Systemic intermediation for transformative research and innovation policy: intermediation activities and networks enabled through a portfolio approach

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Abstract

Systemic intermediation is pivotal for the operationalisation of transformative research and innovation (R&I) policy. This paper examines systemic intermediation at lower and higher system levels, focusing on the activities and networks that emerge through the implementation of a portfolio of R&I programmes and projects. By examining EIT Climate KIC's portfolio through a mixed methods approach, combining semi-structured interviews with programme managers and social network analysis of food-related innovation projects, we uncover how distinct intermediation activities and network characteristics at two system levels underpin systemic intermediation. The paper demonstrates how systemic intermediation can be operationalised in R&I policy through a strategically aligned portfolio of R&I programmes and projects. This portfolio approach enables synergies between multiple interventions across system levels, enhancing complementarities and resource flows between projects, programmes, and overarching strategic objectives. The findings provide guidance for R&I policymakers on designing and implementing policy instruments that can effectively contribute to transformative change by leveraging systemic intermediation across system levels. The paper advances both scholarly understanding and policy practice in designing and implementing transformative R&I policy instruments.

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Keywords: systemic intermediation; sustainability transitions; transformative research and innovation policy; portfolio approach; portfolio design

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1. Introduction

The sustainability transitions research field has witnessed growing scholarly attention to systemic intermediaries (Kivimaa et al. 2020). Most research on intermediation focuses on understanding the roles intermediaries play in transformative change processes through their various strategies and activities(Kivimaa, Boon et al. 2019a; Mignon and Kanda 2018). Alongside this perspective on intermediation activity, an increasing number of studies also examine the networks and relationships that intermediaries build and operate within (Barrie, Zawdie, and João 2019; Kanda et al. 2020).

Scholars who have advanced this concept most recently highlight that intermediation at multiple system levels is particularly important in transformative change processes (Kanda et al. 2020). In referring to Kanda et al. (2020), Kivimaa et al. (2020, 3) emphasise that working across multiple system levels 'better supports the acceleration of sustainability transitions through the creation of common expectations for the overall direction of the transition'. At lower system level this concerns intermediation between actors in a network, while at higher system-level intermediation occurs between actors, networks and institutions (Kanda et al. 2020; Kivimaa et al. 2020).

While these studies indicate that intermediation has distinct characteristics at different system levels, we know little about how intermediation at each system level can complement one another. This is a critical knowledge gap in Research and Innovation (R&I) policy, particularly in how R&I policy operates across different system levels. At higher system level, R&I policy often manifests as a programme portfolio—an aggregate of strategic initiatives working collectively toward a policy goal. At lower system level, R&I policy often materialises as a set of projects that translate programmes into a diverse array of concrete R&I actions. Despite the critical importance of both levels, existing literature on systemic intermediation often lacks an integrated analysis of both levels, creating a blind spot in R&I policy and instrument design for systemic change. In other words, it remains unclear how the resources and opportunities that emerge from intermediation at lower system level can benefit intermediation at higher system level and conversely, how intermediation at higher system-level unlocks resources and opportunities that can be used at lower system level.

This knowledge gap is relevant to both the scholarly literature on intermediation and debates on mission-oriented or transformative R&I policy and instrument design (Larrue 2021; Weber and Rohracher 2012). Not knowing how intermediation at different system levels can be complementary is a shortcoming for R&I policymaking. It limits public actors' understanding of programme and project portfolio design that is effective in contributing to overarching policy goals and efforts to capitalise on the investments made through these instruments. R&I policymakers will benefit from a more in-depth understanding of how granular project-level intermediation contributes to overarching strategic programme level goals, thereby guiding, for example, the allocation of resources. Similarly, understanding how programme level intermediation can unlock and amplify the potential of project level efforts can inform the implementation of project support mechanisms. This paper aims to address this knowledge gap and make a

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contribution to R&I policy making debates by providing a systemic intermediation perspective on the design and implementation of a portfolio of integrated programmes and projects. Hence, this paper explores how a portfolio approach can enable systemic intermediation and what the associated activities and networks at different system levels are.

To answer the research question, we investigate EIT Climate Knowledge and Innovation Community's (hereafter CKIC) portfolio of programmes and projects at two system levels. While others have taken an actor focus to analyse the roles and responsibilities of intermediaries (e.g. Kivimaa, Boon et al. 2019a) we adopt an agency-focused perspective. Importantly, the organisation's programmes and projects that constitute its portfolio is the vehicle for its agency, and therefore the unit of analysis to investigate intermediation. This portfolio focus was chosen because it represents the dominant approach to operationalising R&I policy by organisations that fund and manage national or supranational R&I activities (Bianchi et al. 2024; Dinges, Meyer, and Brodnik 2020; OPSI OECD 2021).

We use the system level conceptualisation of Kanda et al. (2020) who distinguish intermediation in relation to different degrees of system aggregation in a socio-technical system. Intermediation at lower system level (i.e., between individual entities and between entities in a network (Kanda et al. 2020)) is researched qualitatively. The method used for this level of analysis is semi-structured interviews. This is combined with an analysis of intermediation at a more aggregate systems level (i.e., between networks of entities as well as actors, networks and institutions (Kanda et al. 2020)). For this system level, the paper combines a social network analysis with semi-structured interviews.

The paper is structured as follows: section 2 reviews the literature on intermediation in sustainability transitions with a view on their activities as well as the networks they develop. Section 3 outlines the research design, describes the case study and the research methods used to collect and analyse the data. This is followed by a presentation of the results in section 4. In section 5, we discuss the findings of the paper and conclude in section 6.

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2. Intermediaries in sustainability transitions

Intermediaries come in different organisational forms, such as NGOs, government agencies or private-public partnerships, predicated on the specific pursuit of different priorities and intended outcomes. A distinctive characteristic of intermediaries is their 'inbetween-ness' (Moss 2009). According to Van Lente et al. (2003), this multilateral work represents one defining characteristic of systemic intermediaries. Moss (2009) underscores the relational work of intermediaries which goes across 'diverse arenas of collective action' (1484). Another perspective emphasises that directionality can be induced when intermediating between entities and that, in some cases, a collective agenda towards sustainability is formulated (Kivimaa, Hyysalo et al. 2019b). Janssen, Bogers and Wanzenböck (2020) mirror this argument by highlighting intermediaries' dual

role of setting up and coordinating multiple actors while articulating a collective transition agenda to shape innovation processes towards a particular pathway. These recent extensions of the traditional concepts of intermediaries are particularly interesting in the sustainability transition context, as they point to an overarching strategic and normative orientation that guides intermediary agency and influences the entities between which they are intermediating towards a sustainability goal.

Based on this understanding, we draw on the definition of Kivimaa, Boon et al. (2019a) for the purposes of this paper. Kivimaa, Boon et al. (2019a) conceptualise systemic intermediaries 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 demand of networks of actors with existing regimes 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.

