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Combining knowledge bases for system innovation in regions: Insights from an East German case study

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ABSTRACT

A growing number of economic geography scholars have discussed the spatial dimensions of sustainability innovation in socio-technical systems to overcome societal, economic, and ecological problems. This research usually focuses on businesses in the knowledge economy and success factors. However, sustainability innovation involves the collaboration of upstreaming process stages and open innovation processes with a broad range of different actors. Innovation intermediaries, such as universities and research institutes, are needed to support and accelerate the transfer of knowledge. Nevertheless, little is known about the influence of the cognitive and institutional diversity of actors on the configuration of knowledge bases required for sustainability innovation. This article presents insights from 16 semi-structured expert interviews conducted in a regional innovation system (RIS) in East Germany. We investigate four innovation intermediaries in the region of Eberswalde in cooperation with the Eberswalde University for Sustainable Development. The analytical framework links the concept of differentiated knowledge bases to sustainability transitions and sustainability-oriented knowledge transfer. Our results show that, first, in the Eberswalde region, the relevant actors involved in regional knowledge transfer predominantly focus on synthetic knowledge bases, such as experience-based knowledge of local area settings. Second, symbolic knowledge bases are crucial and often prerequisites for intermediary organizations to

recombine knowledge bases and support the capability to innovate in regional knowledge transfer. Symbolic knowledge contains, in particular, the ability to translate scientific findings to a language that can be understood by the various actors in knowledge transfer. Third, organizational innovation complements social innovation to support innovation on a systemic level and foster change processes.

Keywords: Knowledge bases, system innovation, knowledge transfer, innovation intermediation, sustainability transition

JEL: D02, D80, O12, P48, Q56, R11

1. INTRODUCTION

In recent years, innovation-focused research on economic geography has analyzed the effects of different combinations of knowledge sources and actors on the capability to innovate in regions (Asheim, Boschma, and Cooke 2011; Strambach 2017; Fernandes et al. 2021). For pioneering innovation policy, sustainability-related challenges, such as those addressed in the Sustainable Development Goals (United Nations 2015), have become a more important topic in recent years. Consequently, innovation scholars have called for redefining innovation policy toward a transformative framework to overcome "wicked" problems (Schot and Steinmueller 2018). Contextual and supporting conditions for sustainability-oriented innovation are central to consider the effects on the economic, ecological, and social dimensions (Paech 2006; Klewitz and Hansen 2014).[1] Research on sustainability transitions outlines the importance of multi-level interaction for long-term changes in socio-technological systems (Loorbach and Rotmans 2010; Raven, Schot, and Berkhout 2012).

In this literature strand, system innovation is a key concept for understanding transformational processes through the substitution of incumbent technologies, co-evolutionary processes, and upcoming diffusion of new technologies (Geels 2004). The literature on sustainability transitions (ST) has provided profound insights into the diverse and complex dynamics of how system innovation shapes pathways that affect sustainable development (Hofman, Elzen, and Geels 2004; Meadowcroft 2011; Ceschin and Gaziulusoy 2016; Grillitsch et al. 2019; Papachristos 2019; Herrero et al. 2021).

Until recently, the spatial dimension of ST and its effects on innovation processes have played only a subordinate role (Raven, Schot, and Berkhout 2012; Strambach 2017). In an upcoming research strand, economic geography scholars consider the increasing geographical relatedness of transition processes. They contribute approaches to the literature to answer the question of how geographical relatedness affects the development of emerging technologies (Hansen and Coenen 2015). Furthermore, geography scholars can help to understand the dynamics of sustainability transitions, addressing the need for greater sensitivity to place-

[1] Therefore, in this article, we consider innovations not only as technological novelties but also as innovations in economic and social systems and in lifestyles (OECD 2019).

specific factors that shape system innovation and the effects of scale and regions' related interdependencies (Binz et al. 2020). Overall, the field of the geography of sustainability transition requires further research. According to Binz et al. (2020), further research on geographical transitions should introduce the terms "regional" and "urban" as categories related to the multiple factors of socio-technical systems. This would direct the focus of transitions research not only on singular socio-technical systems but also on the effect of transitions through multiple socio-technical systems. Transition studies should build theoretical frameworks that explore the trajectories and settings in which transition processes on a certain geographical scale are shaped by local regimes, such as norms or institutional frameworks (Binz et al. 2020).

The present study contributes to the discussion on differentiated knowledge bases, higher education institutions (HEIs), and their role in system innovation. In their seminal paper, Asheim and Coenen (2005) present insights into how knowledge bases shape innovation processes. On this basis, Strambach (2017) links the concept of differentiated knowledge bases to sustainability transition in her pioneering study. The analysis provides insights into the knowledge bases of heterogeneous actors in transnational cooperation between German and Chinese companies for sustainability innovation. To investigate knowledge bases closely, HEIs play a crucial role as knowledge generators in the development of knowledge bases. HEIs have been considered to support and accelerate the diffusion of sustainability-oriented innovation as change agents (Stephens et al. 2008; Radinger-Peer and Stoeglehner 2013). In a German-Austrian case study on two universities, Pflitsch and Radinger-Peer (2018) investigate the contribution of both universities as intermediaries in the regional knowledge transfer to sustainability transformation. The role of universities as drivers in regional transition processes depends on their boundary-spanning capacity. This capacity is evident in the university's interaction with a wide range of actors, from business to civil society, and in the integration of knowledge from different disciplines, perspectives, and knowledge inside the university (Pflitsch and Radinger-Peer 2018). Moreover, Bohunovsky, Radinger-Peer, and Penker (2020) show that sustainability transformations across 13 universities in Austria are driven by an interplay of change agency and alliances of universities in networks and, to a minor degree, by top-down ministry interventions.

