Mechanisms of knowledge development in a knowledge ecosystem

Christina Öberg and Heléne Lundberg

Abstract

Purpose – *Although ecosystems have been researched extensively over the past decade, we know little about how they should be organised. Focusing on a knowledge ecosystem comprising a university and a regional strategic network (RSN), this paper aims to describe and discuss the mechanisms for knowledge development in knowledge ecosystems.*

Design/methodology/approach – *This paper studies the integration of a university into a Swedish RSN. Data were collected through interviews with representatives of the university, the RSN and all firms comprising the RSN. A qualitative content analysis helped to detect mechanisms for knowledge development.*

Findings – *Two reinforcing mechanisms for knowledge development in the knowledge ecosystem are identified: structure and openness, which relate to insight and outlook, respectively. The findings also indicate a knowledge division, with the university representing the transfer of knowledge capabilities as a linear process, whereas the content-related knowledge is collaborative.*

Originality/value – *This paper contributes to research on knowledge ecosystems by describing how their organisation is based on a number of contradictions (structure and openness, insight and outlook, linearity and collaboration) to accomplish the development of knowledge capabilities and content-related knowledge.*

Keywords *Innovation, Knowledge ecosystem, Mechanism, Regional strategic network, University*

Paper type *Research paper*

Christina Öberg is based at CTF Service Research Center, Karlstad University, Karlstad, Sweden and The Ratio Institute, Stockholm, Sweden. Heléne Lundberg is based at the Department of Economics, Geography, Law and Tourism, Mid Sweden University, Sundsvall, Sweden.

Introduction

The concept of knowledge ecosystems has gained traction in recent research, with such ecosystems focusing on the knowledge-enhancing activities (knowledge sharing, knowledge development) rather than business interactions of a defined number of parties organised around a specified knowledge search or practice (Clarysse *et al.*, 2014; Järvi *et al.*, 2018; Cobben *et al.*, 2022). The proximity of actors is a central characteristic of such ecosystems (Van der Borgh *et al.*, 2012). Knowledge ecosystems have been studied in relation to regional start-ups (Clarysse *et al.*, 2014), quadruple helix initiatives (Miller *et al.*, 2016) and within organisations (Sharma and Bhattacharya, 2013) and related to practices in specified sectors or for specific solutions. Research has focused on the characterising traits and actor composition of knowledge ecosystems and how they transfer into business ecosystems (Clarysse *et al.*, 2014), whereas research on how they should best be organised to accomplish set goals remains limited (Cobben *et al.*, 2022).

In this paper, we focus on a specific type of knowledge ecosystem: one that comprises a regional strategic network (RSN) and a university. RSNs refer to government-supported, structured initiatives to foster business development in an area often characterised by disparity (Lundberg and Johanson, 2011; Eklinder-Frick and Åge, 2017; Lundberg and Öberg, 2021a, 2021b). Past research has highlighted how RSNs often lack knowledge capabilities to meet goals, whereas universities are natural hubs in knowledge ecosystems (Van der Borgh *et al.*, 2012). Traditionally, universities' role in knowledge development has

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been represented either by a linear process of spinning out research ideas for subsequent commercialisation (Smilor, 1990; Friedman and Silberman, 2003) or, more recently, broader, more collaborative roles. While researchers such as Carayannis *et al.* (2018) and Nilsson and Moodysson (2015) have discussed universities' collaborative efforts in regions, RSNs have several distinguishing characteristics with consequences not only for how knowledge development is organised within them but also for how universities would collaborate with them. We capture the organising as "mechanisms for knowledge development" while acknowledging that the university–RSN knowledge ecosystem may differ from other knowledge ecosystems. Compared to past research, which focused on universities' increasingly collaborative role in regional initiatives, we argue for mechanisms where structure meets collaboration and distinguish between content-related knowledge and knowledge as capabilities. The purpose of this paper, therefore, is *to describe and discuss mechanisms for knowledge development in knowledge ecosystems*.

There have been many, often unsuccessful, initiatives to foster knowledge development through the creation of RSNs in regions characterised by disparity and vulnerability, making it important to understand how such initiatives can be improved (Lundberg and Öberg, 2021a, 2021b). The theoretical contribution of this paper is to theorise about the mechanisms of knowledge development in a knowledge ecosystem and expand the understanding of the organising of knowledge ecosystems. Cobben *et al.* (2022) recently pointed out the research gap concerning the organising of knowledge ecosystems. In our theorising, we identify two main types of knowledge that expand the current view on knowledge ecosystems while pointing at how the organising is based on contradictions between structure and openness, insight and outlook and linearity and collaboration to develop knowledge capabilities and content-related knowledge. We are thereby able to show how contradictory mechanisms need to co-exist in university–RSN knowledge ecosystems. In so doing, we provide new insights into research that has increasingly moved away from linear knowledge processes involving universities.

