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The embedding of universities in innovation ecosystems: The case of marine research at the University of Bergen

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ABSTRACT

While historically the core missions of universities have been research and teaching, it has become increasingly recognised that universities have become significant sources of knowledge and capabilities. This third mission is cementing the role of universities as suppliers of qualified labour and generators of knowledge and technologies that promote innovation in a variety of innovation ecosystems. The main goal of the paper is to illustrate an approach that captures the various contributions of universities to their innovation ecosystems. Often territorially bounded, such links provide insights into the characteristics and geography of the various linkage for a university. With the case of the University of Bergen and its role within the marine innovation ecosystem of Western Norway, this 'ecosystem fingerprint', can be seen as a useful means to clarify the third mission of universities through the linkages and interdependencies with various actors. The authors demonstrate that a university can act both as a global pipeline provider and take active part in the local buzz, providing this concept with new empirical insight. The authors conclude that the university is highly embedded in both the marine innovation ecosystem and the knowledge ecosystem, but with linkages extended to interconnected business ecosystems.

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Introduction

Universities embedded in ecosystems

Universities, as well as other research organisations, are considered important players in innovation systems. This can be in terms of collaborative research with industry and public sector organisations, as providers of human capital, through production of academic publications, patents, and though the creation of knowledge-intensive new enterprises. Stimulated by different stakeholder policies, universities are becoming increasingly aware of, and acting on, their role as contributors to economic and social development in a global, national, and regional manner. This role is often referred to as the universities' 'third mission' (Etzkowitz & Leydersdorff 2000; Gulbrandsen & Slipesæter 2007; Laredo 2007).

Thus, universities impact regional, market, and societal actors through interconnections, whereby knowledge and other university-sourced capabilities are shared, transferred, or exchanged. To understand such actor interrelations, the ecosystem metaphor has become increasingly mobilised in the literature to understand a bounded system of innovating actors. In this metaphor, an ecosystem consists of a variety (or

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ecology) of organisms, the physical environment in which they are located, and the variety of interdependencies and interactions at play in a bounded system. The ecosystem concept was introduced into the innovation management literature by James Moore in the early 1990s (Moore 1993) and it adds to the concept of 'systems of innovation' that are frameworks for understanding innovation, such as industrial clusters, national innovation systems, and regional innovation systems (Freeman 1987; Porter 1990; Lundvall 1992; Cooke 2001; Asheim & Gertler 2005). Common to all these frameworks is that they describe actors, networks, different components, and the relations among them as influencing the innovation activities within a geographical area, a value chain, or an organisation.

Ecosystems are described as innovation systems that dynamically evolve over time and consist of networks and clusters of multiple firms, types of organisations, and individuals (Moore 1993; Autio & Thomas 2014). However, within the field of management and innovation studies there are now many, partially overlapping concepts, such as business, innovation, and knowledge ecosystems (Valkokari 2015). In addition, a variety of definitions exists for each concept, with clear emphasis on innovation ecosystems (Granstrand & Holgersson 2020; Klimas & Czakon 2021). Unfortunately, this has resulted in limited consensus and understanding among researchers and practitioners with regard to how and when to use the concepts (Valkokari 2015; Granstrand & Holgersson 2020). The different types of ecosystems have different logics of action. This means that the same actor can be involved in and play different roles in each ecosystem. Furthermore, the various ecosystems have a high degree of interconnectivity and they are evolving and emerging next to each other (Valkokari 2015). Accordingly, universities' third mission efforts are influenced by the ecosystems in which they are embedded. Hence, there have been calls for further research on the interaction between the different types of ecosystems, as well as studies of how particular ecosystem actors perceive their concurrent roles in different ecosystems (Valkokari 2015; Heaton et al. 2019).

The use of ecosystem linkages as a diagnostic tool

To understand the role, contributions, and interrelations between universities and other ecosystem actors, it is desirable to have an approach that uses an ecosystem-linkage diagnostic to capture (1) the types of connections and/or entanglements with ecosystem actors and (2) their intensity. The goal of this paper is to develop and demonstrate such a diagnostic tool with an ecosystem perspective.

The primary motivation for adopting the ecosystem perspective has been the desire to exploit a more self-organising system than the static structures regulated by government bodies (Valkokari 2015; Smorodinskaya et al. 2017). We also recognise the value of insights that shed light on the concept of 'regional buzz and global pipelines', as described by Bathelt et al. (2004). Benneworth & Hospers (2006) show that universities can become temporary venues for local buzz, and Brown (2016) illustrates how a university can engage very actively as policy actor in a region. For university managers at various levels, mobilising such a broader and deeper understanding of the university linkages within various ecosystems can be a first step towards developing a strategy for improved embedding of ecosystems (Robinson et al. 2016). The second step is to *distinguish* these 'understandings' in terms of descriptors and indicators that characterise the degree and form of embedding in various types of ecosystems with regard to the university and its collaborating actors in the systems.

This paper focuses on the second step towards developing a strategy for improved embedding of ecosystems, specifically the development and application of descriptors and indicators. Such indicators should provide knowledge with which to answer the following questions:

1. What types of links do universities have within innovation ecosystems?
2. How can the links provide insights into the performing of third mission activities in universities?
3. What can the links tell us about the relationships and dynamics between overlapping ecosystems?

We apply the ecosystem-sensitive 'research compass methodology' developed by Laredo & Mustar (2000) to the marine research environment in the University of Bergen in Western Norway, to which we add the concept of local buzz and global pipelines as presented by Bathelt et al. (2004). In a third mission context, research has traditionally aimed for excellence through global collaboration and output in terms of codified knowledge such as academic publications, which can easily lead to the conclusion that most universities have a role as a global pipeline provider. However, our study shows that universities in many ways contribute to the local buzz and thus illustrates how a university's third mission efforts are impacted by its embeddedness in ecosystems of different scale and scope.

The remaining part of this paper is structured as follows. The literature overview fleshes out the central goal

of understanding the role and performance of the third mission of universities in various innovation systems, with emphasis on the innovation ecosystem. Subsequent sections describe the analytical frameworks and methods to show how the modified research compass framework, together with the concept of local buzz and global pipelines, can be tailored to such settings, and hence how we apply the tailored framework to the specific case of the University of Bergen in the marine innovation ecosystem of Western Norway. Thereafter, we present and discuss our findings. Finally, we draw some conclusions, address the initial research questions, and suggest some implications for practitioners.