Overall, the literature is still in a premature state, specifically the interplay between HEIs and their effect on knowledge bases to contribute to sustainability-oriented innovation. Therefore,

we apply an exploratory case study to the regional innovation system (RIS) of Eberswalde in Eastern Germany. The region was selected because of the structure of a peripheral innovation system with an HEI—the Eberswalde University for Sustainable Development (EUSD), which plays a central role in regional knowledge generation. Moreover, the EUSD has an explicit focus on sustainability-oriented innovation and cooperates actively with innovation intermediaries. Central to our case study is the cooperation between the EUSD and three intermediaries in the Eberswalde region. Our 14 semi-structured interviews with experts focused on the role of knowledge bases in system innovation. We aim to answer the following research questions: What different regional knowledge bases are recombined in the knowledge transfer of the EUSD and three other intermediaries in the Eberswalde region to system innovation, and in what manner?

This study aims to connect the literature strand on the geography of sustainability transitions with knowledge bases in regions. Our contributions are threefold. First, we investigate the recombination of knowledge bases in the regional knowledge transfer between academic and non-academic actors. This extends Strambach's (2017) transnational approach to a regional level. Second, we extend the empirical insights into universities, providing regionally relevant knowledge and accelerators for sustainability-oriented innovations that enable transformation processes (Pflitsch and Radinger-Peer 2018). Third, the case study presents exploratory insights with a dynamic perspective to examine the knowledge transfer of the EUSD and three affiliated regional intermediary organizations in the period between 1992, the year the Eberswalde University was founded, and 2020.

The remainder of this paper is organized as follows. Section 2 reviews the existing literature, with a focus on the role of knowledge bases in knowledge transfer and the role of system innovation. Section 3 contains the methodology and data. Section 4 presents our insights into the case study in the Eberswalde region. Section 5 discusses the results, considering the relevant literature strands. Section 6 concludes the study with research and policy implications.

2. LITERATURE REVIEW

2.1 Addressing differentiated knowledge bases and regional innovation systems

The concept of differentiated knowledge bases enhances the understanding of the conditions and the emergence of innovations and knowledge flows (Asheim and Gertler 2005; Asheim et al. 2007; Asheim 2007; Asheim, Boschma, and Cooke 2011; 2020). This concept helps develop a broader understanding of knowledge-driven dynamics (Grillitsch, Schubert, and Srholec 2019; Bennat and Sternberg 2020). The early contributions of Nonaka and Takeuchi (1995) and Borras and Lundvall (1997) focused on the interaction and transformation of implicit and codified knowledge to explain the creation and utilization of knowledge. Based on the demand to broaden the concept (Johnson, Lorenz, and Lundvall 2002), knowledge bases have been developed into three different knowledge bases (Asheim and Gertler 2005; Asheim 2007), building the foundation of innovation (Asheim, Grillitsch, and Trippl 2017):

First, the analytical knowledge base, also called "know-why," is built on scientific knowledge derived by deductive, abstract models, theory formation, and testing (Asheim et al. 2011). It is largely codified and universal due to its high degree of abstraction, and thus, it is transferable over distance (Manniche 2012). Second, synthetic knowledge base, also called "know-how," is linked to the application or new combination of existing knowledge (Asheim et al. 2011). This knowledge can be acquired mostly as a result of tests, experiments, simulations, or practical work within a company or in exchange with customers or suppliers (Jensen et al. 2007). It comprises inherently implicit parts and is therefore spatially specific, but it can also entail codified and easily transferable parts (Manniche 2012). Third, symbolic knowledge, also called "know-who," is associated with the innovative creation and economical use of the aesthetic values and attributes of products, such as product design (Asheim et al. 2011). It emerges from interactions with clients or with actors in professional networks and involves "open-ended, creative and artistic thinking, performance and interaction" (Manniche 2012, 1825).

The existing combinations of knowledge bases in regions reflect an important structural factor for regional innovation systems and, consequently, for specific regional innovation policies (Asheim, Grillitsch, and Trippl 2017; Bennat and Sternberg 2020). Within the institutional framework of RIS, the central actors are the companies, which are the users of knowledge, and the universities, private and public research institutes, and intermediary organizations, which are the generators of knowledge (Asheim and Coenen 2005; Asheim, Grillitsch, and Trippl 2015). Universities play an essential role in RIS, both as generators of knowledge and as intermediaries between public and private actors (Cooke 2004). Specifically,

intermediary universities respond to the regional demand for knowledge, especially among actors that have difficulty integrating new knowledge sources (Muscio 2007).

To determine the role of universities in RIS, effective knowledge transfer needs to meet the regional requirements for specific knowledge bases. Knowledge transfer ideally occur through mutual knowledge exchange, with feedback loops between different actors, to provide cultural, educational, and social benefits to society (Formica, Mets, and Varblane 2008). In addition to actors from business and research, knowledge transfer also involves actors from civil society, such as non-governmental organizations, associations, or individual citizens (Grundel and Dahlström 2016).

2.2. Differentiated knowledge bases and knowledge transfer

Previous studies have argued that the knowledge transfer of analytical, synthetic, and symbolic knowledge bases requires intra- and inter-organizational social learning practices, depending on socio-spatial contexts (Asheim and Gertler 2005; Asheim et al. 2007; Asheim 2012; Mattes 2012; Manniche and Testa 2018). Accordingly, specific knowledge transfer channels are necessary to transfer analytical, synthetic, and symbolic bodies of knowledge bases (Yruela and Fernández-Esquinas 2015). Therefore, universities need to adapt their knowledge transfer to the existing knowledge bases of their regions and their demand for innovation support to play an effective role in RIS.

