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Developing Boundary-Spanning Capacity for Regional Sustainability Transitions—A Comparative Case Study of the Universities of Augsburg (Germany) and Linz (Austria)

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Abstract: The potential of universities to become ‘change agents’ for sustainability has increasingly been highlighted in the literature. Some largely open questions are how universities get involved in regional sustainability transitions and how that affects their role in these processes. This paper argues that universities need to develop a boundary-spanning capacity, which enables them to transcend disciplinary as well as sectoral boundaries in order to adopt a developmental role in regional sustainability transitions. It is investigated how universities develop this capacity within a particular regional context, using the method of a transition topology. Comparing how the relationships of universities with their surrounding regions developed in Augsburg (Germany) and Linz (Austria), the paper shows why these processes are place-specific. A university’s boundary-spanning capacity develops over time and differs according to the actors involved. The primarily bottom-up driven process in Augsburg was thematically quite broad and involved diverse actors. In Linz, the top-down initiated process was fragmented and more narrowly focused. Individual value-driven actors that made use of their personal networks played an important role in both regions.

Keywords: universities; sustainability transitions; regional development paths; boundary-spanning capacity; institutional change

1. Introduction

Current challenges such as climate change, impending resource scarcity, demographic change, and migration patterns confront regions with the task to develop in a more sustainable direction. This requires deep structural changes in multiple areas of daily life (e.g., mobility, energy supply, housing), that have changed only incrementally over a long period of time [1]. Due to their multidimensional character, these transformations are extremely complex. They can only be achieved through the participation of a broad range of heterogeneous actors that contribute their specific knowledge, competencies, and perspectives [2,3]. Universities are seen as particularly relevant actors in these processes [4–11].

In the scientific literature, universities are expected to be highly responsive to the concept of sustainability and the problems and questions it brings up, due to their long-term perspective and their societal mandate [7,8]. Stephens et al. [4] and Zilahy and Huisingh [5] argue that they could even take a leading role in regional sustainability transitions through developing strategic long-term visions and goals. Moreover, due to their interdisciplinary structure, universities are expected to have the

capability to bridge different types of knowledge [12]. According to Sedlacek [7], this is particularly important in order to solve complex sustainability challenges. Universities have therefore recently been described as a ‘change agent’ for sustainability (e.g., [4,9]).

In line with these authors, we assert that universities can indeed take an important role in regional sustainability transitions. We do not, however, want to imply that their role is more privileged than that of other actors and that they necessarily act as a frontrunner in these processes. Referring to what has been labeled a developmental role in the literature on universities and regional development [13], we suggest that universities can actively engage in regional governance activities and, in doing so, contribute to direct a region’s development trajectory towards sustainability. Sustainability challenges and the opportunities for approaching them are highly place-specific [2,14,15]. In the context of sustainability transitions, the regional focus of a university’s research and education activities, which is seen as a key element of a developmental role, becomes even more important. At the same time, the integration of the university in and its contribution to regional networking activities and institutional capacity-building become particularly significant.

Most existing studies that explicitly focus on the role of universities in regional sustainability transitions show that universities need to interact with a more diverse range of regional actors—including actors from the economy, the public field, and civil society (e.g., [5,6,8,16,17]). At the same time, they have to integrate knowledge, perspectives, and methods from different disciplines within the university (e.g., [7,17,18]). How universities can develop this boundary-spanning capacity is, however, largely an open question. Most existing studies take a “snapshot” of the activities of universities at the point the research was conducted [18] (p. 615). We argue that boundary-spanning capacity results from a place-specific and temporal process.

Analyzing the involvement of universities in regional sustainability transitions therefore necessitates a long-term approach. For this purpose, the paper uses the methodology of a transition topology, which makes it possible to map the emergence, unfolding, and stabilization of institutional and organizational change processes towards sustainability over time [19]. It reveals how the universities under study developed and institutionalized their boundary-spanning capacity and how this in turn shaped the regional transition towards sustainability. The comparative case study setting showed how these processes differ across regions. It became apparent that the thematically quite broad approach towards sustainability in Augsburg was driven primarily from the bottom up and involved diverse actors, while the top-down process initiated in Linz was fragmented and more narrowly focused on specific topics. By examining how place specificities shaped these different pathways, we shed light on the question of why transitions differ between regions and contribute to the emerging research field on the geography of sustainability transitions [14].

The paper is structured as follows: The theoretical part elaborates how a developmental role in the context of sustainability transitions relies on the institutionalization of boundary-spanning activities to a more diverse range of actors (Section 2). After the methodological approach (Section 3), the two case studies are presented (Section 4). This is followed by a detailed presentation of both regional development paths to sustainability (Section 5). The discussion synthesizes the similarities and differences in a comparative form (Section 6). We conclude with policy recommendations and suggestions for further research (Section 7).

2. The Role of Universities in Regional Sustainability Transitions

2.1. Universities and Regional Development

Within the last decades the interest in universities’ roles within their regional contexts, as part of a so-called ‘third mission’ or ‘task’, emerged [20,21]. The scientific efforts associated with this role produced two bodies of literature, that is, (a) the role of universities in promoting regional economic activities through academic entrepreneurialism (e.g., triple helix model, entrepreneurial university) [22,23], in comparison to (b) university engagement in a broader understanding focused on

the long-term development of a region (e.g., engaged university) [24,25]. Gunasekara [13] differentiates these roles into ‘generative’ or ‘developmental’.

The generative role refers primarily to the provision of knowledge by the university in response to business or institutional demands [13]. The developmental role, in contrast, implies that the university interacts with broader regional governance structures which seek to purposefully shape future development trajectories and network topologies [26]. The developmental role considers that universities contribute to the long-term socio-economic development of a region by adapting their research and teaching activities more closely to regional needs. Moreover, universities play an important role in enhancing the regional institutional and social capacity, as well as fostering the creation of new intra- and interregional relationships [13].

Benneworth et al. [27] showed with the example of Lund University that taking over a developmental role helped to “construct advantage” [27] (p. 1660) through (a) deepening, that is, creating institutions which were conducive for technology transfer; (b) widening, in the sense of broadening regional networks and establishing relations to external actors, and (c) integrating, that is, bringing together various sectors and in this way creating a stronger integration of the formerly fragmented activities of regional actors. Thus, the university engaged in activities spanning industrial sectors, which created new innovative capacity and avoided lock-in.

Taking over a developmental role does not happen independently and autonomously from the universities’ specific regional environment, however. Instead, it is influenced by the regional absorptive capacity (e.g., industrial base, human capital), the regional culture and tradition of university-region linkages, as well as national and regional political framework conditions [13,27]. In this vein, it must be considered that both universities and regions are complex systems, which are unlikely to work together on a rational, linear regional development process [28,29]. Universities are multidimensional, loosely structured communities of scholars who are active in wider knowledge production, transformation, and transfer processes. Regional engagement is just one of multiple agendas, and the regional scale merely one of multiple scales [30]. Regions are complex systems themselves with different actors who consciously (e.g., policy makers, regional development agencies) or unconsciously (e.g., entrepreneurs, businesses) shape the development path of a region. The (developmental) role of the university thus has to be seen as the outcome of complex process dynamics that are shaped by intended and unintended actions of multiple actors from both the university and the region over time.

While existing literature has developed a nuanced understanding of the interdependencies between universities and their regional environment, it privileges the role of universities to support economic growth and regional competitiveness. It is largely an open question of how universities can contribute to a reconfiguration of the regional system in a more sustainable direction by taking over a developmental role.

2.2. *Universities and Regional Development in a Context of Sustainability Transitions*

Sustainability transitions are generally understood as fundamental changes in socio-technical systems (such as energy, transport, or housing), which comprise changes in technologies, infrastructures, policies, consumer practices, and cultural meanings [1]. These processes differ substantially from purely technological, economically motivated innovations, particularly due to the much more complex knowledge dynamics and actor constellations involved [31]. They also have long-term orientations and their outcomes are often unclear [1]. Additionally, sustainability transitions and the opportunities for approaching them are highly place-specific [2,14,15].

This increased complexity affects the roles of universities in regional development processes, in that they become more diverse and complex [6,7]. In addition to combining knowledge from different disciplines (e.g., [7,17,18]), universities need to establish new linkages and relationships between actors, build coalitions, and enable negotiations among regional stakeholders [6–8,16–18,32]. Stephens and Graham [18] therefore see the primary task of universities in the context of sustainability transitions in the formation and guidance of cross-sectoral initiatives. The authors argue that universities have the

potential to provide leadership, long-term orientation, and reflection on the progress of transitions. Sedlacek [7] also highlights these facilitating and mediating functions of universities. She suggests that universities have to generate knowledge together with societal and political actors by “bridging the gap” between these actor groups [7] (p. 75). She thus considers universities mainly as ‘bridging institutions’, which initiate and facilitate interaction among different societal sectors in the region. In a similar vein, Trencher et al. [17] argue that universities do not transfer knowledge to regional actors or advise regional decision-makers anymore, but instead aim at co-creating knowledge with a diverse range of societal actors.

