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RESEARCH

Does the hub and spoke model matter for university-industry engagement in innovation ecosystems?

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Abstract
While the literature has extensively investigated applications of the hub and spoke (H&S) model, its characteristics, dynamics, effectiveness and costs remain little explored in the field of university-industry partnerships for knowledge transfer in innovation ecosystems (IEs). This study contributes to the literature on the organisation of relationships in innovation ecosystems by investigating whether and how the H&S model matters in governing partnerships for knowledge transfer. To do so, a multiple case study was conducted to examine the 11 national IEs funded by the Italian government under the framework of the National Recovery and Resilience Plan in the period 2022–2026. The ecosystems operate across 20 regions, with 11 hubs and 84 spokes involving more than 40 universities and over 200 research organisations and firms. The findings, based on secondary data, two questionnaires and in-depth interviews of individuals involved in H&S governance, reveal that a top-down approach was adopted since the government required for the first time, on a mandatory basis, the creation of ecosystems using the H&S model. The IEs have improved collaboration between universities and firms. Challenges and good practices are discussed. The article identifies three forms of application of the H&S model, depending on the geographical span of the relations between actors: urban, regional and cross-regional ecosystems. Based on the level of coordination among ecosystem actors, three types of solutions to organise knowledge transfer are conceptualised: centralised, decentralised and hybrid models. Implications are suggested to ameliorate university governance and to inform the design of policies for university-industry engagement.

Keywords Ecosystems of innovation · Hub and spoke · Industrial policy · Knowledge transfer · Next generation EU plan · University-industry cooperation

1 Introduction

University-industry cooperation for knowledge exchange continues to receive attention (de Wit-de Vries et al., 2019) from both academics and policymakers (Rossi et al., 2017). Partnerships between universities and firms within innovation ecosystem (IE) contribute

Extended author information available on the last page of the article

to bring research outputs to the market, and support economic growth (Bercovitz & Feldmann, 2006), while paving the way to new research avenues and innovation-driven initiatives (D'Este & Perkmann, 2011). Such partnerships have become crucial for exchanging and acquiring resources, advancing cross-disciplinary and cross-sectoral cooperation, and promoting resilience to shocks in the socio-economic context. However, collaborative partnerships are difficult when universities do not ensure that applied research is correctly conducted for addressing real needs of IE actors (Spigarelli et al., 2024).

To leverage synergies and engage strategic stakeholders within IEs, new organisational models have emerged. For example, the hub and spoke (H&S) model (Mayer, 2013) which is based on a coordination mechanism among a plurality of decentralised nodes of innovation in a community. The literature has extensively investigated the application of the H&S model and its advantages and challenges in specific contexts, such as transportation and logistics (e.g. Bryan & O'Kelly, 1999; Zäpfel & Wasner, 2002) and the healthcare industry (e.g. Elrod & Fortenberry, 2017; Switzer et al., 2013). Although understanding the structure and dynamics of how knowledge is transferred within and between IEs is crucial to fostering innovation (De Moortel & Crispeels, 2024), the H&S model still remains little explored in this field. This model has been presented as suitable for governing complex relationships (Mayer, 2013) because it is able to stimulate catch-up processes between stronger and weaker actors in ecosystems. It can make interactions more effective, efficient and controlled by promoting the distinctive features of the ecosystem and its participants. Nevertheless, the concentration of resources in a certain hub might exacerbate inequalities between and within spokes and their actors located in underdeveloped areas and those in more advanced areas. Furthermore, individual or competitive relationships among actors may hamper the development of common solutions, leading to inefficiency of the whole ecosystem (Shakiba & Belitski, 2024).

Scholars also argue that an IE represents a complex territory-specific phenomenon. This means that IE actors and elements might be not equally relevant, varying across and within the same region. Thus, future research should collect further evidence on this territory-specific matter (Cavallo et al., 2023) and the generalization of results should be cautious. Moreover, partnerships for knowledge transfer within ecosystems remain little explored, especially in geographical areas where the government plays an important role in funding IEs. Indeed, the literature has often taken for granted the cooperation between diverse actors within ecosystems (Shakiba & Belitski, 2024). Furthermore, the literature still questions about the nature of commitment that links IE actors with each other (Audretsch et al., 2025), and how to locate, strengthen and use collaborations more effectively within ecosystems (Spinazzola et al., 2025).

This study contributes to the literature on the organisation of relationships between actors in IEs (e.g. Breslin et al., 2021; Brito, 2018; Iacobucci & Perugini, 2021; Meng et al., 2019) by understanding whether and how the H&S model (Bridoux & Stoelhorst, 2022; Faccin et al., 2020; Lechner et al., 2023; Mayer, 2013; Visscher et al., 2021) matters for governing partnerships for knowledge transfer. Specifically, the following research questions are addressed:

- which forms of the H&S model can be applied to govern university-industry partnerships in innovation ecosystems?
- how does the H&S model contribute to the internal and external relations of the eco-

system actors, differing from the current framework for governing university-industry partnerships?
- how does the H&S model connect actors across disciplines, industrial sectors and geographical areas?

The study considers the 11 national IEs selected, and funded, by the Italian government under the framework of the *Piano Nazionale di Ripresa e Resilienza* (PNRR)—the National Recovery and Resilience Plan (NRRP)—in the period 2022–2026, for a total investment of about 1.5 billion euros. Using a top-down approach, the government sought the formal creation of IEs adopting the H&S model to govern university-industry partnerships. Along with being an experiment on a national scale (the ecosystems operate across all 20 Italian regions), the ecosystems involve numerous, heterogeneous partners: there are 11 hubs and 84 spokes which involve more than 40 universities and over 200 research organisations and firms.

The paper reveals both the challenges, and the good practices adopted in the model. We examine the different forms of the H&S model enacted and suggest implications for ameliorating the governance of ecosystems and for informing the design of policies for university-industry engagement.

The article is organised as follows. Section 2 presents the theoretical background. Section 3 describes the context of the study. Section 4 illustrates the research design, data and methods. Results and discussion follow in Sect. 5. Conclusion, policy implications and avenues for future research end the article.

2 Background

2.1 Innovation ecosystems: from research to innovation

The concept of innovation ecosystems (IEs) has become popular during the last decade, the literature on the question is rapidly growing, investigating the role played by universities, institutions, firms and other actors in promoting innovation (Granstrand & Holgersson, 2020). However, defining an ecosystem is a complicated task since IEs can vary by internal organization, specialisation and network intensity (Hayter et al., 2018). Given the complexity of the concept and its use in diverse contexts, definitions have proliferated. One commonly accepted definition is offered by Autio and Thomas (2014, p. 205): an IE is "a network of interconnected organisations, connected to a focal firm or a platform, that incorporates both production and use side participants, and creates and appropriates new value through innovation". More recently, Granstrand & Holgersson (2020) have defined an IE as "the evolving set of actors, activities, and artefacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors" (Granstrand & Holgersson, 2020, p. 3).

The goal of these manifold relationships between heterogeneous actors, often from diverse sectors, is to enable technology development and innovation, by combining resources, such as funds, equipment and facilities, knowledge, and most importantly and human capital: academic staff and students, employees in private companies and public institutions, professionals and industry representatives (De Moortel & Crispeels, 2024). This means that par-

ticipant heterogeneity and interdependence is a prime characteristic of IEs. The definition proposed by Autio and Thomas (2014) also points to the role played by "focal firms" and the development of relations between actors—i.e. the platform—suggesting that an IE is an organised and planned system of relations.

One strand of the literature, especially relevant for the purpose of this article, has explored the role of universities in IEs and how knowledge transfer activities impact innovation. In particular, the mechanisms that foster innovation rely on the IE framework, which transforms organisation-based innovations into ecosystem-based, collaborative innovations (Yin et al., 2020). Carayannis et al. (2018) also argue that participation and cooperation between all actors such as university, government, industry and civil society is of utmost importance to promote a dynamic and efficient IE. In this context, Civera et al. (2024) emphasise that universities have recently started developing innovations which deal with social and environmental challenges, by integrating sustainability-related content into their courses, and by supporting innovative firms. Furthermore, university accelerate knowledge exchange among IE actors to foster inclusive growth, by leveraging on new technologies (Amitrano & Bifulco, 2024).

However, some studies have emphasised the issues and challenges that may arise in IEs and their ability to foster innovation performance. These issues are mainly associated with the presence of loose knowledge transfer between actors and insufficient coordination and integration in collaborative networks (Wang & Hu, 2020), as well as with a lack of relational factors such as communication, trust or understanding (Plewa et al., 2013). Furthermore, collaborative innovation may have a negative impact on organisational innovativeness because of its economic costs, and it may also face operational, technological and legal barriers (Vivona et al. 2023).

These studies stress the importance of structuring and organising both the relations between actors and the role played by focal actors (firms or universities) which may act as catalysts of such relations. Indeed, Breslin et al. (2021) state that communication between participants is increasingly dependent on the presence of core companies in the ecosystem. Overall, the literature on IEs has identified two main factors which affect knowledge transfer and innovation performance: (a) the presence of key actors in the ecosystem, such as core (large) firms or innovation-driven universities; and (b) how the relationships between actors are arranged. The H&S model could be suitable for acknowledging the importance of key actors in these IEs—usually participants in the hub—and structuring their interactions with the other actors operating within the spokes better.

2.2 The hub and spoke model

The H&S model was first developed as an optimisation model in transportation networks. Given a network of n nodes, only $n - 1$ routes are necessary to connect all nodes in an H&S model, compared with the $n(n - 1)/2$ which would be required to connect all nodes in a point-to-point network. Moreover, the hub is expected to centralise some of the activities, thus achieving economies of scale and simplifying operations in the spokes.

The first author to apply the H&S model to the organisation of local clusters was Ann Markusen who defined a typology of industrial districts. According to Markusen (1996), the H&S district is a district revolving around one or several major corporations in one or a few industries. In this district, "a number of key firms and/or facilities act as anchors or hubs

to the regional economy, with suppliers and related activities spread out around them like spokes of a wheel" (Markusen, 1996, p. 302). One notable example of such a model is the Seattle district (Gray et al., 1996). The H&S district is different from Marshallian districts as its success relies on one dominant firm rather than on a network of small firms. Furthermore, the hub is not always represented by a large corporation. Indeed, non-profit hubs might include a university, a medical centre or a port authority that play a major role in structuring research or economic activities (Gray et al., 1996).

Whatever the nature of the hub, the common feature of the H&S model is the presence of a dominant actor centralising and shaping the organisation of the relations between actors in the ecosystem. Moreover, the hub is the actor that manages both internal and external relations, while the spokes usually have relations only with the hub.