The paper is structured as follows. After this introduction, the theoretical departures are provided. The section has two parts: a brief overview of research on the phenomenon level of RSNs, despair-region support and universities' roles in despair regions and a closer look at knowledge ecosystems. The research design is described thereafter, where the paper departs from an RSN in Sweden and its start of a collaboration with a university. The findings are then reported and analysed, followed by a discussion on the organising of knowledge ecosystems. The paper ends with conclusions and ideas for further research.

Theoretical background

The phenomenon-level position of this paper describes how a university infuses knowledge into an RSN and, together with the RSN, creates a knowledge ecosystem. While our primary theorising goal is to understand the organising in knowledge ecosystems, the specifics of the university–RSN collaboration should not be overlooked.

Background to measures to induce regional developments, regional strategic networks and universities

The issue of regional disparity describes imbalances not only among regions (Martin and Sunley, 2006; Beenstock and Felsenstein, 2008; McCann, 2020) but also among various resources in despair regions: high employment rates, in spite of (potentially) a lack of capabilities; a mismatch between needed resources and those produced locally; and the lack of a local market (Öberg and Aronsson, 2022). "Regions" may refer to countries, clusters of countries or, as in this paper, local areas within countries. Various initiatives, including RSNs, are offered to support despair regions that suffer as the result of the imbalances within them (Naldi *et al.*, 2020). RSNs are normally governed from the top down, with pre-set programmes

and activities to bring local small- and medium-sized enterprise (SME) representatives together (HanssenBauer and Snow, 1996; Connell *et al.*, 2014; Eklinder-Frick, 2015; Leick and Gretzinger, 2020). The underlying idea is that firms within the RSN will start to collaborate commercially if they are brought together socially (cf. Landry *et al.*, 2002; Martins and Ling, 2017; Malecki, 2018; Manniche and Testa, 2018; Baraldi *et al.*, 2019 on social networks as a departure for entrepreneurship). Furthermore, the intention is to imitate natural clusters of firms formed from the co-location of interests and capabilities, as in Silicon Valley (Singh, 2005; Delgado, 2020). A key difference for RSNs, however, is that the firms involved are rarely co-located around shared interests and that government initiatives like RSNs are not needed where firms cluster naturally. Research has indicated that formations of firms for regional development need a natural central firm or hub (Tsouri and Pegoretti, 2021), thus rather emphasising naturally established networks. The literature has suggested that RSN members rarely collaborate beyond formalised socialising (Chiu, 2009; Delgado *et al.*, 2014), RSNs are therefore ineffective (Saha *et al.*, 2018) or only lead to commercial exchanges while support is given (Graf and Broekel, 2020). Furthermore, it has been pointed out that any developments depend on particular cluster policies (Nestle *et al.*, 2019) and that the variety and complementarity of firms in the RSN determine positive developments (Tavassoli and Carbonara, 2014).

In parallel to research on RSNs, there is growing interest in universities' potential role in helping to develop regions (Youtie and Shapira, 2008; Nilsson and Moodysson, 2015; Carayannis *et al.*, 2018; Klofsten *et al.*, 2019; Parmentola *et al.*, 2021), including despair regions (Salomaa and Charles, 2021). Universities could attract firms to the region and be a catalyst for new firm creation (Strauf and Scherer, 2008; Huggins *et al.*, 2012; Cowan and Zinovyeva, 2013; Aaboen *et al.*, 2016; Marques *et al.*, 2019; Laage-Hellman *et al.*, 2020). In such a scenario, clustering is natural with the university as the hub. Theeranattapong *et al.* (2021) describe knowledge co-creation, acting as a conduit, and inter-organisational relationship building as university roles in regions. Theeranattapong *et al.* (2021), though, focus on the innovation system with the university, incubator and science park as organisational units. Over time, linear transfers of knowledge and spin-offs have been complemented by collaborative efforts (Kurdve *et al.*, 2020). Attempts to establish collaborative efforts between universities, society and firms have led to triple and quadruple helix initiatives (Miller *et al.*, 2016; Del Giudice *et al.*, 2017; Carayannis *et al.*, 2018). Such initiatives bring together universities, firms, governmental organisations and civil society, and quadruple helix initiatives emphasise collaborative intentions (Carayannis *et al.*, 2018).