What can be deduced from these studies is that a fundamental and inevitable process underlying the role of universities in the context of regional sustainability transitions is to transcend a broad range of disciplinary and sectoral boundaries. The latter can in this context be defined as the establishment and management of interactions between different organizations, professional groups, or sectors [33,34]. Many authors model universities as ‘change agents’ or ‘frontrunners’ that mobilize regional actors and initialize transitions in their surroundings (e.g., [17,18]). By analyzing best-practice examples, they highlight the importance of leadership by the university management and the existence of a strong mission towards sustainability (e.g., [7,18]). These studies have in common that they derive these conclusions based on the investigation of single sustainability-related projects or initiatives. In doing so, certain aspects, such as regional embeddedness, leadership, and their ‘change agent’ role are assumed as given.

We are of the opinion that the concept of a developmental role provides a more holistic approach to understand the roles of universities in sustainability transition, their long-term emergence, and the establishment of new relationships to and between formerly separated actors. The concept has to be broadened, however; in the context of sustainability, relationships between a much broader range of actors must be established. Based on these considerations, we expect the ability of the university to fulfill a developmental role in regional sustainability transitions to be highly dependent on the institutionalization of the university’s boundary-spanning activities.

2.3. Developing Boundary-Spanning Capacity for Sustainability Transitions

Few insights are available in the literature about how boundary-spanning activities develop and how universities build up a boundary-spanning capacity in the context of sustainability. Most studies focus on the role universities and their individual members play in specific regional sustainability projects at a certain point in time [18], where relationships between diverse actors are already present. Benneworth et al. [27] used the example of the University of Lund to demonstrate that it required a time-intensive and elaborate organizational learning process to engage in boundary spanning between different economic sectors in the region. Referring to insights from institutional theory, we argue that the institutional environment of a university plays an important role in this regard.

Institutions comprise regulative, normative, and cultural–cognitive elements that, together with associated activities and resources, provide stability and meaning to social life [35]. At the same time, they enable and constrain agency [36]. The institutional environment in the context of the university can be described as an organizational field [29], which is composed of all those organizations that “(. . .) in the aggregate, constitute a recognized area of institutional life” [37] (p. 148).

Traditional institutional contexts of universities do not offer particularly favorable conditions for boundary spanning. Examples are very pronounced disciplinary cultures and unwritten rules, which hamper interdisciplinary cooperation, as well as a focus on specialization in the current academic system. Regarding external stakeholders, there are, for example, much stronger incentives to cooperate with economic actors than with other actors in the region, as researchers are strongly dependent on third-party funds from industry. Therefore, the question is how a favorable institutional context develops which triggers or at least supports boundary spanning across disciplines and sectors.

Two general mechanisms can be distinguished which can induce institutional changes: (1) incentives and support from different levels of government and/or the university management, and (2) activities and efforts of individual actors.

(1) The government has an important role due to its regulative influence on universities via rules, laws, evaluations, and sanctions. In addition, it can also provide incentives for certain activities via political programs, subsidies, and funding programs. Over the last years, many political programs have tried to spur the involvement of universities in regional sustainable development [7,11]. Via funding programs or the establishment of intermediary organizations, politicians from the national or federal level have tried to foster the formation and/or institutionalization of relationships between university members and regional actors to foster sustainability transitions [6]. In addition, DiMaggio and Powell [37] emphasize the influence of the academic profession, which at large, as well as within a given national context, exercises a considerable normative influence. Examples are the implementation of transdisciplinary approaches towards research and teaching in certain scientific fields, or on the other hand, their negligence. Another factor within the organizational field which exerts influence on universities are other Higher Education Institutions (HEIs) and their function as role model and cooperation partner, but also competitor. Finally, we expect the regional institutional environment to exert influence on the boundary-spanning capacity of universities. Regional governance and network structures with their own power relations, dynamics, culture, and trust [38] offer proximity between actors [39] and can be important facilitators of (transdisciplinary) cooperation.

The university management may exert influence on other university members to engage in boundary-spanning activities via their normative and cultural-cognitive influence. Examples are the incorporation of sustainability-related networking activities with other disciplines and regional actors, the incorporation of sustainability into the university strategy and mission, or commitments to specific charters or declarations (e.g., Copernicus Charter). Furthermore, the support for new organizational units, such as interdisciplinary platforms or new institutes with a respective focus, can foster boundary-spanning activities. Overall, however, interventions from the 'top' are not as effective in universities as in other organizations [40]. Universities are 'loosely-coupled' [41] organizations that are subdivided into departments and institutes, which each possess a certain extent of autonomy regarding their teaching, research, and outreach activities [30].

(2) Clark [42] suggests that the basic change or adaptation mechanism within 'bottom-heavy' organizations like universities is grassroots innovation, with little interference or steering from managerial structures located at the top. Therefore it is also likely that actors from the university and/or region initiate new relationships due to a shared interest in a topic or a shared concern for a particular sustainability challenge in a more informal way. Actors 'at the bottom' are usually better informed about regional needs than politicians at the federal or national level and can therefore better tailor their activities to the region's demands [43]. Moreover, these relations can be expected to be driven by a stronger intrinsic motivation. Relationships that are initiated bottom-up are often based on existing social relationships that are not purely of a professional character. Thus they already build on trust and shared experiences and therefore function more smoothly [44], while top-down initiated interactions still must be socially embedded. At the same time, this strong personal-boundedness can come into conflict with the long-term nature of relationships necessary for sustainability transitions.

More recent approaches from institutional theory [45,46] suggest that actors on the ground can also induce change in the university's institutional environment. The institutional work approach considers that individual or collective actors can purposefully enact or prevent change through maintaining, disrupting, and creating institutions. Institutional changes are often the result of the purposeful or unintended coordination of actions of multiple actors [47]. In the same vein, Strambach [48] argues that existing institutions always leave actors "room for manoeuvre" [48] (p. 421). By using the interpretative flexibility of institutions, particularly creative and reflexive actors can enact changes in existing cognitions, values, and rules [48,49]. Even gradual institutional changes can have a radical

result over the long run [46]. This implies that even 'less powerful' actors at the bottom of the hierarchy, such as students, can achieve substantial institutional changes [47].

We expect that boundary-spanning activities need to be institutionalized within the university in order to have a positive effect on long-term regional sustainability transitions. Institutionalization is understood as a process which goes through various stages [50]. An increasing degree of institutionalization becomes apparent through formal and informal rules, standards and standardized routines, and structural changes (e.g., new organizational units), as well as the supply of human, financial, and infrastructural resources [35,51,52]. While formal institutions and organizational changes can be implemented relatively quickly, it is much more time-consuming and difficult to change cultural–cognitive institutions such as habits or cultural meanings. The latter, however, is seen as the most developed form of institutional change, as it means that actors have internalized these new institutions and take them for granted [37]. Nevertheless, new organizational structures might also induce learning processes between actors, as in the case of Lund University [27], and thus induce cognitive–cultural changes. The mechanisms and dynamics are very complex and little is known about what kind of institutional and organizational changes effectively initiate and sustain boundary-spanning activities in the context of sustainability.

From our conceptual considerations, we therefore derive the following questions which will guide our empirical analysis:

- (a) How were boundary-spanning activities in the context of sustainability initiated?
- (b) To what extent do different drivers contribute to these boundary-spanning activities?
- (c) How do these boundary-spanning activities differ according to different drivers?
- (d) What does that mean for the role of universities in sustainability transitions?

3. Methodological Procedure

Institutional change processes and their underlying dynamics are hard to grasp due to their often diffuse and gradual character. The approach of a transition topology makes it possible to capture the emergence and outcome of institutional and organizational change processes over time. It helps to understand how intended or unintended activities of actors on the microlevel induce gradual changes and how these add up to a more fundamental change on the aggregate level of a path. The transition topology also makes interactions between different sectors in the region and between spatial levels visible. It therefore provides a useful tool to identify which institutional and organizational changes were important for the emergence and development of boundary-spanning activities, which actors induced these changes, and how these activities in turn shaped the regional sustainability transition [19].

A comparative case study was conducted in order to show how the development of boundary-spanning capacities of universities for sustainability transitions differs among regions. A main criterion for the selection of the cases was a similarity regarding some basic framework conditions, which made it easier to determine other place-specific influences. The Johannes Kepler University (JKU) as well as the University of Augsburg are both relatively young, mid-sized universities with a broad disciplinary spectrum. They are located in the medium-sized cities of Augsburg (Germany) and Linz (Austria). The surrounding regions have both been classical production sites and therefore had rather difficult preconditions for a transition to sustainability. A further criterion was that the two universities are not 'best practice' examples of sustainable universities (as it is the case for the Leuphana University in Lüneburg or the Karl-Franzens University in Graz). With a recent recognition for sustainability, they rather constitute 'normal practice' among universities and thus provide a realistic picture on the topic.

The data was collected through a qualitative mixed methods methodology. In each case, seven interviews with actors from the university as well as key stakeholders from the region were conducted. A mix of narrative and more problem-focused interview techniques was chosen in order to stimulate

the interviewees to reconstruct the evolution of the transition process. Specific details in the process were investigated via telephone or e-mail. In parallel, a thorough document analysis was conducted, which included strategic papers, annual reports, websites, newsletters, etc. The juxtaposition of different perspectives on the topic and the methodological and data triangulation helped to verify and deepen the results. Additionally, both authors had already conducted research in the case study regions. (While one author investigated the role of LA21 in the sustainability transition of the Augsburg region [19], the other author conducted a research project on university engagement in the Linz region [53].) The knowledge gained through previous interviews, participant observations, and document research was important for the interpretation of the results and their integration into the overall context. The authors did not, however, participate in the processes themselves, which enabled them to remain in a neutral and objective position.