Literature overview

Innovation systems

Research on innovation systems was first introduced by Lundvall in the mid-1980s (Lundvall 1985) and has been done and developed in economic and social contexts since the 1990s. Such systems are characterised by the interactions of organisations (actors), networks (relations and/or linkages), and institutions ('rules of the game' such as legislation, and cultural and technical norms). There are several conceptualisations of innovation systems, including global, national, regional, corporate, sectoral, and technological. Research on national innovation systems (NIS) as defined by Freeman in the late 1980s (Freeman 1987) has concentrated mainly on the role of organisations such as firms, universities, and national government in stimulating technological innovation (Lundvall 1992; Nelson 1993; Freeman 1995; 2004; Suominen et al. 2019). The idea that innovation is a territorial and systemic process in a region led to emergence of the concept of a regional innovation system (RIS) (Cooke et al. 1997; Cooke 2001; Asheim & Gertler 2005). The most important aim of research on RISs has been to understand how different clusters or sectors interact with regional governance, research institutions, intermediates, support infrastructure, and the national and global levels of innovation policy and funding structures in order to obtain a competitive advantage (Doloreux & Gomez 2017; Suominen et al. 2019). The ecosystem concept has been developed in parallel with the both the NIS and RIS concepts. This is explained by the need to exploit more complex innovation systems that dynamically evolve over time and are self-organised compared with the structured and static innovation systems regulated by government bodies (Valkokari 2015; Smorodinskaya et al. 2017).

Ecosystems in management literature

James Moore's article 'Predators and prey: A new ecology of competition' (Moore 1993) is considered as marking the establishment of the ecosystem concept within management literature. The metaphor is taken from biological ecosystem and various concepts have since emerged such as business ecosystems, innovation ecosystems, knowledge ecosystems, and digital and entrepreneurial ecosystems, and each of the concepts seems to have a different theoretical background (Valkokari 2015; Tsujimoto et al. 2018). The significance of the ecosystem concept lies in its use in the analysis of organic networks that are based on the competitive and collaborative and/or symbiotic behaviour of the organisms in the system, as well as external physical factors affecting the system. In addition, all actors in the system have their own role to play, with different attributes, decision-making, and purposes. In common with NISs and RISs, the boundary of an ecosystem is not limited to a geographical area or a cluster, but is concentrated around a value chain, a product, a platform, or an organisation, and it consists of both business and non-business actors (Valkokari 2015; Tsujimoto et al. 2018). Ecosystems evolve dynamically through interactions between actors and their boundaries can be set by geographical (global, national, or regional), permeability (open or closed), or temporal (time and/or history) scale or by type of flows (knowledge, technology, products, or services) (Valkokari 2015).

Valkokari (2015) distinguishes between three types of ecosystems: business, knowledge, and innovation ecosystems. In *business ecosystems* the economic outcomes and business relations among actors are highlighted. The value creation for customers is in focus and typical key actors are larger firms. Concepts such as digital, industrial, and service ecosystems are considered subconcepts of the business ecosystem concept. *Knowledge ecosystems* are concentrated on the generation of new knowledge and technologies through joint research, commercialisation projects, and other forms of knowledge and technology transfer. Research organisations and technological entrepreneurs have a central role in such systems. *Innovation ecosystems* are considered as integrating mechanisms between the exploration of new knowledge and the exploitation of such knowledge for value creation. Typical actors are regional clusters, intermediates, and innovative start-ups, policymakers, funding agencies, seed funders, and venture capitalists.

The concept of innovation ecosystems has emerged gradually in line with the growing importance and demands of the non-linear and knowledge-based economies, and the literature on innovation ecosystems

typically focuses on the individual actors, assets (such as platforms), links, and networks within a region (Adner 2006; Bogers et al. 2019; Granstrand & Holgersson 2020). The informal English adjective 'eco' serves to emphasise the non-linear nature of innovation (Smorodinskaya et al. 2017). However, the value of adding 'eco' to innovation system concepts has been questioned (Oh et al. 2016). In a comprehensive review of different definitions of 'innovation ecosystem', Granstrand & Holgersson (2020) argue that the concept does contribute to innovation system research, but it needs to be sufficiently well-defined and employed in an appropriate context. They also find that the most important components of an innovation system are 'actors', 'artifacts' (defined as items such as products, services, resources, and technologies), and 'activities', which are dynamically linked through relations, collaborations, and competition, as well as their relations with other ecosystems. Valkokari (2015) highlights that the relationships and dynamics between overlapping ecosystems is an important research theme and that there is a need to develop tools to enable boundaries between the ecosystems to be crossed.

Universities and the third mission

The concept of the third mission is described as nebulous (Laredo 2007; Gregersen et al. 2009), but it is an evolving and widely recognised concept linked to knowledge and technology transfer and to the engagement of universities with industry and society beyond the two other missions of education and research (Giuri et al. 2019; Compagnucci & Spigarelli 2020). There has been a widespread recognition that the third mission is becoming increasingly important, especially for regional development (Etzkowitz & Leydersdorff 2000; Laredo 2007; Benneworth & Sanderson 2009; Sánchez-Barrioluengo & Benneworth 2019). Encouragement has come from governments and industrial actors, as well as from university managers themselves (Gulbrandsen & Slipersæter 2007; Perkmann et al. 2013; Jiao et al. 2016; Hayden et al. 2018). In addition, there has been a substantial increase in internal university support for entrepreneurship, innovation, and commercialisation activities, and this illustrates the transformation towards entrepreneurial universities (Etzkowitz et al. 2000; Etzkowitz 2017; Sánchez-Barrioluengo et al. 2019). This development has been fuelled by the increasing prevalence of innovative clusters at the regional level and universities' collaboration with them (Dodgson et al. 2014; Etzkowitz 2017).

The ability of actors within innovation systems to absorb knowledge depends on their capability to recognise, assimilate, and apply new academic information for innovation purposes, a process that is often termed 'absorptive capacity' (Cohen & Levinthal 1990; Cockburn & Henderson 1998; Agrawal 2001; Powell & Grodal 2005; Salge & Vera 2012). Universities have been shown to have different roles influenced by their location, and geographical factors are important for how universities execute their third mission (Trippl et al. 2009; Breznitz & Feldman 2012; Kitagawa et al. 2016; Heaton et al. 2019).

Traditionally, universities have been evaluated based on how they execute their third missions according to their ability to patent and license technology and to create spin-off based on university research (Guldbrandsen & Slipesæter 2007; Breznitz & Feldman 2012). However, universities are in a wider sense societal actors through their education of skilled workforces, their participation in policymaking, culture, architecture, and innovation infrastructures, and through their creation and dissemination of knowledge (Breznitz & Feldman 2012; Sánchez-Barrioluengo & Benneworth 2019). According to a broader definition of the third mission, universities are expected to engage in their respective region's social and societal deliberations and decision-making processes, and by providing a window to the world for their local region (Chatterton & Goddard 2000; Pawlowski 2009; Breznitz & Feldman 2012; Blume et al. 2017). Recently, a stronger focus on the transition of universities' strategies to sustainability and to green and social innovation has emerged (Benneworth et al. 2016; Reichert 2019).

By exploring our case, we aim to contribute to a broader understanding of how the linkages between the universities and different actors in an innovation ecosystem both function and evolve.