There is little empirical evidence and limited knowledge about the application of the H&S model to the organisation of relations in IEs.

Visscher et al. (2021) explored the IE strategies implemented by German firms. They found that certain companies aimed at becoming keystone or hub firms, by engaging in orchestration activities such as creating platforms, setting up technology campuses, attracting new members, or building consortia to facilitate the formation of regional networks. In the context of IEs, Faccin et al. (2020) investigated how innovation processes among heterogeneous actors for new value creation require alignment, that is, agreement of purposes, knowledge flows, rules of engagement and complementary contributions of participants. Furthermore, Bridoux and Stoelhorst (2022) found that the model is just one among the various forms of governance that can be adopted to manage stakeholders' engagement in joint value creation. However, the model is successful especially when there is a high level of organisational complexity.

Although some studies have examined the central role of universities in IEs (Miller et al., 2016; Brito, 2018), only a few have partially revealed how the H&S model could be used to manage university-industry relationships for knowledge transfer. Lechner et al. (2023) analysed 41 digital ecosystems located in Asia, Europe and North America governed using the H&S model. Their analysis focused on the obstacles that may arise in the governance of such ecosystems given that the motivation and behaviour of the actors may differ. Lyu et al. (2019) investigated how collaborations between industries, universities and research institutions have evolved in the innovative region of Beijing in China. Findings have shown that while, at the beginning of the process, this geographical area was characterised by a small cluster of players, in early 2000, the H&S type of network began to be the main model for organising the relations between actors.

These studies suggest interesting implications which derive from the application of the H&S model to the organisation of relations in IEs: (a) most of the relations between actors take the form of dyadic links between the hub and its spokes; (b) the links between actors are mediated by the hubs, while there are limited direct relations between the spokes; (c) the hubs usually play a key role in designing and governing the relations in the ecosystem.

3 Context of the study

In 2022, the Italian government started implementing a national policy to promote university-industry engagement for knowledge transfer and innovation by establishing 11 national IEs. These, selected, ecosystems were financed for the period April 2022–June 2026, for a total investment of approximately 1.5 billion euros, under the framework of the *Piano Nazionale di Ripresa e Resilienza* (PNRR)—the National Recovery and Resilience Plan (NRRP)—Mission 4 "Education and Research", Component 2 "From Research to Industry", Investment 1.5 "Creating and strengthening innovation ecosystems for sustainability".[1] The NRRP is part of the Next Generation EU Plan. This 806.9 billion euro[2] recovery plan sets the blueprint for a greener, more digital and more resilient future of the EU while addressing the economic, social and health consequences of the Covid-19 pandemic.

Adopting a top-down approach, the national government required—on a mandatory basis—the formal creation of IEs by applying the H&S model to govern university-industry partnerships. Along with being an experiment on a national scale (the ecosystems operate in all 20 Italian regions), many, heterogeneous, public and private partners are participating in the ecosystems. There are a total of 11 hubs—one for each ecosystem—and 84 spokes, which involve more than 40 universities and over 200 actors including research organisations, firms, foundations, and regional and local governments. The Italian Ministry of University and Research (MUR) supervises spending and target achievement in the IEs.

National regulations allow for a wide variety of forms, modes and tools to be adopted when implanting the H&S model. However, the IEs must have only one hub which acts as rule-setter and connector with actors both inside and outside the ecosystem. The orchestrating hub is composed of a group of founding partners which can vary in number and typology. However, universities are usually in the majority and play a key role. Whereas the spokes perform scientific and knowledge transfer activities, disseminate scientific outputs to the general society, and manage relations with firms. Along with the former partners of the H&S, the IEs can be broadened by engaging further firms which become "affiliated" with the ecosystem. To this end, firms should apply and win "cascading grant calls" (bandi a cascata) for knowledge transfer. Such public calls are issued and managed by the universities.[3]

Thus, the case of Italy is relevant for several reasons. First, it offers an opportunity to identify the different forms of the H&S model. Moreover, the large sample, on a national scale, makes it possible to conceptualise the distinctive features of the IEs, as well as the challenges and good practices implemented in this organisational model. In addition, the Italian context is particularly interesting because the industry structure is dominated by the presence of small and medium-sized enterprises (SMEs), many of them operating in low- or medium-tech industrial sectors. This poses several challenges to university-industry interactions since most firms lack the financial and human resources to engage in formal R&D activity. Furthermore, Italy has few cities or large urban areas, whereas it has a high number of small- and medium-sized towns—which are usually less attractive to university-industry partnerships.

Table 1 offers an overview of the 11 national IEs analysed.

[1] https://www.mur.gov.it/it/pnrr/pnrr-misure-e-componenti.

[2] This figure is in current prices. It amounts to €750 billion in 2018 prices; see https://next-generation-eu.europa.eu/index_en.

[3] About 10% of all funding has been allocated to cascading grant calls.

Table 1 Overview of the 11 national innovation ecosystems. *Source*: Authors' elaboration of data gathered from MUR and the 11 innovation ecosystems

Ecosystems	Location of the hub	Key domains (selection)	Funding (million €)	Websites
MUSA—Multilayered Urban Sustainability Action	Milano	• Green transition • Energy transition • Sustainable mobility	*116.0 (**110.0)	https://musascarl.it/
iNEST—Interconnected Nord-Est Innovation Ecosystem	Padova	• Green transition • Digital transition • Smart and sustainable environments • Smart agri-food • Tourism, culture and creative industries	*110.5 (**110.0)	https://www.consorzioinest.it/
NODES—Digital and Sustainable North-Western Italy	Torino	• Green transition • Digital transition • Aerospace • Agri-food industry • Silver economy • Tourism, cultural and creative industries	*113.0 (**110.0)	https://www.ecs-nodes.eu/
RAISE—Robotics and AI for Socio-economic Empowerment	Genova	• Healthcare • Smart and sustainable environments • Smart ports • Smart cities	*117.6 (**110.0)	https://www.raiseliguria.it/
ECOSISTER—Ecosystem for Sustainable Transition in Emilia-Romagna	Bologna	• Green transition • Energy transition • Sustainable mobility	*112.0 (**110.0)	https://ecosister.it/
THE—Tuscany Health Ecosystem	Firenze	• Life sciences	*111.2 (**110.0)	https://www.tuscanyhealthecosystem.it/
VITALITY—Innovation, digitalisation and sustainability for the diffused economy in Central Italy	L'Aquila	• Digital transition • Aerospace • Smart and sustainable environments	*121.0 (**116.0)	https://fondazionevitality.it/
Rome Technopole	Roma	• Digital transition • Energy transition • Health and bio-pharma	*121.5 (**110.0)	https://www.romeetechnopole.it/
eINS—Ecosystem of Innovation for Next Generation Sardinia	Sassari	• Humanistic culture • Creativity • Social transformations • Social inclusion	*141.5 (**119.0)	https://www.einssardinia.it/
Tech4You—Technologies for climate change adaptation and quality of life improvement	Rende	• Green transition • Energy transition • Sustainable mobility	*122.0 (**119.0)	https://www.tech4youscarl.it/
SAMOTHRACE—Sicilian Micro and Nano Technology Research and Innovation Center	Catania	• Green transition • Energy transition • Healthcare • Smart agriculture • Smart mobility • Cultural heritage	*138.0 (**119.0)	https://samothrace.eu/

The full list of key domains is available on the IEs' websites; *estimated total funding; **estimated MUR funding

4 Research design, data and methods

This study used a multiple case study approach to understand whether and how the H&S model matters for university-industry engagement in IEs. Like other recent studies on ecosystems and H&S model (e.g., Lechner et al., 2023), we have adopted an inductive approach following the guidelines proposed by Yin (2018). This approach was deemed appropriate for the following reasons.

First, the case study approach is ideal, in explorative settings, where obtaining novel insights is the main objective (Yin, 2018). This is true in our case since we have investigated the H&S model applied for the first time, on mandatory basis, and on a national scale. Second, case studies are applicable for addressing "how?" enquiries, especially when examining collaboration processes (e.g. Morandi, 2013), which characterise knowledge transfer in IEs as well as their enablers and barriers (e.g. Steinmo & Rasmussen, 2018). Third, diverse perspectives and levels of analysis should be integrated (Bartlett & Vavrus, 2016; Yin, 2009) when analysing IEs since each ecosystem has one hub and various spokes, and involves heterogeneous partners, including universities, public research institutes, private research organisations, large firms, SMEs, foundations and regional and local governments. Such actors operate across different geographical areas, placing ecosystem activities beyond regional administrative borders. Fourth, the multiple case study also makes it possible to analyse the data both within each situation and across different situations; thus, it facilitates cross-case analysis for understanding similarities and inconsistencies in the findings. This contributes to improving both the generalisability of results and to developing more robust conceptual frameworks (Gustafsson, 2017; Li et al., 2023).

The main units of analysis were the H&Ss of the ecosystems. The time frame of the analysis was April 2022–October 2024, which includes three main phases in the creation and functioning of the IEs: (i) the MUR Decree n. 703, 20 April 2022, which listed the ecosystem projects admitted to funding; (ii) the formal creation of the ecosystems by defining their legal form and the structure for applying the H&S model; and, (iii) the implementation of these ecosystem activities. It is worth noting that the IEs started operating between the end of 2022 and the beginning of 2023. The activities are ongoing (2025) since the NRRP funding will formally end in June 2026.

This research is based on four steps:

(i) Step one. A literature review to define the theoretical framework, to identify relevant gaps in the current literature on IEs and the H&S model, and then to help in designing two questionnaires and a set of semi-structured interviews.

(ii) Step two. A wide range of secondary data were collected and analysed to get a general overview of the structure, actors, main features, functions and strategies in the governance of the IEs. Data were mainly gathered from MUR and from representatives of the hubs who provided public documents, reports and statistics. We also retrieved information from the business press and the web pages of the IEs.

(iii) Step three. Primary data were collected by administering two online questionnaires which were designed, respectively, for representatives of the hubs and for representatives of the spokes. As well as asking for personal information, the questionnaires were divided into two parts that focused respectively on IEs and the H&S model. The questionnaires were tested during a one-day, in-person workshop held in Padova in July 2024 which involved

all the representatives of the national IEs. MUR contributed to organising and coordinating this workshop.

The first questionnaire was administered to the representatives of the 11 hubs, including presidents, scientific coordinators, general directors and programme managers. The response rate was above 83% (20 out of 24 representatives reached). The second questionnaire was sent to the representatives of the 84 spokes. We gathered 61 replies, corresponding to a response rate of 72.6%. Through these two questionnaires, we achieved a response rate of around 75%.