Research is not always clear about whether RSNs (synonymous with clusters, innovation networks, nets, and alliances) depart from natural, emerging or constructed networks, which blurs the findings. In studies including universities, it is often unclear whether the regions are prosperous or in despair. Parmentola *et al.* (2021) and Vega-Jurado *et al.* (2020) focus on low-innovation and low-absorptive capacity regions, concluding that these are different from other regions in their collaboration with universities and the outcome of such collaborations. Grimaldi *et al.* (2021) indicate specific mechanisms and channels for universities to interact with low-technology industries in an Italian region. In these studies, the university's proximity to the region is taken for granted, yet many other characteristics remain unclear. We may not therefore be able to transfer the findings from past research – where firms in regions rather than RSNs seem to have been studied in conjunction with universities – to our case of a university–RSN knowledge ecosystem. Furthermore, the knowledge ecosystem differs from those initiatives taken related to business interactions.

Knowledge ecosystems

Knowledge ecosystems have been defined as a "heterogeneous set of knowledge-intensive companies and other participants that depend on each other for their effectiveness and efficiency and as such need to be located in close proximity" (Van der

Borgh *et al.*, 2012). Compared to business ecosystems, knowledge ecosystems focus on the development, transfer and integration of knowledge among parties (Cobben *et al.*, 2022). Knowledge ecosystems are thereby different from RSNs established to increase business activities in a region, although researchers (Clarysse *et al.*, 2014; Ghazinoory *et al.*, 2021) frequently view knowledge ecosystems as precursors of business ecosystems. *Ecosystems* include ambitions among organisations to co-evolve along the lines of shared visions (Moore, 1996; Clarysse *et al.*, 2014; Valkokari, 2015; Järvi *et al.*, 2018; Scaringella and Radziwon, 2018). *Knowledge* would, in this regard, include how various parties share insights and learning among them, as well as develop and accumulate new ideas. Järvi *et al.* (2018) distinguish between knowledge ecosystems in search of new knowledge and those exploiting existing knowledge within the ecosystem; the former is collectively oriented, whereas the latter is monitored through parties' formal membership.

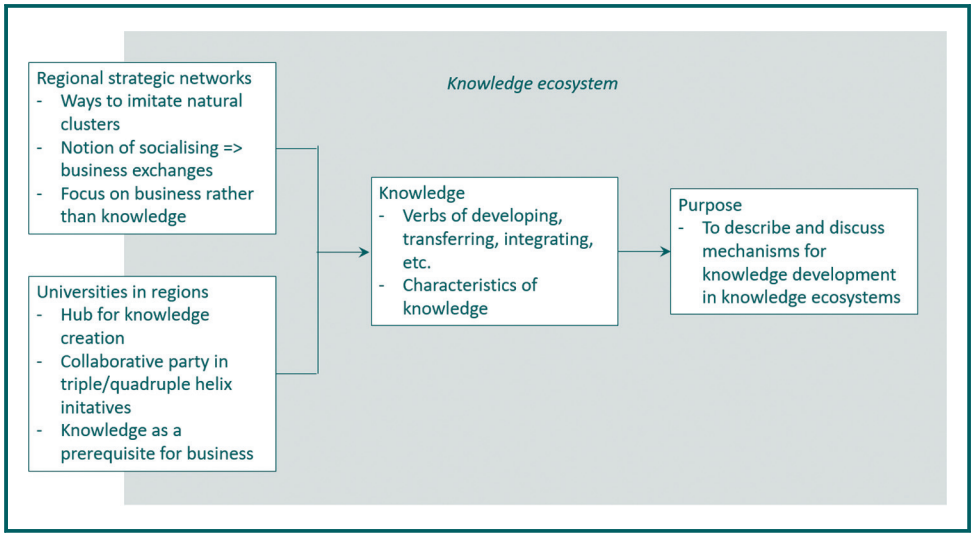
Research on RSNs thus tends to focus on the business potential of the firms, whereas studies on universities may generally refer to the innovation system (i.e. the support system for the spin-off of ideas) as a knowledge ecosystem. Describing the integration of a university into an RSN as a knowledge ecosystem allows us to focus on the development and management of *knowledge* that includes both the university and the RSN.

Knowledge-based view

To frame the mechanisms for knowledge development in the knowledge ecosystem, we adopt a knowledge-based view. Rather than referring to the knowledge base as company-internal, we describe it on the ecosystem level as fluid among the various parties and possibly contained within them. The knowledge-based view emphasises knowledge as a core resource for firm development and management (Nonaka and Takeuchi, 1995; Foss and Pedersen, 2004; Grant and Phene, 2022). As such, the knowledge would – similar to several researchers' definition of knowledge ecosystems – be what is transferred into business opportunities and offerings (Kogut and Zander, 1992; Pereira and Bamel, 2021), while we focus on the knowledge ecosystem as such. In how knowledge develops in transformative ways and transfers across parties without diluting, it is a unique resource: it is fluid and thereby not naturally owned by a firm, but rather held by individuals, between parties or part of specific routines (Felin and Hesterly, 2007). This draws attention to tacit knowledge (Doz *et al.*, 2001) and collaborations as sources of knowledge (Kogut and Zander, 1992). Tacit knowledge has been described in past research as conditioned by the proximity of parties, whereas codifiable, teachable and observable knowledge would enable more distant transfer and transfer among parties without any social component necessarily being present.

