

The role of university-related intermediation in supporting sustainability transitions in regional innovation initiatives in Germany

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Abstract

This dissertation analyzes the roles of university-related intermediation in supporting sustainability transitions in regional innovation initiatives in Germany. Sustainability transitions are required to address grand societal challenges such as climate change. Innovation is seen as a key driver of these transitions but prevailing innovation policy approaches are insufficient to govern the necessary fundamental change processes. Thus, the more holistic concept of ‘transformative innovation policy’ has been introduced. This new paradigm focuses on enabling sustainability transitions and calls for proactive policy interventions to shape a sustainable future, but it also poses new challenges for stakeholders. In Germany, innovation policy promotes collaborative regional innovation initiatives led by higher education institutions (HEIs). HEIs are considered to be important actors in regional innovation systems as they are involved in knowledge transfer as part of their ‘third mission’ and act as knowledge intermediaries. Against this background, this dissertation investigates the role of HEI-related intermediation in supporting transformative change. The first part of this dissertation examines the challenges to provide directionality towards sustainability in innovation policy practice. These chapters analyze the capabilities of HEI-related intermediation to support transformative change by prioritizing and stimulating innovation activities that contribute to sustainability, and thus identify the ability of HEI-related intermediaries to provide and implement directionality. The second part investigates how HEI-related intermediation supports sustainability transitions. As HEI-related intermediaries have not been considered in research on intermediation in transitions, it is analyzed how HEI-related intermediaries involve in supporting sustainability transitions and take on roles that have been predominantly attributed to ‘transition intermediaries’.

Keywords: sustainability transitions, directionality challenges, transformative innovation policy, transition intermediary, regional innovation systems

Zusammenfassung

In dieser Dissertation wird die Rolle hochschulbezogener Intermediation bei der Unterstützung einer Nachhaltigen Entwicklung in regionalen Innovationsinitiativen in Deutschland analysiert. Eine Nachhaltige Entwicklung ist erforderlich, um gesamtgesellschaftlichen Herausforderungen wie dem Klimawandel zu begegnen. Innovation gilt als ein wichtiger Treiber für die erforderlichen Veränderungsprozesse, aber die vorherrschenden innovationspolitischen Ansätze greifen zu kurz, um die notwendigen grundlegenden transformativen Prozesse zu steuern. Aus diesem Grund wurde das ganzheitlichere Konzept der "transformativen Innovationspolitik" entwickelt. Dieses neue Paradigma stellt die Förderung nachhaltiger Wandlungsprozesse in den Mittelpunkt und fordert die proaktive Gestaltung einer nachhaltigeren Zukunft, bringt damit aber auch neue Herausforderungen für die beteiligten Akteure mit sich. In Deutschland fördert die Innovationspolitik kollaborative und regionale Innovationsinitiativen unter der Führung von Hochschulen. Hochschulen gelten als wichtige Akteure in regionalen Innovationssystemen, da sie im Rahmen ihrer "dritten Mission" den Wissenstransfer fördern und als Wissensintermediäre tätig sind. Vor diesem Hintergrund wird in dieser Dissertation die Rolle der hochschulbezogenen Intermediation bei der Unterstützung des transformativen Wandels untersucht. Im ersten Teil der Dissertation werden die Herausforderungen untersucht, die mit der Ausrichtung (directionality) auf Nachhaltigkeit in der innovationspolitischen Praxis verbunden sind. In diesen Kapiteln werden die Fähigkeiten hochschulbezogener Intermediäre analysiert, einen transformativen Wandel zu unterstützen, indem sie Innovationsaktivitäten, die zur Nachhaltigkeit beitragen, priorisieren und stimulieren. Dabei wird identifiziert, wie eine Ausrichtung auf Nachhaltigkeit ermöglicht und umgesetzt wird. Im zweiten Teil wird untersucht, wie hochschulbezogene Intermediation Nachhaltigkeitsübergänge unterstützt. Da hochschulbezogene Intermediäre in der Forschung zur Intermediation in Übergangsprozessen zu einer Nachhaltigen Entwicklung bisher kaum berücksichtigt wurden, wird analysiert, wie hochschulbezogene Intermediäre bei der Unterstützung einer Nachhaltigen Entwicklung mitwirken und dabei Aufgaben übernehmen, die bisher vorwiegend den „Transitionsintermediären“ zugeschrieben wurden.

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Chapter I:

Introduction

In the face of complex ‘wicked’ sustainability problems (Urmetzer et al., 2018), such as climate change and pollution, which cause the crossing of multiple planetary boundaries (Steffen et al., 2015), promoting more sustainable modes of production and consumption is one of the greatest challenges of our time. Addressing sustainability problems requires fundamental change processes in socio-technical systems that are referred to as ‘sustainability transitions’ (Markard et al., 2012). Sustainability transitions are characterized as uncertain, open-ended, long-term, multidimensional and, multi-actor processes (Köhler et al., 2019). Innovation is considered to be a key driver of the required systemic transformations (Schot and Steinmueller, 2018; Grillitsch et al., 2020). Therefore, innovation policy is seen as an important instrument for fostering transformative change as reflected in national and supranational strategies for sustainable development, such as the German Sustainable Development Strategy (The German Federal Government, 2021) or the European Green Deal (European Commission, 2019). However, fostering sustainability transitions poses new challenges for innovation policy. Conventional and predominant policy approaches that focus on economic growth and address market failures, such as the funding of research and development and the fostering of regional innovation systems on different spatial levels, are insufficient to address the necessary change processes. Therefore, scholars have introduced ‘transformative innovation policy’ as a new paradigm that does not exclude economic interests but primarily focus on sustainability transitions and calls for more proactive policy interventions to shape a sustainable future. This more comprehensive and fundamental approach takes into account the complex requirements of sustainability transitions and includes not only technological but also involves needed associated social and behavioral changes and innovation to enable system reconfigurations that meet societal needs (Kuhlmann and Rip, 2018; Schot and Steinmueller, 2018).

Therefore, addressing societal challenges requires a more holistic policy approach that allows contributing to a particular direction of change. This requirement poses new challenges on transformative innovation policy as previous approaches focused on generating innovation as effectively and efficiently, but are insufficient to provide directionality towards sustainability (Weber and Rohracher, 2012). The concept of directionality evolved from research on failures of transformative innovation policy and constitutes a new rationale for policy interventions (Schot and Steinmueller, 2018). On the one hand, it is informed by a discussion on the fundamental question of how to shape the future (Uyarra et al., 2019) and which direction of change to take (Andersson et al., 2021). On the other hand, regarding innovation policy practice, implementing directionality has been identified as a major challenge of transformative innovation policy (Bergek et al., 2023). In addition to that, the implementation of directionality itself poses challenges to policymakers, as proceeding in long-term sustainability transitions requires alignment of visions and joint actions of involved stakeholders and opened-up innovation processes (Parks, 2022). The challenges associated to the implementation of directionality include promoting change agents to enable institutional shifts, resolving conflicting interests in order to align visions and develop actionable strategies, as well as the introduction of new forms of governance (Grillitsch et al., 2019). More specifically, to implement directionality in innovation policy practice and overcome related challenges, capabilities are required that allow to prioritize and stimulate innovation activities that contribute to the desired direction of transformative change (Yap and Truffer, 2019).

The concept of directionality has been connected to (Grillitsch et al., 2019) and integrated (Tödtling et al., 2021) in the framework of ‘regional innovation systems’ (RIS) (Cooke et al., 1997). Originally, the RIS approach emphasizes the importance of proximity for knowledge transfer and mutual learning (Asheim et al., 2015) and comprises analytical perspectives on the interactions of actors, networks and institutions in innovation processes. It is applied by researchers to analyze the collaboration of multiple actors, such as universities, research institutions, intermediaries, companies, and policymakers, in regional networks that are influenced by institutional settings. Additionally, the RIS approach informs

policymaker in the design and implementation of innovation policies (Tödtling et al., 2021). Nevertheless, in line with the recent shift towards transformative innovation policy and considering transitions as place-dependent processes (Hansen and Coenen, 2015) that complementarily need to be addressed at the regional level (Wanzenböck and Frenken, 2020) the RIS approach has been advanced. For example, Tödtling et al. (2021) introduced ‘challenge-oriented RIS’ (CoRIS), which integrates both directionality as well as civil-society actors into the RIS framework in order to meet the needs of societal challenges and transformative change. However, although the implementation of directionality has been identified as a major challenge for transformative change, it needs further research on how to design innovation policy instruments that allow to implement directionality (Grillitsch et al., 2019) and empirical evidence remains scarce (Grillitsch et al., 2020). Moreover, it is still unclear, which stakeholder of innovation processes could be employed to address the challenges related to directionality (Haddad et al., 2022).

Another important research strand on fostering sustainable transitions investigates the facilitating role of intermediation. In the last decades, the concept of intermediation has gained attention in innovation policy and research (van Lente et al., 2003; Howells, 2006; Stewart and Hyysalo, 2008). Intermediation comprises multiple practices that aim to enhance the productivity, connectivity, and functionality of innovation systems by fostering inter-organizational network building and knowledge exchange between different stakeholders (Howells, 2006; Dalziel, 2010; Nauwelaers, 2011). Departing from this, the notion of transition intermediaries (Kivimaa et al., 2019) evolved and gained significant attention in transition research (Köhler et al., 2019). They are perceived as enablers (Kivimaa et al., 2020c; Vihemäki et al., 2020), facilitators (Kivimaa et al., 2019) and accelerators (Gliedt et al., 2018; Kivimaa et al., 2020b) of transitions. In early stages of transitions that are characterized by high uncertainty (Geels, 2019), transition intermediaries create momentum for the creation of niches, as they connect actors and translate and disseminate knowledge (Kivimaa et al., 2019). Thus, the concept of transition intermediaries is closely connected to strategic niche management, which has been developed in order to understand the introduction and diffusion of sustainability innovations from niches (Giganti and Falcone, 2022). Intermediaries empower niches by contributing to niche-internal processes (Kivimaa, 2014). These processes include the articulation of expectations and visions, the building of social networks, the enablement of learning processes and the support of other transitions related processes (Vihemäki et al., 2020).

Moreover, research on intermediation in transitions indicates that roles and activities of intermediaries correspond to challenges related to directionality (Kivimaa et al., 2019; Sovacool et al., 2020; Vihemäki et al., 2020). For example, equivalent functions of intermediation in transitions have been identified, such as conflict resolution (Sovacool et al., 2020), governing in multi-stakeholder settings (Hodson et al., 2013), networking (Fischer and Newig, 2016; Gliedt et al., 2018; Kanda et al., 2020; Loorbach et al., 2020), vision building (van Lente et al., 2003; Kivimaa, 2014; van Boxstael et al., 2020a) or strategy development (Hodson and Marvin, 2012; Hamann and April, 2013; Cramer, 2020). Furthermore, Kanda et al. (2020) examined that intermediaries acting in-between the actors, networks, and institutions of innovation systems are able to facilitate sustainability transitions by contributing to an overall direction through their influence on institutions. Thus, in order to gain a better understanding of the potential effects of intermediation on implementing and providing directionality, the two overlapping but yet not systemically connected research strands need to be interrelated.

In their seminal typology of transition intermediaries Kivimaa et al. (2019) define intermediation in transitions as roles and activities of “actors and platforms that positively influence sustainability transition processes by linking actors and activities, and their related skills and resources, or by connecting transition visions and demands of networks of actors with existing regimes in order to create momentum for socio-technical system change [...]” (Kivimaa et al., 2019, p. 1072). Although this broad definition has been criticized for overestimating the impact of intermediation on transitions, the importance of intermediaries in transition processes is generally emphasized in transition research (Manders et al., 2020). However, the characterization of transition intermediaries can be explained by

the wide array of practices intermediaries involve (Vihemäki et al., 2020) and the heterogeneous group of actors covered in the typology of transition intermediaries. Based on a literature review on intermediation in transitions, this typology lists various exemplifying actors ranging from national innovation agencies to building managers but not consider or list higher education institutions (HEIs) such as universities (Kivimaa et al., 2019).

This indicates that research on intermediaries in transitions predominantly neglected to consider the role of HEIs. Although the importance of intermediation in transitions at the regional level has been emphasized (Kivimaa et al., 2020a; van Boxstael et al., 2020b; van Lente et al., 2020; Vihemäki et al., 2020), research on the involvement of HEI-related intermediation in sustainability transitions remains scarce (Kivimaa et al., 2017). Moreover, HEIs are regarded as not suitable to address societal challenges, as they are found to lack the ability to open-up innovation processes and thus not bear potentials to provide directionality (Parks, 2022). In contrast to this, few contributions emphasize the role of HEIs in supporting transformative change towards sustainability by enabling co-creation for sustainability (Trencher et al., 2014), by acting as boundary-spanners (Pflitsch and Radinger-Peer, 2018) or by supporting niches (Wolf et al., 2021). Despite from this, HEIs and particularly their knowledge and technology transfer offices have predominantly been discussed as innovation intermediaries (Pinto et al., 2015; e.g. Perkmann et al., 2021) and knowledge intermediaries. The main objectives of this latter type of intermediary centers around the promotion of reciprocal knowledge exchange between academic and non-academic stakeholders in order to foster the transfer and commercialization of research results (Yusuf, 2008; Youtie and Shapira, 2008; Clayton et al., 2018).

The discussion on the roles of HEI-related intermediation in sustainability transitions calls for further analyzing the potential contributions of HEI in supporting transformative change and providing directionality. This investigation becomes more important considering actual innovation policy practice. In Germany, governmental funding programs focus on promoting collaborative and regional innovation initiatives centered on HEIs, such as the "Innovative University"¹ and "Change through Innovation in Regions"², recognizing that universities are key actors in RIS as they generate knowledge and are involved in knowledge transfer and intermediation as part of their 'third mission'. In addition, in these funding programs, regional HEI-led initiatives are existent that explicitly focus on contributing to sustainability transitions, while others aim for conventional objectives such as strengthening regional innovativeness and competitiveness. The need for further research into the capabilities of HEI-related intermediation to induce, promote and govern sustainability transitions is underscored by the scarcity of empirical examination and reinforced by the increasing urgency to bring about socio-technical change processes.

Against the background of the current grand societal challenge and contributing to the strands of literature discussed above, this dissertation aims to analyze the roles of HEI-related intermediation in supporting sustainability transitions in regional innovation initiatives in Germany. From a scholarly perspective, it makes a twofold contribution: First, Chapters II and III of this dissertation address the identified research gaps with regard to the challenges to provide directionality in innovation policy practice. These chapters analyze the capabilities of HEI-related intermediation to support transformative change by prioritizing and stimulating innovation activities that contribute to sustainability, and thus identify their ability to provide and implement directionality. Second, the research contributions included in this dissertation investigate the role of HEI-related intermediation in supporting transitions. More specifically, as HEI-related intermediation has not been considered in research on transition intermediaries but are regarded important actors in regional level innovation policy, Chapters IV and V analyze how HEI-related intermediaries are involved in supporting sustainability transitions in German regional innovation initiatives and take on roles that have been predominantly attributed to transition

¹ For further information see <https://www.innovative-hochschule.de/foerderinitiative/ueber-die-foerderinitiative>.

² For further information see https://www.innovation-strukturwandel.de/strukturwandel/de/innovation-strukturwandel/wir/wir_node.html.

intermediaries. Accordingly, both chapters underscore their consideration in transformative innovation policy. Complementary, Chapter VI investigates interdependencies of knowledge transfer and digitalization and aims on informing future research and knowledge transfer policies.

Chapter Overview

This dissertation consists of five contributions centered on the role of HEI-related intermediaries in supporting transformative change. All contributions are based on in-depth case studies in four German regional innovation initiatives led by HEI. To allow insights into regional intermediation practices and conduct analysis, semi-structured interviews were conducted including intermediaries and participants of regional innovation initiatives in the regions of Darmstadt, Eberswalde, Augsburg and Goettingen. This data form the core of the analysis and is investigated applying qualitative methods that are complemented by quantitative approaches (Chapter III). The cases have been selected, because they are comparable in structural and formal parameters (e.g. publicly funded, HEI-led, comprising additional regional intermediaries, knowledge transfer-oriented) but are different in their primary goals: The cases assessed in Darmstadt and Eberswalde are explicitly sustainability-oriented while the two cases of Augsburg and Goettingen focus on non-transformative and thus conventional objectives, e.g. regional innovativeness. The chosen sample of cases combined with comparative analysis allows identifying distinctive and characterizing features of sustainability-oriented and HEI-related intermediation. The following overview provides a brief summary of all five research papers, their key results, and policy implications.

HEI-related intermediaries provide directionality to transformative change (Chapter II and Chapter III)

Departing from the requirement to implement directionality in transformative innovation policy practice, the chapter “The course to sustainability: The role of university-related intermediaries in providing directionality to regional innovation initiatives” focuses on how HEI-related intermediation practices are affected by directionality challenges and on how intermediaries respond to these challenges in order to support transformative change processes towards sustainability. To investigate the capability of HEI-related intermediation to induce and maintain directionality, the paper builds on the directionality challenges identified by Grillitsch et al. (2019) and connects them to roles of activities of intermediaries in transitions (Kivimaa et al., 2019; Vihemäki et al., 2020). To make visible characterizing intermediation practices that aim to address directionality challenges, the sustainability-oriented regional innovation initiatives of Darmstadt and Eberswalde are compared to the conventional cases in Augsburg and Göttingen. For the comparative analysis, 63 interviews were conducted including intermediaries from the academia, industry, municipalities as well as from civil-society. The qualitative content analysis provides insights into operational and strategical adaptations of intermediation practices in regional sustainability-oriented innovation initiatives that differ from conventional approaches. Moreover, the identified adaptations of intermediation correspond to directionality challenges and allow stimulating and prioritizing sustainability related innovation activities. First, in order to contribute to sustainability, intermediation focus on enabling groups of participants to align interests and visions as well as to resolve conflicts by applying including and participatory methods. Regarding the capabilities of participants, intermediaries in sustainability-oriented cases aim to facilitate cooperation and initially provide an understanding of problems related to sustainability. This shared understanding is the basis on which regional actors are enabled to legitimize and coordinate joint actions. Therefore, HEI-related intermediaries develop capabilities to take the moderating and guiding role in these processes. Second, intermediaries build up specialized networks that include regional actors that are considered relevant or feasible to enable transformative change. Therefore, intermediaries develop a specific actor selection strategy that makes possible the formation of actionable groups particularly including civil society actors. Third, intermediaries raise awareness and sensitize participants regarding sustainability in order to stimulate a change of mindsets, regional policy and day-to-day practices by acting as role models or by persistent engagement with sustainability. Thus, adapted roles and activities of HEI-related intermediation in sustainability-oriented cases enable intermediaries to implement and provide

directionality, and thus to overcome a major impediment of transformative change towards sustainability.

Building on the findings of the previous article, Chapter III *“Providing directionality to change: Indicating the potentials of university-related intermediaries in German regions”* aims at advancing empirical insights on HEI-related and sustainability-oriented intermediation. Applying an exploratory mixed-methods approach, this article concerns with the question on how HEI-related intermediaries implement and provide directionality in sustainability-oriented regional innovation programs in Germany. In a first step, based on qualitative analysis of the 63 interviews, a set of 16 indicators is derived that characterize how intermediaries proactively stimulate and prioritize specific innovation activities in order to contribute to sustainability transitions. Following, to triangulate and test the qualitative findings, an online survey that addresses 200 German HEI-led regional innovation initiatives and 265 transfer offices of German HEI is employed. The analysis of 112 fully answered questionnaires of which one third of participants have classified their own intermediation efforts as ‘sustainability-oriented’ provides quantitatively support for seven out of the 16 indicators. To prioritize innovation related to sustainability, the results indicate that sustainability-oriented intermediaries in Germany include sustainability in goal sets and strategies and measure their success with regard to sustainability. In order to stimulate change processes in the intended direction, they aim to enable actors to act as change agents and act as role models for sustainability related actions. Moreover, they adopt participatory methods to open up innovation processes to diverse groups of stakeholders. These practices enable participants to align interests and jointly develop legitimized solutions for societal challenges. The quantitatively supported characteristics represent capabilities that allow to prioritize as well as to stimulate innovation related to sustainability. By revealing the potentials of HEI-related intermediaries to provide directionality, the mixed-methods analysis emphasize their role in transitions.

Next to contributions to ongoing scholarly debates, this section holds implications for policymakers. Both chapters find HEI-related and sustainability-oriented intermediaries employ practices that allow to prioritize and stimulate specific innovation activities and thus to provide and implement directionality. Therefore, HEI-related intermediation should be considered a suitable instrument to provide directionality to transformative change processes in regional level innovation policy. Moreover, Chapter II highlights that implementing directionality is related to the capability of HEI-related intermediaries to induce and govern participatory and inclusive initiatives. Participatory methods for joint vision building and initial problem identification are a prerequisite for empowering actor groups to contribute to transformative change. Therefore, to enable HEI-related intermediation that is capable to provide directionality, transformative innovation policy should strive for the development of required intermediation skills and competencies. As reflected in the data, proactive HEI internal transformative processes towards sustainability are important to act as drivers of regional sustainability transformations and to implement directionality. For this reason, suitable innovation policy instruments, for example national funding programs that aim to promote sustainability transitions, should not only provide resources, but complementarily focus on developing HEI’s potentials by encouraging HEI to induce internal processes that allow to legitimize a prioritization of sustainability related innovation. The findings of Chapter II are reinforced by Chapter III, which finds several practices that allow implementing directionality are employed in HEI-related intermediation in Germany. Thus, as capabilities are already existent in HEI-related intermediation, this on the one hand corroborates the suitability of HEIs to provide directionality and on the other hand points towards a considerable foundation for extending capabilities by appropriate innovation policy efforts. With regard to the latter, current qualitative data show that HEI-related intermediaries are aware of their involvement in transitions and enact their role as facilitators. Having one third of survey participants classify themselves as sustainability-oriented, involvement is also reflected in quantitative data.

The role of HEI-related intermediation in transitions

As research on intermediaries in transitions has neglected the role of higher education institution (HEI) related intermediaries in supporting sustainability transitions, Chapter IV *“Paving the way for*

sustainability transitions? Supportive potentials of university-related intermediaries in regional innovation systems” analyses the involvement of HEI-related intermediation in sustainability transitions. Conducting a multiple case study comprising 86 interviews with intermediaries and participants of the four German regional and HEI-led innovation programs, it analyses intermediation practices in the assessed cases against the backdrop of the identified roles and activities of transition intermediaries (Vihemäki et al., 2020). The findings show that HEI-related intermediaries involve proactively in roles that have been predominantly attributed to actors considered as transition intermediaries regardless of whether they are sustainability-oriented or strive for conventional objectives. HEI-related intermediaries contribute to sustainability transitions in a twofold way: First, they indirectly improve preconditions for transitions fostering and mobilizing the potential of their regional innovation system by articulating demands, aligning visions and connecting different actors expanding and building new networks. Enhancing learning and exploration in order to foster cooperation, intermediaries help to improve conditions for mutual learning and knowledge transfer. Furthermore, they are involved in innovation support providing advice and support for regional actors. Second, using particularly participatory and inclusive methods, they actively induce impulses for change processes towards sustainability introducing concrete and regionally fitting strategies for the respective industries and projects allowing for concrete steps towards sustainability. Moreover, the findings indicate that sustainability-oriented cases are more likely to actively induce change processes and to involve in roles and activities that are attributed to systemic and regime-based transition intermediaries (Kivimaa et al., 2019). In contrast to that, the conventional cases involve in diverse sets of roles related to enabling appropriate preconditions and therefore cannot be classified to a predefined type of transition intermediary.

These findings again underscore the potentials of HEI-related intermediation in supporting sustainability transitions as the examination reveals the involvement in transitions intermediation related roles and activities. Chapter IV provides insights on how HEI-related intermediation practices could potentially support sustainability transitions. Policymakers should encourage and support HEI-related intermediaries to develop capabilities to adapt and adopt activities supporting the preconditions for socio-technical system change. In particular, intermediation capabilities to directly inducing impulses for change should be fostered by supporting intermediaries in implementing participatory and inclusive initiatives fitting their regional potentials. Additionally, the findings point towards the importance of implementing sustainability goals and commitments of regional HEI-related intermediation activities to enable change processes. For these reasons, policymakers should consider and employ HEI-related intermediation as complementary instruments at the regional level to foster change towards sustainability.

The following Chapter V “The contribution of knowledge intermediation to sustainability transitions and digitalization: Qualitative insights into four German regions” extends the analysis of HEI-related intermediation by exploring its contribution to sustainability transitions and digitalization. It addresses the research question on how knowledge intermediation contributes to sustainability and additionally explores how digitalization affects the role of intermediation in sustainability. An explorative qualitative approach based on 63 interviews with German HEI-related intermediaries is used to gain insights on their involvement in both interconnected transition processes. The article addresses the gap concerning the understanding of knowledge intermediation and transition intermediation and connects both strands of literature, because HEI-related intermediation has been predominantly classified as knowledge intermediation. The analysis finds three major contributions of HEI-related intermediaries to sustainability transitions and digitalization. First, the dissemination of information and awareness raising for transition goals via events. Second, the building of specialized networks that allow the information and knowledge necessary for innovation processes to circulate. Third, the support of the implementation of regional innovation processes that identify problems or promote technical solutions. Moreover, regarding the correlation of both transitions the analysis suggests an important role of HEI-related intermediaries that have not been discussed before. They purposeful identify digital innovation projects in terms of sustainability and monitor digital innovation projects with regards to sustainability.

Intermediaries ensure the incorporation of knowledge and act as knowledge generators in transition processes, because they are in the position to estimate the potential positive and negative effects of digitalization on sustainability. Thus, operating at the intersection of both transitions, HEI-related intermediaries are key actors in developing digitalization projects that avoid rebound effects on sustainability or contribute to sustainability transitions.

From a policy perspective, this calls for intermediation that covers dissemination via events, networks that allow to exchange information and knowledge, and implementation of change processes. Moreover, the analysis indicates that the perception of sustainability and digitalization as open-ended transitions requires a procedural perspective that addresses the different progress levels of regional actors with different activities. Moreover, the basis of a comprehensive, ideal-type transition support efforts are low-threshold events that allow communicating to a broad range of actors and ensuring their participation. Concerning the regional organizational landscape, this indicates the need to strive for complementary capabilities between different intermediaries. Concerning the scope of knowledge intermediation policy, the analysis suggests two adaptations: First, knowledge intermediation approaches should purposefully include mission-oriented activities to support regional transition processes. Second, the societal effects of knowledge and technology transfer should be taken into consideration. As reflected in our data, most current knowledge and technology transfer approaches presuppose desirable effects, especially in digitalization projects, and neglect possible negative side effects of the innovations they support. Their unique position at the intersection between creators and users of knowledge enables HEI-related intermediaries to fulfill monitoring functions valuable for a development towards sustainability-oriented innovation.

Digitalization and regional knowledge transfer: interdependencies and challenges

The final chapter of this dissertation, Chapter VI “*Digitalization and regional knowledge transfer: interdependencies and challenges*” concerns the research questions on how regional knowledge transfer contributes to digitalization and which challenges occur in related processes. The article aims to inform future knowledge transfer and innovation policy. Additionally, the objective is to make interdependencies visible in order to identify avenues for forthcoming research projects but not to strive for in-depth results. To answer the research questions a set of 56 interviews with knowledge transfer stakeholders from the regions of Augsburg, Darmstadt, Eberswalde, Goettingen, Osnabrueck and Hannover is included in a multiple case study analysis. The interviews are purposefully sampled from two different studies on the role of intermediation and knowledge transfer that employ two different interview guidelines. In line with the novel research questions applied, the data is analyzed inductively and exploratively in order to identify challenges as well as the relevant interfaces between digitalization and knowledge transfer.

The analysis reveals that knowledge transfer contributes to firm digitalization in several ways and that supporters of knowledge transfer often apply digital instruments. Within regional knowledge transfer systems, intermediaries disseminate relevant knowledge, establish specific networks and support particular digitalization efforts. Digital tools play an important role in processing these activities as well as in cooperating within knowledge transfer systems. However, it also becomes clear that the possibilities of knowledge transfer in digitalization are limited and that several challenges remain in utilizing digital instruments in knowledge transfer. Challenges in digitalization often consist of selecting and implementing digital solutions, which cannot always be supported by academia. Further, it remains challenging to initiate and establish trust-based network relationships and cross administrative borders via digital channels.

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Chapter II:
**The course to sustainability: The role of university-related
intermediaries in providing directionality to regional innovation
initiatives**

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The course to sustainability: The role of university-related intermediaries in providing directionality to regional innovation initiatives

Abstract

Implementing directionality is a major challenge for transformative innovation policy. Contributing to a desired direction of change requires the proactive stimulation and prioritization of specific innovation activities. These requirements for providing directionality, in turn, pose their own particular challenges to stakeholders that engage in facilitating sustainability transitions. Against this background, we connect the concepts of directionality and intermediation to analyze the role of university-related intermediaries in providing directionality in sustainability-oriented regional innovation initiatives. Therefore, we address the influence of directionality challenges on intermediaries in sustainability-oriented regional innovation initiatives and intermediaries support for transformative change processes towards sustainability. We conduct a comparative analysis of four German regional and university-led innovation initiatives based on 63 interviews. Our analysis provides insights into operational and strategic adaptations of intermediation practices in regional sustainability-oriented innovation initiatives. The adapted roles and activities of intermediaries we identify represent responses to directionality challenges, and allow intermediaries to induce and maintain directionality. By extending their capabilities and taking on new roles, university-related intermediaries help to overcome a transition impediment and thus facilitate sustainability transitions. By revealing the potentials of university-related intermediaries to provide directionality, the analysis emphasizes their role in transitions and additionally contributes to the ongoing discussion on how to implement directionality in transformative innovation policy practice.

Keywords

sustainability transition, directionality challenges, innovation policy, transition intermediary

JEL

O32, O38, Q58, R11

1. Introduction

The implementation of directionality is a major challenge for transformative innovation policy (Schot and Steinmueller, 2018; Grillitsch et al., 2019; Haddad et al., 2022; Bergek et al., 2023). In the context of sustainability transitions (ST) (Markard et al., 2012), conventional innovation policy concepts, with a focus on strengthening R&D and innovation systems, have shown insufficient (Blok et al., 2016; Kuhlmann and Rip, 2018) as they fall short in providing directionality by proactively stimulating and prioritizing innovation activities that contribute towards a desired direction of change (Yap and Truffer, 2019). Addressing this shortcoming, concepts such as innovation policy 3.0 (Schot and Steinmueller, 2018) and the ‘next generation of innovation policy’ (Edler and Boon, 2018; Kuhlmann and Rip, 2018) have been introduced and advanced in the last years (Schot and Kanger, 2018; Kivimaa et al., 2019). These concepts take into consideration the requirements of providing directionality in transformative innovation policy. Implementing directionality in innovation policy practice, in turn, poses distinct challenges to stakeholders that engage in facilitating ST (Grillitsch et al., 2019; Bergek et al., 2023). Although specific sets of challenges have been identified, that include the need to resolve conflicting interests, to develop suitable governance capabilities and a shared vision in order to implement and provide directionality (Grillitsch et al., 2019), it is still unclear how policy instruments should be designed to address directionality challenges (Bergek et al., 2023), which policy stakeholders are capable to induce and maintain directionality in policy practice (Haddad et al., 2022), and empirical evidence is rare (Grillitsch et al., 2019).

Grand societal challenges that are considered in new policy approaches not only need to be addressed nationally or globally, but complementarily require responses and actions at the regional level (Tödtling

et al., 2021), considering that transitions are also regional and place-dependent phenomena (Hansen and Coenen, 2015). Accordingly, research on regional innovation system (RIS) has started to integrate and emphasize directionality in new RIS approaches as the challenge-oriented RIS (CoRIS) (Tödtling et al., 2021). Within RIS, higher education institutions (HEI) are important actors as they engage as intermediaries (Howells, 2006) facilitating knowledge transfer and regional development (Youtie and Shapira, 2008), especially by serving their third mission (Villani et al., 2017). In the context of their intermediary role, HEI serve primarily in knowledge intermediation (Yusuf, 2008; Hayter et al., 2018) although their involvement in ST is analyzed in a growing number of studies (Trencher et al., 2014; Pflitsch and Radinger-Peer, 2018; Bäumle et al., 2023). Regarding the role of intermediaries in transitions, research has not yet comprehensively considered HEI-related intermediation (Kivimaa et al., 2017; Kivimaa et al., 2019) and neglected their potential as enablers (Kivimaa et al., 2020b; van Lente et al., 2020; Vihemäki et al., 2020), facilitators (Kivimaa et al., 2019), and accelerators (Gliedt et al., 2018; Kivimaa et al., 2020a) of ST.

In practice, acknowledging the importance of HEI, national funding programs in Germany, for example “Innovative University”³ and “Change through Innovation in Regions”⁴, focus on collaborative and regional innovation programs led by HEI (Eickelpasch and Fritsch, 2005). Within these publicly funded programs, HEI-led regional innovation initiatives particularly focus on contributing to sustainability transitions are existent that allow to analyze the effects of directionality challenges empirically. Against this background, we connect the concepts of directionality and intermediation in transitions (Kivimaa et al., 2019; Vihemäki et al., 2020) to analyze the role of HEI-related intermediaries in providing directionality in sustainability-oriented regional innovation initiatives. Therefore, we address the following research questions: How do directionality challenges affect the roles of HEI-related intermediaries in sustainability-oriented regional innovation initiatives? And, how do intermediaries respond to these challenges in order to support transformative change processes towards sustainability? Contributing to the discussion of how to implement directionality in practice, the aim of this paper is to understand the capability of HEI-related intermediation to induce and maintain directionality. To answer the research question, a multiple case study (Yin, 2018) based on 63 semi-structured interviews is conducted. We analyze intermediation practices of HEI-led innovation initiatives in the four German regions of Augsburg, Darmstadt, Eberswalde and Goettingen. To identify and analyze operational and strategical adaptations of intermediaries and responses to directionality challenges, cases with and without a focus on sustainability are compared.

The remainder of this article is organized as follows. Section 2 connects the literature strands on intermediaries in transitions and on directionality in transformative innovation policy. On this basis, an analytical framework for evaluating the roles and activities of intermediaries is developed in Section 3. It combines directionality challenges on the basis of generic key features of RIS identified by Grillitsch et al. (2019) with roles of activities of transition intermediaries (Kivimaa, 2014; Vihemäki et al., 2020). Additionally, Section 3 outlines the multiple case study method, interviewee selection and the qualitative content analysis. Additionally, the cases are introduced. In Section 4, empirical findings from the comparative analysis of the four cases are presented. Section 5 discusses the findings, and Section 6 ends the paper with conclusions emphasizing the role of HEI-related intermediation in transitions, resulting policy implications, and avenues for future research.

2. Literature background

2.1 Intermediaries and directionality

HEI-related intermediation services and structures involved in knowledge transfer play an important role in RIS (Uyarra, 2010) due to complexity and novelty of knowledge produced in academic

³ For further information see <https://www.innovative-hochschule.de/foerderinitiative/ueber-die-foerderinitiative>.

⁴ For further information see https://www.innovation-strukturwandel.de/strukturwandel/de/innovation-strukturwandel/wir/wir_node.html.

organizations (Pflitsch and Radinger-Peer, 2018). Knowledge and technology transfer offices have been discussed in the context of HEI extensively (Pinto et al., 2015; e.g. Perkmann et al., 2021) as ‘innovation intermediaries’ (Howells 2006). To complement this, a broad strand of literature (e.g., Yusuf, 2008; Youtie and Shapira, 2008) discusses knowledge intermediaries as a heterogeneous group of HEI-related or public actors fostering the transfer and commercialization of academic knowledge (Kivimaa et al., 2017; Villani et al., 2017). In this context, forming transfer ecosystems surrounding HEI’s local environments is particularly important (Miller and Acs, 2017; Lahikainen et al., 2019). Nevertheless, empirical analyses of HEI-related intermediation suggest a more active involvement in intermediation activities supporting regional transitions (Trencher et al., 2014; Bäumle et al., 2023).

Yet another distinct literature strand studies the role of intermediation in ST. Transition intermediaries have been synthesized as “*actors and platforms that positively influence sustainability transition processes by linking actors and activities, and their related skills and resources, or by connecting transition visions and demands of networks of actors with existing regimes in order to create momentum for socio-technical system change, to create new collaborations within and across niche technologies, ideas and markets, and to disrupt dominant unsustainable socio-technical configurations*” (Kivimaa et al., 2019, p. 1072). This broad definition can be explained by the heterogeneous group of actors covered, e.g. online forums, consultancies, innovation funders, and non-governmental organizations (Fischer and Newig, 2016; Kivimaa et al., 2020a). Nevertheless, HEI are not explicitly considered in the literature review that is the basis for the seminal definition of “transition intermediaries” (Kivimaa et al., 2019).

For ST, intermediaries fulfill a central function in supporting and accelerating change processes in socio-technical systems (van Lente et al., 2003; Gliedt et al., 2018; Kivimaa et al., 2019). Intermediaries help to translate sustainability-related knowledge for inexperienced actors, recombine innovations for new sectors, and influence contextual conditions (Smith, 2007). Other activities include shaping knowledge exchange within (Hodson and Marvin, 2009) and between spatial areas (Kanda et al., 2020), boundary spanning between networks (Kanda et al., 2020), establishing an institutional framework that fosters ST (Smink et al., 2015), and coordinating in multi-stakeholder settings (Hodson et al., 2013). Multiple specific roles and activities of intermediaries in transitions have been synthesized and summarized *inter alia* by Vihemäki et al. (2020), Kivimaa et al. (2019), and Glaa and Mignon (2020). Although large parts of the literature can be traced back to innovation intermediaries (Howells 2006), transition intermediaries are distinct due to their focus on sustainability, socio-technical configuration, and long-term impact on technological trajectories (Kivimaa et al., 2019). Nevertheless, the contribution of knowledge intermediaries to ST by accelerating knowledge production has been emphasized (Stephens et al., 2008; Trencher et al., 2014). However, the role of academic knowledge transfer in ST is still underexplored (Kivimaa et al., 2017).

2.2 Directionality

Since innovation policy has taken into account the complex needs of societal change (Elzen and Wieczorek, 2005) research has paid attention to the directionality of innovation (Edler and Boon, 2018; Grillitsch et al., 2019; Andersson et al., 2021). Implementing directionality has been identified a major challenge to transformative innovation policy (Grillitsch et al., 2019; Bergek et al., 2023). The concept of directionality relates to the purpose and the normative orientation of transformative innovation policy (Könnölä et al., 2021) and evolved from the necessity not just to generate innovation, but to contribute to particular directions of transformative change (Weber and Rohracher, 2012). More specifically, directionality is referred to as “*proactive stimulation and prioritization of specific innovative activities in order to contribute to a particular desired direction*” that emerges from bottom-up strategies involving multiple economic, scientific and civil-society actors complemented by governmental interventions (Yap and Truffer, 2019). Although conceptual research on directionality has advanced, e.g. by case studies in the energy sector (Yang et al., 2021), in urban waste management (Bugge et al., 2019), and in terms of the circular economy (Bauwens et al., 2020), there is still little knowledge about how to implement transformative policy instruments on an operational level (Grillitsch et al., 2019; Grillitsch et al., 2020). Next to this, research on directionality implementation pays attention to

associated challenges but has not investigated how to overcome those identified impediments of transformative change in policy practice. Both Grillitsch et al. and Bergek et al. found that providing directionality itself is connected to multiple challenges (Grillitsch et al., 2019; Bergek et al., 2023).