To reduce bias from the policy-driven context, all the 11 national IEs were included in the analysis. During data gathering all the representatives of the hubs and spokes had an equal chance to reply to the questionnaires. By having individuals from all the 20 Italian regions, with diverse roles in the IEs, different scientific backgrounds, heterogeneous professional experience (e.g., scholars, former public managers, former firm managers, former entrepreneurs), it was possible to obtain different perspectives and to identify and address biases, thus obtaining more accurate and reliable results.

(iv) Step four. We performed 16 semi-structured interviews to better understand the governance of the H&S model, the challenges, good practices, and partnerships for knowledge transfer, internationalisation, and the evolution of the IEs. The interviews were performed between July and September 2024, involving the scientific coordinators, general directors and programme managers of the hubs. The research project was first introduced to the interviewees at the workshop in Padova, and then they were approached via e-mail to schedule the interview in person or via videoconferencing. The interviews averaged 45 min and were recorded (when possible), transcribed and summarised. Transcripts and identifiers were anonymised in accordance with research ethic guidelines. To reduce any inaccuracies of answers, due to factors such as leading questions, misinterpretation and policy-driven context, the key questions of the interview were sent in advance to the interviewees via e-mail. Interviewees could accept, or not, whether to be recorded. Furthermore, anonymity and aggregation were ensured in data elaboration. Interviewees were also invited to send follow-up e-mails or to arrange follow-up calls in case they would like to add further information to their previous answers. Open coding was applied to the results obtained (Corbin & Strauss, 1990), marking items that occurred more frequently. These codes were gathered and abstracted in iterative rounds, which led to the themes discussed in Sect. 5. Table 2 summarises data and information sources for this research, while Fig. 1 shows a flowchart of the methodology.

5 Results and discussion

In this section, we discuss the results obtained from the questionnaires and the semi-structured interviews, which led us to identify the following as key themes: (1) the institutional setting of the H&S model; (2) models, opportunities and challenges for knowledge transfer; (3) internationalisation of the ecosystems; (4) training and placement of enrolled staff; and (5) the evolution of the ecosystems in the medium-long term.

Figures 2, 3, 4, 5, 6, 7, 8 and 9 summarise the results obtained from the two questionnaires, which were administered respectively to representatives of the hubs and representatives of the spokes.

Table 2 Data and information sources. *Source*: Authors' elaboration

	Questionnaire for hubs	
Primary data	N. of hubs	• 11 (1 for each IE)
	N. of respondents	• 20
	Role of respondents	• Hubs' presidents, scientific coordinators, general directors and programme managers
	Questionnaire for spokes	
	N. of spokes	• 84
	N. of respondents	• 61
	Role of respondents	• Spokes' scientific coordinators and project managers
	In-person and online interviews	
	N. of interviews	• 16
	Role of interviewees	• Hubs' scientific coordinators, general directors and programme managers
	Average length	• 45 min
	Period	• July–September 2024
Secondary data	• Documents, reports and statistics gathered from the Ministry of University and Research (MUR) and the hubs' representatives • Information from business press and the web pages, including websites and social networks—when available—of the innovation ecosystems	

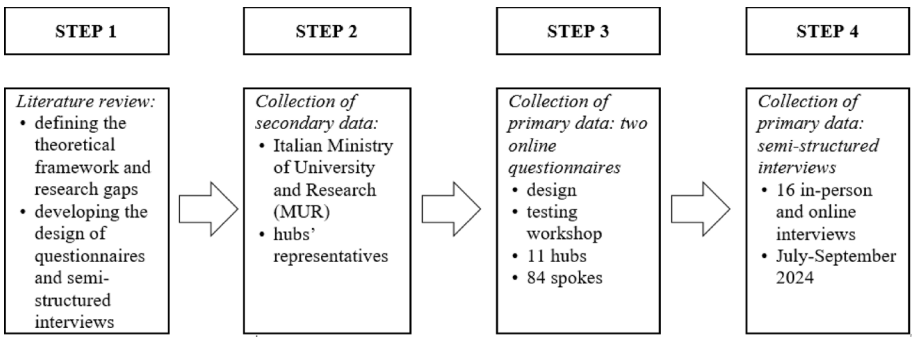

Fig. 1 Flowchart of the methodology. *Source*: Authors' elaboration

Overall, people responsible for the scientific coordination and management of the hubs agree that the creation of the IEs has improved collaboration between universities and firms. This might also result in the promotion of innovation and economic growth at the local level in the long term. Even though some IEs focus on social transformations and social inclusion, less than 50% of the hub respondents agreed that these ecosystems can strengthen social sustainability. Some respondents even doubted the existence of any positive contribution of the ecosystem to the environmental dimension of sustainability (Fig. 2). Whereas,

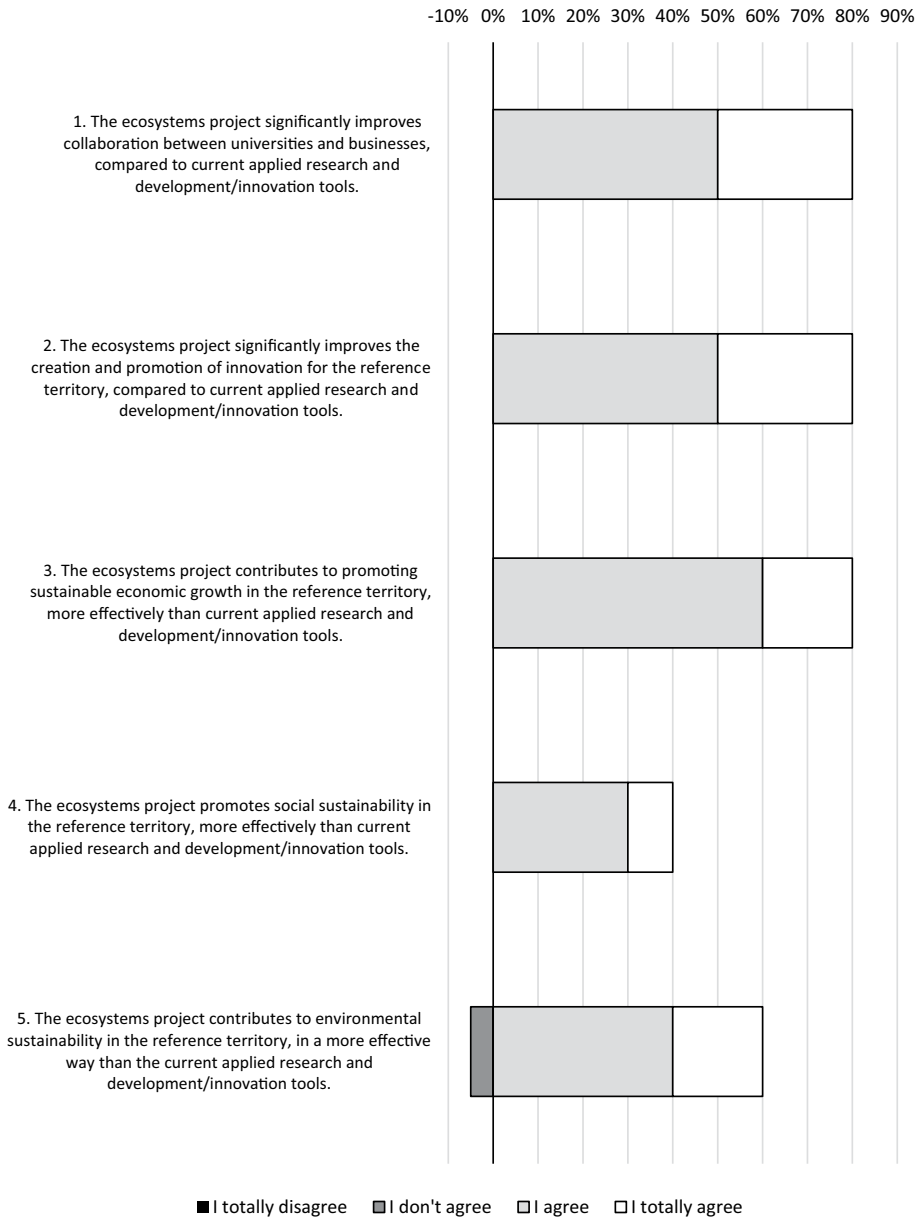

Fig. 2 Answers provided by the Hubs to Sect. 1 of the questionnaire about innovation ecosystems. *Notes*: The graph shows the answers provided by the 20 respondents with scientific and management responsibilities in the hubs, to the questions included in Sect. 1 of the online questionnaire (Innovation Ecosystem). Figures refer to the percentage of respondents who answered to each question as: "I totally disagree" and "I don't agree" (negative values); "I Agree" and "I totally agree" (positive values). Totals do not necessarily reach100% because the alternative answer "Neutral" does not appear in the graph. *Source*: Authors' elaboration