Historically, analytical knowledge has been argued to be effectively transferred in technology transfer without geographical proximity through extra-regional knowledge linkages (Chen and Hassink 2020). This knowledge base is largely built on explicit knowledge that can be easily codified and is less relevant in social and geographical proximity (Mattes 2012). Sectors with a dominant analytical knowledge base predominantly use codified research and development (R&D) results, such as patents and publications (Asheim 2007). However, only a small fraction of companies uses analytical knowledge bases to improve competitiveness (Yruela and Fernández-Esquinas 2015; Grillitsch, Schubert, and Srholec 2019), as the majority of companies (i.e., small- and medium-sized enterprises [SMEs]) only have limited or no capacity to conduct R&D (Tödtling and Trippl 2005; Grillitsch, Schubert, and Srholec 2019).

Even companies with a strong analytical knowledge base, such as those focusing on patenting, rely on informal channels of knowledge transfer (Gulbrandsen, Mowery, and Feldman 2011).

Synthetic knowledge bases require greater involvement of actors in the process of knowledge exchange. This knowledge base relies on tacit knowledge (Asheim et al. 2011), which is connected to geographical, cultural, and social contexts (Tödtling and Trippl 2016). Without interaction between the knowledge provider and user, tacit knowledge is difficult to convey and detach from the social context (Bozeman 2000). Furthermore, transfer activities for synthetic knowledge bases consist of the synthesis and recombination of different forms of knowledge (Yruela and Fernández-Esquinas 2015). In particular, learning in this context is considered collaborative, with the application of bottom-up approaches (Mattes 2012). Effective knowledge transfer for synthetic knowledge offers advice, practical support through applied research, and tailored analyses (Yruela and Fernández-Esquinas 2015).

The transfer of symbolic knowledge requires localized learning and bi- or multi-directional interaction. Symbolic knowledge is characterized by tacit knowledge and its context-specificity (Asheim, Boschma, and Cooke 2011; Martin and Moodysson 2011b), depending to a large extent on location, class, gender, and other contextual factors (Gertler 2008; Asheim and Hansen 2009). Symbolic knowledge is also characterized by the norms, habits, and everyday cultures of different social groups (Gertler 2008; Asheim, Boschma, and Cooke 2011). Knowledge transfer in RIS has been discussed according to the integration of civil society actors (Grundel and Dahlström 2016), participatory activities (Grundel and Dahlström 2016), and participatory communication (Mattes 2012) to enable shared and mutually localized learning.

Research has concentrated mostly on the perspective of differentiated knowledge bases. According to various studies, innovative companies combine different types of knowledge bases (Jensen et al. 2007; Tödtling and Grillitsch 2015; Grillitsch, Martin, and Srholec 2017; Grillitsch, Schubert, and Srholec 2019). Knowledge bases are required in companies as compound mixes, depending on the different phases of the innovation process (Moodysson, Coenen, and Asheim 2008; Asheim, Boschma, and Cooke 2011), even if one knowledge base is dominant in an industry (Martin and Moodysson 2011a). In a Spanish case study, Pinto and Fernández-Esquinas (2018) show that industries with dominant analytical knowledge bases depend on synthetic or symbolic knowledge for implicit co-transfer. This affects the role of

knowledge transfer and the perception of its effectiveness (Pinto and Fernández-Esquinas 2018).

Although many studies have elaborated on knowledge transfer and knowledge bases, to the best of our knowledge, differentiated knowledge bases have not yet been investigated in the context of regional knowledge transfer. Our study expands the perspective on knowledge bases by exploring knowledge bases in civil society and their combination with other knowledge bases.

2.3 Recombination of differentiated knowledge bases for system innovation

Research on sustainability transition analyses existing socio-technical systems and change processes towards sustainable socio-technological configurations (Truffer and Coenen 2012). Within sociotechnical theory, the multi-level perspective (MLP), which examines upcoming radical innovation, has become a core framework (Geels 2002, 2019). System innovation is central to changes in social-technical systems (Geels 2004; Lawhon and Murphy 2012). System innovation involves not only technical substitutions but also the co-evolution of cultural, political, and social institutions, the everyday activities in a system, and the new unexpected uses of artefacts enabled by changes (Kemp, Schot, and Hoogma 1998; Geels 2004). System innovation is characterized by the combination of three dimensions—technical innovation, social innovation, and infrastructure—in which these innovations are embedded (Howaldt and Schwartz 2010; Schneidewind and Scheck 2013). According to Strambach (2017), the awareness of the diverse social, environmental, and economic dimensions of innovation conditions the heterogeneous networks of actors collaborating in different stages of innovation processes.

Thereby, the MLP approach often takes technology and technical innovation as an analytical entrance point for wider estimation of innovation trajectories and the various involved actors there. For a long time, transition studies usually and the MLP-approach have been criticized to focus on artefacts and technologies neglecting cultural and political aspects of transitions (Lawhon and Murphy 2012). Recent MLP-studies have also examined social actors, such as citizens engaged in the implementation of these technologies (Ockwell et al. 2018; Hirt, Sahakian, and Trutnevyte 2021; Xu 2021) and the influence of societal discourses

on the acceptance of niche-innovations (Geels 2019). However, we argue, that the role of knowledge itself, its different variations and it transfer between heterogenous actors plays a subordinate role in the MLP-framework. For example, Geels (2019) mentions codified and tacit knowledge in his description of innovation trajectories but he does not dwell on these categories of knowledge.

Therefore, the differentiated knowledge base approach is theoretically valuable for the MLP-approach because it values social knowledge bases beside technological and science-based knowledge bases as equal important source of knowledge with different mixes of tacit and codified knowledge (Asheim 2007; Manniche 2012; Strambach 2017). This can contribute to highlighting the role of cultural meanings of transitions. Symbolic knowledge is characterized by "a deep understanding of the habits, norms and everyday culture of specific social groupings" (Asheim, Boschma, and Cooke 2011, 897). However, according to transition research, system innovation requires change in the so-called socio-technological systems that contain elements such as technologies, regulations, and cultural meanings (Geels, Elzen, and Green 2004). As the differentiated knowledge base approach recognizes this socio-cultural knowledge as a critical source of innovation aside from science- and engineering-based knowledge, it can significantly contribute to transition research (Strambach 2017).