The knowledge-based view has been linked to the development of ideas and described in conjunction with clusters. In a knowledge ecosystem, knowledge would develop, transform and be transferred to, and integrated into, parties (Cobben *et al.*, 2022). Traditional discussions about knowledge ecosystems typically focus on actors rather than activities (Van der Borgh *et al.*, 2012) and do not expand on how knowledge is processed or how the knowledge ecosystems are organised (Cobben *et al.*, 2022). The knowledge-based view helps to describe various characteristics of knowledge and provides some knowledge verbs (developing, transferring, integrating, etc.). In this paper, we examine the ecosystem level and the development of knowledge within it. Figure 1 summarises the main components from past research and shows how they relate to this paper. More precisely, the left-hand side of the figure describes past studies' claimed rationales for universities' and RSNs' respective roles in regions and knowledge development. In our paper, the university and RSN are actors in the knowledge ecosystem (greyed area in the figure), and we analyse how knowledge is managed (verbs) and its type (characteristics) to – in line with our purpose – describe and discuss mechanisms for knowledge development in knowledge ecosystems. The verbs refer to whether knowledge is transferred, developed,

Figure 1 Component as the point of departure



etc., whereas the characteristics describe the type of knowledge as tacit, capabilities, innovation and so on. Together, these dimensions, along with the RSN's and university's roles, capture the knowledge organising in the knowledge ecosystem. The paper thereby fills the verb and characteristic box with content that arises from our empirical data. The figure should, in that way, be seen as the combination of an analytical framing tool and a summary of dimensions and perspectives taken in past research.

The following research questions are addressed:

RQ1. How can the organising of knowledge in a knowledge ecosystem comprising an RSN and a university be characterised?

RQ2. What implications for knowledge management does the organising have?

Research design

While there is plenty of research on knowledge ecosystems, RSNs and universities' potential roles in developing regions, research into the organising within knowledge ecosystems and the collaboration between a university and RSN for knowledge purposes is scarce. With the various actors involved and to capture the phenomenon from their perspectives, we adopted a case study approach (cf. Pettigrew, 1973; Eisenhardt, 1989; Yin, 1994). We looked for the following criteria in our selection of a suitable case:

- for benchmarking purposes, it needed to be about an RSN with a history before a university got involved;
- it needed to be located in a region of despair; and
- collaboration with a university was prompted.

These criteria may make the case very specific, but while research on collaborations between RSNs and universities is limited, the regional initiatives for RSNs and the difficulties of achieving developments in them made it a relevant phenomenon to study.

The chosen RSN is located in a sparsely populated administrative region in Sweden. The region encompasses three neighbouring cities of 6,000–18,000 inhabitants each, including their surrounding rural areas. The RSN was founded to support SMEs in the region and,

initially, it focused on their business development but, over time, shifted to a focus on knowledge development together with a university located quite far away outside the region. This collaboration included six university representatives and the RSN consisting of nine SMEs. Data were collected primarily from interviews with representatives of the nine firms, university representatives and the project manager and coordinator of the RSN. Firm representatives were selected primarily on the basis of their involvement with the RSN, whereas the university representatives were chosen from those directly engaging in the collaboration (see Table 1).

The interviews were semi-structured and open ended to engage the interviewees in conversation and allow them to talk freely, but more focused questions were asked when necessary. Questions addressed the following areas: rationale for participating in the collaboration; description of regional engagement and business and knowledge interactions prior to the knowledge ecosystem; changes during the collaboration; view and description of knowledge interaction in the ecosystem; and their own contribution and contributions by other parties, including the respective roles of the coordinator, manager, university and other firms in the RSN. The interviews were recorded and transcribed directly after each interview. In addition to interviews, we used secondary data from the RSN's and firms' websites, and a review of newspaper articles mentioning the names of the firms was conducted. The secondary data sources provided opportunities to capture descriptions produced at the time of various events and decrease the risk of retrospective rationalisation (Huber and Power, 1985).

The data analysis followed the three main steps suggested by Miles and Huberman (1984):

- data reduction;
- data displays; and
- conclusion drawing and verification.