Analytical framework

The embeddedness of innovation systems and the concept of local buzz and global pipelines

Innovation systems in general and regional-based systems in particular are highly embedded by nature. As stated by Bathelt et al. (2004), when locally embedded knowledge is combined in novel ways with codified and accessible external knowledge, new value can be generated. This concept has become known as local buzz and global pipelines. Local buzz refers to the thick web of information and knowledge that is embedded within and circulates among actors within a cluster. It is created by face-to face contacts in mutual arenas with the possibility to meet and co-locate people, companies, and other organisations within the same industry or region. Such local buzz consists of specific information, knowledge, and technology transfer, and

the possibility for learning, associated with continuous updating. The nature of the buzz is spontaneous and flows easily within the cluster, and the various actors can access the buzzing information without much investment in time or other resources. By contrast, global pipelines refer to a deliberately established connection to global knowledge linkages. The information and knowledge that flows through such pipelines are far from being automatic and participation does not come without costs. The establishment of global pipelines with new partners requires that new trust will be built in a conscious and systematic way, which takes time and involves investments. Bathelt et al. (2004) argue further that the extra-local knowledge coming from the global pipelines is spread by the mechanism of the local buzz within a cluster, and due to global pipelines' potential to intensify local interaction, they support and strengthen the translation processes within a cluster.

The concept of local buzz and global pipelines has often been discussed in the literature and is acknowledged for deepening our understanding of the interrelatedness of local and non-local knowledge linkages that promote innovation processes within a cluster (Trippl et al. 2009; Fitjar & Rodríguez-Pose 2015; Aarstad et al. 2016; Musil & Eder 2016) However, the concept has also been subject to criticism for being too general and because the distinction between local and non-local relationships is too broad, which does not allow for deeper insights into the mechanisms by which actors gain knowledge and expertise at different spatial scales. In addition, it has been pointed out that there is a lack of empirical evidence in support of the concept and there has been a call for studies that explicitly examine whether the local buzz and global pipelines merely substitute and reinforce each other (Aarstad et al. 2016; Musil & Eder 2016).

The research compass methodology

To create an ecosystem linkage diagnostic tool for universities, as well as to capture the important territorial context and embedding described in the preceding subsection, we operationalise the 'research compass methodology', which was developed as a framework to collect and characterise the territorial embedding of universities (Laredo & Mustar 2000; Robinson et al. 2016). By exploring the characteristics and geography of the various links to and from a university, we aim to clarify how universities perform their third mission activities and position themselves as actors within an innovation ecosystem. The methodology acknowledges that measuring the dynamics of science by codified knowledge (e.g. through scientific publications) alone is not sufficient, due to the complex nature and relationships between research organisations, industry, and society.

A research laboratory is described as a laboratory for conducting research or investigation into science and can be both public and private, a separate organisation, or part of a larger organisation or company (Laredo & Mustar 2000). The research compass methodology captures five dimensions of activities in which research laboratories are considered to interact with industries and society: (1) certified knowledge instruments, (2) training as embodied knowledge, (3) competitive advantages – the innovation aspect, (4) research and public debate, and (5) policy and society links (Fig. 1). The degree of involvement within each of the five dimensions, or impacts, of the compass defines a mix specific to the laboratory in question and is called its 'activity profile'. It also demonstrates that simple indicators are sufficient to measure the levels of involvement in each activity. The methodology acknowledges that it is difficult for research laboratories to be strongly involved in all activities and it describes two extreme situations where (1) the only contributions are in the form of codified knowledge such as publications, and (2) activities are dedicated solely to gaining competitive advantages in order to foster innovation in industry.

For our study we used the research compass methodology in data collection and contextualisation of links to and from the marine biological and biotechnological activities at the University of Bergen (UiB) in Norway. The marine activity at UiB is not strictly defined as a research laboratory. However, Laredo & Mustar (2000) convincingly argue that activity profiles across institutional and disciplinary barriers are of more importance to how a laboratory interacts with society and industry than to the organisation of the laboratory itself. By this, they mean that the combination of strategies developed by the different laboratories and the organisations to which they belong, their logics of actions, and the norms, procedures, and policies that accompany, foster, or inhibit them are superior to organisational structures. Therefore, we hold that the research compass methodology is transferable to the creation of an ecosystem-linkage diagnostic tool for a university, which can consist of many types of research laboratories. We have used the research compass methodology to capture the five dimensions of activities in which universities interact with industry and society in a specific field, namely marine research. This field corresponds to a research laboratory in the methodology. We have also added the concept of local buzz and global pipeline (Bathelt et al. 2004) to our methodology, thereby contributing a spatial quality to the five dimensions in the research compass. To put our

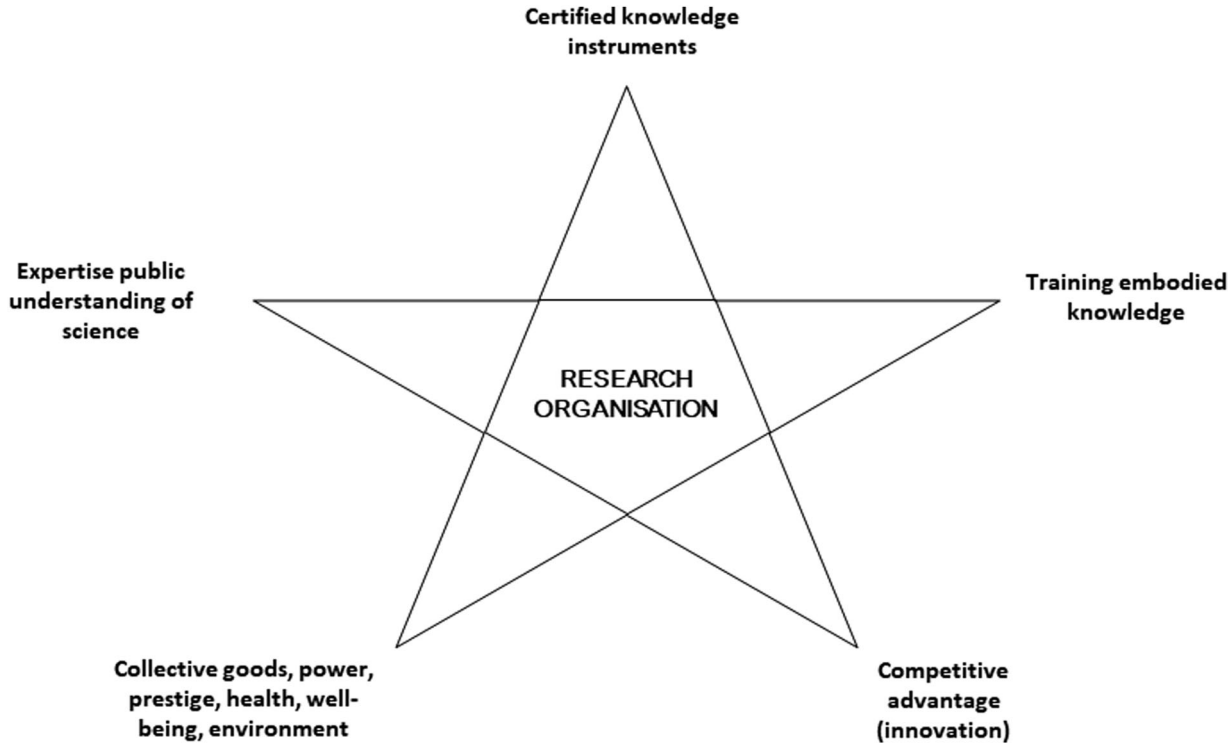

Fig. 1. The research compass and its five forms of impact to be measured in the activity profiling methodology (adapted from Laredo & Mustar 2000, 521)