As the only study to apply the differentiated knowledge approach to sustainability transitions, Strambach (2017) argues that knowledge bases should be combined to develop system innovation to change socio-technical systems. Socio-technical systems comprise niches in which innovation is nurtured, learning occurs, and networks are built between heterogeneous actors, such as firms, policymakers, or citizens (Lawhon and Murphy 2012). As system innovation also changes socio-technical regimes, the social context and the institutional environments of socio-technical regimes are associated with system innovation. According to Strambach (2017), addressing these social dimensions requires integrating synthetic and analytical knowledge bases with symbolic knowledge.

In summary, sustainability transition theory provides an understanding of how socio-technical systems are changed by system innovation toward sustainability. However, the social aspects of these change processes are not yet fully understood. The concept of a differentiated knowledge base can complement transition theory with the category of a symbolic knowledge base. Thus far, little is known about how the combination and utilization of differentiated

knowledge bases of heterogeneous actors affect and favor system innovation. Our case study addresses this research gap with this research question. As a first approach, Strambach (2017) highlights the importance of symbolic knowledge in the transnational cooperation of actors with different cultural backgrounds. Our study aims to build on these findings and extend knowledge in the context of regional knowledge transfer among heterogeneous actors.

3. METHODOLOGY AND RESEARCH DESIGN

This section discusses the methodological basis that links the methods to synthesis and theory building. We use a multiple case study (Eisenhardt 1989; Ridder 2017) approach to expand theoretical concepts and models, going beyond the status quo in the role of knowledge bases in system innovation. Specifically in the exploratory phases of research, case studies effectively describe and investigate new or surprising empirical phenomena. Multiple case studies help reveal the multidimensionality of empirical phenomena by analyzing the differences within cases and between cases (Yin 2018). The empirical material helps to gain insights into how the different knowledge bases of heterogeneous actors are recombined into sustainability-oriented system innovation in knowledge transfer. The material should also help to understand the structure of the RIS of the Eberswalde region and the actors involved.

In our empirical study, we conducted semi-structured interviews based on a guideline with representatives of the EUSD and regional organizations actively involved in regional knowledge transfer as intermediaries between different actors. The interviewer repeatedly referred to a previously introduced problem (Mayring 2012; Assarroudi et al. 2018). In the guidelines, a distinction is made between the main questions, which should always be asked. Detailed questions, which vary significantly in wording, can be omitted or supplemented situationally, if necessary (Azul 2016). The interviewer had already dealt with theoretical and empirical findings relevant to the problem (Mayring 2016). The questions themselves were formulated openly so that the interview partners could freely answer, and the collected rich data set could avoid closed questions (Mayring 2015; Kuckartz 2019). The interviewees were former employees or were currently working for the faculties and the intermediary organizations, covering a period from the establishment of the EUSD in 1992 to the present. At the EUSD,

former and current professors and research assistants from three of the four faculties of the university were recruited as respondents.

The semi-structured questionnaire was structured into four sections (Table 1). First, we began with the general structure, the activities of knowledge transfer, and the initiated learning processes. Second, we discussed targeted and implemented innovations during knowledge transfer projects and knowledge bases, which are the basis for these innovations. Third, we asked about long-term cooperation and networks between actors in regional knowledge transfer. Finally, the respondents were asked about the role of sustainable development and sustainability-oriented innovation in regional knowledge transfer. As knowledge base is a concept not known by most of the interviewees, we used proxy terms such as "academic knowledge" for analytical knowledge bases, "experience knowledge" for synthetic knowledge bases, and "communication knowledge" for symbolic knowledge bases to facilitate discussions.

TABLE 1

Key questions in the four interview sections

Section 1: Knowledge transfer

- Please describe the organizational structures of regional knowledge transfer.
- Please exemplify how knowledge transfer projects take place in the region.
- How does knowledge transfer trigger learning processes?

Section 2: Innovations and the innovation process

- Please describe the innovations created or currently being developed.
- Please describe your role during innovation processes.
- What role do universities, experience-based knowledge, and communication-based knowledge play in the innovation process?

Section 3: Regional innovation system

- What kind of cooperation exists among regional actors?
- How durable is cooperation? What actors have joined or disappeared over time?

Section 4: Sustainable development

- What role does sustainable development play for your organization/work?
- Please describe the role of innovation in sustainable development.

Interviews with 14 experts between March and May 2020 were conducted. The interviews lasted between 52 and 150 minutes. They were recorded, transcribed, and discussed among the authors. The interviewees' statements were checked and, if necessary, supplemented by consulting other publicly available sources. To evaluate the interview data, we used content-structured qualitative content analysis (Kuckartz 2018). The methodology divides the interview material into categories and sub-categories derived from the literature relevant to the research questions (Kuckartz 2018). All main categories and subcategories are listed in the coding guideline (Appendix 1). In the main category, "knowledge bases," we analyzed the role of knowledge bases in regional knowledge transfer using proxy terms in the questions to make them easier to understand. These proxy terms are "academic knowledge" for analytical knowledge bases, "experience knowledge" for synthetic knowledge bases, and "communication knowledge" for symbolic knowledge bases.

4. EMPIRICAL SETTING

In this section, we provide a brief description of the case study, namely the faculties of the EUSD and the three intermediary organizations, as well as the regional knowledge transfer structures to which they are linked. To address the heterogeneity of the university's support in the innovation process, three faculties were selected to expose the differences in how system innovation was promoted and how the building of regional knowledge bases was supported.

