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Working Paper

Knowledge-based regional development by university and regional entrepreneurial ecosystems: Permeability, boundaries and complementarities

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Knowledge-based regional development by university and regional entrepreneurial ecosystems

permeability, boundaries and complementarities

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Abstract

This paper discusses the interplay between university entrepreneurial ecosystems (UEE) and regional entrepreneurial ecosystems (REE) in knowledge-based regional development, focusing on their permeability, boundaries, and complementarities. Using qualitative data from 176 events attended by startups from UEE and REE in the German Ruhr region, the research reveals an asymmetric permeability: UEE startups frequently engage with REE events to access market knowledge and managerial skills, while REE startups rarely participate in UEE activities beyond recruiting graduates. Both ecosystems deliver similar types of entrepreneurial knowledge, such as managerial and funding insights, but differ in their emphasis. UEEs focus more on market insights linked to technology commercialisation, whereas REEs emphasise marketing knowledge reflecting closer market proximity. The findings highlight the REE's nurturing role by providing practical support and market access for the UEE startups. The study suggests fostering greater inclusivity of UEEs to benefit a broader range of founders and recommends hybrid event formats combining UEE and REE resources to enhance regional innovation dynamics.

Keywords: university entrepreneurial ecosystems, regional development, knowledge transfer, entrepreneurial ecosystems

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Introduction

Entrepreneurial ecosystems have become a central concept in discussions of knowledge-based regional development (Harris & Menzel, 2023; Isenberg, 2010; Stam, 2015). Within regional research and practice, growing attention has been directed towards innovative startups and their role in generating, transferring, and commercialising knowledge (Kraus et al., 2021; Mason & Brown, 2014; Stam, 2015) and the regional anchoring of new knowledge (Butzin & Flögel, 2023; Harima et al., 2021; Mason et al., 2025; Ryan et al., 2021). From this perspective, a key question concerns the support structures and actors that enable entrepreneurs to transform innovative ideas into viable business ventures (Flögel et al., 2025).

In response, entrepreneurial ecosystem research has diversified, examining ecosystems centred on specific actor groups, such as universities (Prokop, 2021), migrant entrepreneurs (David et al., 2025), or sector-specific entrepreneurial communities (Butzin & Flögel, 2023). While these studies have generated important insights, they typically analyse individual ecosystem types in isolation. Yet, in larger metropolitan regions, multiple entrepreneurial sub-ecosystems coexist and interact, creating a complex and multilayered support environment for entrepreneurs.

Against this background, this paper investigates the relationship between university entrepreneurial ecosystems (UEEs) and the broader regional entrepreneurial ecosystems (REEs). Recent research on UEEs has highlighted their role in facilitating the transfer of academic knowledge and technologies into the economy, primarily through university spin-offs (Prokop, 2021, 2022). A UEE can be understood as "a unique set of ties [...] that a university builds and utilises for its commercialisation activities, in particular, forming spinoffs and ensuring their success" (Prokop, 2021, p. 1). Likewise, entrepreneurial ecosystems (Isenberg, 2010; Mason & Brown, 2014; Stam, 2015) and their regional emphasis (labelled regional entrepreneurial ecosystems [REE] by Prencipe et al., 2020), contribute to regional economic growth through supporting knowledge-intensive ventures with high-growth ambitions. Mason and Brown (2014, p. 5) define an REE as a "set of interconnected entrepreneurial actors, entrepreneurial organisations, institutions and entrepreneurial processes which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment".

Although both ecosystem types contribute to knowledge-based regional development, UEEs are examined as separate phenomena. The boundaries between UEE and REE, however, appear permeable, as entrepreneurs may engage with actors, networks, and support structures across both ecosystems. This raises important yet underexplored questions regarding the distinct functions of UEEs and REEs, their degree of overlap, and their respective contributions to entrepreneurial development and regional knowledge transfer. Against this background, we aim to contribute to the broader discussion on knowledge-based regional development through (university) entrepreneurial ecosystems and explore the following research questions: To what extent are UEE and REE permeable, confined or complementary, and what is their distinct contribution to knowledge-based regional development?

The research question is particularly relevant because, although the role of universities as providers of knowledge for regions has long been studied (Charles, 2006; Fischer et al., 2017), their spin-off production and the subsequent impact on regional development has not been examined to the same extent. On the one hand, through their entrepreneurship and knowledge-transfer support activities,

universities generate their own spin-offs and have the facilities to promote startups from their regions that are initially not related to the university. This is especially relevant in regions with less developed REE. On the other hand, insufficient support from UEE could be balanced by a vibrant REE that nurses university spin-offs. This implies that universities which are located outside dynamic REE may lack the full potential of spin-off-based knowledge commercialisation, to the disadvantage of knowledge-based regional development.

To investigate the research question, we draw on the concepts of startup journeys and knowledge events. We conceptualise a startup journey as the process that spans from the initial motivation to develop a business idea to the early years of operating a registered company. Throughout this journey, entrepreneurs encounter knowledge events, defined as critical episodes that provide learning opportunities and contribute to venture development. Examples include mentoring sessions, participation in startup schools, engagement with incubators, and interactions with support organisations.

The empirical analysis comparatively examines 176 knowledge events identified across eleven startup journeys in the Ruhr region, Germany, including six REE-affiliated and five UEE-affiliated startups. This approach enables an assessment of the permeability, boundaries, and complementarities between UEEs and REEs.

The remainder of the paper is structured as follows. Section 2 reviews the literature on knowledge-based regional development, entrepreneurial ecosystems, and startup journeys. Section 3 introduces the case study region and outlines the methodological approach. Section 4 presents the empirical findings regarding the permeability, boundaries, and complementarities of UEEs and REEs. Section 5 discusses the implications of these findings for understanding entrepreneurial ecosystems and regional knowledge transfer. Finally, Section 6 concludes by summarising the paper's contributions and identifying avenues for future research.