research in context, we use the definition of innovation ecosystem formulated by Mazzucato & Robinson (2018, 168): 'The network of interconnected actors, organised around a particular value chain/industry where the actors include public agencies, firms, intermediates and other actor that contributes to the production and use of a product or service stemming from that value chain/industry'. Mazzucato & Robinson point out that according to their definition the innovation ecosystem can be both regionally bounded to a city and/or region or it can be global. We assume that the definition covers the components of an innovation ecosystem as described by Granstrand & Holgersson (2020). Accordingly, we have created a lens through which to understand the meaning and position of the various links a university has within the innovation ecosystem and beyond.

Research design and methodology

Robinson et al. (2016) developed the 'territorial embedding analysis' (TEA method) as an assessment tool, based on the research compass methodology, as a part of the Horizon 2020 project EMBRIC: 'European Marine Biological Research Infrastructure Cluster to promote the Blue Bioeconomy'. The tool captures the links and indicators used for activity profiling. A description of the items in the data set linked to the compass is provided in Table 1. In addition, in acknowledging the importance of artifacts and infrastructures such as platforms, intermediates, networks, and common resources in innovation ecosystems, we collected a comprehensive list of the most important platforms, intermediates, and networks in which UiB either plays or has played an important role. Our methodology, although not new in origin, corresponds very well to state of the art within knowledge and technology transfer measurements (Campbell et al. 2020).

Our data cover the field of 'marine research' at UiB, which in this study, and in accordance with the definition in the EMBRIC project, we define as 'research, innovation, and training within marine biology, including aquaculture, and marine biotechnology in addition to stock-assessment/management and fisheries'. The data presented in this paper relate to the period 2010–2017 and were systematically collected in 2017 and 2018. However, also some newer data have been included, especially in the case of data concerning infrastructure, policy, and society links. To identify relevant publications (Table 1, 1a), we identified a set of scientific keywords and extracted data from the database for Norwegian academic publications, Cristin. The database Web of Science was then used to extract the names of all co-authors. To identify the competitively funded

Table 1. Descriptions for data collection for territorial embedding analysis (TEA method, Robinson et al. 2016) along the corresponding five dimensions of the research compass methodology

Data set linked to the five dimensions in the research compass	Territorial embedding analysis description (based on Robinson et al. 2016)	Data collected in this study
Scientific institutions 1. Certified knowledge instrument	(1a) Peer-reviewed academic publications identified as broadly linked to the field in question	All recorded marine publications from the University of Bergen (UiB) in the period 2010–2017 (extraction based on keywords from bibliometric databases and information systems)
	(1b) Competitive publicly funded projects, most often from public funding organisations (e.g. European Commission, national research councils) but can also include, for example, regional funds and foundations	Data collected on all competitively funded projects at UiB financed by the Research Council of Norway, the EU, and others, in the period 2010–2016
Educational system 2. Training embodied knowledge	Professional and academic training activities from the research centre broadly linked to the field in question	Data on all marine courses directed towards professionals in the period 2010–2017 Data on all the marine PhD graduates from UiB and their first job in the period 2010–2017
Economic system 3. Competitive advantage (innovation)	(3a) Economic relations between the research centre or university and the private and public sector. This includes, for example, contract research, consultancy, service provision, provision of a PhD student, and commercial use of infrastructure.	Data collected on all economic links and contracts involving UiB within marine activities in the period 2010–2016 Data collected on all patents within the marine field from UiB in the period 2010–2016
	(3b) Patents as broadly linked to the field in question	
Public authorities 4. Collective goods, power, prestige, health, well-being, environment	Participation in standardisation organisations, for example on boards and policy committees, broadly linked to the field in question	Data collected on a variety of policy links from UiB in the period 2010–2016 (not exhaustive)
Museums, public debate 5. Expertise and public understanding of science	Links between the research centre (and individual researchers) with civil society broadly linked to the field in question (society links)	Data collected on a variety of society links from UiB in the period 2010–2016 (not exhaustive)

research projects (Table 1, 1b), we used lists from the Research Council of Norway (RCN), the Horizon 2020 database (EUPRO and Cordis), and additional lists provided by departments at UiB and the Sars International Centre for Marine Molecular Biology, which is based at the university. Additionally, information about the various data and projects was collected from the research projects' webpages and databases.

Information relating to training portfolios (Table 1, row 2) was provided by the Department of Biological Sciences at UiB. To obtain information on doctoral degrees, we used lists from a database held by NIFU (Nordisk institutt for studier av innovasjon, forskning og utdanning), supplemented by information from institutional websites, social networks such as Facebook and LinkedIn, and personal contact by e-mail or personal communication. Contracts with public and private sector actors (Table 1, row 3) were provided by departments at UiB, Vestlandets innovasjonsselskap AS (VIS), and UiB's Technology Transfer Office (TTO). Data on relevant patents (Table 1, 3b) were collected from the VIS patent database. Additional information on the patents was extracted from the European Patent Office's PATSTAT database and Google Patent. For policy and society links (Table 1, rows 4 and 5), data from UiB were extracted from Cristin and a variety of sources provided by UiB. For the collection of data not formally registered by UiB, we contacted 50 scholars. The departments and contacted persons were selected due to their associated activities, which were deemed relevant for the data in question as suggested by department and university managers in various positions, and by the 'snowball' method. The data collection was not exhaustive for the period in question and the timespan might have varied for the different data sets, especially for data within the area of research, training, policy, society areas, and infrastructures. However, we consider the material provided an adequate description of the activities. Strategic documents were collected in collaboration with UiB managers, researchers, VIS, and representatives from the regional industry clusters. The CorTexT platform was used to analyse both publication and project data.[1]

Characterising the ecosystem embedding of the marine research environment at the University of Bergen

Setting the scene

In this section we apply the research compass framework to the marine research environment at the University of Bergen in Western Norway. The region has a longstanding tradition in harvesting seafood and holds

[1]For additional inks to data sources and other resources used in the research, but not cited or referenced in this paper, see Supplementary Appendix 2.

a prominent position in the global seafood market for fish, production, processing, and sales. Since the early 1970s the region has been central in the development of the modern global aquaculture industry. Additionally, it has all the components for 'blue bio' knowledge and innovation ecosystems (Valkokari 2015; Andersen et al. 2016; Fløysand & Jakobsen 2016; Connected Places Catapult 2021). The actors within the ecosystems cover the whole value chain, ranging from the production of fry and fish to the processing and export, equipment suppliers, R&D institutions, common technological platforms (i.e. industrial catapults), and several intermediates such as industry cluster organisations, incubators, and a technology transfer office. Furthermore, the region hosts the headquarters of a number of Norway's multinational and international seafood companies, several of which have been central in innovation and in developing market opportunities for fresh fish, making Norwegian seafood, especially farmed salmon, an important export commodity.