Furthermore, we use the work of Kanda et al. (2020) to differentiate the system levels at which systemic intermediation occurs. The levels are: (a) intermediation between individual entities; (b) intermediation between entities in a network; (b) intermediation between networks of entities; and (c) intermediation between actors, networks, and institutions.

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2.1. Activities of systemic intermediation

Research has identified multiple intermediation activities supporting niche practices. For example, activities related to the articulation of expectations and visions for change are emphasised (Kivimaa, Hyysalo et al. 2019b). Kivimaa (2014) shows that the articulation of renewable energy needs and expectations requires intermediation. More generally, intermediaries are effective in consolidating different perspectives on niche practices and help to create a common and trusted voice for them (Giurca and Metz 2018; Sovacool et al. 2020) which supports the communication about a niche practice with other sectors or incumbents (Smith et al. 2016).

The building of social networks encompassing a wide variety of stakeholders at local, national, and supranational level is another activity that features prominately in the literature (Giurca and Metz 2018; Hodson and Marvin 2010). Related activities involve setting up joint actions that strengthen the relationships between actors, including establishing network governance and orchestrating collaboration at multiple levels and across territories and organisations (Bianchi et al. 2024). Accordingly, intermediaries negotiate and align different perspectives to increase the compatibility between standpoints and to prevent strategic games (Van Lente et al. 2003).

Intermediary actors facilitate learning and capacity building (Kivimaa 2014). This involves, for example, improvements to knowledge flows between stakeholders, the aggregation of learnings and experiences across niches as well as the synthesis of knowledge for the benefit of a particular niche (Geels and Deuten 2006; Klerkx and Leeuwis 2009). Capacity building and training are another salient intermediation activity

(Kivimaa, Hyysalo et al. 2019b). These take the form of dedicated training for professionals (Brown, Farrelly, and Loorbach 2013) or citizen education events (Kivimaa, Hyysalo et al. 2019b).

Another key intermediary activity involves brokering and translating between actors with different interests. Such brokering can involve the translation of consumer preferences and business needs or citizens demands and governmental priorities (Fadeeva 2005; Kivimaa, Boon et al. 2019a). Studies also point to the importance of translating the benefits of niche practices to make them more attractive to policy agendas or the needs and interests of incumbent actors (Smith et al. 2016). Conversely, intermediaries also translate new policy and regulation so that niche practices can adapt (Moss 2009). Brokering can also involve creating strategic connections between separate entities in an innovation system by scanning for promising partners, filtering, and matchmaking between actors from different sectors and backgrounds (Klerkx and Leeuwis 2009).

Intermediaries play a crucial role in both the support of alternative practices, and the destabilisation and opening up of regimes (Kivimaa, Boon et al. 2019a).
Specifically, intermediaries can help decrease public legitimacy for an existing regime (Kivimaa, Boon et al. 2019a). Related activities include de-legitimising dominant discourses (Smith et al. 2016) or developing counter narratives that challenge existing storylines and shift the terms of debate into a desired direction (Brown, Farrelly, and Loorbach 2013). Intermediaries also disturb existing network structures or markets to overcome or bypass entrenched networks of incumbents and their transaction routines (Klerkx and Leeuwis 2009).

Another important activity of systemic intermediaries is creating institutional spaces or favourable framework conditions that facilitate the establishment and embedding of niche practices (Sovacool et al. 2020). In this regard, intermediaries have used agenda setting through foresight processes (Klerkx and Leeuwis 2009). Additionally, policy lobbying serves to shift policy goals beyond a particular niche practice and relate to a desirable system state more generally (Smith et al. 2016). Evidence-based framing strategies for policymaking are highloghted in this regard (Smith et al. 2016). Institutional agency also manifests in terms of developing and strengthening standards as well as certification schemes that rely upon the coordination of reliable accreditation and evaluation procedures (Heiskanen, Lovio, and Jalas 2011; Rohracher 2009).

Intermediaries are also active in demand articulation and targeted demand stimulation. Through their strategic role, intermediaries co-construct markets and related institutions. For example, Moors et al. (2018) show that intermediaries co-create new market segments and proto value-chains by initiating transactions between suppliers and customers. Additionally, intermediaries integrate end-users in the innovation process, help articulate user requirements, and develop and codify user-profiles (Moors et al. 2018).

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2.2. *Networks of systemic intermediation*

Researchers increasingly use network types and characteristics as a tool to understand systemic intermediation in sustainability transitions (Barrie, Zawdie, and João 2019). This analysis examines the nature of interactions between entities. For example, the weak and strong ties typology of interactions proposed by Reinders (2011) explains how intermediaries influence knowledge circulation, diversification, and consolidation of visions. Studies of intermediation networks in R&I studies primarily examine intermediation across entities located in multiple geographies and from multiple sectors or knowledge areas. To this end, network structures serve as an indication of how multiple entities interact (Rafols and Meyer 2010; Rudnick et al. 2019). Two network types most researched regarding intermediation are broad networks and brokered networks.

Broad networks are characterised by densely interconnected entities, while brokered networks are hierarchical structures where few entities foster information flows. The main difference between these two network types is the level of cohesion and diversity between entities. Brokered networks are associated with lower degrees of cohesion, where informal networking (weak ties) fosters the diversification of the networks. Broad networks, in contrast, have higher degrees of cohesion but less diversity than brokered networks. Both types of networks are characterised by intermediation between individual entities (Rafols and Meyer 2010; Rudnick et al. 2019).

More complex structures such as modular networks have received less attention in R&I research (Fleming, King, and Juda 2007). In modular networks, entities are highly interconnected in subgroups (i.e., modules). These can be considered subnetworks or networks of networks. They have few links to entities outside their subgroup (i.e., other modules) (Pan and Sinha 2009). These links are, however, critical for facilitating the circulation and exchange of knowledge and experiences between subgroups as well as sharing a common vision and trust in the whole network (Giurca and Metz 2018; Pan and Sinha 2009; Ramirez et al. 2020). Modular networks establish stable interconnections between heterogeneous networks. This structure suggests intermediation between networks of different entities. The emergence of such networks signals the maturing of the network as a whole.

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Our research examines how a portfolio of programmes and projects can shape network structures and thus systemic intermediation. Research and innovation agencies commonly use portfolios to manage programme-based research and innovation investments (Palavicino, Matti, and Brodnik 2023; OPSI OECD 2021). Figure 1 illustrates how structures emerge from a portfolio of programmes and projects, revealing relationships among actors, thematic areas, and geographical spaces that characterise the network as a whole.