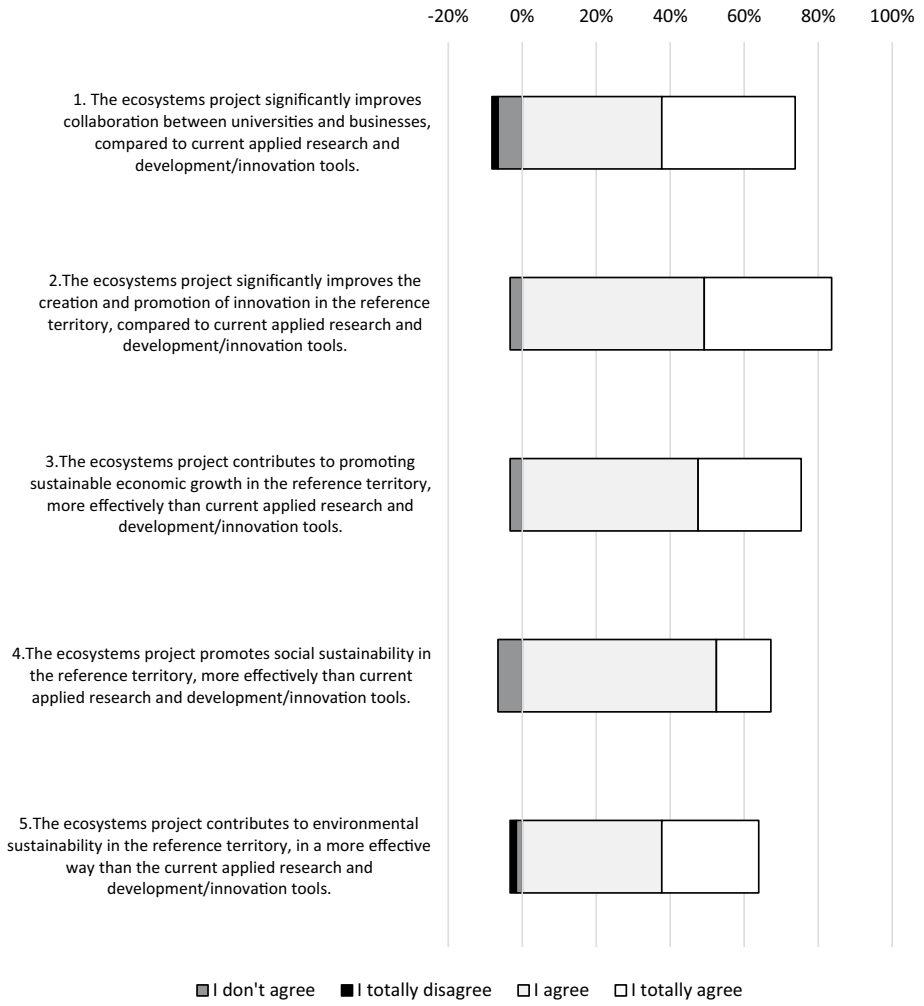

Fig. 3 Answers provided by the Spokes to Sect. 1 of the questionnaire about innovation ecosystems. *Notes*: The graph shows the answers provided by the 61 respondents with scientific and management responsibilities in the spokes, to the questions included in Sect. 1 of the online questionnaire (Innovation Ecosystems). Figures refer to the percentage of respondents who answered to each question as: "I totally disagree" and "I don't agree" (negative values); "I Agree" and "I totally agree" (positive values). Totals do not necessarily reach 100% because the alternative answer "Neutral" does not appear in the graph. *Source:* Authors' elaboration

the representatives of the spokes emphasised the potential positive contribution of the IEs to social sustainability (Fig. 3). This is also evident when comparing the mean values obtained for the first five questions on the contribution of the IEs (Fig. 4). On the one hand, achieving economic, social, and environmental sustainability requires the commitment of all IE actors (Civera et al., 2024). On the other hand, our preliminary results show a lack of shared values on this crucial point, especially at hub level. Instead of orchestrating the development of sustainable solutions within the IE, the interactions among hub members and the heterogeneity of their interests may affect negatively the sustainability of the ecosystem.

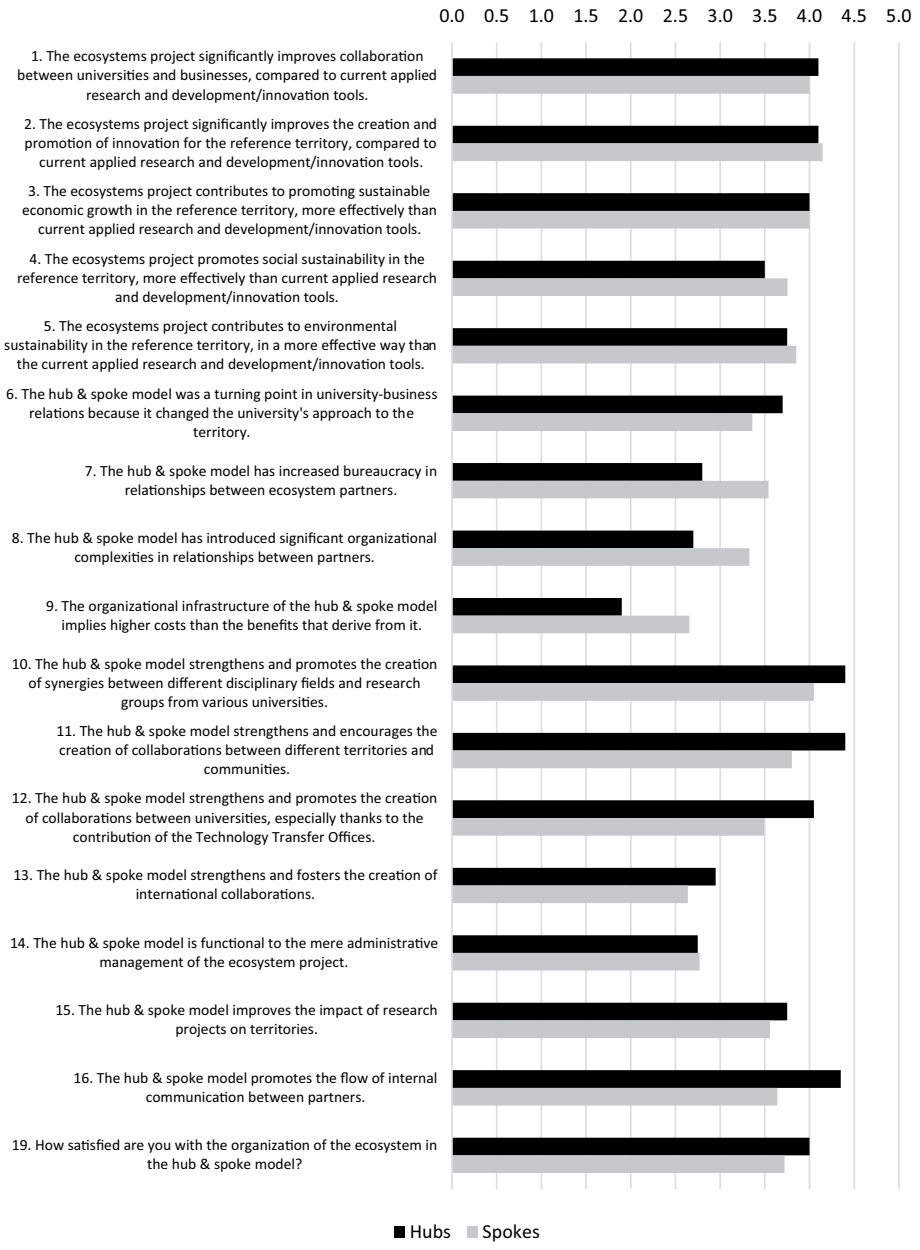

Fig. 4 Answers provided by Hubs and Spokes to the questionnaire (mean values). *Notes*: The graph shows the mean values of the answers provided by the respondents with scientific and management responsibilities in the hubs and in the spokes. For questions 1–16 the scale goes from 1 (I totally disagree) to 5 (I totally agree). For question 19 the scale goes from 1 (very dissatisfied) to 5 (very satisfied). *Source*: Authors' elaboration

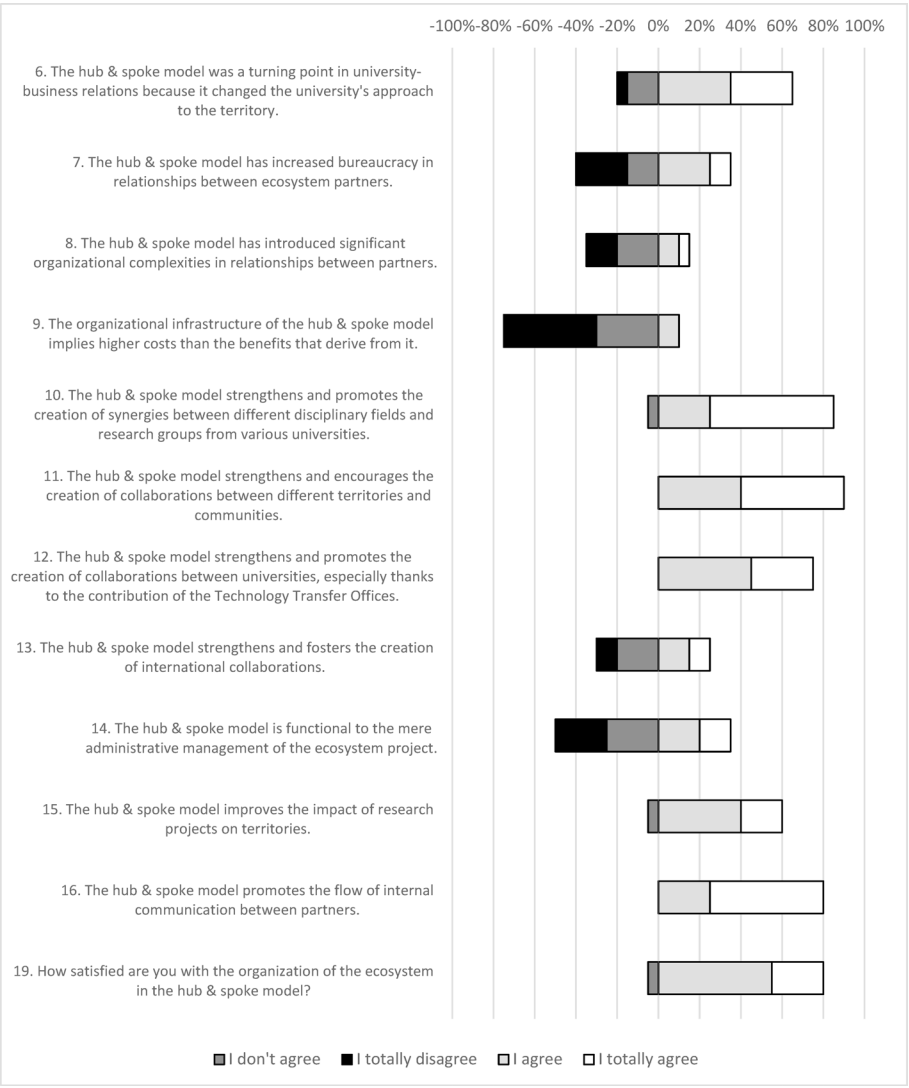

Fig. 5 Answers provided by the Hubs to the Sect. 2 of the questionnaire about the hub and spoke model. *Notes*: The graph shows the answers provided by the 20 respondents with scientific and management responsibilities in the hubs, to the questions included in Sect. 2 of the online questionnaire (hub and spoke model). Figures refer to the percentage respondents who answered to each question as: "I totally disagree" and "I don't agree" (negative values); "I Agree" and "I totally agree" (positive values). For question 19, the scale is: "Very dissatisfied" and "Dissatisfied" (negative values); "Satisfied" and "Very satisfied" (positive values). Totals do not necessarily reach100% because the alternative answer "Neutral" does not appear in the graph. *Source*: Authors' elaboration

The answers to the questions about the H&S model show the major differences between respondents from the hubs and spokes (Figs. 5 and 6). Respondents from spokes were more likely to agree that the new model increased complexity and bureaucracy (questions 7–8) but not to the point of reverting the ratio between costs and benefits (question 9). At the