NVivo was used to systematically code the interview transcripts and other textual sources based on their content (Krippendorff, 2004). This allowed us to develop empirical codes and, subsequently, theoretical codes based on data reduction (Gioia *et al.*, 2013) while

Table 1 Interviewees

Interviewee	Duration (min)	Organisation	No. of employees	International markets
Project leader	50	Project	N/A	N/A
Regional strategic network coordinator and assistant project leader	20 + 20	Regional strategic network	N/A	N/A
R&D manager, Firm 1 (F1)	45	Manufacturer of solar collectors	21	Global business
CEO, Firm 2 (F2)	40	Manufacturer of micro pumps	6	Global business
CEO, Firm 3 (F3)	40	Manufacturer of lifters	24	Global business
R&D manager, Firm 4 (F4)	30	Manufacturer of contact press systems	155	Global business
Site manager and CFO, Firm 5 (F5)	40	Manufacturer of tools	30	Selling to more than 60 countries
CEO and R&D manager, Firm 6 (F6)	10 + 40	Manufacturer of aluminium boats	49	Selling to about 10 countries
Site manager, Firm 7 (F7)	55	Manufacturer of floor heating	19	Selling to 12 countries
CEO, Firm 8 (F8)	45	Manufacturer of sawmills and cutting tools	35	Global business
CEO, Firm 9 (F9)	20	Producer of software for the automotive industry	8	Exporting to one country
Professor (P1)	20 + 20	University of Technology	N/A	N/A
Professor (P2)	25	University of Technology	N/A	N/A

enabling the tracing of linkages among codes and their explanations. Codes focused on knowledge management and how knowledge could be characterised and changed – by, for example, transferring it to other parties, developing or modifying it within a firm, between firms, at the RSN level or between the university and the RSN or firms (cf. Figure 1). They also concerned the change, spread and development of knowledge (cf. Felin and Hesterly, 2007). By focusing on these dimensions, we could capture the organising of knowledge in the ecosystem and theorise mechanisms for knowledge development. Initial coding was done per firm, next per perspective (the firms in the RSN, the university and the governmental representatives of the RSN, respectively) and finally, on the knowledge ecosystem level. The cross-firm and cross-perspective analyses helped identify similarities and differences among the interviewees' statements while remaining sensitive to the unique perspective of each party. Throughout this analysis, we used tables and graphs to illustrate the data material (cf. Miles and Huberman, 1984).

As a final step, we compared our findings with previous research to ensure theoretical rigour and refine the research gap. As we identified two mechanisms related to different types of knowledge and transfer, we compared types and mechanisms across to see if, for instance, a mechanism could be linked to the type of knowledge of the other mechanism or whether they were distinct. Our mechanisms revealed a number of contradictions, so we compared our findings to past research on tension and paradoxes (Poole and Van de Ven, 1989; Lado *et al.*, 2006; Smith and Lewis, 2011) to better understand our findings and develop our conclusions.

University–RSN knowledge ecosystem

The knowledge ecosystem aimed to link together an RSN (consisting of the nine firms in a region marked by sparse resources and opportunities) and a university. The RSN had largely failed in developing the firms and exchanges among them before the university got involved. Previously, the focus had been on business creation, but with the university on board, the focus shifted to knowledge development. The collaboration between the university and the RSN commenced in 2018. In the collaboration, the university representatives positioned themselves as teachers rather than innovators, with initial collaboration comprising lectures and seminars. In September 2019, the university representatives presented six online lectures on methods and structures for development processes. Another seminar series focusing on the Internet of Things took place in the autumn of 2019. The content of the lectures was agreed upon between the RSN and the firms. The idea behind the lectures was to use them to transfer knowledge about innovating and developing operations rather than the university getting involved directly in such activities. Lectures were complemented with seminars to make the firms in the RSN share experiences and discuss issues together and with the university. Furthermore, meetings were arranged, including all the firms, the RSN project manager and the university representatives. These meetings aimed to discuss the collaboration's progress and the firms' development work. Over the course of the collaboration, firms increasingly stepped forward to host lectures themselves and increasingly influenced the content of lectures and seminars.

As the collaboration continued, two key mechanisms of knowledge management came to the fore: structure and openness. Together, these mechanisms increased idea generation and exchange among the firms in the knowledge ecosystem.

Firstly, the *structure* was central to the content of the knowledge transferred from the university. The teaching focused on structured development processes and stemmed from the firms' lack of such processes. One of the university professors (P1) noted: "They have chosen to learn more about product development methods; many have no processes for that." The other professor (P2) concluded: "They don't test the functionality in simulations before putting the product on the market." The lack of knowledge about development methods and processes was confirmed by the firms in the RSN. F8's representative, for

instance, stated: "We need to improve our development processes." Likewise, F3's representative noted: "We knew very little about these matters; we needed to improve our development structure." F5's representative described how the firm's previous processes were rather unsystematic. The researchers supported the firms through lectures and seminars about methods and structures for development processes by demonstrating various simulation tools related to the different needs of the firms and by frequently interacting with the firm representatives on these issues. In doing so, the focus was on *capabilities* to develop rather than on the content of such developments and described a linear knowledge transfer accomplished through the lectures from the university to the firms in the RSN.