2 Regional knowledge-based development by UEE and REE

Knowledge-based regional development has emerged as a dominant paradigm in economic geography and regional studies, emphasising the creation, diffusion, and utilisation of knowledge in fostering sustainable economic growth at the regional level (Etzkowitz & Klofsten, 2005). This approach builds upon foundational works such as those by Lundvall (1992) and Nonaka (1994), who highlighted the systemic nature of innovation processes rooted in interactive learning and tacit knowledge exchange, and view regional actors as dynamic entities capable of generating endogenous growth through localised knowledge generation (Cooke et al., 1997). The concept stresses that innovation performance depends on institutional thickness, e.g. the density and quality of interactions among firms, research institutions, government bodies, and other actors embedded within a specific geographical context, constituting the regional knowledge base (Asheim & Coenen, 2005).

Entrepreneurial ecosystems gained increasing attention in knowledge-based regional development since they foster an institutionally thick environment facilitating the generation, dissemination, and commercialisation of knowledge (Jones & Ratten, 2021; Stam, 2015). In addition to systemic relationships enabling knowledge spillovers, emphasis is on resource mobilisation for founding and scaling knowledge-intensive startups (Spigel & Harrison, 2018). By providing access to financial capital,

mentorship networks, skilled labour pools, and market information within a geographically bounded context, entrepreneurial ecosystems reduce transaction costs and uncertainty inherent in innovation processes (Acs et al., 2017; Stam, 2015). In this chapter, we first discuss knowledge-based regional development by UEE (2.1) and REE (2.2) followed by an account on knowledge in entrepreneurial journeys.

2.1 Regional knowledge-based development by UEE

UEEs are the pivotal catalysts for the creation and diffusion of academic knowledge and innovation to the (local) environment via startups (Zhang et al., 2016). Furthermore, they play a strong role in the regional anchoring of new knowledge, which can attract and retain regional talent (Kitagawa et al., 2022) and lead to new industrial development paths (Butzin & Flögel, 2023), due to universities' interaction with knowledge-intensive international networks. As such, UEEs have the capacity to bridge the gap between scientific knowledge production and market application. Technology transfer offices, incubators, accelerators, etc. are crucial factors of UEE and provide critical infrastructure that de-risks early-stage ventures emerging from academic research by offering intellectual property management, business mentoring, access to funding networks, and physical space (Chen et al., 2025). Moreover, UEEs contribute significantly to human capital development tailored for entrepreneurial endeavours. Entrepreneurial education programmes integrated into curricula cultivate students' skills not only in opportunity recognition but also in resource mobilisation and innovation management as competencies essential for sustaining knowledge-intensive startups (Breznitz & Zhang, 2019, 2021; Prokop, 2021).

The university itself and its technology transfer agencies are the obvious organisational anchor in UEEs. This necessarily directs UEE activity towards the people connected to the university, like researchers and students, and creates a beneficial context for them, which at the same time also sets the UEE's organisational boundaries. Specific funding programs that only allow academic founders, such as the German EXIST program[2], enhance such boundaries. Founders from non-university contexts might not feel to belong (see also David et al., 2025; Terstriep et al., 2025) to the UEE, hence seeking consultancy, networks, etc. in other entrepreneurial contexts.

Literature critically points out challenges faced by UEEs. One recurring issue is the tension between academic values centred on open science versus proprietary commercialisation goals and the ambivalence among faculty regarding engagement in entrepreneurial activities (Perkmann et al., 2013; Shibayama, 2012). Additionally, disparities exist across institutions depending on size, disciplinary focus, or geographic location, with elite research-intensive universities often dominating patenting and spin-off outputs while smaller or teaching-focused institutions struggle to develop robust ecosystems (Prokop, 2022).

[2] EXIST is a federal startup funding programme of the German Federal Ministry for Economic Affairs and Energy (BMWI), co-financed by the European Social Fund, that supports students, graduates and researchers in preparing innovative, technology- or knowledge-based company foundations emanating from universities and research institutions (https://exist.de/).

2.2 Regional knowledge-based development by REE

REEs are broader socio-economic environments that encompass a diverse array of actors, entrepreneurs, established firms, investors, support organisations, policymakers, and educational institutions, interacting within a specific geographic region to foster entrepreneurship and innovation (Mason & Brown, 2014). Unlike UEEs, REEs operate at a regional systemic level, integrating multiple knowledge sources and economic sectors to stimulate economic dynamism.

One key contribution of REEs to knowledge-based regional development lies in their ability to facilitate localised knowledge spillovers through social networks and repeated interactions among actors. These spillovers rely on proximity and trust for effective transmission, which Bathelt et al. (2004) describe as "local buzz". Such interactions enable diverse entrepreneurs to access complementary resources, including finance, skilled labour, market intelligence, and mentorship, beyond what any single organisation can provide (Stam, 2015). Moreover, REEs help create favourable institutional frameworks, such as targeted innovation policies, that reduce barriers for startups and encourage risk-taking behaviours critical for sustaining innovative activity over time (Mason & Brown, 2014).

Compared with UEEs that tend to emphasise technology commercialisation from academic research outputs, REEs have a more pluralistic and combinatorial approach toward knowledge sources. They integrate not only scientific knowledge but also knowledge embedded within firms and communities. This inclusiveness allows REEs to support a wider variety of entrepreneurial ventures, including incumbent spin-outs or service-oriented business models that contribute to regional employment and diversification (Isenberg, 2010; Spigel & Harrison, 2018).

However, the effectiveness of REEs is subject to several challenges, too. Regional disparities often reflect uneven resource endowments or institutional weaknesses in REEs that constrain collaboration or limit access to external markets (Wei, 2022). Fragmentation among ecosystem actors can impede coordinated action necessary for scaling ventures or attracting investment. Furthermore, while UEEs have relatively clear organisational anchors facilitating coordination internally, REEs must rely on more diffuse governance mechanisms, which may lack formal leadership, strategic vision or continuous funding. This complexity makes policy interventions aimed at strengthening REEs inherently challenging.