Single projects and programmes (A) can enable interactions between network entities in a particular knowledge domain or geography, while a broader network (B) can diversify relations and knowledge flows among entities. Modular networks (C) are more complex structures where projects, programmes, and actions enable connections with subgroups of projects and programmes (i.e., modules) by creating linkages among

thematic (i.e., sectors, topics) and geographical dimensions (cross-regional and/or multi-level relations).

3. 3. Research design and methodology

Before going into the details of the methodology, this section provides an overview of the research design (Figure 2). While EIT Climate KIC is used as a single in-depth case study, the paper focuses on CKIC's portfolio of innovation programmes and projects to investigate systemic intermediation. To investigate intermediation at two system levels, a parallel mixed methods approach is used (Creswell 2014). While the quantitative and qualitative methods are not integrated in a parallel mixed methods approach, the combination of the results obtained from each method individually allows us to approach the research topic of this paper from two complementary angles.

The qualitative part consists of semi-structured interviews (N = 14) with senior programme managers conducted in 2020. Interviews were used to investigate intermediation activities and the networks that emerge at both system levels. Semi-structured interviews were used to investigate intermediation between individual entities (Smink et al. 2015), between entities in a network (Hargreaves et al. 2013) (i.e., intermediation at lower system level) as well as intermediation between entities and institutions (Matschoss and Heiskanen 2018) (i.e., intermediation at higher system level). The quantitative part consists of a social network analysis of CKIC's project portfolio of food-related projects. This method was used only for the higher system level perspective and was not used to investigate intermediation at lower system level.

Before we introduce both methods in more detail, we introduce the case itself.

3.1. EIT Climate KIC and its portfolio approach

The inception of EIT Climate KIC is best understood in the context of the European Institute for Innovation and Technology. The EITwas launched in 2008 by the European Commission and is a dedicated innovation organisation for the pursuit of the European Union's innovation strategy. EIT's organisational structure resembles a network organisation with a small headquarters in Budapest responsible for establishing different KICs which were

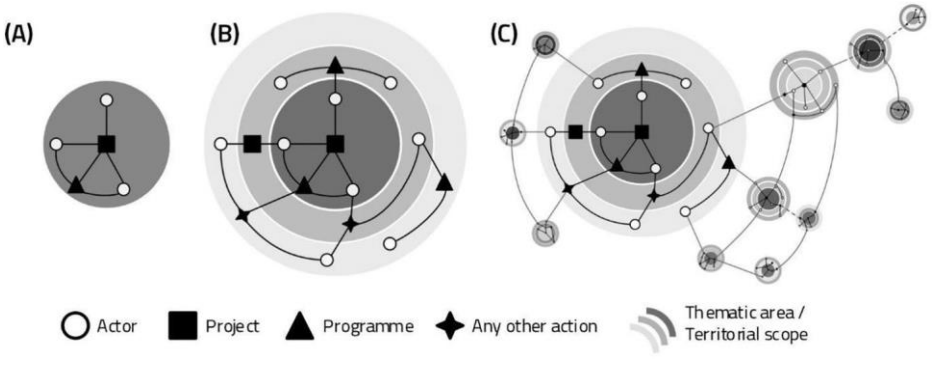

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Figure 1. Schematic representation of modular networks from an intermediation perspective.

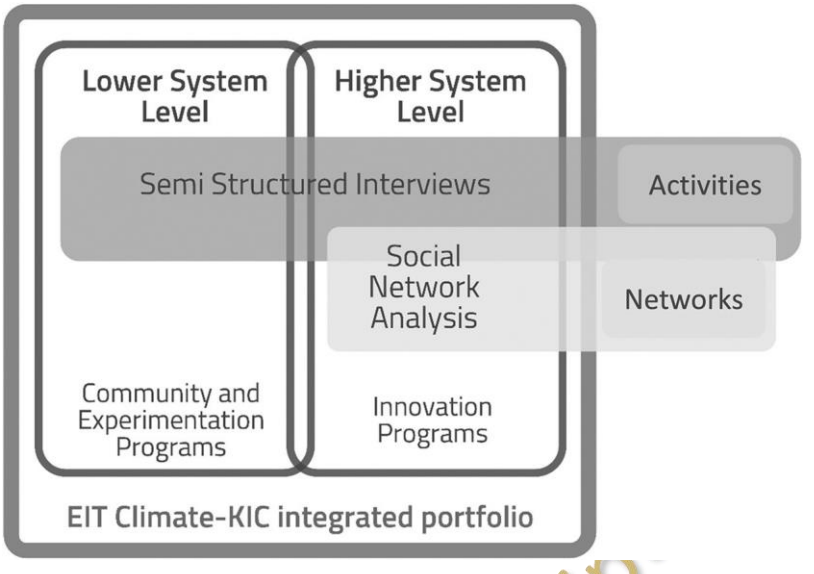

Figure 2. This papers' single case study and parallel mixed methods research design.

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tasked with carrying out work independently in three priority areas (Energy, ICT, Climate). The KICs were set up as the operational units through which the EIT undertakes its activities. In 2009, the first call for KICs was launched. Their overarching aim was to address societal challenges through innovation, education and entrepreneurship programmes. CKIC defined its purpose and mandate much broader than the other KICs which were mainly focused on strengthening Europe's economic competitiveness. In contrast, CKIC positioned itself as a cross-sectoral and cross-regional initiative that goes beyond matters of research and innovation policy in a strictly economic sense which makes it interesting from a transformative research and innovation policy perspective (Diercks 2018).

CKIC is a suitable case to investigate systemic intermediation as defined in section 2 of this paper. The reasons are that CKIC's activities range from the very local or regional level to pan-European activities. Second, CKIC pursues a systemic innovation approach that crosses innovation domains (e.g., social and technical) and combines single-point interventions (Palavicino, Matti, and Brodnik 2023). Third, CKIC's strategy (EIT Climate KIC 2018) has a clear normative direction towards sustainability and transformative change and structures its activities with a portfolio logic that becomes realised through its programmes and projects (Vivas Lalinde et al. 2019).

While CKIC is the intermediation actor with distinct roles and responsibilities, this study focuses on intermediation agency to zoom in on the activities and actions of CKIC. While actors and agency are inextricably linked, this analytical choice shifts the focus of this study away from, for example, the position or profile of CKIC in Europe's research and innovation system and directs the focus towards the organisation`s operations.

Importantly, we understand the organisation's portfolio of programmes and projects as the vehicle by which intermediation is realised.

A portfolio can be defined as a group of programmes and projects that share common resources including partners, funding schemes or knowledge assets (Lock and Wagner 2016). They are used by research and innovation organisations (e.g. Vinnova (Hill 2022) or the UNDP Regional Innovation Centre (UNDP 2022)) who aim to address systemic change through multiple lines of R&I actions and interventions (Matti et al. 2022, OPSI OECD 2021; Palavicino, Matti, and Brodnik 2023).