In a first step, the data was analyzed in order to establish the transition topology, a directed graph which maps the major institutional and organizational changes in the region and the connections between them in a chronological order [19]. In addition, political programs or initiatives at the supraregional level that had an impact in the region were taken into account. In total 135 events were recorded (see Appendix A). Institutional changes were operationalized as events, which indicated a shift in regulative, normative, or cognitive elements [35]. Organizational changes refer to the establishment of a new organization, which includes new independent organizations as well as new departments in existing organizations, more fluid as well as more permanent organizations. (For a more detailed description of the methodology see [19].) The connections between the events are of a genealogical nature. They either indicate an organizational affiliation or an impulse from one event to another that has been vital for the latter's establishment. This impulse can be of a material (e.g., financial support) or non-material nature (e.g., founding idea, transfer of personnel). The topology covers a time period of more than two decades, capturing institutional and organizational changes within the university and their relation to the regional development paths to sustainability [19]. It enables the identification of the main organizations and most influential events in the transition through the number of changes they induced in the path. In the next step, a qualitative content analysis of the interviews was conducted. This enabled the detailed analysis of the boundary-spanning activities that the main organizations identified in the first section engaged in and how these influenced the role of the university in the transition process.

4. The Case Study Regions

4.1. Augsburg

After Munich and Nuremberg, Augsburg is the third largest city (with 286.374 inhabitants in 2015), as well as the third largest economic center in Bavaria (together with the districts of Augsburg and Aichach-Friedberg). After a long economic crisis due to the decline of the textiles industry and rationalization measures in the machinery industry, the city of Augsburg recorded a positive trend in employment numbers over the last years [54]. With the help of political support programs, Augsburg's production-intensive industry managed a structural change towards a knowledge-intensive and more environmentally sound economy. Today, Augsburg hosts many leaders as well as a cluster organization and a competence network in the field of environmental technologies. In 2011, the city of Augsburg officially adopted a resource efficiency 'Leitbild' (mission statement) in order to jointly promote the leading sectors in the region: automation and mechatronics, information and communication technologies, fiber composite and lightweight technologies, aerospace and environmental technologies. At the same time, a comprehensive research infrastructure with a similar focus was built up at the two higher education institutions in the region [55]. In 2014, Augsburg was even ranked among Germany's top five innovation regions, particularly due to its networking activities in the field of resource efficiency [56]. Parallel to this development, the city of Augsburg received the German Sustainability Award in 2013 for its broad range of achievements in the fields of climate protection,

economic and demographic change. The jury emphasized the success of Augsburg's local agenda 21 (LA 21) process and its outcomes in multiple thematic fields. The broad participatory process through which the holistic sustainability concept of the LA 21 was developed was seen as particularly valuable [57].

The University of Augsburg was founded in 1970 with a focus on the social sciences, law, and economic studies. Only in the mid-1980s was the faculty of the natural sciences established, which then expanded quickly during the 1990s. 20,386 students were enrolled at the university in the winter term of 2017 [58]. The University of Augsburg is referred to as one of the first 'Reformuniversitäten' (reform universities) in Germany. The societal relevance and applied character of study programs were thus emphasized right from its establishment [59]. The only other HEIs in the region that delivered specific expertise for the regional transition was the University of Applied Sciences. (The German system of higher education comprises universities and universities of applied sciences. The latter are required by law to conduct more applied research than universities and offer an education with a strong practical orientation (e.g., through long internships, degree theses written in companies). Professors and students at universities of applied sciences therefore usually have comparatively strong ties to the local industry [60].)

4.2. Linz

Linz, the capital of Upper Austria, has a population of 201,595 (in 2016). The city of Linz with its surrounding region, the Central area of Upper Austria, has around 580,000 inhabitants (including the districts of Linz, Wels, and Steyr). The city of Linz acts rather autonomously within its field of competence due to its size as well as political and economic significance. Between the end of World War II and the 1970s, Upper Austria became the leading industrial region in Austria with the highest export and employment rates. Small but innovative firms grew to become internationally known enterprises (e.g., Voestalpine, BMW-Motorenwerk Steyr, KTM, Bombardier-Rotax, etc.). More recently a 'green economy' has developed and, supported by the state government, a number of clusters have been set up, representing the Green Tech Region Upper Austria. While Linz had the image as a grey industrial city for several decades, restoration and reutilization projects of former industrial sites (e.g., the Tabakfabrik) as well as social and economic programs led to the declaration of Linz as European Capital of Culture in 2009.

The Johannes Kepler University (JKU) was founded in 1966. 19,406 students were enrolled at the university in the winter term of 2015/16. Like the University of Augsburg, the JKU offers a broad thematic spectrum ranging from law studies and the social and economic sciences, to the technical and natural sciences. First attempts to found a university in Linz date back to 1962, when the city and the federal-state government of Upper Austria founded the 'Linzer Hochschulfond' (Higher Education Fund Linz), a public corporation between the city of Linz and the federal country Upper Austria in order to raise the financial capital needed to found the university. This corporation, besides financing the infrastructural and operational needs of the university, also influenced the development of the study program, the appointment of the professorships and departments, and thus the self-perception of the university and its role within its regional environment. Compared to Augsburg, in Linz a broad range of HEIs is located in the region, ranging from public universities, private universities, and universities of applied sciences, to two colleges of education. These universities are also engaged in sustainability-related activities (see [11]) but are not in the focus of this paper. (If no reference is mentioned, the information was acquired through the interviews.)

The regions as well as the universities of Augsburg and Linz share many similarities. It is important, however, to consider that the region of Linz accounts for a large proportion of Upper Austria and is its main economic center. Augsburg is the third largest of three economic centers and only accounts for a much smaller proportion of the Bavarian population.

5. Developing Boundary-Spanning Capacities for the Regional Sustainability Transition—The Cases of Augsburg and Linz

The empirical analysis is organized into two subchapters in which the case studies are presented separately. Each subchapter is further divided into (1) a description and analysis of the transition topology and (2) a qualitative analysis of the boundary-spanning activities of the main organizations that have been identified in the first section, as well as their outcomes.

5.1. The Augsburg Case

5.1.1. Emergence of Boundary-Spanning Organizations

The topology (see Figure 1) captures the genealogical relationships in the regional development path to sustainability. The university's internal dynamics are displayed on the left side. Those of the other regional subsystems can be found in the three columns in the middle. On the right side, events that happened on other spatial scales, but had an impact on events within the region, are displayed.

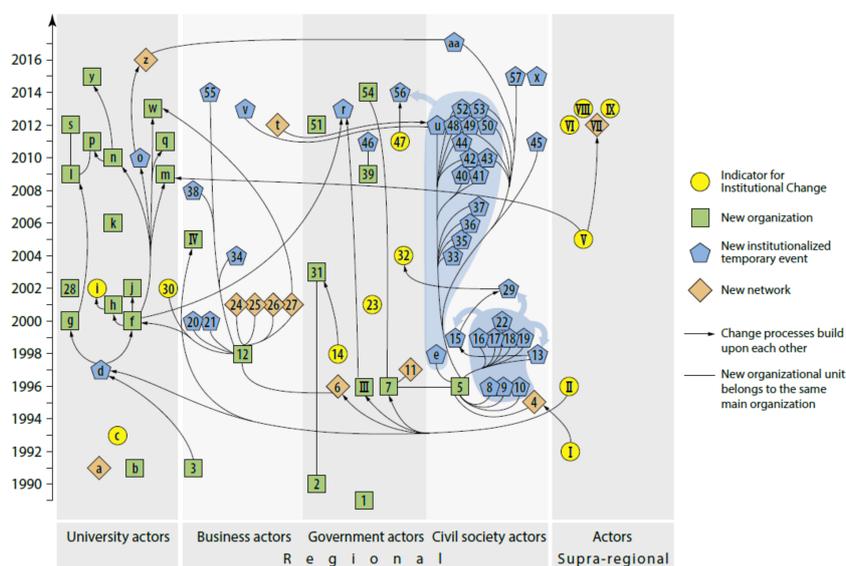


Figure 1. Transition topology for the University of Augsburg and the surrounding region. Cartography: Christiane Enderle.

The topology makes it possible to identify the most important actors in the regional transition. It makes apparent that in the university, the interdisciplinary Research Center for the Environment (WZU) (f), founded in 2000 with the aim to explore the sustainable use of substances, materials, and energy, initiated several institutional and organizational changes towards sustainability. Amongst others it gave impulses for the establishment of new sustainability-related interdisciplinary study programs (j, m, q), the establishment of a global non-profit organization advancing sustainable business practices (h), a chair for resource strategies (n) and two working groups on sustainability among researchers, administrative staff (o) and students (z) with the aim to foster sustainability in the operation of the university and generally raise awareness for sustainability within the university. With the User Center for Material and Environment Research (AMU) (g) and the Center for Material Resource Management (MRM) (l), a second ‘strand’ developed. In contrast to the WZU, the MRM follows a technology-oriented approach focused on the exploration of new materials for a resource-efficient economic development.