To summarise, both UEE and REE play complementary roles in fostering knowledge-based regional development. The former by channelling academic discoveries into marketable innovations through structured support mechanisms; the latter by embedding entrepreneurship within wider economic networks that mobilise diverse forms of local knowledge. The knowledge in both ecosystems and the question of how far the respective support structures are permeable, overlap, or complement each other, remains a question to be answered empirically by asking for the knowledge provided at dedicated knowledge events.

2.3 Knowledge in entrepreneurial journeys

To operationalise and examine knowledge flows, we intersect Lundvall and Johnson's taxonomy on economically relevant know-what, -how, -who and -why (Lundvall & Johnson, 1994) with the narrative perspective of entrepreneurship (Garud & Giuliani, 2013) that understands a startup journey as an evolving, experimental process (Politis, 2005). This enables to grasp a startup as a dynamic

sequence of critical incidents in the ecosystems, such as interactions with investors, workshops, startup summer schools, or participation in incubators.

Lundvall and Johnson's taxonomy is the analytical starting point for operationalising knowledge in start-up journeys. Accordingly, know-what "refers to the knowledge about 'facts'" (Lundvall & Johnson, 2016, p. 112) and is close to what is commonly understood as information. Know-why is about the "principles and laws of motion in nature, in the human mind and in society" (Lundvall & Johnson, 2016, p. 112). Next to the technological dimension crucial for product development, we want to stress the societal dimension of know-why. It includes the motivational and purposive aspects of business formation, for example, knowledge to recognise a problem, knowledge about the market, and meaning-making. Such know-why dimensions can emerge from events where founders engage with the external environment – conducting market research, interacting with customers, or attending industry fairs (Shane & Venkataraman, 2000). Know-how relates to the practical capabilities and skills that entrepreneurs develop when they face managerial or organisational challenges, for example, related to financial or marketing aspects. Know-how is essential for transforming entrepreneurial ideas into viable operations and aligns closely with the concept of dynamic capabilities, which allow ventures to integrate, build, and reconfigure resources in changing environments (Teece et al., 1997). Know-who emphasises the relational dimension of entrepreneurial knowledge. Entrepreneurs operate within networks of mentors, investors, customers, and peers, and knowledge events frequently involve encounters with such stakeholders. Meeting an investor not only provides capital but also generates knowledge about stakeholder expectations and expands the entrepreneur's social capital. These relational resources are critical for mobilising support and co-creating opportunities.

To capture the dynamic sequence and the complexity of venture creation and growth, we further suggest grasping 1) Motivation & Problem Recognition, which reflects the internal drives, passion, and cognitive processes that lead individuals to identify meaningful problems and pursue entrepreneurial opportunities (Cardon et al., 2009; Shane & Venkataraman, 2000). 2) Market Insights involve acquiring external knowledge about customer needs, competitors, industry gaps, regulations, and market access (Blank, 2020; Eisenhardt & Martin, 2000). 3) Technological & Managerial Knowledge refers to the practical skills necessary for product development, innovation, legal compliance, and marketing - capabilities that enable entrepreneurs to operationalise ideas effectively within institutional contexts while navigating technological change (Cohen & Levinthal, 1990; Teece et al., 1997). 4) Funding, Investment Opportunities & Pitching Knowledge captures how entrepreneurs secure financial resources by mastering pitching techniques, financial management, and cultivating relationships with investors - demonstrating the interplay between social networks and financial acumen critical for scaling ventures (Hoang & Antoncic, 2003). Lastly, 5) Unexpected Challenges & Learning from Obstacles acknowledges entrepreneurship's inherent uncertainty, where unforeseen events demand adaptive responses. Experiencing failure or obstacles fosters resilience and iterative learning that reshape strategies and enhance long-term viability (Cope, 2011).

From this theoretical standpoint, the entrepreneurial path in both UEE and REE is a sequence of situated knowledge events providing know-how, -who, -what and -why, understood as knowledge about the motivation or recognition of an entrepreneurial problem, market insights, technologies, management, and funding and investment opportunities (Table 2).

3 Methodology

In this chapter, we shortly introduce our case study region and then explain the operationalisation of startup journeys and their knowledge events, followed by disclosing the coding process.

3.1 Case study region

The Ruhr region in Germany is the case study area for examining REE and UEE. Historically defined by coal and steel, the Ruhr region transitioned into a metropolitan area comprising 53 municipalities, each with its own economic development agency, counting 5,3 Mio. inhabitants. While structural change has been ongoing for decades, the region now positions itself as a broad innovation landscape supported by 22 universities and Universities of Applied Sciences with 290.000 students (Kriegesmann et al., 2019; Metropole Ruhr, 2023), STARTERCENTER NRW offices[3], public-private partnerships, and locally anchored initiatives that provide basic guidance to prospective founders. This setting reflects a long-term shift toward knowledge-intensive sectors and a growing culture of inter-municipal collaboration.

The Ruhr region's REE has expanded steadily since the early 2000s and has generated more than 641 start- and scale-ups (Gründerallianz Ruhr, 2024). A key milestone was the creation of ruhrHUB[4] in 2016, which strengthened coordination across municipalities and improved access to shared support infrastructures. Current REE strengths include its diverse set of actors and complementary instruments, from business idea competitions at the municipal level to region-wide events such as ruhrSUMMIT and ruhrSTARTUPWEEK for multiple thousands of people each year. Core sectors include green technology, health tech, cybersecurity, urban transformation, IT services, and intelligent logistics. At the same time, ecosystem intermediaries note persistent weaknesses, particularly limited funding for later-stage ventures, overlapping structures between municipalities, and strong competition from neighbouring regions such as Cologne and Düsseldorf (Butzin & Flögel, 2023; Butzin et al., 2024; Flögel et al., 2024). Heavy reliance on project-based financing further threatens long-term ecosystem stability. In our case study, six startups come from the regional entrepreneurial ecosystem.