Grillitsch et al. (2019) identified directionality challenges in the design and implementation of transformative innovation policy. Their framework relates directionality challenges for policymakers and stakeholders to three generic features of innovation systems (see Table 1): First, challenges in relation to *actors' interests and capabilities* include promoting institutional entrepreneurship towards the change in socio-technical regimes, resolving conflicting interests between involved actors, and developing suitable governance capabilities that consider the challenges of ST. Second, regarding *networks*, the challenge of coordinating directionality exercised by multiple heterogeneous actors from different spatial and institutional contexts arises. Third, directionality challenges concerning *institutions* include developing a shared vision among multiple actor groups that includes future scenarios and identifies associated problems, and setting actionable objectives that provide direction. Thus, although the challenge are known, there is the need to analyze how to respond to these challenges in order to address this major impediment to transformative change.

Table 1: Directionality challenges (Grillitsch et al. 2019)

Features of innovation systems	Directionality challenges
Actor interests and capabilities	Promote institutional entrepreneurs Resolve conflicting interests due to skewed distribution of power and resources Develop capabilities in new forms of governance
Networks	Connect and integrate directionality exercised by multiple types of actors, locally and globally
Institutions	Develop shared vision among multiple actor groups Set objectives that provide direction in a concrete and actionable way

Though not yet intertwined, research on intermediaries in transitions indicates a connection between intermediation and directionality implementation that is to be assessed in order to make visible the potential capabilities of intermediaries in providing directionality. Kanda et al. (2020) determined that intermediaries acting in between the actors, networks, and institutions of innovation systems are able to facilitate ST by contributing to an overall direction through their influence on institutions. Regarding actors' interests and capabilities, Sovacool et al. (2020) highlight the importance of trust building and conflict resolution, as well as brokering between actors and their interests. The role of institutions in ST is often addressed by intermediaries through advocating and lobbying for policy renewal, as well as policy implementation (Kivimaa, 2014; Bush et al., 2017). Support for vision-creation processes has been mentioned as an especially important activity on the part of transition intermediaries (Hodson and Marvin, 2010; Kivimaa, 2014) based on the articulation and shaping of collective expectations and requirements (Sovacool et al., 2020).

3. Analytical framework and methodological approach

3.1 Analytical framework

The literature indicates interdependencies between intermediation and directionality implementation, but a beneficial interweaving of both strands of literature is missing. Thus, the potential capabilities of intermediation to implement directionality in transformative innovation policies have not been explored in detail. To analyze how HEI-related intermediation is affected and how intermediaries respond to directionality challenge, we derive a framework connecting directionality challenges based on the RIS approach (Grillitsch et al., 2019) and intermediation roles in transitions (Vihemäki et al., 2020). Using the RIS approach in combination with roles of intermediaries in transitions allow us to assess how intermediaries target regional actors, networks and institutions in order to contribute to a particular direction of transformative change.

The derived framework draws on the three features of innovation systems to which Grillitsch et al. (2019) attribute directionality challenges: actor interests and capabilities (1), networks (2), and institutions (3). These features are used for several reasons. First, RIS form the environment in which the analyzed HEI-related intermediaries primarily perform their roles and carry out their activities. Second, elements of regional innovation systems can be directly linked to the directionality of the regional innovation program within which intermediaries operate. Third, assessment using the RIS approach facilitates, (1) capturing what directionality challenges intermediaries face and (2) analysing how they attempt to overcome these challenges while addressing regional actors, networks and institutions. To analyze the activities and roles of transition intermediaries in this context, the framework is supplemented by the roles and activities compiled by Vihemäki et al. (2020). Vihemäki et al. (2020) analyzed types of transition intermediaries identified by Kivimaa et al. (2019) regarding their roles and activities in support of ST: (1) articulation of expectations and visions, (2) building of networks, (3) learning processes and exploration, and (4) other roles. These roles are the basis for analysis that allows to classify the activities of HEI-related intermediaries with regard to supporting ST.

The combination of the approaches by Vihemäki et al. (2020) and Grillitsch et al. (2019) results in an analytical framework that relates the roles of transition intermediaries to actors, networks and institutions of their regional innovation systems that they are targeting to induce directionality in order to support ST. Table 2 illustrates the framework, with columns showing intermediary roles according to Vihemäki et al. (2020) and rows showing features of innovation systems according to Grillitsch et al. (2019). The activities identified by Vihemäki et al. (2020) that match certain combinations of intermediary roles and innovation system features are listed in the corresponding matrix cell.

Table 2 underlines the variability of the roles of transition intermediaries with respect to innovation system features. It also shows that the roles of intermediaries can be linked to the characteristics of innovation systems. Nevertheless, roles are not exclusively attributed to a specific innovation system feature but addresses different features of innovation systems. The combination of the two underlying frameworks in a new analytical framework therefore allows to analyze how the activities and roles of intermediaries in RIS are affected by a focus on ST that induces directionality challenges. Relating a broad array of intermediaries' roles and activities to the features of innovation systems, the derived framework is suitable for an exploratory research approach in order to analyse if and how HEI-related intermediation supports directionality.

Table 2 Analytical framework showing the activities of transition intermediaries in fulfilling certain roles and supporting ST addressing different features of innovation systems.

Roles of transition intermediaries					
	Articulation of expectations and visions (1)	Building of networks (2)	Learning processes and exploration (3)	other roles (4)	
Features of innovation systems	Actor interests and capabilities	<ul style="list-style-type: none"> - Articulation of needs, expectations, requirements - Speed up application and commercialization of new technologies - Strategy development 	<ul style="list-style-type: none"> - Aligning actors (or their interests) and options - Facilitate vertical and horizontal cooperation - Facilitating co-operation between actors - Negotiating between interests and priorities to create a consolidated vision - Providing, managing or finding funding 	<ul style="list-style-type: none"> - Advice and support (including tailor made info) - Configuring innovations - Creating conditions for learning by doing and using - Education and Training - Knowledge gathering, processing, generation and combination - Prototyping and piloting - Qualifying the characteristics and suitability of innovations for various contexts 	<ul style="list-style-type: none"> - Advancing day-to-day activities to advance transitions - Arbitration (based on neutrality, trust) - Identifying, mobilizing actors - Job creation - Project design, management, evaluation (e.g. complex, long-term innovation projects) - Providing professional services - Representing users at the niche-regime interfaces - Seeking consensus, organizing discourse - Translating new technologies to users
	Networks	<ul style="list-style-type: none"> - Articulating demands of the users - Assisting others in articulating the direction of change 	<ul style="list-style-type: none"> - Brokering and gatekeeping - Connecting experimental projects - Creating and managing networks informing the government - Creating and managing networks to lobby for transition oriented policies - Developing connections between groups of actors - Facilitating between the niche and dominant configurations - Formation of knowledge sharing networks, e.g. platforms - Network creation and facilitation 	<ul style="list-style-type: none"> - Advancing exchange of information - Dissemination - Investments in new businesses 	<ul style="list-style-type: none"> - Developing shared infrastructure between projects - Managing external relations of the projects
	Institutions	<ul style="list-style-type: none"> - Aligning niche performance with prevailing policy discourses - Campaigning, advocating, (targeted) lobbying - Influencing political vision building - Promotion of sustainability related aims 	<ul style="list-style-type: none"> - Facilitating policy dialogue (e.g. policy forums) 	<ul style="list-style-type: none"> - Collecting evidence for key policy issues - Technology assessment & evaluation (for policy development) 	<ul style="list-style-type: none"> - Brokering between different organizational or local-national priorities - Influencing new legislation and standard setting - Policy design - Policy implementation - Policy support - Policy translation - Standard creation and accreditation

Source: Own depiction based on Grillitsch et al. (2019) and Vihemäki et al. (2020).

3.2 Case selection and methods

This paper applies a multiple case study methodology that analyses differences between cases (Yin, 2018) to gain in-depth insights into how HEI-related intermediaries in regional and HEI-led innovation programs are affected by their focus on directionality and how they aim to address directionality challenges. To further theoretical insights (Eisenhardt, 1989) in a dynamically evolving research field, it applies qualitative methods that have proven suitable for intermediary research (Polzin et al., 2016; Kanda et al., 2018; Kivimaa et al., 2020b).

The cases were identified and selected based on an initial review of recent policy programs funding regional innovation initiatives in Germany. The selected cases are regions with publicly funded projects supporting knowledge transfer and innovation, with a strong emphasis on regional impact and universities coordinating the initiatives in Darmstadt, Eberswalde, Augsburg, and Goettingen (descriptions see Section 3.3). The comparative analysis concentrates on the effects and differences that occur from focusing on ST: two cases, Darmstadt and Eberswalde, explicitly focus on ST (sustainability-oriented cases), while the other two primarily aim to contribute to other innovation goals and, therefore, do not have a normative orientation toward sustainability (conventional cases). Referring to literature on directionality discussed above, the focus on sustainability evokes distinctive directionality related challenges. Therefore, comparing innovation sustainability-oriented cases with conventional allows to pinpoint the effects of directionality challenges from operational and strategical differences and to obtain contrasting results.

In order to consider different forms of policy supported path development, the cases represent different types of regions (Tödtling and Trippel, 2005; Isaksen and Trippel, 2014; Grillitsch and Asheim, 2018). In each of the two groups one region is more urban and one is peripheral (see Table 2; Section 3.3). While in peripheral regions support systems for innovation are considered weaker and limited, urban regions possess stronger and more comprehensive structures for innovation support. Furthermore, in urban regions specialized industries are more likely to exist, while peripheral regions often do not have specialized industries (Grillitsch and Hansen, 2019).

In total, 63 semi-structured interviews were conducted in four regional innovation programs (see Table 3 for an overview). Questions centered on the roles and activities of intermediaries (Kivimaa et al., 2019; Vihemäki et al., 2020), asking about the structures and characteristics of knowledge transfer, the involved actors, innovation processes, the embedding of the program in the regional context, and contributions to ST were asked. The questionnaire was composed of open questions, using guiding questions with follow-up sub-questions to ensure the reflexivity of the interviews (Questionnaire see Appendix A). Additionally, information on professional backgrounds and position in the regional innovation system was collected to gain information on contextual factors. The interviewees represent the diversity of intermediaries involved in HEI-led regional innovation program in each case (List of interviewees see Appendix B). The selection strategy followed the principles of purposeful sampling that is, including a comparable set of intermediary actors in the four different case study regions from academia, industry, public administration, and civil society. The interview material gathered was sufficient to reach theoretical saturation (Glaser and Strauss, 2017).

Table 3: Case overview and number of interviews per region

Case	Case A	Case B	Case C	Case D
Region	Darmstadt	Eberswalde	Augsburg	Goettingen
Federal state	Hesse	Brandenburg	Bavaria	Lower Saxony
Characteristic	Urban	Peripheral	Urban	Peripheral
Assessed initiative	<i>s:ne</i>	<i>region 4.0</i>	<i>HSA_transfer</i>	<i>SNIC</i>
Focus	Focus on system innovation for sustainability	Focus on regional ST	Focus on building networks	Focus on innovativeness
Number of Interviews	17	18	13	15

In each region, at least 13 interviewees were identified and selected from exploratory discussions and website evaluations (see Table 2). From February to September 2020, 63 interviews were conducted (see Appendix B). Because of the COVID-19 pandemic, all interviews except one were conducted via online video tools or telephones. The interviews lasted from 34 to 138 minutes. The material was recorded and transcribed, except for two interviews that were logged by the interviewers. The material was coded using the software MAXQDA. In addition to the interviews, internal documents, as well as the reports and information published, were collected and reviewed.

Based on a qualitative content analysis (Kuckartz, 2018), the study uses a mix of deductive and inductive codes for its collaborative analysis. In the first step of the analysis, focusing on the first research question on strategical and operational practices, we use deductive categories informed by the derived framework for innovation system features, transition intermediaries' activities, and roles (see Table 2) supplemented by inductive coding where necessary. We collaboratively coded and compared the material in order to reveal differences in intermediation practice between sustainability-oriented and conventional cases to make visible effects of directionality. In a second step, addressing the second research question on how directionality challenges are addressed, the coded material of sustainability-oriented cases was summarized and categorized with regard to directionality challenges to identify strategically and operational responses that allow to overcome the challenges. To ensure reliability and validity of final results, in each region, a digital workshop took place presenting preliminary results, receiving feedback, discuss results, and refine insights.

3.3 Case Overview

Sustainability-oriented cases

Case A: The city of Darmstadt is located in the Frankfurt metropolitan area in the middle of Germany and has the fourth largest number of citizens in the state of Hesse. It is characterized by an extensive university and research landscape. Next to several smaller HEI and research institutes in Darmstadt, the Darmstadt University of Applied Sciences ('h_da') is second in scale and number of students to the Technical University Darmstadt ('TUD'). With the TUD being one of the leading universities in Germany for engineering research and teaching, the h_da gives more attention to its economic, social, media and design departments, though engineering remains to play an important role.

The analyzed initiative *s:ne* (system innovation for sustainable development) started in 2018 as part of the "Innovative University" funding initiative by the Federal Ministry of Education and Research. Pursuing the goal of creating and applying mutual transformative knowledge transfer activities to foster learning processes and sustainability transitions with partners from industry and civil society, *s:ne* has a strong orientation towards sustainability. The orientation towards sustainability is informed by previous internal initiatives to support sustainability. To make possible system innovation, *s:ne* developed an innovation and transfer platform as a core element to initiate cooperation and to support

participating actors align visions and implement projects on sustainability challenges. Project partners to *s:ne* include actors that especially engage in sustainability transitions like the Institute for Applied Ecology.

Case B: The city of Eberswalde is located in the north-eastern part of the federal state of Brandenburg. It is situated between the metropolitan areas of Berlin and Stettin and characterized by agriculture and small and medium enterprises (SMEs) except for a limited number of petrol and chemical industries. Additionally, there are large biosphere reserve areas that are sparsely populated, but contribute with nature sights to touristic services. One central actor of the regional innovation system is the Eberswalde University for Sustainable Development ('HNEE'). This University, with an explicit focus on sustainability, specializes on sustainable production and rural development.

This study analyzed the initiative *region 4.0* that is part of the funding program "Change through Innovation in Regions" by the Federal Ministry of Education and Research. It aims to establish a transdisciplinary regional innovation network supporting sustainability-oriented innovation. It is led by HNEE that is the central actor for knowledge transfer and innovation support in the peripheral region. As one unique feature, starting in the late 1990s the university has comprehensively converted its educational, scientific and transfer activities in order to consider sustainable development, expressed e.g. by the renaming of the university in 2010. The project comprises three fields of actions that are agriculture and regional nutrition, public services and infrastructure and nature-oriented tourism. The fields of actions represent the regional endowments and were developed jointly with regional actors that also are participants of the alliance formed by launching *region 4.0*. Important regional partners are regional business development agencies, the regional transport company as well as the municipality utility company. Furthermore, HEI from Berlin as well as other Brandenburg regions are taking part evaluating and accompanying the project.

Conventional cases

Case C: The city of Augsburg is located in the western part of the federal state of Bavaria. Augsburg and its greater surroundings including Munich and Nuremberg form one of the strongest economic areas in Germany. Additionally, two HEI and several research institutions make Augsburg a knowledge-intensive location. A unique regional aspect is, dating back in the 1990s, multiple and heterogeneous regional stakeholders established the local agenda 21 initiative in the city of Augsburg. Forming committees called "agenda forums" that address different regional sustainability issues and backed by the municipality, they aim for a cooperative and sustainable city development.

The assessed initiative led by the University of Applied Sciences Augsburg ('HSA') is *HSA_transfer* and refers to itself as "agency for cooperative HEI projects". It is part of the funding program "Innovative University" and it develops and tests new formats for knowledge transfer like student service learning and alumni networking. Project goals are to support and improve knowledge transfer activities, by providing a transfer "toolbox" for HEI members, and to foster networks with civil society actors through cooperative projects with e.g. schools, museums, civil initiatives or associations. *HSA_transfer* increases the visibility of transfer activities for civil society with a strong emphasis on internal and external communication.

Case D: The city of Goettingen is situated the south of the federal state of Lower Saxony between the metropolitan areas of Hannover in the north and Kassel in the south. Goettingen is home of three HEI and multiple research institutions while the economy of its more peripheral environment is mostly influenced by SMEs except for a few major companies, e.g. in life sciences. For the southern part of lower Saxony, the HEI of Goettingen are important actors referring to knowledge transfer and innovation support.

The initiative led by the University of Goettingen is *SNIC* (Innovation Campus in Southern Lower Saxony) that was established in 2016 on behalf of regional intermediaries and is funded by the federal state of Lower Saxony. The catchment area of *SNIC* is not limited to the city of Goettingen but also

includes surrounding counties as well. It refers to itself as an innovation network and connects HEI and research institutions with other regional intermediary actors as chambers and municipalities to support the transfer of knowledge to local stakeholders and to foster the knowledge transfer structure without a specific sustainability orientation. Providing interfaces for actors to connect, the *SNIC* program aims to strategically improve the knowledge economy and the region's innovative capacity. Complementary to and also cooperatively with participating HEI knowledge transfer offices, it provides multiple innovation support and transfer activities including, e.g. an innovation accelerator, best-practice on-site and networking events, funding support, innovation scouting and innovation consulting.

4. Results

The findings from the comparative analysis that includes sustainability-oriented and conventional cases are presented following the structure of the analytical framework in order to make visible effects related to directionality challenges that occur from a sustainability-orientation, and to identify strategical and operational responses of HEI-related intermediaries in order to stimulate and prioritize innovation activities in the direction of ST. In Section 4.4, the findings are attributed to the directionality challenges identified by Grillitsch et al. (2019).

4.1 Actor interest and capabilities

In Case A and Case B, HEI-related intermediation roles that target interests and capabilities of regional actors are affected by the sustainability orientation of the assessed initiatives. Intermediation efforts focus on enabling actors to act as change agents by education and training. As one interviewee in Case B explained: *“The primary aim is to impart competencies for action. In other words, education for sustainable development should not impart knowledge as much as classic environmental education, but rather skills for action.”* (32_B_Public administration, item 73).

Referring to the role to articulate expectations and visions, HEI-related intermediaries face communication barriers between project participants resulting from heterogeneous backgrounds. The interviewees found it difficult to communicate in a ‘common language’ and aim to facilitate cooperation. Differences in communication cultures given their respective economic, academic, governmental, or societal backgrounds complicate joint knowledge transfer projects. Additionally, the encountered challenge is intensified by the fact that the involved participants lack a consistent understanding of sustainability. Heterogeneous backgrounds, moreover, result in reservations regarding communicating and cooperating between groups. While interviewees from Case C and Case D also speak of these difficulties, the complexity of sustainability in Case A and Case B intensifies the need to advance communication efforts in relation to expectations and visions. Intermediaries describe translation a key role in enabling cooperation and co-creation, aligning involved actors and their interests, and facilitating innovation between heterogeneous actors: *„So I think it's a bit of a diplomatic role, that is, to understand what the problems of the individual actors are, to understand at the same time, to speak different languages.”* (07_A_Academia, item 57). In order to address identified challenges in communication to allow for co-creation, intermediaries in Case A developed a glossary containing key terms and definitions important to understand the initiatives' understanding of sustainability as well as approach to contribute to transformative change. It provides common ground for communication and interaction with internal and additionally to new participants and external actors. In Case B, communication between actors from different backgrounds is facilitated through small group events with application-oriented content and settings that allow informal exchange.

In Cases A and B, intermediaries proactively identify, select and align groups of heterogeneous participants in order to build networks capable of contributing to ST. Aiming for system innovations, in sustainability-oriented cases individual intermediation, such as single-firm innovation support, is not in center of intermediaries' attention. In contrast to that, to incite transformative change, intermediaries initiate processes that address and involve actors, such as industries, value chains, or heterogeneous participants from their regions. In Cases A and B, the interviewees describe the initiation and moderation of multi-actor processes in subprojects as key intermediation activity. One interviewee in case A stated:

“[...] I am the moderator in our transfer processes, [...] trying to bring together actors both from university and practice in such a way that together we can achieve a change in the direction of sustainable development. That is my facilitation role.” (13_A_Academia, item 11). Intermediaries in sustainability-focused programs also aim for settings with heterogeneous participants, because these are expected to facilitate transition processes. Consequently, intermediaries reach out to societal actors as for example foundation, schools or churches. Furthermore, intermediaries in sustainability-oriented cases face the challenge of persuading actors to participate in regional innovation projects. Potential participants are described by interviewees to have difficulties in estimating individual benefits of engaging in sustainability projects in advance. Instead, interviewees report reservations regarding sustainability efforts that include individual overextension and high expenditures. To convince actors to participate, intermediaries in Case A initially foster the creation of a shared understanding of the problems related to sustainability. Consequently, efforts to convince potential participants to take part in sustainability-oriented initiatives are increased in comparison to efforts in conventional cases that focus on individual innovation support.

Intermediaries in sustainability-focused programs closely moderate and accompany initiated innovation and transition processes beyond initial stages. They support actor learning processes and exploration capabilities that enable regional actors to contribute to ST. Thus, intermediaries in Cases A and B adapt and implement participatory methods. Additionally, one interview clarifies the goal to resolve conflicting interests by applying participatory methods: *“And the important thing is to strive for a participatory exchange in order to resolve precisely these conflicting goals. And yes. And to find solutions.”* (33_B_Academia, item 137). The applied participatory methods serve to identify and develop a common understanding of relevant problems and align actors’ interests to allow a joint contribution to sustainability and to avoid conflicting individual interests: *“There are so many ideas for sustainable development and recommendations on what should be done, and yet relatively little happens. And in our project, we are looking at how we can implement them. In other words, we are working on things that can be implemented because they have been developed together.”* (7_A_Academia, item 53). In Case A, actors aim to enable relevant participants to develop a common understanding of impediments to system innovation in specific socio-technical systems. Thus, they use participatory methods to allow solutions to be developed and legitimized inside the group of involved participants. The selected participants develop solutions in moderated workshops, targeting system innovation in specific value chains. In practice, based on future scenarios, problems are forecasted and suitable responses are formulated. The intermediaries thereby aim to align actor interests and raise their awareness of opportunities for joint action in order to enable participants to contribute to ST. In Case B, intermediaries aim to integrate existing local initiatives into their superordinate program objectives. They seek to form a core group of potent regional partners and legitimize the program’s goals with a broad regional alliance. In later stages of the subprojects, they encourage additional regional actors to become involved in transition efforts and thus extend the variety of participants. The intermediary activities help guide and direct expectations, visions, and efforts toward sustainability in implementation processes. Thus, intermediaries adjusted resources and capabilities not only to initiate transitions processes but also to closely moderate and coordinate the implementation of induced changes.

In contrast to conventional cases, intermediaries in Case A and Case B additionally consider their knowledge transfer activities systematically in terms of their potential impact regarding transformative change. New intermediation methods and concepts are adopted to improve intermediating efforts targeting sustainability. In Case B, a research center of ‘sustainability knowledge transfer’ was established, and in Case A, external mediators were brought in to evaluate and advance intermediaries’ capabilities. Consequently, intermediaries reflect their roles and enhance their own capabilities in supporting ST within their regional project structures. The intermediaries act and operate according to an operationalized and concrete strategy of change on university or project level toward sustainability, because they are aware of the possibility that the focus on sustainability can be challenged by actors.

4.2 Networks

The strategic decision about sustainability-orientation shapes networks of regional innovation programs. Directionality poses challenges in building and sustaining networks concerning the role of articulating the actors' expectations and visions. The selection strategy for project partners, continuous cooperation, and the inclusion of new project partners in the assessed cases vary based on whether there is a focus on sustainability or on conventional transfer objects.

The sustainability-orientation of regional innovation programs influences the intermediaries' selection strategies for network building and expanding network capacity. To support innovations, in conventional Cases C and D, intermediaries concentrate their knowledge transfer activities on bilateral projects. In contrast, in Case A and Case B a more deliberate perspective is implemented on choosing whom to include in their networks and how to organize intermediary activities. Interviewees report that the selection of participants included a discussion of their potential contribution to prospective system innovation: *"So we always look closely at who we need for this thematic area. That's why there are no generally relevant actors for all of them. But rather the specific, relevant actors, so to speak."* (3_A_Civil society, item 71). Instead of considering companies solely, intermediaries in sustainability-oriented cases focus on targeting a broader range of actors: public organizations, such as schools, environmental protection parks, and museums, next to organizations concerning civil society, such as churches, NGOs, and artistic actors. The interviewees in Case C and D perceive the limited number of participants in their networks as a major problem for their goals. Consequently, they intend to increase the number of network members. Intermediaries in Case A and B evolve their strategy to find network members that are qualified to contribute to the network's goals, e.g., by shared expectations and visions. Therefore, they aim not for extensive but specified and actionable networks: *"We need to partner with those, with the actors who can really make a difference."* (08_A_Academia, item 71). Moreover, when intermediaries in Case A discuss new collaborations, incumbent actors that support the existing regime are not chosen, due to their low expected impact on system innovations.

Network building is impacted by contextual conditions where the networks are embedded and dynamic developments over time. The assessed regions are characterized by different social and economic conditions. While Case A and Case C intermediaries benefit from urban environments with various potential network partners, Case B and Case D are influenced by more peripheral conditions: *"I think that is perhaps the biggest problem [...], that we have far too few actors in the region with whom innovative projects can be implemented [...]. This means [...], we always come back to the same actors. On the one hand, this makes it easier because we only have to start the knowledge transfer once. On the other hand, it also leads to a high workload for the actors and requires a lot of flexibility in order to look at projects across different fields of action."* (23_B_Academia, item 27). Interviewees from urban regions describe a more diverse portfolio of potential network partners with knowledge about guiding ST to develop networks. In Case A, actors rely specifically on resources of specialized sustainability-oriented organizations. Interactions to shape specialized networks require time to build up capacities and to engage actors in system innovations. In both Case A and Case B, interviewees describe a long-term process, with decades of sustainability-oriented networking and knowledge transfer project experience. In Case B, the sustainability focus has been described as being the core of the strategy of the university: *"Yes. So we actually only work under this heading: Sustainable Development. And all our efforts go in this direction. And I can really speak for everybody on that."* (33_B_Academia, item 135). In Case A, informal networks have existed since the beginning of the 1990s, with a research group behind the program that focuses on sustainability established in 1997.

Learning and exploration in networks differ according to the objectives pursued. Interviewees in Case A report that they concentrate on capability building's effects on the impact orientation of cooperation partners. Thus, the selected actors are intended to support system innovation. In Case B, emphasis is placed on the inclusion of new partners from the existing regime so as to establish sustainability-oriented innovation in traditional industries. In Case C and Case D, learning and exploration are described more

as building up individual capabilities and overcoming difficulties in finding appropriate innovation partners due to the project's structure.

4.3 Institutions

Intermediaries in sustainability-oriented cases experience institutions such as existing laws, regulations but also actors' routines as impediments. Interviewees explained that institutions can reinforce current, unsustainable trajectories. The analysis suggests that intermediaries with sustainability-orientation therefore address institutions more directly than conventional cases when performing their intermediation roles.

Articulating expectations and visions is a common role among intermediaries in all examined cases. Nevertheless, there are activities distinct to cases that are sustainability-oriented. Intermediaries in Case B and Case A actively challenge existing institutions and aim to develop solutions aimed at more sustainable technological trajectories by inciting public discussions with practitioners about sustainability at events like workshops. HEI-related intermediaries in Case A and Case B also promote sustainability-related aims when communicating with stakeholders. In this way, they aim to place sustainability objectives on the regional political agenda, e.g., the goal of becoming a showcase region in terms of sustainable development in Case B. They also facilitate the implementation of sustainability-oriented policies by identifying impediments in complex constellations of actors influenced by institutions and providing research-based strategies regarding how to overcome them. Promotional efforts also include leading by example, such as establishing rules for sustainable event planning and procurement or implementing certified environmental management to demonstrate possibilities regarding the status quo and set best practices for orientation: *“So in any case, the role model effect. That is, how we organize our events. That it's all done with sustainable procurement, so there's simply a guideline. We set an example of what is possible.”* (19_B_Academia, item 154). In Case A and Case B, the focus on ST functions as a guideline for all activities, as well as measuring success, intermediaries also articulate visions and develop transformative strategies regarding sustainable development internally to address current practices in their organizations, which complicates inter- and transdisciplinary research intended to solve sustainability problems.

The intermediaries aim for a close relationship with regional governments, counties, and municipalities to influence policy: *“So if you relate this to the region, we have a very active role. That is also confirmed [...]. So if we start with the city, there is now also a climate protection manager and a climate protection plan and so on. These are all things that we have basically recommended and initiated.”* (33_B_Academia, item 77). In sustainability-oriented cases, intermediaries include actors from public administration, politics and business as well as societal actors in the innovation process on a specific sustainability problem, including its institutional framework. Furthermore, in the context of Case A and Case B, teaching sustainability-oriented knowledge and competencies at the universities enables graduates who begin working in regional organizations to act as change agents seeking to overcome unsustainable routines. Sustainability-oriented intermediaries also follow a participatory approach to setting rules and goals within their own structures. In Case B, intermediaries promote the creation of success indicators for the project in discussions with all relevant actors in the region.

Reflexivity is important in overcoming institutional impediments. Although in all cases reflexivity is reported important for learning, interviewees in Cases A and B have developed strategies to enhance their reflexive capability. With the goal of overcoming disciplinary thinking routines, e.g., a specific team in Case A helps intermediaries and innovative actors within the project reflect on their inter- and transdisciplinary collaboration, identifying challenges and considering solutions. In Case B, interviewees highlighted the importance of reflecting on actor-specific understanding of sustainability and corresponding innovation process. Furthermore, intermediaries focused on ST tend to see learning as an important activity to change institutions in terms of the status quo. In Case B, interviewees expect that impulses provided by their constant engagement with sustainability raises awareness and will slowly change rules and routines in regional organizations: *“[T]hey come into contact with us, into*

conversation. [...] So I believe that this constant, this constant exposure [...] to the topic sustainability, is already having an effect. And, of course, the students and university staff, who are important anchors or transformers, so to speak, in the region and beyond.” (20_B_Academia, item 139). In Case A, intermediaries identify cognitive rules and practices of stakeholders impeding ST through surveys and workshops, subsequently attempting to develop a new institutional framework to overcome these impediments, taking into account potential rebound effects. In Case C and Case D, changing practices through learning is also of importance; however, intermediaries tend to focus on facilitating innovation in general by including actors from science, economy, and society in innovation collaborations.

In addition to these roles, intermediaries focused on ST also translate political aims and strategies at international and national levels, such as the UN Sustainable Development Goals and subsequent national sustainability strategies, into the regional context.

4.4 HEI-related intermediaries addressing directionality challenges

Operational and strategical adaptations of intermediation practices in regional and sustainability-oriented innovation initiatives are elaborated in Section 4.1 to 4.3. Table 4 relates the identified adaptations to the six directionality challenges identified by Grillitsch et al. (2019). In this way, it is revealed how intermediaries aim to provide and implement directionality by proactively stimulating and prioritizing sustainability related innovation activities and change processes in order to contribute to overcome a major impediment of ST.

Referring to the directionality challenge of *promoting institutional entrepreneurs*, intermediaries proactively identify and include actors that are relevant to regional transformative change and enable them to cooperate, e.g. by acting as translators between heterogeneous groups. Selected and included actors are willing to involve in sustainability related innovation and, supported by the HEI introduced initiatives, are made capable of acting as change agents based on an understanding and also raised awareness of sustainability related challenges (Row 1). Intermediaries contribute to *resolve conflicts*, by empowering participants to align their interests and to induce joint change processes. Potential conflicts are reduced by enabling groups of heterogeneous actors to develop shared visions and legitimated contributions to ST on the basis of a common understanding of relevant sustainability problems (Row 2). They address the challenge of *developing suitable governance capabilities* by adopting participatory approaches and methods they focus on. Additionally, developing moderation capabilities for the interaction of actors allows to guide and accompany long-lasting transition processes (Row 3).

Aligning actors' interests and developing shared visions also helps to *connect and integrate the directionality* exercised by multiple types of actors. In order to meet this challenge related to networks in RIS, intermediaries complementarily develop actor-selection strategies that take into consideration the potential impact of participants. In sustainability-focused cases, intermediaries aim to establish long-term cooperation of a broad range of heterogeneous actors and integrate existing regional sustainability initiatives in order to connect multiple actors that are identified as relevant to the projected transition effort. The related activities also contribute to overcoming challenges regarding institutions. Third-party initiatives with common preferences regarding sustainability are integrated to bundle efforts in terms of common interests (Row 4).

The participatory approaches aiming on the development of *shared visions* and solutions using including scenario processes with a broad range of stakeholders, make possible co-creation. Making heterogeneous actors groups work together, it allows participants to induce a change of existing institutions (Row 5). By formulating explicit objectives and by forming sustainability-oriented initiatives, focusing on *actionable transition strategies*, and closely accompanying HEI-induced transition processes, intermediaries support actors in finding and maintaining directionality. Moreover, acting as role models regarding sustainability related day-to-day actions, they aim to incite and promote a change of mindsets (Row 6).

Table 4: Directionality challenges and responses of HEI-related intermediaries

	Features of innovation systems	Directionality challenges (Grillitsch et al., 2019)	Responses of intermediaries to meet challenge in regional contexts
1	Actor interests and capabilities	Promote institutional entrepreneurship	Identify and include willing actors and make them capable to act as change agents
2		Resolve conflicting interests due to skewed distribution of power and resources	Enable groups to develop legitimated solutions and align interests on the basis of a common understanding of relevant problems
3		Develop capabilities in new forms of governance	Adopt participatory methods and develop moderation skills
4	Networks	Connect and integrate directionality exercised by multiple types of actors locally and globally	Develop an actor selection strategy for long-term cooperation and build networks specialized on sustainability
5	Institutions	Develop shared vision among multiple actor groups	Enable actor groups to develop shared vision using scenario processes and include and integrate visions into policy
6		Set objectives that provide direction in a concrete and actionable way	Establish a concrete and actionable ST strategy in co-creation with participants and accompany transition processes to provide and maintain direction

5. Discussion

Intermediation and directionality are the center of recent scholarly debates on how to support and facilitate sustainability transitions. Connecting both research strands, our findings highlight the necessity to consider HEI-related intermediation as a potential instrument to provide and implement directionality in transformative innovation policy practice and thus emphasize the role of HEI in regional sustainability transformations. More particularly, our analysis contribute to the ongoing research debates in a threefold way:

First, the analysis of HEI-related intermediaries addressing directionality challenges contributes to the ongoing discussion on how to implement directionality in innovation policy practice as research has primarily concentrated on identifying challenges related to directionality (Grillitsch et al., 2019; Bergek et al., 2023), but yet not explored suitable responses. Thus, in contrast to the findings of Grillitsch (2020) and Parks (2022), in the assessed cases, conflicting interests are dealt with participatory processes to align interests and to develop a common understanding of sustainability problems among participants at first before working on solutions. So, this study addresses the call for empirical assessment of how directionality is implemented in practice (Grillitsch et al., 2019; Haddad et al., 2022) by providing detailed insights on how intermediaries in HEI-led and sustainability-oriented regional innovation initiatives induce and maintain directionality. Intermediaries in the sustainability-oriented Case A and Case B address directionality challenges by strategical and operational adaptations of intermediation practices that affect actors, networks and institutions (see Table 4).

Second, regarding the intermediation roles of HEI (Kivimaa et al., 2017; Kivimaa et al., 2019), we corroborate that HEI-related intermediaries engage in roles that predominantly have been attributed to transition intermediaries (Bäumle et al., 2023). In contrast to Kivimaa et al. (2017), our analysis in the context of academic knowledge transfer find HEI-related intermediaries in Case A and B capable of involving in roles that support transformative change and that include facilitating activities beyond the commercialization of academic knowledge. Moreover, taking the lead in regional innovation initiatives with sustainability orientation, data show that HEI-related intermediaries are aware of their roles regarding the support of sustainability transitions and take responsibility. Next to this, applying the

framework of directionality challenges on intermediaries, our analysis confirms indicated linkages (Kanda et al., 2020; Sovacool et al., 2020) and therefore adds an analytical perspective on intermediation in ST that allows for a better understanding of how intermediaries promote transitions processes in innovation policy practice.

Third, revealing the capability of HEI-related intermediation to provide and implement directionality to overcome a major impediment of transformative change, we contribute to the understanding of the roles of HEI in regional transformative innovation policy. Our study underscores the role of HEI in RIS as they are able to engage as drivers of regional transformative change. However, in both sustainability-oriented cases that can employ the necessary capabilities, the leading HEI have undergone internal change processes informed by sustainability beforehand the introduction of the assessed initiatives. This legitimizes the prioritization of innovation activities related to sustainability. Furthermore, both initiatives rely on public funding programs to acquire necessary resources to develop sustainability-oriented intermediation and knowledge transfer capacities. Thus, while we find strategic adaptations to prioritize sustainability are closely connected to internal change processes, the operational implementation of new intermediation practices to stimulate innovation activities contributing to transformative change are depending on additional external resources. Thus, our empirically study additionally helps to a better understanding on how to induce processes to reorient RIS towards CoRIS approaches (Tödtling et al., 2021). We argue that due to the availability of both requirements, in Cases A and Case B the HEI are able to employ the innovation initiatives to nurture change processes towards CoRIS that are capable to tackle the challenges of sustainability transitions.

6. Conclusion

The starting point of this paper is the ongoing discussion on how to implement directionality in transformative innovation policy practice. Aiming for a contribution closing this gap, we connect the concepts of directionality and intermediation and analyze intermediation in sustainability-oriented and HEI-led regional innovation initiatives by applying a comparative case study that includes sustainability-oriented and conventional cases.

Concerning the first research question on how directionality challenges affect the roles of HEI-related intermediation in sustainability-oriented regional innovation initiatives, our analysis shows that sustainability orientation is associated with extended intermediation capabilities and competencies that differ from conventional intermediation practices. Thus, by comparing sustainability-oriented cases against the background of conventional cases, we identify operational and strategical adaptations of intermediation roles and activities that allow to stimulate and prioritize sustainability related innovation activities. First, in order to contribute to sustainability, intermediation roles that target actor's interests focus on enabling groups of participants to align interests and visions as well as to resolve conflicts by applying including and participatory methods. Regarding the capabilities of participants, intermediaries aim to facilitate cooperation and initially provide an understanding of problems related to sustainability. This shared understanding is the basis on which regional actors are made to legitimize and coordinate joint actions in the HEI-led initiatives that are to induce transformative change. Therefore, HEI-related intermediaries develop capabilities to take the moderating and guiding role in these processes. Second, regarding networks, intermediaries build up specialized networks that include regional actors that are considered relevant or feasible to enable transformative change. Therefore, intermediaries develop a specific actor selection strategy that make possible the formation of actionable groups particularly including civil society actors. Third, roles and activities addressing institutions aim to raise awareness and sensitize participants regarding sustainability in order to stimulate a change of mindsets, regional policy and day-to-day practices by acting as role models or by persistent engagement with sustainability. Regarding the second research question on how intermediaries respond to directionality challenges in order to support transformative change processes towards sustainability, we find that applied adaptations on the strategical and operational level allow to address the challenges related to directionality. Consequently, adapted roles and activities of HEI-related intermediation enable intermediaries to

implement and provide directionality in their regional innovation initiatives, and thus to overcome a major impediment of transformative change towards sustainability.