In the region, several important actors, which induced many further institutional and organizational changes, become visible as well. The Environmental Competence Center Augsburg-Schwaben (Kumas) (12) initiated several networks and exhibitions on the topic of environmental technologies (20, 21, 24–27,

30, 34, 38, 55). The LA 21 (5) continuously established new institutionalized temporary events on specific topics, in which more sustainable social practices were developed (7, 8–10, 13, 16–19, 22, 33, 35–37, 40–45, 48–50, 52, 53, 57, e, u, aa). It also initiated the city's environmental advisory board (11), where all relevant organizations from the region regularly come together to advise the city council on environmental and sustainability-related questions.

The topology also helps to understand how these main actor groups emerged. After the first organizational changes at the university (a, b) and in the public field (1–3), the declaration of Augsburg as an environmental competence region by the Bavarian government in 1996 gave an important stimulus for the emergence of Kumas, the LA 21, the WZU, and AMU. The LA 21, which had been founded by actors from civil society (4), used the new label to secure a permanent position in the city administration (7) and to initiate the city's environmental advisory board (The advisory board was later renamed into agenda and then sustainability advisory board) (11). Kumas was established shortly after the declaration by actors from the IHK, the university management, and the city of Augsburg in order to formulate concrete strategies and actions for the environmental competence region. Amongst others it recommended the establishment of applied research centers on environmental topics at the university to support the emerging environmental industry in Augsburg. In this vein, the Bavarian government provided seed funding for the WZU (f) and the AMU (g) at the university.

The interviews show, however, that it was due to the personal interest of the founders of the WZU, three professors from the natural and social sciences, as well as the manager of the WZU, that the organization's intended focus on environmental topics expanded and a holistic sustainability perspective developed. The latter was based on previous research activities of these actors and impulses by colleagues from the institute of geography, which had already engaged with the topic of sustainability.

In both the region and the university, new foundations generated foundations themselves. In this way, the number of actors working on the topic of sustainability steadily increased. Over time, two different strands developed in the region: a technology-oriented approach focused on the transformation of Augsburg's resource-intensive machinery industry into a more environmentally sound and resource-efficient economy, and a strand which engaged in broadening the understanding of an environmental competence region towards a holistic sustainability 'Leitbild'. This dynamic recently even started to cut across regional subsystems, e.g., with the establishment of a new LA 21 forum (aa) through the Green Office, a student initiative from the University of Augsburg (z).

5.1.2. Boundary-Spanning Activities Driving Sustainability Transition

This section describes the boundary-spanning activities, how they were influenced by the key organizations and events that have been identified in the previous section, and how they contributed to the regional transition process. Hence, the focus is on interactions between organizations or individual actors on the microlevel that do not directly become visible in the topology.

Through the WZU, boundary-spanning activities across diverse disciplines and sectors were established. The network of the WZU meanwhile involves 74 researchers from seven faculties (covering both the natural and social sciences) and several external organizations. Members of the WZU cooperated repeatedly with regional actors, such as members of the Bavarian Institute for Research into Waste Disposal (Bifa), the chamber of crafts (HWK) and the IHK, the association of landscape management, the city's environmental office, and the public utility company. They also participated in several LA 21 forums, enabling students to do internships and practical projects, e.g., in the city's environmental education station. The working groups on sustainability and the Green Office frequently cooperate with regional actors such as the LA 21 and other actor groups from civil society, e.g., Cityfarm Augsburg or Foodsharing e.V., as well. The Bavarian State Ministry for the Environment (LfU), which had been moved to Augsburg in the course of its declaration as an environmental competence region, also became a close cooperation partner of the WZU.

While the WZU has built up a very heterogeneous actor network, the sectoral boundary-spanning activities of the AMU and MRM are primarily focused on actors from industry and government. Although the MRM also engages in knowledge transfer to the broader public, for instance, by conducting workshops in education facilities, the activities are mainly targeted at the techno-economic development of the region. Boundary spanning between disciplines is also taking place in the MRM, but with a narrower focus on material sciences and resource strategies.

The boundary-spanning activities of the WZU were not initiated top-down but emerged through a shared interest of persons in a specific topic, often in an informal way. It was important for the stabilization of sectoral boundary-spanning activities that members of the WZU were integrated into regional organizations, such as Kumas, the city's environmental advisory board and some LA 21 forums right from the beginning. This was actively fostered by the founders of Kumas and the LA 21, who were not commissioned by the city of Augsburg but had their own agenda and mobilized a variety of actors in the region in order to realize their personal vision for the Augsburg region. In this way, the network relationships with regional actors became relatively stable and are no longer dependent on specific actors. At the same time, institutionalized temporary events, including regular meetings at the WZU, the Kumas' networks, and the LA 21 forums, where actors met repeatedly for a limited amount of time, enabled the initialization of new relationships and the creation of new ideas for joint projects.

The university management is not perceived as a strong driver of boundary-spanning activities in the context of sustainability. Although it mentioned the aim to network with regional actors in the field of environmental technologies in the university's development plan in 1990 and signed the Copernicus Charter in 1993, it has not proactively fostered interdisciplinary networking or the establishment of relationships to a broader range of regional actors. Most researchers that have entered the WZU's network seem to be mainly interested in finding new cooperation partners or getting new impulses for their research and teaching activities. However, without the support of the university management and the engagement of individual committed actors at the federal-state level, the increasing institutionalization of the bottom-up driven activities would not have been possible.

On the contrary, third-party funds and research programs have given strong incentives for boundary-spanning activities with industry actors in the field of resource and material efficiency. Particularly in the Augsburg region, with its carbon industry, these activities have been strategically promoted by the city of Augsburg and the federal-state government, e.g., through the establishment of the new innovation park on resource efficiency. The regional development agency also fostered cooperation between researchers from different disciplines with industry actors by initiating a platform for resource efficiency in 2011. Through regular meetings, inter- and transdisciplinary projects or joint project applications developed, which would—according to an interview partner—not have been established automatically through the spatial or even organizational proximity of these actors in the region or the university.

In this way, university actors have contributed to the regional transition in various ways. Through its boundary-spanning activities, the WZU absorbed impulses from a broad range of actors from different disciplines and societal sectors with different perspectives on sustainability. Thus members of the WZU were able to identify topics that are particularly relevant for the region in the context of sustainability and develop more extensive research approaches, e.g., the comprehensive approach 'Stoffgeschichten' (material histories).

Since the foundation of the WZU, a total of 25 research projects with an explicit regional focus were conducted. The contributions range from the legitimation of sustainability measures (e.g., the implementation of an environmental zone) in the region, the choice of potentially sustainable technologies for the local transition (e.g., through the establishment of a heating atlas), the identification of conflicts between different aspects or dimensions of sustainability (e.g., in an open lecture series on the renaturation of the local river), and impulses for the future development of the region (e.g., the development of a concept for an environmental department at the new university clinic), to a critical reflection of the progress and direction of the regional transition process (e.g., by taking

a critical stance on the implementation of the resource efficiency ‘Leitbild’ in the local economy). By integrating sustainability into the university’s teaching activities and by extensive educational work in the region, the WZU also raises awareness for sustainability topics and their multidimensional character among students.

The establishment of relationships between university members and regional actors not only enabled the university to contribute to the transition process, but also gave impulses for a transformation process within the university. Both working groups on sustainability have received impulses and support from the LA 21, for instance, to implement ecological standards in several buildings or to start a campaign to reduce the use of paper at the university. More recently, the Green Office even received funding for its foundation from the LA 21 and financial support to take part in international networking activities with other student initiatives.

The AMU and in particular the MRM are involved in various cooperations with industry actors and the latter takes over an important role in the regional innovation park on resource efficiency. Actors affiliated to these organizations moreover participate in various projects, which often have a huge impact on the external image of the region. One example is a project financed by the German government with the aim to analyze how a region with an energy-intensive industry like Augsburg can deal with the volatile energy supply from renewables and this way manage the ‘Energiewende’ (energy transition).

5.2. The Linz Case

5.2.1. Emergence of Boundary-Spanning Organizations

The topology (see Figure 2) shows that at the Johannes Kepler University (JKU) Linz, the actor which induced the largest number of further organizational and institutional changes towards sustainability, is the Institute for Environmental Law (b). Besides establishing an association with the aim to support the institute financially but also to involve other stakeholders from the region (d), the institute initiated an event series (c), a new specialization in the study program law (g), and an international conference (k), as well as the future lecture series (m). Two other organizational changes provided a basis for further changes at the JKU, the Institute for Environmental Management in Companies and Regions (UWI) (e) and the Energy Institute (IX), which both started new study programs in their respective fields of expertise (f, j).