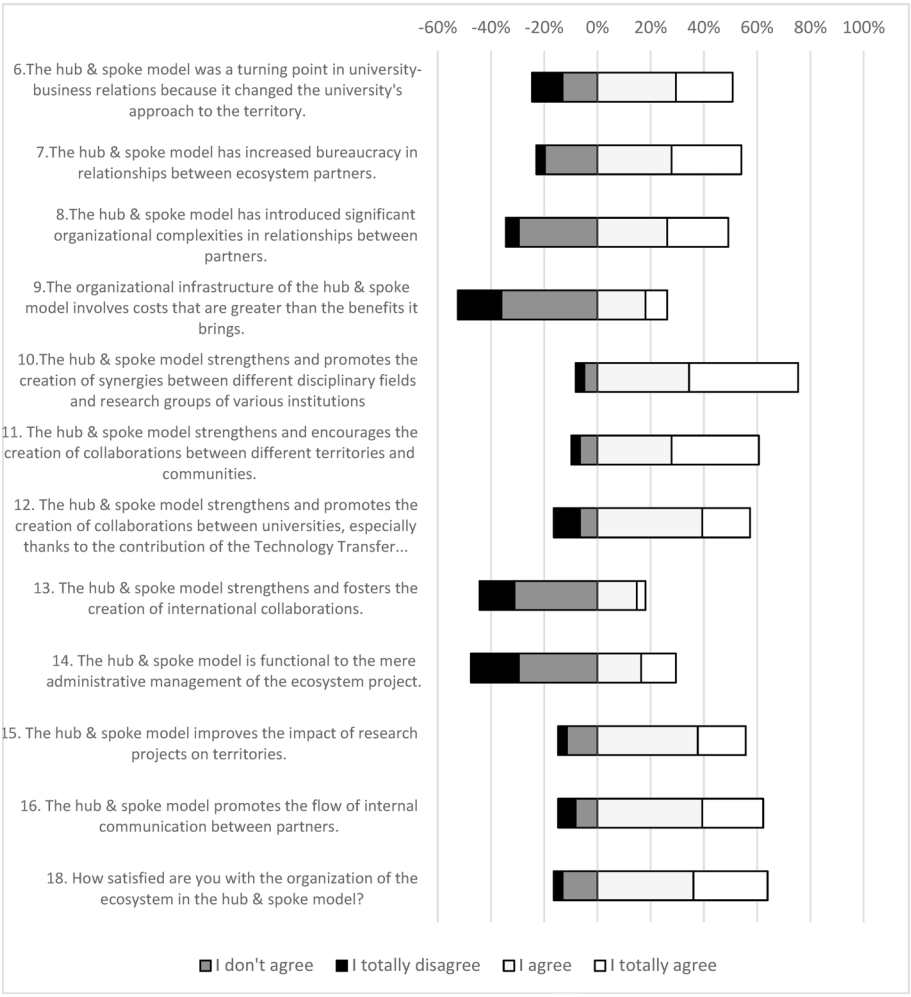

Fig. 6 Answers provided by the Spokes to the Sect. 2 of the questionnaire about the hub and spoke mode. *Notes*: The graph shows the answers provided by the 61 respondents with scientific and management responsibilities in the spokes, to the questions included in Sect. 2 of the online questionnaire (hub and spoke model). Figures refer to the percentage respondents who answered to each question as: "I totally disagree" and "I don't agree" (negative values); "I Agree" and "I totally agree" (positive values). For question 18, the scale is: "Very dissatisfied" and "Dissatisfied" (negative values); "Satisfied" and "Very satisfied" (positive values). Totals do not necessarily reach 100% because the alternative answer "Neutral" does not appear in the graph. *Source*: Authors' elaboration

same time, respondents from spokes showed lower mean values for the contribution of the H&S model to promoting collaborations between universities and the actors operating in their territories, and to encouraging cross-disciplinary research (questions 10–12). This is understandable given that spokes have a limited territorial and thematic scope.

The H&S model seems to play a minimal role in promoting international relations. In fact, less than 25% of respondents for the hubs agreed that the new model had fostered the creation of international collaborations (question 13). The percentage is lower for the

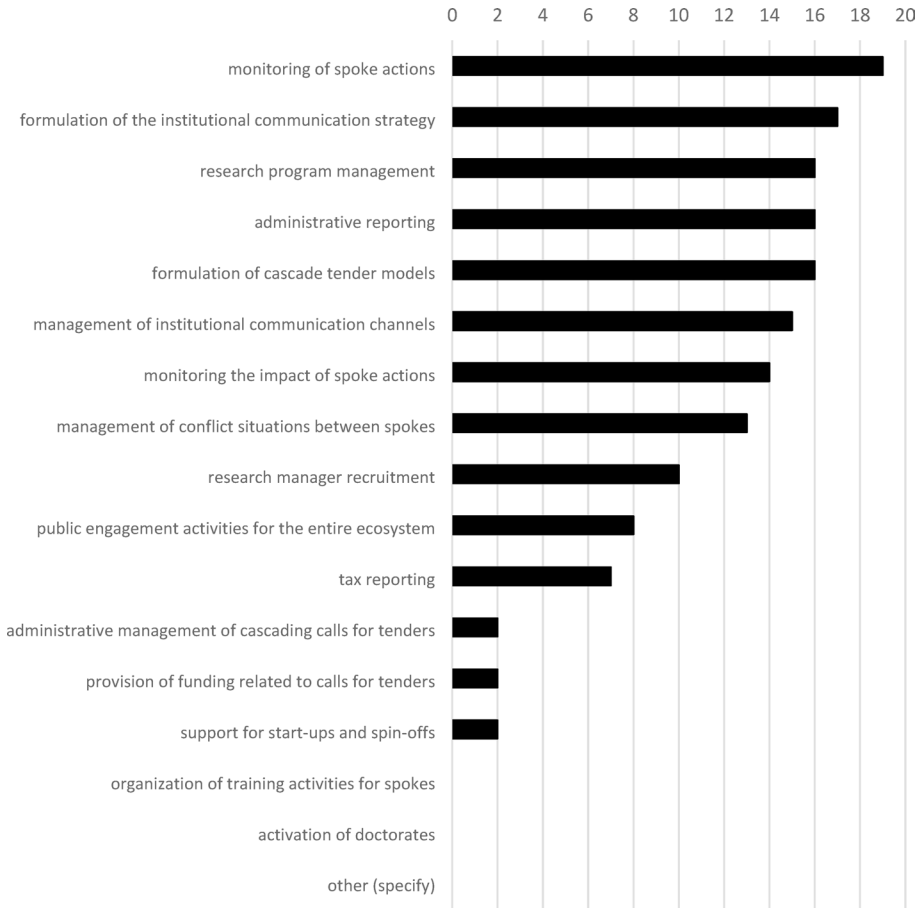

Fig. 7 Activities covered by the Hubs. *Note*: Figures indicate the number of answers. Multiple answers were possible. *Source*: Authors' elaboration

spokes. This confirms that the national policy is seeking to address key local priorities and to stimulate partnerships between actors in the same ecosystem, dedicating less attention to relations between ecosystems. Findings also show the positive role of the H&S model in promoting communication between partners (question 16). This is true for all respondents, although the percentage is higher for the hubs.

The following sub-sections offer in-depth analysis of the key themes that we identified, highlighting emerging patterns which informed the implications outlined in the concluding section.

5.1 The hub & spoke model

Table 3 shows descriptive data for the H&S models implemented by the 11 national IEs. The H&S structure is quite simple since each ecosystem has one hub, while the number of spokes ranges from 5 to 10. However, there are important differences in the internal organ-

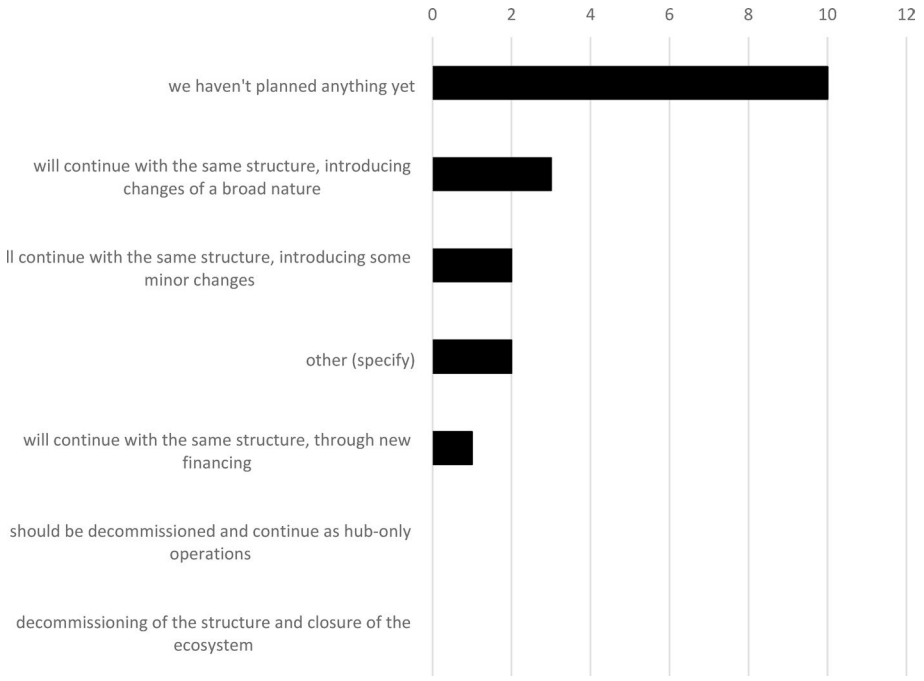

Fig. 8 Answers provided by the Hubs about the evolution of the innovation ecosystems. *Note*: Figures indicate the number of answers. Multiple answers were possible. *Source*: Authors' elaboration