From a transformative innovation policy perspective, our findings emphasize the role of HEI in regional sustainability transformation processes as HEI-related intermediation is a suitable instrument to implement and provide directionality. Our study highlights that implementing directionality is closely related to the capability of HEI-related intermediaries to induce and govern participatory and inclusive initiatives. Participatory methods for joint vision building and initial problem identification are a prerequisite for empowering actor groups to cooperatively contribute to ST. Therefore, to enable HEI-related intermediation that is capable to provide directionality, transformative innovation policy should strive for the development of required extended intermediation skills and competencies. As reflected in our data, next to additional resources to develop intermediation capabilities, proactive HEI internal transformative processes towards sustainability are important to act as drivers of regional sustainability transformations and to implement directionality. For this reason, suitable innovation policy instruments, for example national funding programs that aim to foster ST, should not only provide resources but complementarily focus on developing HEI's potentials by encouraging HEI to induce internal processes that allow to legitimize a prioritization of sustainability related innovation.

From a scholarly perspective, our approach connecting HEI-related intermediation and directionality is a first step of assessing a complementary perspective on the facilitating role of intermediation in ST. However, our qualitative approach has some limitations. Our multiple case study including four cases provides a solid database to grasp a first set of distinctive characteristics and requirements of sustainability-oriented intermediation efforts in terms of directionality. However, neither can we explain if internal change processes in Case A and B are a prerequisite to prioritize sustainability innovation or if required capabilities and strategical adaptations could also originate from other rationales nor can we assess if the adapted practices actually contribute to sustainability transitions that are considered long-term processes which outcomes are not in the scope of this study. Considering our sample of interviewees, the latter limitation is reinforced by the fact that we not included the demand side of knowledge transfer but focused on the supply side, which are HEI-related intermediaries.

Therefore, further research should focus on these aspects to advance knowledge on the capability of HEI-related intermediation with regard to directionality and ST. Additional case studies and quantitative approaches should be used to test the identified adaptations and add further suitable approaches to address the challenges of directionality. Furthermore, future research should explore the origins of required capabilities as well as incentives and barriers regarding the implementation of directionality. Hence, future research should focus on how to enable key stakeholders of transitions to implement directionality in order to introduce suitable policy instruments to prepare RIS to contribute to ST.

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Appendix

A) Interview guide

Section 0: Background of the interviewee

- Please briefly describe your job/function.
- How do you / how does your organization understand 'knowledge transfer'?

Section 1: Knowledge transfer structures and characteristics of key stakeholders

- Please describe the [organizational] structures of the regional knowledge transfer program you participate in.
- Please give an example of how knowledge transfer takes place in the region.
- Can you describe how learning processes are induced in the knowledge transfer program you participate in?

Section 2: Innovation processes

- Please describe what kind of innovations have already been developed so far.
- Please describe what kind of innovations are currently being developed.
- Please describe your role in an [exemplary] innovation process.

Section 3: Evaluation and assessment of results

- How do you evaluate your activities and results in the knowledge transfer program?

Section 4: The regional innovation system

- Please describe special features of the regional innovation system.
- What are the barriers to knowledge transfer and innovation in the region?

Section 5: Sustainable development

- What role does sustainable development play in your organization / for your role?
- What is the importance of innovations related to sustainable development for you?
- What contributions to sustainable development do you see through the knowledge transfer program and the resulting innovations?

B) Interviews

No.	Region	Sector	Role	Duration (min)
1	Case A	Academia	Professor (s:ne team member)	112
2	Case A	Academia	Research Associate (s:ne team member)	40
3	Case A	Civil society	Research Associate of a foundation (s:ne team member)	54
4	Case A	Industry	Representative of chamber of commerce	61
5	Case A	Academia	Research Associate of a Research Institute (s:ne team member)	66
6	Case A	Academia	Research Associate of a Research Institute	36
7	Case A	Academia	Research Associate (s:ne team member)	65
8	Case A	Academia	Senior Researcher of a Research Institute (s:ne team member)	91
9	Case A	Academia	Senior Researcher (s:ne team member)	90
10	Case A	Industry	Representative of chamber of commerce	91
11	Case A	Public administration	Innovation support and technology transfer manager	34
12	Case A	Industry	Representative of Business Association	40
13	Case A	Academia	Senior Researcher (s:ne team member)	58
14	Case A	Industry	Sustainability consultant (s:ne team member)	57
15	Case A	Academia	Representative of university sustainability office	45
16	Case A	Academia	Representative of university presidential board	59
17	Case A	Public administration	Representative of university transfer office	42
18	Case B	Academia	Professor	80
19	Case B	Academia	Innovation support and technology transfer manager	94
20	Case B	Academia	Innovation support and technology transfer manager	97
21	Case B	Industry	Innovation support and technology transfer manager	138
22	Case B	Public administration	Business developer (region 4.0 team member)	61
23	Case B	Academia	Professor (region 4.0 team member)	53
24	Case B	Public administration	Business developer	64
25	Case B	Academia	Project manager (region 4.0 team member)	61
26	Case B	Civil society	Representative of a civil association (region 4.0 team member)	71
27	Case B	Industry	Innovation manager	89
28	Case B	Industry	Innovation manager	66
29	Case B	Civil society	Representative of a civil association	91
30	Case B	Public administration	Knowledge transfer manager	58
31	Case B	Industry	Representative of regional craft sector	77
32	Case B	Public administration	Representative of biosphere reserve	100
33	Case B	Academia	Professor	70
34	Case B	Academia	Professor	70
35	Case B	Academia	Professor	76
36	Case C	Academia	Professor (HSA_transfer team member)	103
37	Case C	Academia	Professor (HSA_transfer team member)	86
38	Case C	Public administration	Representative of innovation support and technology transfer agency	77

39	Case C	Academia	Program Manager (HSA_transfer team member)	73
40	Case C	Public administration	Business developer	35
41	Case C	Public administration	Representative of an innovation center	54
42	Case C	Industry	Representative of chamber of commerce	54
43	Case C	Academia	Representative of university transfer office (HSA_transfer team member)	72
44	Case C	Academia	Research associate	73
45	Case C	Public administration	Representative of university sustainability office	54
46	Case C	Academia	Communication manager (HSA_transfer team member)	77
47	Case C	Civil society	Representative of a foundation	62
48	Case C	Civil society	Representative of a civil association	73
49	Case D	Academia	Professor (SNIC team member)	87
50	Case D	Academia	Project manager (SNIC team member)	92
51	Case D	Public administration	Representative of SNIC Office (SNIC team member)	72
52	Case D	Public administration	Innovation support and technology transfer manager (SNIC team member)	62
53	Case D	Civil society	Representative of a foundation	59
54	Case D	Academia	Professor (SNIC team member)	75
55	Case D	Public administration	Business developer (SNIC team member)	64
56	Case D	Public administration	Business developer (SNIC team member)	48
57	Case D	Academia	Research associate (SNIC team member)	53
58	Case D	Academia	Innovation scout (SNIC team member)	50
59	Case D	Industry	Representative of chamber of crafts	71
60	Case D	Public administration	Business Developer (SNIC team member)	50
61	Case D	Industry	Representative of chamber of commerce	78
62	Case D	Academia	Innovation scout (SNIC team member)	55
63	Case D	Public administration	Business developer (SNIC team member)	52

Chapter III:
**Providing directionality to change: Indicating the potentials of
university-related intermediaries in German regions**

with Elaine Horstmann and Simon J. Winkler-Portmann

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Providing directionality to change: Indicating the potentials of university-related intermediaries in German regions

Abstract

Applying an exploratory mixed-method approach, the paper reveals how university-related intermediation in Germany address the challenges of implementing directionality towards sustainability. In a first step, based on 63 interviews with intermediaries in four German higher education institution (HEI)-led and regional innovation programs, we provide a set of 16 indicators that characterize how intermediaries proactively stimulate and prioritize specific innovation activities in order to contribute to sustainability transitions. Following, using an online survey covering 112 HEI-related intermediation organizations in Germany, the derived indicators are triangulated to reveal the potentials of HEI-related intermediation to promote transformative change processes. In our exploratory analysis, we find adapted practices in sustainability-oriented HEI-related intermediation that help to induce and maintain directionality towards sustainability. Therefore, we argue that HEI-related intermediation can be a useful instrument to implement directionality. By revealing the potentials of HEI-related intermediaries to provide directionality, the analysis emphasize their role in transitions and additionally contributes to the ongoing discussion on how to implement directionality in transformative innovation policy practice.

Keywords

sustainability transition, directionality challenges, innovation policy, transition intermediary, mixed-methods analysis

JEL

O32, O38, Q58, R11

1. Introduction

Tackling grand societal challenges poses new requirements on innovation policy (Grillitsch et al., 2019), as conventional innovation policy lacks the ability to effectively “*contribute to a particular direction of transformative change*” (Weber and Rohrer, 2012, p. 1042). Since that, innovation policy concepts have been introduced that take into consideration the necessity of inducing and maintaining directionality (Kuhlmann and Rip, 2018; Schot and Steinmueller, 2018). In the context of contributing to sustainability transitions, providing directionality requires the stimulation and prioritization of specific innovation activities (Yap and Truffer, 2019).

In practice, policymakers have already implemented regional innovation policy that aims for transformative change to address societal challenges. Research on tackling societal challenges emphasizes that these challenges not only need to be addressed globally, but also require complementary regional level responses and actions (Wanzenböck and Frenken, 2020; Tödting et al., 2021) as transitions are considered as place-dependent processes (Hansen and Coenen, 2015). Accordingly, research on regional innovation systems (RIS) has also started to integrate and emphasize the importance of directionality in new RIS approaches as the “challenge-oriented RIS (CoRIS)” (Tödting et al., 2021). In Germany, publicly funded regional innovation programs led by higher education institutions (HEI) are existent that explicitly aim to contribute to sustainability transitions in the context of their “third mission”. However, it is not yet clear how innovation policy instruments supporting sustainability transitions should be designed and implemented in order to provide directionality, which actors should be employed to address the challenges related to directionality and empirical evidence remains rare (Grillitsch et al., 2020; Haddad et al., 2022; Parks, 2022).

Addressing this gap, the aim of this paper is to analyze characteristics of HEI-related intermediation practices that aim for supporting sustainability transitions. Particularly, we identify how challenges related to directionality implementation are addressed and how intermediaries stimulate and prioritize

specific innovation activities. Therefore, this paper addresses the research question: How do HEI-related intermediaries implement and provide directionality in sustainability-oriented German regional innovation programs? Answering this question, we aim to assess if intermediation could be a suitable instrument for policymakers to support directionality implementation in order to promote sustainability transitions. We apply the analytical framework of directionality challenges by Grillitsch et al. (2019) combined with research on roles and activities of transition intermediaries (Kanda et al., 2020; Vihemäki et al., 2020). This combined approach allows us to identify characteristics and roles that are specific for intermediaries that aim to promote sustainability transitions. We analyze intermediaries as they are perceived as enablers (Kivimaa et al., 2020b; Vihemäki et al., 2020), facilitators (Kivimaa et al., 2019) and accelerators (Gliedt et al., 2018; Kivimaa et al., 2020a) of transitions, making them potentially suitable for governing transformative change and relevant for innovation policy aiming on sustainability.

We apply a mixed-methods approach by combining a comparative multiple-case study (Yin, 2018) with an online-survey. This exploratory approach allows us to qualitatively grasp distinctive characteristics and practices of sustainability-oriented intermediation in the context of supporting sustainability transitions. Subsequently, we test the obtained insights quantitatively on a broader sample covering HEI-related intermediation in Germany. For our qualitative approach, we conducted 63 semi-structured interviews assessing intermediation practices in four governmental funded German collaborative and regional-level innovation programs led by HEI. In context of their “third mission” HEI are to foster regional knowledge transfer and innovation but also involve in promoting regional transformative change processes (Trencher et al., 2014; Bäumle et al., 2023). The cases are selected, because they are comparable in structural and formal parameters (e.g. publicly funded, HEI-led, comprising additional regional intermediaries, knowledge transfer-oriented) but are different in their primary goals: Two of the cases are explicitly sustainability-oriented while two cases focus on other more conventional and non-transformative transfer goals, e.g. regional innovativeness. The conventional cases act as “control cases” in our analysis. Against the background of directionality challenges, our comparative analysis enable us to pin down 16 distinctive features of sustainability-oriented intermediation that reveal how directionality is implemented. We subsume these differences within the analytical framework of directionality challenges and derive indicators comprising responses for each challenges that support the stimulation and prioritization of sustainability related innovation activities.

In order to test robustness and applicability, and to gain a better understanding of our case study findings, we run an online-survey with a questionnaire comprising questions related to all derived indicators. We invite representatives of 200 German HEI-led regional innovation programs to take part anonymously. In addition to temporary initiatives, we also invite 265 transfer offices of German HEI to expand our sample for triangulation of intermediation practices, as they are actively engaged in regional innovation and transfer in the context of intermediation. The analysis of 112 fully answered questionnaires provides quantitatively support for seven out of 16 indicators. This indicates the involvement of HEI-related intermediaries in the support of transformative change. The analysis contributes to the ongoing discussion on directionality implementation by proposing a set of empirically derived indicators. Thus, our findings reveal that sustainability-oriented intermediaries related to German HEI respond to the challenges of directionality and how they stimulate and prioritize sustainability related innovation activities by adapting their intermediation roles and activities.

The paper is structured as follows. Section 2 outlines and connects the literature on directionality and intermediation in the context of sustainability transitions. Section 3 presents the applied multiple-case study method and the analyzing strategy for the applied comparative analysis. Additionally, the online survey and quantitative analysis is introduced. Section 4 provides the main findings and results. First, from the distinctive features of sustainability-oriented cases a set of 16 indicators is derived and presented. Following, the results of quantitative testing of the indicators are provided. In Section 5, we discuss our empirical findings and results. To end, in Section 6 we present conclusions and provide policy recommendations.

2. Directionality and intermediation

Providing directionality has been identified a major challenge to transformative innovation policy (Grillitsch et al., 2019; Bergek et al., 2023). The concept of directionality relates to the purpose and normative orientation (Könnölä et al., 2021) of transformative innovation policy. More specifically, it is referred to as “*proactive stimulation and prioritization of specific innovative activities in order to contribute to a particular desired direction*” that emerges from bottom-up strategies involving multiple economic, academic and civil-society actors complemented by governmental interventions (Yap and Truffer, 2019).

Accordingly, research on directionality has advanced by, e.g. case studies in the energy sector (Yang et al., 2021), in urban waste management (Bugge et al., 2019), in public procurement (Uyarra et al., 2019), and in terms of the circular economy (Bauwens et al., 2020) and additionally by contributions to the question which transformation pathway to take (Schlaile et al., 2017) or the consideration of more or less desirable outcomes of directionality (Andersson et al., 2021). Parks (2022) contributes to the question of how directionality can be provided, finding that innovation processes for transformative change require to be opened-up to civil society actors and end-users to allow co-creation. Next to this, research on directionality implementation pays attention to associated challenges. Both Grillitsch et al. and Bergek et al. found that providing directionality itself pursues multiple challenges on associated stakeholder (Grillitsch et al., 2019; Bergek et al., 2023).

In this regard, Grillitsch et al. (2019) identified six challenges related to directionality for policymakers and stakeholders in designing and implementing transformative innovation policies (see Table 1). First, directionality challenges in relation to *actors’ interests and capabilities* include promoting institutional entrepreneurship towards the change of socio-technical regimes, resolving conflicting interests between involved stakeholders, and developing suitable governance capabilities that consider the challenges of sustainability orientation. Second, regarding *networks*, the challenge of coordinating directionality exercised by multiple heterogeneous actors from different spatial and institutional contexts arises. Third, directionality challenges concerning *institutions* include developing a shared vision among multiple actor groups that includes future scenarios and identifies associated problems, and setting actionable objectives that provide direction. Although directionality is identified a key requirement for sustainability transitions, it has yet to be investigated in detail how these challenges are addressed in regional innovation policies and how directionality can be implemented in policy practice.

Table 1: Directionality challenges (Grillitsch et al. 2019)

Generic feature of an innovation system	Directionality challenges
Actor interests and capabilities	Promote institutional entrepreneurs Resolve conflicting interests due to skewed distribution of power and resources Develop capabilities in new forms of governance
Networks	Connect and integrate directionality exercised by multiple types of actors, locally and globally
Institutions	Develop shared vision among multiple actor groups Set objectives that provide direction in a concrete and actionable way

In the context of directionality implementation, the role of intermediation has not been considered yet (Haddad et al., 2022). Intermediation comprises various roles and activities that aim to enhance productivity, connectivity, and functionality of innovation systems by fostering inter-organizational network building and knowledge exchange between different stakeholders (Howells, 2006). Intermediation literature identifies several different types of intermediaries of which HEI-related intermediaries, e.g. knowledge transfer offices, have been widely regarded as knowledge intermediaries. This type of intermediaries’ main roles and activities are considered to be centered around fostering the “third mission” of HEI that is knowledge transfer for commercialization of academic knowledge and

development of regional innovation ecosystems through connecting academic and non-academic stakeholders (Yusuf, 2008; Clayton et al., 2018; Lahikainen et al., 2019). Nevertheless, empirical analyses on HEI-related intermediaries indicate a more active and comprehensive involvement in intermediation activities supporting regional transitions (Trencher et al., 2014; Bäumlé et al., 2023). Thereby, HEI-related intermediaries also take over functions that are perceived to be part of transition intermediation. Intermediation in transitions is described as roles and activities of *“actors and platforms that positively influence sustainability transition processes by linking actors and activities, and their related skills and resources, or by connecting transition visions and demands of networks of actors with existing regimes in order to create momentum for socio-technical system change, to create new collaborations within and across niche technologies, ideas and markets, and to disrupt dominant unsustainable socio-technical configurations”* (Kivimaa et al., 2019, p. 1072). Although this definition is not uncontroversial, the importance of intermediaries in transitions processes is generally emphasized in transition research (Manders et al., 2020).

Research on intermediation in transitions indicates that roles and activities of intermediaries correspond to challenges related to directionality (Kivimaa et al., 2019; Sovacool et al., 2020; Vihemäki et al., 2020). For example, equivalent vital functions of intermediation in transitions have been identified, such as conflict resolution (Sovacool et al., 2020), governing in multi-stakeholder settings (Hodson et al., 2013), networking (Fischer and Newig, 2016; Gliedt et al., 2018; Kanda et al., 2020; Loorbach et al., 2020), vision building (van Lente et al., 2003; Kivimaa, 2014; van Boxstael et al., 2020) or strategy development (Hodson and Marvin, 2012; Hamann and April, 2013; Cramer, 2020). Furthermore, Kanda et al. (2020) found that intermediaries acting in-between the actors, networks, and institutions of innovation systems are able to facilitate sustainability transitions by contributing to an overall direction through their influence on institutions. Against this background, we aim to analyze the ability of HEI-related intermediation to implement directionality towards sustainability and add to the understanding of the roles of intermediaries in transitions.

3. Methods

Conducting a sequential, qualitative-quantitative mixed-methods analysis (Johnson and Onwuegbuzie, 2004) that aims to provide exploratory insights (Palinkas et al., 2011) concerning the ability of German HEI-related intermediation to implement directionality in practice, this section is structured according to the sequence of methods applied. First, the qualitative multiple-case study method is elaborated on. Following, the online survey informed by the case findings representing the quantitative part of the analysis is introduced.

3.1 Qualitative derivation of indicators

To reveal how intermediaries implement directionality, we conduct a multiple-case study (Yin, 2018) and analyze intermediaries in four regional innovation programs in the German regions of Darmstadt, Eberswalde, Augsburg and Goettingen (see Table 1; Case description see Appendix A). All assessed regional innovation programs are publicly funded, led by at least one HEI and comprise additional regional intermediaries (e.g. chambers of commerce or crafts, municipal economic development offices). The assessed programs represent HEI efforts in the context of their “third mission” that is to improve regional knowledge transfer. Apart from these similarities, the selected case studies differ in their primary objectives. Referring to programs main goals published and expressed e.g. in strategy documents or on web pages, the cases of Darmstadt and Eberswalde focus explicitly on contributions to sustainability (henceforce: sustainability-oriented cases). Pursuing more conventional and non-transformative innovation policy goals targeting regional economic development, the program in the region of Augsburg primarily aims to build up transfer networks including the civil society and the program in Goettingen tends to improve regional innovativeness (henceforce: conventional cases). Additionally, in order to consider different forms of policy supported path development, one case in each group represents a more peripheral type of region and one is more urban (Grillitsch and Asheim, 2018; Grillitsch and Hansen, 2019). Furthermore, considering the heterogeneity of regional innovation

systems and the differences in regional endowments (Tödting and Tripl, 2005; Cappellano et al., 2022), we propose indicators based on intermediation responses to the challenges occurring from inducing and maintaining the given directionality towards sustainability (Grillitsch et al., 2019).

In each case, at least 13 interviewees were identified and selected from initial dialogues with persons in authority and website evaluations and interviewed to collect data (Interviews see Appendix B). The selection of the interviewees represents the diversity of intermediaries involved in the HEI-led regional innovation program in each case. The selection strategy follows the principles of purposeful sampling, that is, including a comparable set of intermediaries in each case study from academia, industry, public administration, and civil society in each case study. These include lecturers, technology transfer office members, consultants, and innovation managers involved in the programs. Representatives of the chambers of commerce and crafts as well as industry specific associations were interviewed for the consideration of economy. In order to reflect public administration, business development agencies and representatives of the municipalities were included in the interviewee sample. To map civil society actors, the board members of foundations and societies were interviewed. From February to September 2020, 63 interviews were conducted. Because of the COVID-19 pandemic, all interviews except one were conducted via online video conferencing tools or telephones. The interviews lasted from 34 to 138 minutes. The material was recorded and transcribed, except for two interviews that were logged by the interviewers. In addition to the interviews, internal documents, as well as the reports and published information, were collected and reviewed.

Table 2: Case overview and number of interviews per region

Case	Case A	Case B	Case C	Case D
Region	Darmstadt	Eberswalde	Augsburg	Goettingen
Characteristic	Urban	Peripheral	Urban	Peripheral
Assessed initiative	<i>s:ne</i>	<i>region 4.0</i>	<i>HSA_transfer</i>	<i>SNIC</i>
Focus	Focus on system innovation for sustainability	Focus on regional sustainability transition	Focus on building networks	Focus on innovativeness
Number of Interviews	17	18	13	15

We collect data on intermediaries' roles and activities, and program's structures using a semi-structured interview guideline (Guideline see Appendix C). The interview guideline consists of open-ended questions, using guiding questions for each section, with follow-up questions to ensure the reflexivity of the interviews. After gathering information on individual backgrounds of the interviewee, we ask for structures of the innovation program to learn more about organizational setups and approaches of intermediation, innovation support and knowledge transfer. Afterwards, to gain insights on how knowledge transfer processes take place, we ask for examples of applied knowledge transfer activities and how intermediaries aim to induce learning processes for participants and for key stakeholders in reference to the program's goals. Subsequently, questions on the role of intermediaries in knowledge transfer activities were asked, to identify the involvement and methods used in innovation processes (Kivimaa et al., 2019; Kanda et al., 2020; Vihemäki et al., 2020). Next, we made the interviewees describe how they evaluate their activities and assess the outcomes of the programs to identify potential features to assess contributions to the programs goals. Then, we asked for distinctive features of the regional innovation systems to collect information on regional contexts of the programs and on obstacles intermediaries have to deal with to learn on the challenges intermediaries face. Finally, we asked on the role of sustainability in their program to collect data on their perspective on directionality of the program.

We applied a qualitative content analysis (Kuckartz, 2018) using transcripts, to gain insights on the effects of directionality towards sustainability and on occurring differences in intermediation. In order to reveal how intermediaries in sustainability-oriented innovation programs prioritize and stimulate innovation activities in order to implement directionality, categories were developed referring to the six directionality challenges identified by Grillitsch et al. (2019) and complemented by inductive coding.

Inductive coding led to the introduction of an additional category covering the normative orientation towards sustainability that is expressed in strategies and objectives of the assessed sustainability-oriented cases. The findings of the analysis were discussed and reviewed internally. After reducing coded interview content to characterizing statements on intermediation practices, findings were discussed with representatives from the respective cases in online-workshops. Then, the findings from the coding process were compared between sustainability-oriented and conventional cases. By comparing and contrasting the findings, we incrementally eliminated similarities and identified distinctive organizational features and specific as well as adapted intermediation practices that are associated to implementing directionality. During this process, the authors classified the found intermediation practices regarding their contribution to prioritizing or to stimulating specific innovation activities in order to make visible the targeted leverage. Based on the cross-case compared and contrasted findings, we derived a set of 16 indicators. The indicators represent practical intermediation adaptations that are employed by intermediaries in sustainability-oriented cases in order to prioritize and stimulate innovation activities that contributes to the desired direction of transformative change and thus support the implementation of directionality.

3.2 Quantitative triangulation

To triangulate the findings from our case study analysis regarding distinctive sustainability-oriented HEI-related intermediation practices that allow to implement directionality, we conducted an online survey (see Appendix D). The questions comprised, cover all 16 indicators and by using the wording from the interviews, we try to ensure the survey participants' understanding.

The survey is set up and provided in qualtrics^{XM} and was online from May 31 to July 7, 2022. In total, we asked 465 representatives of innovation initiatives and knowledge transfer offices to participate in our online survey. Therefore, they were invited by e-mail including an anonymous, single-use survey link. A first invitation was sent May 31 and a reminder three weeks later, June 21, 2022. Survey participants are drafted from 200 German regional innovation programs, e.g. from publicly founded innovation initiatives that target HEI and aim to foster regional innovation potentials through knowledge transfer, as for example “Innovative University”⁵ or “Change through innovation in regions”⁶ that support regional innovation programs pursuing different goals. Additionally, 265 knowledge transfer offices of German HEI were invited to take part in the survey. We broaden our sample by knowledge transfer offices, as they are key stakeholders in innovation and transfer activities of HEI’s “third mission” and involve in intermediation away from temporary funded innovation programs. Contact information and addresses were collected by manual web-search. We searched for knowledge transfer offices and regional innovation programs on websites of 423 German HEI listed by the German Rectors' Conference⁷ and additionally screened state and federal ministry funding program websites to find innovation programs particularly assigned for HEI. From a total of 194 responses, we use 112 fully answered questionnaires resulting in a response rate of 24%.

In our attempt to test specific characteristics and operating principles of sustainability-oriented intermediation in implementing directionality, we choose a comparative approach. Therefore, the majority of questions in the survey depict a bipolar rating scale, allowing us to distinguish sustainability-oriented intermediation characteristics from those with a more conventional orientation. To make possible the comparison of the two different orientations, one introducing question is specifically designed to classify intermediaries in terms of their most important goals based on the participant's self-assessment. Participants (N=112) are asked to sort their efforts into one of four categories (see Figure 1) that fits their general orientation. Categories at the poles designate a focus on either comprehensive contributions to strengthening (regional) economic development (conventional cases) or comprehensive

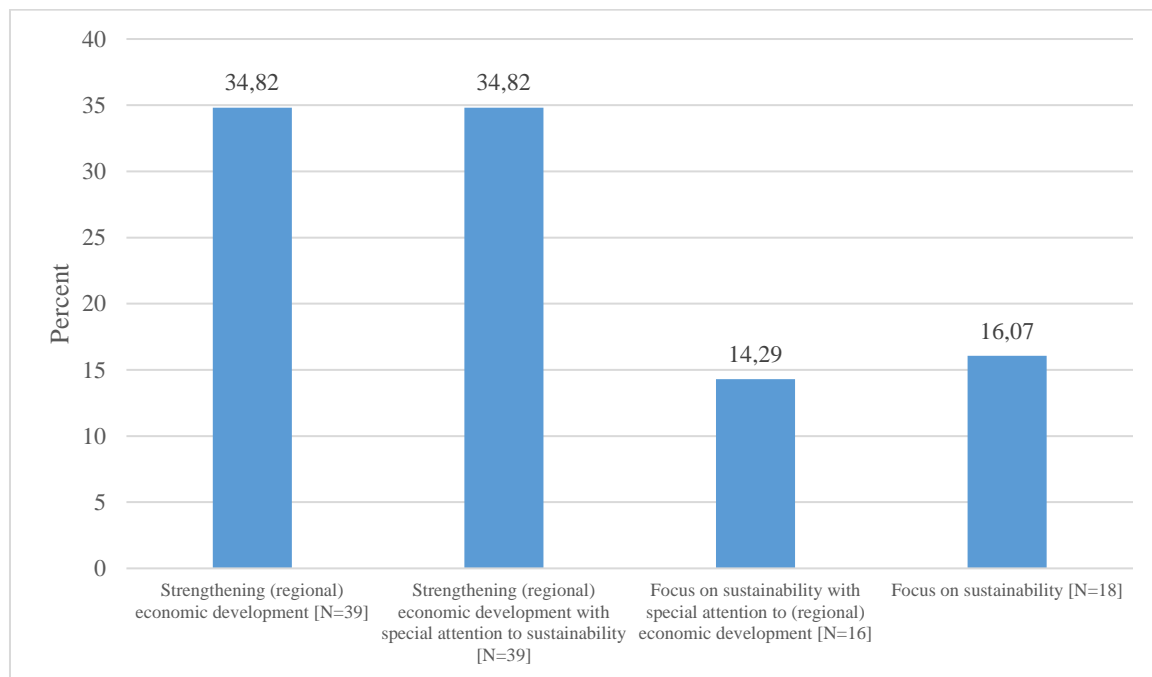
⁵ For further information see <https://www.innovative-hochschule.de/foerderinitiative/ueber-die-foerderinitiative>

⁶ For further information see https://www.innovation-strukturwandel.de/strukturwandel/de/innovation-strukturwandel/wir_/wir_node.html

⁷ For further information see: www.hochschulkompass.de

contributions to sustainability (sustainability-oriented cases). Both middle categories are a combination of both goals but with a primary focus on either one of them. This should simplify self-assessment for the survey participants, as we assume more hybrid than extreme forms of strategies and goals to exist. However, for reasons of better comparability in our analysis, we pool the two categories aiming for conventional and non-transformative goals and the two striving for contributions to sustainability and proceed with these two categories in the further analysis. However, this does not imply excludability but is used to highlight the respective orientation and allows finding intermediation strategies that are associated to tackle directionality challenges. Accordingly, our analysis is based on two populations of 78 cases that refer to themselves as conventional and 34 cases that classify themselves as sustainability oriented. To make visible specific differences between the two groups and to reveal the occurrence of the qualitatively derived indicators in sustainability-oriented cases we employ two-sided t-tests.

Figure 1: Distribution of primary goal of survey participants (N= 112)



Source: Results of Question 2 in online survey (see Appendix D).

4. Findings and results

The findings of the case study analysis and the results of online survey are presented following the sequence of the research approach introduced in Section 3.

4.1 Case study findings

By extending the framework for directionality challenges by (Grillitsch et al., 2019) by a fourth feature from inductive coding that comprise normative prioritization of sustainability (Yap and Truffer, 2019), we add *Normative sustainability orientation* comprising specific aspects of intermediary structures in sustainability-oriented cases. Thus, we derived three indicators from the qualitative comparison for this feature. The first indicator *Include sustainability in goal sets and strategies (I1)* subsumes innovation programs articulating the objective to contribute to sustainability transitions specifically in defined and actionable strategies or other forms of formalized documents such as mission statements. Several interviews reveal that the objective to contribute to sustainability is explicitly articulated in order to prioritize and legitimize concrete steps towards sustainable development. Additionally, sustainability can be included in a program's name or subprojects as in case A, which is named "system innovation for sustainable development" or case B incorporating "Eberswalde University of Sustainable Development". Second, declaring contributions to sustainability transitions as the main objective, in cases A and B, intermediaries *Prioritize sustainability in goal-sets and strategies (I2)* over other aspects.

Third, to reflect and improve their impact in terms of transformative change, intermediaries *Measure success concerning sustainability (I3)*. In both cases, A and B, external mediators and experts for sustainable development processes are consulted to evaluate strategies and activities as well as subproject outcomes of the programs.

Table 3: Indicators regarding normative orientation towards sustainability (I1-I3)

Challenge	Indicator No.	Leverage	Designation	Description	Example quotes
Normative sustainability orientation	I1	Prioritization	Include sustainability in goal sets and strategies	Intermediaries articulate the objective to contribute to sustainability transitions in defined and actionable strategies, its name or in other forms of formalized documents as mission statements.	“Yes, good. I mean, we are of course extremely inoculated by mindsets about the university. I don't know if I do anything that is not always reflected in terms of sustainability. I would say that the most important point for us is that we think about sustainable development from the ground up and have incorporated it into the program.” (23_B_Academia, item 47).
	I2	Prioritization	Prioritize sustainability in goal-sets and strategies	Intermediaries formulate orientation towards the normative goal of sustainability in its strategy as main objective.	“Yes. So we actually only work under this heading: Sustainable Development. And all our efforts go in this direction. And I can really speak for everybody on that.” 33_B_Academia , item 135)
	I3	Prioritization	Measure success with regards to sustainability	Intermediaries define terms of success regarding sustainability transitions.	“And this ‘for what do we want to develop possible solutions’ can also be described in criteria. And these criteria can be translated into indicators.” (9_A_Academia, item 44)

Regarding *Actor interests and capabilities* in an innovation system, Grillitsch et al. (2019) identify the challenge to promote institutional entrepreneurs, as actors are essential to initiate and engage in change processes. Responding to that directionality challenge, in programs focused on sustainability intermediaries *Enable participants to act as change agents (I4)*. Therefore, as a prerequisite for change, intermediary activities are explicitly designed to develop a common understanding of the problems of sustainability among participants, including identifying conflicting goals, recognizing related challenges and helping to overcome them. Furthermore, intermediaries involved in case A and B *Act as role models for participants (I5)*. Sustainability-oriented practices are incorporated into intermediaries’ roles and activities as well as organizational structures. The intermediary organizations undergo an internal transformation adopting sustainability-oriented practices and processes their self to create understanding and experiential knowledge in relation to sustainable change. These practices range from resources saving usage of paper or energy to integrating sustainable principles of action into knowledge transfer, research, teaching, and procurement. The intermediaries in case A and B thus set an example and share their experiences and knowledge of implementing sustainable practices in working with project participants.

Due to skewed distribution of power and resources among involved actors, the challenges of resolving conflicting interests arises (Grillitsch et al., 2019). This challenge is addressed by intermediaries in cases A and B as they *Enable participants to align interests and jointly develop legitimized solutions (I6)*. To achieve this, scenario and back-casting workshops are used in case A. First, in these workshops, participants jointly developed a common understanding of regional issues and demands related to sustainability based on back-casting methods applied to anticipated future scenarios, e.g., for regional industries or specific groups. In a subsequent step, based on the shared understanding of problems, specific challenges are identified and suitable solutions are developed through the collaboration among the stakeholders. This methodical approach, using scenarios, helps to discuss and align interests, and allows solutions to be developed and legitimized within the affected group.

To meet the requirements of transformative change, new forms of governance capabilities (Grillitsch et al., 2019) are introduced by intermediaries in order to provide direction towards sustainability.

Intermediaries in case A and B *Adopt participatory methods* (I7) in their activities and formats that activate and involve participants. In case A and B, future-oriented workshops, world cafés or business games are used to develop a common understanding of problems in order to provide more than one-sided transfer of knowledge or the facilitation of contacts. In order to explore previously novel solution approaches for the participants outside of established options, intermediaries ensure that different actors contribute perspectives to an idea, knowledge and technology transfer process. Thus, knowledge exchange in case A and B is understood and organized as a reciprocal and recursive process. Intermediaries *Develop moderation skills* (I8) that allow for encompassing engagement in their projects and processes that goes beyond brokering activities. Furthermore, intermediaries *Accompany change processes to provide and maintain direction* (I9). Thus, intermediaries involve more actively in innovation processes beyond initial stages and support participants in working cooperatively and continuing the change process.

Table 4: Indicators regarding actor interests and capabilities (I4-I9)

Challenge	Indicator No.	Leverage	Designation	Description	Example quotes
Promote institutional entrepreneurship	I4	Stimulation	Enable actors to act as change agents	Intermediaries support participants to act as change agents for sustainability through relevant knowledge and information in order to develop understanding of problems related to changes.	“The primary aim is to impart competencies for action. In other words, education for sustainable development should not impart knowledge as much as classic environmental education, but rather skills for action.” (32_B_Public administration, item 73)
	I5	Stimulation	Act as role model for participants	Intermediaries adopt sustainable practices or initiate internal change processes towards sustainability and act as role models.	“So in any case, the role model effect. That is, how we organize our events. That it is all done with sustainable so there is simply a guideline. Procurement, too, of course. In other words, we set an example of what is possible.” (19_B_Academia, item 154) “Yes, above all through example-giving, example-effect, example-giving. If you show for individual areas how it can work, so that it invites imitation.” (32_B_Public administration, item 181)
Resolve conflicting interests	I6	Stimulation	Enable participants to align interests and jointly develop legitimized solutions for societal challenges	Intermediaries support participants to jointly develop solutions based on aligned interests and a shared understanding of challenges related to sustainability.	“And the important thing is to strive for a participatory exchange in order to resolve precisely these conflicting goals. And yes. And to find solutions.” (33_B_Academia, item 137) “We [...] have an approach that always develops things bottom up, we start with participation formats. And in these participation formats, through mutual knowledge transfer at various levels[...] then we involve logistics experts, regional producers, municipal companies [...], as well as end users, so to speak, citizens. [...] What we are doing is actually organizing this exchange, this transfer, within the framework of participation formats, and transferring knowledge in a specific direction, so that we communicate and discuss approaches and results with each other [...]” (23_B_Academia, item 19)
Develop capabilities in new forms of governance	I7	Stimulation	Adopt participatory methods	Intermediaries ensure recursive exchange of knowledge, ideas and perspectives using participatory methods in activities and formats to activate and involve participants.	“The method of choice was to do a scenario process with different actors. And then it's like, when you think about it, which format is the right one? Which actors are the right ones? How do you bring them together? Where do you bring them together?” (3_A_Civil society, item 17)
	I8	Stimulation	Develop moderation skills	Intermediaries develop transitions process moderation capabilities that allow for encompassing engagement in projects beyond initial stages.	“I am the moderator in our transfer processes, trying to bring together the actors from the university and from practice in such a way that together we can achieve a change in the direction of sustainable development. That is my role as moderator.” (13_A_Academia, item 11)

19	Prioritization	Accompany change processes to provide and maintain direction	Intermediaries involve actively in transition processes beyond initial stages and support participant in working cooperatively and continuing the process.	<p>“For us, it is about actually advancing change processes towards sustainable development, on the one hand, and orienting the university and what it teaches towards this, and of course research as well. In other words, we see the universities as actors in the process of societal change towards sustainable development.” (1_A_Academia, item 31)</p> <p>“And the unique characteristic I think we have is that we have a clear focus on the actors. That means we don't just say this is the problem and this is the solution, but we consider for each individual actor what their motivational factors are, where they see obstacles. [...] And then develop quasi tailor-made solutions for this constellation of actors.” (1_A_Academia, item 53)</p>
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Regarding the networks feature of regional innovation systems, the challenge is to connect and integrate directionality of different actor groups (Grillitsch et al., 2019). In order to meet this challenge, intermediaries in Case A and B *Consider the diversity of participants* (I10). Dealing with societal challenges, civil society actors are specifically considered and included in sustainability related transitions processes. Participants from the civil society are identified as an additional target group for knowledge transfer activities. Diversity is also be taken into account in terms of the disciplines, professional groups, hierarchical levels involved and the degree to which they are affected by the changes initiated. Furthermore, intermediaries aim to make practitioners and theorists cooperate in their projects. The diversity of perspectives is seen crucial to the success of transfer processes in cases A and B. Already existing regional *Sustainability initiatives and projects are included* (I11) into the work of the innovation programs to pool resources and knowledge as well as to align goals and interests. The intermediaries developed a *Participant selection strategy for long-term cooperation* (I12). This strategy aims on specifically integrating participants into the programs regional network that are already committed to sustainable development, who can develop a great development potential with regard to sustainable development or who can serve as door openers for other relevant actors through their regional importance or connectedness. These participants are specifically approached for long lasting cooperation in order to establish a relationship of trust, which allows for intensified cooperation. In this way, participants are qualified with regard to sustainable development and participants build up competencies over time. They build *Networks specialized on sustainability* (I13) by *Identifying and including participants willing and capable to act as change agents* (I14). Therefore, in cases A and B, intermediaries aim not for extensive but specified and actionable networks.