Universities in the Ruhr region operate their own entrepreneurship support infrastructures alongside their institutional knowledge-transfer missions. Central and faculty-level units offer consulting, seminars, coaching, co-working spaces, makerspaces, and incubators, often funded through time-limited federal and state programs. Major examples include the WORLDFACTORY Startup Centre at Ruhr University Bochum, the Centre for Entrepreneurship and Transfer at Technical University Dortmund, and the ruhrvalley Startup-Campus of three Universities of Applied Sciences (from 2017 until 2025). University activities primarily target students and researchers but, in principle, remain open to external teams and often focus more strongly on technology-intensive ventures. Some initiatives, such as the specialised CUBE5 incubator for IT security startups, demonstrate deep disciplinary anchoring and national reach (Flögel et al., 2024). Our empirical data includes startup journeys from two UEEs

[3] A network of certified business startup support centres in the German state of North Rhine-Westphalia that provide free, independent information, guidance and advice to founders and prospective entrepreneurs on starting and developing a business, including help with business plans, formalities and access to funding and support services.

[4] A digital hub and network in the Ruhr region that supports startups and innovation by connecting founders with companies, investors and regional support structures to strengthen digital economic development.

in the region, the one of Ruhr University Bochum (2 startups) and of the Westphalian University of Applied Sciences (3 startups).

3.2 Startup Journeys & Knowledge events

11 startup journeys were reconstructed in 2024 following the principles of the innovation biography method (Butzin & Widmaier, 2015) as part of the "Anonym"-project funded under the EU Horizon Europe. Innovation biographies allow in-depth reconstruction of innovation processes from the first idea until the implementation. In the case of startups, the process began with the early expression of the business idea until the first three to five years of running a business. The data collection process combined in-depth narrative interviews with founders (60 to 180 minutes), document analysis, and media analysis to capture the multilayered evolution of each venture. Through systematic triangulation of interview transcripts and supplementary materials, a rich and coherent account of entrepreneurial development throughout the startup journey was produced.

The 11 journeys capture a diverse spectrum of economic sectors and business models. We have re-constructed six journeys of startups from the Ruhr REE, including two business-to-consumer (B2C) models and four business-to-business (B2B). The other five journeys of university startups are one student startup with a B2C and four UEE spin-offs with B2B business models. Table 1 gives an overview of the empirical data, including the starting year and the number of coded knowledge events per journey. It is important to note that despite the variety of startup journeys, the empirical insights are limited by the small number of startup journeys analysed, which constrains the generalizability of the findings.

We utilise knowledge events and types of knowledge that entrepreneurs draw upon to approximate the permeability, boundaries and complementarities of UEE and REE and how this influences startup development. Drawing upon the narrative perspective of entrepreneurship (Garud & Giuliani, 2013), we examine 1) the organisational background of a knowledge event (UEE or REE organised) and whether it was mentioned by a UEE or REE startup to assess the permeability and boundaries of the two entrepreneurial ecosystems. 2) The types of knowledge gained at REE/UEE-affiliated events and 3) the types of knowledge gained by REE/UEE-related startups to assess the complementarities and functions for knowledge-based regional development.

Table 1. Overview of startups

Startup	Sector	Business Model	Year of foundation	UEE/ REE	Number of coded knowledge events in the startup journey
1	Social innovation	B2C	Idea 2011; foundation 2014	REE	23
2	Cybersecurity	B2B	2016	UEE	17
3	IT & Webdesign	B2B	2018	REE	11
4	Cybersecurity / IoT	B2B	Idea 2013; foundation 2016	UEE	12

5	Consulting	B2B	2016 as a hobby; restart 2020	REE	17
6	Ecological innovation in fashion	B2C	Idea 2017; foundation 2019	REE	19
7	Cybersecurity	B2B	Idea 2018; foundation 2019	UEE	18
8	Cybersecurity (started as a student startup)	B2B	Idea 2018; foundation 2019	UEE	18
9	Ecological innovation for household goods (student startup)	B2C	2023	UEE	17
10	IT & Consulting	B2B	2015 idea; foundation 2016; shut down 2025	REE	9
11	Design in health	B2B	2023	REE	15

3.3 Coding process

In a first step, the 11 startup journeys were investigated for the sequence of knowledge events, which is the main empirical data in this study. As shown in Table 1, the startups contained 9 to 23 knowledge events. This resulted in the identification of 176 events in total. They range from application processes for idea competitions, consultations with mentors, attendance at startup schools, lifehacking shows, membership in the local incubator, meetings with business angels, etc. The knowledge events could be very short (e.g. a meeting with a business investor at a conference) or last for several months (e.g. being in a local incubator).

These events were then categorised according to their occurrence in a UEE or REE, resulting in 32 UEE events and 75 REE events considered for further analysis5. In a second step, the knowledge gained within the events was identified according to the five dimensions of the startup journey discussed in section 2: (1) Motivation & Problem Recognition; (2) Market Insights; (3) Technological & Managerial Knowledge; (4) Funding, Investment Opportunities & Pitching Knowledge; (5) Unexpected Challenges & Learning from Obstacles. Each dimension was coded to capture the knowledge gained, also in correspondence to the Lundvall and Johnson (1994) taxonomy. Table 2 visualises the operationalisation of the theoretical framework on knowledge generation within the applied coding system, including examples of coded segments.

[5] The remaining 69 events are divided between: 48 non-regional, 5 online and 16 events where the location could not be specified.