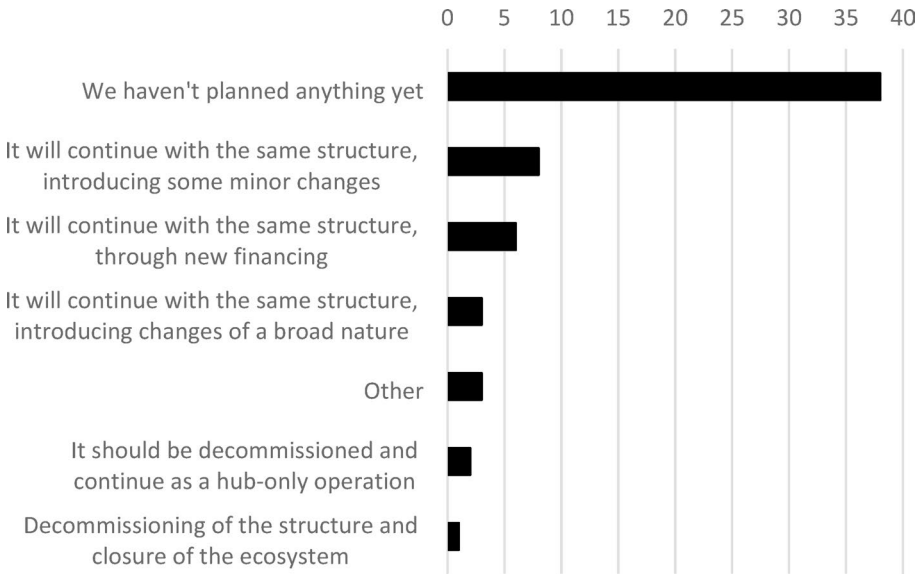

Fig. 9 Answers provided by the Spokes about the evolution of the innovation ecosystems. *Note*: Figures indicate the number of answers. Multiple answers were possible. *Source*: Authors' elaboration

Table 3 Descriptive data about the H&S models implemented by the 11 national innovation ecosystems. *Source*: Authors' elaboration

Innovation ecosystems	Proposer (hub or main member of the hub)	N. of spokes	N. of partners of the IEs	N. of public universities	N. of public research institutes	N. of private research organizations	N. of firms	Total public subjects involved	Total private subjects involved
				A	B	C	D	E=A+B	F=C+D
TECH4YOU	Università della Calabria	6	18	4	5	3	6	9	9
THE	Università di Firenze	10	23	7	2	6	8	9	14
SAMOTHRACE	Università di Catania	9	25	4	5	1	15	9	16
ROME TECHNOPOLE	Università di Roma La Sapienza	6	25	5	4	2	14	9	16
ECOSISTER	Alma Mater Studiorum Università di Bologna	6	23	5	3	10	5	8	15
RAISE	Università di Genova	5	25	1	7	4	13	8	17
NODES	Politecnico di Torino	7	24	7	3	5	9	10	14
MUSA	Università di Milano Bicocca	6	24	3	0	4	17	3	21
E.INS	Università degli Studi di Sassari	10	18	4	2	3	10	6	13
VITALITY	Università dell'Aquila	10	24	9	5	2	9	14	11
INEST	Università degli Studi di Padova	9	24	10	3	9	3	13	12
Total	**11**	**84**	**253**	**59**	**39**	**49**	**109**	**98**	**158**
Mean values		**7.6**	**23.0**	**5.4**	**3.5**	**4.5**	**9.9**	**8.9**	**14.4**

The table shows the actors who are formally recognized as partners of the IEs and participated in their creation. However, the IEs can be broadened by engaging further firms which become "affiliated" with the IEs. To this end, firms should apply and win "cascading grant calls" (bandi a cascata) for knowledge transfer. These public calls are issued and managed by the universities.

isation of both the hubs and the spokes, as well as regarding the relations between them. Because the national regulations for the creation of the IEs were quite flexible, this resulted in considerable heterogeneity in both the size and the internal structure of the 11 hubs.

When considering the institutional setting of the H&S model, unlike the cases presented in the literature, the forms of the H&Ss implemented by the Italian IEs are not associated with one actor but are composed of several institutions (Faccin et al., 2020). This is always true for the spokes, which have, on average, three partners each. Moreover, some actors were present in more than one spoke, or in both the hub and the spokes. The law required the hubs to be constituted as a legal entity (consortium or foundation), while the spokes are organised in the form of partnerships where one of the partners acts as leader, which is usually a university.[4]

These characteristics have several implications for the organisation of the H&S model (Ferdinand & Meyer, 2017). First, the spokes define specific areas of research and knowledge transfer in which several actors, public or private, may be involved. Second, in this model the activities are concentrated in the spokes, while the hub is the orchestrator and plays an administrative role. In the case of Italy, MUR is in charge of allocating funding and monitoring activities, spending and the achievement of targets.

Regardless of either the legal form chosen for the hub or the number of founding partners, the management structure of the hubs is generally very small, involving a scientific coordinator, a general director or the programme manager, and two or three junior collaborators in some cases. However, some hubs have invested more resources in establishing an extensive and articulated internal structure so as to act as connectors with actors outside the ecosystem, and to ensure effectiveness and efficacy in the design and implementation of management and control systems, and in financial planning (Fig. 7).

When the hubs were created, the founding partners had different missions, values and interests, depending on the presence of a pre-existing ecosystem, the degree of intensity and complexity of the interactions between the actors, and the distinctive social, economic and institutional features of the geographical areas where the ecosystems were expected to operate. It is worth noting that a general dissatisfaction with the obligation to set up a hub emerged when actors were already in charge of orchestrating the ecosystem's actors. This dissatisfaction was mainly due to the high degree of complexity of managing the administrative processes for establishing the hub, and avoiding overlapping activities between the former entities and the new hub.

The application of the H&S model determined heterogeneous solutions which could respond to different strategies in terms of the number of actors participating, the geographical areas involved in the ecosystem, and their specialisations. Three forms of application of the H&S model were identified. The conditions under which each form is preferable are described below.

[4] For example, the hub of the IE of Emilia-Romagna (ECOSISTER), promoted by Alma Mater Studiorum Università di Bologna, is a foundation with the following founding members: Alma Mater Studiorum Università di Bologna, Università degli Studi di Ferrara, Università degli Studi di Modena e Reggio Emilia, Università degli Studi di Parma, Università Cattolica del Sacro Cuore (private university), Politecnico di Milano, Istituto Nazionale di Fisica Nucleare (INFN), Consiglio Nazionale delle Ricerche (CNR) and Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo sostenibile (ENEA). INFN, CNR and ENEA are public research institutes. The foundation includes ART-ER Attrattività Ricerca Territorio which is a consortium which aims to foster Emilia-Romagna's sustainable growth by developing innovation and knowledge, and attractiveness and internationalisation. The members of the hub are also members of most of the spokes.

(i) *Ecosystem focused on defined urban or metropolitan areas.* This ecosystem works when there is a high density of innovation players in the hub, high maturity of entrepreneurial fabric and high availability of incubation and knowledge transfer services. This geographical focus is usually associated with a very specific innovation theme and clearly defined domains of intervention. For example, this is the case of MUSA (Multilayered Urban Sustainability Action) which was established in Milan as a response to the challenges that the metropolitan area faces in the transition to the three domains of sustainability: environmental, economic and social.

(ii) *Region-based ecosystem.* With one leading university in the hub, governance appears to be an expression of different actors, ensuring greater participation in both the collaborative and innovation process. Specialisation also seems more focused on one, or only a few, key domains. For example, this is the case in RAISE (Robotics and AI for Socio-economic Empowerment), which is based in Liguria where only one university, the Università degli Studi di Genova, leads the IE along with two public research institutes: the Consiglio Nazionale delle Ricerche (CNR) and the Istituto Italiano di Tecnologia (IIT). It is worth noting that the region-based ecosystem can include several universities. For example, in the case of Rome Technopole, where five public universities operate on regional basis, along with further private universities. When the spokes include several universities, the risk is that a sort of displacement effect may emerge with respect to other innovation actors, saturating the governance of the whole ecosystem. Furthermore, there may be multiple innovation domains which are sometimes very broad. This may result in more scattered innovation-driven actions across the spokes, reducing the overall effectiveness of the IE.

(iii) *Cross-regional ecosystem.* This IE operates across diverse geographical areas with heterogeneous social, economic and institutional characteristics. This is the case, for example, of iNEST (Interconnected Nord-Est Innovation Ecosystem), VITALITY (Innovation, digitalisation and sustainability for the diffused economy in Central Italy), and NODES (Digital and Sustainable North-Western Italy). Here the H&S model has been applied to manage a high degree of complexity in terms of organisation, coordination and management. The H&S model is considered to be particularly efficient in these cases, given the absence of a pre-existing ecosystem. In particular, the hierarchical institutional set-up, with strong mechanisms for orchestrating relations between actors, encourages collaboration between universities and firms within the spokes. On the other hand, organisational complexity is also associated with the absence of a unique specialisation since the IE is the expression of highly diversified and complementary vocations and excellences. It means that topics for joint research and innovation-driven actions are usually very different.

Regardless of the geographical extension, the H&S model has required both scholars and administrative staff of universities to very quickly redesign their internal procedures and work-flows in order to coordinate the heterogeneous interests of both public and private actors, inside and outside the IE, and to achieve ambitious milestones and targets—set by the Ministry—in a time frame (around 3 years) which is too short for knowledge transfer. Some hubs have also developed a set of common indicators for spokes to evaluate their activities and achievements and a common work, and communication, flow. We found the following most recurring domains in the actions indicated by the hubs for their spokes: the

engagement of firms in applied research; the creation of start-ups and academic spin-off companies, more broadly accelerating academic and non-academic entrepreneurship; the formation of a network of co-working spaces and shared laboratories for scholars and firm collaborators; the involvement of citizens in research and dissemination activities; and education and lifelong learning for enrolled staff and non-academic actors.

The proliferation of spokes usually comes with the desire to assign responsibility for resources and the development of specific lines of action to various actors in each area. In the case of multiple university actors in the same ecosystem, the number of spokes is particularly large. Indeed, the spokes usually respond to the specialisation of innovation sub-ecosystems included in the broader ecosystem; this is especially true in the case of cross-regional ecosystems, and results in the development of a broad range of research and innovation themes.

Regardless of the form in which the H&S model is applied, it still, in the long run, risks "compartmentalising" both the spokes and the knowledge produced. Indeed, the spokes coordinate many people—in some cases more than 300 researchers—and many activities, and at the same time they must comply with mounting administrative constraints, especially related to the management of cascading grant calls and knowledge transfer activities. There is a general risk of losing the overall sense of the IE. To address this risk, some hubs continuously promote initiatives to foster co-designed research and co-created activities among research groups belonging to the different spokes. Such interactions are of utmost importance since cross-disciplinary and territorial complementarity will play a key role in the evolution of the ecosystems. As described in the next sub-section, some ecosystems have also created "service" spokes to handle knowledge transfer activities and the organisation of common services, including the dissemination of research results on behalf of the other spokes.