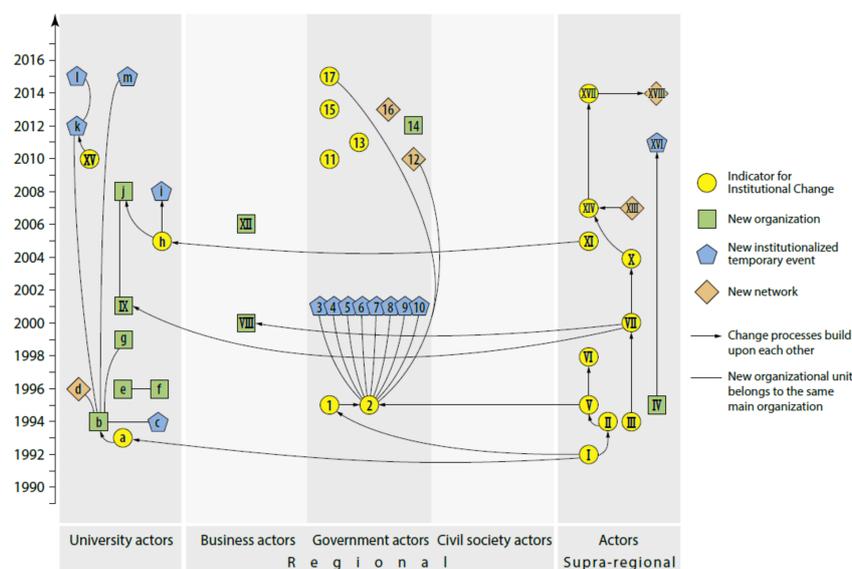


Figure 2. Transition topology for the JKU Linz and the surrounding region. Cartography: Christiane Enderle.

In the region, there seem to be no main actors which fostered the topic of sustainability. The main changes towards sustainability which have been initiated by regional actors, such as the eco-energy cluster, have received comprehensive support from the federal government. The LA 21 (2) is the only actor which induced a number of further organizational changes in the form of working groups around different aspects of sustainability (3–10). The latter do not, however, initiate further changes over time, as they have not been continuously supported by the city government.

Regarding the emergence of the main actors, the topology shows that the Rio Conference in 1992 was an important impulse for several changes at the national and regional level. Inspired by this event, the JKU Linz, as one of the first universities in Austria, signed the Copernicus Charter (a) in 1993, which provided the basis for the establishment of the Institute for Environmental Law (b). However, from the interviews we know that the establishment of the Institute for Environmental Law and the UWI, founded in 1998, was also strongly promoted by the subsequent heads of the institutes.

Inspired by the UN conference in Rio de Janeiro (I), the federal-state government of Upper Austria decided in 1994 as the first federal country in Austria on a sustainability concept (II). Stimulated by these same developments, in 1995, the city of Linz became a member of the Local Governments for Sustainability Initiative (ICLEI) (1), which resulted in the resolution of the municipal council to start an LA 21 process (2). In 2012, due to changes of the governing political parties, the LA 21 process slowed down, however, and was transformed into a non-binding process.

In 1994, the government of Upper Austria decided on an energy concept (III), formulating precise targets and measures until 2010, as well as the decision on an environmental program for Upper Austria (IV) in 1995. In 2000, this energy concept was updated, which supported the establishment of the Energy Institute in 2001 (IX). The institute was founded by the government of Upper Austria, the Energiesparverband Upper Austria, the Energie AG, Linz AG, the Upper Austrian Ferngas AG, the Chamber of Labor, and the Chamber of Commerce, with the purpose to conduct inter- and transdisciplinary applied research projects in the fields of energy law, energy economics, and energy technology, and to support politics and the regional economy in energy-related issues with scientific evidence. The Energy Institute was founded as an independent organization, although two of the three directors of the Energy Institute also hold positions at institutes of the JKU.

Overall, the government of Upper Austria induced a large number of political programs that gave strong impulses for the emergence of all the key actors at the university, both in the form of financial funding and thematic orientation. Regarding the dynamic of organizational and institutional changes, it becomes apparent that there are only a few second-stage foundations compared to Augsburg. There are no connections between events which cut across different regional subsystems.

5.2.2. Boundary-Spanning Activities Driving Sustainability Transition

The sustainability-related network in Linz mainly consists of a number of highly engaged university members and actors from the public field. The Institute for Environmental Law has been in ongoing cooperation with the federal-state government of Upper Austria in the form of joint events, project cooperation, informal knowledge exchange, and lecturing activities. Most of these activities were informal and not institutionalized. The members of the Institute for Environmental Management in Companies and Regions (UWI) served in different transdisciplinary working groups or advisory boards, established by the federal-state government, to whom they voluntarily applied or were invited. Examples for these are a working group for the development of measures in the frame of the Upper Austrian energy concept or the Upper Austrian 'Zukunftsakademie' (future academy). The working groups, which included actors from the economy, science, civil society, and the public field, were usually set up for a limited time. The managing directors of the Energy Institute also actively participated in these working groups, in particular in those focused on energy-related topics. They also cooperated regularly with the public body as well as with energy suppliers.

The relationships of the institutes to actors from the city of Linz are less pronounced than those to the federal-state government. Particularly noteworthy is that the UWI has not been in contact with

the city of Linz or their LA 21 process, although the latter is clearly in the field of expertise of the institute. Only one scientific representative from the Energy Institute at the JKU has been involved in the air, climate & energy working group. Only recently, initial talks have taken place between these actors regarding the start of a smart city process. Overall, the relationships to the city administration have not been that manifold and close as those to the federal-state government. Only the Institute for Environmental Law is well connected to the city of Linz, especially to the city counsellor from the Green party, who is, among others, responsible for nature and environment-related issues.

In the interviews, it turned out that rarely any boundary-spanning activities between disciplines at the JKU have been taking place, and the mentioned institutes rarely cooperated with each other. All of the mentioned institutes, however, integrated interdisciplinary sustainability topics into their teaching activities despite the fact that, apart from the Energy Institute, the institutes themselves are not interdisciplinary in nature. They also do not coordinate with other Higher Education Institutions (HEIs) in the region of Linz that focus on sustainability-related issues.

It became apparent that it have been mostly the same individuals (mainly the department heads of the presented institutes as well as the rector) at the university that have shown a strong engagement in regional activities over the years. The appreciation of the city or federal-state government has been pointed out as a main motivation for these individuals.

Overall, the sustainability-related activities of the JKU to other societal sectors have been strongly shaped and incentivized by the federal-state government of Upper Austria. The initial environmental focus of the UWI was altered to a more holistic sustainability perspective only through a request of the federal-state government to conduct an evaluation of the LA 21 processes in Upper Austria. The interview partners furthermore pointed out two recent developments regarding the research activities of the institute, which are again influenced by the strategies and therewith funding programs of the government of Upper Austria, as well as by national funding programs: (a) the holistic focus on sustainability is altered into a more thematically specified one (e.g., mobility, climate change, demographic change) and (b) the discourse on sustainability is no longer focused on rural regions but moves towards urban agglomerations (e.g., smart cities). The Energy Institute also had the clear mission, right from its foundation, to support the energy transition of the energy-intensive industries, a topic which was and is high on the agenda for the federal-state government.

The low amount of boundary-spanning activities between the institutes and the city of Linz is due, among others, to the fact that there is no actor responsible for the topic of sustainability in the city administration. Moreover, the LA 21 working groups were initiated and strongly dominated by representatives from the municipal administration, which outnumbered participants from other public bodies, companies, and associations, as well as representatives from political parties.

The high fragmentation of activities seems to be due, amongst others, to the lack of leadership by the university management. Although the rectorate signaled awareness for the topic of sustainability at a very early point in time by signing the Copernicus Charter and later the Graz declaration, there has been no continuous engagement by the university management since then.

Outcomes of sectoral boundary-spanning activities of the UWI initiated by the government of Upper Austria include the identification of 'hot spots' for the environmental policy program of Upper Austria up to 2030, the design of a regional plan on using biogenic resources for food, energy and raw material, a synergetic concept for sustainable energy strategies in regions, the increase of material efficiency by means of environmental management accounting tools, and a feasibility study for solar fuels, to name only a few examples.

The Energy Institute strongly shaped the technological, legal, and economic spheres of the energy transition within the region, for example, by comprehensively supporting the Ecoenergy and the Environmental Cluster and by taking part in broader political discussions. One interview partner also mentioned that sometimes researchers have raised their 'critical voice' to point out unsustainable directions of development.

The JKU thus mainly induced awareness for sustainability issues in a ‘classical’ way through knowledge transfer, expertise, and consulting. The contributions of the institutes and their individual members are overall fragmented and show a high level of thematic specification.

6. Comparative Discussion: Different Development Trajectories in Augsburg and Linz

The questions of interest of the present paper referred to the connections between the emergence, drivers, and type of boundary-spanning activities and the roles of the universities in the regional sustainability transition. Comparing the cases, we can now deduce some more general mechanisms and results.

In the case of Augsburg, boundary-spanning activities in the context of sustainability are based on a lot of bottom-up work by individual actors in the context of the WZU and from the region. A dynamic process was initiated through the continuous foundation of new organizations, in which, over time, an increasing number of heterogeneous organizations and individuals within the university and in the region became involved, covering different thematic aspects of sustainability. This dynamic was spurred by institutionalized temporary events, where actors came together for a limited amount of time and where new relationships could emerge. At the same time, more permanent organizations enabled the development of trustful long-term relationships between actors from all regional subsystems [19].