Table 2. Operationalisation of the theoretical framework on knowledge generation within the coding system

Dimension (depicts the entrepreneurial journey)	Codes (derived as sub-categories of the dimensions)	Type of knowledge: what, how, who and why	Exemplifying events from the data
Motivation & Problem (MP)	**MP1 – General Motivation & Purpose:** Learning about personal drive and passion for entrepreneurship	**Know why**	"'Another support network that had definitely had a very strong influence on my startup is the **Happy Startup School from England...'** This journey gave Thomas personal motivation to start with a startup all over again focusing sustainable impact." (Startup 5)
	MP2 - Problem Recognition: Identifying a problem point	**Know why**	"Michelle used the **maternity leave** to deepen her interest in sustainability. … This endeavour led her to the idea of starting ChangeFashion." (Startup 6)
Market insights (MI) gained through research or industry exposure provide knowledge on competition, customer behaviour, and emerging trends, helping founders refine their business models.	**MI1 – Industry Gaps**: Recognizing inefficiencies or unmet needs	**Know why**	"The development of the penetration testing is Matteo's speciality, and he and his team received research funding for this. … Matteo and Chris **applied** with their first results from a research project … and **proposed to develop software** that quickly calculates a first penetration risk score based on publicly available data." (Startup 7)
	MI2 – Customer Behaviour: Understanding user needs and preference	**Know why**	"'… we could still gain experience and earn money quickly through **consulting** in the cybersecurity sector, which we were happy to do.'" (Startup 4)
	MI3 – Competitive Landscape: Learning about competitors	**Know who**	"At a **major lifehacking show,** they were once told off the record that their prices were much lower compared to their competitors. However, making low-price offers was not intended, but the result of lack of knowledge on price structures in the corporate world." (Startup 7)
	MI4 – Regulatory & Policy Changes: Understanding compliance and industry-specific regulations	**Know what**	"Backed by this substantial [public] funding, the startup allocated most **attention away from the mobility market and private sector clients to the E-Government market."** (Startup 2)
	MI5 – Access to customers	**Know who**	"That was actually the very first **conversation at this congress**, and we got a major project for a pharmaceutical company." (Startup 11)
Technological & managerial knowledge (TM) provide learning opportunities on adapting to industry changes, leveraging innovation, and	**TM1– Technological knowledge**	**Know why**	"The founder started his **PhD** at the cybersecurity institute in 2013. The technology combines cryptographic and telecommunication aspects to extend security verification from data to physical objects..." (Startup 4)
	TM2 – Managerial (legal form) knowledge (nicht financial)	**Know how**	"Christine applied for another entrepreneurship scholarship at the Impact Factory, a **local incubator**. … Even though some years had passed since

ensuring compliance—knowledge that can determine a company's sustainability.			Exchange Education for Habitation started, Christine joined the first phase to reflect on her business model." (Startup 1)
	TM 3 – Marketing	**Know how**	"During the pandemic, an influential individual in the Ruhr's entrepreneurial ecosystem developed an **online entrepreneurship training** course and SustainConsult and other startups provided the content for it. 'That was also marketing and networking for us.'" (Startup 5)
Funding, investment opportunities & Pitching (FI) bring financial support and knowledge about financial management, valuation, and investor expectations. Founders learn how to pitch their ideas, navigate negotiations, and structure their businesses for long-term success.	**FI1 – Financial Management:** Learning about budgeting, financial planning, and scaling	**Know how**	"At one point, the Social Entrepreneurship Academy and the Vodafone Foundation assigned a fundraiser to Christine's cause. Although **engaging an external fundraiser** didn't yield the anticipated results, it left Christine with a valuable lesson – fundraising is undeniably a matter for the CEO. Retrospectively, Christine recognises a vital need for a dedicated financial manager." (Startup 1)
	FI2 – Pitching: Gaining knowledge on securing funding and structuring deals	**Know how**	"The experience was both amusing and challenging, as it marked her first-ever pitch, which turned out surprisingly well." (Startup 6)
	FI3 – Investors & funders: know-who, knowing investors, funding institutions	**Know who**	"The two founders promoted their technology at an **institute celebration conference**, with an oral presentation and networking at the evening party. … They first met a business angel at the party who later invested in their venture." (Startup 2)
Unexpected Challenges & learning from obstacles	**CL1 – Unexpected Challenges**		"Then came the Covid19 pandemic in March 2020, which completely changed the business model. The whole marketing strategy was anchored around lifehacking events. ... Two or three new orders were actually always generated from this. '**With the pandemic, all events were cancelled**, challenging our business model.'". (Startup 7)
	CL2 - Learning from obstacles/failures that reshape the startup strategy		"Michelle criticizes the barriers for startups presented by the German legal system. Particularly in the test phase, they found it very complicated to just pilot an idea in a low-key manner. There is no space for that in the legal system, there must be a legal form behind every endeavour, so they **felt forced to find the company** before they had proof of concept." (Startup 6)

To ensure quality and validity of the coding process all journeys were coded in MaxQDA by two of the authors and emergent differences of opinion were discussed in the authors team. Conclusively, each event received 3 types of codes: it was coded (1) according to the sequence of events by receiving a number; (2) as originating in the UEE or REE; and (3) according to the knowledge gained (Table 2).

Some events provided access to more than one knowledge type and were coded multiple times within this category.

The detailed engagement with the events and respective knowledge allowed for a combination of quantitative and qualitative data analysis. We compare the events using pearson-Chi^2 to identify significant differences between UEE and REE startups or events respectively. Following this, we analyse the identified variations qualitatively event by event.

4 Findings

4.1 REE/UEE startups at REE/UEE affiliated knowledge events

The participation in REE or UEE-related events differs between the startups' offspring from the UEE or REE (Table 3). The Chi2 sig. level indicates that REE startups more frequently visit REE events, and UEE startups more frequently UEE events. No significant differences were observed for non-regional and online events.