Two different types of programme areas were selected to investigate systemic intermediation: (1) community and experimentation programmes and (2) innovation programmes:

(1) In the community and experimentation area, two long-standing and strategic programmes were selected: 'Pioneers into Practice' and 'Climathon'. Both programmes have a strong focus on connecting actors from different sectors and multiple geographies by providing a space for experimentation, the development of innovation communities within and across locations and the development of entrepreneurial skills. Pioneers into Practice (Pioneers hereafter) is a professional placement and mobility programme for professionals which has been operating since 2010. Since its creation, Pioneers involved over 1500 participants, with an average of around 200 professionals per year, and 300–400 placement opportunities in corresponding host organisations. Climathon is a city-based ideation and awareness-raising programme co-organised between local public and private sector organisations of a city in collaboration with CKIC. During the 24-hour hackathon-style event, entrepreneurs, students, developers, and others get together to work on climate challenges their city is facing to create innovative solutions for problem owners. In 2018, the Climathon took place in 113 cities in 46 countries and involved over 5000 participants.

(2) In the innovation programs area, three long-standing programmes were selected: The Thematic Innovation Program, the Climate Innovation Ecosystem (CIE) and the Regional Innovation Scheme (RIS). The Thematic Innovation Program seeks to support the development of new products and services through projects addressing different stages of the innovation process (i.e. Early-stage, Demonstrator and Scaler) as well as strategic topics (Flagships) in four thematic areas.[1] The CIE programme focuses on multi-location collaboration to support the cross-fertilisation of innovative practices across geographies. Finally, the RIS programme covers the innovation activity in 14 countries categorised as moderate innovators according to the EU innovation scoreboard. Overall, the programmes represent an investment architecture for innovation projects where partners interact across projects addressing cross-sectoral, cross-regional, multi-stakeholder aspects as well as different stages of the innovation process from ideation and prototyping to the more mature stage of demonstrating products, services and business models. Food-related innovation projects are a subset of all projects that these programmes implement. They are particularly

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interesting for the network perspective of this study because they are embedded across multiple programmes.

3.2. Semi-structured interviews

We conducted semi-structured interviews with programme managers from CKIC. Sampling interviewees was based on recommendations from a previous CKIC programme manager, who is also a co-author of this study. Interviewees had to match the following criteria. First, they had to have a managerial role in the selected programmes and secondly, they had to be employed by CKIC for at least 3 years. Our final sample of interviewees comprised a total of 14 interviewees related to the programmes Pioneers (N = 3), Climathon (N = 2) as well as the Thematic Program (N = 3), CIE (N = 4) and the RIS programme (N = 2) occupying middle and senior positions in the organisation. Interviewees were asked to provide answers from their personal standpoint until the year 2020 – a time of significant organisational reform at CKIC which was not fully implemented at the time the interviews took place. Given the interrelatedness between programmes and the seniority of most of the interviewees, some of them were able to provide insights for more than one programme and speak to the relationship between programmes.

Semi-structured interviews were conducted online, lasted from 1 to 1.5 h, and were recorded and transcribed. We used two semi-structured interview guides: one for community and experimentation programmes (Pioneers, Climathon) and one for innovation programmes (CIE, RIS, Thematic Program). Interview questions differed between the guides. For interviewees in relation to community and experimentation programmes, the questions related to the characteristics of support for sustainability innovation (e.g. support for the emergence and growth as well as establishment and mainstreaming) as well as intermediation activities and associated outcomes derived from the literature (e.g. learning, networking, visions and expectations, shielding, embedding of alternative practices, circulating ideas and experiences (see Ghosh et al. 2021). For interviewees in relation to innovation programmes, the questions related to geographies and sectors (e.g. development of connections and strategic exchange of resources) individual innovation projects (e.g. connection between project ideas, activities and outputs), the portfolio of projects and contextual factors (e.g. translation of external developments into strategy and project requirements and translation of portfolio insights into strategy), and the embedding of innovative practices as well as engagement with incumbent actors. As this research was deemed low risk, no formal ethics approval or assessment was conducted.

The interviews were transcribed, and systematic reduction of data was undertaken through coding with the help of qualitative data analysis software (MAXQDA). A thematic analysis method was used to categorise the data (Braun and Clarke 2006) and all codes were inductively derived through an iterative process of thematic identification. This involved going back and forth between the concepts identified in the literature review (section 2 of this paper) and the interview transcripts. We thereby followed a theory-informed coding process (Fereday and Muir-Cochrane 2006). Similarly, two analytical

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dimensions for entangling system levels were used to delineate between the levels, namely (a) between what intermediation occurs and (b) who benefits fromintermediation (Kanda et al. 2020).

To strengthen internal validity (Yin 2009) we drew on the experience of one co-author of this study (at that time, a senior CKIC programme manager) who was asked to provide feedback on the preliminary analysis of the results. While secondary data (programme reports, evaluations and business plans) was not systematically coded, it was used and analysed to strengthened internal validity by contrasting it with earlier versions of the analysis and informed the write-up of the results. External validity was strengthened by grounding the data in existing theory (Yin 2009), namely, established concepts of intermediation in sustainability transition research outlined in section 2 of this paper.

3.3. Social network analysis of food-related innovation projects

Our analysis drew from a dataset of 1784 projects with 437 project partners between 2016 and 2020 to conduct the social network analysis (Figure 3). Data include anonymised ID of individual partners, partner types, locations, along with project descriptions and titles, which we used to identify food related projects across programmes. Based on the thesaurus developed by Ramirez et al. (2019), we generated a stable language[2] comprising 93 terms to identify food-related projects. We then searched for these terms in the data set. This yielded a final selection of 221 projects and 178 partners between 2016 and 2020.. To track network evolution, we segmented this data into four time windows.

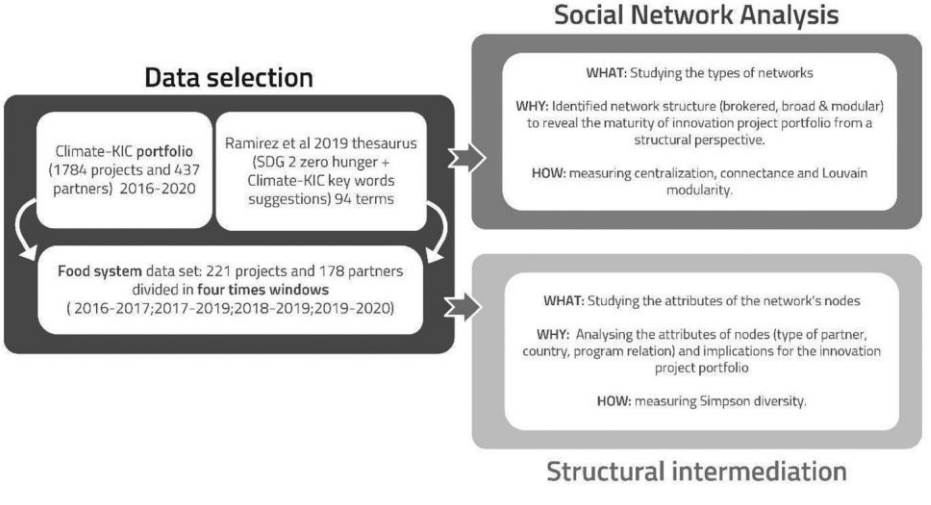

Figure 3. Research approach for the social network analysis.