The focus on structure resulted in more systematic development processes and an increased awareness of knowledge development. Moreover, the structured processes meant that the firms became increasingly visionary and more aware of their context in development considerations. For example, F2's representative reported how the firm now started the development processes with market analyses and not, as before, by developing a product and then trying to find a market for it. In his opinion, the firm would not have taken the time to learn about these matters if it had not been for the infusion of the university's knowledge into the RSN. F7's representative concluded: "There is a risk that we would not have realised that we needed this knowledge. [. . .] I don't think that we would have made simulations if it had not been for this collaboration." This firm has now built its own test facility for simulations. In general, the more the firms learnt about how to structure and run development processes, the stronger their commitment became to the development of new ideas and operations and the university–RSN knowledge ecosystem. Previous research has often linked structures to less innovative efforts by firms yet pointed to how structures may help firms take small but steady steps. In the knowledge ecosystem, though, and compared to the firms' previous levels of development, more structured processes helped firms to make room for thinking innovatively and to reconsider their operations. In other words, structures actually fostered new ideas in their more radical form. From a knowledge perspective, this part of the university–RSN knowledge ecosystem focused on knowledge about innovating rather than knowledge about specific ideas, hence creating a different kind of knowledge to that defined in past research on knowledge ecosystems and on universities' collaboration with regions or as part of triple/quadruple helix initiatives. The structures could be said to provide *insights*, that is, how the firms better understood their current ways of acting and their potential limitations.

Secondly, *openness* came to the fore as a key mechanism as the university promoted sharing activities. Openness describes how the firms, through their collaboration with the university and in meetings, were brought together for common or shared purposes. Complemented by the teaching and seminar activities, the firm representatives became increasingly willing to talk with others about their developments in the meetings. The collaboration also entailed the sharing of resources. Simulation programmes, for instance, were considered too expensive for individual firms, but by sharing and testing ideas among the firms and with the university, the firms were able to identify new opportunities for sharing. Previously, the RSN had only led to socialising among the firm representatives with low engagement; many representatives had never participated and even fewer of them prioritised meetings arranged by the RSN coordinator. Instead, the university filled meetings around development with a purpose. The representative of F4, for instance, stated: "These meetings are very rewarding, much more than the meetings in the [RSN before the collaboration with the university]. We help and support each other and get new ideas from each other." Compared to structure, the first mechanism, openness, focused on content-related knowledge and firms developing ideas or solving problems together. The project leader and the university researchers noted the benefits of this collaboration: "New ideas often pop up during their discussions" (P2).

The openness broadened the firms' *outlook* by seeing other firms' ideas by connecting with and developing them together. This outlook could be described as a new approach to other parties also beyond the knowledge ecosystem: the firms became increasingly willing to collaborate with others outside the knowledge ecosystem, both in and beyond the geographical region. In the autumn of 2021, the experiences of interacting and sharing knowledge in the knowledge ecosystem inspired the shared creation of a platform for development-related interaction that was open to firms outside the RSN. The idea was to share, discuss and disseminate ideas and experiences from the knowledge ecosystem on how to manage development processes, develop collaborations and share resources with other organisations. The inclusion of the university thus highlighted the importance of knowledge capabilities for development (demonstrated by the structure mechanism), whereas knowledge creation was stimulated by the increased openness and collaboration among the firms.