Western Norway is home to many important research organisations within marine sciences, which contribute in terms of educational programmes within aquaculture and engineering, as well as the scientific management of fisheries. These research organisations have also contributed to the development of modern aquaculture through collaborative research and development, along with education within fields such as fish biology and farming technologies. UiB has marine research as a strategic priority (University of Bergen n.d.) and is recognised internationally across a diverse range of marine sciences, and for excellence within selected areas of teaching in marine disciplines (Kiørboe et al. 2014; QS Top Universities 2018). The university is also the official United Nations Academic Impact (UNAI) SDG Hub14: Life Below Water, as well as a member of the International Association of Universities. UiB has been active in both the establishment and maintenance of many of the marine infrastructure initiatives in Western Norway, both within research and innovation.

We believe the marine research environment at UiB, as an integrated part in the marine innovation ecosystem described above and with its overlapping links to business and knowledge ecosystems, serves well as a case for the application of ecosystem-linkages as a diagnostic tool. In the following subsections we elaborate on our key findings and interpretations of these links.

Scientific institutions: profiling through certified knowledge instruments

The CorTexT-based analysis in our study revealed that marine scientists at UiB engaged in a large amount of international collaboration. However, other national universities and research institutions, and even regional ones, are still the most frequent collaborators (Fig. 2).

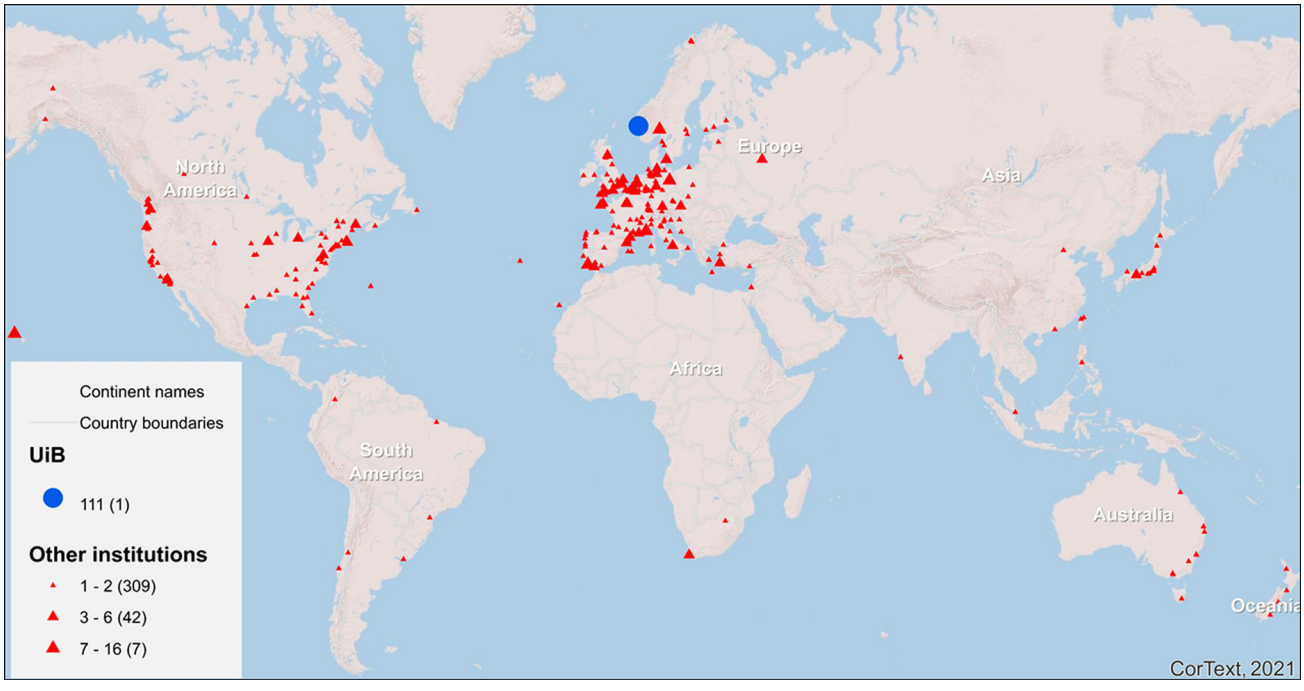

Fig. 2. Location of co-authoring institutions mentioned in publications within marine biology produced by UiB between 2010 and 2014 (map not to scale) (Generated by CorText, based on the data sources the Sars International Centre for Marine Molecular Biology, Cristin, and Web of Science)

Table 2. Collaborative partners in competitive-funded 'blue bio' related research projects (data are from projects for which UiB was a coordinator or partner, 2010–2016)

Institution	Type	No. of projects
Institute of Marine Research (including NIFES)	Pub	49
NORCE (formerly Uni Research AS)	Pub	36
VIS AS (formerly BTO AS)	Pub	15
University of Oslo (UiO)	Pub	13
Norwegian University of Science and Technology (NTNU)	Pub	12
Nofima AS	Pub	11
The Norwegian Seafood Research Fund (RCN)	Pub	8
Consejo Superior de Investigaciones Científicas (CSIC), Spain	Pub	7
Norwegian Biodiversity Information Centre	Pub	7
Stichting Dienst Landbouwkundig Onderzoek, Netherland	Pub	7
Centre national de La recherche scientifique (CNRS), France	Pub	5
Hellenic Centre for Marine Research, Greece	Pub	5
L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), France	Pub	5
Lerøy Seafood Group Asa	Priv	5
Norwegian Centre for International Cooperation in Education	Pub	5
University of Helsinki, (UH), Finland	Pub	5
Wageningen University and Research Centre, Netherland	Pub	5
Technical University of Denmark (DTU)	Pub	4
Natural Environment Research Council, UK	Pub	4
Norwegian University of Life Sciences (NMBU)	Pub	4

Furthermore, we collected data on competitive projects that had been awarded funding based on expert reviews. The source of funding, as well as the size and form of finance, can provide useful insights into the institutional profile. In total, 82% of the funding came from national funding sources, mainly the Research Council of Norway (RCN) and the Norwegian Seafood Research Fund (FHF). Public funding agencies are considered important governmental actors in the innovation ecosystem and therefore we have reason to believe that the RCN, FHF, and EU, through their research and innovation programmes and strategies, all have significant influence on the evolvement and dynamics of the marine innovation ecosystem in Western Norway. The regional funding sources were mostly from private research foundations based in the region, and the absence of regional governmental funding was striking.