5.2 Knowledge transfer

Knowledge transfer or, rather, the activation of co-creation processes for knowledge and innovation, is the core functioning of the ecosystems (Bacon et al., 2020). This aim is obtained in two main ways. On the one hand, private actors are involved in the spokes. In fact, on average about two-thirds of the partners involved in the spokes are private R&D organizations or companies. On the other hand, large amount of the whole budget managed by the spokes is used—in compliance with the rules set for the IEs by the government—to promote innovation in the private sector through public calls, addressed primarily to SMEs and start-ups.[5]

The IEs have mainly been structured around three models for managing knowledge transfer: a centralised model; a decentralised model; and a hybrid model. The conditions under which each model would be preferable are described below.

(i) *Centralised model.* A unique "service" spoke acts entrepreneurially by managing strategies for unlocking the potential of scientific discoveries on behalf of the other spokes in the ecosystem. Furthermore, it manages the development of innovation, increases in technology readiness levels, and collaboration between research groups and firms. This spoke also ensures homogeneous processes and more efficient workflows, as well as

[5] "Cascading grant calls" (*bandi a cascata*).

the sharing of expertise and good practices for knowledge transfer among the actors in the ecosystem. In this way, the ecosystem can achieve and strengthen a strategic critical mass for implementing knowledge transfer activities. Adoption of the centralised model seems preferable in two specific cases. The first one is when the leader of the "service" spoke has greater maturity and awareness of the dynamics of knowledge transfer in favour of an entire geographical area which usually shows a high degree of specialisation in one or a few domains. Among other activities, the "service" spoke manages training on entrepreneurship and soft skills for junior scholars, supervises the acceleration of start-ups and academic spin-off firms, and provides consulting and support for intellectual property rights protection. For example, this is the case of SAMOTHRACE (Sicilian Micro and Nano Technology Research and Innovation Center) where the "service" spoke was established in order to coordinate knowledge transfer activities across nine spokes which focus on a variety of heterogeneous scientific domains. Furthermore, the creation of this "service" spoke also addressed the need to support the KTOs of the universities which did not have sufficient resources to manage both ordinary activities and ecosystem-related actions. Overall, this spoke has contributed to improving the overall efficiency of the IE by ameliorating both collaboration and communication flow among partners. The second case is associated with ecosystems with strong scientific identity, e.g. life sciences. In this instance, the "service" spoke usually offers more sophisticated and structured support. Indeed, the spoke does not simply bridge scientific research and the business domain in order to promote the commercialisation of scientific outputs. Indeed, the "service" spoke also manages several activities to coordinate diverse actors inside and outside the ecosystem. In particular, the spoke focuses on complex scientific, ethical and regulatory aspects of the process of innovation such as, amongst others, phases of clinical trials (in the fields of medicine and biotechnologies), product certifications and the protection of regulatory profiles of innovation. For example, this is true in the case of the THE (Tuscany Health Ecosystem) where the "service" spoke focuses on implementing innovation for healthcare and well-being. Moreover, in those geographical areas that show high maturity in the management of knowledge transfer activities, centralisation has been implemented by delegating specific actions to pre-existing actors, which are also founding partners of the ecosystem. This strategy is aimed at enhancing existing expertise in the field of knowledge transfer, avoiding the duplication of services, and reducing the use of public resources. However, this model is usually associated with higher costs and risks of duplicating knowledge transfer processes unless coordination between different actors is not accurately planned.

(ii) *Decentralised model.* In the absence of a unique "service" spoke dedicated to knowledge transfer activities, the actors of the ecosystem autonomously design and carry out actions to develop innovation and to support entrepreneurship, patenting, licensing and market entry. Like the centralised model, the decentralised one has also been applied in different ways depending on the distinctive features of the ecosystem involved. Indeed, the actors have either acted autonomously by using in-house structures for knowledge transfer, or have jointly defined shared actions for transferring scientific outputs from research laboratories to the market. For example, this is true in the case of the Emilia-Romagna ecosystem ECOSISTER where the actors operate autonomously and usually involve an in-house structure for knowledge, also a founding partner of the IE, ART-ER Attrattività Ricerca Territorio which is a consortium whose purpose is fostering

regional sustainable growth by developing innovation and knowledge, and attractiveness and internationalisation. The decentralised model also seems better suited for contexts where only a few universities are involved, each with already established offices for industry-academic cooperation and with very specific vocation and industry focus. This is the case, for example, in the SAFINA spoke (VITALITY ecosystem), where universities, only focused on social sciences and humanities (SSHs), collaborate with STEM research poles within a very broad geographical area, covering three regions. Risks associated to this model are related to the fragmentation of innovation processes and a loss of potential synergies of cross university cooperation.

(iii) *Hybrid model*. This model has two levels of action. The first level is managed by a "service" spoke which operates on behalf of all the actors in the ecosystem by encouraging cross-disciplinary research through joint workshops, the creation of start-ups and academic spin-off companies, and cross-sectoral events and experimental co-creative processes involving firms. As regards the second level of action, each spoke autonomously carries out knowledge transfer and co-creation initiatives specifically designed and targeted to promote their own specialisation. This model seems to be particularly suitable for IEs where there are few spokes and knowledge transfer structures with diverse characteristics: some infant, some well-established, and with different specialisations. However, they do need some form of coordination in order to enhance the potential for cross-disciplinary and cross-sectoral synergies as, for example, in the case of RAISE (Robotics and AI for Socio-economic Empowerment).

In all three models, knowledge transfer activities are managed by the spokes rather than by the hubs. Respondents emphasised that university KTOs have to manage a considerable increase in both the amount and the complexity of work, which derive from the tasks and goals of the spokes. As has been observed in recent studies (e.g. Compagnucci & Spigarelli, 2024a), when addressing this issue, it is important not only to upskill or reskill KTO staff and to recruit new administrative personnel, but also to design and implement policies and incentives in order to encourage more commitment from collaborators. Furthermore, ecosystems should diversify knowledge transfer channels and consider associated contextual dynamics, including the relations between IE actors. This may contribute to improve the effectiveness of the process of knowledge creation and transfer (Radko et al., 2023).

Regardless of the model adopted, all respondents argued that the time frame envisaged by the national policy (NRRP), namely April 2022–June 2026, is "physiologically" incompatible with the time horizon usually required for creating new technologies and products from scratch, and achieving high technology readiness levels (TRLs) that could be attractive to firms. This is especially clear in the medical and natural sciences, which require longer time frames for complex processes if they are to obtain authorisations and certifications, as well carrying out experiments and tests.

To address this challenge, some hubs have not considered the ecosystem to be a tool for the creation of new technologies but, rather, as one for accelerating the development of existing prototypes and technologies, and promoting the acquisition of patents. For example, this is true in the case of the SAMOTHRACE and RAISE ecosystems which operate, respectively, in Sicily and Liguria. These IEs have mapped the technologies that already exist in their spokes and assessed their TRL also by considering commercial potential, the needs of regional and national industries, and complementarities with the specialisations of

the ecosystem. The final aim is to select a limited number of "flagship projects", accelerate their development, and then transfer the outputs to the market by increasing the allocation of resources and providing continuing support after the conclusion of the NRRP.

5.3 International exposure

The creation of IEs in compliance with the policy and the regulations enacted by the national government has determined the importance of prioritising the domestic dimension rather than orienting the ecosystems towards an international dimension. Although the promotion of innovation-driven activities has stimulated the formation of networks within and between ecosystems, especially in the field of digitalisation, the ecosystems have not been being designed according to a "born global" configuration. Instead, they are still in an "early stage" since they started operating in an effective manner between the end of 2022 and the beginning of 2023.

Findings have revealed that any future planning for internationalisation of the ecosystems will depend heavily on a common, and agreed, vision of the partners, on the availability of further funding sources, and on active participation of both regional and national governments. However, some IEs have already started encouraging the formation of international collaborations among research groups for drafting project proposals so as to apply for European funding programmes that support research and innovation. Furthermore, some IEs have already involved their research groups in international initiatives organised by the regional governments involved in the ecosystems. Leveraging the resources of their IEs, some research groups have further strengthened international scientific collaborations which were already underway before the formation of the ecosystems.

5.4 Training and placement of enrolled staff

Recent studies have found that collaboration between universities and firms for industrial PhD programmes or innovative doctoral programmes is increasing, suggesting that the number of both such programmes and of doctoral positions could rise in the coming years (Compagnucci & Spigarelli, 2024b). This is also true in the case of Italian IEs (Compagnucci et al., 2024), which have financed around 6000 industrial PhD scholarships. As in previous studies (e.g. Grant et al., 2022; Sarrico, 2022), respondents stressed that the steady increase in the number of such positions has raised various concerns among scholars regarding the preparedness of PhD graduates, the rigour of their training, and their employability.

Industrial PhD candidates benefit from applied research environments, training in soft skills, and a business-driven approach to innovation, all of which are usually valued by the non-academic labour market, thus providing an alternative to the lack of university positions (Amaral & Carvalho, 2020; Moghadam-Saman, 2020). Furthermore, these doctoral programmes are usually co-funded by national and regional governments in order to implement innovation strategies and improve the innovation capacity of firms (Roolaht, 2015).

On the one hand, almost all ecosystems provide advanced training for enrolled staff—namely industrial PhD candidates, post-doctoral researchers and junior researchers—by organising cross-disciplinary and cross-sectoral initiatives on scientific domains of strategic interest, such as energy transition, sustainability, healthcare, and digital transformation.

On the other, only few IEs reported that they have designed and started to enact specific actions to place the enrolled staff—inside or outside academia—after the conclusion of the funding ensured by the NRRP. For example, the ecosystems ECOSISTER and SAMOTHRACE have planned a two-stage training programme for their enrolled staff: first, the development and assessment of entrepreneurial skills acquired by young researchers; second, favouring their placement in non-academic positions by organising showcase events and co-working initiatives to match the competences of researchers and the needs of firms. The final aim is to train these researchers to become agents of innovation who are able to strengthen university-industry partnerships in the long term, by developing an entrepreneurial mindset and shared methodological approaches and workflows.

5.5 Evolution of the ecosystems: from start-up phase to maturity

In very limited cases, the ecosystem has already identified possible trajectories for future development. This is true for both the hubs (Fig. 8) and the spokes (Fig. 9). More than 50% of hubs and 60% of spokes declared that they have not yet planned anything for further development after the end of the NRRP in June 2026.

For example, in the case of iNEST (Interconnected Nord-Est Innovation Ecosystem), the approach to future development is innovative in its pro-active involvement of stakeholders from an early stage. A participatory consultation was launched and guided by a consulting firm. Interviews were held involving public and private actors in the IE so as both to map their interests and needs and identify the expectations of local communities. Thematic meetings dedicated to innovation and entrepreneurship were subsequently organised. Finally, working groups were set up and entrusted with the goal of identifying business models that the ecosystem could implement in the medium-long term to ensure its sustainable development.