As shown in Figure 3, the WZU, which is the nucleus of most sustainability-related activities at the university, has absorbed impulses from different actor groups and on this basis defined its own research focus and priorities. As such it succeeded to cross organizational, disciplinary, and sectoral boundaries. In this vein, the University of Augsburg is currently transitioning from its more passive and restrained position into a more active, independent, and developmental role. This does not mean, however, that sustainability has penetrated the self-perception of the whole university. The WZU and individual engaged institutes are relatively small organizational units within the university. Apart from the WZU, the MRM has emerged as a strong player, although mainly targeting the industry and techno-economic development of the region. This makes apparent that there is no unitary role of the university in the regional sustainability transition process [43].

In Linz, the network constellations around sustainability built on the already existing historically evolved network relations and relational proximity [39] of individual actors at the university and in the region. The long-term study revealed that these networks around sustainability did not change significantly over the years. Boundary-spanning activities with actors from civil society and the economy are taking place only indirectly, through the participation of university members in the transdisciplinary advisory boards and working groups set up by the federal-state government (see Figure 3).

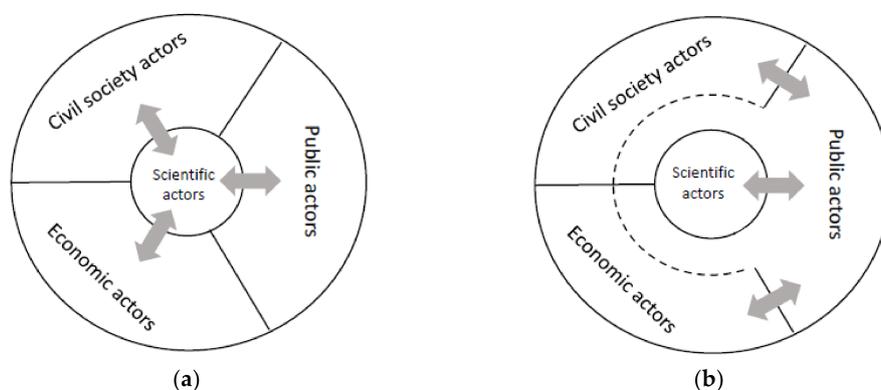


Figure 3. Relationships of the WZU at the University of Augsburg (a) and the Institute for Environmental Law, the UWI and the Energy Institute at the JKU Linz (b) to other regional actors.

Disciplinary boundary-spanning activities within the university are limited to the interdisciplinary Energy Institute. The Energy Institute, however, is organized as an association and organizationally decoupled [61] from the university, preventing the institute from initiating further changes within the rest of the university. Moreover, a platform or organizational unit which bundles and institutionalizes sustainability-related research and teaching activities within the university is missing. Therefore, selected university institutes act in a rather fragmented fashion, independently of each other. Regional organizations which engage in boundary-spanning activities are largely missing in Linz. Therefore, a different, more top-down-oriented approach, which made use of the historically-evolved close relationships between the university and actors at the federal-state level, was more effective. Overall, the role of the JKU is rather fragmented and passive today due to this development. In addition, it is more narrowly focused on topics which are particularly relevant for the region from the perspective of the federal-state government.

In the two examples, differences regarding the actors involved and their interaction mechanisms become apparent, which have been shaped by place-specific path dependencies. The latter can be differentiated into (a) socio-spatial and socio-economic characteristics (pre-existing industrial base, natural resource endowment, human capital), (b) relational aspects (networks, power relations, roles of specific actors, proximity between actors), and (c) the institutional environment (regulations, policies, visions, norms, culture) [13,14,38,39,62]. Although the two case studies share some similarities with regard to the size of their location city, the history of their industrial basis, and the age of the universities, they took over a different role in the regional sustainability transition. Differences mainly refer to relational and network aspects as well as the institutional environment.

In Augsburg, the state played the classical role of providing financial resources [63] and thus supported the foundation of the WZU, which was initiated by the university management and regional actors. The holistic sustainability approach of the WZU is, however, primarily a result of the engagement and ideas of individual researchers at the university. The WZU also supported the institutionalization of already existing bottom-up-driven boundary-spanning activities from other researchers. In parallel, a bottom-up-driven sustainability process in the region developed, which gave impulses for actors at the university and also spurred sectoral boundary-spanning activities. The example of Augsburg confirms that regional sustainability transitions are, to a great extent, also driven by business communities and civil society actors [64]. The cooperation of frontrunners from these different sectors was key in order for these actors to generate momentum.

While in the case of Augsburg the state government was an enabler via opening a window of opportunity, the federal government of Upper Austria was a strong agenda-setter right from the beginning, not only by providing funding for the relevant research institutes at the JKU, but also by influencing their research focus and boundary-spanning activities. Policies and regulations stated important pull factors [14] in the case of Linz. Interestingly, the national Austrian University Law, which clearly outlines the role of universities to contribute to a sustainable societal and environmental development, is not really in the consciousness of the university members. It is mainly the policies, regulations, and funding programs of the federal government of Upper Austria which moderate the engagement of the JKU. The self-perception of the JKU and its members is that of a demand-oriented service provider for politics and the regional economy. This seems to be historically imprinted through the 'Linzer Hochschulfond' (Higher Education Fund Linz), an Austria-wide unique cooperation between the municipal government of Linz and the federal-state government of Upper Austria. The Higher Education Fund Linz enabled the foundation of the JKU via its financing, but at the same time consolidated power constellations, with the regional and city government expressing clear expectations towards the JKU. The top-down approach, however, profited from the strong engagement of individual actors at the university, who often participated in sustainability activities in addition to their normal working hours.

The case studies illustrate the two different mechanisms through which boundary spanning is institutionalized that have been discussed in the theoretical part. They reveal their advantages and

disadvantages and make apparent that a mixture of bottom-up and top-down approaches is probably the most feasible path for most universities.

In both cases, the intrinsic motivation of individual university members was essential to induce institutional and organizational change towards sustainability. In most cases, these individuals felt a normative obligation to engage in sustainability topics due to the position they held (institute head, rector) or their personal convictions. As such, they have been 'frontrunners' [65] and role models for other institute members. Apart from this, the interviews revealed that there was also a personal interest to contribute to the region they are living in. It has been confirmed in one case (Institute for Environmental Law, JKU) that this personal engagement works at the expense of international cooperation and publishing activities. The cases thus underline the important role of individual frontrunners or 'champions' at the university and in the region that has frequently been emphasized in the transition literature [65].

The cases, however, make it apparent that support from the university management and from the federal-state is necessary to develop organizational and institutional structures which facilitate and sustain relationships to regional actors and between disciplines [18,66]. The latter is particularly important when highly engaged individuals leave the university [11,67]. Contrary to the finding of Lozano et al. [68], Feldman and Desrochers [69], or Sedlacek [7], we found, however, that even without a strong leadership by the university management, university members as well as regional actors can initiate boundary-spanning activities and foster their institutionalization. On the other hand, the missing (continuous) leadership of the university management also prevents universities from taking a leading role in regional sustainability transition, as no strategic long-term vision and goals are formulated [4,5].

Both case study regions are characterized by a strong industrial basis, which leads policy makers and other actors from the top to favor economic development and economically relevant aspects within sustainability-related activities over others such as societal and environmental ones [70]. According to Croog [43], this implies the danger that sustainability endeavors are tailored to policy and funding cycles and thereby more holistic, long-term, and systemic approaches are marginalized (see also [67]). Universities are expected to take into account the plurality of perspectives, remain in a neutral position, and stay open for criticism. This expectation of being a 'guardian' of a holistic understanding of sustainability on the one hand and on the other hand being dependent on industrial and public funding makes the tension for universities apparent. This is part of the reason why there is no unitary role of the university in the regional transition process [43], but different university units and members have different perceptions of their regional (developmental) role and are also influenced by proponents of competing visions for the region's future development [15].

7. Conclusions

Taking the examples of two mid-sized university cities and their surrounding regions, the paper shows different ways of how universities can be involved in regional sustainability transitions. It makes apparent that the ability of taking over a development role in these processes relies on their boundary-spanning capacity, which needs to be understood as the capacity to transcend both disciplinary and sectoral boundaries. In particular, the long-term perspective and the comparative approach were key in order to realize which actors and events shaped the boundary-spanning activities of the university and how that influenced the role of the university in the regional sustainability transition. The transition topology showed that developing a boundary-spanning capacity is the outcome of a long-term process of institutional and organizational change, which can only be driven to some extent by actors from the top. In particular, cultural-cognitive changes have to be induced, which are more effectively driven by actors on the ground.

Different roles of the universities in the regional sustainability transition became apparent. The roles we found in our examples can be distinguished on the basis of two dimensions: their depth and autonomy. Regarding the first dimension, we found the roles to be (1) comprehensive, involving

diverse actors and approaching sustainability with a holistic perspective, and (2) more fragmented and passive, but also more focused on specific topics [17]. Regarding the second dimension, the roles were (1) autonomous, the university defining its own focus and priorities through interacting with a broad range of regional actors, and (2) more directed, the university working on topics that are relevant from the perspective of the regional or federal-state government. These categories can be seen as different manifestations of a developmental role in the context of sustainability.

