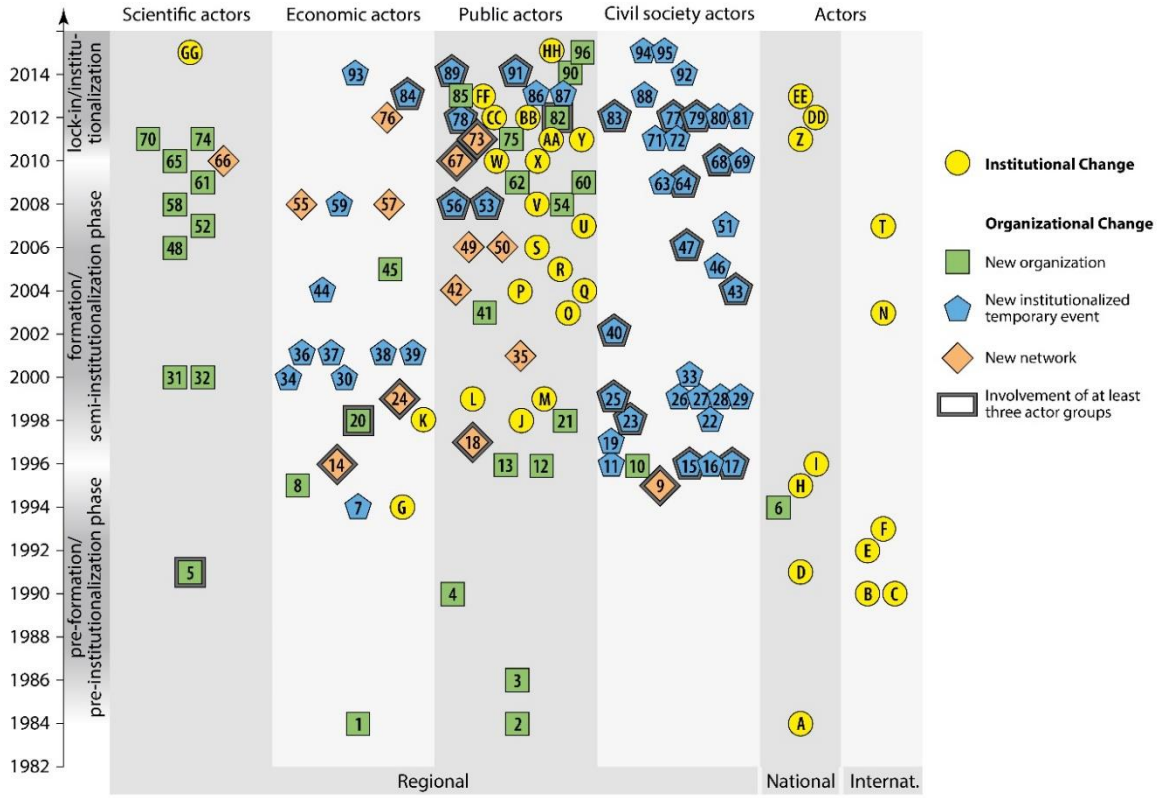

Figure 1: Transition topology for the Augsburg region

Source: Own graphic; Cartography: Christiane Enderle

The pre-institutionalization or pre-formation phase

From the mid-1980s until 1996 there are relatively few events in the topology. Institutional changes, which gave impetus for the regional transition process, mainly took place at the national and international level (see right column in figure 1 letters A-H). In parallel some initial organizational changes happened at the regional level, mainly in the public field (2-4). Taking a closer look at these early organizational changes, an important characteristic of this phase becomes apparent: No organizations were established which cut across different institutional settings. Actors thus mainly operated within their institutional field and did not get confronted with conflicting field logics, yet.

However, from the interviews we know that many informal interaction processes already took place, which become visible in form of organizational changes in the second phase. In addition, it became apparent that despite some value-driven individuals, most collective actors in the region did not have an understanding for sustainability yet. Changes in this early phase happened due to a regulatory-push from the national and international scale and were not based on a cognitive understanding or a change in values.