Table 5: Indicators regarding networks (I10-I14)

Challenge	Indicator No.	Leverage	Designation	Description	Example quotes
Connect and integrate directionality	I10	Stimulation	Consider diversity of participants	Intermediaries deliberately involve relevant actors with different perspectives from academia, industry, administration and from the civil society.	<p>“And we discussed it in a fixed circle of 18 to 20 people from city politics, the city economy and companies and associations. That is, it was a fixed group, so that a certain culture of discussion could also develop.” (1_A_Academia, item 37)</p> <p>“And secondly, of course, simply because it is a participatory approach. So we are always looking for regional players. In addition to the scientific actors, also economic actors, or social actors, or to bring in.” (25_B_Academia, item 17)</p>
	I11	Stimulation	Include sustainability projects and initiatives	Intermediaries include and integrate existing regional sustainability initiatives and projects to pool resources and knowledge as well as to align goals and interests.	<p>“Then the WIR project came along. After the application was awarded, we said, “We already have the working groups here. We don't need to do anything extra in parallel.” We have a total of ten working groups. And we are managing them as part of the WIR process, so to speak, in order to work with the companies to identify the projects that really fit in with this WIR project.” (29_B_Public administration, item 19)</p> <p>“And from the Recode Uckermark, ideas have also emerged that will then be transferred to the WIR project, so to speak.” (22_B_Public administration, item 47)</p>

I12	Prioritization	Develop an actor selection strategy for long-term cooperation	Intermediaries include actors regarding their potential contribution to sustainability. Long-term co-operations are targeted in order to build up the participants competencies related to sustainability.	<p>“You then look for project partners who can contribute. And the question is always: Who can bring such projects forward and with what power?” (21_B_Industry, item. 176)</p> <p>“We gathered the actors relevant to us or to the region during the concept phase in 2017 and entered into a long-term dialogue with them. That means, if you look at it, that the actors are already relatively constant.” (23_B_Academia, item 27)</p>
I13	Prioritization	Build networks specialized on sustainability	Intermediaries specifically choose network participants according to their relevance in the respective field of action.	<p>“Because we really look closely at each sub-project or field of action: What do we want, what is it about, what is the question and who do we need for it? So that's how it is [...] this actor mapping. So we really look at who has something to say about this. [...] So we always look closely at who we need for this thematic area. That's why there are no generally relevant actors for all of them. But rather the specific, relevant actors, so to speak.” (3_A_Civil society, item 71)</p>
I14	Stimulation	Identify and include actors willing and capable to act as change agents	Intermediaries specifically choose network participants according to their potential contribution and their already existing commitment.	<p>“Because we are of course acting under the flag of sustainability, that of course makes it easier to look for like-minded people, so to speak. [...] And in this respect, it sorts itself out relatively quickly that you then tend to come together with the sustainability actors and pioneers.” (18_B_Academia, item 90)</p>

Developing a shared vision among actors, is a challenge referring to the feature of institutions (Grillitsch et al., 2019). In order to develop shared ideas of the future among multiple actor groups, intermediaries *Use participatory methods for vision building* (I15). In case A, a scenario method is used to create a common understanding of problems among the participants, to promote dialogue on conflicting goals and thereby helps developing a common vision. This shared visions as a basis allows *Joint strategy development* (I16) for solutions for sustainability-related challenges with the participants. In order to address the challenge to set actionable objectives and maintain direction of change, intermediaries use back-casting methods that allow participants to coordinate individual steps towards the shared goals on the basis of a jointly developed strategy taking into consideration individual needs, abilities and resources of actors.

Table 6: Indicators regarding institutions (I15-I16)

Challenge	Indicator No.	Leverage	Designation	Description	Example quotes
Develop shared visions among multiple actor groups	I15	Prioritization	Use participatory methods for vision building	Intermediaries use participatory methods involving groups of heterogeneous actors to build shared visions among participants.	<p>“And then we would say, well, what goals do you have, where do you want to go? We now know climate neutrality in 2035, that helps you. Where is the difficulty in achieving that? [...] Where do you want to go [...], where do you actually have to go. And then to say, how can we use a selected example to demonstrate that we can get to where you want to go?” (8_A_Academia, item 87)</p>
					<p>“When you try to build up value-added chains that broke away after reunification, you have to consider a vision for the future at the same time. [...] Instead, future goals should be considered and, I would say, incorporated into the processes. [...] That just not only a farmer and a catering facility cooperate, but that there are of course other partners, that society is involved in it, the public, science.” (26_B_Civil society, item 47)</p>
Set objectives and provide direction in a concrete and actionable way	I16	Stimulation	Joint strategy development with relevant actors	Intermediaries moderate joint strategy development processes based on a shared vision by groups of heterogeneous actors considering individual steps and goals.	<p>“Another idea of the Theory of Change is that you make transparent: What is your scope? What concrete outputs can you achieve in your project? And what are the surrounding spheres, where can you perhaps still-, that is, do you still have the possibility of contributing to a change? And which sphere is in your interest? You want to change it, but you can't actually work towards it. So that simply also makes transparent what the possibilities and where the limits of such a project are. So we have classified the many ideas into such a theory of change.” (13_A_Academia, item 47)</p> <p>“They have now developed something, also so-called roadmaps. So that was one of the results of the scenario process. So, now we have thought about, we want a positive</p>

4.2. Online survey results

Based on our extended framework for directionality challenges by Grillitsch et al. (2019), the first three indicators illustrate the intermediaries' normative orientation on sustainability. Based on our survey data, participants who categorized themselves as sustainability-oriented more often feature an overarching sustainability strategy ($\chi^2 = 8.28, p = 0.004$), thus, including sustainability in goals and strategies (I1). However, contrary to our cases study findings, in the survey data there are no considerable differences in embedding sustainability goals in specific processes or formalized documents between both types of orientation. Furthermore, both types show no differences in prioritizing sustainability in their formal goals (I2). Next, survey participants are to self-assess their effort to sustainability and the sector their institution has the largest impact (I3). We find intermediaries' largest contributions in line with their self-categorization. Thus, intermediaries with a conventional orientation perceive their greatest contribution in regional economic and technical development whereas sustainability-oriented intermediaries indicate their largest effect in sustainable and societal development ($\chi^2 = 29.19, p = 0.000$). Additionally, the latter evaluate their activities and operations particularly regarding their potential contribution to sustainability as we also find in our qualitative analysis ($t(110) = -2.03, p = 0.045$). In summary, we find quantitative support for two (I1, I3) out of three indicators for *normative sustainability orientation* that we derived from our case study.

In terms of *actor interests and capabilities* in regional innovation systems, we find sustainability-oriented intermediaries *promoting institutional entrepreneurship by Enabling participants to act as change agents* (I4). In line with the case study findings, they help their participants to become change-agents providing them with understanding of sustainability related problems and with skills to enable change even beyond their initial collaboration with HEI related intermediaries. In contrast to that, survey data indicates that conventional cases primarily support their participants in overcoming their individual innovations challenges and successfully finish their innovation projects (I4: $t(110) = -3.21, p = 0.002$). Moreover, intermediaries that categorized themselves as sustainability-oriented more likely apply to *Act as role models* for cooperation partners concerning sustainable practices and emphasize the concept of being role models (I5: $t(110) = -2.58, p = 0.011$). However, survey participants of both orientations claim that internal steps have been taken within their organization in order to contribute to sustainability e.g. saving resources (paper, energy etc.), establishing interdisciplinary working groups or educational work regarding sustainability. Facing the challenge to *resolve conflicting interests*, in our case study we find intermediaries *Enable clients to align their interests and develop solutions for societal change* (I6). Sustainability-oriented cases approach this issue by initiating working groups with researchers and practitioners and motivating them to jointly discuss and develop problem-solving approaches for challenges related to sustainability. Contrary to this broader and more inclusive approach, intermediaries focused on conventional goals show a project-based perspective addressing tangible, individual innovation challenges by specifically connecting companies with suitable researchers and experts (I6: $t(110) = 3.39, p = 0.001$). The orientation of an intermediary affects its way to address the challenge *develop capabilities in new forms of governance*. From the survey data, a focus on conventional goals more likely involves transfer activities that aim to disseminate information among participants. In sustainability-oriented cases, intermediaries organize transfer activities that are more participative instead, allowing to stimulate active exchange of information and knowledge (I7: $t(110) = 1.76, p = 0.081$). This *Adoption of participatory methods* (I7) is reflected by the most frequently used transfer activities. Sustainability-oriented intermediaries primarily try to connect with researchers and organize talks and presentations, e.g. by experts for specific topics, and workshops. These formats have in common that they allow for participation of other actor groups. On the other hand, conventional cases address more distinct and individual innovation challenges. Therefore, conferences

and promoting contacts between researchers and companies are the leading formats of transfer activities. However, in contrast to our qualitative findings, in both types of cases, intermediaries support participants' innovation processes through *Moderation* (I8), *Close companionship* (I9) during innovation processes and matching with relevant partners.

In their *networking* activities, intermediaries face the challenge to *connect and integrate the directionality of multiple types of actors*. Considering *diversity of participants* (I10), sustainability-oriented intermediaries try to establish diverse regional networks that includes the civil society, e.g. foundations, schools or cultural institutions, to foster innovation. Conversely, to tackle individual innovation problems in conventional cases, a comprehensive network that mainly brings together business and science fits best ($t(110) = 2.96, p = 0.038$). Regardless of orientation, *Including existing sustainability projects and initiatives* (I11) and *Strategically selecting actors for cooperation* (I12) is relevant for intermediation. For both types of cases, *Building a network specialized on sustainability* (I13) is not particularly important, reflecting the significance of diversity for intermediaries focused on sustainability. Additionally, survey data do not point towards sustainability-oriented intermediaries being more likely to *Identify and include actors willing and capable to act as change agents* (I14).

On an *institutional level*, intermediaries face challenges related to *develop shared visions among multiple actor groups* and to *set objectives that provide direction in a concrete and actionable way*. However, referring to the data, we do not find support for sustainability-oriented cases concerning *Using participatory methods for vision building* (I15) or *Joint strategy development* (I16) as we found in our qualitative assessment. Nevertheless, participants from sustainability-oriented cases more often employ scenario-processes.

The results of the online survey are summarized in Table 7. The data indicate that in comparison to conventional cases, intermediaries that categorized themselves sustainability-oriented more likely employ seven of the qualitatively found characteristics related to directionality. Accordingly, for nine indicators we do not found significant quantitative support. Participants that classified themselves sustainability-oriented formally incorporate sustainability in their goal sets (I1), strategies or other kinds of formalized documents concomitant with a definition of success for promoting sustainability transitions (I3) in order to legitimize and prioritize engagement in sustainability-oriented innovation efforts. Moreover, sustainability-orientated cases stimulate the emergence of change agents by focusing on an understanding of problems initially (I4). Acting as role models in terms of sustainability (I5) they strive to encourage participant to adopt sustainable practices, as for example sustainable procurement, and to stimulate internal change processes. Furthermore, conflicting interests in programs are addressed by the intermediaries by supporting participants align interests and jointly develop solutions (I6), based on participatory methods (I7) that allow for discussion and exchange of ideas and knowledge. In order to connect and integrate different perspectives on sustainability related change processes, intermediaries consider diverse sets of participants in their projects and reach out to civil society actors to participate in their regional programs (I10). Thus, the analysis reveals that next to normative orientation that supports prioritization, intermediation efforts to implement directionality in German HEI-related and sustainability-oriented regional innovation programs are characterized by employing practices that allow the stimulation of innovation activities contributing to transformative change.

Table 7: Indicators supported quantitatively in the online survey

RIS Feature	Challenge	Indicator No.	Leverage	Designation	Description
Orientation	Normative sustainability orientation	I1	Prioritization	Include sustainability in goal sets and strategies	Intermediaries articulate the objective to contribute to sustainability transitions in defined and actionable strategies, its name or in other forms of formalized documents as mission statements.
		I3	Prioritization	Measure success with regards to sustainability	Intermediaries define terms of success regarding sustainability transitions.
Act or inter est and	Promote institutional entrepreneurship	I4	Stimulation	Enable actors to act as change agents	Intermediaries support participants to act as change agents for sustainability through relevant knowledge and

					information in order to develop understanding of problems related to changes.
		15	Stimulation	Act as role model for participants	Intermediaries adopt sustainable practices or initiate internal change processes towards sustainability and act as role models.
	Resolve conflicting interests	16	Stimulation	Enable participants to align interests and jointly develop legitimized solutions for societal challenges	Intermediaries support participants to jointly develop solutions based on aligned interests and a shared understanding of challenges related to sustainability.
	Develop capabilities in new forms of governance	17	Stimulation	Adopt participatory methods	Intermediaries ensure recursive exchange of knowledge, ideas and perspectives using participatory methods in activities and formats to activate and involve participants.
Neworks	Connect and integrate directionality	I10	Stimulation	Consider diversity of participants	Intermediaries deliberately involve relevant actors with different perspectives from academia, industry, administration and from the civil society.

5. Discussion

The implementation of directionality is at the center of scholarly debates on designing and implementing transformative innovation policy. We contribute to this discussion by connecting the concepts intermediation and directionality. With the aim to assess HEI-related intermediation against that background, our exploratory mixed-methods analysis highlights the role of HEI-related intermediation in supporting transformative change as we identify adapted practices that allow to prioritize and stimulate innovation activities contributing to sustainability and thus to implement directionality. More particularly, our exploratory analysis contributes in a twofold way:

First, regarding the discussion on how to implement directionality in policy practice and how to address directionality challenges (Grillitsch et al., 2019; Bergek et al., 2023), our analysis of HEI-related intermediation roles and activities finds that sustainability-oriented intermediaries prioritize and stimulate innovation activities that contribute to transformative change and thus provide directionality. Our mixed-methods analysis reflects that HEI-related intermediation employs adapted practices that are able to address directionality challenges. Thus, our findings indicate that HEI-related intermediaries should be considered a suitable stakeholder to support the implementation of directionality in transformative innovation policy practice (Haddad et al., 2022) as they are able to address a major transitions impediment and can help to avoid “directionality failure” (Weber and Rohrer, 2012). Moreover, this study addresses the call for empirical assessment of how directionality is implemented in practice (Grillitsch et al., 2019; Haddad et al., 2022) by providing detailed insights on how intermediaries in HEI-led and sustainability-oriented regional innovation initiatives induce and maintain directionality. Yet, our findings contradict the results of Parks (2022), who finds that “innovation supply-side” actors, e.g. universities and companies, “*are not necessarily well-suited to organize innovation processes that address societal challenges, where it is necessary to open-up innovation [...]*” and that they do not have “*the capacity to provide directionality to innovation processes*” (Parks, 2022). In contrast to that, we find HEI-related intermediaries in sustainability-oriented German cases make use of participatory methods including a broad set of actors in order to open-up innovation processes and enable co-creation for transformative change (Yap and Truffer, 2019). Moreover, the found approaches point to the potential of HEIs as important drivers of change processes from RIS towards CoRIS (Tödting et al., 2021).

Second, our exploratory mixed-methods study reveals interesting insights into how HEI-related intermediation is involved in regional transformative change processes. Adding directionality implementation as an complementary analytical perspective, it informs the ongoing discussion on the role of HEIs in transitions (Bäumle et al., 2023). From our comparative qualitative assessment, we provide a set of 16 characterizing features that are associated with sustainability-orientation as they differ significantly from practices in conventional cases. The employed practices allow HEI-related intermediation to prioritize and stimulate innovation activities contributing to the object of the Cases A

and B that is to enable regional transformative change towards sustainability. Using an online survey comprising data from a broad set of German HEI-related intermediaries, we find quantitative support for 7 out of 16 indicators reflecting the capability to implement and provide directionality. Unsurprisingly, not all qualitatively derived indicators are supported quantitatively, as we chose sustainability-oriented cases A and B as they are both have dealt extensively with sustainability. Nevertheless, we find quantitative support for prioritization and stimulation practices related to normative orientation, actors and networks. In contrast to our qualitative findings, practices addressing institutions are not supported by our survey data. Moreover, prioritization is heavily informed by normative orientation practices. Therefore, based on our data, we argue that HEI-related and sustainability-oriented intermediation in Germany employs practices that allow implementing and providing directionality to transformative change processes. Next to this, qualitative data demonstrates that HEI-related intermediaries are aware of their involvement in transitions and enact their role as facilitators. Having one third of survey participants classify themselves as sustainability-oriented, involvement is also reflected in quantitative data.

6. Conclusion

The implementation of directionality has been identified as a major challenge for transformative innovation policy, but there is a lack of knowledge and empirical evidence on how to implement directionality in policy practices. The need for innovation policy to evolve in order to effectively contribute to grand societal challenges calls for further investigation of policy instruments that enable implementing and providing directionality. Based on an exploratory mixed-methods approach, we identify how HEI-related intermediaries prioritize and stimulate innovation activities that contribute to sustainability and make visible which adapted practices are employed in HEI-related intermediation. That allows us to characterize how HEI-related intermediation in Germany implements directionality in towards sustainability in regional transformation processes.

Concerning the research question on how HEI-related intermediaries implement and provide directionality in sustainability-oriented German regional innovation programs, we provide a set of characterizing indicators that comprise practices to prioritize and stimulate innovation activities that contribute to the targeted transformative change. From our qualitative analysis, we identify 16 characterizing practices that address actors, networks, and institutions as well as the HEI's normative orientation in order to provide directionality. Quantitatively, we find support for seven indicators that reflect the potential to implement and provide directionality. To pave the way for change directed towards sustainability, we find intermediaries participating in our survey include sustainability in goal sets and strategies and measure success with regards to sustainability. They enable actors to act as change agents and act as role models for sustainability related actions in order to stimulate change. Moreover, they adopt participatory methods to open up innovation processes to diverse groups of stakeholders. These practices enable participants to align interests and jointly develop legitimized solutions for societal challenges. Therefore, they adopt new and adapt existing intermediation practices that respond to the challenges of directionality. Based on these findings, we argue that intermediation could be a useful instrument for policymakers to implement directionality in policy practice.

From a policy perspective, our findings corroborate that HEI-related intermediation bears the potential to be a suitable instrument to implement and provide directionality in regional transformative innovation policy. Moreover, we found that HEI-related intermediaries already employ suitable practices that could be strengthened and extended to increase impact. Policymakers could use the provided indicators for guidance and develop policies that nurture intermediation practices to prioritize and stimulate transformative change. Nevertheless, equipping HEIs with required resources and capabilities will not be a short-term and straightforward process. Referring to HEIs, policymaker should encourage internal changes regarding sustainability-orientation to allow prioritization in a first step as change processes are complex. Complementary they should provide additional resources that allow adapting existing practices and adopting participatory methods that allow stimulating change. Alternatively, in reference to Cappellano et al. (2022), we argue that the presented set of 16 indicators could also be a useful tool

to estimate the “preparedness” of intermediaries to implement directionality. The presented findings also comprise implications for intermediation practitioners, as they could incorporate or adopt practices in their own efforts to provide directionality towards sustainability transitions.

From a scholarly perspective, our findings emphasize the role of HEI-related intermediation in transitions. Our analysis is only a first step to gain a better understanding of the potentials of intermediation in implementing and providing directionality. As we found HEI-related intermediaries proactively involve in sustainability transitions, this calls for further investigation of HEI-related intermediaries in the context of “transitions intermediaries” (Kivimaa et al., 2019). However, our mixed-methods study has several limitations. Our set of indicators is not exhaustive. Including further sustainability-oriented cases in an in-depth analysis against the background of directionality would help to identify additional practices supporting change. Moreover, instead of six challenges (Grillitsch et al., 2019) considered in this study, Bergek et al. (2023) recently provided a framework comprising eight directionality challenges that should be comprised in further analysis. Next to this, concentrating on intermediation practices, our study only covers the “input-side” of innovation policy and is not able to elaborate on actual outcomes of the employed practices as transformative change requires a long-term perspective.

Future research could enrich the ongoing discussions by addressing these limitations. Moreover, we see promising avenues of research on intermediaries’ capabilities to implement directionality in other regions and on other spatial levels as well as considering different types of intermediaries. Furthermore, future research should investigate how to build up stimulation capabilities as well as explore incentives and barriers concerning preceding change processes that allow for prioritization. Hence, future research should focus on how to enable key stakeholders of transitions to introduce practices providing directionality in order to employ suitable policy instruments to increase the “preparedness” of RIS to contribute to sustainability transitions.

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Appendix

A) Case Overview

Sustainability-oriented cases

Case A) The city of Darmstadt is located in the Frankfurt metropolitan area in the middle of Germany and has the fourth largest number of citizens in the state of Hesse. It is characterized by an extensive university and research landscape. Next to several smaller HEI and research institutes in Darmstadt, the Darmstadt University of Applied Sciences ('h_da') is second in scale and number of students to the Technical University Darmstadt ('TUD'). With the TUD being one of the leading universities in Germany for engineering research and teaching, the h_da gives more attention to its economic, social, media and design departments, though engineering remains to play an important role.

The analyzed initiative s:ne (system innovation for sustainable development) started in 2018 as part of the "Innovative University" funding initiative by the Federal Ministry of Education and Research. Pursuing the goal of creating and applying mutual transformative knowledge transfer activities to foster learning processes and sustainability transitions with partners from industry and civil society, s:ne has a strong orientation towards sustainability. The orientation towards sustainability is informed by previous internal initiatives to support sustainability. To make possible system innovation, s:ne developed an innovation and transfer platform as a core element to initiate cooperation and to support participating actors align visions and implement projects on sustainability challenges. Project partners to s:ne include actors that especially engage in sustainability transitions like the Institute for Applied Ecology.

Case B) The city of Eberswalde is located in the north-eastern part of the federal state of Brandenburg. The rural county in between the metropolitan areas of Berlin and Stettin is characterized by agriculture and small and medium enterprises except for a limited number of petrol and chemical industries. Additionally, there are large biosphere reserve areas that are sparsely populated, but are nature sights that are used to offer touristic services. One central actor of the regional innovation system is the Eberswalde University for Sustainable Development. This University, with an explicit focus on sustainability, specializes on sustainable production and rural development.

This study analyzed the initiative region 4.0 that is part of the funding program "Change through Innovation in Regions" by the Federal Ministry of Education and Research. It aims to establish an transdisciplinary regional innovation network supporting sustainability-oriented innovation. It is led by Eberswalde University for Sustainable Development ('HNEE') that is the central actor for knowledge transfer and innovation support in the rural region. As one unique feature, starting in the late 1990s the university has comprehensively converted its educational, scientific and transfer activities in order to consider sustainable development, expressed e.g. by the renaming of the university in 2010. The project comprises three fields of actions that are agriculture and regional nutrition, public services and infrastructure and nature-oriented tourism. The fields of actions represent the regional endowments and were developed jointly with regional actors that also are participants of the alliance formed by launching region 4.0. Important regional partners are regional business development agencies, the regional transport company as well as the municipality utility company. Furthermore, higher education institutions from Berlin as well as other Brandenburg regions are taking part evaluating and accompanying the project.

Conventional cases

Case C) The city of Augsburg is located in the western part of the federal state of Bavaria. Augsburg and its greater surroundings including Munich and Nuremberg form one of the strongest economic areas in Germany. Additionally, two HEI and several research institutions make Augsburg a knowledge-intensive location. A unique regional aspect is, dating back in the 1990s, multiple and heterogeneous regional stakeholders established the local agenda 21 initiative in the city of Augsburg. Forming committees called "agenda forums" that address different regional sustainability issues and backed by the municipality, they aim for a cooperative and sustainable city development.

The assessed initiative led by the University of Applied Sciences Augsburg ('HSA') is HSA_transfer and refers to itself as "agency for cooperative HEI projects". It is part of the funding program "Innovative university" and it develops and tests new formats for knowledge transfer like student service learning and alumni networking. Project goals are to support and improve knowledge transfer activities, by providing a transfer "toolbox" for HEI members, and to foster networks with civil society actors through cooperative projects with e.g. schools, museums, civil initiatives or associations. HSA_transfer increases the visibility of transfer activities for civil society with a strong emphasis on internal and external communication.

Case D) The city of Goettingen is situated the south of the federal state of Lower Saxony between the metropolitan areas of Hannover in the north and Kassel in the south. Goettingen is home of three HEIs and multiple research institutions while the economy of its more peripheral environment is mostly influenced by SMEs except for a few major companies, e.g. in life sciences. For the southern part of lower Saxony, the HEI of Goettingen are important actors referring to knowledge transfer and innovation support.

The initiative led by the University of Goettingen is SNIC (Innovation Campus in Southern Lower Saxony) that was established in 2016 on behalf of regional intermediary actors and is funded by the federal state of Lower Saxony. The catchment area of SNIC is not limited to the city of Goettingen but also includes surrounding counties as well. It refers to itself as an innovation network and connects HEI and research institutions with other regional intermediary actors as chambers and municipalities to support the transfer of knowledge to local stakeholders and to foster the knowledge transfer structure without a specific sustainability orientation. Providing interfaces for actors to connect, the SNIC program aims to strategically improve the knowledge economy and the region's innovative capacity. Complementary to and also cooperatively with participating HEI knowledge transfer offices, it provides multiple innovation support and transfer activities including, e.g. an innovation accelerator, best-practice on-site and networking events, funding support, innovation scouting and innovation consulting.

B) Interviews

No.	Region	Sector	Role	Duration (min)
1	Case A	Academia	Professor (s:ne team member)	112
2	Case A	Academia	Research Associate (s:ne team member)	40
3	Case A	Civil society	Research Associate of a foundation (s:ne team member)	54
4	Case A	Industry	Representative of chamber of commerce	61
5	Case A	Academia	Research Associate of a Research Institute (s:ne team member)	66
6	Case A	Academia	Research Associate of a Research Institute	36
7	Case A	Academia	Research Associate (s:ne team member)	65
8	Case A	Academia	Senior Researcher of a Research Institute (s:ne team member)	91
9	Case A	Academia	Senior Researcher (s:ne team member)	90
10	Case A	Industry	Representative of chamber of commerce	91
11	Case A	Public administration	Innovation support and technology transfer manager	34
12	Case A	Industry	Representative of Business Association	40
13	Case A	Academia	Senior Researcher (s:ne team member)	58
14	Case A	Industry	Sustainability consultant (s:ne team member)	57
15	Case A	Academia	Representative of university sustainability office	45
16	Case A	Academia	Representative of university presidential board	59
17	Case A	Public administration	Representative of university transfer office	42
18	Case B	Academia	Professor	80
19	Case B	Academia	Innovation support and technology transfer manager	94
20	Case B	Academia	Innovation support and technology transfer manager	97
21	Case B	Industry	Innovation support and technology transfer manager	138
22	Case B	Public administration	Business developer (region 4.0 team member)	61
23	Case B	Academia	Professor (region 4.0 team member)	53
24	Case B	Public administration	Business developer	64
25	Case B	Academia	Project manager (region 4.0 team member)	61
26	Case B	Civil society	Representative of a civil association (region 4.0 team member)	71
27	Case B	Industry	Innovation manager	89
28	Case B	Industry	Innovation manager	66
29	Case B	Civil society	Representative of a civil association	91
30	Case B	Public administration	Knowledge transfer manager	58
31	Case B	Industry	Representative of regional craft sector	77
32	Case B	Public administration	Representative of biosphere reserve	100
33	Case B	Academia	Professor	70
34	Case B	Academia	Professor	70
35	Case B	Academia	Professor	76
36	Case C	Academia	Professor (HSA_transfer team member)	103
37	Case C	Academia	Professor (HSA_transfer team member)	86
38	Case C	Public administration	Representative of innovation support and technology transfer agency	77
39	Case C	Academia	Program Manager (HSA_transfer team member)	73
40	Case C	Public administration	Business developer	35
41	Case C	Public administration	Representative of an innovation center	54

42	Case C	Industry	Representative of chamber of commerce	54
43	Case C	Academia	Representative of university transfer office (HSA_transfer team member)	72
44	Case C	Academia	Research associate	73
45	Case C	Public administration	Representative of university sustainability office	54
46	Case C	Academia	Communication manager (HSA_transfer team member)	77
47	Case C	Civil society	Representative of a foundation	62
48	Case C	Civil society	Representative of a civil association	73
49	Case D	Academia	Professor (SNIC team member)	87
50	Case D	Academia	Project manager (SNIC team member)	92
51	Case D	Public administration	Representative of SNIC Office (SNIC team member)	72
52	Case D	Public administration	Innovation support and technology transfer manager (SNIC team member)	62
53	Case D	Civil society	Representative of a foundation	59
54	Case D	Academia	Professor (SNIC team member)	75
55	Case D	Public administration	Business developer (SNIC team member)	64
56	Case D	Public administration	Business developer (SNIC team member)	48
57	Case D	Academia	Research associate (SNIC team member)	53
58	Case D	Academia	Innovation scout (SNIC team member)	50
59	Case D	Industry	Representative of chamber of crafts	71
60	Case D	Public administration	Business Developer (SNIC team member)	50
61	Case D	Industry	Representative of chamber of commerce	78
62	Case D	Academia	Innovation scout (SNIC team member)	55
63	Case D	Public administration	Business developer (SNIC team member)	52

C) Interview guide

Section 0: Background of the interviewee

- Please briefly describe your job/function.
- How do you / how does your organization understand 'knowledge transfer'?

Section 1: Intermediary structures and characteristics of key stakeholders

- Please describe the [organizational] structures of the innovation program you participate in.
- Please give an example of how knowledge transfer takes place in the region.
- Can you describe how learning processes are induced in the innovation program you participate in?

Section 2: Innovation processes

- Please describe what kind of innovations have already been developed so far.
- Please describe what kind of innovations are currently being developed.
- Please describe your role in an [exemplary] innovation process.

Section 3: Evaluation and assessment of results

- How do you evaluate your activities and results in the innovation program?

Section 4: The regional innovation system

- Please describe special features of the regional innovation system.
- What are the barriers to knowledge transfer and innovation in the region?

Section 5: Sustainable development

- What role does sustainable development play in your organization / for your role?
- What is the importance of innovations related to sustainable development for you?
- What contributions to sustainable development do you see through the innovation program and the resulting innovations?

D) Online survey questionnaire

Q1) What are the top 3 goals of your institution or department?

- Strengthen regional innovation capacity (1)
- Expand regional networks (2)
- Improve collaboration between individual industries (3)
- Bring together people from science and practice (4)
- Provide consulting services for innovators (5)
- Establish long-term transfer structures (6)
- Develop a regional culture of cooperation (7)
- Transform socio-technical systems (e.g., regional mobility) (8)
- Contribute to sustainable development (9)
- Change established practices at companies & organizations (10).
- Strengthen regional business location (11)
- Other: (12)

Q2) Which of the following categories, in terms of your institution's/department's focus, do you believe is most true?

- Focus on comprehensive contributions to strengthen (regional) economic development. (1)
- Primary focus on strengthening (regional) economic development but with special attention to sustainable development. (2)
- Primary focus on contributions to sustainable development but with special attention to (regional) economic development. (3)
- Primary focus on comprehensive contributions to sustainable development. (4)

Q3) In which of the following areas do you think your institution/department makes the greatest contribution?

- The promotion of (regional) economic development. (1)
- The promotion of technical development. (2)
- Promoting sustainable development. (3)
- To promote social development. (4)
- Other: (5)

Q4) Does your institution have an overarching sustainability strategy?

- o Yes. (1)
- o No. (2)
- o I am not aware of it. (3)

Q5) Are there specific goals or implementation measures designated in your institution/department to promote sustainable development?

- o Yes. (1)
- o No. (2)
- o I am not aware of any. (3)

Q6) In what is an orientation of your institution/department towards sustainable development reflected? (Multiple answers possible)

- Sustainability strategy (1)
- Transfer strategy (2)
- Objectives of individual projects (3)
- Mission, vision, or guiding principles of the institution (4)
- Project application/application for funding (5)
- The name of the institution is related to sustainable development (6)
- Not known to me. (7)
- Other (8)

Q7) Have steps been taken within your institution/department or higher-level organization to make direct contributions to sustainable development itself?

- o Yes. (1)
- o No. (2)
- o Not known to me. (3)

Q7.1) What steps have been taken within your institution/department or higher-level organization to contribute directly to sustainable development?

- Implementation of a sustainability strategy (1)
- Saving resources (energy, paper, etc.) (2)
- Implementation of sustainability management (3)
- Educational work on sustainable development (4)
- Structural changes (insulation, etc.) (5)

- Involving external sustainability consulting (6)
- Sustainable procurement (7)
- Establish interdisciplinary working groups (8)
- Reflection (9)
- Quality management (10)
- Other: (11)

Q7.2) Do you, as an institution or department, actively share your experience and knowledge of these internal change processes related to sustainable development with interaction partners?

- Yes. (1)
- No. (2)
- Not known to me. (3)

Q7.3) Can you observe that these change processes are adopted by interaction partners or motivate them to contribute to sustainable development themselves in other ways?

- Yes. (1)
- No. (2)
- Not known to me. (3)

Q7.4) More specifically, are these change processes more likely to be adopted by your interaction partners or are they more likely to be motivated by your actions to contribute to sustainable development in their own way?

- There is more of an adoption of the change processes and actions we have taken. (1)
- It is more likely that our interaction partners are motivated to contribute to sustainable development in their own way. (2)
- Both, adoption and motivation, are observed in about equal proportions. (3)
- Not known to me. (4)

Q8) Please indicate how strongly you believe the following statements apply to your facility/department.

	Does not apply (1)	Tends not to apply. (2)	Tends to apply (3)	Applies (4)
We set a good example in terms of sustainability. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is very important to us that there are role models when it comes to sustainability. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Our activities and operations make a particular contribution to sustainable development in the region. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For us, the integration of already existing initiatives and networks is elementary in order to be able to make our contribution to sustainable development. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For us, repeated cooperation with regional actors is crucial to strengthen their competences in sustainable development. (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Building a network specialized in sustainable development is particularly important to us. (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q9) Below are three activity priorities that often play a role in promoting sustainable and economic development. Please rank the three activities in terms of importance to the work of your institution/department. The most important should be at the top and the least important should be at the bottom.

Education and information (e.g., event planning, communication) (1)

Network development and matching (e.g. bringing together and arranging relevant contacts) (2)

Implementation support (e.g. monitoring and steering of innovation projects and processes) (3)

Q10) Please indicate how frequently you estimate the following formats are used for transfer activities at your institution/department.

	frequently (1)	occasionally (2)	rarely (3)	never (4)
Lectures (e.g. by experts on specific topics) (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
On-site appointments with companies / organizations (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Workshops (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scenario processes with stakeholders (scenario technique) (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contact talks with companies / organizations (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contacting-talks with researchers (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Consulting / acquisition of funding (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Workshop/laboratory talks (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Networking events (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Conferences (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trade fairs (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Action days/weeks (12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Exhibitions (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Award ceremonies (14)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
other: (15)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q11) In the following, we show you four blocks in which two statements are always juxtaposed. In between, there are five options to select which of the statements you think (rather) applies to your institution/department.

	applies	rather applies	neither	rather applies	applies	
	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	
We connect business and science.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	We involve the civil society (foundations, cultural institutions, schools, associations, etc.) in innovation processes.
We address individual problems with individual companies and experts.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	We form dedicated working groups on challenges for society as a whole with researchers and practitioners who can contribute to a solution.
We want to offer the possibility to develop and legitimize solutions for societal challenges through joint cooperation.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	We specifically interconnect researchers and practitioners who can develop a solution to specific innovation challenges faced by individual actors.
Individual innovation challenges that have come to our attention provide the driving force for our transfer activities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	The drive for our transfer activities comes from challenges we have identified for society as a whole.
We primarily want to develop an understanding of problems.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	We primarily want to provide solutions to problems.
Participants in our formats should become change agents and be able to contribute to systematic solutions to societal challenges.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Participants in our formats should become innovators and be able to overcome individual innovation challenges.
We actively and specifically approach potential cooperation partners for innovation projects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	We offer a comprehensive range of services to support innovation projects and make these available on request.
We select participants specifically based on the potential significance of their contribution to our project goals.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	We do not select participants specifically, but design projects for broad participation.
We support innovation processes through close monitoring and moderation.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	We support innovation processes by identifying potentials and matching people.
The primary purpose of our transfer activities is to be participatory.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	The primary purpose of our transfer activities is to be informative.
For us, the ability to moderate innovation processes and projects is important.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	For us, the ability to induce innovation processes and projects is important.
Our regional network should be as diverse as possible.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Our regional network should be as extensive as possible.
Participants should gain skills through collaboration to be able to drive change beyond our projects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Participants should receive support through collaboration to successfully complete projects.
We want to enable long-term cooperation from the collaboration with regional stakeholders.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	We want to involve as many different regional players as possible in a cooperation.

Q12) Which of the following statements do you think best describes the orientation of your institution/department?

- o Comprehensive focus on joint development of solutions to challenges facing society as a whole (e.g., local mobility). (1)
- o Primary focus on joint development of solutions for challenges facing society as a whole, with a secondary objective of cooperation on individual challenges (e.g. optimization of production or communication processes). (2)
- o Primary focus on supporting cooperation on individual challenges (e.g. optimization of production or communication processes) with the secondary goal of jointly developing solutions for challenges facing society as a whole (e.g. local mobility). (3)
- o Comprehensive focus on supporting cooperation on individual challenges (e.g. optimization of production or communication processes). (4)

Chapter IV:
**Paving the way for sustainability transitions? Supportive
potentials of university-related intermediaries in regional
innovation systems**

with Simon J. Winkler-Portmann and Daniel Feser

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Paving the way for sustainability transitions? Supportive potentials of university-related intermediaries in regional innovation systems

Abstract

Research on intermediaries in transitions has neglected the role of university-related intermediaries in supporting sustainability transitions at the regional level. Conducting a multiple case study comprising 86 interviews in four German regional and higher education institution (HEI)-led innovation programs, we show that HEI-related intermediaries are involved in roles and activities that are predominantly attributed to systemic and regime-based transition intermediaries. Extending and adapting activities, we find HEI-related intermediaries pave the way for sustainability transitions in two ways: First, by performing roles and activities of transition intermediaries, they foster and mobilize potentials of regional innovation systems and thereby indirectly improving preconditions to enable change processes. Second, they directly induce impulses for sustainability transitions introducing concrete strategies and projects by using inclusive methods that allow for co-creation by diverse sets of regional stakeholders. Therefore, we argue that regional-level HEI-related intermediation should be considered in the design and implementation of transformative innovation policy.