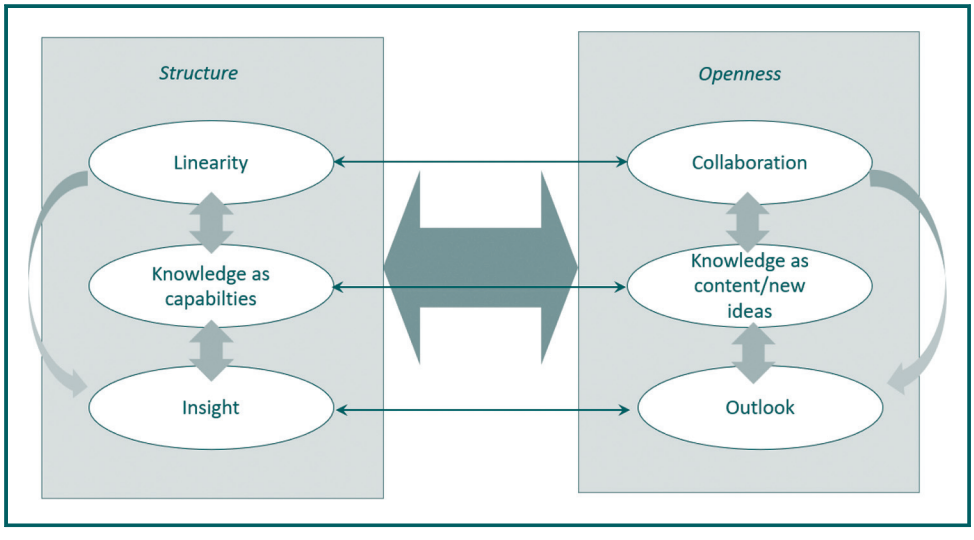
Discussion

With structure and openness as the two mechanisms for knowledge development being related to knowledge as capabilities and content, insight and outlook and linearity and collaboration, Figure 2 illustrates a number of contradictions in the organising of the knowledge ecosystem.

These contradictions indicate not only how previous studies into knowledge ecosystems have focused only on content-related knowledge at the ecosystem level (Clarysse *et al.*, 2014; Järvi *et al.*, 2018; Cobben *et al.*, 2022) but also how crucial it is that ecosystem members develop their capabilities. Co-existing contradictory forces means dealing with paradoxes (Poole and Van de Ven, 1989; Lado *et al.*, 2006; Smith and Lewis, 2011) in knowledge ecosystem organising. The paradox here is that past research on knowledge development has described how structure would positively influence incremental developments and counteract any more radical developments. Openness, however, would be positive for radical developments. In the knowledge ecosystem, though, these mechanisms have somewhat complementary functions, whereas the paradoxical nature of co-existence cannot be ignored.

Firstly, consider the items in the structure column in Figure 2: linearity, knowledge as capabilities and insight have traditionally been overlooked in past research on knowledge

Figure 2 Mechanisms in knowledge ecosystems



ecosystems (Moore, 1996; Clarysse *et al.*, 2014; Valkokari, 2015; Järvi *et al.*, 2018; Scaringella and Radziwon, 2018), yet they each play a part in knowledge transfer and hence add knowledge per party through sharing and wider dissemination of knowledge. Meanwhile, the transfer *per se* does not add new knowledge on the ecosystem level: what is known before by one party in the ecosystem has not expanded; rather, that knowledge is now held by multiple parties. The linearity of the knowledge transfer supports this, whereas it creates insights for those parties obtaining the knowledge. Secondly, consider the items in the openness column in Figure 2: collaboration, knowledge as new content/new ideas and outlook represent knowledge development and hence how the ecosystem expands its knowledge base (Van der Borgh *et al.*, 2012; Järvi *et al.*, 2018). Such development reaches beyond the knowledge ecosystem to collaborate with – and teach – parties outside the knowledge ecosystem. In the knowledge ecosystem, these collaborative efforts are made by the firms rather than the RSN coordinator or the university. The outlook beyond the knowledge ecosystem and thereby its contextualisation has not been discussed in past research on knowledge ecosystems, whereas it creates an important dimension for continuous knowledge creation.

So what does this tell us about the organising of knowledge ecosystems? Firstly, parties in a knowledge ecosystem need to reach a certain and similar level of understanding before they are able to develop knowledge together. This is where the knowledge capabilities, in our case, transferred from the university, come into play: they become a means to synchronise the knowledge level in the ecosystem. Secondly, role division is important for a knowledge ecosystem, where the university maintains a teaching role throughout the collaboration. Role divisions would, initially, reflect the various parties' reasons for being part of the knowledge ecosystem and their respective capabilities. However, over time and as the parties in the ecosystem gradually synchronised their knowledge levels, roles might become blurred. This means that the knowledge ecosystem is defined by the interconnectivity of activities among parties rather than – as RSN research often demonstrates (Lundberg and Johanson, 2011; Eklinder-Frick and Åge, 2017; Lundberg and Öberg, 2021a, 2021b) – being focused on its actors. Thirdly, organising entails dealing with paradoxes and the co-existence of contradictions, which would include how structure helps in synchronising, whereas openness stimulates knowledge development. Insight means dealing with the critical self-reflexive understanding of how knowledge development has been handled in the past, whereas outlook indicates how the knowledge ecosystem needs to be understood as part of a broader context that would affect and be affected by the activities in the knowledge ecosystem. Linearity and collaboration are linked to role division, types of knowledge and levels of insight and outlook. Last, knowledge capabilities and content-related knowledge reflect how a knowledge ecosystem, when developing knowledge, is dependent on the capabilities of those in the ecosystem to do so.

Conclusions

This paper describes and discusses mechanisms for knowledge development in knowledge ecosystems. The theory section raised two questions: How can the organising of knowledge in a knowledge ecosystem comprising an RSN and a university be characterised? What implications for knowledge management does the organising have?