Semi-institutionalization or formation phase

The second phase is characterized by a strong increase in organizational changes across

different institutional fields. The emergence of three collective actors (9, 14, 18) that explicitly aim at fostering change towards more sustainable production and consumption patterns, also marks an important point of change and thus for us the beginning of the second phase in Augsburg's transition process. These networks bring together actors from different institutional fields with different interests and logics and foster the establishment of cognitive proximity. The double framing of the events in the topology indicates that all three organizations bring together actors from at least three different institutional fields. Hence, the emergence of organizations that break up institutional consolidations are a new phenomenon, characteristic for this second phase. Through the topology it also becomes apparent that after the formation of these three main actors a large number of new institutionalized temporary events were established. In parallel, several institutional changes happened in the public field.

The interviews revealed that throughout this second phase the focus on environmental issues broadened and a more holistic understanding of sustainability was established, particularly in the city administration. However, at the beginning of this phase actors in the public field and the economy were still skeptical about sustainability. In order to convince actors of the purpose of these activities, individual boundary spanners played an important role. The interview partners explained that it took a long time until a sense of responsibility for the topic developed in different organizations. In this vein, the importance of temporary events was emphasized, which fostered the exchange of ideas and different perspectives between actors across organizational boundaries.

Institutionalization or positive lock-in phase

Since 2010, a further intensification of institutional and organizational changes, particularly in the public domain can be observed. Most importantly, institutional changes occurred that reinforced or strengthened the developments which took place in the second phase. One example for the latter is a decision of the city council to continue the sustainability advisory board set up at the beginning of the second phase (AA) or update and expand its sustainability program (BB).

From the interviews we know that positive feedback effects, e.g. through a recognition of the process from outside, set in. Compared to the beginning of the second phase, where actors in the public and economic fields were still very skeptical about sustainability, the principle in this third phase started to guide social practices in different institutional settings and thematic fields. At the same time, the interview partners raised concerns about a certain “abuse” of the sustainability term and an uncontrolled proliferation of the process.

4.2 Connections between organizational and institutional changes

The topology can furthermore be used to make connections between organizational and institutional changes apparent (see figure 2). In this way, it also enables to identify important actors and events (critical junctions) in the transition process.

Figure 2 makes apparent that there have been two collective actors (10, 20), which induced a substantial number of further organizational and institutional changes at later points in time in the path. This central position in the topology indicates that these actors played a

particularly important role in the regional transition process to sustainability.

As expected, the topology shows that most connections between organizational and institutional changes exist within particular institutional fields. There are however also connections which cut across these boundaries. In a multi-scalar process, institutional changes at the supra-regional level (e.g., F, H, I) have induced change processes in several institutional fields within the region. An organizational actors in the economic field (20) (co-)initiated several organizational changes at the university (31, 32, 52, 58). In the case of Augsburg, these connections can be found in particular between actors form civil society and the public field. In this case they even go back and forth between these fields (e.g., 40, Q, Y, 83). Different forms of connections become apparent in the topology as well. In this way, it becomes apparent that temporary events in civil society have given many impulses for institutional changes in the public field (e.g., 40, Q). The topology event reveals that one of the two central actors is a hybrid organization (10, 12) that cuts across the public and the civil society fields.

From the interviews we know that the actor that fostered a holistic understanding of sustainability in Augsburg over time moved from a peripheral to a more central position in the path. It turned out that this actor was able to strengthen its position mainly due to its hybrid organizational form. Trough establishing permanent organizational proximity to actors from the public field, the collective actor was able to bridge the two different institutional logics and foster a more holistic sustainability understanding in the city administration.