Keywords

Intermediaries, sustainable development, sustainability transitions, innovation policy, regional innovation systems

JEL

O32, O38, Q58, R11

Introduction

The ‘wicked’ sustainability problems (Urmetzer et al., 2018) leading to current societies crossing multiple planetary boundaries (Steffen et al., 2015) call for fundamental changes, i.e. sustainability transitions (Markard et al., 2012). Intermediaries play an important role in accelerating (Gliedt et al., 2018) and facilitating (Kivimaa et al., 2019a) sustainability transitions. The contributions of intermediaries to sustainability transitions have been discussed extensively in the literature. Studies have looked at intermediation in sustainability transitions of specific socio-technical systems such as building and construction (Lazarevic et al., 2019; Kivimaa et al., 2020; Vihemäki et al., 2020), energy (Rohracher, 2011; Mignon and Ebers Broughel, 2020; van Boxstael et al., 2020), or shipping (Bjerkan et al., 2021). Intermediary roles have been identified in relation to how they contribute to sustainability transitions on different system levels (van Lente et al., 2003; Smith, 2007; Kanda et al., 2020; Sovacool et al., 2020; Ehnert et al., 2022) and in different phases of transitions (van Lente et al., 2011; Kivimaa et al., 2019b). Other scholars have examined intermediaries’ contribution to specific aspects of sustainability transitions, e.g. activism (Matschoss and Heiskanen, 2017), or policy change (Kivimaa et al., 2020). Research on intermediation in transitions led to the identification of ‘transition intermediaries’ (Kivimaa et al., 2019a). Further, a typology of transition intermediaries by Kivimaa et al. (2019a) differentiates between systemic, regime-based, niche, process, and user intermediaries. Based on a systemic literature review on intermediation in transitions, the typology covers a broad set of exemplifying actors ranging from national innovation agencies to building managers but is not listing nor considering higher education institutions (HEI) such as universities as transition intermediaries (Kivimaa et al., 2019a).

For this reason, an analysis of the potentials of higher education institutions to contribute to sustainability transitions through intermediation is lacking. HEI-related intermediation has mainly been examined with regard to its role in the commercialization of academic knowledge and the promotion of

knowledge exchange (Yusuf, 2008; Clayton et al., 2018). Moreover, HEIs are regarded as not suitable to address societal challenges, as they are found to lack the ability to open-up innovation processes (Parks, 2022). However, sustainability has already become an important field of action for HEIs in recent years. Dealing with sustainability challenges becomes relevant for HEIs with regard to education (Mehling and Kolleck, 2019), but particularly with increased transfer activities serving their “third mission” (Nölting et al., 2020). This includes technology transfer (Kivimaa et al., 2017), as well as collaboration with industry (Orecchini et al., 2012) and other sectors (Mehling and Kolleck, 2019), or even co-creation with government, industry and civil society (Trencher et al., 2014). Nevertheless, research on contributions of knowledge transfer of HEIs to regional transition processes remains scarce (Kivimaa et al., 2017).

Moreover, taking into account that transitions are localized and place-dependent (Hansen and Coenen, 2015), requiring action not only at the national, but also at the regional and local level (Tödtling et al., 2021), regional innovation systems are of particular interest for sustainability transitions. Serving their “third mission” and disseminating academic knowledge throughout surrounding regions, HEIs are important actors in regional innovation systems. Though regional bottom-up approaches are considered more recently (Isaksen et al., 2022), with few notable exceptions, e.g. Mattes et al. (2015) on energy transitions, regional innovation systems have also not played an important role in research on sustainability transitions. As regional innovation systems incorporate structures for knowledge and technology transfer, it should be analyzed how they can enable sustainability transitions. Furthermore, roles of HEIs in regional development processes have been assessed mostly from an economic perspective, but not with regards to sustainability transitions (Radinger-Peer et al., 2021) and research on contributions of innovation intermediaries to regional transition processes considering their involvement in strategic niche management remains scarce (Kivimaa et al., 2017). Moreover, except for Pflitsch and Radinger-Peer (2018) and Wolf et al. (2021), there are no systematical analyses of the context of academic knowledge transfer in sustainability transitions.

As HEIs are important actors in regional innovation systems, this article connects the acknowledged roles and activities of transition intermediaries (Vihemäki et al., 2020) in facilitating change processes towards sustainability with existing HEI-related intermediation in regional innovation systems to explore their transformative potentials. Using a multiple-case study approach based on 86 semi-structured interviews it addresses the research question: *How do HEI-related intermediaries in regional innovation systems pave the way for sustainability transitions?*

This paper analyzes how HEI-related intermediaries make possible contributions to sustainability transitions through their activities and networks – or even (re-) organize themselves. This not only includes HEI-related intermediaries explicitly focusing on sustainability, but also such cases primarily focused on economic or societal development of their regions. The theoretical part reviews roles of intermediaries in regional innovation systems as well as in transitions and introduces the applied analytical framework. Following, case and data sampling strategy as well as conduction of content analysis are elaborated. In its empirical part, the article analyses four regional innovation systems in Germany with their HEI-related intermediaries regarding their sustainability-oriented activities, comparing them to roles of intermediaries in transitions. Taking a multi-case study approach, it takes a close look at possibilities and barriers of intermediaries in their regional contexts. The conclusion draws a line back to the roles of intermediaries in transitions, showing how HEI-related intermediaries pave the way for sustainability by creating valuable preconditions and inducing change processes, and by taking over roles of systemic and regime-based transition intermediaries.

Literature background and analytical framework

Starting from the initial framing as ‘consultants in technology transfer’ (Bessant and Rush, 1995), a significant attention in research over the last two decades could broaden the depicted roles of intermediaries in innovation processes (Howells, 2006; Yusuf, 2008; Nauwelaers, 2011; Bergek, 2020) and in sustainability transitions (van Lente et al., 2003; Kivimaa et al., 2019b). This connects to research

on innovation intermediaries (Howells, 2006), acting as knowledge brokers and network creators in innovation systems on national (Lundvall, 1995, 2007) or regional levels (Cooke et al., 1997; Cooke, 2010). *Innovation intermediaries* are understood as organizations that act “as an agent or broker in any aspect of the innovation process between two or more parties” (Howells, 2006, p. 720). They seek to enhance the productivity, connectivity and functionality of innovation systems and thereby the innovative capacity of their regions, nations or sectors (Nauwelaers, 2011; Dalziel and Parjanen, 2012).

Innovation intermediaries take various roles in innovation systems from identifying needs of companies and articulating them to supporting collaborations (Howells, 2006; Nauwelaers, 2011; Dalziel and Parjanen, 2012). Their activities are mostly directed at companies, although results may also impact other actors in the innovation system (Dalziel and Parjanen, 2012). In their brokering role, innovation intermediaries create networks connecting different actors of the innovation system, especially economic actors and research communities, for collaborations (Howells, 2006; Nauwelaers, 2011; Dalziel and Parjanen, 2012). These networks can be complex with intermediaries connecting multiple actors, both vertically and horizontally, for a collaboration, seeking to establish long-term relationships (Howells, 2006). Intermediaries also support collaborators, e.g. by organizing advice and providing funding support (Howells, 2006; Nauwelaers, 2011; Dalziel and Parjanen, 2012), and more directly by supporting technological development in testing and validation throughout prototyping, piloting and configuration (Howells, 2006; Stewart and Hyysalo, 2008). Supplementing these bilateral and multilateral connections, *systemic (innovation) intermediaries* act at system or network levels, orchestrating collective innovation activities of a broader set of actors around a shared vision (van Lente et al., 2003; Janssen et al., 2020). In connection to the concept of innovation intermediaries, studies have also analyzed how intermediaries support incremental contributions to sustainability such as ‘eco-innovation’ (Kanda et al., 2018), sustainability-oriented innovation’ (Kant and Kanda, 2019) or ‘green innovation’ (Gliedt et al., 2018), e.g. by helping to diffuse renewable energy technology (Bergek, 2020).

Various actors can take the role of an innovation intermediary. This can be business incubators, technology parks, (regional) economic development agencies directly installed with the purpose to enable innovation or established organizations taking this role, such as industry and trade associations or chambers of commerce (Dalziel and Parjanen, 2012). Transfer units of HEI, e.g., aim to create transfer ecosystems (Miller and Acs, 2017; Breznitz and Zhang, 2019; Lahikainen et al., 2019) and to strengthen formal and informal linkages between HEIs and industry (Siegel et al., 2003; Debackere and Veugelers, 2005; Radinger-Peer and Pflitsch, 2017). They often act as *knowledge intermediaries*, which facilitate knowledge exchange between academic (HEI) and non-academic actors, thereby fostering commercialization of academic knowledge (Macho-Stadler et al., 2007; Siegel et al., 2007; Clayton et al., 2018). In that sense, they act as an intermediary hybrid which primarily represent aims of their HEI. However HEIs also contribute to innovation systems, e.g. by promoting entrepreneurship (Di Gregorio and Shane, 2003; Wright et al., 2004; Markman et al., 2005; Rothaermel et al., 2007).

Intermediaries support and accelerate change processes in socio-technical systems (van Lente et al., 2003; Kampelmann et al., 2016; Gliedt et al., 2018; Kivimaa et al., 2019a). In this context, supportive functions of intermediaries to sustainability transitions have been identified, such as strategy development (Hodson and Marvin, 2012; Hamann and April, 2013; Cramer, 2020), vision building (van Lente et al., 2003; Kivimaa, 2014; van Boxstael et al., 2020), knowledge brokering (Barnes, 2019; Kanda et al., 2019; Janssen et al., 2020; van Lente et al., 2020) and networking (Fischer and Newig, 2016; Gliedt et al., 2018; Kanda et al., 2020; Loorbach et al., 2020), exchanging knowledge (Kemp et al., 1998; Frantzeskaki et al., 2019), fostering knowledge dissemination (Fischer and Newig, 2016; Hyysalo et al., 2018; Sovacool et al., 2020), and building institutions (Horne and Dalton, 2014; Bush et al., 2017; Kivimaa et al., 2019b). The concept of ‘transition intermediaries’ has been synthesized as “*actors and platforms that positively influence sustainability transition processes by linking actors and activities, and their related skills and resources, or by connecting transition visions and demands of networks of actors with existing regimes in order to create momentum for socio-technical system change, to create new collaborations within and across niche technologies, ideas and markets, and to*

disrupt dominant unsustainable socio-technical configurations” (Kivimaa et al., 2019a, p. 1072). Although this definition is not uncontested, importance of intermediaries for transitions processes is generally emphasized in transition research (Manders et al., 2020).

Transitions are complex processes that can take decades. Early stages are characterized by experimentation and learning with niche innovation under high uncertainty (Geels, 2019). In this phase, intermediaries are important to create momentum and conditions for niches, as they connect actors and translate and disseminate knowledge (Kivimaa et al., 2019b). They involve in the creation of niches (Matschoss and Heiskanen, 2017), trigger interaction within niches (Hargreaves et al., 2013; Kivimaa, 2014; Seyfang and Longhurst, 2016), coordinate partnerships across niches (Bush et al., 2017; Kivimaa et al., 2019a) and organize cross-level regime-niche interaction (Smith, 2007; Audet and Guyonnaud, 2013; Gliedt et al., 2018; Cramer, 2020). In this context, the concept of strategic niche management helps to understand the introduction and diffusion of sustainability innovations from niches (Giganti and Falcone, 2022). Strategic niche management “is the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology” (Kemp et al., 1998, p. 186). Intermediaries empower niches by contributing to niche-internal processes (Kivimaa, 2014). Engaging in a broad set of intermediation activities to facilitate change, they support (1) articulation of expectations and visions, (2) building of social networks, (3) learning processes and (4) other processes (Vihemäki et al., 2020) (see Table 1). Taking into account the level at which a transition intermediary operates, five not mutually exclusive types can be distinguished: systemic, regime-based, niche, process, and user intermediaries (Kivimaa et al., 2019a) that also differ in attributed intermediation activities.

Table 1: Analytical framework showing the activities of types of transition intermediaries in fulfilling certain roles (Own depiction following Vihemäki et al. (2020)).

Roles of transition intermediaries	Activities of transition intermediaries	Type of transition intermediary				
		Systemic	Regime-based	Niche	Process	User
Articulation of expectations and visions (1)	Aligning niche performance with prevailing policy discourses			x		
	Articulating demands of the users					x
	Articulation of needs, expectations, requirements	x	x			
	Assisting others in articulating the direction of change				x	
	Campaigning, advocating, (targeted) lobbying			x		
	Influencing political vision building	x	x	x	x	x
	Promotion of sustainability related aims	x	x	x		
	Speed up application and commercialization of new technologies	x	x			
	Strategy development	x				
Building of networks (2)	Aligning actors (or their interests) and options	x	x			
	Brokering and gatekeeping	x	x			
	Connecting experimental projects			x		
	Creating and managing networks informing the government		x		x	x
	Creating and managing networks to lobby for transition oriented policies			x		
	Developing connections between groups of actors				x	
	Facilitate vertical and horizontal cooperation				x	

	Facilitating between the niche and dominant configurations			X		
	Facilitating co-operation between actors	X				
	Facilitating policy dialogue (e.g. policy forums)			X		
	Formation of knowledge sharing networks, e.g. platforms					X
	Negotiating between interests and priorities to create a consolidated vision			X		
	Network creation and facilitation	X				
	Network creation, including with other types of intermediaries		X			
	Providing, managing or finding funding	X	X			
Learning processes and exploration (3)	Advancing exchange of information				X	
	Advice and support	X	X	X		
	Collecting evidence for key policy issues			X		
	Configuring innovations					X
	Creating conditions for learning by doing and using	X				
	Dissemination	X	X	X	X	
	Education and Training	X	X			
	Investments in new businesses	X	X			
	Knowledge gathering, processing, generation and combination	X	X	X		
	Prototyping and piloting	X	X	X		
	Qualifying the characteristics and suitability of innovations for various contexts					X
	Technology assessment and evaluation (for policy development)	X	X			
Other roles (4)	Advancing day-to-day activities to advance transitions				X	
	Arbitration (based on neutrality, trust)	X	X			
	Brokering between different organizational or local-national priorities				X	
	Developing shared infrastructure between projects			X		
	Identifying, mobilizing actors	X				
	Influencing new legislation and standard setting		X	X		
	Job creation	X				
	Managing external relations of the projects				X	
	Policy design		X			
	Policy implementation	X	X			
	Policy support			X		
	Policy translation		X			
	Project design, management, evaluation (e.g. complex, long-term innovation projects)	X				
	Providing professional services			X		
	Representing users at the niche-regime interfaces					X
	Seeking consensus, organizing discourse	X				
Standard creation and accreditation			X			
Translating new technologies to users					X	

Methodology

In order to gain in-depth insights into the roles and activities of HEI-related intermediary structures in their regional context, this paper uses the multiple-case study methodology of Yin (2018). A case study methodology fits to the exploratory nature of the research question and the literature. It additionally allows a detailed analysis of the specific context in which intermediaries conduct their activities. By choosing multiple cases, general assumptions can be clarified. Thus, this multiple case study can further theoretical insights (Eisenhardt, 1989) on the roles and activities of HEI-related intermediaries with regards to sustainability transitions. The following sections describe the selection of cases (3.1), the gathering of the empirical basis (3.2) and explain which steps are taken in the analysis (3.3) to answer the research question.

Selection of cases

The analysis includes four cases of publicly funded projects supporting knowledge transfer and innovation with universities as coordinators in four regions of Germany. Innovation on the regional level has been in the focus of recent innovation policy in Germany, with funding programs aimed at that direction (Eickelpasch and Fritsch, 2005). Also, several authors analyzing sustainability transitions and directionality have chosen a regional scope (Mattes et al. 2015; Grillitsch et al. 2019; Pflitsch and Radinger-Peer 2018).

For the selection of cases, we reviewed current funding programs for regional innovation initiatives in Germany with the aim of obtaining a heterogeneous sample with varying degrees of orientation towards sustainability. Two cases, Darmstadt (A) and Eberswalde (B), explicitly focus on sustainability, while the other two, Augsburg (C) and Göttingen (D) primarily aim to contribute to regional development.

Empirical basis

To analyze the four cases, the research team conducted 86 explorative in two rounds (see Table 2 for an overview and Appendix A) Interviews for the full list): In 2020, the team interviewed 61 intermediaries involved in four regional innovation systems. The interviewees represent the diversity of intermediaries in each case. The selection followed the principles of purposeful sampling, including a comparable set of actors from academia, economy and industry, public administration, and civil society for each case. The interviewed intermediaries act on various operational levels and positions. For academia, this includes lecturers, technology transfer office members, consultants and innovation managers in universities. Representatives of the chambers of trade and commerce or crafts, as well as industry associations, represent the economy and industry helix. For the consideration of public administration, the sample includes business development agents and innovation managers of the municipalities. As intermediaries from civil society, the team interviewed board members of foundations and societies.

For the second round of interviews in 2021, the team interviewed 25 innovators that are related to the intermediary structures of the first interview round in order to represent their perspectives on the innovation initiatives they collaborate with. This includes companies from different sectors such as food retail, software developing, construction, consulting, leather production and bicycle manufacturing. In addition, actors from civil society were interviewed, such as theaters, social initiatives and schools. The interview material gathered was sufficient to reach theoretical saturation (Glaser and Strauss, 2017).

Table 2: Case overview and number of interviews per region

Case	A	B	C	D
Region	Darmstadt	Eberswalde	Augsburg	Göttingen
Characteristic	Urban	Peripheral	Urban	Peripheral
Assessed initiative	<i>s:ne</i>	<i>region 4.0</i>	<i>HSA_transfer</i>	<i>SNIC</i>
Focus	Focus on system innovation for sustainability	Focus on regional sustainability transition	Focus on building networks for societal benefits	Focus on innovativeness of region
Number of Interviews with Intermediaries	17	17	13	14
Number of Interviews with participating innovators	7	5	8	5
Total number of Interviews	24	22	21	19

The interviews were semi-structured through guidelines (Yin, 2011). The guidelines were composed of open questions, using guiding questions for each section, with follow-up questions to ensure the reflexivity of the interviews. The guideline of the first round (Appendix B) asked questions about the structures and characteristics of knowledge transfer, the involved actors, innovation processes, the embedding of the program in the regional context, and contributions to sustainable development. For the interviews in 2021, the guideline (Appendix C) started with questions on the organization of the interviewee including the business model, markets, long-term objectives and the role of innovation and sustainability. Similarly to the 2020 interviews, the guideline inquires about the embedding of the organization in the region. The main focus was however on the cooperation with the intermediary structure, including the initiation, the process, involved actors, goals, as well as challenges. The guidelines were not rigorously adhered to (in contrast to surveys with questionnaires), but rather adapted to the specific flow of the individual interviews in line with the exploratory nature of the research question.

Due to the COVID-19 pandemic, all interviews, except one, were conducted via online video conferencing tools or telephones. The material was recorded and transcribed. In addition to the interviews, internal documents as well as reports and published information were collected and evaluated. These formed the basis in particular for determining to what extent and in what way the intermediary structures are oriented towards sustainability.

Data analysis

The transcripts as well as the internal documents, reports and the published information are analyzed based on qualitative content analysis (Mayring, 2015). The chosen approach uses a mix of deductive and inductive codes. Deductive codes have been developed on the basis of the framework transition intermediaries' roles (see Table 1): 'articulation of expectations and visions', 'building of networks', 'learning processes and exploration', as well as 'other roles' (Vihemäki et al., 2020). Inductive coding supplements the activities related to these roles. The inductive coding follows the exploratory nature of the research question and acknowledges the differences of the cases to transition intermediaries. At the same time, the deductive codes assure comparability between the cases and with existing literature. The resulting set of codes was discussed between the authors. Several workshops with the interviewed and

other stakeholders from the cases discussing preliminary findings provided feedback and allowed the team to refine insights.

Results

The four cases differ in the conditions of the regional innovation systems and in the goal sets of the analyzed programs as well as in the specific roles and activities the intermediaries fulfill. Each case is described separately, with a discussion consolidating the results in relation to the typology of intermediaries.

Case A: Darmstadt / “s:ne”

The city of Darmstadt is located in the Frankfurt metropolitan area in the middle of Germany. It is characterized by an extensive university and research landscape. Next to several smaller HEI and research institutes, Darmstadt University of Applied Sciences (‘h_da’) and Technical University Darmstadt (‘TUD’) are the most important HEI. With the TUD being one of the leading universities in Germany for engineering, the h_da gives more attention to its economic, social, media and design departments.

The analyzed program ‘s:ne’ (*system innovation for sustainable development*) started in 2018 as part of the “Innovative University” funding initiative by the federal states and the Federal Ministry of Education and Research. Pursuing the goal of creating and applying mutual transformative knowledge transfer activities to foster learning processes and sustainability transitions with partners from industry and civil society, project ‘s:ne’ has a strong orientation towards sustainability. Aiming towards innovating socio-technical systems, it developed an innovation and transfer platform as core element to initiate cooperation and to support participating actors align visions and implement projects on sustainability challenges. Project partners include actors that especially engage in sustainability transitions, e.g. the Institute for Applied Ecology.

Regarding the *articulation of expectations and visions*, interviews show that intermediaries in ‘s:ne’ mainly take two roles. Firstly, intermediaries ask innovators who are generally interested in collaborating which challenges they encounter with regards to sustainability and where they see potential solutions. Perspectives of different actors are picked up for collaborations and articulated within the process of developing a strategy as well as aligning the actors. Intermediaries thereby fulfil the ‘articulation of needs, expectations and requirements’ role. Secondly, the intermediaries fulfil the ‘strategy development’ role by supporting innovators of a specific socio-technical (sub-)system to cooperatively develop a strategy towards sustainability. They organize strategy workshops with actors of these subsystems, e.g. the leather supply chain. The ideas resulting from these workshops are further formulated into a ‘theory of change’ including success indicators. The importance of innovators following through on that strategy has been underlined by one of the interviewees by saying: *“that’s very important, a commitment from the people, that we want to develop solution options together with you there as well”* (Interview 9, item 32).

For *building of networks*, intermediaries of ‘s:ne’ focus on developing connections between groups of actors and aligning their interests, therefore negotiating between interests and priorities. When ‘developing connections between groups of actors’, intermediaries are strategically oriented towards sustainability. They select actors from a specific socio-technical (sub-)system which are seen as relevant to solve identified sustainability problems. Furthermore, actors are selected on whether they are motivated to participate. One interviewee described it as: *“What is important is that you have a core team of actors who want to work together on a solution development process”* (Interview 9, item 36). The selectiveness also is also shown in the ‘providing or managing funding’ role, as the collaboration is only funded if it is directed towards the sustainability-oriented goal sets of the ‘s:ne’ project. For ‘aligning actors (or their interests) and options’, ‘s:ne’ intermediaries actively moderate the cooperation, especially by developing a common understanding of the sustainability problem with the actors of the respective socio-technical (sub)system. This process starts with organizing input from experts which

explain possible problems. Actors then exchange positions and expectations with intermediaries aiming to underline the necessity of coming to a common understanding. The momentum of actors understanding the dimensions of the sustainability problem is used to establish collaborations, starting with a strategy.

With regards to *learning processes and exploration*, intermediaries in the ‘s:ne’ program support prototyping and piloting of sustainability-oriented innovation by enabling actors to develop solutions for identified sustainability problems. They also support in configuring innovations, e.g. a vehicle for sustainable commuting, by exploring the user perspective and help innovators identify impediments for their change processes. By conducting surveys with local citizens, the program qualifies the suitability of sustainability solutions for its local context. In addition, the intermediaries ‘advance the exchange of information’ through several activities. They create situations for actors relevant for a specific sustainability problem to contribute their experience and expertise to the innovation process. Within the transdisciplinary cooperation, knowledge is thus transferred between all actors in multiple directions: *"that's where new questions come in to academia and at the same time, however, impetus can be given from academia to practice"* (Interview 5, item 47). The intermediaries try to ‘create optimal learning conditions’ for actors in these cooperation, helping them to learn together in developing solutions. In addition, intermediaries also help educate and train actors by informing about preconditions for sustainability-oriented change.

Other roles which intermediaries within the ‘s:ne’ program fulfill are ‘advancing day-to-day activities to advance transitions’ and ‘identifying, mobilizing actors’. As for the former, intermediaries create impulses for sustainability-oriented change within their own HEI. One interviewee described the motivation as: *"we are concerned with actually advancing change processes in the direction of sustainable development, on the one hand, and aligning the university, and what it teaches, with that as well, and of course research anyway"* (Interview 1, item 31). Identifying and mobilizing actors is a key activity of intermediaries in the ‘s:ne’ program. They identify operating fields for collaborations for which they see potential for sustainability-oriented change, car-intensive urban commuting for instance. In a second step, they conduct an actor mapping to identify actors in the field which are relevant for change processes and should thus participate in vision and strategy building. For successfully mobilizing actors, intermediaries analyze specific motivations and challenges of actors, trying to find an angle which helps actors to see a need for change. The collaboration can then be presented as an opportunity.

Case B: Eberswalde / “region 4.0”

The city of Eberswalde is located in the north-eastern part of the federal state of Brandenburg. The rural county in between the metropolitan areas of Berlin and Stettin is characterized by agriculture and small and medium enterprises except for a limited number of petrol and chemical industries. Additionally, there are large biosphere reserve areas that are sparsely populated, but are nature sights that are used to offer touristic services.

The program assessed is ‘region 4.0’. It aims to establish a transdisciplinary regional innovation network supporting sustainability-oriented innovation. It is led by Eberswalde University for Sustainable Development (‘HNEE’) which is the central actor for knowledge transfer and innovation support in the rural region. As a unique feature, starting in the late 1990s the university has comprehensively converted its educational, scientific and transfer activities in order to consider sustainable development, expressed e.g. by the renaming of the university in 2010. Referring to the direction towards sustainability a representative of region 4.0 stated *"I don't know if I do anything that is not always reflected in terms of sustainability. So I would say that the most important point for us is that we think about sustainable development from the ground up and have incorporated it into the project [...]"* (Interview 30, item 47). The program comprises three fields of actions that represent the regional endowments and were developed jointly with regional actors that also are participants of the alliance formed by launching ‘region 4.0’. Important regional partners are regional business development agencies, the regional transport company as well as the municipality utility company.

Regarding the role of *articulation of needs, expectations and requirements*, intermediaries brought up the fields of action they developed considering potentials for sustainability-oriented change that fit regional conditions. Referring to conditions and actor's needs, they articulated demands of regional actors. Using participatory workshops, intermediaries help regional actors to find direction for change, by supporting them in identifying problems and formulating questions regarding regional sustainability issues. Additionally, vision building was supported in preparation of the launch of project 'region 4.0' by conducting an analysis of regional potentials that created the basis for developing fields of action and a regional strategy to foster sustainability-oriented innovation. Furthermore, the internal conversion strategy towards sustainability of the university includes a strong emphasis on role modelling and promoting sustainability related aims through knowledge transfer. This strategy fundamentally informs roles and activities of intermediaries. Acting as role models, intermediaries spread sustainable day-to-day practices, e.g. resource saving, or induce change processes cooperating with regional actors. Through close cooperation with municipalities for example, intermediaries aim to influence political vision building. Innovation creation is supported by taking impulses from universities' research and matching involved researchers with regional actors to induce innovation processes. By inducing, supporting and accompanying innovation processes that are based on sustainability oriented research, they help to speed up the application and commercialization of new technologies and processes.

Referring to itself as an innovation network, the role of *network building* is of special importance. With implementation of 'region 4.0', new networks are built and existing ones are expanded. Network building efforts concentrates on including societal actors, pooling networks through cooperation with other regional intermediary actors and implementing a "culture of cooperation". To enhance cooperation and exchange of information in transfer and innovation activities the university introduced a knowledge transfer advisory board involving regional actors such as the chamber of commerce, county municipalities or churches. Additionally, a regional fair is organized jointly and periodic meetings are held. The intermediaries use participatory methods, e.g. workshops, to align visions, understandings of sustainability and to develop strategies. The used formats include societal actors, e.g. foundations, clubs or churches, as well as actors from municipalities, industries or academia to ensure a broad basis of acceptance for jointly developed solutions and change processes. Moderated by intermediaries, the participatory approach take into consideration heterogeneity of actor groups. It enables exchange and discussion of interests and options among actors in order to resolve conflicting interests, align visions and bundle sustainability efforts. One interviewees elaborated: "*And the important thing is to strive for a participatory exchange in order to resolve precisely these conflicting goals. And yes. And to find solutions.*" (Interview 40, item 137). To facilitate cooperation between groups of actors the intermediaries accompany and moderate innovation processes. Combining their theoretical and practical knowledge, they act as "translators" between interdisciplinary groups of actors. They lower cooperation thresholds bringing together different groups of actors in events hosted by the intermediaries, e.g. volunteer days or city cleanups, to make them familiarize with each other. Regarding the role of finding funding, intermediaries support actors by offering funding consultancy or forwarding actors to funding experts. Intermediaries also act as brokers and gatekeepers. Making contacts, they match innovative actors from their regional networks and knowledge on actors and existing projects.

Intermediaries of project 'region 4.0' pave the way for change processes by improving and offering conditions for *learning and exploration*. The university established the research center "Sustainability, Transitions and Transfer" that aims to advance the HEI's capabilities to align transfer activities with the goal to contribute to sustainability. Learning through mutual information exchange and knowledge transfer as well as problem orientation is crucial to project 'region 4.0' supporting sustainability. One interviewee pointed out: "*We are very interested in the problems and challenges that companies or stakeholders have and bring to us. And this exchange, this two-way exchange, is actually the actual transfer.*" (Interview 27, item 7). Learning is also facilitated by programs that allow actors to switch roles, e.g. entrepreneurs and professors. Knowledge exchange is fostered by best-practice show cases and on-site events. Intermediaries cooperate with researchers and actors in innovation processes. Connecting multiple regional actors, they make possible pilot projects, e.g. delivery services via public

transportation. Additionally, innovations are configured bringing together innovators and users, e.g. by matching developers of a pesticide-free weed control system with farmers. Intermediaries closely accompany processes as moderators and motivators as well as project managers. They offer support services reaching from professional research to organizational advice. In 'region 4.0', innovation support is not limited to individual enterprises but involves several actors and stakeholders that potentially benefit from innovative technologies or practices.

Two *other important roles* intermediaries fulfill are the sensitization for sustainability and the identification and mobilization of actors. The constant engagement with sustainability during events, cooperation and projects due to orientation of the university and the project familiarize participants and regional actors with problems and challenges of sustainability. Identifying potential participants on the basis of strategic considerations and actively inviting them, they mobilize relevant regional actors to involve in projects and cooperation.

Case C: Augsburg / "HSA_transfer"

The city of Augsburg is located in the western part of the federal state of Bavaria. Two HEI and several research institutions make Augsburg a knowledge-intensive location. A unique regional aspect is that, dating back to the 1990s, multiple and heterogeneous regional stakeholders established the 'local agenda 21' initiative. Forming committees called 'agenda forums' that address different regional sustainability issues and backed by the Augsburg municipality, they aim for a cooperative and sustainable city development.

The assessed program of the University of Applied Sciences Augsburg ('HSA') is called 'HSA_transfer' and refers to itself as "agency for cooperative HEI projects". It develops and tests new formats for knowledge transfer like student service learning and alumni networking, including but not exclusively focusing on sustainability. Project goals are to support and improve knowledge transfer activities by providing a transfer "toolbox" for HEI members and to foster networks with civil society actors through cooperative projects with e.g. schools, museums, civil initiatives or associations. One interviewee summarizes the main goals as: "[...] *an increase in transfer activities and making them visible.*" (Interview 48, item 9). Therefore, 'HSA_transfer' increases visibility of transfer activities for civil society with a strong emphasis on internal and external communication and the showroom-like 'HSA_transmitter' that make HEI transfer projects and knowledge accessible to Augsburg inhabitants through temporary exhibitions.

Referring to data, the role of *articulation of expectations and visions* is not in the focus of intermediaries in project 'HSA_transfer'. Nevertheless, they develop a "guide to sustainability" to articulate needs and requirements for sustainability the project commits to. Additionally, sustainability is a field of action and an advisory board for sustainability was established to raise awareness in order to promote sustainability related aims. Intermediaries support HEI-internal strategy and vision building by starting discourse across all disciplines and including all groups of university members.

The role of *network building* is of particular importance for 'HSA_transfer'. In order to enable the addressing of societal challenges they aim to include civil society actors and their perspectives in innovation and transfer processes. "In principle, we simply want to open up to the city society with this project. That means that we are also trying to address new target groups. As a university of applied sciences, our target group is, of course, companies. That's the one we're targeting already, and we're well known there." (Interview 54, item 29). Through targeted expansion of networks including groups of actors that have not been in the focus of transfer before, they involve in developing connections between groups of actors by actively making connections to societal actors and cooperating in projects with museums, schools, foundations and societies. To get in touch with societal actors, they establish events inviting citizens to discuss with university members. 'HSA_transfer' employs student seminars, student's theses and service learning projects to cooperate with actors and to enable mutual knowledge transfer. For student's projects, 'HSA_transfer' provides funding, but also supports actors in handling or finding funding. Additionally, intermediaries facilitate cooperation and emergence of new projects

by providing a centralized documentation of existing and former projects as well as cooperating partners interested actors can build on. For members of the university, a platform and method-toolbox is provided to facilitate project development and partner identification. For external actors a “transfer catalog” listing projects and professionals is published. Making contacts and matching actors for potential cooperation using their expanded networks, intermediaries engage in brokering and gatekeeping. Complementary to the conventional transfer agency, ‘HSA_transfer’ is a vital contact point for cooperation enquiries that are forwarded to potential partners. ‘HSA_transfer’ staff organizes appointments and accompany initial meetings to facilitate cooperation. Furthermore, strategically aligning efforts with the existing agenda processes and by bundling expertise in a program called ‘Experts for Sustainability’ that make the university closely cooperate with the municipalities agents for sustainability, project ‘HSA_transfer’ supports alignment of interests and options on sustainability.

Regarding the role of supporting *learning processes and exploration*, intermediaries of ‘HSA_transfer’ engage in multiple ways. They use student seminars with cooperative partners to involve actively in prototyping, e.g. developing and testing a ramp for barrier-free entrances, or configure technologies in order to develop innovative applications, e.g. using chat-bots for initial disease consulting. Dissemination and communication are central approaches of ‘HSA_transfer’. One interviewee stated: “*science communication is also an important component of transferring knowledge to society. And that's why we massively included the element of knowledge communication in this application.*” (Interview 57, item 11). Professional staff accompany and report on projects. The exchange of information is advanced using social-media, weekly newsletters and a magazine-like periodical to spread information and to process knowledge for transfer and innovation. The intermediaries also host informative events as well as dialogue formats for civil society actors to enable mutual exchange. Dissemination is also fostered by the showroom-like ‘HSA_transmitter’ with temporary exhibitions to inform citizens and present results from ‘HSA_transfer’ activities. Referring to learning processes, using on-site students seminars dealing with actual and real problems and offering service-learning projects, conditions for mutual learning by doing are created. Next to this, involvement of professionals, e.g. researchers or lecturers, in activities and projects provides advice on the basis of experience and professionalism.

Additionally, referring to *other roles*, ‘HSA_transfer’ intermediaries especially support project management tasks referring to themselves as “*service providers*” (Interview 50, item 117), e.g. handling bureaucratic formalities and evaluating projects for partners that are less familiar working in funded projects. They also involve in active mobilization of actors by proposing project ideas and cooperation to actors that beforehand have not been in cooperation with ‘HSA_transfer’. This approach helps to promote openness for cooperation and reduces inhibitions of potential actors in order to broaden the group of participating actors.

Case D: Goettingen / “SNIC”

The city of Goettingen is situated in the south of the federal state of Lower Saxony between the metropolitan areas of Hannover and Kassel. Goettingen is home of three universities and multiple research institutions while the economy of its more peripheral environment is mostly influenced by SMEs except for a few major companies, especially in life sciences. For the southern part of lower Saxony, the HEI of Goettingen are important actors referring to knowledge transfer and innovation support.

The program analyzed is ‘SNIC’ (Innovation Campus in Southern Lower Saxony) that was established in 2016 on behalf of regional intermediary actors and is funded by the federal state of Lower Saxony. The catchment area of ‘SNIC’ is not limited to Goettingen but also includes surrounding counties. It refers to itself as an innovation network and connects HEI with other regional intermediary actors to support the transfer of knowledge to local stakeholders and to foster the knowledge transfer structure without a specific sustainability orientation. Providing interfaces for actors to connect, the ‘SNIC’ program aims to strategically improve the knowledge economy and the region’s innovative capacity. Complementary to the participating HEI knowledge transfer offices, it provides multiple innovation

support and transfer activities including an innovation accelerator, best-practice on-site and networking events, funding support, innovation scouting and innovation consulting.

The *articulation of expectations and visions* is not a particularly important role for intermediaries in 'SNIC'. With regards to articulating needs, expectations and requirements, intermediaries invite actors to 'future workshops' in which they can collectively name topics or developments that have raised their concern and prioritize them according to their importance. The situation is quite different for the *building of networks*, which is by far the most important role for intermediaries in the 'SNIC' program. The program is focused on developing connections between groups of actors, using a wide range of formats and activities. While all regional actors relevant for innovation are in scope, a particular spotlight is placed on small and medium-sized enterprises, which constitute the economic backbone of the region. Intermediaries organize events called 'practice forum' in which actors from HEI and companies in the region both present short introductions into their experiences in a specific field. This creates connections that can result in business-science collaborations. Other formats connect innovators in different companies in co-working spaces or connects companies in cooperation projects with students.

Most importantly, intermediaries connect innovators in companies and HEI directly. For that, so-called 'technology consultants' which work for regional economic development agencies create a network of regional SMEs, establishing contact at events as well as through cold-calls. In an initial interview, intermediaries inquire about companies' area of activity, and in particular their innovation needs. Similarly, so-called 'innovation scouts' screen departments and institutes of HEI for innovation potentials. They interview scientists, describing their competencies and activities as well as potential application fields in 'technology reports'. In regular meetings, technology consultants and innovation scouts discuss the needs of companies and the potentials in the HEI, identifying matches: "*In the end, innovation scouts and technology consultants are one unit. They have to understand each other, they have to pull together, and they have to bring needs and offers into line with each other so that a match can be made*" (Interview 70, item 31). The matching can include several actors from science or business if required and may connect unexpected knowledge bases such as forestry science and packaging industry "*who, without this interplay of innovation scouting on the one hand and technology consulting on the other, would almost certainly never have come up with the idea of establishing contact with each other in any form*" (Interview 70, item 19). Intermediaries also facilitate co-operation between actors from science and business by helping actors to understand other's perspectives, to build trust and to find suitable arrangements. Intermediaries also help in finding funding. This also applies for startup founders, which intermediaries connect with investors at events or through a crowdfunding platform. The program also forms a knowledge sharing platform for startups in the region.