The faculty of forest and environment (faculty 1), the faculty of landscape management and nature conservation (faculty 2), and the faculty of sustainable business (faculty 4) were selected to analyze in-depth their effects on knowledge bases and their contributions to system innovation.[2] A transfer center supported the faculties in their knowledge transfer, from which two staff members were interviewed to obtain a general overview of the overall transfer activities of the EUSD. We also interviewed members of three regional intermediary

[2] Due to the close linkages of the transfer activities of faculty 3 to those of the Transfer Center and faculty 4, we decided not to include it in our sample.

organizations, each of which had a close partnership with the three faculties (Table 2). For the external stakeholders, a regional organization that had a close relationship with a specific EUSD faculty was selected in each case. These intermediary organizations are the State Competence Center Forest Eberswalde (SFE) for faculty 1, the biosphere reserve Schorfheide-Chorin (BRSC) for faculty 2, and the Chamber of Commerce and Industry of Eastern Brandenburg (CIEB) for faculty 4. Employees in management or knowledge transfer positions were interviewed.

Structurally, instead of RIS as a coherent institutional framework, the Eberswalde region has various autonomous networks of actors. However, there are also interfaces between them through individual organizations or individuals. The collaborative relationships are integral parts of the three networks of knowledge transfer. First, the network of faculty 1 and the SFE is primarily focused on forest owners and foresters of private and state forests as stakeholders. It also included other stakeholders around the forest ecosystem, such as conservationists. Second, the network of faculty 2 and the BRSC includes actors in the fields of organic agriculture, ecotourism, and nature conservation. These actors are farmers, beekeepers, nature conservation associations, administrations such as the county, and food processing companies or schools in the field of environmental education. Other important partners of the BRSC in projects are supra-regional universities aside from the EUSD, such as the University of Greifswald.

Third, the network of faculty 4 and the CIEB covers SMEs in the areas of manufacturing, tourism, and services. Other important intermediaries in this network are the economic development agencies of the local counties and the state of Brandenburg, as well as private law business associations. The EUSD students are an important actor group in the knowledge transfer of all three networks, as they make independent contributions to EUSD transfer projects and participate independently in the civil society sector (e.g., in initiatives).

In addition to these networks, a wide range of civil society actors, such as initiatives, foundations, associations, schools, and even students of the EUSD, has established themselves as important actors in the RIS of Eberswalde. The EUSD, SFE, CIEB, and especially the BRSC have developed knowledge transfer activities for these groups in the form of public contests, such as school competitions, and workshops. According to the interviewees of the transfer office of the EUSD, actors of civil society are mostly characterized by high intrinsic motivation

and enthusiasm for social processes. In some applied research projects of the EUSD, questions on participation concern not only partner actors from the economy but also those from civil society. The WaldWelten Foundation, founded by the city of Eberswalde and the EUSD and sponsored by the SFE, is involved in environmental education and cultural events. The BRSC is active in the field of education for sustainable development by providing guided tours and courses, especially for school classes. The CIEB organizes robotics competitions for children and teenagers to engage with their technical skills and interests.

In sum, the Eberswalde region has no RIS as a coherent institutional framework but has three autonomous networks of knowledge transfer: faculty 1 and SFB, faculty 2 and BRSC, and faculty 4 and CIEB. These networks are surrounded by a lively network of civil society actors.

TABLE 2

	Organization	**Status**	**Position**	**Professional network**
1	Faculty 1	Active	Professor	Forestry
2	Faculty 1	Retired	Professor	Forestry
3	SFE	Active	Transfer-specific	Forestry
4	SFE	Retired	Management	Forestry
5	Faculty 2	Active	Professor	Ecological land use
6	Faculty 2	Active	Professor	Ecological land use
7	BRSC	Active	Management	Ecological land use

8	BRSC	Retired	Management	Ecological land use
9	Faculty 4	Active	Professor	Commerce and industry
10	Faculty 4	Active	Professor	Commerce and industry
11	CIEB	Active	Management	Commerce and industry
12	CIEB	Retired	Management	Commerce and industry
13	Transfer Center	Active	Transfer-specific	Superordinate
14	Transfer Center	Active	Transfer-specific	Superordinate

5. RESULTS: Linking different knowledge bases for system innovation in the Eberswalde region

This section presents the results of our case study in the Eberswalde region. To answer the research questions, in the first subsection, we present the characteristics and functions of knowledge bases relevant to regional actors during sustainability-oriented knowledge transfer. In the second subsection, we present the contributions of knowledge transfer to system innovation.

5.1 Role of knowledge bases in sustainability-oriented knowledge transfer

This subsection answers the question of which knowledge bases of different actor groups are used in the knowledge transfer activities of the EUSD with three selected intermediaries in the RIS of the Eberswalde region. We argue that the different forms of knowledge relevant in regional knowledge transfer are based on analytical, synthetic, and symbolic knowledge bases.

Academic knowledge clearly plays a major role in knowledge transfer between the EUSD and regional intermediaries. However, transfer goes beyond the classic transfer from universities to businesses in the region. One interviewee from faculty 2 emphasizes the relevance of academic knowledge to rationalize discussions between actors in the RIS and to find evidence-based solutions in the innovation process. Academic knowledge is used based on different knowledge bases:

- The academic knowledge used by faculty 2 and the BRSC is based primarily on the analytical knowledge base. The respondents specifically described in depth codified expertise or further thinking processes based on natural laws. This knowledge is crucial as basic knowledge in research between the BRSC and the EUSD.
- Similarly, the academic knowledge used in the knowledge transfer between faculty 1 and the SFB is mainly analytical knowledge. In the interviews, references were mentioned in connection with basic knowledge, mainly from the natural sciences, such as botany.
- The academic knowledge used by faculty 4 is based on the synthetic knowledge base. According to one interviewee, it usually originates from case studies on specific problems, for example, experiential knowledge in written form, such as case studies and technical literature on knowledge transfer. The knowledge transfer of faculty 4 does not have a high proportion of R&D activities. As discussed in the interviews, it mostly aims at solving problems, such as the modelling of business processes.