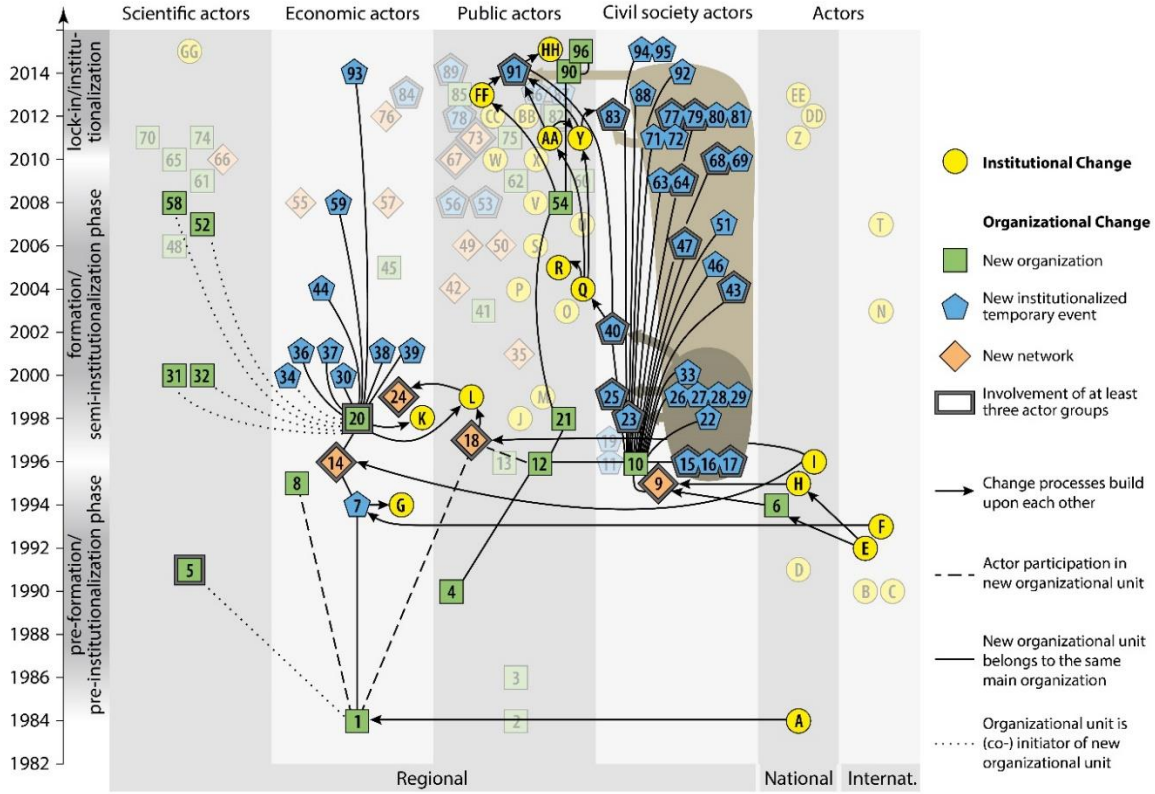

Figure 2: Main actors in Augsburg's RTPS

Source: Own graphic; Cartography: Christiane Enderle

4.3 The effects of events in their specific temporal and spatial context

Through the topology, impacts of events can be analyzed in their specific temporal and spatial context. In this vein, the topology enables to consider the timing and sequencing of events. In this way, change processes can be reconstructed and the underlying causalities become apparent.

The topology (figure 2) shows that the main actors in the process are established due to the same developments at the supra-regional level. It becomes apparent that at an early point in time impulses from outside the region were necessary in order to spur the process. Afterwards, the further development took mainly place within the region.

It also shows that specific events at a later points in time build on sometimes long sequences of events. In this way, it can be seen for instance that an event that happened in the mid-1980s (1) lay a foundation for an event that took place nearly two decades later (93). Another example is a new organization (1), which builds the basis for a network (14) that was established twelve years later. Two years after its foundation, the network is transformed into a more permanent organizational form (20).