Table 3. REE/UEE startup gaining knowledge from REE/UEE affiliated knowledge events

	Total number of events	REE events	UEE events	Non-regional events	Online events
REE startups (6 journeys)	88	57	4	23	4
UEE Startups (5 journeys)	72	18	28	25	1
Chi^2 sig. level		< 0,001	< 0,001	0,238	0,254

own calculation

However, UEE startups also visit REE events, as 18 such events have been identified and all five UEE startups reported to have gained knowledge from REE events. These events include contacts with potential clients, financing from local banks, business angels, and strategic investors, incubators and accelerators, business plan competitions, and advice from business promotion agencies or regional corporations. For example, the cybersecurity startups 2 and 4 find crucial financial support in terms of business angels, a local bank that supported one of the company's restructurings and a strategic investor in the REE. Startup 7 reports on an event with the local business promotion agency that helped them with access to office space and directed them to an incubator. Startup 8 was motivated to start its business at a hackathon competition of a local startup incubator.

Nevertheless, UEE events are much more frequent for UEE startups, with 28 identified events. These events are related to the academic work the founders were involved in, like research projects and PhD programmes, but also incentives and support from professors. A founder summarises: "The professor gave us the final incentive, […] and said, […], you need a business plan somehow, these are

documents that you can take, and I have a handful of contacts that you should talk to" (startup 2). Another founder remembers the advice from a professor, "as a graduate, you don't necessarily have to go to Bosch or another corporate, you can also set up your own venture," and the professor later invested in the company as a business angel (startup 4). The UEE startups were able to benefit from events designed for UEE startups, like funding programmes, finding first customers in research projects or attending workshops for student founders, like "'fit for foundation' held by the university's faculty of engineering and economics" (startup 4). Occasionally, the founders participated in events hosted by neighbouring UEEs (startup 7) or applied for a patent through the university (like startup 8).

REE startups hardly ever reported gaining knowledge at UEE-affiliated events (only at 4 out of 88 identified events). Among the four events, three refer to employing graduates or students from the nearby universities: The founder of startup 10 mentions, "We've had plenty of university graduates come here; for most of them, this was actually their first job. And there were some good people among them" (startup 10). Another founder considers the knowledge flow from university graduates as "somehow very practical" (startup 5). Only one REE startup (number 11) participated in the health tech incubator of the Ruhr University Bochum: "The conversations with the mentors, where we received a great deal of feedback, supported us a lot" (startup 11).

Therefore, the analysis reveals an asymmetric permeability of knowledge flows between REE and UEE. REE startups hardly ever participate in UEE-related knowledge events, and when they do, their interactions with the university are largely confined to recruiting competence through new employees. This suggests that apart from staff recruitment, the UEEs are confined and hardly accessible for actors originating outside the university context.

Both UEE and REE startups use non-regional events for learning. Of the 48 identified non-regional events, many refer to winning awards or participating in startup competitions, attending sector-specific events or simply finding customers. Some of them, though, are dedicated educational events. One founder, for example, shares: "During that time, I was in Amsterdam and learned about lean machine and lean startup methods" (startup 5). In other cases, further education referred to regulatory frameworks or general trends, which directly affected the business, as another founder explains: "There will soon be a new amendment to the law, which will mean that even more companies will have to deal with the topic of cybersecurity. As a result, the scope of possible clients will continue to grow" (startup 7). The high number of non-regional knowledge-events indicates that neither the UEE nor the REE provides all the resources required for entrepreneurial development, prompting startups to seek complementary knowledge and contacts beyond their home entrepreneurial ecosystems.

4.2 Types of knowledge gained at REE/UEE-affiliated events

In a second step, we examine whether there are differences in the types of knowledge our sample startups gained from UEE- and REE-affiliated events to assess the complementarity of both EEs. Table 4 reports this comparison, including the Chi^2 test results. In absolute terms, "know-how" and "technological and managerial knowledge" are the most common types of knowledge. The qualitative comparison shows that the gained knowledge is similar in REE and UEE-affiliated events. In both cases, it includes finding the right team, acting as an employer, understanding how to run a business by securing funding, deciding on the company's legal form, pitching, looking for guidance from professors,

mentors, regional development agencies, or attending workshops, incubator programmes or startup competitions, etc. A founder sums up the struggle all our interview partners shared: "[Administration is] simply not my area of expertise, because I am an expert in my topic, not an administration expert" (startup 10). One of the founders of startup 5 also exemplifies the search for the right team: "I met there [a regional event for startups] a person with skills in IT development, and in exchange I helped him out with his business management issues" (startup 5). This kind of entrepreneurial knowledge is of relevance for all startups in the sample and is transferred at comparable events in both ecosystem types.

Table 4. Types of knowledge gained at REE/UEE-affiliated events

	Total number of events	Know who	Know how	Know why	Know what	Motiva-tion Problem *MP*	Market insights *MI*	Techno. Manag. Know-ledge *TM*	Funding *FI*	Challen-ges *CL*
REE events	75	21	38	21	0	16	16	31	19	8
UEE events	32	11	16	12	1	6	12	13	9	2
Chi^2 sig. level	-	0,510	0,950	0,330	0,124	0,762	0,082	0,946	0,764	0,472

own calculation

The Chi^2 test identifies differences at the 10 % level, in that there are more UEE events dedicated to knowledge on "market insights" than REE events. Such knowledge is predominantly gained through learning about the customers by actively engaging with them or by identifying industry gaps through the support of experienced mentors and within research projects. The customers are often related to the research projects the founders were working on in their university context: "We already had our first customers, with whom we mainly had […] consulting and familiarisation projects" (startup 4.