With regards to *learning processes and exploration*, intermediaries mainly support prototyping and piloting by facilitating the science-business cooperations. In addition, intermediaries identify innovation ideas suitable for startups within the HEI and motivate actors to found startups: "*through appropriate capacity building, through appropriate sensitization, we have to first get people to think about something like, well, what could be done with my research*" (Interview 75, item 27). Potential founders can get advice and support by taking part in a pre-incubator, an incubator and an accelerator. In addition, an academic program provides education and training, qualifying actors for founding startups. The intermediaries take *other roles* in general by providing professional services fitted for specific situations of actors. These services interact wherever beneficial, for example if the screening of innovative activities in HEI for matching a companies' need identifies a potential for a startup, innovation scouts create a connection to the startup consultants. In order to provide these interacting services, the partnering organizations of the program have developed a shared infrastructure, with a headquarter within a regional foundation.

Discussion: Positioning results in the typology of transition intermediaries

Our findings indicate that HEI-related intermediaries pave the way for sustainability transitions involving in various intermediation roles and activities of transition intermediaries. Table 3 provides an overview over characterizing intermediation activities they involve in - linked to the typology of transition intermediaries developed by Kivimaa (2019a) in order to reveal as which of the five types of transition intermediaries the assessed cases could be classified.

The comparison in Table 3 points out that intermediaries in regional innovation programs related to HEI do not fulfill roles of one specific type of transition intermediary. Instead, intermediaries fulfill roles overlapping several transition intermediary types comprising different sets of adopted activities. This finding correlates with the analytical framework based on Vihemäki et al. (2020) which also suggests similar or comparable activities for different types of intermediaries.

In cases dedicated to facilitating and accelerating sustainability transitions, Cases A and B, we find intermediaries more likely to fulfil activities associated with systemic and regime-based intermediaries. This points towards a connection of a sustainability focus and systemic and regime-based intermediation activities. In Case C, focusing on including societal actors in an emerging network, systemic and regime-based intermediation activities are also traceable, but their execution differ in intention and intensity. In Case A and B, for example, using participatory and inclusive methods, intermediaries aim to align actors' visions as well as their understanding of sustainability-related problems as a basis for active and joint steps towards sustainability, e.g. in introduced projects allowing for co-creation. With this, intermediaries directly aim to contribute to sustainability transitions. In contrast to that, intermediaries in Case C concentrate on creating conditions for change but these are not advanced into actions to foster tangible change processes. In Case D, sustainability is not a primarily pursued goal and we find intermediation activities that can be attributed to all five types of transition intermediaries that nevertheless support preconditions for transitions. Therefore, we find intermediaries in Cases C and D focus on improvements that indirectly support the emergence of change processes, whereas intermediaries in Cases A and B additionally induce change processes actively, aiming to contribute directly to sustainability in their region. Additionally, our data indicate that the combination of sustainability orientation and commitments, combined with a strong focus on participatory and inclusive methods, support directing change towards sustainability (Kivimaa et al., 2019a).

On the basis of these observed differences, we argue that when classifying intermediation, it is also important to consider the intensity and intention of activities applied, instead of only reflecting on the occurrence of activities. Our data indicates that differences in execution may occur from the specific goal-sets of the programs in Case A and B and the self-commitment to sustainability of the intermediaries itself. Referring to the definition of transition intermediaries (Kivimaa et al., 2019a), in Case A and B, we find intermediaries 'create momentum for socio-technical system change', while in Case C and D we find intermediaries more involved in 'connecting transition visions and demands of networks of actors' enabling 'new collaborations' but less proactively stimulate impulses for change. Referring to Case D in particular, which does not explicitly aim to contribute to sustainability, our findings of indirect support of transition preconditions are in line with Manders et al. (2020) who found intermediaries are not always consciously applying activities that potentially contribute to enabling sustainability transitions.

The analysis shows that the roles attributed to transition intermediaries can in fact be transposed to HEI-related innovation and knowledge intermediaries, underlining their ability to pave the way for sustainability transitions in regional innovation systems directly and indirectly. The paper therefore provides an important addition to the discussion in transition intermediary research, opening up a new research agenda analyzing the contribution and role of HEIs and their related intermediaries.

Table 3: Activities of the intermediaries in the analyzed cases with reference to the literature

Intermediary Role ⁸	Case A Darmstadt “s:ne”	Case B Eberswalde “region 4.0”	Case C Augsburg “HSA transfer”	Case D Göttingen “SNIC”
Articulation of expectations and visions	- facilitate and support stakeholders in cooperatively developing a strategy for sustainability-oriented change [S: Strategy development]	- identify regional potentials for change on the basis of regional endowments [S, R: Articulation of needs, expectations, requirements] - develop fields of action for regional change processes towards sustainability [S: Strategy development] - act as role model to promote and disseminate sustainability goals [S: Promotion of sustainability related aims]	- develop common understanding of sustainability [S, R: Articulation of needs, expectations, requirements]	- identify needs of regional companies to foster regional innovation system [S, R: Articulation of needs, expectations, requirements]
Building of networks	- develop connections specifically for sustainability-oriented change [P: Developing connections between groups of actors] - align stakeholders by developing common problem understanding cooperatively [S, R: Aligning actors (or their interests) and options]	- create network through cooperation of intermediaries including societal actors [P: Developing connections between groups of actors] - use participatory methods to align interests and legitimize solutions [S, R: Aligning actors (or their interests) and options] - facilitate a “culture of cooperation” [R: Network creation, including with other types of intermediaries] - support finding funding and funding consulting services [S: Providing, managing or finding funding] - match actors from different actor groups [S, R: Brokering and gatekeeping]	- expand network to include societal actors and their perspective on societal challenges [S: Network creation and facilitation] - facilitate development of cooperative projects [R: Facilitating co-operation between actors] - support finding funding [R: finding funding] - match actors from different actor groups [S, R: Brokering and gatekeeping] - align strategically with municipal initiatives [S, R: Aligning actors (or their interests) and options]	- connecting regional actors for cooperations through various activities [P: Developing connections between groups of actors] - facilitate science-business cooperations [R: Facilitating co-operation between actors] - finding funding for cooperations and startups [R: Finding funding]
Learning processes and exploration	- enable and facilitate development of solutions for sustainability problems [S,R,N: Prototyping and piloting] - qualify suitability of sustainability-oriented innovations through surveys [U: Qualifying the characteristics and Suitability of innovations for various contexts] - support stakeholders from practice and science to learn together in developing solutions [S, R: Creating conditions for learning by doing and using]	- establish research center to improve knowledge transfer for sustainability transitions [S, R: Knowledge gathering, processing, generation and combination] - use reciprocal transfer for mutual learning, e.g. through on-site events to help learn form best-practices [S, R: Creating conditions for learning by doing and using] - provide professional and organizational advice and innovation support [S, R:Advice and support]	- focus on dissemination and communication as part of transfer [S, R, N, P: Dissemination] - use student and cooperative projects to transfer knowledge and for mutual learning by doing [S, R: Creating conditions for learning by doing and using]	- facilitating innovations in regional cooperations as well as in start-ups originated from HEI [S, R, N: Prototyping and piloting] - consulting interested actors on founding startup [R, N,: Advice and support]
Other roles	- identify relevant actors for sustainability action fields through actor mapping and mobilize them by analyzing their motivations [S: Identifying, mobilizing actors]	- identify and mobilize actors to involve in sustainability projects [S: Identifying, mobilizing actors]	- refer to itself as “service-provider” supporting for transfer activities [N: Providing professional services] - identify and mobilize actors inviting them to involve in cooperative projects [S: Identifying, mobilizing actors]	- providing interacting services specifically fitted for situation of regional actors [N: Providing professional services]

⁸ Types of transition intermediaries Kivimaa et al. (2019a): S = Systemic, R = Regime-based, N = Niche, P = Process, U = User.

Conclusion

The starting point of this paper was the missing attention in transitions intermediary research on HEI-related intermediaries in regional innovation systems. By conducting a multiple-case study including four German regional innovation programs led by HEIs, we revealed how HEI-related intermediaries pave the way for sustainability transitions involving multiple roles that are predominantly attributed to transitions intermediaries. Moreover, referring to the typology of transitions intermediaries, we mainly found HEI-related intermediaries in our cases involve in the roles and activities are attributed to systemic and regime-based intermediaries. We found HEI-related intermediaries contribute to sustainability transitions in a twofold way: First, they indirectly improve preconditions for transitions fostering and mobilizing the potential of their regional innovation system by articulating demands, aligning visions and connecting different actors expanding and building new networks. Enhancing learning and exploration in order to foster cooperation, intermediaries help to improve conditions for mutual learning and knowledge transfer. Furthermore, they are involved in innovation support providing advice and support for regional actors. Second, using particularly participatory and inclusive methods, they actively induce impulses for change processes towards sustainability introducing concrete and regionally fitting strategies for the respective industries and projects allowing for concrete steps towards sustainability.

Our findings have several implications for designing and implementing transformative innovation policy. We provided insights on how HEI-related intermediaries and transition-oriented regional innovation projects could potentially support sustainability transitions. Policymakers should encourage and support HEI-related intermediaries to develop capabilities to adapt and adopt activities supporting the preconditions for socio-technical system change. In particular, intermediation capabilities to directly inducing impulses for change should be fostered by supporting intermediaries in implementing participatory and inclusive initiatives fitting their regional potentials. In this regard, our findings – particularly in Cases A and B – could also be used as examples of how HEI-related intermediaries can indirectly and directly pave the way for transitions. Additionally, our findings point towards the importance of implementing sustainability goals and commitments of regional HEI-related intermediation activities to enable change processes. For these reasons, policymakers should consider and employ HEI-related intermediation as complementary instruments at the regional level to foster change towards sustainability.

From a scholarly perspective, our findings add to the discussion of intermediation in transitions by revealing that HEI-related intermediaries are involved in activities aiming to support transitions that are attributed to systemic and regime based transition intermediaries. However, our analysis faces several limitations. Although we interviewed intermediaries of the ‘input-side’ of innovation, innovators and participants in our analysis, we are not able to assess the actual impacts of the assessed projects and initiatives as transitions are long term processes. Furthermore, considering a set of four German cases, the generalizability of our findings is limited. Our findings should be triangulated and advanced with further analyses applying not only qualitative but also quantitative data. Thus, our analysis is only a first step to investigating the potentials and contribution of HEI-related intermediation in regional innovation systems in the context of transitions. Future research should further explore the capabilities of HEI-related intermediation in terms of inducing and implementing change directed towards sustainability.

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Appendix

A) Interviews

N o.	Case	Year	Sector	Role of interviewee	Dura tion (min)
1	A	2020	Academia	Professor (s:ne team member)	112
2	A	2020	Academia	Research Associate (s:ne team member)	40
3	A	2020	Civil society	Research Associate of a foundation (s:ne team member)	54
4	A	2020	Economy / Industry	Representative of chamber of commerce	61
5	A	2020	Academia	Research Associate of a Research Institute (s:ne team member)	66
6	A	2020	Academia	Research Associate of a Research Institute	36
7	A	2020	Academia	Research Associate (s:ne team member)	65
8	A	2020	Academia	Senior Researcher of a Research Institute (s:ne team member)	91
9	A	2020	Academia	Senior Researcher (s:ne team member)	90
10	A	2020	Economy / Industry	Representative of chamber of commerce	91
11	A	2020	Public administration	Innovation support and technology transfer manager	34
12	A	2020	Economy / Industry	Representative of Business Association	40
13	A	2020	Academia	Senior Researcher (s:ne team member)	58
14	A	2020	Economy / Industry	Sustainability consultant (s:ne team member)	57
15	A	2020	Academia	Representative of university sustainability office	45
16	A	2020	Academia	Representative of university presidential board	59
17	A	2020	Public administration	Representative of university transfer office	42
18	A	2021	Economy / Industry	Representative of a municipal company	51
19	A	2021	Economy / Industry	Representative of a network operator	52
20	A	2021	Economy / Industry	Representative of a municipal company	45
21	A	2021	Economy / Industry	Representative of a manufacturing company	59
22	A	2021	Economy / Industry	Representative of a manufacturing company	43
23	A	2021	Economy / Industry	Representative of an industry association	55
24	A	2021	Economy / Industry	Representative of a software firm	35
25	B	2020	Academia	Professor at University	80
26	B	2020	Academia	Innovation support and technology transfer manager	94
27	B	2020	Academia	Innovation support and technology transfer manager	97
28	B	2020	Industry	Innovation support and technology transfer manager	138
29	B	2020	Public administration	Business developer (region 4.0 team member)	61
30	B	2020	Academia	Professor (region 4.0 team member)	53
31	B	2020	Public administration	Business developer	64
32	B	2020	Academia	Project manager (region 4.0 team member)	61
33	B	2020	Civil society	Representative of a civil association (region 4.0 team member)	71
34	B	2020	Economy / Industry	Representative of a chamber of crafts	89
35	B	2020	Economy / Industry	Representative of a chamber of crafts	66
36	B	2020	Civil society	Representative of a civil association	91
37	B	2020	Public administration	Knowledge transfer manager	58
38	B	2020	Economy / Industry	Representative of regional craft sector	77
39	B	2020	Public administration	Representative of biosphere reserve	100
40	B	2020	Academia	Professor at University	70
41	B	2020	Academia	Professor at University	70
42	B	2021	Economy / Industry	2 representatives of a public transport company	62

43	B	2021	Economy / Industry	Representative of a farm	50
44	B	2021	Economy / Industry	Representative of a book store	21
45	B	2021	Economy / Industry	Representative of a robotics firm	38
46	B	2021	Economy / Industry	Representative of a regional food retailer	42
47	C	2020	Academia	Professor (HSA_transfer team member)	103
48	C	2020	Academia	Professor (HSA_transfer team member)	86
49	C	2020	Public administration	Representative of innovation support and technology transfer agency	77
50	C	2020	Academia	Program Manager (HSA_transfer team member)	73
51	C	2020	Public administration	Business developer	35
52	C	2020	Public administration	Representative of an innovation center	54
53	C	2020	Industry	Representative of chamber of commerce	54
54	C	2020	Academia	Representative of university transfer office (HSA_transfer team member)	72
55	C	2020	Academia	Research associate	73
56	C	2020	Public administration	Representative of municipal sustainability office	54
57	C	2020	Academia	University communications manager (HSA_transfer team member)	77
58	C	2020	Civil society	Representative of a foundation	62
59	C	2020	Civil society	Representative of a civil association	73
60	C	2021	Civil society	Director of a church social service	57
61	C	2021	Civil society	Director of a museum	42
62	C	2021	Civil society	Representative of a health counselling center	85
63	C	2021	Civil society	Director of a youth center	84
64	C	2021	Civil society	Representative of an inclusivity initiative	44
65	C	2021	Civil society	Director of a school	52
66	C	2021	Civil society	Director of a school	52
67	C	2021	Economy / Industry	Planning and construction company	52
68	D	2020	Academia	University professor (SNIC team member)	87
69	D	2020	Academia	Project manager (SNIC team member)	92
70	D	2020	Public administration	Representative of SNIC Office (SNIC team member)	72
71	D	2020	Public administration	Innovation support and technology transfer manager (SNIC team member)	62
72	D	2020	Civil society	Representative of a foundation	59
73	D	2020	Public administration	Business developer (SNIC team member)	64
74	D	2020	Public administration	Business developer (SNIC team member)	48
75	D	2020	Academia	Research associate (SNIC team member)	53
76	D	2020	Academia	Innovation scout (SNIC team member)	50
77	D	2020	Industry	Representative of chamber of crafts	71
78	D	2020	Public administration	Business Developer (SNIC team member)	50
79	D	2020	Industry	Representative of chamber of commerce	78
80	D	2020	Academia	Innovation scout (SNIC team member)	55
81	D	2020	Public administration	Business developer (SNIC team member)	52
82	D	2021	Economy / Industry	Representative of a startup	59
83	D	2021	Civil society	Representative of a theater	43
84	D	2021	Economy / Industry	Representative of a software firm	70
85	D	2021	Economy / Industry	Representative of a mechanical engineering company	63
86	D	2021	Economy / Industry	Representative of a consultancy	60

B) Interview guideline for 2020

Section 0: Background of the interviewee

- Please briefly describe your job/function.
- How do you / how does your organization understand ‘knowledge transfer’?

Section 1: Intermediary structures and characteristics of key stakeholders

- Please describe the [organizational] structures of the innovation program you participate in.
- Please give an example of how knowledge transfer takes place in the region.
- Can you describe how learning processes are induced in the innovation program you participate in?

Section 2: Innovation processes

- Please describe what kind of innovations have already been developed so far.
- Please describe what kind of innovations are currently being developed.
- Please describe your role in an [exemplary] innovation process.

Section 3: Evaluation and assessment of results

- How do you evaluate your activities and results in the innovation program?

Section 4: The regional innovation system

- Please describe special features of the regional innovation system.
- What are the barriers to knowledge transfer and innovation in the region?

Section 5: Sustainable development

- What role does sustainable development play in your organization / for your role?
- What is the importance of innovations related to sustainable development for you?
- What contributions to sustainable development do you see through the innovation program and the resulting innovations?

C) Interview guideline for 2021

Section 1: Actor (companies and other organisations)

- Please describe your role in your organization.
- Please outline the founding history of your organization.
- Please describe your business model.
- In which markets do you operate (regional, national, international)?
- What is your organization's long-term objective?
- What role do innovations play in your organization (New products? New services? Organizational change)?
- What role does sustainable development play for your company?

Section 2: Embedding of the organization in the region

- Please describe strengths of the region.
- Please describe weaknesses of the region.
- What role does the region play for your organization?
- Which cooperation partners are relevant for you in the region?

Section 3: Cooperation with the intermediary structure / innovation program

- How did the collaboration with the intermediary structure begin?
- Please describe the collaboration with the intermediary structure.
- Which actors are working together?
- What goals do you pursue with the cooperation with the intermediary structure?
- How long do you cooperate with the intermediary structure? How long is the cooperation planned?
- What barriers to collaboration do you perceive?
- What changes could be made to improve collaboration?

Chapter V:
The contribution of knowledge intermediation to sustainability transitions and digitalization: Qualitative insights into four German regions

with Philipp Bäumle and Daniel Feser

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The contribution of knowledge intermediation to sustainability transitions and digitalization: Qualitative insights into four German regions

Abstract

This paper explores the contribution of knowledge intermediation to sustainability transitions and digitalization. Currently, there is a gap in the literature concerning the understanding of knowledge intermediation and transition intermediation, even though the systemic coaction of different intermediaries is essential for policy making. We use an explorative qualitative approach based on interviews with German knowledge intermediaries. We find three functions of knowledge intermediation that proactively contribute to socio-technical transitions: (i) information dissemination via events, (ii) knowledge exchange via network building, and (iii) implementation support via consulting. Thereby, we reveal an increasingly active role of knowledge intermediation in regional transitions. We identify additional roles concerning the identification and monitoring of new projects that emerge from the effects of digitalization on sustainability. We contribute to the current scholarly discussion about knowledge intermediation by complementing its' contributions to innovation and regional development by proactive contributions to transition processes.

Keywords

knowledge intermediation; sustainability transitions; digitalization; higher education institutions; qualitative case studies

1. Introduction

Considering recent debates on pervasive transition processes, regions and their innovation systems face two major, intertwined “twin challenges” (European Commission, 2019, p. 7) that affect their innovative capacity: the successful transition toward more resource-efficient modes of production and consumption (henceforth, sustainability⁹; e.g., Markard et al., 2012; Kraker et al., 2013) and the transition toward the development and implementation of digital technologies (henceforth: digitalization¹⁰; e.g., Isaksen et al., 2021). Presuming a high relevance of innovation processes for tackling these challenges, current approaches argue for a shift in innovation policy that incorporates the complex needs of grand societal challenges and the implied socio-technical transition processes (Kuhlmann and Rip, 2018; Schot and Steinmueller, 2018), most importantly sustainability and digitalization (Andersen et al., 2021; Ortega-Gras et al., 2021). Such approaches emphasize the importance of regional bottom-up approaches that have the potential to be scaled up in order to tackle grand societal challenges (Bours et al. 2022; Isaksen et al. 2022).

Therein, higher education institutions (HEIs) play a central role by serving their “third mission” of disseminating academic knowledge throughout regions. HEIs are acknowledged as central constituents of regional innovation dynamics, with regard primarily to harnessing academic knowledge for entrepreneurship and technological innovation (Etzkowitz et al., 2000; Huggins et al., 2008; Etzkowitz and Zhou, 2017; Klofsten et al., 2019). In this regard, the concept of knowledge intermediation, defined as the facilitation of “knowledge exchange between universities and external stakeholders through the creation of bi-directional, value-added network relationships” (Hayter, 2016, p. 636), gained track as an instrument to foster academia-industry relations and configuring HEIs’ non-academic activities (Yusuf, 2008; Clayton et al., 2018). However, although recent works postulate an extended understanding of HEIs’ third mission (Zilahy et al., 2009; Sedlacek, 2013; Trencher et al., 2014; Blume et al., 2017),

⁹ We follow the seminal work by Markard et al. (2012) and perceive sustainability transitions as “long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption.” (Markard et al. 2012, p. 956)

¹⁰ We follow the recent approach by Isaksen et al. (2021) and perceive digitalization as a multifaceted process that exceeds the development of new technologies, requires the modification of regional assets and depends on “new competences and skills in the workforce, new firm competencies, new public attitudes and know-how, all supported by changes in the organizational and institutional support infrastructure of RISs.” (Isaksen et al. 2021, p. 134)

evidence regarding the relevance of knowledge intermediation and reciprocal transfer of knowledge between academia and non-academic regional actors in transition-oriented policy approaches remains scarce (Kivimaa et al., 2017; Radinger-Peer and Pflitsch, 2017).

Despite a vibrant discussion about the importance of intermediation in regional transitions (Kivimaa et al., 2020a; van Boxstael et al., 2020; van Lente et al., 2020; Vihemäki et al., 2020), the peculiarities of academia-focused knowledge intermediation have seldom been addressed in this context (Kivimaa et al., 2017). Instead, studies of knowledge intermediation mainly focus on the commercialization of academic knowledge via entrepreneurship and technology transfer (Siegel et al., 2007; Wright et al., 2008; Hayter, 2016) and, more recently, the formation of entrepreneurial and technology transfer ecosystems surrounding HEIs' local environments (Good et al., 2019; Lahikainen et al., 2019). Meanwhile, the concept of intermediation in transitions processes has been assessed in regard to in the activities of government-affiliated organizations that address failures in innovation systems (Smits and Kuhlmann, 2004; Klein Woolthuis et al., 2005) in order to foster sustainability (van Lente et al., 2003; Kivimaa, 2014).

Therefore, this paper focuses on the contribution of knowledge intermediation and their roles in socio-technical transitions to address two aspects that have hitherto been neglected in the context of intermediation and transitions: First, extant research on the concept of knowledge intermediation has a strong focus on supporting roles in the diffusion and commercialization of academic knowledge, while neglecting possible contributions to transition processes. Second, existing research on intermediation in transitions has a strong focus on ecological sustainability while not making room for other contemporary transition processes. What is missing in the literature is an analysis of how practices of knowledge intermediation contribute to socio-technical transitions that includes digitalization as the second 'twin' transition and its' effects on sustainability. Against this background, this paper addresses the following research questions:

RQ1: How does knowledge intermediation contribute to sustainability and digitalization?

RQ2: How does digitalization affect the role of intermediation in sustainability?

We conducted 62 interviews with knowledge intermediaries and stakeholders from four German regions. We adopt an explorative qualitative approach to generate insights into the contribution of knowledge intermediation to sustainability and digitalization. Based on a qualitative content analysis, we also derived insights into the effects of the co-occurrence of and the interdependencies between sustainability and digitalization and the subsequent effects of digitalization on sustainability. The paper makes a threefold contribution to the literature. First, the paper shows that knowledge transfer and the actors and activities that promote it, play a more proactive role in pushing transition process than suggest by previous studies. Second, the paper enriches the research on the various functions of knowledge intermediation by revealing an extension of tasks that utilizes field-tested formats to support transition processes. Finally, the paper identifies additional functions that emerge from the interdependencies between sustainability and digitalization.

The remainder of this paper is organized as follows. Section 2 reviews the literature on the concepts of intermediation and regional transitions. Section 3 introduces the cases and presents the methodological approach. Section 4 presents the empirical findings. Section 5 discusses these findings against the background of extant literature, and finally, Section 6 concludes the paper by drawing some initial managerial and scientific conclusions.

2. Literature Review

2.1 Knowledge and transition intermediation

The concept of intermediation has gained significant attention in innovation policy and research during the last two decades (van Lente et al., 2003; Howells, 2006; Stewart and Hyysalo, 2008). Intermediation comprises various roles and activities that aim to enhance the productivity, connectivity, and

functionality of innovation systems by fostering inter-organizational network building and knowledge exchange between different stakeholders (Howells, 2006; Dalziel, 2010; Nauwelaers, 2011), and has come to be a central component of two related yet insufficiently interwoven strands of literature that discuss two focal functions of actors in innovation systems: *knowledge intermediation* and *transition intermediation*.

The knowledge and technology transfer literature discusses *knowledge intermediation* as activities that foster the reciprocal exchange of knowledge and other resources between academic and non-academic stakeholders to foster the transfer and commercialization of research results (e.g., Yusuf, 2008; Youtie and Shapira, 2008; Clayton et al., 2018). The multifaceted tasks of knowledge intermediation are mainly performed by HEI-owned actors that aim to push the HEIs' third mission and the development towards an entrepreneurial university and publicly owned actors that aim to enhance the competitiveness of local firms (e.g., Villani et al., 2017; Good et al., 2019). The activities they perform in order to enhance the connectivity between academic and non-academic actors can be ascribed to two main objectives: fostering the commercialization of academic knowledge assets via licensing and patenting (Macho-Stadler et al., 2007; Siegel et al., 2007), while strengthening formal university-industry linkages (Siegel et al., 2003; Debackere and Veugelers, 2005; Wright et al., 2008) and promoting academic entrepreneurship (Phillips, 2002; Wright et al., 2004; Lockett and Wright, 2005; Markman et al., 2005; Rothaermel et al., 2007), and furthering the formation of nascent transfer ecosystems surrounding HEIs' local environments (Huang-Saad et al., 2017; Miller and Acs, 2017; Breznitz and Zhang, 2019; Lahikainen et al., 2019). Contemplating these two main objectives, research on the effects of knowledge intermediating activities on socio-technical transition processes remains scarce (Kivimaa et al., 2017).

Table 4: Functional differentiation between Knowledge Intermediation and Transition Intermediation

<i>Dimension¹¹</i>	<i>Knowledge Intermediation</i>	<i>Transition Intermediation</i>
Focus	Technological innovation	Systemic change
Functions	<ul style="list-style-type: none"> • Identify knowledge relevant for innovation • Motivate academics to engage in entrepreneurship • Provide resources required for knowledge commercialization • Initiate and facilitate collaborative R&D 	<ul style="list-style-type: none"> • Raise awareness for importance of transitions • Establish networks between manifold actor groups • Align strategies and activities of various actors • Enable system-wide learning processes
Main sources of funding	Academia; Government	Government; Municipalities (national, regional, or local)
Main recipients of support	Academics; Students; emerging Start-ups/Spin-offs	Firms; Public Actors; Civil society
Related literature	Debackere and Veugelers, 2005; Yusuf, 2008; Wright et al., 2008; Youtie and Shapira, 2008; Hayter, 2016; Clayton et al., 2018	van Lente et al., 2003; Kivimaa, 2014; Kivimaa et al., 2017; Kivimaa et al., 2019a; van Lente et al., 2020; van Boxstael et al., 2020

The sustainability transitions literature discusses *transition intermediation* as activities that foster sustainability by catalyzing the change of structures and institutional arrangements within socio-technical systems and multi-actor processes (Kivimaa et al., 2019a). Following the prevalent definition of Kivimaa et al. (2019a, p. 1072), transition intermediation describes activities “that positively

¹¹ Inspired by dimensions for differentiation of intermediaries suggested by Mignon and Kanda (2018) and van Lente et al. (2003)

influence sustainability transition processes by linking actors and activities, and their related skills and resources, or by connecting transition visions and demands of networks of actors with existing regimes in order to create momentum for socio-technical system change". In the context of transitions, key functions of intermediation have been discussed, such as strategy development (Hodson and Marvin, 2012; Hamann and April, 2013; Cramer, 2020), vision building (van Lente et al., 2003; Kivimaa, 2014; van Boxstael et al., 2020), knowledge brokering (Barnes, 2018; Kanda et al., 2019; Janssen et al., 2020; van Lente et al., 2020) and networking (Fischer and Newig, 2016; Gliedt et al., 2018; Kanda et al., 2020; Loorbach et al., 2020), exchanging knowledge (Kemp et al., 1998; Frantzeskaki et al., 2019), fostering knowledge dissemination (Hyysalo et al., 2013; Fischer and Newig, 2016; Hyysalo et al., 2018; Sovacool et al., 2020), and building institutions (Horne and Dalton, 2014; Bush et al., 2017; Kivimaa et al., 2019b). Table 4 sums up the functional differences between knowledge and transition intermediation (based on dimensions for contrasting different forms of intermediation suggested by Mignon and Kanda, 2018).

Although the concepts of both knowledge and transition intermediation are based on the fundamental idea that an increasingly systemic perception of innovation processes requires the intercalation of specialized activities that enhance the connectivity between different actor groups and fulfill similar functions (i.e., inducing politically favored development processes by initiating, and moderating networks and cooperative endeavors between distant and dissimilar actors from different contexts), conceptual or empirical connections between the two accrued strands of literature remain scarce. A deeper understanding of the effects of intermediation in innovation and transitions calls for a comprehensive assessment of intermediary activities across their respective fields.

2.2 Sustainability and digitalization

The concept of transitions has been used in science, technology, and innovation research to explain large-scale changes in socio-technical systems (Geels, 2005; Geels, 2019) and can be understood as the relationship between long-term technological changes and customers' changing technological preferences (Kemp and van Lente, 2011). Transitions are connected to multiple challenges as for example the challenges to provide directionality of change, possibilities for experimentation, interfaces for demand articulation, or learning and coordination (Grillitsch et al., 2019), that intermediaries have to address in order to facilitate change processes (Kanda et al., 2020; Manders et al., 2020).

Sustainability represents the systemic technological, institutional, and ecological alterations required for a comprehensive shift toward the sustainable redesign of socio-technical and societal systems (Loorbach et al., 2017). Therefore, research on sustainability transitions has discussed the multi-level interactions of various actors and their effects on system innovation (Geels, 2002; Geels, 2005; Markard et al., 2012; Köhler et al., 2019). Recently, spatial analyses have contributed to a remarkable body of literature (Hansen and Coenen, 2015; Strambach and Pflitsch, 2018; Tödtling et al., 2021) that argues that a regional scale is the scale best suited for creating comprehensive approaches to regional challenges and the associated demands of actors (Hansen and Coenen, 2015).

Popularized in business media (Fitzgerald et al., 2014; Nambisan et al., 2019), the concept of digitalization originally focused on disruptive organizational change and strategies that allow for the effective integration and exploitation of emerging digital technologies, marketing channels, and business models for increases in productivity and innovation (Matt et al., 2015; Zimmermann et al., 2021). Earlier approaches have focused on challenges that firms, especially small and medium-sized enterprises (SMEs), face in transforming their organizational structures in order to meet the requirements of a digitized economy (Chen et al., 2016; Galati and Bigliardi, 2019; Garzoni et al., 2020). Whereas recent approaches, often discussed in the context of *Industry 4.0*, have attempted to go beyond this organizational perspective and emphasized the relevance of different spatial innovation contexts requiring institutional adaptations that allow for an effective support of digitalization (Kopp et al., 2016; Reischauer, 2018). Despite the supposed nullifying effects of digital technologies on spatial peculiarities, these approaches emphasize the importance of trust-based network relations (Götz and

Jankowska, 2017) and the concerted bottom-up creation of a common understanding of digitalization, place-based support instruments, and digital infrastructure (Hervas-Oliver et al., 2019; Hervas-Oliver et al., 2021). In a recent study, Isaksen et al. (2021) illustrate that non-appealing regional innovation structures may hamper organizational transformation processes and, just like firms, regional innovation structures may need to re-use existing digital assets, create new regional assets, and remove non-functioning structures and assets in order to support digitalization.

Despite the ubiquity of digitalization, it remains underrepresented in transition research (Andersen et al., 2021). Only recently, and mostly in response to high-level policy strategies that claim a digital and sustainable ‘twin transition’ (European Commission, 2019), has a burgeoning strand of literature started to assess the interdependencies between sustainability and digitalization on an organizational level (see Del Río Castro et al., 2021 for an overview). These works acknowledge digitalization as both a key element and a driver of sustainable production, as it supposedly supports resource efficiency and can lead to ‘digital sustainability’ (Bican and Brem, 2020; George et al., 2021). Accordingly, the steady enhancement of information and communication technologies is perceived as a means of reducing traffic emissions, while Big Data is seen as an important instrument of resource management and circular economy (e.g., Boone et al., 2017; Antikainen et al., 2018; Rosa et al., 2020). However, notwithstanding a predominantly positive perception of the effects of digitalization on sustainability, recent works also highlight the threat of unintended negative effects (e.g., Stock et al., 2018). In this vein, Liu et al. (2019) emphasize the importance of assessing the relationship between the fostering of sustainability for increasing resource efficiency and the increase of demand for resources through the expansion of digital infrastructure. Initial studies assessing the underlying relation between an increased intensity of carbon emissions and an emission reduction via the enhancement of cross-industry spillovers indicate a preponderance of the latter (Wang et al., 2021). Unfolding positive effects requires coherent place-based policy approaches making the best use of both digital technologies and ‘analogous’ knowledge spillovers in order to develop appealing agendas for a sustainability-oriented use and development of increasingly digitalized environments (Scholz, 2016; Linkov et al., 2018).

2.3 Rationale for a consideration of knowledge intermediation in regional transitions

Although studies on the role of universities in regional development processes postulate the incorporation of regional transition processes (Zilahy et al., 2009; Sedlacek, 2013; Trencher et al., 2014; Blume et al., 2017) and a ‘change agent’ role for universities (Peer and Stoeglehner, 2013), evidence regarding the effects of knowledge intermediation in this context remains scarce.

By focusing on the promotion of knowledge and technology transfer via commercialization and academic entrepreneurship, the concept of knowledge intermediation describes an instrument for the meso-level connection between academia and the regional innovation system and thus stimulate digital innovation that fosters sustainability transition (Paniccia and Baiocco, 2018). Furthermore, HEIs can contribute to regional transitions via outreach activities. These activities comprise different forms of informal engagement in non-academic contexts that call for a certain level of institutionalization and can support the ongoing knowledge exchange between academic and non-academic actors required for both transition processes (Radinger-Peer and Pflitsch, 2017) and the emergence of transdisciplinary projects as a driver of transition processes (Stephens et al., 2008). However, hitherto, the roles of HEIs in regional development processes have been assessed mostly from an innovation perspective (Radinger-Peer et al., 2021). As HEIs often focus their activities on the promotion of technological innovation processes, they lack the specialized resources and capabilities to promote the commercialization of sustainability-related inventions (Kivimaa et al., 2017). Hence, the incorporation of sustainability-related aspects has been described as insufficient. Accordingly, Kivimaa et al. (2017) propose the broadening of existing entrepreneurial ecosystem concepts in order to meet the increasing demands and advance co-creation for sustainability.

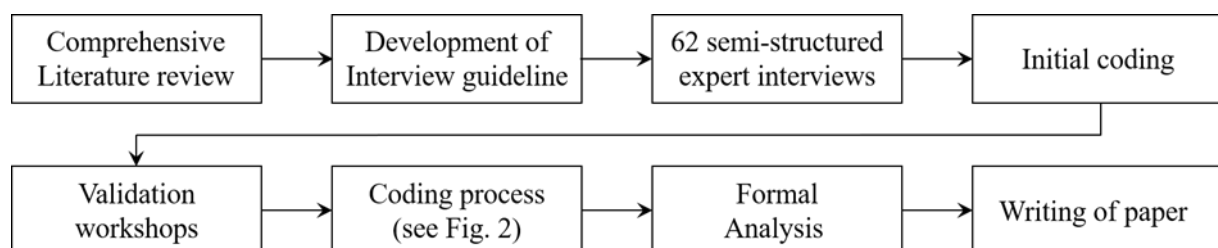
The concept of knowledge intermediation has advanced from a solely academia-oriented instrument to foster research commercialization toward an important factor of regional development dynamics and a central conduit of regional knowledge transfer. However, it remains unclear if (and if so, how) knowledge intermediation contributes to sustainability and digitalization. The scarcity of research on this topic is in spite of the consideration of sustainability and digitalization in (academic) entrepreneurship arguing for the assessment of ‘Sustainable Entrepreneurial Ecosystems’ (Volkman et al., 2021). For instance, Lamine et al. (2018) point toward the interdependencies between business incubation and sustainable regional development, while Schaltegger et al. (2018) denote a conceptual overlap between sustainability and entrepreneurship in the drive for inter-organizational collaboration. On the other hand, Secundo et al. (2020) support the recently suggested “digital transformation of innovation and entrepreneurship” (Nambisan et al., 2019) by examining the concept of digital academic entrepreneurship and arguing for the assessment of ‘Digitally supported University-based Entrepreneurial ecosystems’.

In sum, two observations in current scholarly discussions indicate a role for knowledge intermediation in regional transition processes and call for further investigation. First is the development of knowledge transfer, intermediaries, and HEIs’ ‘third mission’ toward a more holistic perception of knowledge transfer. Second is the recent emphasis on sustainability and digitalization in innovation systems and (academic) entrepreneurship.

3. Methodological approach

We chose an exploratory, inductive approach to analyze the roles and contributions of knowledge intermediation in sustainability and digitalization (Eisenhardt, 1989; Yin, 2018). Such explorative, inductive approaches have proven auspicious in identifying intermediary roles in particular topics (Klewitz et al., 2012; Polzin et al., 2016; Kanda et al., 2018; Kivimaa et al., 2020b). An overview over the whole research process is illustrated in Figure 1. After an initial literature review, a theoretically informed interview guide was developed and used to conduct 62 interviews as the empirical data base of this research. Using a semi-structured interview guideline (see Appendix C), we asked theoretically informed questions focused on the roles and activities of intermediaries in transition processes (Kanda et al., 2018; Kivimaa et al., 2019a). We began by collecting information on the personal backgrounds and recent assignments of each interviewee before broaching the issues of the central structures and characteristics of involved actors, the innovation processes, the embedding of the respective initiatives in a regional context, and the role sustainability plays in the activities of the intermediaries.