As such it became evident that not only are sustainability transitions highly dependent on their geographical and spatial surrounding [2,14,15], but so are the roles specific regional actors and organizations play within these transition processes. By focusing on two normal practice examples of universities and their sustainability engagement, we have been able to identify internal dynamics as well as external influencing factors which shape their boundary-spanning capacity. It turned out that it is not a self-evident process that universities become change agents for sustainable development, but it is the result of interrelated aspects of bottom-up engagement, top-down consolidation, and regional embeddedness. We therefore conclude that to foster the involvement of universities in regional sustainability transitions, it is not sufficient to support actors at the university or in the region. Political programs should be targeted at both sides in order to stimulate a productive interaction between the university and its regional environment. There is no ‘one-size-fits-all’ strategy [71]. When designing policy approaches, the place- and path-dependent character of these processes needs to be considered.

More systematic, comparative, case study research is needed in order to shed light on the question of why the role and involvement of universities in regional sustainability transitions differ across places [14]. The transition topology provides a good starting point for that. It could be used in further research to establish a typology of different regional transition paths to sustainability. This typology could, for instance, be based on variations in key actors, the nature of their interactions with each other, and the organizational dynamics that develop over time.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Institutional and Organizational Changes in the Regional Development Paths to Sustainability

(1) Augsburg

Table A1. Institutional and Organizational Changes in the Regional Development Paths to Sustainability of the Augsburg region.

	Change	Type	Year	Location
Institutional change (supra-regional level)				
I	Recommendation of the United Nations (UN) to start Local Agenda 21 (LA 21) groups and implementation of a framework convention on climate change	Institutional change	1992	Internat.
II	Declaration of the Augsburg region as an environmental competence center (“Umweltkompetenzregion”) by the Bavarian state government	Institutional change	1996	Federal
III	Establishment of the Bavarian State Office of the Environment (LfU) through the integration of several Bavarian state offices and relocation of the LfU to Augsburg by the Bavarian state government	New organization	1996	Public

Table A1. Cont.

	Change	Type	Year	Location
IV	Foundation of a cluster organization to manage the Bavarian environmental cluster in Augsburg	New organization	2005	Economy
V	Implementation of the UN Decade for Education on Sustainability	Inst. Change	2005	Internat.
VI	Resolution to provide special funding for climate- and energy-related research by the Bavarian government	Inst. Change	2012	Federal
VII	Foundation of the regional network of Higher Education Institutions and Sustainability in Bavaria (as part of the national network)	New network	2012	Federal
VIII	Implementation of the Bavarian sustainability strategy	Inst. Change	2013	Federal
IX	Declaration of Augsburg as the most sustainable city in Germany by the German Sustainability Award Foundation e.V.	Inst. Change	2013	National
Organizational and institutional change in the region				
1	Establishment of an environmental laboratory in the city's health department	New organization	1989	Public
2	Establishment of an environmental department in the city of Augsburg	New organization	1990	Public
3	Establishment of a recycling research center (Bifa Institute) by the Bavarian state government, the IHK and the city of Augsburg	New organization	1991	Economy
4	Foundation of a network between the 'Werkstatt Solidarische Welt', the 'Bund Naturschutz' as well as a group of solar engineers with the aim to build an LA 21 group in Augsburg	New network	1995	Civil Society
5	Foundation of the LA 21 group in Augsburg	New organization	1996	Civil Society
6	Establishment of a steering committee by (IHK) to define an action plan for the environmental competence center	New network	1996	Public
7	Dedication of a permanent position in the city administration to the LA 21 group	New organization	1996	Public
8	Foundation of an LA 21 forum on energy issues ("FF Energie")	New inst. temporary event	1996	Civil Society
9	Foundation of an LA 21 forum on development policy issues ("FF Eine Welt")	New inst. temporary event	1996	Civil Society
10	Foundation of an LA 21 forum on mobility issues ("FF Verkehr")	New inst. temporary event	1996	Civil Society
11	Establishment of an environmental advisory board in the city administration of Augsburg (later renamed into sustainability advisory board)	New network	1997	Public
12	Establishment of an environmental competence center (KUMAS)	New organization	1998	Economy
13	Start of a workshop series for the development of sustainability guidelines for the city of Augsburg	New inst. temporary event	1998	Civil Society
14	Accession of the city of Augsburg to the climate alliance of European cities (Alianza del Clima e.V.) and adoption of the alliance's voluntary standards	Inst. Change	1998	Public
15	Start of a workshop series for the development of sustainability indicators for the city of Augsburg	New inst. temporary event	1999	Civil Society
16	Foundation of LA 21 forum to implement the Eco-Profit program in Augsburg ("FF Ökoprofit")	New inst. temporary event	1999	Civil Society
17	Integration of a forum on poverty and social discrimination issues into the LA 21 ("FF Armutskonferenz")	New inst. temporary event	1999	Civil Society
18	Foundation of a LA 21 forum for a family friendly Augsburg ("FF Familienfreundlichkeit")	New inst. temporary event	1999	Civil Society
19	Foundation of a forum for a partnership between generations ("FF Partnerschaft der Generationen")	New inst. temporary event	1999	Civil Society
20	Establishment of annual Bavarian waste and disposal days by Kumas	New inst. temporary event	2000	Economy
21	Foundation of an annual exhibition on renewable energies ("Renexpo") in Augsburg	New inst. temporary event	2000	Economy
22	Foundation of LA 21 forum to foster civic commitment ("FF Bürgerstiftung")	New inst. temporary event	2000	Civil Society
23	Accession of the city of Augsburg to the Local Governments for Sustainability Initiative (ICLEI)	Inst. Change	2001	Public
24	Establishment of a working group on environmental education within the KUMAS network, which meets twice a year	New network	2001	Economy
25	Establishment of a working group on international issues within the KUMAS network, which meets twice a year	New network	2001	Economy
26	Establishment of a working group on project management within the KUMAS Network, which meets twice a year	New network	2001	Economy

Table A1. Cont.

	Change	Type	Year	Location
27	Establishment of a working group on environmental medicine within the KUMAS network, which meets twice a year	New network	2001	Economy
28	Establishment of an endowment chair for environmental management	New organization	2002	Science
29	Establishment of a three-part workshop series for the definition of concrete sustainability goals for the city of Augsburg	New inst. temporary event	2002	Civil Society
30	Awarding the Kumas award for frontrunner projects in the field of environmental technologies to the WZU	Inst. Change	2002	Science
31	Establishment of a municipal climate protection department	New organization	2003	Public
32	Implementation of the LA 21's sustainable action program by the city council of Augsburg including a regular monitoring and reporting of the progress	Inst. change	2004	Public
33	Foundation of an LA 21 forum on nature conservation and environmental education ("FF Nanu! e.V.")	New inst. temporary event	2004	Civil Society
34	Establishment of the annual water protection days by KUMAS	New inst. temporary event	2004	Economy
35	Foundation of an LA 21 forum on sustainable education ("FF Bildung und Nachhaltigkeit")	New inst. temporary event	2005	Civil Society
36	Foundation of an LA 21 forum for the implementation of an online guide for sustainable consumption ("FF Lifeguide")	New inst. temporary event	2006	Civil Society
37	Foundation of an LA 21 forum on sustainability in the financial sector (FF Fließendes Geld)	New inst. temporary event	2007	Civil Society
38	Establishment of the annual Bavarian emission protection days by KUMAS	New inst. temporary event	2008	Economy
39	Establishment of a regional (economic) development agency ("Regio Augsburg Wirtschaft GmbH")	New organization	2009	Public
40	Foundation of an LA 21 forum to promote the usage of recycling paper ("FF Papierwende")	New inst. temporary event	2009	Civil Society
41	Foundation of an LA 21 forum on climate protection issues ("FF Prima Klima")	New inst. temporary event	2009	Civil Society
42	Foundation of an LA 21 forum on fair trade issues ("FF Fairtrade Stadt")	New inst. temporary event	2010	Civil Society
43	Foundation of an LA 21 forum to strengthen regional economic activity ("FF Unser Land")	New inst. temporary event	2010	Civil Society
44	Foundation of an LA 21 forum for social and ecological sustainability ("FF ThinkCamp")	New inst. temporary event	2011	Civil Society
45	Foundation of an LA 21 forum on urban gardening ("FF Urbane Gärten")	New inst. temporary event	2011	Civil Society
46	Establishment of an organizational platform on resource efficiency in the regional (economic) development agency	New inst. temporary event	2011	Public
47	Resolution to update the sustainability action program by the city council of Augsburg	Inst. change	2011	Public
48	Foundation of an LA 21 forum to promote the consumption of organic, regional and seasonal food in Augsburg ("FF Biostadt")	New inst. temporary event	2012	Civil Society
49	Foundation of an LA 21 forum on refuge and asylum issues ("FF Flucht und Asyl")	New inst. temporary event	2012	Civil Society
50	Foundation of an LA 21 forum for a self-determined life for girls and women ("FF Terre des Femmes")	New inst. temporary event	2012	Civil Society
51	Establishment of an advisory board for the Augsburg innovation park on resource efficiency	New organization	2012	Public
52	Foundation of an LA 21 forum to implement the transition town model in Augsburg ("FF Transition Town")	New inst. temporary event	2013	Civil Society
53	Foundation of an LA 21 forum on education ("FF Bildungsbündnis")	New inst. temporary event	2013	Civil Society
54	Relocation of the LA 21 office to from the climate department to a new staff position for environment, sustainability and integration and increase in personnel	New organization	2014	Public
55	Organization of a discussion series to foster environmental competence in regional companies by KUMAS and the local unites of the Federation of German Industries (VDI and VDE)	New inst. temporary event	2014	Economy
56	Start of workshops for the further development of the sustainability goals for the city of Augsburg	New inst. temporary event	2014	Public
57	Foundation of an LA 21 forum for a sustainable redevelopment of a local shopping mall ("FF Schwabencenter")	New inst. temporary event	2015	Civil Society

Table A1. Cont.