Both ecosystems are equipped to deliver knowledge essential for early-stage venture development. However, the results also reveal meaningful UEE/REE differences for knowledge necessary to further the entrepreneurial journey. The more frequently gained knowledge about "market insights" in UEE events, although with little statistical significance, is noteworthy because it relates to universities' functions as technology-pushed ecosystems. As a result, UEE startups often have a greater need for market-related knowledge (as compared to their REE counterparts), which may drive their active search for such insights within university settings and beyond. UEE events providing market exposure through pitching or mentoring by industry partners suggest that universities attempt to strengthen their market integration in response to these needs. This does not necessarily mean that UEEs are inherently strong at providing market knowledge; rather, the higher demand from UEE startups and the growing institutional effort to integrate market elements into university structures may explain this pattern.

4.3 Types of knowledge gained by REE/UEE-related startups

In a final step, we analyse whether REE or UEE startups differ in the knowledge they acquire at the events (Table 5) to understand if the difference in the use of UEE/REE events may result from different knowledge needs. The Chi^2 analysis identifies "know why" (5 % level), "market insights" (5 % level) and "Technological & managerial knowledge" (10% level) as significantly different. The UEE startups reported events on "know why" and "market insights" more often than REE startups. REE startups, in turn, more often revived "technological & managerial knowledge" during knowledge events. Since "know why" (tough without high significance) and "market insights" also differ in the previous REE/UEE event affiliation comparison, it seems likely to assume that this difference stems from the higher frequency of UEE startups gaining such knowledge.

Table 5. Types of knowledge gained by REE/UEE-related startups' journeys

	Total number of events	Know who	Know how	Know why	Know what	Motiva-tion Problem *MP*	Market insights *MI*	Techno. Manag. Know-ledge *TM*	Funding *FI*	Challen-ges *CL*
REE startups	93	27	46	22	0	16	21	28	19	14
UEE startups	83	26	32	30	2	13	33	23	25	7
Chi^2 sig. level	-	0,741	0,146	0,070	0,132	0,783	0,014	0,067	0,138	0,176

own calculation

The observation that "Technological & managerial knowledge" is relatively more often gained by REE startups is particularly driven by the sub-category of "marketing knowledge" (REE startups ten times, UEE startups three times), and to a lesser extent, managerial knowledge, whereas actual technological knowledge is proportionally distributed between REE and UEE startups. Even though the essence of the gained knowledge at UEE- and REE-events dedicated to managerial knowledge was identified above as comparable, the REE startups report more such events on average than the UEE startups. The four UEE-events acknowledged by REE startups from Table 3 above fall in that category, but also their participation in multiple startup programmes, competitions and classes, searching for team members with managerial skills or finding the right management for the company. As one of the founders of startup 10 shares: "And then we started asking, how can we actually structure our company differently? We engaged with sociocracy. How can we build such company structures? And we visited workshops on that" (startup 10).

The results indicate that UEE startups have a greater need for market-related knowledge than their REE counterparts. We interpret the stronger focus on the provision of market knowledge in UEE knowledge-events as a measure to balance out the tech-driven nature of UEE. In comparison, REE startups have a greater need for marketing knowledge than UEE startups. We see this finding as an indication of greater market proximity of REE startups compared to UEE startups, because market knowledge is a precondition for marketing activities.

5 Discussion

We return to our research question to examine the extent of which UEE and REE are complementary, permeable, or confined, and of the UEE / REE contribution to knowledge-based regional development.

The entrepreneurial ecosystems play distinct roles in fostering knowledge-based regional development. Drawing on both the conceptual discussion and empirical findings, complementarities and synergies can be identified in terms of the approach to knowledge commercialisation, the types of knowledge delivered at UEE and REE events, the sources of knowledge for entrepreneurial ideas and market creation, and the utilisation of non-regional knowledge sources.

In their approach to knowledge commercialisation, UEE transfer scientific discoveries into viable business cases (Breznitz & Zhang, 2019, 2021; Jones & Ratten, 2021; Prokop, 2021) and integrate scientific knowledge with market knowledge, including information on customer needs and industry gaps. Empirically, this is reflected in UEE startups reporting events focused on "know why" and "market insights" more frequently than REE startups (see Table 5). REE startups, by contrast, commercialise knowledge primarily through co-creation within the REE. This aligns with the literature highlighting the diverse range of actors in (regional) entrepreneurial ecosystems (Mason & Brown, 2014) and is empirically supported by the greater market proximity of REE startups, which we interpret in the higher reliance on marketing knowledge compared to UEE startups (see Table 5).

With respect to entrepreneurial knowledge in a startup journey and the knowledge taxonomy (Lundvall & Johnson, 1994), the types of knowledge delivered at UEE and REE events are similar in both ecosystem types. However, the sources of knowledge for entrepreneurial ideas and market creation differ fundamentally. UEE startups are driven by technological opportunities and must create markets (Prokop, 2021), whereas market conditions themselves generate entrepreneurial opportunities for REE startups, for example, through spin-offs (Table 6).

The utilisation of non-regional knowledge sources of UEE startups is particularly relevant, as it can anchor new knowledge within the region and potentially lead to the development of new industrial paths (Butzin & Flögel, 2023; Mason et al., 2025). UEE startups participate in non-regional events more frequently during their journey (Table 3), further enhancing the potential for new path development.