Figure 1: Research Flowchart (Source: own compilation)



For each initiative, we identified at least 13 interviewees via initial online research and subsequent referrals by interviewees. The selection of the interviewees represents the diversity of intermediaries involved in each initiative. The selection strategy is informed by the quintuple helix-approach (Carayannis et al., 2012) and followed the principles of purposeful sampling, that is, including a comparable set of intermediary actors from academia, industry, public administration, and civil society in each case. Thus, each sample includes lecturers, technology transfer office members, consultants, and innovation managers involved in the initiatives. Additionally, representatives of the chambers of trade and commerce as well as industry specific associations were interviewed for the consideration of

economic actors. In order to reflect public administration, regional business development agents and representatives of the municipalities were included in the sampling. To map civil society actors, the board members of foundations and societies that engage in the initiatives were interviewed. From February to September 2020, we conducted 62 interviews (see Appendix B). Because of the Covid-19 pandemic, we conducted the interviews via online video conferencing tools or telephones. One interview was conducted in person. The interviews lasted from 34 to 138 minutes and were recorded and transcribed. In addition to the interviews, we collected and reviewed internal documents, as well as reports and information published on the websites of the initiatives and actors. In each case, we carried out interviews until, in combination with data from the documents reviewed, data saturation (Glaser and Strauss, 2017) was reached. We presented and discussed results in regional workshops with the interviewees, with researchers at a research seminar, and at two subject-specific international workshops. In addition, the first author, who was not involved in conducting interviews, was involved as strategic support in Case D, granting access to additional internal documents and discussions concerning this particular case.

Interviews were recorded and transcribed in order to enable the development of a code system using the software MaxQDA. The codes were discussed and checked internally (see Fig. 2 for an overview over the coding process) and externally in workshops with representatives of the assessed cases.

We adopted a regional scope, as the collaborative development of regional innovation capabilities is a key element of German innovation policy (Eickelpasch and Fritsch, 2005). The four selected initiatives are regional knowledge intermediation projects in the regions of Darmstadt (Case A), Eberswalde (Case B), Augsburg (Case C), and Goettingen (Case D) (see Table 5 and Appendix A for details). The initiatives are publicly funded alliances between knowledge intermediaries. They receive funding from different federal innovation policy programs that all aim to strengthen the innovativeness of regions by enhancing connectivity and knowledge exchange between regional stakeholders. Each initiative is centered on one or more local HEIs that lead and coordinate the collaborative activities as part of their third mission. It is thus noteworthy that the assessed initiatives are temporary projects with the objective to initiate and push the development of an institutional frame that fosters innovation and they do not represent independent actors with adaptable long term strategies. These cases allow for an analysis based on heterogeneous regional innovation policy approaches and incorporation of different intermediation and knowledge transfer strategies.

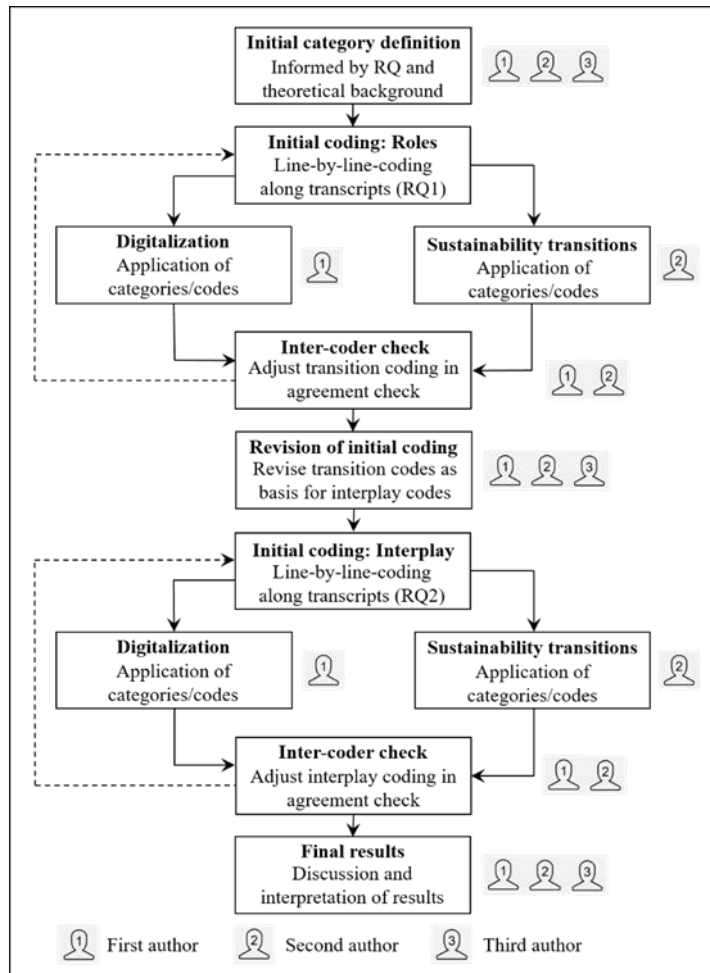
Table 5: Case overview

	<i>Case A</i>	<i>Case B</i>	<i>Case C</i>	<i>Case D</i>
Region	Darmstadt	Eberswalde	Augsburg	Goettingen
Assessed initiative	<i>s:ne</i>	<i>region 4.0</i>	<i>HSA_transfer</i>	<i>SNIC</i>
Year of establishment	2018	2017	2018	2016
Anticipated duration	2022	2025	2022	2024
Focus	Focus on system innovation for sustainability	Focus on regional sustainability transition	Focus on building networks	Focus on innovativeness
No. of Interviews	17	18	13	15

To analyze our empirical data, we collaboratively conducted a qualitative content analysis (Mayring, 2015) to summarize and categorize the relevant material, namely the contribution of knowledge intermediation to sustainability and digitalization. Informed by our research questions, we began by inductively coding the data to identify recurrently mentioned themes that indicated certain roles and activities to focus on the first research question. Informed by intermediary roles identified in previous literature (Kivimaa, 2014; Kanda et al., 2018), we then deduced superordinate roles in transition processes, which the initiatives fulfill by performing these activities. Therefore, each author focused on

one particular transition before adjusting codes in a first inter-coder check and engaging in discussions between the authors. Working with the revised initial coding, we focused on the second research question and shed further light on the interplay between transitions by repeating the procedure described above. Figure 2 precisely illustrates the process of analysis and the division of tasks between the three authors.

Figure 2: Procedure of analysis – inductive category development in a team of authors (Source: own compilation based on Mayring (2015, p. 80))



4. Results

4.1 The contribution of knowledge intermediation to sustainability and digitalization

As illustrated in Table 3, we identified three different contributions of knowledge intermediation in the context of sustainability and digitalization: *information dissemination*, *knowledge exchange*, and *implementation support*. It is noteworthy that the prerequisite for performing the identified roles is the HEIs joining and leading the regional initiatives. We begin our analysis by examining these roles in detail and analyzing the main channels by which knowledge intermediaries aim to fulfill them. We then proceed to use these initial insights as a basis for elaborating on the interdependencies between sustainability and digitalization and the additional roles that result from these interdependencies.

4.1.1 Information dissemination

By disseminating information, knowledge intermediation can contribute to raising awareness among regional actors to the complex subjects of sustainability and digitalization to reduce possible reservations. In this context, we find that organizing, holding, and establishing different sorts of *events*

represents one of the main activities undertaken by the academia-led initiatives. Furthermore, information on regional projects and initiatives is offered to reach out for and attract potential partners for collaboration. The respective events differ in size, scope, and target groups.

Referring to digitalization, the initiatives organize events that address multiple regional actors, such as SMEs and public administration. These events focus on the dissemination of information on topics in digitalization such as public procurement, IT security, agile working, or different regional best practices (Row 1 in Table 3), such as experts delivering speeches to as many as 200 participants to raise awareness of strategic actions for tackling digitalization challenges. We found that academia-driven intermediaries identify relevant topics, acquire speakers from academia, and host the events. Furthermore, knowledge intermediaries engage in more specific, small group (e.g., about 20 participants) events that focus on particular target groups and aim to introduce these groups to emerging technologies and encourage informal contacts between the participants (Row 2 in Table 3). These events often take place as on-site events in either firms or academic laboratories to demonstrate technologies and possible applications and enable peer-to-peer-learning processes. For instance, HEIs and external intermediaries in Case B held a series of events concerning various aspects of digitalization and robotics, which were presented by academics in an academic environment with the aim of enabling informal networking and encouraging dialogue between academic and non-academic actors.

Similar to their contribution to digitalization, the initiatives use events as a channel to inform regional actors about different aspects of sustainability. In addition, the events aim to reduce concerns and lower thresholds against sustainability efforts, such as high costs and personal inconveniences (Row 3 in Table 3). Although there are also thresholds regarding digitalization, the benefits of engaging in sustainability-related measures that do not yield short-term, individual advantages need to be explained more explicitly. The events are also used to highlight ongoing regional projects and innovation processes related to sustainability. As a distinctive feature in cases A and B, events targeting sustainability can be seen to not only address industry and public administration but also include stakeholders from civil society, such as schools, associations, or cultural organizations.

As knowledge intermediaries in two cases have implemented sustainability-related practices in organizing and hosting events, we find that knowledge intermediaries act as role models and showcase sustainability measures for the participants (Row 4 in Table 3). For example, events in Case B are characterized by the offering of regional, organic catering. Furthermore, printed invitations were abandoned in favor of digital alternatives to contribute to resource-saving, so showing another example of interdependencies between digitalization and sustainability. The sustainability-related practices introduced are reported to diffuse and to be adopted by regional partners. Initiative C created an exhibition on the impacts indicated by implemented sustainability-related measures that have been introduced and presented the exhibition in both an on-campus showroom and various off-campus spaces open to the regional public.

Putting these events into the context of the whole processes that they aim to contribute to, the awareness raising character of the events mainly addresses firms and other actors that have not or barely been involved in strategic activities for sustainability or digitalization. Accordingly, the focal information is of a rather general nature and usually addresses a broad range of actors from different actor groups as there are basically no entry requirements and the provided information is of relevance for all sorts of actors.

4.1.2 Knowledge exchange

Knowledge intermediaries span the boundaries between academic and non-academic subsystems by configuring and expanding regional networks between different groups of actors with a view to fostering knowledge exchange and learning processes between regional stakeholders. The superordinate objectives of supporting regional networks concerning transitions are to create a common understanding among regional stakeholders, adopt this understanding, and be able to bundle regional demands and interests and articulate them to academia and supra-regional policy makers. The associated HEIs act as

initiators of regional networks, contributing to their knowledge transfer mission. Furthermore, the research institutions and experts of the associated HEIs represent a significant share of network participants.

Either knowledge intermediaries participate in existing regional networks concerning key topics of digitalization, such as automation or IT solutions for SMEs, which already comprise important stakeholders, or they support the implementation of completely new regional initiatives (Row 5 in Table 3). In such expert networks, intermediaries cross the boundaries between academic experts, private consultants, and practitioners to bundle regional digitalization expertise. In cooperative initiatives between several scientific institutions, these intermediaries support the development of appealing support formats for different aspects of digitalization.

Knowledge intermediaries use these regional networks and initiatives to screen and bundle regional interests, capabilities, and demands in order to act as ‘spokesmen’ for the region concerning the development of new funding programs and schemes. Interviewees emphasize their own networks with federal policy makers and recurrent involvement in the initial design of future funding schemes for knowledge transfer and innovation (Row 6 in Table 3). Knowledge intermediaries also report being part of bigger, supraregional, and national knowledge transfer networks providing access to multiple experts.

The initiatives allow the circulation of knowledge in the evolving networks by implementing a shared understanding of sustainability. Accordingly, interviewees reported difficulties in finding a common language between the heterogeneous involved actors (Row 7 in Table 3). In particular, differences in communication cultures from their respective economic, academic, governmental, or societal backgrounds made it harder for different actors to share the same perspective. These discrepancies result in actor groups being hesitant to cooperate with each other. For instance, knowledge intermediaries in Case A developed a ‘sustainability glossary’ containing central terms and definitions to offer a common ground for communication and interaction with internal as well as external actors.

Furthermore, to support sustainability, the initiatives build specialized multi-actor networks. Our data indicate that, in comparison to digitalization, heterogeneous groups of actors are identified, selected, persuaded, and aligned more actively in order to build regional networks capable of contributing to sustainability (Row 8 in Table 3). Actor selection strategies therefore consider the potential contributions to sustainability of participating actors and aim for heterogeneous networks, as these are expected to facilitate transition processes (Row 9 in Table 3). These networks explicitly include public actors such as schools, environmental protection parks, and museums, as well as civil organizations like churches, NGOs, and actors from the creative sector. Interviewees describe the building of specialized networks as a long-term effort, but positioning themselves in the center of new and existing regional networks provides knowledge intermediaries with the opportunity to bundle and articulate regional demands.

With regard to the addressed sustainability and digitalization processes in firms, public actors and regions, purposeful networking with other actors that pursue similar objectives is seen as an important instrument to address actors that have grasped and acknowledged the relevance of the respective transition to pinpoint possible solutions to existing challenges by the provision of expert knowledge and peer experience likewise. Given this need for reproducibility of challenges and opportunities, the networked stakeholder need to show certain commonalities regarding size, industry, and structure.

4.1.3 Implementation support

Information dissemination and network building cover preliminary aspects of transition processes and seldom address particular firms or stakeholders. To foster and accelerate the implementation of particular projects, the initiatives also participate in more distinct activities that aim for the implementation of tools, technologies, and processes directly related to digitalization and sustainability. These consulting activities include the support for public fund application, the development of transition strategies, the initiation of student projects, and assistance in the individual adjustment of technical

solutions. In this context, the HEIs offer the subject-related expertise that the intermediaries can build their support on.

The configuration of these consulting activities differs across cases. Some interviewees put special emphasis on their involvement in the development of innovation and digitalization strategies in several firms. Thereby, they aim to go beyond sensitization and precisely explain existing technological and supporting opportunities in order to support the identification of those that meet the respective demands. In some cases, intermediaries employ their own personnel for fostering digitalization projects (Row 10 in Table 3). Our analysis indicates that one reason for the intensified involvement of HEIs is the expectation of higher levels of trust in their technological expertise. In addition, intermediaries initiate different sorts of student projects that aim to analyze firms' structures and take a first step in preparing the ground for digitalization.

On an even more tangible level, the initiatives contribute to the support of bringing these newly generated strategies to life. For instance, they try to accompany the application for public funds from both perspectives (i.e., the firm seeking additional expertise and the scientists seeking options to tie their research to existing demands and hence secure transfer activities) (Row 11 in Table 3). In this sense, knowledge intermediaries try to complement partnering institutions' consultations and add additional expertise. For example, a chamber of handicrafts, an HEI, private consultants, and a carpenter teamed up for the development of an IT security strategy in Case B. A distinctive feature of digitalization is that in the most cases there are proven solutions available on the market for implementing the transition process. The innovative aspects therefore refer to technologies that are new to the organization but not new to the market. The main challenge is therefore not the development of new solutions, but the implementation of existing solutions in organizations that are not able to manage these change processes, for example, due to a lack of expertise or insufficient finances.

Referring to sustainability, the initiatives actively induce change processes in multi-actor projects and closely moderate and accompany these projects. In contrast to digitalization, and in place of providing technical implementation support, they support vision building and actor learning processes and exploration skills that enable actors to contribute to sustainability. Instead, they adapt and implement participatory methods to help regional actors identify impediments to transition. The applied methods serve to identify and develop a common understanding of relevant problems to contribute to sustainability and align actors' interests from the start. In Case A, for instance, they enable participants to develop a common understanding of impediments to system innovation related to sustainability in specific socio-technical systems by the use of participatory methods to allow solutions development and legitimization within a predefined group of actors (Row 12 in Table 3). Participating actors develop solutions in moderated workshops that target system innovation in particular value chains. On the basis of future scenarios, problems are forecasted and response activities are formulated. The intermediaries thereby aim to align actors' interests and raise their awareness of opportunities that enable them to contribute to sustainability transitions. In Case C, however, intermediaries targeted the integration of existing local initiatives into superordinate policy objectives. The approach forms a core group of regional partners in order to legitimate policy goals. In the later stages of the projects, intermediaries encourage additional regional actors to participate (Row 13 in Table 3).

In order to create tangible benefits from the resource intensive events and networks, knowledge intermediaries engage in transition-related consulting offers for individual firms or actors. This happens either by supporting the access to external sources of funding for particular projects or the participation in permanently established support structures. In contrast to the functions described in the previous sections, these activities address individual actors who have already made remarkable progress in transition processes.

In summary, our interviews indicate that intermediaries contribute to digitalization and sustainability through the roles that they perform. They use events to disseminate information and to raise awareness of the targeted goals. The building of networks allows the information and knowledge necessary for

innovation processes to circulate. Furthermore, they support the implementation of regional innovation processes by helping to identify problems or by promoting technical solutions. Notably, the identified roles and activities include the basic elements of knowledge intermediation by enhancing the connectivity between academic and non-academic actors. However, traditional activities of knowledge intermediation mainly address academic actors and try to support their interests, whereas the functions identified in the context of transitions show more of a service feature for non-academic actors.

Table 3: Roles of knowledge intermediaries in sustainability and digital transitions

<i>Transition</i>	<i>Role</i>	<i>Description</i>	<i>Main Channel</i>	<i>Examples</i>	<i>Representative quotes</i>
1	D	Information dissemination	Events	Hosting informative events concerning particular digitalization topics and upcoming trends (up to 200 participants)	“For example on-site events in firms, that describe how they tackle the whole digitalization topic. Such typical Good Practice events, which always attract 120 persons.” [CASE-C-3]
2	D	Hosting singular and sequential workshops in firms or laboratories to demonstrate digital technologies (~20 participants)		“We already had like nine or ten workshops concerning different aspects of digitalization. We had about 15 craftsmen invited and service providers invited [...] and they got the opportunity to test new technologies.” [CASE-B-10].	
3	S	Hosting informative events concerning potential reservations of regional actors towards sustainability transitions		“So it is communicated from the outset that it is quite subliminal. So there is a certain amount of input, of course. The professors introduce themselves. But they are also very pragmatic.” [CASE-B-2]	
4	S	Utilizing own events to function as role models and sensitize regional stakeholders for sustainability		“So in any case, the role model effect. So how we organize our events. That everything is done in line sustainability, well, there is simply a guideline. Procurement, too, of course. So we set an example of what is possible.” [CASE-B-2]	
5	D	Knowledge exchange	Network building	Forming regional networks of academic, public and private experts in digitalization	“For digitalization, we also have the [experts network], which is a new initiative in which we united several experts not only from academia but also from private firms.” [CASE-C-3]
6	D	KI support the building of regional multi-actor networks concerning strategies for sustainability and digitalization		Articulating demands and interests between federal/national governments and regional stakeholders	“So we got the [federal digitalization funding scheme] which funds Software, Hardware and consulting. [...] And in this sense, I think, we are intermediaries between national government, federal government and firms. And governments keep asking us: ‘What else can we do?’” [CASE-B-4]
7	S			Establishing a common regional understanding to enable learning and strategy development	“We have already included a glossary in the application. And the feedback, especially from the practitioners, is that it is enormously helpful to have something like this. Because you can come to an agreement on that here, anyway.” [CASE-A-1]
8	S			Incorporating actors from civil society in regional projects and initiatives	“And our partners are quite explicitly businesses. But also public institutions, administrations, politics, civil society, associations, clubs and even individual citizens and initiatives. Because of

<i>Transition</i>	<i>Role</i>	<i>Description</i>	<i>Main Channel</i>	<i>Examples</i>	<i>Representative quotes</i>
9	S			Identifying, selecting and including heterogeneous regional stakeholders	course, the less institutionalized they are, the more difficult it is to engage in systematic communication.” [CASE-B-1] “What is the sustainability challenge for leather? And how are the supply chains structured? What are the rough positions of the different actors? That you already have an overview. I have more or less familiarized myself with this. And I also started to build up a network very early on. And I simply wrote to the actors quite wildly at the beginning. And I also invited them a bit to join us in this project, which is very inclusive.” [CASE-A-13]
10	D	Implementation support	Consulting	Creating additional regional support structures	“That is the SME competence center. That is two jobs, Ms. [X] and Mr. [Y], that have been created to foster digitalization projects. And that is located within the HEI.” [CASE-B-4]
11	D			Providing support for the application for public funds concerning digitalization of firms (and maintain long-term relationship)	“To us, it is not only important to provide a contact but to be a stable contact person because that is how new projects emerge. If you know each other, the firm is more likely to approach you with new ideas and we can find new funding opportunities for digitalization or other topics.” [CASE-D-15]
12	S			Enabling and closely moderating change processes in multi-actor projects	“Yes, [...] in everything we do, we have the claim to contribute to the sustainable development of the region and to promote it. And so we enable [...] the processes, the projects that we support and accompany and advise. So I would say we also do our part to support and promote sustainable development.” [CASE-B-3]
13	S			Supporting vision building and peer-to-peer learning processes	“Then the offer after the kick-off workshop was, if you want to move forward, we invite you to a scenario process. Scenario process means four or five full-day meetings where you think together about the future. In other words, we do scenario back casting and identify drivers, classify them in their interactions, and so on. In order to arrive at scenario stories in the end, and the practitioners were ready for this. [...] And in the end we had two scenario stories that the practitioners formulated themselves. In other words, they provided the input for the driving and driven factors that comprise the market situation of leather chemistry in 2035.” [CASE-A-1]

4.2 Additional contributions resulting from effects of digitalization on sustainability

“The idea was not to make IT for the sake of IT. But IT as an enabler of sustainable development.”

[Case-A-1]

Knowledge intermediaries acknowledge sustainability and digitalization as two important fields of activity and as superordinate objectives that are also supported and directed by federal ministries and other policy makers (along with other omnipresent societal challenges, such as mobility). As illustrated by the introductory quote, our analysis provides insights into two previously identified interdependencies between sustainability and digitalization and suggests additional functions of knowledge intermediation that result from these interdependencies.

The first one is the facilitating and accelerating effect of digital technologies on sustainability. Many innovative digital solutions afford firms the opportunity of optimizing internal processes or enhancing working conditions, while at the same time reducing the consumption of energy or other resources. Accordingly, several of our interviewees perceive fostering digital innovation as an increasingly important part of their work that automatically enhances their contributions to sustainability. However, some interviewees contrast this positive viewpoint with a more critical one that questions these desirable effects and finds fault with the inflationary use of sustainability labels for the legitimation of digital innovation projects. Table 4 contrasts both effects. These contrary effects of digitalization on sustainability each suggest different additional contributions that complement the roles discussed above.

In discourses about the effects of digitalization on sustainability, the enabling and accelerating effect of digital solutions on sustainability is brought to the fore. This line of argument is also reflected in the interview data. Progress in digitalization is considered an important driver and prerequisite for the development of sustainability. Interviewees report fostering digitalization by screening HEIs' research portfolios in order to identify research on digitalization topics with positive sustainability effects. Furthermore, they report supporting emerging projects by initiating cooperation. For instance, knowledge intermediaries in Case A identified a project to digitally optimize urban traffic conditions in favor of a publicly financed sharing system for electric cargo bikes and subsequently organized and monitored the resulting innovation process. Thus, they first carried out one of the roles discussed above by organizing a dialogue event to address multiple regional stakeholders. However, it became obvious during this process that prioritizing e-bikes in urban traffic led to extended traffic light phases for cars, which in turn induced air pollution and fuel consumption. As a result, the intermediaries acquired further academic expertise so that they could cooperatively develop and implement a monitoring tool.

In Case B, intermediaries supported the development of a digital regional delivery platform that makes use of public buses to enhance the degree of capacity utilization in rural areas. Therein, they participate in, and in some cases lead, inter-organizational working groups that connect different actor groups and therefore create special positions within HEI administrations. Furthermore, knowledge intermediaries span the boundaries between regional sustainability projects and academics, who provide additional knowledge and interregional networks and so complement these projects with digital solutions.

The second effect that we identify in our interviews suggests a lack of reflection in current technology transfer processes and was brought forward in several interviews. With sustainability and digitalization being omnipresent megatrends, interviewees suspected a lack of critically questioning sustainability issues in cases of promising digitalization results. Accordingly, several interviewees criticized the vague standards and the manifold opportunities to label almost all knowledge transfer and innovation projects as 'sustainable' while not taking into account possible rebound effects (see Gossart, 2015 for an overview). In this vein, interviewees criticized innovators for using different dimensions of sustainability to legitimate their digital projects while rejecting sustainability in favor of technological and monetary progress whenever high turnovers are expected. Following this line of argument, that leads to a scenario in which high-tech solutions are fostered without assessing possible rebound effects. This perspective points toward an additional role for knowledge intermediation that concerns the

monitoring of innovation processes. Interestingly, although the lack of this function was criticized by several interviewees, they did not report to fulfill this role yet.

Table 4: Main perceptions of the interplay between sustainability and digitalization and of emerging roles for knowledge intermediaries

	<i>Digitalization as a driver of sustainability</i>	<i>High potential of digital technologies as a threat to sustainability evaluation</i>
<i>Effects</i>	Digitalization and digital innovation support sustainability via resource efficiency and/or enhanced working conditions	Deficient monitoring/evaluation of rebound effects in anticipation of digital improvements
<i>Rating</i>	Supportive/Positive	Critical/Negative
<i>Representative quotes</i>	<p>“In addition, these projects are permeated by digitalization, industry 4.0, IT, artificial intelligence. That is a very important topic. At the end of the day, we hope that these technologies that are developed here will have a significant positive effect on the topic of resource efficiency, because that’s what the planet indispensably needs.” [CASE-C-6]</p> <p>“In the matter of digitalization, basically everything is sustainable.” [CASE-B-10]</p> <p>“And our task was to identify potentials for sustainable development by digitalization. [...] Therefore, we reactivated a format we had already used before, namely the [dialogue events with several stakeholders].” [CASE-A-1]</p>	<p>“Of course, it’s fine if you create digital solutions. However, is it okay if the benefits focus on a handful of companies that make billions while, on the other hand, you destroy hundreds of thousands of jobs? We ought to evaluate every technological innovation in a broader context considering social and ecological aspects. I miss that in the whole concept of technology transfer.” [CASE-C-6]</p> <p>“And usually, especially if it is about a lot of money, the topic of sustainability is not in the foreground. Instead it is digitalization, artificial intelligence, robotics, assisting systems.” [CASE-C-8]</p> <p>“I bet that any innovation project in [other innovation system] can pick at least one SDG with no struggles. [...] And in case of a digitalization project, it’s education or resilient infrastructure or whatever. Unfortunately, the application of SDGs is unlimited.” [CASE-A-14]</p>
<i>Roles for knowledge intermediaries</i>	Targeted identification and support of digital projects for sustainability	Monitoring/evaluation of digitalization projects to avoid rebound effects

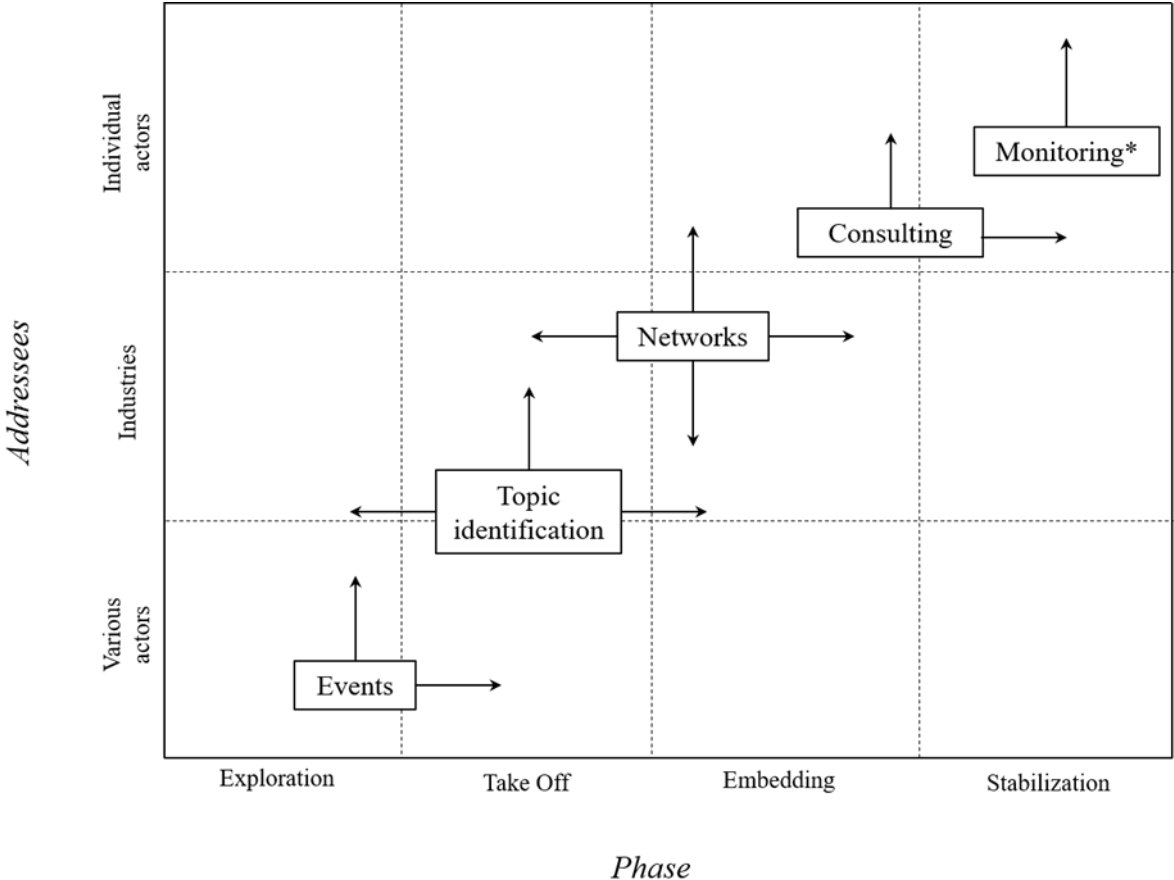
5. Discussion

The functions of knowledge intermediation and the institutional arrangements in which they are fulfilled are at the center of current scholarly debates. Being positioned on the intersection between academia, industry and government, knowledge intermediation is mainly discussed as an instrument to foster research commercialization and academic entrepreneurship. We contribute to a holistic understanding of knowledge intermediation by showing that the core activities are pro-actively used to foster socio-technical transition processes. Further, we show that this proactive perception of the own role in different transition processes leads to the emergence of new functions that relate to the interdependencies between different transitions.

Adding to the rich discussion about the third academic mission scholars have recently started to assess the roles of HEIs in regional sustainability transitions and emphasize their importance as regional drivers of change. Therein, extant studies discuss several dimensions and activities that HEIs use to contribute to sustainability (Zilahy et al., 2009; Peer and Stoeglehner, 2013; Trencher et al., 2014; Radinger-Peer and Pflitsch, 2017; Purcell et al., 2019). However, the manifold forms of participation seem rather fragmented with formats of institutional support for knowledge transfer playing a minor role (Blume et al., 2017; Radinger-Peer et al., 2021). The paper adds to this discussion by generally corroborating the prevalent perception of HEIs as important drivers of regional transitions. In all assessed initiatives, HEIs have admitted their regional responsibility by taking leading roles. Second, as indicated by the

composition of the initiatives, the emerging roles are based on close collaboration between HEIs and non-academic, mostly public stakeholders. Considering recent conceptualizations of HEI-centered ecosystems for technology transfer and entrepreneurship (Good et al., 2019), these collaborative structures suggest a group of particularly transition-oriented activities that result from these ecosystems. The willingness to participate in temporary yet institutionalized initiatives indicates an organizational shift toward a permanent intensification of transition-related activities. This willingness is underlined by certain tentative organizational adjustments, such as the creation and funding of additional personnel and internal mechanisms that aim to pave the path for sustainable and digital role modeling. In a nutshell, the collaborative acting on transition-related topics represents an additional facet of the broadening regional mandate of HEIs.

Figure 3: Contribution of knowledge intermediation to different phases of transitions Source own compilation, partly based on van Lente et al. (2003)



*role suggested but not reported

Whilst activities and effects of knowledge intermediation are vibrantly discussed in the context of entrepreneurship and research commercialization, research focusing on the role and relevance of knowledge intermediation in socio-technical transitions is emerging at best (Kivimaa et al., 2017; Paniccia and Baiocco, 2018). The contributions that we identify show several overlaps with previously identified functions of transition intermediation, as they relate to the articulation of demands and the formation of regional networks (Kivimaa, 2014; Kanda et al., 2018). What is novel, is the proactive filling of these functions by actors that per definition have a focus on knowledge intermediation, which contradicts extant research inasmuch as these works state that on the part of HEI focused actors a “lack of explicit procedures to functionally integrate sustainability into innovation support” results in a “dominance of traditional roles of technology transfer related to intellectual property and start-ups” (Kivimaa et al., 2017, p. 11) and that “their role can be regarded as responsive rather than active” (Radinger-Peer and Pflitsch, 2017, p. 182).

Hence, despite our general corroboration of HEIs' relevance in transition processes, these findings point towards an underrepresentation of functions of knowledge intermediation. The proactive formation and development of initiatives that, among other activities, address transitions, indicates that it is particularly important to assess the role of knowledge transfer in order to analyze how HEIs can contribute to the tackling of greater societal challenges on a regional level.

Our analysis carves out two diverging effects of digitalization on sustainability that have previously been identified and discussed: (i) the resource-saving effects of digitalized processes as a driver for sustainability and (ii) the high innovative potential of digital solutions as a threat for sustainability-related evaluation (e.g., Brenner and Hartl, 2021; Del Río Castro et al., 2021). Interestingly, these well-known interdependencies lead to additional contributions of knowledge intermediation that have not been discussed before, namely the purposeful identification of digital innovation projects for the sake of sustainability and the monitoring of digital innovation projects with regards to sustainability.

Consolidating these additional options with the three previously identified functions and questioning their scopes and objectives, shows that all five functions unfold their value at different transition stages and therefore address different groups of actors. Awareness-raising activities, mainly different sorts of *Events*, address various regional actors that are not yet perceiving and tackling transitions as pestering challenges. Subsequently, sensitized actors are addressed in industry-specific *networks* to develop more specific support mechanisms and enable peer-learning. Hence, actors who develop competencies can be addressed in more specific activities to *identify particular topics* and projects. Such projects are then supported via *Consulting* and *Monitoring* activities to secure their success. This phased progression connects to the seminal work by van Lente et al. (2003), who suggest that transitions occur in different phases and intermediaries fulfill different functions in each phase.¹² Therein, van Lente et al. (2003, p. 261) suggest that during an initial phase of *Exploration*, intermediaries identify major trends and articulate societal needs. We substantiate this suggestions by showing how different sorts of *Events* are utilized for this articulation. The addressees of these activities are various actors that have not been involved in transitions before. This phase merges into the *Take Off* that develops visions and agendas. This relates to the opportunity to make use of the affiliation to academia to identify projects and technologies that contribute to sustainability. Further, this focus supports the inclusion of academics in emerging regional *Networks* that address relevant questions and challenges in particular industries. These emerging networks also support the *Embedding* of transitions in regions by enabling the formation of sustainability-related pilot projects involving academia and academic knowledge stocks. In this regard knowledge intermediation also includes the consultation of individual actors of projects in order to ensure the success of cooperative endeavors. Finally, concerning the interdependencies between sustainability and digitalization, the position on the intersection between academia and industry enhances the opportunity to observe and examine various digitalization projects in terms of potentially undesired effects on sustainability. Thereby, knowledge intermediation can directly contribute to the stabilization of transitions.

6. Concluding implications

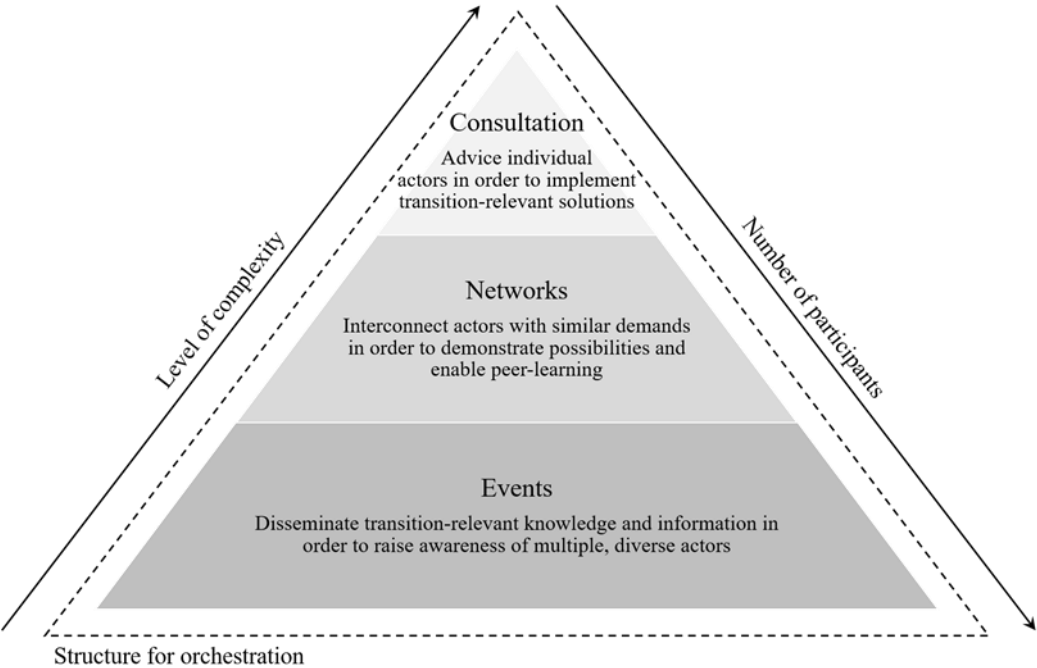
The starting point of this paper was the apparent yet under-researched conceptual overlap between different functions of intermediation in innovation systems. Aiming for a contribution to closing this gap, the paper links the concept of knowledge intermediation to current discussions about co-occurring socio-technical transitions. Concerning the first research question about knowledge intermediation in sustainability and digitalization, we find three major contributions to transition intermediation by actors whose main focus is on knowledge intermediation. First, the dissemination of information and awareness raising for transition goals via events. Second, knowledge intermediaries build specialized

¹² van Lente et al. (2003) recognize the contradiction between a systemic approach and phases but use them to denote that different addressees have a different perception of and approach to tackling transitions. Consequently, neither the suggested phases nor the assignment to phases are meant to describe a sequentially linear process but an iterative and contemporaneous one.

networks that allow the information and knowledge necessary for innovation processes to circulate. Third, they support the implementation of regional innovation processes that identify problems or promote technical solutions. Regarding the research question concerning additional roles emerging from the interplay between sustainability and digitalization, we find that this suggests an important role for actors that ensure the incorporation of knowledge and knowledge generators in transition processes because they are in the right position to estimate the potential positive and negative effects of digitalization on sustainability. Working at the intersection of both transitions, they are key actors in developing digitalization projects that avoid rebound effects on sustainability or contribute to sustainability transitions.

From a policy perspective, this calls for intermediation that covers all of the three functions (Fig. 4). The perception of sustainability and digitalization as open-ended transitions requires a procedural perspective that addresses the different progress levels of regional actors with different activities. The basis of a comprehensive, ideal-type transition support are low-threshold events that communicate to a broad range of actors and ensure their participation. Importantly, the knowledge and information disseminated in these events needs to show a rather low level of complexity to attract high numbers of participants. Once an actor has acknowledged and internalized the relevance of a strategically and proactively tackling transition processes, further activities can be fostered by networking with and peer-learning from other actors with similar demands and potentials. To finally apply newly acquired knowledge and make progress in their transition efforts actors require support in the adaptation and implementation phases. This requires intermediaries that represent trustworthy expertise in different transitions and an institutional orchestration of different intermediation actors and functions that ensures permeability between different support formats. The assumed progression from freshly sensitized event guests to the purposive implementation of transitions-related technologies implies that all clients are well-informed about all regional opportunities and a versatility of activities that allows for participation in all phases.