	Change	Type	Year	Location
Organizational and institutional change in the University				
a	Foundation of a network Society for Environmental Economics (“Gesellschaft für Umweltökonomie e.V.”)	New network	1991	Science
b	Foundation of an institute for environmental law	New organization	1991	Science
c	Signing of the Copernicus Charta and adoption of its principles by the Science management	Inst. Change	1993	Science
d	Day of Environmental and Material Sciences at the Science of Augsburg in cooperation with the Bifa Institute	New inst. temporary event	1997	Science
e	Foundation of LA 21 forum for a sustainable urban development (“FF Nachhaltige Stadtentwicklung”)	New inst. temporary event	1998	Civil Society
f	Establishment of an applied environmental research center (“Wissenschaftszentrum Umwelt (WZU)”)	New organization	2000	Science
g	Establishment of a center for material and environmental research (“Anwendungszentrum Umwelt (AMU)”)	New organization	2000	Science
h	Establishment of the European Headquarter of the World Environmental Center (WEC) at the WZU	New organization	2001	Science
i	Establishment of the Augsburg Materials Declaration	Inst. Change	2002	Science
j	Establishment of a study program on environmental ethics	New organization	2002	Science
k	Establishment of a study program on global change ecology	New organization	2006	Science
l	Establishment of the Center for Material Resource Management (MRM)	New organization	2009	Science
m	Establishment of a new study program on sustainability education	New organization	2009	Science
n	Establishment of a new chair for resource strategies	New organization	2010	Science
o	Foundation of a working group with the aim to foster sustainability in the University	New inst. temporary event	2010	Science
p	Establishment of a study program on economic engineering focused on resource management	New organization	2011	Science
q	Establishment of a study program on climate and environmental Sciences	New organization	2011	Science
r	Establishment of a lecture series on climate protection in Bavaria by the state department for the environment (LfU) and the Science of Augsburg	New inst. temporary event	2013	Public
s	Establishment of a graduate school on resource strategies and concepts for future energy systems	New organization	2012	Science
t	Foundation of a network with the aim to foster corporate responsibility in the Augsburg region (“Augsburger Schule”)	New network	2012	Economy
u	Foundation of LA 21 working group on corporate responsibility (“FF Unternehmerische Verantwortung”)	New inst. temporary event	2012	Civil Society
v	Establishment of a first sustainability day for the regional economy (“Fokus N”) by the LA 21 forum on corporate responsibility	New inst. temporary event	2013	Economy
w	Establishment of a new chair and institute for environmental medicine at the Science clinic in Augsburg (UNIKA-T) in cooperation with the TU and LMU Munich and the Clinic Augsburg	new organization	2013	Science
x	Foundation of LA 21 forum on animal rights (“FF Tierrechte”)	New inst. temporary event	2015	Civil Society
y	Establishment of a chair for resource strategies in human geography	New organization	2015	Science
z	Foundation of a student initiative (“Green Office e.V.”) with the aim to foster sustainability in the university	New network	2016	Science
aa	Foundation of LA 21 working group Green Office (“FF Green Office”)	New inst. temporary event	2017	Civil Society

(2) Linz**Table A2.** Institutional and Organizational Changes in the Regional Development Paths to Sustainability of the Linz region.

	Change	Type	Year	Location
Organizational and institutional change (supra-regional)				
I	Recommendation of the United Nations (UN) to start Local Agenda 21 (LA 21) groups and implementation of a framework convention on climate change	Inst. Change	1992	Internat.

Table A2. Cont.

	Change	Type	Year	Location
II	Resolution of a sustainability concept by the federal government of Upper Austria	Inst. Change	1994	Federal
III	Resolution of an energy concept formulating precise targets and measures till 2010 by the federal-state government of Upper Austria	Inst. Change	1994	Federal
IV	Establishment of the Austrian Academy for Environment and Nature, which was amongst others responsible for coordinating the implementation of the environmental program and the LA 21 program in Upper Austria	New organization	1995	Federal
V	Resolution of the environmental program by the government of Upper Austria	Inst. Change	1995	Federal
VI	Resolution of the LA 21 program by the government of Upper Austria	Inst. Change	1998	Federal
VII	Resolution of the second phase of the energy concept "Energy 21" by the government of Upper Austria	Inst. Change	2000	Federal
VIII	The Upper Austrian Energiesparverband takes over the management of the Eco-Energy Cluster	New organization	2000	Economy
IX	Foundation of the Energy Institute on initiative of the government of Upper Austria, the Energieverband Upper Austria, the Energy AG, Linz AG and the OÖ Ferngas AG	New organization	2001	Science
X	Resolution of an energy efficiency program by the government of Upper Austria	Inst. Change	2004	Federal
XI	Implementation of the UN Decade for Education on Sustainability	Inst. Change	2005	Federal
XII	Foundation of a cluster organization to manage the Environmental Technology Cluster	New organization	2006	Economy
XIII	Establishment of a working group to elaborate measures in the frame of the energy concept under the leadership of the energy officer of Upper Austria	New network	2007	Federal
XIV	Resolution of an energy strategy "Energy Future 2030" by the government of Upper Austria	Inst. Change	2007	Federal
XV	Awarding the Austrian Sustainability Award to the Institute for environmental law at the JKU by the government of Upper Austria	Inst. Change	2010	Science
XVI	Foundation of the future academy (Zukunftsakademie), a think tank to support the political decision making of the government of Upper Austria—replacing the Upper Austria Academy for Environment and Nature	New Inst. Temporary Event	2011	Federal
XVII	Resolution of an environmental program till 2030 by the government of Upper Austria	Inst. Change	2014	Federal
XVIII	Establishment of a working group for the elaboration of the environmental program	New network	2014	Federal
Organizational and institutional change in the region				
1	Accession of the city of Linz to the Local Governments for Sustainability Initiative (ICLEI)	Inst. Change	1995	Public
2	Resolution of eight basic principles for sustainable development and to start an LA 21 process by the municipal council	Inst. Change	1995	Public
3	Foundation of the LA 21 working group on air/climate/energy	New Inst. temporary event	2001	Public
4	Foundation of the LA 21 working group on nature/soil	New Inst. temporary event	2001	Public
5	Foundation of the LA 21 working group on water	New Inst. temporary event	2001	Public
6	Foundation of the LA 21 working group on mobility	New Inst. temporary event	2001	Public
7	Foundation of the LA 21 working group on waste	New Inst. temporary event	2001	Public
8	Foundation of the LA 21 working group on economy	New Inst. temporary event	2001	Public
9	Foundation of the LA 21 working group on social issues	New Inst. temporary event	2001	Public
10	Foundation of the LA 21 working group on as well as administration/service level	New Inst. temporary event	2001	Public
11	Implementation of the Open Commons Linz Initiative	Inst. Change	2010	Public
12	Establishment of an advisory board for the Open Commons Linz Initiative	New network	2010	Public
13	Resolution of the Linzer social program	Inst. Change	2011	Public
14	Integration of the environmental department into the department of planning, technology and environment ("Planung, Technik und Umwelt")	New organization	2012	Public
15	Re-elaboration and adoption of the cultural development plan	Inst. Change	2013	Public

Table A2. Cont.

	Change	Type	Year	Location
16	Establishment of an advisory board to accompany the implementation of the cultural development plan	New network	2013	Public
17	Resolution of a smart city project by the city of Linz	Inst. Change	2015	Public
Organizational and institutional change in the University				
a	Signing of the Copernicus Charta and adoption of its principles by the JKU management	Inst. Change	1993	Science
b	Foundation of the Institute for Environmental Law	New organization	1994	Science
c	Establishment of the event series “Austrian Days of Environmental Law”	New Inst. temporary event	1994	Science
D	Foundation of the Association of the Institute for Environmental Law	New network	1996	Science
e	Foundation of the Institute for Environmental Management in Companies and Regions (UWI)	New organization	1996	Science
f	Establishment of a new study program on “Environmental-, resource and quality management”	New organization	1996	Science
g	Establishment of the specialization environmental law in the study program law (as first Austrian wide)	New organization	1999	Science
h	Signing of the Graz Declaration and adoption of its principles by the JKU management	Inst. Change	2005	Science
I	Establishment of the event series “Education for Sustainable Development”	New Inst. Temporary Event	2008	Science
j	Establishment of the graduate Master program “Energy Management”	New organization	2008	Science
k	Establishment of an international conference on European environmental law	New Inst. Temporary Event	2012	Science
l	Establishment of a symposium on European environmental law	New Inst. Temporary Event	2015	Science
m	Organization of the Future Lecture Series at the JKU by the Institute of Environmental Law	New Inst. Temporary Event	2015	Science

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