Moreover, experiential knowledge based on synthetic knowledge is conducive in the Eberswalde region, as it is often used as the only source by the cooperation partners of the EUSD, SFC, BRSC, and CIEB, including organic farmers, SMEs, and forest owners. It also shapes the interaction between the EUSD and the three intermediary organizations. In fact, most

interviewees emphasized experiential knowledge because of its site-specific and person-specific characteristics. In the case of forestry, experience knowledge is based on specific knowledge of the forest areas on site, which is mainly accessible to district foresters and forest owners. Eberswalde, as a forest science location, is characterized by its traditional emphasis on this site-specific knowledge.

Communication knowledge is used exclusively by the EUSD, SFC, BRSC, and CIEB. These intermediaries have specialists who handle communication with other organizations in terms of knowledge transfer. Communication knowledge is also based on symbolic knowledge bases, the responsibility for which is held by the specialists of the EUSD, SFC, BRSC, and CIEB. These communication experts handle the communication of intermediary organizations with other regional actors. Therefore, communication knowledge is not broadly dispersed inside organizations.

The main function of communication knowledge in knowledge transfer is to overcome communication barriers between heterogeneous actors and stakeholders that have different perspectives on problems and communication styles. For example, the partner actors of the EUSD, BRSC, SFC, and CIEB can only use academic knowledge for problem solving if this knowledge is transformed into everyday language. Academic knowledge from universities or research institutes requires translation to be accessible and usable for regional stakeholders, such as SMEs. Communication knowledge is necessary to build communication channels that capture diverse perspectives and consist of comprehensive language. Therefore, communication knowledge and the associated symbolic knowledge bases serve as a connector to link experiential and academic knowledge in the transfer processes.

In summary, analytic, synthetic, and symbolic knowledge bases are relevant in sustainability-oriented knowledge transfer in the Eberswalde region. All actors depend on experiential knowledge related to synthetic knowledge bases in all transfer activities, while only the EUSD, SFE, and BRSC use academic knowledge based on synthetic and analytical knowledge bases. Communication knowledge related to symbolic knowledge bases is essential to generate academic knowledge that corroborates synthetic and analytical knowledge bases that are useable for regional stakeholders by translating and enhancing trust in a RIS.

5.2. Knowledge flows in the Eberswalde RIS

In this chapter, we explain the direction of knowledge flow in regional knowledge transfer between heterogeneous actors. A mutual knowledge exchange exists between the EUSD and the intermediaries and their partner actors. The interviewed experts emphasized the collaborative process as a prerequisite for system innovation and related knowledge transfer activities.

Academic, experience, and communication knowledge flow bi-directionally between regional knowledge transfer networks, including societal actors. The knowledge outputs of one actor are usually exploited by other actors. The analyzed intermediary organizations are not only mediators and generators but also recipients of knowledge. In all knowledge transfer networks, a variety of actors, such as forest owners, organic farming, or SMEs, contribute exclusively to experiential knowledge in knowledge transfer projects. The EUSD, BRSC, and SFC utilize this knowledge as input for prospective transfer or research projects to recombine academic and experience knowledge to answer new application-oriented research questions. Stakeholders in these projects can facilitate innovation and knowledge exchange processes using practice-oriented knowledge as innovation output.

The EUSD students are central actors in the Eberswalde RIS that characterize reciprocal regional knowledge transfer. On the one hand, students benefit from knowledge outputs in projects with regional actors about innovation processes and challenges, such as time constraints in production, interacting in innovation networks, and the effects of scientific findings on the capability to innovate. In these projects, the students also gather new experience about roles in knowledge transfer, such as being teachers, researchers, or university representatives of the EUSD. On the other hand, students enrich their academic knowledge with new ideas and perspectives as knowledge input in knowledge transfer projects. Students also apply this knowledge in civil society to advance sustainable change processes in regional innovation outputs.

Furthermore, societal actors exchange knowledge with the EUSD to solve pressing societal and sustainable problems as innovation output. Whereas there is a direct knowledge exchange between university and societal actors, there is almost no direct knowledge exchange between societal actors and business. Instead, the EUSD indirectly supports and accelerates ideas from societal actors in knowledge transfer with actors from business and administration.

According to most interviewees, a combination of experience knowledge, academic knowledge, and communication knowledge is necessary for successful knowledge transfer in the Eberswalde region. The academic and experience knowledge of the EUSD, SFE, BRSC, and CIEB is combined with the experience knowledge of stakeholders of the regional knowledge transfer. This requires effective network structures by the EUSD, SFC, BRSC, and CIEB encompassing the stakeholders. Therefore, communication knowledge, which gives communication experts deep insights into the roles of different actors in knowledge transfer, is necessary. In the Eberswalde region, communication knowledge seems to have the role of an accelerator and a link between experience and academic knowledge.

How do bi-directional knowledge flows affect the composition of knowledge bases? Based on empirical results, an effective regional knowledge transfer of the EUSD, SFE, BRSC, and CIEB also requires the combination of analytical and synthetic knowledge bases with symbolic knowledge bases, as academic knowledge is strongly related to analytical and synthetic knowledge bases, experience knowledge with synthetic knowledge bases, and communication knowledge with symbolic knowledge bases. In summary, the synthetic knowledge bases of regional partners are combined with the analytical and synthetic knowledge bases of the EUSD, SFB, BRSC, and CIEB in knowledge transfer to facilitate a collaborative innovation process. For this combination of different knowledge bases, symbolic knowledge bases in the form of the communication knowledge of transfer specialists from the EUSD, SFB, BRSC, and CIEB are crucial.