A limited number of ecosystems have recently started to think about their future, focusing on two crucial aspects: on the one hand, the type of specialisation that the ecosystem should have in the future and, on the other, its vocation. While, during the start-up phase, a wide range of innovation themes may have been taken on board, to better test and experiment on the needs of university-business-innovation actors, after almost 3 years of activity, it was time to "pick up the winners", i.e. narrow down the activities and lines of specialisation. However, vocation concerns the type of management of knowledge transfer processes: as in the case of ECOSISTER, the hub could become the infrastructure responsible for research transfer activities in place of the universities. The hub could act as a highly specialised entity overseeing activities related to the industrialisation of research results, while universities could invest more resources in the production of knowledge. According to the representatives of SAMOTHRACE, the hub could thus become a regional accelerator to support the further development of a selection of flagship projects, namely the most promising prototypes and profitable technologies that would be able to respond to the needs of both regional and national industry. In the future development of the IEs, some ecosystems also encourage the idea of a federation of IEs to create a powerful tool with scientific, social and policy impact for the Italian university system.

Most ecosystems have not embraced a specific strategy discussion on future development while they are still waiting for input from the Ministry of University and Research (i.e. clarification on what is expected from ecosystems at the end of NRRP coverage). Choices

regarding evolution cannot ignore institutional legitimacy from the Ministry as well as the need for regional government involvement to create the essential synergy required to implement the Smart Specialisation Strategy.

6 Conclusion, policy implications and avenues for future research

This article is based on a selection of the most recent advancements regarding the organisation of the relationships for knowledge transfer within IEs (e.g. Amitrano & Bifulco, 2024; Audretsch et al., 2025; Breslin et al., 2021; Brito, 2018; Cavallo et al., 2023; Civera et al., 2024; De Moortel & Crispeels, 2024; Iacobucci & Perugini, 2021; Meng et al., 2019). The purpose of the study was to understand whether, and in what ways, the H&S model (Bridoux & Stoelhorst, 2022; Faccin et al., 2020; Lechner et al., 2023; Mayer, 2013; Visscher et al., 2021) matters in governing university-industry partnerships for knowledge transfer and co-creation.

Our research questions have sought to investigate the architecture and forms of application of the H&S model in IEs, and how, and in what ways, the H&S model can contribute to the internal and external relations of ecosystem actors. We have tried to conceptualise precisely how the H&S model connects actors across disciplines, industrial sectors and geographical areas.

Compared with the experiences observed in other countries in which the H&S model has been adopted, the novelty of the context examined in this paper is that the hubs are represented by universities, whereas, previously, all the cases examined in the literature had analysed hubs led by large firms. In the Italian case, the national government adopted a top-down approach and required IEs created by implementing a university-driven H&S model, in order to strengthen relations between universities and firms, as well as to promote knowledge transfer at a regional or cross-regional level. This means that universities act as focal actors. While there is large room for improvement, the analysis revealed that universities have different degrees of effectiveness in orchestrating the ecosystems. These findings advance the knowledge about the co-evolution of roles played by universities, acting as initiators, facilitators, coordinators, and stimulators during the emergence of ecosystems (Amitrano & Bifulco, 2024).

Overall, the representatives of the hubs agreed that the adoption of the H&S model has contributed to improving collaboration between universities and firms, and to promoting long-term paths for the development of innovation at the local level. About 80% of the respondents declared that they were “satisfied” or “highly satisfied” with the model. Moreover, most of the interviewees stressed that the H&S model facilitates the flow of communication between actors in the ecosystem in a novel and effective way, thus activating new, promising connections within the IE. Two-thirds of the respondents from the spokes were “satisfied” or “highly satisfied”. However, the stringent administrative constraints and the complexity of the architecture imposed by the H&S model, were seen as weak points. Indeed, several criticisms were associated with increasing bureaucracy in administrative procedures, especially in the universities. These concerns seem to be mainly determined by the regulations which discipline the use of the resources of the Next Generation EU Plan.

We identified three forms of the H&S model, depending on the geographical breadth of the relations between actors: urban ecosystems, regional ecosystems and cross-regional eco-

systems. In all these cases, the ecosystems have mainly been focused on internal relations rather than on international collaborations or on joint initiatives across different ecosystems.

We also conceptualised three models of knowledge transfer: centralised, decentralised and hybrid. These models are based on the level of coordination of activities among different actors of the ecosystem. Regardless of the model, the organisation of knowledge transfer and co-creation is usually fostered by involving private actors. This is especially clear in the spokes, where about two-thirds of the partners are firms and R&D companies. Moreover, part of the financial resources managed by the spokes are used to promote knowledge transfer and innovation in the private sector through public calls addressed primarily to SMEs and start-ups, most of them have to be based in Southern Italy.

The limitations of our study include the fact that it embraces only one specific context for H&S model adoption: we analysed a policy-driven intervention, in the context of the measures of the Italian NRRP. The H&S model was not chosen by innovation actors, and some key features were imposed by the Ministry itself. Therefore, generalization of results should be cautious and not extensive. Although the questionnaires and interviews targeted the governance of the hubs and spokes, including representatives with diverse roles in the IEs, different scientific backgrounds, and heterogeneous former professional experience, there is a lack of investigation on other ecosystem stakeholders or representatives of communities where the H&S model has been implemented. Furthermore, the IEs started functioning only after a quite recent policy intervention in 2022. In addition, investment of the stock of financial resources transferred to the 11 ecosystems has still not yet been completed since the NRRP will finish in June 2026. Thus, we were not able to conduct a full evaluation of the impacts generated by the policy on the territories where the IEs operate.

Future lines of research should investigate, with specific reference to the "Italian case", the implications of the H&S model for the innovation capacity of territories and therefore the efficacy of the NRRP measures as regards achieving its goals. In particular, there is a need for more quantitative studies to advance knowledge about territory-specific characteristics of ecosystems in diverse geographical areas (Cavallo et al., 2023). However, appropriate measures for evaluating knowledge transfer and co-creation capacity must be proposed and developed. Measures to assess impact should examine both university capacity to enhance teaching, research, and third missions through and within ecosystems as well as the innovation performances of firms. Moreover, attention should be paid to the link between the H&S model and the capacity to foster sustainable and inclusive practices in ecosystems and their communities. Another line of research should advance understanding of factors that promote the success of the H&S model as a means of enhancing knowledge transfer. However, there is, as yet, little evidence available regarding the "country-specific" or "place-based" features which might affect the implementation of this model.

While we acknowledge the limitations of our study, it does offer many suggestions for policymakers, universities and ecosystems.

For policymakers: the H&S model seems to be effective in promoting sustainable economic growth and innovation capacity. The ability of the model to drive social and environmental sustainability goals is less clear. So far, evidence about the application of the H&S model to IEs in other countries has referred to the relations between firms while there is a lack of evidence about the application of the model in the university context. Based on our findings, the university context could be the most appropriate for the adoption of the model, given the prominent role that universities already play in knowledge transfer and co-

creation activities, thus acting as catalysts of relations within the IE. This role is crucial in the Italian case, given the prevalence of SMEs. Moreover, the H&S model could be useful in similar contexts as a policy tool for better organizing the relations between universities and firms within IEs, thereby fostering cross-disciplinary and cross-sectoral research initiatives. The H&S model could also be implemented to trigger collaborative processes when the level of interaction among ecosystem actors is unsatisfactory or not spontaneous. In those areas characterised by multiple innovation actors and a limited capacity of universities to act as catalysers of knowledge exchange, the model could encourage a re-evaluation of the practices and attitudes of actors. When the H&S model is applied because of public policy, attention should be paid to evaluations of its initial impact, as well as to the post-start-up phase, when public funds are perhaps no longer available to sustain the ecosystem. Since public resources are often limited, it is recommended to identify a selection of trigger points within each IE. This may contribute to guide policymakers in adopting more effective decisions.

Also, any lack of a common, shared set of indicators for economic, industrial and social impacts might encourage opportunistic behaviours in institutions involved in the IE. At the same time, uncertainty about the long-term outcomes could prove to be one of the incentives that encourage the most expert actors to leave the ecosystems. If this happens, the H&S model might exacerbate any inequalities between actors located in underdeveloped areas and those in more advanced areas which will have better capacities to plan and activate collaborative networks for innovation. When implementing the H&S model, policymakers should consider its sustainability in the long run, both from the financial point of view and in terms of the commitment of the key actors involved. Moreover, attention should be paid to the relations between ecosystems which operate in different geographical areas. Indeed, increasing efforts towards the internationalization of IEs could well reduce both the risks and impacts of external and internal shocks, thanks to multiple sources of innovation and to the diversification of markets. However, internationalization seems to be a topic that is often neglected by policymakers.

For university governance: a limited capacity in knowledge transfer and co-creation could be enhanced by implementing the H&S model. This model could potentially act as a means for structural changes in industry-university relations. The hub could play an important role in promoting cross-disciplinary and cross-sectoral collaboration also by providing a mechanism for coordination. The spokes could collect and gather outputs of applied research and innovation from complementary research groups and firms within the same ecosystem. Indeed, an open-minded and forward-looking governance is necessary to overcome the pitfalls of a policy-driven action financed by public resources. The main risk is to be found in the post-funding phase when the ecosystems should be able to capitalise the resources provided by the government and act on their own strengths. Even in the case of a university, structural change is possible only if a long-term approach is followed, one that defines multi-level cooperation mechanisms to strengthen innovation capacity and co-creation with all the actors involved.

For ecosystem managers: implementation of the H&S model should be carried out alongside constant efforts to keep burden of any bureaucracy in administrative procedures at the lowest possible level. This could prevent private actors leaving the IE. Also, they should promote tools and incentives to reinforce trust in the value of collaboration between private and public entities. Showcasing good examples of cooperation, and disseminating practices,

could contribute to strengthening the reputation of the ecosystem, as well as to encouraging new partners to join in the mid-term. University commitment to the IE should always be kept high in terms of talent cultivation so as to benefit both ecosystem actors and local communities. Another important implication is related to the risk of "compartmentalisation" of both the spokes and of the knowledge produced within the H&S model. When spokes are too diverse and if there is no coordination mechanism for cross knowledge transfer and co-creation, the overall aims of the IE might be lost in the long run. Thus, it is crucial to foster co-designed research and co-created activities among research groups within the different spokes of the ecosystem.

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Declarations

Competing interests The authors declare no competing interests.

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