The topology makes apparent that the transition path of the Augsburg region relies on a substantial amount of organizational and institutional changes. It shows how different forms of organizational changes interrelated, e.g. loosely coupled networks are turned into more permanent organizational forms with resources and clear structures (14 & 20, 9 & 10).

Through the interviews, we know that a few value-driven actors lay important foundations for the transition process in the Augsburg region. They used windows of opportunity in order to start institutional work processes. Temporary events enabled them to react spontaneously to changes in context conditions. Through these temporary events they were able to convince other actors of the need to act and develop more sustainable practices. In this way, these actors continuously involved new actors groups in the process.

4.4 Comparing dynamics and actor roles in different transition paths

The topology also builds a basis for a systematic comparisons of cases. The example below shows that it can be used to compare the role of a particular actor type in the regional transition process and make different place-specific dynamics visible. The following figures display the relationships of the universities of Augsburg (Germany) and Linz (Austria) with their surrounding regions in the context of sustainability (Pflitsch and Radinger-Peer 2018). Through a comparison of the two topologies different ways of how particular actor types get involved in the transition process and how that affects their role in these processes become visible.

In this example, the left columns (in figures 3 and 4) differ from the other columns as they displays the university's internal organizational and institutional dynamics. In this column the central actors at the university, which induced the largest amount of further organizational changes within the university, can be identified.