5.3. Development of system innovation in the Eberswalde region

In this chapter, we examine the type of innovation developed in the collaborative innovation process of knowledge transfer of the Eberswalde RIS. Specifically, we analyze the extent to which these innovations can be combined effectively with system innovation. The development of system innovation in the Eberswalde region requires the integration of existing organizational innovations with social and technical innovations.

The knowledge transfer projects discussed in the interviews brought up only a few examples of product innovation. These examples are innovations explicitly designed to conserve resources, often with reference to wood material. Faculty 3 is a driver of sustainable

product innovation. The aim of newly developed products is to reduce the overconsumption of wood, particularly tropical wood, and to initiate sustainable and circular product cycles. Examples of these products are market-ready bicycles made largely of wood and guitars made of domestic wood, which sounds similar to guitars made of tropical wood. These products are created in technology transfer projects in which knowledge is predominantly imparted unilaterally by faculty 3 without the involvement of other actors (e.g., from civil society). This is exacerbated by the fact that the public sector mainly promotes technology transfer, and only now is it increasingly promoting civil society knowledge transfer.

All three knowledge transfer networks collaborate mostly for incremental organizational innovations, while radical technical innovation plays a subordinate role. For example, faculty 2 and the BRSC collaboratively develop organizational innovations, such as new marketing channels in organic farming or concepts of ecological land use. Faculty 4 and the CIEB experiment with modelling business processes and testing digital applications and processes. In the case of faculty 1 and the SFE, their knowledge transfer focuses on reorganizing forest conversion.

Organizational innovation in combination with social innovation was discussed during the interviews as essential in knowledge transfer in the regional projects between the EUSD and intermediaries. The contributions to system innovation can be linked to three dimensions. First, in the Eberswalde region, the strong combination of social innovation and organizational innovation helps generate contributions to sustainable development. An example of such a combination is a participatory discussion across all faculties and the involvement of professors, researchers, administrators, and students within the EUSD before the university was renamed "Eberswalde University for Sustainable Development" in 2010. This led to a stronger organizational orientation in everyday working practices and knowledge transfer activities that contribute to sustainability. Another example of combining social and organizational innovation is the attempt of the BRSC to increase the acceptance of its land use practices. The BRSC teaches and communicates to stakeholders, such as regional farmers and other land users, the processes of sustainable land use as an organizational innovation. Therefore, the BRSC develops these processes of sustainable land use together with the stakeholders in a participatory learning process that enables new social practices and represents social innovation.

Second, there is regional potential for linking organizational and social innovations to system innovation by bringing together heterogeneous actor groups, as social innovation requires diffusion in broad sections of society (Appendix 1). All three knowledge transfer networks have developed specific activities for societal actors, such as civic associations like the Civic Foundation Uckermark-Barnim, which is engaged in the promotion of children's education, initiatives like "wandelBar," which is a transition initiative in the county of Barnim, individual citizens, and school classes. However, in the Eberswalde region, there are separate platforms and events for societal actors and businesses, such as SMEs or organic farms. The two groups of actors are usually not engaged in common knowledge transfer activities and events. However, organizational innovations usually emerge from the knowledge transfer of these intermediaries without the participation of civil society.

The "Region 4.0" project is a new milestone that develops system innovation in the region because its goal is to bring together heterogeneous actor groups of the civil society, the public sector, and the economy through multi-stakeholder approaches (Müller et al. 2015). The idea of this approach is to implement a cyclical innovation process and foster knowledge transfer among these heterogeneous actors. "Region 4.0" is a project platform comprising different projects. In this context, the direct exchange between actors from civil society, business, and administration is promoted in small projects. One of these projects is "Soziale Logistik," which uses feedback from citizens as knowledge input to enable regional transport to adapt its mobility services to regional needs. This also represents an innovation with social and organizational aspects.

Third, there is a potential for system innovation in the Eberswalde region by combining technical innovation with social and organizational innovation. Technical innovation hardly plays a role in "Region 4.0's" attempt to develop system innovation. We argue that this can be counteracted by promoting new technical innovation in the region that is explicitly geared toward system innovation from the outset by combining it with social innovation. However, as few technical innovations have emerged in regional knowledge transfer to date, these innovations cannot build on existing innovation but need to emerge without prior regional knowledge transfer. Analytical knowledge bases, which allow the emergence of radically new innovations in the region, for example, through the branches of analytically oriented large companies, can increase the diversity of knowledge bases in the region and promote the emergence of radically new technical innovations that can be combined for system innovation.

In summary, incremental organizational innovations are the predominant kind of innovation created in the knowledge transfer of the EUSD, SFB, BRSC, and CIEB. They are particularly relevant in combination with social innovation, which has enabled new sustainability-oriented practices in the EUSD and BRSC to form system innovation. However, many organizational innovations and the few technical innovations in the region still have almost no links to social innovation, which is a prerequisite for system innovation. System innovation approaches exist in the Eberswalde region to combine social innovation with organizational innovation. However, to reach a new level of system innovation, it is important to implement new technical innovations in the region and combine them with existing socio-organizational innovations.

6. DISCUSSION

Our finding that communicative knowledge based on symbolic knowledge bases is necessary for overcoming cognitive differences is also supported by the literature on knowledge bases. According to Asheim (2007), trust in connection with norms and behavior is part of the informal intentional context in which interactive learning takes place. Therefore, it corresponds to the social dimensions of actor groups (Strambach 2017). In her study of Chinese–German projects, Strambach (2017) shows that symbolic knowledge bases are necessary to bridge cognitive and cultural differences and problem understanding. These differences go beyond language barriers. Our results show that the translation of research knowledge to comprehensive content for stakeholders' innovation projects requires symbolic knowledge for effective knowledge transfer.