Regional and national institutions dominate the top 20 collaborative partners in research projects in Norway. The Institute of Marine Research (IMR) and NORCE, both of which are national research institutes with head offices in Bergen, are top collaborators (Table 2). It is noteworthy that an intermediate organisation, VIS, which is a regional innovation company and UiB's TTO, is listed in third place, thus indicating the close involvement of innovation in UiB's marine biology research.

Education system: profiling training

According to Laredo & Mustar (2000), profile training constitutes an important activity for many research organisations. Through training, research organisations can become vehicles for capacity building, especially in the local sphere of an innovation ecosystem, and can provide skilled workforces to build socio-economic value. Also, research centres and universities involved in such training can attract talent to a region (Benneworth & Hospers 2006). For our study, we characterised the training activities into four different categories (Table 3, a). In addition, we tracked all biology PhD candidates who graduated in the period 2010–2017 (n = 141). Of those, 79% were awarded a PhD within a marine field and 92% of those, regardless of nationality, eventually found their first job in Norway. The two local institutions, IMR and UiB, were by the far the dominant first employers for the PhD graduates.

Table 3. Categories of training (2010–2017), contracts (2010–2016), policy (2010–2016), and social links (2010–2016) identified in the study (sources: UiB and VIS databases, supplemented with information from departments and individual researchers at UiB)

3a) Course/event directed towards following types of attendees	**No. of courses/ events**	**%**
Professional from industry	1	2.4
Professionals from public organisations (incl. schools)	9	21.4
Graduate	27	64.3
Postgraduate	2	4.8
Researcher	3	7.1
Total	**42**	**100**

3b) Type of contractual relation	**No. of contracts**	**%**
Consultation/contract research	98	51.0
Product development/commercialisation	55	28.6
Licence agreements	17	8.9
Other*	11	5.7
Start-up/Spin-off	6	3.1
Services	4	2.1
Collaborative groups/laboratories	1	0.5
Total	**192**	**100**

*Mainly contract research in terms of PhD candidates engaged in doctoral projects in industry as part of the Research Council of Norway's industrial PhD scheme, funding of master's projects, and adjunct professorships funded by the industry

3c) Type of policy link	**No. of links collected**	**%**
Building markets	6	7.8
Participation in politics of a domain	13	16.9
Producing data for policy	13	16.9
Research and innovation agenda setting	45	58.4
Total	**77**	**100**

3d) Type of society links	**No. of links collected**	**%**
Participation in debates	19	31.1
Public outreach (self-organised)	40	65.6
Other	2	3.3
Total	**61**	**100**

Alumni from universities facilitate communication between universities and wider society, and thus strengthen both social capital and learning (Pavitt 2005; Perkmann & Walsh 2007; Grimpe & Hussinger 2013). A survey of master's students (Høgestøl & Bjørnebekk 2018) and our findings relating to PhD graduates showed that such UiB alumni tend to stay in the region, and thus contribute to knowledge and technology transfer through research and innovation activities within the regional innovation ecosystem.

Economic system: profiling competitive advantages

Contracts

The vast majority of the economic links and contracts within marine biology are with private companies, and where contracts with a few multinational aquaculture companies situated in Western Norway dominate (Table 1 and Table 3, a). We categorised the links into seven types of contractual relations (Table 3, b). Fig. 3 shows the geographical distribution of the links to and from UiB. Only six contracts involved insitutions outside Europe. The European links were diverse, but larger multinational companies dominated. More than half of the national contracts involved local companies and public organisations. This is in accordance with our findings that the international contracts mainly involved larger multinational companies, many within pharmaceuticals and biotechnology, and were not necessarily dependent on proximity to the coast. The geographical distribution along the coast for the regional and national links illustrates the historical emergence and genesis of a marine innovation ecosystem and the 'blue bio' profile at UiB. The nature and distribution of the links in our data