To identify the type of networks that emerge from the food-related project portfolio, we calculated network metrics. For instance, brokered networks are associated with high levels of centralisation (Rafols and Meyer 2010). Centralisation measures (degree and betweenness) near to 1 indicate hierarchical structures with concentrated interactions

and information flows. On the other hand, high values of connectance (C) indicate high interconnection between projects and partners, suggesting a broad network structure (Dormann et al. 2009). When connectance (C) is equal to 1, all projects are connected to all partners. For identifying modular structures, we applied the Girvan-Newman modularity (M) for bipartite networks (mode 2 – Networks) (Newman and Girvan 2004). This metric indicates perfect modular structures when values are equal to 1, and it enables the identification of the number of modules in each network.

We also examined the diversity of project and partner attributes as a complementary strategy to explore the evolving composition of the project portfolio in terms of sectors and locations. As attributes, we used CKIC's innovation programmes described above, and for the partners, 26 country attributes and five types of partner attributes.[3] Using these attributes, we computed Simpson (1-D) diversity to measure the dominance of each attribute in the network (Harrison and Klein 2007; Somerfield, Clarke, and Warwick 2008; Stirling 2007).[4]

4. 4. Results

This section presents the results from an intermediation activity as well as network development perspective at two system levels (Figure 4). First, the results at lower system level are presented followed by the results at higher system level.

4.1. Intermediation at lower systems level (activities & network perspective combined)

4.1.1.Facilitating new and productive relationships

One important activity for intermediation at lower system level is developing new and productive relationships between individual actors with shared values but different

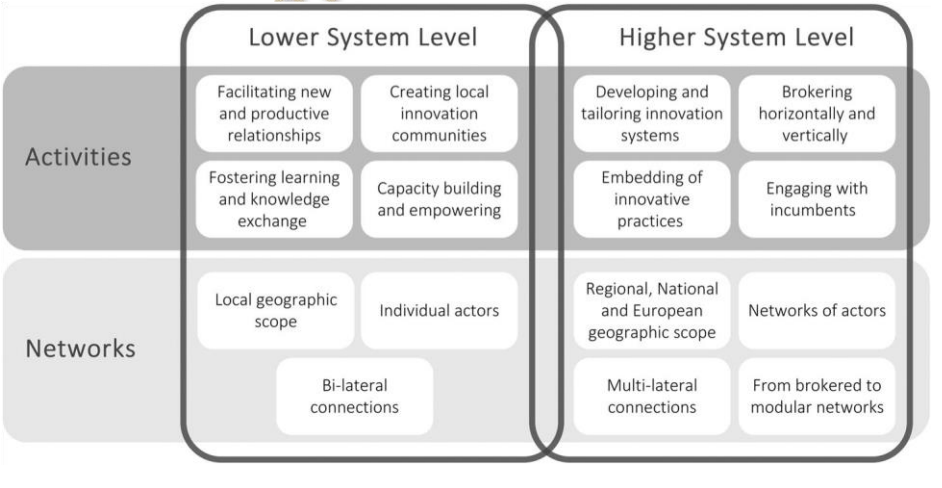

Figure 4. Activities and networks of systemic intermediation at lower and higher system level.

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backgrounds. This enables actors to engage with different perspectives, ideas, and areas of expertise, allowing new combinations of knowledge to form. CKIC develops opportunities for relationships to form around a shared challenge in the same geographic area. This takes on different forms in the programmes. For example, it involves matching actors with complementary resources or pairing challenge owners with potential solution providers. CKIC capitalises on the diversity of programme participants through guided and structured collaboration activities that are part of the programmes. The aim is to build on shared values and to leverage the diversity of expertise, skills, and other resources from participants.

> we're really looking for diversity and believe that having that kind of diverse network to interact with, which enables you to open yourself up and to think of it differently. [CKIC programme manager involved with Pioneers]

4.1.2.Creating local networks of innovation communities

Productive and lasting relationships are the basis on which local networks of innovation communities can start to form. Pioneers establishes strong connections over time, whereas in the Climathon, networks have less time to develop and often depend upon the output of a team during the event and the progression of their idea. Although CKIC provides the impetus for development of local community networks through their programmes with additional support measures, it remains primarily a self-driven process that relies on participants developing these communities after the programmes have finished.

> I think it's unrealistic that somebody can keep this network from outside. I mean, it has to come naturally from people that want to interact. So, we are giving the floor for it, but it depends on them if they still want to do it. [CKIC programme manager involved with Pioneers]

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While both programmes operate internationally, the networks usually include actors from a particular location (e.g., city or region) and form around particular sustainability challenges of a place. Community development and maintenance are encouraged by CKIC but driven and implemented by local actors. To foster the continuation of ideas over time, CKIC links ideas and innovations with other support instruments. This, however, is often limited to ideas that have commercial value because they align better with the objectives of CKIC's entrepreneurial support programmes. Therefore, local and selfdriven community networks are particularly important for maintaining the momentum of non-commercial ideas.

> So, from a systems perspective the idea is to think, okay, what can we do to develop these ecosystems locally, these communities locally so that they can support their ideas, so we don't have to step in. [CKIC programme manager involved with Climathon]

While community network building happens predominantly locally, both programmes link up to other community networks in different locations. In the case of Pioneers, this enables people and resources to exchange across geographies. In the case of the Climathon, cross-geographic connections are more a perceived benefit of the programme, as participants feel that they are part of a global community working on climate challenges.

4.1.3.Fostering learning and knowledge exchange

Learning and knowledge exchange is facilitated through Climathon and Pioneers and concerns climate change issues specific to a location or region and associated stakeholder needs. Learning is mostly experiential, and programme participants are exposed to different perspectives, ideas, backgrounds, and skills when working with others on innovative ideas for addressing a local challenge (i.e., Climathon) or on a group assignment during a placement (i.e., Pioneers).During Climathon, learning takes place predominately for the duration of the event, while Pioneers facilitates learning and knowledge exchange over a longer period. In both cases, learning and knowledge exchange are not only based on the interactions between individuals but also on the quality and processes during these exchanges. CKIC also encourages systems thinking in both programmes by offering training in the use of systems thinking tools and approaches.