With respect to the permeability and boundaries (Table 6), there is an asymmetric permeability between the two ecosystems. UEE startups benefit substantially from REE knowledge events, but REE startups make little use of UEE events. This highlights the supportive 'nurturing' role that the REE plays for the UEE in the Ruhr region. Of the 18 REE events attended by UEE startups, ten involved the transfer of "know-how", that is, the practical skills and capabilities entrepreneurs require when facing managerial or organisational challenges. Of these ten events, UEE startups participated in seven to acquire management-related knowledge, in two to gain financial knowledge, and in one to focus on learning how to pitch a business idea. Moreover, the REE's proximity to actual markets manifested in the presence of lead customers or incumbent-firm spin-outs addressing concrete market problems, provided UEE startups with valuable "know-why" at seven REE knowledge events: Specifically, UEE startups gained insights into industry gaps and customer behaviour at four events, and into entrepreneurial motivation, purpose, and problem recognition at three events. Additionally, UEE startups accessed investors and funders ("know-who") at three REE events. In contrast, only four occasions have been identified at which regional start-ups engaged in knowledge events related to regional

universities, of which three related to recruiting students, and only one was a university-led incubation program. Barriers such as limited awareness, weak social networks, or a perceived lack of relevance of university support structures might restrict the flow of resources from the university into the broader region. This pattern indicates that the REE is comparatively more open for and of high relevance for startups emerging from the university.

The main implication of our research is that the REE nurtures university spin-offs by supplying entrepreneurial know-how and ensuring market proximity. In so doing, the REE compensates for gaps in the technology-transfer structures of the analysed UEEs. With reference to knowledge-based regional development, the openness of the REE seems crucial for knowledge provision to university startups and for making the regional knowledge base accessible. On the other hand, university ecosystems supply knowledge to start-ups originating in the region only rarely, suggesting that UEEs tend not to balance incomplete regional entrepreneurial ecosystems.

Table 6 highlights UEEs and REEs in fostering knowledge-based regional development, emphasising their distinct yet interconnected contributions. UEEs primarily focus on knowledge transfer and integration by transforming scientific discoveries into viable business opportunities, driven by technological opportunities that create new markets. This process is nurtured by the REE, which plays a crucial supportive role by providing entrepreneurial know-how and maintaining close market proximity. REEs, in contrast, emphasise knowledge co-creation through a diverse range of actors and rely more heavily on marketing knowledge as markets themselves generate entrepreneurial and technological opportunities.

A key implication from this dynamic is that UEEs serve as vital sources for anchoring new knowledge within the region, potentially leading to the emergence of new industrial paths via their engagement with non-regional knowledge sources. Meanwhile, REEs contribute to regional development by strengthening and diversifying existing industrial paths through their embeddedness in local markets. The asymmetric permeability between these ecosystems underlines the nurturing function of REEs towards UEEs. This permeability ensures that university startups gain practical managerial skills ("know-how"), market insights ("know-why"), and access to investors ("know-who"), thereby compensating for gaps in technology-transfer mechanisms within UEEs.

Another implication is that the openness of REEs to UEE participation is critical for effective knowledge provision and utilisation within the region. It facilitates access to broader entrepreneurial resources while reinforcing market relevance, ensuring that both ecosystems collectively drive sustainable regional innovation and economic growth.

Table 6. Knowledge-based regional development by UEEs and REEs

Knowledge-based regional development	*Complementarities & Synergies*				*Permeability & Boundaries*	
	Knowledge commercialisation approach	*Knowledge types at EE events*	*Knowledge sources for entrepreneurial ideas*	*Utilisation of non-regional knowledge sources*	*Inter-linkages*	*Access to EE knowledge*
UEE	Knowledge transfer and integration	Similar to REE events (market insights slightly more important)	Technological opportunities create markets, nurtured by the REE	Can be crucial for anchoring new knowledge in the region (leading to new industrial paths)	UEE resources are used by REE startups to a much lesser extent	Restricted to UEE startups
REE	Knowledge co-creation by actor variety	Similar to UEE events (marketing slightly more important)	Markets create entrepreneurial (and technological) opportunities	Enhance existing knowledge in the region by strengthening and diversifying existing industrial paths	REE nurtures UEE startups (which benefit from REE know-how and market proximity)	Open to UEE startups

6 Conclusion

Even though this research is restricted to a specific geographic region and a limited number of enterprises, the rich qualitative data of the startup journeys allows us to draw the following conclusions for knowledge-based regional development:

REE functions as a "safety net" for UEE start-ups. The university entrepreneurial ecosystems (UEEs) in the Ruhr region have strong links to the surrounding regional entrepreneurial ecosystem (REE), resulting in one of the study's most salient findings. The REE compensates for weaknesses in UEEs, particularly regarding market access and managerial expertise. While the studied UEEs focus on research-based opportunity generation and technology transfer, they struggle to accompany startups throughout the entire startup journey. All the analysed UEE startups developed further based on REE resources.

An asymmetric permeability privileges UEE startups. The analysis clearly reveals that the permeability between the ecosystems is asymmetric. UEE startups draw on REE resources, while REE startups rarely access UEE infrastructures. This pattern privileges academic entrepreneurs since they can choose from a greater diversity of events, a privilege that all the UEE startups have used. The

challenge lies in preventing UEEs from evolving into exclusive spaces serving only a narrow subset of founders. The implications for regional development are that UEEs must be more open to non-university founders if they are to compensate for the ill functionalities of regional ecosystems. This entails functioning as open innovation hubs that embed regional startups, firms, policymakers, investors, and civil society actors within university-led entrepreneurial ecosystems to ensure all can benefit from the (publicly funded) scientific knowledge. As our empirics show, REE startups can profit from UEE resources if the access is provided (in our case, being part of a university incubator).

Open hybrid event formats can bundle ecosystem resources. Our research conceptualised knowledge events as a critical connective mechanism between different entrepreneurial ecosystems. Much of the entrepreneurial learning occurs via workshops, hackathons, mentoring sessions, and investor meetings. This finding suggests the value of open hybrid event formats that deliberately combine UEE and REE resources.

For future research, promising avenues are comparative regional case studies on UEE-REE interrelations and longitudinal analyses that trace the evolution of UEE–REE relationships. Furthermore, comparative analyses of the performance of ventures embedded in both systems versus those with a strong embeddedness in one of the entrepreneurial ecosystems seem promising to advance understanding of UEE-REE relationships and their complementary contributions to knowledge-based regional development.

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