The organising of knowledge would be characterised by paradoxes between structure and openness, insight and outlook, linearity and collaboration, include knowledge capability transfer for synchronisation and content-related knowledge from collaborative development, and be based on role division. The implications are that parties increasingly learn from each other, while also being increasingly inclined to look beyond the knowledge ecosystem. Albeit role division is important for synchronisation, the knowledge ecosystem's governance should preferably be distributed among parties.

Theoretical contributions

This paper contributes to research by theorising about structure and openness as mechanisms of knowledge development in a knowledge ecosystem. It points at the need for capability synchronisation, role division and dealing with the paradoxes of the mechanisms and their connection to linearity and collaboration, insight and outlook and knowledge capabilities and content-related knowledge. Figure 1 outlined the ambition of linking together verbs of knowledge management with knowledge characteristics in a knowledge ecosystem consisting of a university and an RSN. As illustrated in Figure 2, our findings link together openness with collaboration as a mechanism and knowledge as new ideas as a type of knowledge. It also links together structure with linear knowledge transfer related to capabilities. This indicates how knowledge in ecosystems is not a matter of either–or but paradoxically should include both structure and openness. While Järvi *et al.* (2018) have explained how knowledge ecosystems may orient to new or existing knowledge with various organisational characteristics, we indicate that knowledge transfer and development should not be treated as separate but rather as co-dependent in a knowledge ecosystem including capabilities. The synchronisation of knowledge capabilities adds to past foci in research on knowledge ecosystems (Van der Borgh *et al.*, 2012; Clarysse *et al.*, 2014; Järvi *et al.*, 2018), whereas the role division, with the university transferring knowledge linearly, provides insights that question past research foci on universities' increasingly collaborative role for knowledge development (Kurdve *et al.*, 2020) and the organising of triple and quadruple helix initiatives (Miller *et al.*, 2016; Del Giudice *et al.*, 2017; Carayannis *et al.*, 2018). Treating knowledge capabilities as a baseline for possible knowledge development adds to our knowledge of RSNs (HanssenBauer and Snow, 1996; Connell *et al.*, 2014; Eklinder-Frick, 2015; Leick and Gretzinger, 2020) as capabilities have been overlooked in previous research. Moreover, this highlights activities as part of collaborations rather than actor composition and relates to role division as separation of activities, synchronisation as adjusting activities and collaboration as shared activities. By focusing on a knowledge ecosystem including an RSN rather than the possibility of creating business opportunities through the RSN (Eklinder-Frick *et al.*, 2011; Saha *et al.*, 2018), we show how RSNs would need to ensure knowledge synchronisation through capabilities to enable development. For the knowledge ecosystem, the contradiction between the mechanisms of structure and openness helps us grasp the circumstances under which knowledge *per se* only spreads (structure) or enhances (openness) as part of a knowledge ecosystem.

Managerial implications

In the creation of a knowledge ecosystem, parties would need to be mutually evaluated on the basis of similarities in capability levels, openness for collaboration and complementarities of content-related knowledge. The ability to include actors (such as the university) for capability development should also be considered. Firms need to address questions related to what other parties know and how parties could contribute together to knowledge development and how parties (such as the university) would help expand knowledge capabilities. In the organising, it would be important to consider how the RSN should be governed bottom-up by its participating parties rather than by a coordinator.

Questions to address for participating parties to establish commitment and possibilities for knowledge synchronisation and development would be: What knowledge capabilities do we currently hold? What parties could help us develop these? How would our knowledge capabilities need to be developed to match potential collaborators for knowledge development? How do we create a collaborative atmosphere for knowledge development? How would we benefit from such knowledge development? Should we also consider joint commercial ventures with identified parties in the future? How can we create collaborative governance of a possible RSN, cluster or knowledge ecosystem?

Limitations and further research

This paper addresses a specific type of knowledge ecosystem comprising an RSN and a university. While this adds to past research, it contains specificities that may not be valid for other types of knowledge ecosystems. Further research should therefore focus on other types of knowledge ecosystems, including those involving universities in regions of despair (but without an RSN), natural clusters of firms born out of shared interests and those with a firm as their central hub. Given Sweden's specific innovation policies and its standing as a knowledge nation, comparative studies should ideally be conducted in other countries. Quantitative testing of findings would be desirable for greater generalisation of results from larger sample sizes, where hypotheses could be developed about the mechanisms contradictions and in relation to structure, capabilities, transfer, linearity and insight and openness, content-based knowledge, development, collaboration and outlook, respectively.

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Corresponding author

Christina Öberg can be contacted at: christina.oberg@kau.se