Mutual knowledge transfer between different actors is a basis for system innovation. This is in accordance with Strambach's (2017) assumption that system innovation requires the cooperation of heterogeneous and multiple actors. For further empirical research, the question of whether system innovation necessarily requires the integration of technical, social, and organizational innovations arises. According to Geels (2004), system innovation relies on the generation and diffusion of technological innovations. Technology plays a significant role in combination with the social functions and practices of everyday life, such as transportation, communication, housing, and nutrition. As shown in our case study, combining only social and organizational innovations is not enough for system innovation. Further studies can help to

understand the extent to which the lack of technical innovations affects the emergence of system innovation.

7. CONCLUSION

To capture the underexplored innovation processes for sustainability-oriented system innovation on a regional level, we focus on the knowledge flows and interaction networks between intermediaries and their partner actors in inter-organizational knowledge transfer. This case study aimed to answer the question of what regional knowledge bases are recombined in the knowledge transfer of the EUSD and three other intermediaries in the Eberswalde region into sustainability-oriented innovation and in what manner. We used a qualitative case study approach, which is based on guideline-based expert interviews and a category-based evaluation methodology of a qualitative content analysis.

The key findings of our qualitative empirical analysis are trifold. First, in the Eberswalde region, most actors in the regional knowledge transfer of the EUSD, BRSC, SFE, and CIEB have predominantly synthetic knowledge bases based on experience knowledge (Asheim 2007). This dominance of synthetic knowledge characterizes geographically and structurally peripheral regions (Tödtling and Trippl 2005), such as the Eberswalde region. At least three autonomous networks of knowledge transfer have been formed around these regional actors. In our study, we selected for expert interviews faculty 1 and the SFE as intermediaries of the first network, faculty 2 of the EUSD and the BRSC for the second network, and faculty 4 and the CIEB for the third network. These networks are surrounded by a growing number of societal actors. However, civil society is, in most cases, not in direct exchange with partner actors (e.g., from business). The EUSD, SFE, BRSC, and CIEB successfully address the predominantly synthetic knowledge bases of their partner actors through their recursive knowledge transfer based on consultation and communication. These findings support the argument of Strambach (2017) that the mutual collaboration of heterogeneous actors is important for developing sustainability-oriented innovation.

Second, symbolic knowledge plays an important role in participative forms of knowledge transfer. In the participatory research approach, groups of heterogeneous actors collectively gather knowledge about a specific problem (Lindberg, Danilda, and Torstensson

2012). We assume the importance of symbolic knowledge in communication not only in professional communities (Asheim and Hansen 2009) but also in participatory communication in the knowledge transfer between heterogeneous actors. The reason for this is that symbolic knowledge is also characterized by a deep understanding of the norms, habits, and everyday cultures of different social groups (Asheim, Boschma, and Cooke 2011). This finding supports Strambach's (2017) conceptual assumption that the innovation process for sustainability-oriented innovations needs to address the social and institutional environments of heterogeneous actors in knowledge transfer. Therefore, synthetic and analytical knowledge bases must be integrated with symbolic knowledge bases.

We found that the integration of synthetic, analytical, and symbolic knowledge can also be observed in the knowledge transfer of the EUSD, SFC, BRSC, and CIEB in the Eberswalde region. Communication specialists of symbolic knowledge allow the EUSD, SFC, BRSC, and CIEB to combine their own analytical and synthetic knowledge with the experience-based synthetic knowledge of their partner actors. Therefore, the SFE, BRSC, and CIEB exchange knowledge and contributions to innovations through knowledge transfer with their partner actors, including actors from civil society, on a multiple and reciprocal basis to create approaches for sustainability-oriented system innovation in the region.

Third, the organizational innovations that emerge from these innovation processes are predominantly incremental. Regional actors increasingly combine organizational and social innovations to form system innovation approaches, with "Region 4.0" representing a milestone for this development in the region. According to Asheim, Boschma, and Cooke (2011), incremental innovations emerge in industries with dominant synthetic knowledge bases. We assume that social innovations within the EUSD and BRSC emerge through the participatory interaction of distinct groups of actors (Howaldt and Schwartz 2010). Furthermore, these innovations develop in close connection with symbolic knowledge bases, but there is a particular lack of radical new technical innovations. These radical innovations are developed with the participation of analytical knowledge bases in a formal R&D process with explicit scientific knowledge (Asheim, Boschma, and Cooke 2011; Bennat and Sternberg 2020) and can be combined with social innovations to form system innovations. Therefore, closely related to this is a shortage of analytical knowledge that can contribute to the emergence of radically new technical innovations.

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Appendix 1

Coding guideline	
Category	**Definition and differentiation**
1. Knowledge base	See Asheim, Boschma, and Cooke (2011)
1.1. Academic knowledge	Knowledge brought in by EUSD and other universities in the transfer process that plays the greatest role in analytical knowledge bases but is also relevant in synthetic knowledge bases (Asheim et al. 2007)
1.2. Experience knowledge	Represents synthetic knowledge mostly based on personal experience through practical learning and work experience (Asheim 2007)
1.3. Communication knowledge	Represents symbolical knowledge with an in-depth understanding of social groups (Asheim, Boschma, and Cooke 2011)
2. Innovation	Novel products, processes, and practices or the enhancement of existing ones
2.1. Technical innovation	Novel or upgraded products
2.2. Process innovation	Adaptation of new ideas and behavior in organizations
2.3. Social innovation	Purposeful reconfigurations and improvements of social practices that diffuse in broad sections of society (Howaldt and Schwartz 2010)

3. Initiators for innovation	Actors that initiate innovation processes
4. Contribution to sustainable development	Effects of regional innovation on sustainable development by changing socio-technical regimes (Lawhon and Murphy 2012)
5. Learning process	Learning as a process that leads to new knowledge or transfers old knowledge to new people (Lundvall and Johnson 1994)
6. Actors in knowledge transfer	Participants in knowledge transfer
6.1. Active actors	Actors that actively shape knowledge transfer
6.2. Stakeholder groups	Passive actors addressed by knowledge transfer