> And what we really focus on more in the last couple of years is the idea that we're developing this systems' innovation mindset. [CKIC programme manager involved with Pioneers]

4.1.4.Capacity building and empowering

Both programmes have a strong focus on developing entrepreneurial and innovation capacities of participants in order to empower them to act. A strong emphasis is placed on personal development in terms of self-awareness, collaboration, risk-taking, as well as creativity and productivity. This is accompanied by using and teaching tools and methods that individuals can employ themselves (e.g., design thinking tools, business model canvas, etc.). Taken together, the activities help develop entrepreneurial capacities and create a sense of ownership of climate change solutions. In the case of Climathon, capacity building also addresses local partner organisations who host the Climathon event. CKIC develops their capacity to organise and run ideation and awareness raising programmes.

> I think the first thing that came to my mind is the empowerment that it gives to the participants so that they feel that their ideas are useful, or they have this familiarity or the family feeling that what they do, or what they think or what they are, the ideas are of some value for somebody else. [CKIC programme manager involved with Pioneers]

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4.2. Intermediation at higher systems level

4.2.1. Networks perspective

The network analysis results span four time windows (Figure 5). In the first time window (2016–2017), we identified a brokered network with high degree betweenness centralisation, in which food related projects mainly relate to the Sustainable Land Use theme, which, forms part of the Thematic Programme. Partners represent multiple locations, and the geographic spread is high. With limited projects enabling the connectivity and flow of information, this type of network is characterised by a highly cost-efficient transfer structure, but lacks resilience to the loss of entities (Pan and Sinha 2009).

In the second (2017–2018) and third time window (2018–2019), networks are composed of projects with an increased number of partners (i.e., a higher diameter of the network) indicating growing network size. During2017–2018, the network remains shaped by the Sustainable Land Use theme (Thematic Program), but the CIE programme gains prominence. This suggests that the CIE programme served as a key enabler of interconnectivity between projects and partners (Figure 3). In the third-time window (2018– 2019), new food-related projects emerge in other themes of the Thematic Programme (e.g. Decision Metrics and Finance as well as Urban Transitions), indicating a diversification of food-related project themes.

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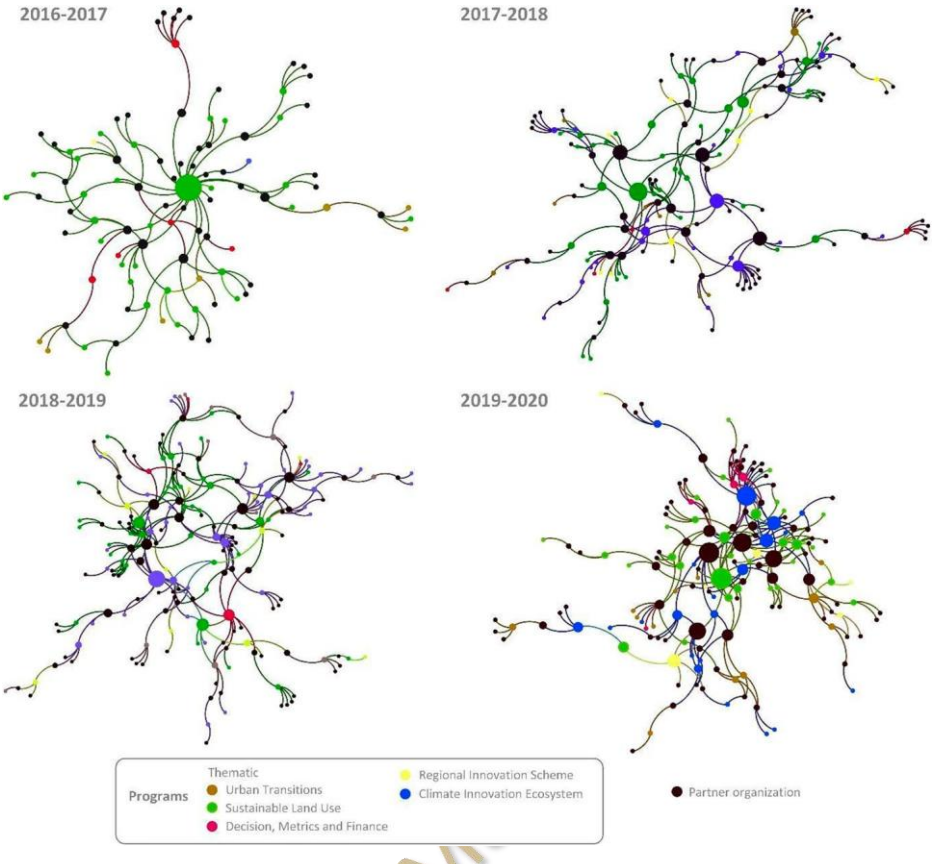

Figure 5. Project partner network. Black nodes represent partners and coloured nodes projects under different programmes. Node size indicates the betweenness centrality.

The networks in the second (2017–2018) and third (2018–2019) time window show an increasing degree of modularity (high modularity and number of modules). This type of network structure enables cohesive diversification of networks, supporting their stability and durability. This finding suggests that the connectivity between networks of different entities and themes (i.e., sub-portfolios of multi-thematic and/or multi-location projects and related partners) has increased. While the diameter of the network is very high (>10), the average path length does not increase significantly, indicating network growth in a cohesive way, further increasing the overall stability.

In the final time window (2019–2020), a new modular network emerges that exhibits fewer modules. Overall, 59% of the partners present in the final time window participated in projects before. Moreover, the different attributes of the network (types of actors, location, programme and thematic area) are equally distributed. None of these attributes are more frequent than the others (high diversity). While the overall network shows high diversity (with no single attribute dominating), individual modules within the network show higher levels of specialisation. This suggests that diversification occurs at the network level, while specialisation and cohesion happen at the module level. These

mechanisms of simultaneous diversification at network and specialisation at group level are key for the establishment of food-related innovations.

Although the network structure changed considerably between 2016 and 2019, the diversity of partners remained stable. By contrast, the diversity of projects among the evolving portfolio increased significantly from the second time window onwards. This suggests that the diversity of projects, enabled by multiple programmes, has a strong influence on generating more modular networks.

4.2.2. Activities perspective

4.2.2.1. Developing and tailoring innovation systems. Building on the social capital developed through intermediation at lower systems level (see section 4.1), CKIC is developing and consolidating climate change related themes in innovation systems at regional or national level. To this end, CKIC is working with national partners to support the development of governance arrangements and new partnerships. This is most strongly pursued in countries with modest and moderate innovation performance, so-called RIS countries. CKIC translates between partners to establish a governance model that suits the conditions of a particular territorial level and leverages the competencies that the different actors bring to the system.