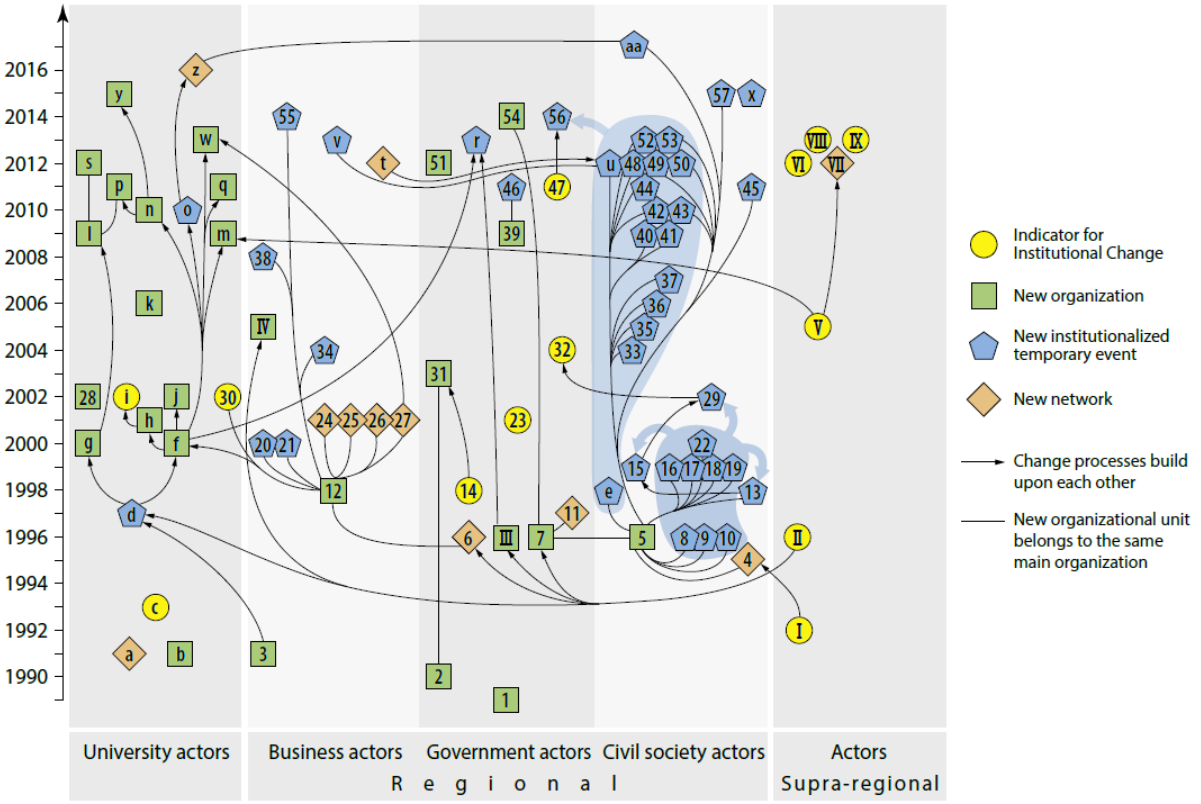

Figure 3: Grafik Augsburg

Source: Own graphic; Cartography: Christiane Enderle

In Augsburg it is particularly one collective actor (f), which induced many further organizational changes within the university. The topology shows that this actor was established due to impulses from regional actors/events. The process within the university and the process in the other regional institutional fields then developed in parallel. As indicated by the arrows in the topology, the collective actors from the university (f, z) recently gave important impulses for organizational changes in the region (r, aa).

In the interviews it became apparent that in Augsburg many relationships between university members and regional actors developed in a bottom-up way. University actors have direct relationships to actors from all other institutional fields. In addition to these sectoral boundary spanning activities, a variety of actors from different disciplines are involved in the transition process. Although these activities are only managed by a relatively small unit within the university, the process meanwhile involves a large amount of actors and spans a variety of different topics.