Figure 4: Possible composition of intermediary functions for transitions Source own compilation



Concerning the regional organizational landscape, this indicates the need to strive for complementary capabilities between different intermediaries. Concerning the content and activities of policies of knowledge intermediation, the analysis suggests two amendments: First, knowledge intermediation approaches should purposefully include mission-oriented activities to support regional transition

processes. Second, the societal effects of knowledge and technology transfer should be taken into consideration. As reflected in our data, most current knowledge and technology transfer approaches presuppose desirable effects, especially in digitalization projects, and neglect possible negative side effects of the innovations they support. Their unique position at the intersection between creators and users of knowledge enables knowledge intermediaries to fulfill monitoring functions valuable for a development toward sustainability-oriented innovation.

From a scholarly perspective, our explorative approach is a first step in disentangling the interdependencies between the various functions and activities of intermediation as well as between sustainability transitions and digitalization. However, our qualitative approach also has some limitations. Tailored to the incorporation of sustainability aspects by publicly funded knowledge intermediary initiatives, our data provides a rich database for identifying and illustrating self-perceived roles. However, neither can we elaborate on the underlying motivations and the organizational embeddedness of the identified roles, nor assess their effects on the ambiguous position of intermediaries within the innovation systems. Considering the sample of interviewees, our results represent nothing more than a self-assessment. While this approach has proven to yield relevant results in previous research, it evaluates only the input side of the intermediation process and a broader sample would be required to incorporate the output side.

Future research could enrich current discussions by focusing on these aspects. To do so, these analyses should incorporate insights and opinions from scientists, firms, regional policy makers, and members of other relevant target groups that have participated in intermediation formats and thus evaluate intermediaries' roles from an external perspective and allow for additional design implications. Furthermore, blurring the lines between the roles and activities of different sorts of intermediaries fuels the ongoing debate on the regional interplay between intermediaries. Hence, future research should focus on organizational drivers, barriers, and peculiarities of intermediary collaboration to support the development and formulation of comprehensive policies that combine innovation-focused and transition-focused approaches. From a regional perspective, it seems self-evident that innovation policy orchestrates different sorts and functions of intermediation comprehensively. However, more nuanced insights regarding the interplay between different concepts and its' translation into regional institutions are needed to fully grasp the inherent potential and inform policy makers.

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Appendix

A) Case descriptions: Regions and Initiatives

Case A) The city of Darmstadt is located in the Frankfurt metropolitan area in the middle of Germany and has the fourth largest number of citizens in the state of Hesse. It is characterized by an extensive university and research landscape. Next to several smaller HEI and research institutes in Darmstadt, the Darmstadt University of Applied Sciences ('h_da') is second in scale and number of students to the Technical University Darmstadt ('TUD'). With the TUD being one of the leading universities in Germany for engineering research and teaching, the h_da gives more attention to its economic, social, media and design departments, though engineering remains to play an important role.

The analyzed initiative s:ne (system innovation for sustainable development) started in 2018 as part of the "Innovative University" funding initiative by the Federal Ministry of Education and Research. Pursuing the goal of creating and applying mutual transformative knowledge transfer activities to foster learning processes and sustainability transitions with partners from industry and civil society, s:ne has a strong orientation towards sustainability. To make possible system innovation, it developed an innovation and transfer platform as a core element to initiate cooperation and to support participating actors align visions and implement projects on sustainability challenges. Project partners to s:ne include actors that especially engage in sustainability transitions as for example the Institute for Applied Ecology.

Case B) The city of Eberswalde is located in the north-eastern part of the federal state of Brandenburg. The rural county in between the metropolitan areas of Berlin and Stettin is characterized by agriculture and small and medium enterprises except for a limited number of petrol and chemical industries. Additionally, there are large biosphere reserve areas that are sparsely populated, but are nature sights that are used to offer touristic services. One central actor of the regional innovation system is the Eberswalde University for Sustainable Development. This University, with an explicit focus on sustainability, specializes on sustainable production and rural development.

This study analyzed the initiative region 4.0 that is part of the funding program "Change through Innovation in Regions" by the Federal Ministry of Education and Research. It aims to establish an transdisciplinary regional innovation network supporting sustainability-oriented innovation. It is led by Eberswalde University for Sustainable Development ('HNEE') that is the central actor for knowledge transfer and innovation support in the rural region. As one unique feature, starting in the late 1990s the university has comprehensively converted its educational, scientific and transfer activities in order to consider sustainable development, expressed e.g. by the renaming of the university in 2010. The project comprises three fields of actions that are agriculture and regional nutrition, public services and infrastructure and nature-oriented tourism. The fields of actions represent the regional endowments and were developed jointly with regional actors that also are participants of the alliance formed by launching region 4.0. Important regional partners are regional business development agencies, the regional transport company as well as the municipality utility company. Furthermore, higher education institutions from Berlin as well as other Brandenburg regions are taking part evaluating and accompanying the project.

Case C) The city of Augsburg is located in the western part of the federal state of Bavaria. Augsburg and its greater surroundings including Munich and Nuremberg form one of the strongest economic areas in Germany. Additionally, two HEI and several research institutions make Augsburg a knowledge-intensive location. A unique regional aspect is, dating back in the 1990s, multiple and heterogeneous regional stakeholders established the local agenda 21 initiative in the city of Augsburg. Forming committees called "agenda forums" that address different regional

sustainability issues and backed by the municipality, they aim for a cooperative and sustainable city development.

The assessed initiative led by the University of Applied Sciences Augsburg ('HSA') is HSA_transfer and refers to itself as "agency for cooperative HEI projects". It is part of the funding program "Innovative university" and it develops and tests new formats for knowledge transfer like student service learning and alumni networking. Project goals are to support and improve knowledge transfer activities, by providing a transfer "toolbox" for HEI members, and to foster networks with civil society actors through cooperative projects with e.g. schools, museums, civil initiatives or associations. HSA_transfer increases the visibility of transfer activities for civil society with a strong emphasis on internal and external communication.

Case D) The city of Goettingen is situated the south of the federal state of Lower Saxony between the metropolitan areas of Hannover in the north and Kassel in the south. Goettingen is home of three HEIs and multiple research institutions while the economy of its more peripheral environment is mostly influenced by SMEs except for a few major companies, e.g. in life sciences. For the southern part of lower Saxony, the HEI of Goettingen are important actors referring to knowledge transfer and innovation support.

The initiative led by the University of Goettingen is SNIC (Innovation Campus in Southern Lower Saxony) that was established in 2016 on behalf of regional intermediary actors and is funded by the federal state of Lower Saxony. The catchment area of SNIC is not limited to the city of Goettingen but also includes surrounding counties as well. It refers to itself as an innovation network and connects HEI and research institutions with other regional intermediary actors as chambers and municipalities to support the transfer of knowledge to local stakeholders and to foster the knowledge transfer structure without a specific sustainability orientation. Providing interfaces for actors to connect, the SNIC program aims to strategically improve the knowledge economy and the region's innovative capacity. Complementary to and also cooperatively with participating HEI knowledge transfer offices, it provides multiple innovation support and transfer activities including, e.g. an innovation accelerator, best-practice on-site and networking events, funding support, innovation scouting and innovation consulting.

B) Interviews

<i>No.</i>	<i>Case</i>	<i>Sector</i>	<i>Role</i>	<i>Duration [min.]</i>
1	Case A	Academia	Professor	112
2	Case A	Academia	Research Associate	40
3	Case A	Civil society	Research Associate of a foundation	54
4	Case A	Industry	Representative of chamber of commerce	61
5	Case A	Academia	Research Associate of a Research Institute	66
6	Case A	Academia	Research Associate of a Research Institute	36
7	Case A	Academia	Research Associate	65
8	Case A	Academia	Senior Researcher of a Research Institute	91
9	Case A	Academia	Senior Researcher	90
10	Case A	Industry	Representative of chamber of commerce	91
11	Case A	Public admin.	Innovation support manager	34
12	Case A	Industry	Representative of Business Association	40
13	Case A	Academia	Senior Researcher	58
14	Case A	Industry	Sustainability consultant	57
15	Case A	Academia	Representative of university sust. office	45
16	Case A	Academia	Representative of presidential board	59
17	Case A	Public admin.	Representative of university transfer office	42
18	Case B	Academia	Professor	80
19	Case B	Academia	Innovation support manager	94
20	Case B	Academia	Innovation support manager	97
21	Case B	Industry	Innovation support manager	138
22	Case B	Public admin.	Business developer	61
23	Case B	Academia	Professor	53
24	Case B	Public admin.	Business developer	64
25	Case B	Academia	Project manager	61
26	Case B	Civil society	Representative of a civil association	71
27	Case B	Industry	Innovation manager	89
28	Case B	Industry	Innovation manager	66
29	Case B	Civil society	Representative of a civil association	91
30	Case B	Public admin.	Knowledge transfer manager	58
31	Case B	Industry	Representative of regional craft sector	77
32	Case B	Public admin.	Representative of biosphere reserve	100
33	Case B	Academia	Professor	70
34	Case B	Academia	Professor	70
35	Case B	Academia	Professor	76
36	Case C	Academia	Professor	103
37	Case C	Academia	Professor	86
38	Case C	Public admin.	Representative of innovation support	77
39	Case C	Academia	Program Manager	73
40	Case C	Public admin.	Business developer	35
41	Case C	Public admin.	Representative of an innovation center	54

42	Case C	Industry	Representative of chamber of commerce	54
43	Case C	Academia	Representative of university transfer office	72
44	Case C	Academia	Research associate	73
45	Case C	Public admin.	Representative of university sust. office	54
46	Case C	Academia	Communication manager	77
47	Case C	Civil society	Representative of a foundation	62
48	Case C	Civil society	Representative of a civil association	73
49	Case D	Academia	Professor	87
50	Case D	Academia	Project manager	92
51	Case D	Public admin.	Representative of SNIC Office	72
52	Case D	Public admin.	Innovation support	62
53	Case D	Civil society	Representative of a foundation	59
54	Case D	Academia	Professor	75
55	Case D	Public admin.	Business developer	64
56	Case D	Public admin.	Business developer	48
57	Case D	Academia	Innovation scout	50
58	Case D	Industry	Representative of chamber of crafts	71
59	Case D	Public admin.	Business Developer	50
60	Case D	Industry	Representative of chamber of commerce	78
61	Case D	Academia	Innovation scout	55
62	Case D	Public admin.	Business developer	52

C) Interview guide

Section 0: Background of the interviewee

- Please briefly describe your job/function?
- How do you/your organization understand "knowledge transfer"?

Section 1: Knowledge transfer structures and characteristics of key stakeholders

- Please describe the [organizational] structures of regional knowledge transfer.
- Please give an example of how knowledge transfer takes place in the region.
- Can you describe how learning processes are induced the knowledge transfer?

Section 2: Innovation processes

- Please describe what kind of innovations have already been developed so far.
- Please describe what kind of innovations are currently being developed.
- Please describe your role in an [exemplary] innovation process.

Section 3: Evaluation and assessment of results

- How do you evaluate your activities and results in terms of knowledge transfer?

Section 4: The regional innovation system

- Please describe special features of the regional innovation system.
- What are the barriers to knowledge transfer in the region?

Section 5: Sustainable development

- What role does sustainable development play in your organization/work?
- What is the importance of innovations related to sustainable development for you?
- What contributions to sustainable development do you see through the project / the knowledge transfer structures / and the resulting innovations?

Chapter VI: Digitalisierung und regionaler Wissenstransfer: Interdependenzen und Herausforderungen

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Digitalisierung und regionaler Wissenstransfer: Interdependenzen und Herausforderungen

Zusammenfassung

Die Digitalisierung von Unternehmen und der Wissenstransfer (WT) zwischen akademischen und nicht-akademischen Akteuren sind zentral für regionale Innovationsstrategien. Dennoch ist weder klar, wie der WT zur Digitalisierung beitragen kann, noch wie digitale Arbeitsweisen den WT unterstützen können. Um beide Fragestellungen näher zu beleuchten, untersuchen wir sechs regionale Wissenstransfersysteme in Deutschland. Die Analyse zeigt, dass Maßnahmen des WT auf unterschiedliche Weise zu Digitalisierungsprozessen regionaler Akteure beitragen und sich die Akteure des WT vielfach digitaler Arbeitsweisen bedienen. Innerhalb regionaler Wissenstransfersysteme werden sowohl Informationen zu digitalisierungsrelevanten Themen vermittelt und in Netzwerken vertieft, als auch konkrete Digitalisierungsprojekte unterstützt. Digitale Tools und Arbeitsweisen spielen eine wichtige Rolle, einerseits für die Durchführung entsprechender Veranstaltungsformate und andererseits für die Zusammenarbeit zwischen Organisationen. Die Analyse zeigt jedoch auch, dass die Möglichkeiten der Unterstützung durch WT begrenzt sind und auch hinsichtlich der Nutzung digitaler Instrumente verschiedene Herausforderungen bestehen. Letztere konzentrieren sich auf die Auswahl und Umsetzung bestehender Lösungen, die von wissenschaftlicher Seite nur begrenzt sinnvoll unterstützt werden können. Themen von größerem wissenschaftlichem Interesse finden nur bei wenigen, bereits stark digitalisierten Unternehmen intensivere Beachtung. Darüber hinaus gestaltet es sich schwierig, vertrauensbasierte Netzwerkbeziehungen über digitale Kanäle zu initiieren und für Kooperationen zwischen Organisationen nutzbar zu machen.

Schlüsselwörter

Wissenstransfer, Digitalisierung, regionale Wissenstransfersysteme, Wissensintermediäre

Abstract

Digitalization and knowledge transfer represent central aspects of most regional innovation strategies. Nonetheless, we know little about the interdependencies between both topics. We neither know how knowledge transfer can contribute to digitalization nor how digital instruments can support knowledge transfer. To shed more light on these aspects, we analyze six regional knowledge transfer systems in Germany. The analysis reveals that knowledge transfer contributes to firm digitalization in several ways and that supporters of knowledge transfer often apply digital instruments. Within regional knowledge transfer systems, intermediaries disseminate relevant knowledge, establish specific networks and support particular digitalization efforts. Digital tools play an important role in processing these activities as well as in cooperating within knowledge transfer systems. However, it also becomes clear that the possibilities of knowledge transfer in digitalization are limited and that there remain several challenges in utilizing digital instruments in knowledge transfer. Challenges in digitalization often consist of selecting and implementing digital solutions, which cannot always be supported by academia. Innovative academic topics are only taken up by a few digital pioneers. Further, it remains challenging to initiate and establish trust-based network relationships and cross administrative borders via digital channels.

Keywords

knowledge transfer, digitalization, regional knowledge dynamics, knowledge intermediaries

JEL

I29, O32, O39, Q29

Digitalisierung und Wissenstransfer als standortspezifische Herausforderungen regionaler Innovationspolitik

Die Digitalisierung stellt eine der zentralen Herausforderungen für das wirtschaftliche und gesellschaftliche Zusammenleben dar, mit denen sich Unternehmen und Politik konfrontiert sehen. Gerade für Geschäftsführung und Mitarbeiterschaft kleiner und mittlerer Unternehmen (KMU) gestalten sich die Entwicklung und Adaption von Strategien zur Digitalisierung eigener Prozesse und Geschäftsmodelle herausfordernd (Demary et al., 2016; Öz, 2019). Mit der digitalen Transformation sind weitgehende Veränderungen von Berufsfeldern und Arbeitsmärkten (Arntz et al., 2020) sowie Anforderungen an Beschäftigte und Arbeitgeber*innen verbunden (Weber, 2017), die über die Ebene von Einzelunternehmen hinausgehen. Auch die regionale Ebene ist relevant für Digitalisierungsprozesse (Zika et al., 2018).

Der Zugang zu externem Wissen stellt in wissensbasierten ökonomischen Strukturen einen wichtigen Bestimmungsfaktor der Wettbewerbs- und Innovationsfähigkeit von Unternehmen und Standorten dar. Politische und gesellschaftliche Erwartungen gegenüber wissenschaftlichen Einrichtungen führen dazu, dass sowohl Universitäten im Rahmen ihrer „third mission“ als auch öffentliche Akteure den wechselseitigen WT zwischen Wissenschaft, Wirtschaft und Gesellschaft aktiv fördern (Czarnitzki et al., 2001; Bercovitz and Feldman, 2006).¹³ Universitäten sind zunehmend gefordert, sich von „Elfenbeintürmen“, zu gesellschaftlich engagierten Akteuren zu entwickeln, um den rekursiven Transfer produzierten Wissens zwischen Wissenschaft, Wirtschaft und Gesellschaft zu ermöglichen (Breznitz and Feldman, 2012). Der Aufbau regionaler Netzwerkstrukturen, die KMU den Zugang zu akademischem Wissen und damit die Teilhabe an Innovationsprozessen ermöglichen, ist zentraler Bestandteil innovationspolitischer Strategien (Back and Fürst, 2011), beispielsweise im Kontext clusterpolitischer Ansätze (Wissenschaftsrat, 2007). Akteure der Wirtschafts- und Innovationsförderung haben in den vergangenen Jahren sowohl WT als auch Digitalisierung als zentrale Arbeitsfelder erkannt. In diesem Sinne verstehen politische Strategien WT zunehmend als Mechanismus zur Förderung von Digitalisierung (Wissenschaftsrat, 2016; Sachverständigenrat, 2020).

Hinsichtlich zweier zentraler Aspekte besteht Forschungsbedarf: Erstens wirft die steigende Relevanz der Digitalisierung die Frage auf, inwiefern regionale WT-Strukturen die Veränderungen in Unternehmen unterstützen. Zweitens stellt Digitalisierung neben steigendem Wettbewerbsdruck zwischen Wissenschaftseinrichtungen und sich ändernden gesellschaftlichen Erwartungen eine der zentralen Herausforderungen für WT-Formate dar (Wissenschaftsrat, 2016), sodass Diskussionen darüber aufkommen, wie WT-Akteure selbst von der Adaption digitaler Kommunikationskanäle und Werkzeuge profitieren können (Ebers, 2021; Terstriep and Rabadijeva, 2021). Dieser Beitrag nimmt zwei verschiedene Perspektiven ein, um einen Beitrag an der Schnittstelle zwischen WT und Digitalisierung zu leisten. Einerseits zeigt der Beitrag auf, wie WT-Systeme Digitalisierungsprozesse in KMU fördern, und beleuchtet damit die nach außen gerichtete Perspektive der analysierten WT-Systeme. Andererseits adressiert der Beitrag die interne Perspektive der WT-Akteure, indem er Herausforderungen identifiziert, die bei der Digitalisierung eigener Aktivitäten und Strukturen auftreten. Gemäß dem explorativen Charakter des Forschungsthemas und der genutzten Datengrundlage zielt der Beitrag darauf ab, die Interdependenzen zwischen WT und Digitalisierung als Gegenstand zukünftiger innovationspolitischer Forschungsvorhaben und Instrumente zu positionieren. Spezifische Detailergebnisse zu präsentieren liegt deswegen nicht im Fokus der Analyse.

Auf Basis einer Analyse von sechs regionalen WT-Systemen adressiert der Beitrag folgende Forschungsfragen:

1. *Wie tragen regionale Wissenstransfersysteme zu Digitalisierungsprozessen in KMU bei?*

¹³ Der Beitrag legt ein breites Verständnis des Begriffs Wissenstransfer zugrunde, das alle Aktivitäten umfasst, die nötig sind um Wissen im Kontext einer anderen Organisation in Wert zu setzen (vgl. hierzu Wit-de Vries et al. (2019, p. 1238).

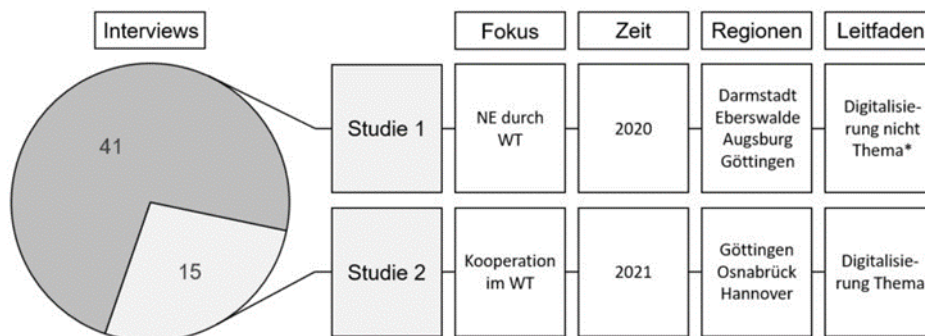
2. Welche Herausforderungen treten bei der Verwendung digitaler Wissenstransferformate auf?

Quellstudien und Methodik

Zur Beantwortung der Forschungsfragen verwenden wir einen Multi-Fallstudienansatz zur Analyse von sechs WT-Systemen in den Regionen Augsburg, Darmstadt, Eberswalde, Göttingen, Osnabrück und Hannover. Hierbei untersuchen wir 56 Expert*inneninterviews mit an WT beteiligten Stakeholdern, insbesondere Wirtschaftsförderungseinrichtungen (18), Transferstellen von Wissenschaftseinrichtungen (24), Kammern (9) sowie Unternehmen bzw. Unternehmensverbänden (5). Die Untersuchung basiert auf zwei Forschungsprojekten zu WT-Strukturen in Deutschland. Der Fokus der Forschungsprojekte lag auf dem Potenzial regionaler WT-Systeme für Nachhaltige Entwicklung (NE) (Studie 1, siehe Bäumle et al., 2022) und dem Zusammenwirken verschiedener Akteure der Innovationsförderung (Studie 2, siehe Bäumle and Bizer, 2022). Studie 1 zielte auf die Erforschung der Rolle von NE in WT-Systemen und basierte auf je zwei Regionen mit und ohne explizitem Fokus auf NE. Studie 2 adressierte Voraussetzungen und Effekte der strategischen Zusammenarbeit zwischen verschiedenen WT-Akteuren und berücksichtigte drei Regionen.

Abbildung 1 gibt einen Überblick über die genutzten Interviews. Entsprechend der Neuartigkeit unseres Forschungsinteresses, analysieren wir die Interviews induktiv und explorativ, um die maßgeblichen Schnittstellen zwischen Digitalisierung und WT zu identifizieren. Dabei ist zu beachten, dass alle Interviews nach Beginn der Covid19-Pandemie bzw. dem Beschluss der damit verbundenen Einschränkungen durchgeführt wurden.

Abbildung 1: Eckpunkte der genutzten Erhebungen (Quelle: eigene Darstellung)



* Studie 1 beinhaltet 22 weitere Interviews, in denen das Thema Digitalisierung nicht oder nur am Rande thematisiert wurde

Ergebnisse

Den Forschungsfragen folgend, gliedern sich die Ergebnisse in zwei Teile. Zunächst stehen die Ergebnisse zur Unterstützung von Digitalisierungsprozessen in KMU durch regionale WT-Systeme im Fokus. Darauf folgen die Herausforderungen, die mit der Digitalisierung von WT-Strukturen selbst einhergehen.

Unterstützung der Digitalisierung regionaler KMU

Viele KMU haben einen erheblichen Orientierungsbedarf und schrecken häufig vor dem Ausmaß der Veränderungen zurück, die Digitalisierung auslösen kann: Sensibilisierung und Peer-Learning sowie Unterstützung bei der Umsetzung sind deshalb von großer Bedeutung.

Sensibilisierung und Weiterentwicklung des Problembewusstseins

Der erste Schritt bei Digitalisierungsprozessen innerhalb von Unternehmensstrukturen besteht darin, ein Problembewusstsein unter den Verantwortlichen zu schaffen. Dazu bedarf es gezielter Maßnahmen zur Sensibilisierung und der Möglichkeit, Bedarfe, Ziele und Anwendung der Digitalisierung zu kommunizieren. In allen betrachteten WT-Systemen wurden kooperative Veranstaltungsformate zur

Informationsvermittlung entwickelt und durchgeführt. Daran sind insbesondere universitäre Transferstellen und Wirtschaftsförderungseinrichtungen beteiligt. Zudem sind Akteure aus der Wissenschaft eingebunden, indem sie demonstrieren, welche Möglichkeiten aus aktuellen Forschungsvorhaben entstehen. In diesem Zusammenhang beschreiben die Befragten unterschiedliche Formen und Zuschnitte von Veranstaltungen. Auf der einen Seite ziehen Veranstaltungen zu Grundlagenthemen und mit breit gefächerten Zielgruppen viele Teilnehmende an. Beispielhaft ist die virtuelle Innovations- und Kooperationsmesse des SüdniedersachsenInnovationsCampus zu nennen, die in den vergangenen beiden Jahren jeweils dreistellige Teilnehmendenzahlen zu verzeichnen hatte und zuletzt das Thema „Nachhaltigkeit und digitale Transformation“ in den Fokus rückte (Abbildung 2). Dies ergänzen Veranstaltungsformate mit stärkerem thematischem Fokus und branchenspezifischen Zielgruppen. Wiederholt wurde der Mehrwert von Good-Practice-Beispielen betont, in deren Rahmen Unternehmen anderen Unternehmen – entweder am eigenen Standort oder in wissenschaftlichen Einrichtungen – Einblicke in gelungene Digitalisierungsprozesse gewähren.

Peer-Learning und Unterstützung der Netzwerkbildung

Aufbauend auf der über die Veranstaltungsformate geschaffenen Sensibilisierung wurden innerhalb der analysierten WT-Systeme regelmäßige Dialogveranstaltungen zu Potenzialen der Digitalisierung etabliert. In diesen Netzwerken können Vertreter*innen aus KMU, Wissenschaft, Verwaltung und Gesellschaft verschiedene Perspektiven kennenlernen und Wissen und Erfahrungen austauschen. So werden innerhalb der Netzwerke Peer-Learning-Prozesse induziert.

Innerhalb der Wissenstransfersysteme sind Netzwerke an den Schnittstellen zwischen Unternehmensnetzwerken und Akteuren aus der Wissenschaft entstanden und durch Akteure des WT aufrechterhalten worden. In diesem Kontext sind neben dem Austausch in regionalen Netzwerken auch nationale und internationale Verflechtungen von Bedeutung. Besonders die Vernetzung mit bestehenden Innovationsschwerpunkten und -netzwerken ist wichtig, um Wissensvorsprünge weiter zu stärken und digitale Innovationen zu ermöglichen.

Unterstützung der Implementation

Aus themenspezifischen Innovationsnetzwerken entwickeln sich Kooperationen, in deren Rahmen WT-Akteure aktiv zur Implementation digitaler Technologien in Unternehmen beitragen. Vorrangige Zielgruppe dieser Formate sind KMU, die beabsichtigen, identifizierte Digitalisierungspotenziale umzusetzen (s. Abbildung 3). Die Interviews thematisieren Partnerschaften zwischen Hochschulen und Akteuren der kommunalen Wirtschaftsförderung, in denen letztere Beratungsangebote durch Wissenschaftler*innen fördern und so den direkten WT gewährleisten. In Einzelfällen berichten die Interviewpartner*innen auch von der Einrichtung zusätzlicher Personalstellen in hochschuleigenen Transferstrukturen mit dem Ziel, Wissenstransferprojekte zur Förderung der Digitalisierung im Mittelstand zu initiieren und zu begleiten. Hierbei handelt es sich jedoch um projekt- und zeitgebundene Stellen. Darüber hinaus werden Studierende in Digitalisierungsprozesse eingebunden: Ihre digitalen Kompetenzen fließen über Seminare und Abschlussarbeiten in Problemlösungsprozesse ein. Zugleich werden so die digitalen Kompetenzen der Studierenden als zukünftige Fachkräfte gefördert.

Die Interviews verdeutlichen jedoch, dass sich viele digitalisierungsspezifische Herausforderungen nicht durch originäre Maßnahmen des WT adressieren lassen. Unternehmen geht es häufig darum, aus vielen Möglichkeiten die am besten geeignete auszuwählen und die notwendige Akzeptanz und Qualifikation der Belegschaft zu gewährleisten oder bestehende digitale Lösungen an eigene Bedarfe anzupassen. Die Neuentwicklung von Instrumenten, die durch Wissenschaftler*innen unterstützt werden könnte, erscheint nur in Einzelfällen zielführend. Dies liegt nicht zuletzt in dem niedrigen Digitalisierungslevel vieler KMU begründet. So berichten die Befragten, dass digitale Zukunftsthemen wie Cloud-Technologien und Künstliche Intelligenz (noch) nicht Bestandteil der alltäglichen Arbeit sind.

Digitalisierung eigener Aktivitäten und Strukturen

Für die WT-Akteure verändern sich durch Digitalisierung die eigene Arbeitsweise und regionale Kooperationsstrukturen. Digitale Kommunikationskanäle erhöhen die geografische Reichweite der Aktivitäten und erlauben es, größere Zielgruppen zu adressieren bzw. spezialisierte Angebote zu gestalten und dafür die kritische Masse zu generieren. Die Integration neuer Instrumente und Formate fiel den meisten Befragten – nicht zuletzt durch den pandemieinduzierten Anpassungsdruck – relativ leicht. Die Befragten betonen den für sie selbst erleichterten Zugang zu digitalen Informationsangeboten von Kooperationspartnern. Dies vereinfacht die individuelle Fortbildung und den Austausch von Erfahrungen. Jedoch benennen die Befragten in diesem Zusammenhang auch verschiedene Herausforderungen.

Bevorstehender Generationenwechsel

WT-Akteure stehen vor einem Generationenwechsel, der sich auf die Organisationsstrukturen des WT auswirken wird. Jüngere Befragte nehmen Digitalisierungsprozesse grundsätzlich als positiv und erfolgreich wahr, betonen in diesem Zusammenhang aber intergenerationale Diskrepanzen hinsichtlich der Bereitschaft, digitale Arbeitsweisen zu akzeptieren und zu adaptieren. Neue Formen der Aus- und Weiterbildung sowie der persönlichen Sozialisation sorgen dafür, dass jüngere Beschäftigte den Aufbau neuer Strukturen anstreben. Älteren Beschäftigten fällt es schwerer, die gewohnten, auf physische Präsenz ausgerichteten Arbeitsweisen weiterzuentwickeln. Das Gelingen von Digitalisierungsprozessen hängt demnach auch von einer erfolgreichen Moderation des Generationenwechsels und gegenseitiger Lernprozesse zwischen Beschäftigtengruppen mit unterschiedlichen Ausbildungshintergründen ab.

Inhaltlich-methodische Herausforderungen

Ungeachtet der Relevanz und der Potenziale der Digitalisierung für den WT, betonen die Interviewpartner*innen die Grenzen digitaler Kommunikation und Zusammenarbeit. Demzufolge ist die Ansprache zusätzlicher Akteure bzw. die Verbreitung von Informationen ohne größere Einschnitte auch über digitale Kanäle möglich. Zusätzlich bieten digitale Tools die Möglichkeit, personengebundenes Wissen und Netzwerke bei Personalwechseln innerhalb der eigenen Organisation weiterzugeben. Jedoch gestaltet sich die Netzwerkarbeit über digitale Kanäle schwieriger. Im Zentrum vieler WT-Aktivitäten steht, Vertrauensverhältnisse sowie kreative Kollaboration aufzubauen, die sich nicht oder nur eingeschränkt über physische Distanz induzieren lassen. Die Befragten berichten beispielsweise von neuen Mitgliedern in Innovationsnetzwerken, zu denen sie noch keinen persönlichen Kontakt und daher kein belastbares Vertrauensverhältnis aufbauen konnten. Zwar beobachten die Befragten Fortschritte bei der Entwicklung neuer Softwarelösungen, die diese Problemstellungen adressieren, den persönlichen Kontakt können diese jedoch nur bedingt substituieren. Zukünftig bedarf es den Befragten zufolge eines Modus, der Vorteile und Potenziale beider Herangehensweisen nutzbar macht. Vielfach besteht die Motivation, einzelne, seit Pandemiebeginn erfolgreich erprobte Formate auch weiterhin im virtuellen Raum zu verankern bzw. physische Treffen oder Veranstaltungen zu reduzieren.

Infrastrukturelle und regulatorische Herausforderungen

Obschon die Interviewpartner*innen von der proaktiven Implementation verschiedener infrastruktureller und organisatorischer digitaler Anpassungen berichten, betonen sie auch, dass die digitale Zusammenarbeit über Organisationsgrenzen hinweg schwierig sein kann. Zum einen sind unterschiedliche digitale Lösungen etabliert, die technisch nicht immer auf eine organisationsübergreifende Zusammenarbeit ausgelegt sind. Zum anderen führen der teilweise hohe Grad an Sensibilität der anfallenden Daten und die daraus resultierenden datenschutzrechtlichen Einschränkungen zu Schwierigkeiten bei Kooperationen. Eine gemeinsame, regional – im Idealfall gar überregional – einheitliche Informationsinfrastruktur könnte die Zusammenarbeit untereinander als auch mit den Zielgruppen vereinfachen. In den Interviews beschriebene Versuche scheiterten an technologischen und regulatorischen Problemen. Daraus ergibt sich ein Bedarf an digitalen Tools,

welche die Kollaboration über Organisationsgrenzen hinweg und die Aufbereitung regionsspezifischer Daten und Entwicklungen rechtssicher ermöglichen.

Fazit und standortpolitische Implikationen

Die Analyse zeigt, dass Akteure und Mechanismen des WT die Digitalisierung regionaler KMU auf unterschiedliche Arten unterstützen. Vor allem Veranstaltungsformate und Netzwerke sind wichtig, um ein Problembewusstsein zu schaffen und darauf aufbauend Lernprozesse anzustoßen. Diese Erkenntnisse unterstreichen die Bedeutung standortspezifischer Perspektiven für die Entwicklung funktionierender Fördermaßnahmen zur Digitalisierung. Hochschulische Wissenstransferinstitutionen können kommunale und private Akteure bei der Konzeption und Ausrichtung niedrigschwelliger Veranstaltungs- und Beratungsangebote zur Steigerung des Problembewusstseins regionaler Akteure unterstützen. Konkrete Bedarfe und Vorhaben von KMU im Kontext der Digitalisierung lassen sich jedoch nicht in allen Fällen durch WT fördern. Nichtsdestotrotz ist die Informations- und Netzwerkarbeit innerhalb regionaler WT-Systeme Grundlage und Ausgangspunkt für eine intensivere Zusammenarbeit, um Digitalisierungsherausforderungen zu überwinden.

Abbildung 2: Regionale Wissenstransfersysteme und Digitalisierung: Herausforderungen und Lösungsansätze (Quelle: eigene Darstellung)

Regionale Wissenstransfersysteme und Digitalisierung		
Unterstützung der Digitalisierung regionaler KMU		
Sensibilisierung & Problembewusstsein	Peer-Learning & Netzwerkbildung	Implementation & Umsetzung
<ul style="list-style-type: none"> • Verschiedene Veranstaltungsformate entwickeln und durchführen • Good Practices kommunizieren 	<ul style="list-style-type: none"> • Branchenspezifische Netzwerke aufbauen • Schnittstellen zwischen Netzwerken einrichten und bespielen 	<ul style="list-style-type: none"> • Konkrete Projekte beratend unterstützen • Zusätzliche Potenziale identifizieren
Digitalisierung eigener Aktivitäten und Strukturen		
Bevorstehender Generationenwechsel	Inhaltliche & Methodische Herausforderungen	Infrastrukturelle & regulatorische Herausforderungen
<ul style="list-style-type: none"> • Aktive Moderation d. Generationenwechsels • Lernprozesse zwischen Beschäftigtengruppen 	<ul style="list-style-type: none"> • Mix aus digitalen und physischen Formaten • Revitalisierung „eingeschlafener“ Netzwerke 	<ul style="list-style-type: none"> • Vereinheitlichung digitaler Tools • Regulatorischer Rahmen für regionale Zusammenarbeit

Die Befragungen der WT-Akteure zeigen auch die Grenzen der Digitalisierung der eigenen Arbeit. Einerseits lassen sich Aktivitäten mit dem Ziel der Verbreitung oder dem Austausch von Informationen in digitale Räume verlagern. Andererseits lassen sich Formate mit dem Ziel vertrauensbasierter Netzwerkbildung oder der Verknüpfung einander unbekannter Akteure nur in begrenztem Maße digital durchführen. Hinzu kommen Herausforderungen hinsichtlich der Akzeptanz innerhalb des WT sowie datenschutzrechtlicher und infrastruktureller Probleme.

Die Potenziale des WT für die Digitalisierung sollten auf regionaler Ebene aufgegriffen werden. Dafür ist standortspezifisch herauszuarbeiten, zu welchen Anstrengungen im Bereich Digitalisierung die Aktivitäten des WT beitragen können und zu welchen nicht. Insbesondere die Anknüpfung an regional verfügbares Wissen ist für die Diffusion digitaler Technologien entscheidend. Weiterhin gilt es zu analysieren, ob die Zielsetzungen einer WT-Aktivität ein digitales Format zulassen. Zu diesem Zweck ist die Weiterbildung von Mitarbeiter*innen und der Abbau infrastruktureller Barrieren zentral.

Abschließend offenbart dieser Beitrag zwei maßgebliche Forschungsbedarfe: Erstens bedarf es detaillierter Fallstudien, die auf standortspezifische Kontexte eingehen und die Interdependenzen zwischen WT und Digitalisierung in unterschiedlich organisierten WT-Systemen analysieren. Zweitens bedarf es eines besseren Verständnisses, wie sich die verschiedenen Digitalisierungsaspekte auf die Wirksamkeit des WT auswirken.

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Kalkulierte Eigenanteile

Chapter	Titel	Status*	Zieljournal	Autor:innen	Kalkulierte Anteile
2	The course to sustainability: The role of university-related intermediaries in providing directionality to regional innovation initiatives	Under Review	Review of Regional Research	Daniel Hirschmann	50%
				Dr. Daniel Feser	25%
				Simon J. Winkler-Portmann	25%
3	Providing directionality to change: Indicating the potentials of university-related intermediaries in German regions	Under Review	European Planning Studies	Daniel Hirschmann	50%
				Dr. Elaine Horstmann	25%
				Simon J. Winkler-Portmann	25%
4	Paving the way for sustainability transitions? Supportive potentials of university-related intermediaries in regional innovation systems	Under Review	Environmental Innovation and Societal Transitions	Simon J. Winkler-Portmann	45%
				Daniel Hirschmann	45%
				Dr. Daniel Feser	10%
5	The contribution of knowledge intermediation to sustainability transitions and digitalization: Qualitative insights into four German regions	Veröffentlicht	Technology in Society	Philipp Bäumle	45%
				Daniel Hirschmann	45%
				Dr. Daniel Feser	10%
6	Digitalisierung und regionaler Wissenstransfer: Interdependenzen und Herausforderungen	Veröffentlicht	Standort	Philipp Bäumle	55%
				Daniel Hirschmann	25%
				Dr. Daniel Feser	10%
				Simon J. Winkler-Portmann	5%
				Prof. Dr. Kilian Bizet	5%