> … this led to the fact of saying okay, we need now a governance model. That has not to be the same, but we can offerguidance based on understanding the local context and what is already in and which is the model that best fits the hubs, … in which the role of Climate KIC is really to support them to understand which is the best model that fit the country. [Senior CKIC program manager]

Another mechanism for supporting the development of climate change related themes in innovation systems is enabled through programming modalities. For example, the CIE programme requires project consortia to collaborate across regional innovation systems in the same thematic area. Another example is the Deep Demonstrations programme, which is place-based and aims to create connections between different sectors and thematic domains. Both programmes work towards further developing climate change related themes in innovation systems, albeit with different foci and approaches (i.e., transnational and service-oriented versus local with a challenge-driven approach).

> For that, we have this program that is called Climate Innovation Ecosystem. It's a type of programme that somehow forces partners to work together across at least three countries on the same topic, on the same innovation domain, which is building an ecosystem. [Senior CKIC programme manager]

4.2.2.2. Brokering horizontally and vertically. CKIC maintains the links between innovation systems of different locations for the cross-fertilisation of ideas and the exchange of resources. Brokering happens horizontally (i.e., between locations), but also

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vertically by establishing links between, for example, regional innovation systems and national ones. This is facilitated through, for example, co-creation workshops and partner meetings where different CKIC partners come together for a structured and guided exchange. CKIC facilitates these events, translates between actors, facilitates connections between them and supports knowledge transfer and idea generation. Additionally, these workshops are an important instrument for collecting and synthesising knowledge 'bottom up' to gain oversight of the different activities, outputs, and needs across locations and actors from different sectors.

> So, you have policy, you have corporates, we had start-ups and students and alumni, quite often and partners, yes from academia, and NGO's depends on the country … So, we would have specific work sessions sometimes. And quite often it would be topical, so partners interested in land use, landscapes, in industry, in cities. So, they would come together, and we would discuss there: what do they see for the future? What can we do together? And what is already available? And how can we actually collaborate in the future?. [Senior CKIC programme manager]

Another strand of activities in this category concerns the strategic mapping of activities and outputs from various programmes and projects. This provides a strategic overview and the basis for brokering synergies with other programmes (also outside CKIC) orto scan for political opportunities. These activities also help to create alignment between projects and national or European policy priorities. CKIC thereby capitalises on the close connection to partners at local and national level and links project outputs, outcomes, and other resources emerging at lower system level to strategic developments at higher system level.

> Or in Portugal, it has been found that water and the land use are strategic areas for example. And then we are trying then to merge this top-down requirement of working in specific areas together with the local strategies designed by each hub based on their priorities. [Senior CKIC program manager]

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4.2.2.3. Embedding of innovative practices. CKIC encourages projects to collaborate with actors that have a demand or a clear need for an innovative solution already at an early stage of the project. This demand-led approach serves as an attempt to facilitate the uptake of project activities and outputs from the outset. This strategy is illustrated by the design and implementation of the Deep Demonstration projects, which are firmly rooted in the specific geographic context to ensure relevance and embedding of innovative solutions from the initial stages of the programme.

> … they want to go that way because Deep Demonstrations, you are not looking for one innovation. You are looking to establish say a landscape for innovation, an ecosystem for innovation with the challenge owner in a particular location. [Senior CKIC programme manager]

Another approach is the collection and synthesis of insights and outputs across a range of projects and innovation activities to influence policy and achieve buy-in from financial actors with the capacity to sustain and scale innovative solutions. For example, policy

recommendations on the interface of circularity and digitalisation were developed by synthesising the findings from a range of different innovation projects. Policy influence relied on aggregating these insights alongside partners who had political weight and experience in influencing policymaking.

> So, we had a two-year process with the commission, with all relevant DG's. And what we brought in was learnings from a two-year portfolio of start-ups and projects, showing the barriers for them at the interface between digitalisation and circularity, for our start-ups, for our projects. So, I could not say that due to this one report and this these two years of work, because we were a multi stakeholder group, right? But we know that the commission was there, was listening, they would pick up the recommendations and all this flows into their work. [Senior CKIC programme manager]

Understanding the needs of policymakers to link resources with different policy agendas and policy narratives is an approach CKIC strategically pursues. By engaging policymakers, CKIC aims to gain a foothold in the governance arrangements of regional or national innovation systems, thereby anchoring its agenda, approach, and ultimately, its influence on R&I policymaking.

> So we are now in discussion with the vice president of the government of Greece and our local hub to say: the Climate-KIC can offer the approach of portfolio on how to design also the recovery plan for a portfolio, so it's a competency we have been developing, because it supports you in designing better the plans for the country. [Senior CKIC programme manager]

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4.2.2.4. Engaging with incumbents. CKIC identifies and targets incumbent actors, discerns their needs, and connects them with actors who have the capabilities and interest to address them. By fostering linkages between incumbents and a diverse array of CKIC partner organisations, CKIC broadens incumbents' access to organisations beyond their traditional sectoral boundaries. This includes facilitating introductions to specialised entities like start-ups focused on climate innovation, which may fall outside the incumbents' conventional networks.

> So, the CKIC community spectrum puts us in a very original position in that sense. And in fact, they are asking somehow for external "contaminators" if you want, that we can bring into the system. But we can do it, because we have intelligence of the system to refresh their working areas. [Senior CKIC programme manager]

Working with incumbent organisations opens up avenues to influence their agendas and goals by pointing to the opportunities that alternative system configurations can bring (e.g., new value chains in a circular economy). Through this process, CKIC can exert influence on incumbents and their business strategy by supporting them in an organisational change process.

> So, it has been really to say we have the tools, we have the methodology, we can guide you through this process. But we need to co-create it. Because that there is a strong identity

usually in these regions and also industries, and if you come as a consultant, it's not really helping in terms of transforming or transitioning, while the approach that we were having was mostly to say: we can give you the process through which you can reach the vision that you want to reach. [Senior CKIC programme manager]

5. Discussion

This study investigated the activities and networks associated with systemic intermediation at two system levels. It contributes to current scholarly debate on the role of systemic intermediation in sustainability transitions (Kivimaa, Hyysalo et al. 2019b) for which intermediation across system levels and geographies is particularly relevant (Kanda et al. 2020; Kivimaa et al. 2020; Van Boxstael et al. 2020). Additionally, it provides a practical contribution to R&I policy design and implementation, given that a dominant way of operationalising R&I policies is through a portfolio of programmes and projects, which represents multiple coordinated interventions in a system aligned by overarching objectives (Grillitsch et al. 2019; OPSI OECD 2021). In this regard, our contribution addresses the description of important intermediation activities and network properties that can link resources and opportunities at two systems levels.