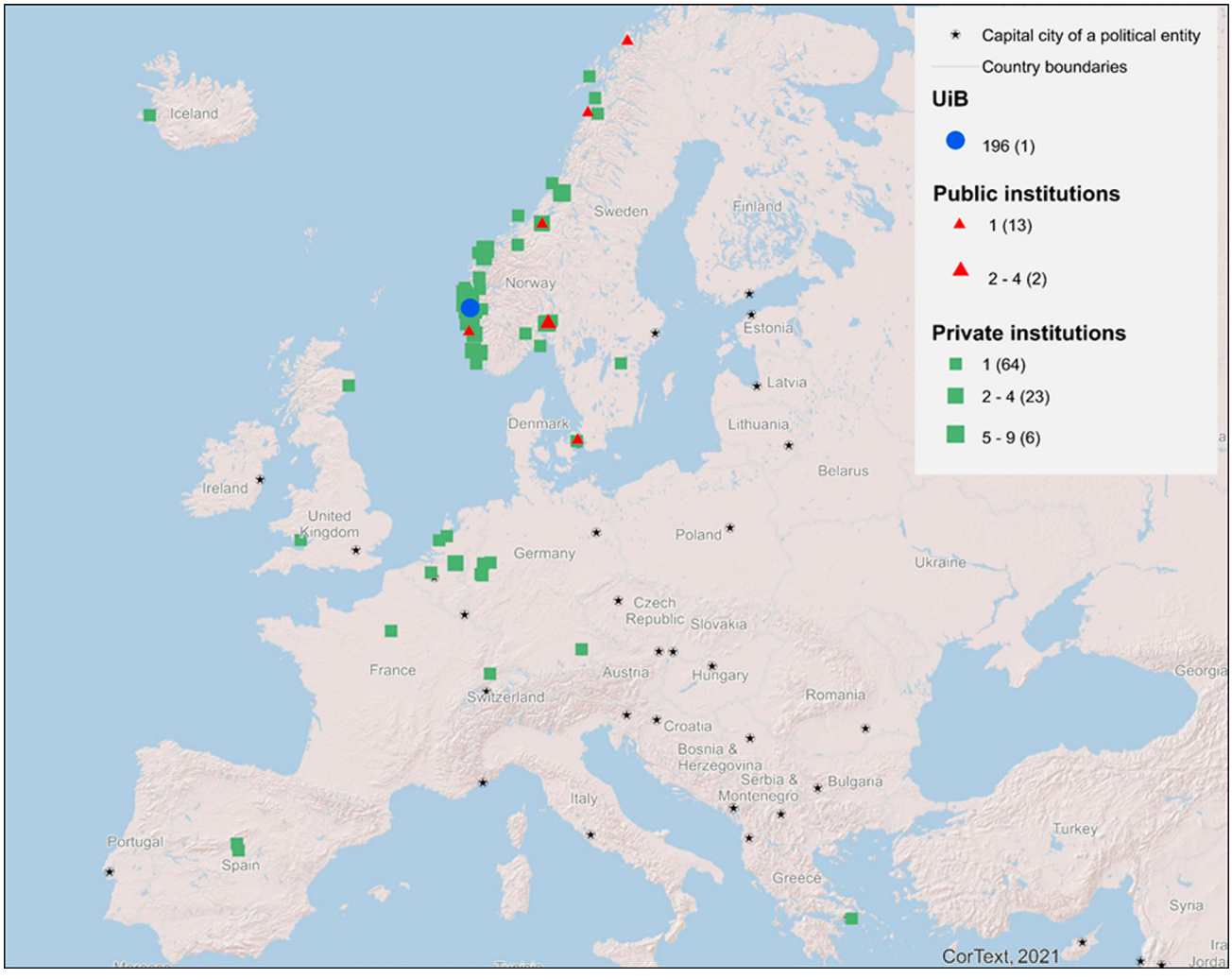

Fig. 3. Location of partner institutions with economic linkages to and from UiB in the period 2010–2016 (map not to scale) (Sources: UiB databases and VIS databases, supplemented with information from the Faculty of Mathematics and Natural Sciences and the Department of Biological Sciences at UiB)

indicate the presence of a business ecosystem, as defined by Valkokari (2015). The business ecosystem seems to be dominated by a few strong regional-based multinational firms but is not strictly restricted to a regional sphere. The business ecosystem also consists of many small and medium enterprises (SMEs) along the value chain and with which UiB collaborates. These links suggest that UiB may take part in the local buzz, as defined by Bathelt et al. (2004). Our findings also show the presence of a global network in which UiB has long-term collaborations with multinational firms, thus suggesting that UiB may act as global pipeline in the region. Furthermore, UiB is a contributor to innovation and commercialisation activities through licence agreements and academic spin-offs within 'blue bio', thus indicating the presence of a marine knowledge ecosystem.

Patents

According to the research compass methodology, the transformation of an idea into proprietary knowledge is considered an important part of the competitive advantages for a research organisation. A total of 29 marine biology patents were registered in the VIS patent database by inventors at UiB in the period 2010–2016. Seven of the patents were priority patents and all but one were linked to marine biological applications and projects where the inventors were strictly local and the applications and projects were the result of long-term collaboration.

The exploitation of marine resources is considered a new frontier and the value of patents within the field has been discussed, especially with regard to marine genetic resources (Strand 2013). The willingness to patent within aquaculture, marine biology, and biotechnology seems low in Norway compared within the life sciences (Herstad & Sandven 2017). The FHF, which is an important funder of aquaculture research in Norway, requires that all results generated from their projects must be openly accessible. This may partly explain the limited patenting within marine resources. In addition, according to a research and innovation manager at Lerøy Seafood Group, the marine industry has reduced interested in research collaboration when research organisations want to patent the results themselves (H. Sveier, personal communication, 2020). Norway generally performs low in terms of patent generation, and in this regard the former county of Hordaland (now part of the county of Vestland), where Bergen is situated, is below average by Norwegian standards (Norges forskningsråd 2019). Furthermore, Strand (2013) shows that Hordaland has also performed low in the industry part of R&D expenditures and average in terms of securing industry-related rights, such as patents. However, VIS has a large portfolio of marine commercialisation projects compared with other TTOs and has been appointed by the Research Council of Norway as a national coordinator for marine commercialisation activities.

Thus, our findings demonstrate the existence of an innovation ecosystem where the innovation and commercialisation activities are taking place without a high dependency on patents within the field. This in turn suggests there is a more open and transparent innovation system fuelled by the policy of the funding agency, FHF.

Public authorities: profiling connections with policy

Universities and other research institutions are linked to the overall research and innovation ecosystems through various policy and societal links at local, national, and global scale. Representatives from research organisations can be highly involved in political and economic forums and committees as experts and advisors, as well as through board memberships in companies, public organisations, and associations. In the case of the University of Bergen, data on 77 links from activities within the period 2010–2017 were identified and collected from different sources and divided into four categories: (1) building markets, (2) participation in the politics of a particular domain, (3) production of data for policy, and (4) research and innovation agenda setting (Table 3, c). The geographical distribution of the policy links was evenly distributed. It should be emphasised that many of those links are associated with themes within sustainability and environmental issues supporting a transition of UiB's strategies and activities into sustainability and green and social innovation.

Media, museums, and public debate: profiling connections with civil society

Research organisations can be embedded in their regions through strong relationships with civil society (specific and general publics) (Table 3, d). Our findings show that the links were quite diverse, but the public outreach category (e.g. open seminars, conferences, fairs, meetings) was most prominent, followed by participation in debates. The links were highly dominated by regional events (92%), implying that these kinds of links contribute to the local buzz.

UiB's role in developing and maintaining marine infrastructures and networks

Infrastructures are mediators and drivers of regions (Robinson et al. 2016), and they provide sustained

connections with the various 'spheres' of the research compass. In addition, they are important part of the innovation ecosystem. Therefore, many of the infrastructures connected to UiB are important for understanding the overall contribution of the university as a participating actor in society. We assume that the start of the marine innovation ecosystem occurred in 1989, with the establishment of the High Technology Centre in the city of Bergen (Høyteknologisenteret i Bergen) and the shared Industrial and Aquatic Laboratory (ILAB) at UiB (Table 4), in which the university was central. Since then, the innovation ecosystem has grown substantially, and many new intermediates and shared technological platforms have emerged, especially in the last decade.

Summarising the activity profile in relation to the business, the knowledge, and the innovation ecosystem

The links identified through the activity profiling in our study demonstrate a university with many connections and different roles in the innovation ecosystem surrounding the marine value chain in Western Norway. A summary of our main findings and key interpretation is presented in Supplementary Appendix 1.

The local connections between UiB and other research organisations, companies, intermediates, and networks are dominant in all dimensions of the research compass, also in addition to many global connections. This is especially the case with the many links from co-authorship in publications and partnerships in research projects, but also found in contracts with international companies and through the various policy links from international committees, global infrastructure, and networks. Together, these links demonstrate how UiB contributes as a global pipeline in Western Norway. We also see that the research compass dimensions of the certified knowledge instruments, training embodied knowledge, and, to a certain degree, the dimension of competitive advantage in many ways correspond to a knowledge ecosystem, as described by Valkokari (2015). The knowledge ecosystem is characterised by knowledge exploration and knowledge exchange, and it consists typically of research organisations and technology entrepreneurs. We also see, mainly through the links from the dimension of competitive advantage, the contours of a marine business ecosystem, with actors such as suppliers, customers, and focal companies as a core, many of them multinational.