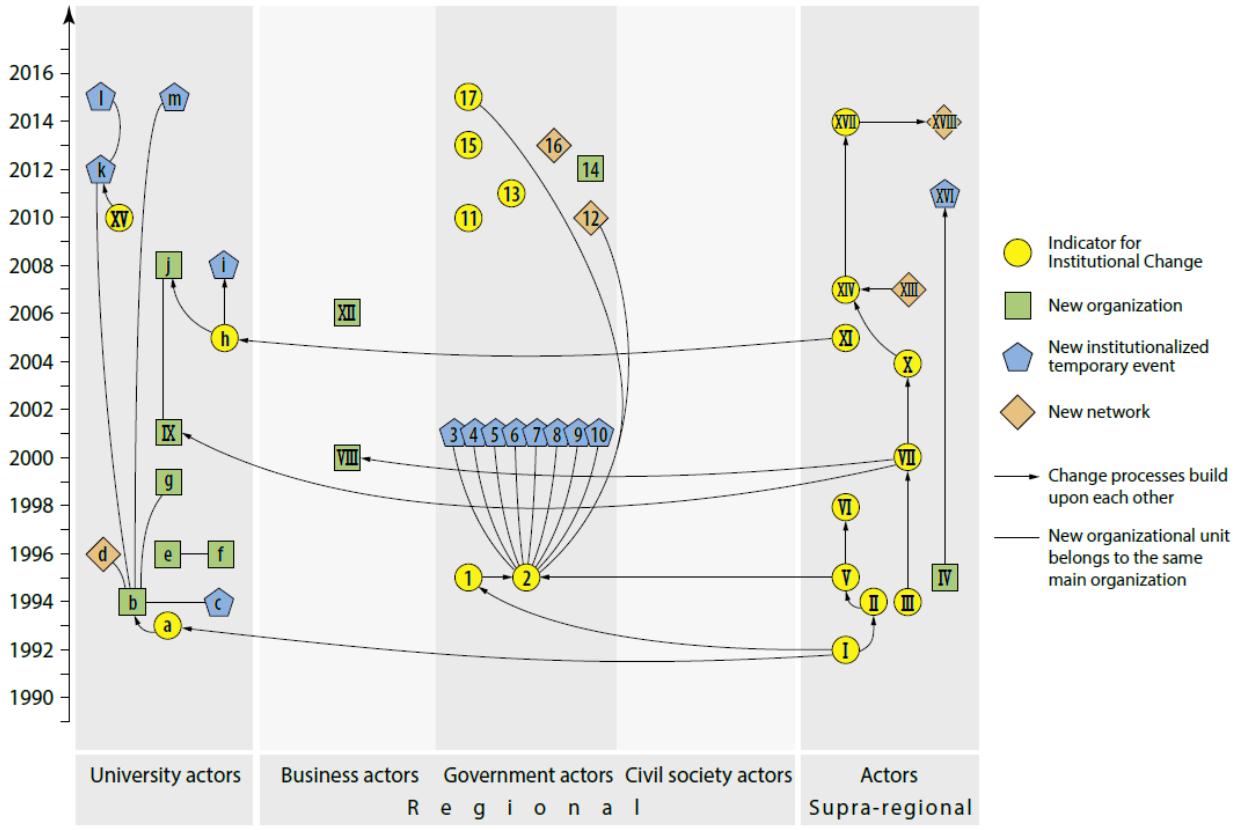

Figure 4: Grafik Linz

Source: Own graphic; Cartography: Christiane Enderle

In Linz, both the processes within the university and in the other regional fields look very differently. There are no sequences of events like in the topology of the Augsburg region. Neither in the university not within the region a dynamic process set in. At several points of time, there have been impulses from the supra-regional level, which initiated organizational changes within the university. There are however few actors in the region, with which these organizational units at the university could cooperate.

Through the interviews and the document analysis, it became apparent that actors from the university work in close cooperation with actors from the federal-state government. Only indirectly through the participation of university members in advisory boards and working groups of the federal-state government relationships to actors from civil society and the economic field exist. Boundary spanning activities within the university are also relatively rare. Overall, the current role of the university in the transition process is rather fragmented and passive, but therefore more focused on specific topics that are perceived as relevant by the federal-state government.

5. Conclusion

The aim of the paper was to make hidden organizational and institutional changes and the underlying micro-dynamics visible in systemic transition paths. Therefore, we developed the methodological approach of a transition topology, which captures a system's transition path across different institutional settings over time in a multi-scalar way. To illustrate the potential

of our approach, we draw on empirical examples from the Augsburg region and a comparative case study of the involvement of the universities in Augsburg and Linz in the transition of their surrounding regions.

The empirical examples underlined our conceptual assumption that organizational changes are an important driver of institutional change in regional paths. In the Augsburg region, these organizational dynamics lead to a diffusion of sustainable practices and finally the start of a transition in many different areas. New hybrid organizations which combined different institutional logics, broke up institutional consolidations and induced dynamic in the regional path. Temporary institutionalized events, like forums, working groups or trade fairs, enabled the participation of a broad range of actors – also from outside the region. They were important for problem framing and knowledge combination processes. Individual actors that participated in several organizations at the same time were also extremely important. In particular in an early phase, where sustainable practices were critically evaluated and often rejected, value-driven actors initiated change by using the plasticity of institutions.

The topology also made obvious that the regional level is characterized by the overlap and interdependency of different institutional settings. Through the topology we were able to see how actors from different settings influence each other in their activities and which organizational changes enable this. The topology also shows that the institutional settings of different regimes are strongly interrelated and are mutually reinforcing each other in their transition dynamic at the regional level – in particular through hybrid forms of organizations.

These changes are not radical but gradual at first but have the potential to lead to a more fundamental change over the long run. Through the transition topology we can show how change processes at an early point induce a dynamic at far later points in time. The topology makes these “hidden dynamics” visible.

It was also shown that the transition topology enables to compare transition paths of different spatial systems. It could provide a starting point for the establishment of a typology of different spatial transition pathways. Based on the topology it would be possible to identify variations in the role of specific actor types and the nature of organizational dynamics.

The topology could also be used for a deeper analysis of multi-regime dynamics. Deeper insights into the latter could substantially enhance our understanding about why regional transition paths differ across space.