We present a discussion that integrates the findings of the activities and networks perspective related to each system level (see Figure 6). We found that intermediation unfolds at two systems levels simultaneously, and that an integrated portfolio of blended programmes and projects can create synergies between both system levels. At a lower level, CKIC intermediates predominantly between individual actors, often from the same sector and at a local geographic scale. Intermediation at lower level pertains to forging new relationships, building and maintaining local innovation communities, facilitating learning and knowledge exchange, as well as capacity building and empowerment of individuals. Importantly, these intermediation

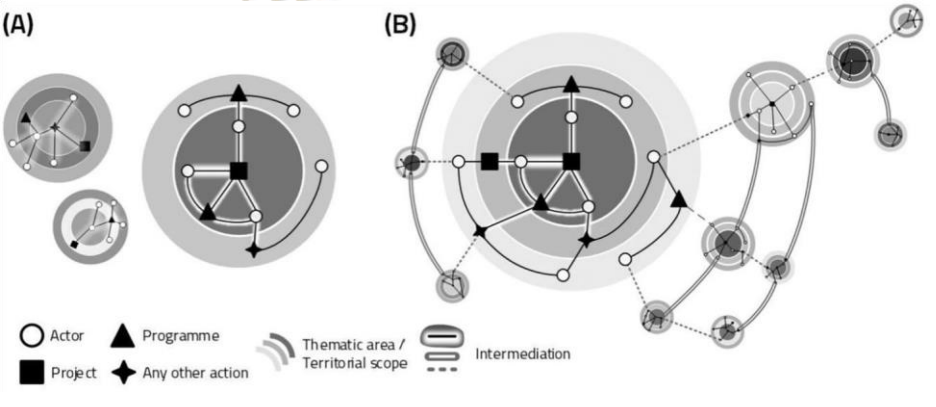

Figure 6. This figure visualises the relationship between these two levels schematically, where single programmes and innovation projects operate at local scale (A) but the portfolio at large follows a cross-geographic and cross-thematic approach (B). Importantly, (A) is shaped by the

translation of elements and dynamics at higher systems level (knowledge gaps, interest of key stakeholders, societal needs, political priorities, etc.) into the specifics of innovation activities at local level. Conversely, (B) is shaped by the new knowledge, innovation outputs and new relationships that are predominantly formed at local level but become aggregated and interconnected at higher system level.

activities at lower system level create the resources that can be used for intermediation at higher system level. At higher system level, intermediation activities relate to tailoring innovation systems, brokering between actors horizontally and vertically, supporting the embedding of innovation as well as the engagement with incumbent actors. The activities at higher system level, in turn, provide important resources that shape and support intermediation activities at lower system level. This duality between distinct, yet complementary intermediation activities at higher and lower system levels underpins systemic intermediation which the portfolio enables and operationalises.

Taken together, we demonstrate how portfolio modalities provide the vehicle for systemic intermediation. We argue that programmes that foster horizontal connectivity and exchange are very well complemented by programmes that foster vertical and deep knowledge development and relationship building. Key to this is how these programmes work together through intermediation activities thereby creating effective linkages that enable resources flows between them. Seen this way, systemic intermediation is enabled by strategic portfolio design and emerges through a continuous process of managing interactions among actors, resource flows and opportunities across levels. Rather than intermediating for the optimisation of innovation output only, the portfolio considerations described here are more relevant for intermediaries whose ambition is to address wicked problems and grand societal challenges, which typically require multiple and simultaneous R&I interventions in socio-technical systems (Kivimaa et al. 2020).

There are limitations to this research. First, CKIC as a case study has an inherent focus on operational aspects of R&I policy design and implementation. This limits the applicability of this paper to other systemic intermediaries who do not engage with R&I policy. Second, the selection of programmes as well as the food-themed projects has revealed activity and network characteristics that might look different with a different sample of the portfolio. This limits the conclusions we can draw on an ideal-typical portfolio design for R&I policy based on a systemic intermediation perspective. Third, this research is based on a single case study. Yet, recent studies have shown that intermediaries interact, complement each other, or overlap in their goals and activities (Barrie and Kanda 2020). Future research should look more closely at the interactions between CKIC and other R&I policy instruments at EU level (e.g. European Partnerships) and their cumulative effects. Such research would extend the ecology of intermediaries' debate (Barrie and Kanda 2020) which underscores that transformational change dynamics cannot be relegated to a single intermediary, no matter how skilled or powerful (Manders, Wieczorek, and Verbong 2020). Another fruitful avenue for further research would be to investigate the role of systemic intermediation through portfolios at the crossroads of innovation policy and climate policies in the context of regional development. CKICs place-based approach ingrained in the programmes and projects (e.g. RIS, Climate Innovation Ecosystems) provides an interesting perspective on agency

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for regional development. From a place-based perspective, the implementation process for regional development strategies, characterised by a portfolio approach, offers a unique opportunity to foster innovation while addressing climate challenges. While this paper did not adopt such a perspective, we did find signals that the portfolio created opportunity spaces for innovation, enterpreneuership, and institutional change agency, which is key for regional development (Grillitsch and Sotarauta 2020).

6. Conclusions

Our research examines systemic intermediation from a transformative R&I policy perspective. We demonstrate that systemic intermediation through a portfolio approach offers distinct yet complementary benefits at each system level. We identify the specific activities and networks that materialise through the implementation of the portfolio, ultimately enabling systemic intermediation.

Our findings show that simultaneous and complementary intermediation activities at lower and higher system levels underpin systemic intermediation. At the lower level, activities such as facilitating new relationships and creating local networks of innovation communities generate diverse, place-based solutions. At the higher level, developing and tailoring innovation systems and engaging with incumbents enable scaling and embedding of solutions. These outcomes are realised when the portfolio of projects and programmes enables these synergies across levels.

A well-designed portfolio acts as a mechanism for bi-directional resource flows between system levels. Portfolios should be designed with a balanced mix of programmes that foster both horizontal connectivity and vertical knowledge building. This approach enables R&I policy actors to effectively connect and leverage resources across system levels, optimising R&I investments. The synergies derived from operating across levels enhance the complementarity between R&I projects and programmes in socio-technical systems, ultimately increasing their combined contribution to system change.

By providing a more nuanced understanding how systemic intermediation can be operationalised, this paper contributes to the scholarly debate on transformative R&I policy. It also offers guidance organisations responsible for R&I policy design and implementation, demonstrating how they can improve their portfolio's contribution to systemic change by incorporating systemic intermediation properties within their portfolio's design and implementation processes.

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Notes

1. EIT Climate-KIC thematic areas: (1) Urban Transitions, (2) Sustainable Land Use, (3) Decision making, metrics and finance and (4) Sustainable Production Systems.
2. This vocabulary was validated by EIT-Climate KIC staff to align it with the terms used by the organisation in its projects.
3. Types of partners: higher education, research, business, business SME and NGOs.
4. We calculated other indicators of disparity - GINI and Shannon Evans indicators. We did not find significant differences between them; therefore, we only report the Simpsons results.

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During the conceptualisation of this research and preparation of the manuscript, Cristian Matti was employed by EIT Climate-KIC.

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