The innovation ecosystem integrates the exploration (knowledge) ecosystems and exploitation (business) ecosystems, and the baseline of the ecosystem is co-creation of value (Valkokari 2015). In our study we found the innovation ecosystem around UiB expressed by all the geographically clustered links to various actors in the region. We identified the influence of funding agencies such as the RCN, EU, and FHF in competitive funded projects, the connections to intermediates such as VIS, and collaboration with industry cluster organisations. Many infrastructures, platforms, and networks within research and innovation, and where UiB has a role in establishment and/or maintenance, must also be considered important part of the innovation ecosystem. In addition, the training events for professionals and the various industrial-tailored educational programmes established by the university, along with the absorptive capacity associated with the many master's and PhD candidates who tend to stay in the region after graduating, are recognised components of the system, adding to the local buzz.

Intermediates are considered an important part of innovation ecosystems (Kivimaa et al. 2019). Based on the frequencies and nature of the links, we see that many of the intermediates, such as VIS and industry cluster organisations, and infrastructures and platforms, such as industry-related catapults, typically span the boundaries between the three different ecosystems, as illustrated in Fig. 4. It should also be emphasised that the large number of such intermediates and platforms in the marine innovation ecosystem, indicating a numerous and intricate set of actors, adds to the complexity of the system.

The marine innovation ecosystem in Western Norway has a typical regional concentration but must be considered global in its boundaries. Furthermore, it seems characterised by a transparent and open innovation culture, fuelled by the policy of the funding agencies such as the FHF and encouraged by the multinational leading aquaculture companies in the business ecosystem. Historically, UiB has been very active in the development of important elements of the innovation ecosystem such as the High Technology Centre, the shared marine infrastructure platform ILAB, and the establishment of the intermediate innovation company and TTO, VIS. However, our links from the period 2010–2017 indicate a story of the university's declining role as a leading actor in the innovation ecosystem. Although present, UiB does not seem to have a significant leading role in the regional policy links or local infrastructures included in our study. In addition, important local governmental bodies such as Vestland County Council and Bergen Municipality seem to have few visible research or innovation links to and from UiB. However, we find that national and global organisations such as the RCN, EU, and FHF seem to

Table 4. The University of Bergen's role in the establishment and maintenance of important infrastructure in the marine innovation ecosystem (sources: information on affiliation from both the Faculty of Mathematics and Natural Sciences and the Department of Biological Sciences at UiB, in addition to available web pages for the listed infrastructures and networks)

Infrastructure	Description*
Collaborative structures and/or spaces	
ILAB (Industrial and Aquatic Laboratory) (1989) Regional	A foundation for management of the wet laboratory facility for aquaculture and other tank-based research set up between the UiB and Marineholmen, in Bergen
Espeland Marine Biological Station (1957) Regional	The station is owned by UiB and has several specialized marine facilities.
Norwegian Ocean Observation Laboratory (2016) National	This is an open infrastructure on Marineholmen, established byUiB, the Institute of Marine Research, and the Norwegian Defence Research Establishment (FFI).
Marineholmen, including the High Technology Centre Regional	This physical area (owned by Marineholmen Research Park) is a cluster containing several companies, many of them multinational and with a strong innovative edge.
Vestlandets innovasjonsselskap AS (VIS) (2004) Regional	VIS is an innovation company and technology transfer office (TTO) and is owned by UiB and most of the other research and higher organizations in Bergen. VIS is organised into two different segments: VIS Startup and VIS TTO.
Ocean Industries Accelerator (OIA) (2017) Regional	OIA is a community for companies in ocean industries. It is run by VIS and the marine industrial clusters in Bergen for entrepreneurial start-ups and companies from the ocean industries.
Hatch (2017) Global	Hatch operates as a global catalyst for start-ups within aquaculture and alternative seafood innovation. It is situated in Marineholmen and is a close collaborator with VIS and UiB (project-based).
KG Jebsen Centre for Deep Sea Research (JC-DeepSea) (2017) Global	JC-DeepSea was established based on funding from the Kristian Gerhard Jebsen Foundation. It aims to be a leading international centre for deep ocean research.
Austevoll Research Station (1978) and Matre Research Station (1971), Regional	The two marine research stations are owned by the Institute of Marine Research but have close links to UiB. The stations are open for other users on commercial basis when there is capacity.
Research Vessel Department, Institute of Marine Research	A shipping unit in the Research Vessels Department at the Institute of Marine Research (IMR), which runs the national research vessel fleet. The unit runs research vessels owned by IMR, UiB, NORAD, UiT The Arctic University of Norway, and the Norwegian Polar Institute.
Computational Biology Unit (CBU) National (2002), Global (2014)	CBU is a joint research centre at UiB, which has an open service unit assisting departments and researchers, as well as Haukeland University Hospital in their work on bioinformatics.
Centre for Digital Life Norway (DNL) (2016) National	Centre for Digital Life Norway (DLN) is a unique transdisciplinary research centre creating the biotechnology for tomorrow within health sciences, marine disciplines, and agriculture. UiB is an active partner in this centre.
Ocean Sustainability Bergen (OSB) (2019) Global	OSB is a virtual centre at UiB and works with partner institutions worldwide in ocean science and education. The centre is part of the university's strategic initiative, SDG Bergen, and UiB's status as the Hub for SDG 14: Life below water, as appointed by the United Nations Academic Impact (UNAI) initiative and is also the SDG 14 representative in the International Association of Universities (IAU) SDG Cluster.
Sars International Centre for Marine Molecular Biology (1977) Global	The Sars Centre is a research facility under UiB. It is a member of the European Molecular Biology Laboratories (EMBL) for which it serves as the marine hub.
Sea Lice Research Centre (2011) National	The Sea Lice Research Centre was established as a research-based innovation centre at UiB focusing on salmon lice. It is funded by the Research Council of Norway.
Networks, platforms, and industry cluster organisations	
NCE Seafood Innovation (2015) National	The NCE [National Centre of Expertise] Seafood Innovation cluster is a cluster funded by Innovation Norway and its headquarters are in Bergen. UiB is a member of the cluster and collaborates closely with the cluster management and administration.
GCE Ocean Technology National (2006), Global (2014)	The Global Centre of Expertise (GCE) Ocean Technology is an industry-driven initiative within ocean technology. UiB is a member of the cluster and collaborates closely with the cluster management and administration.
NCE Maritime CleanTech Regional (2011), National (2014)	The NCE Maritime CleanTech cluster represents one of the world's most complete maritime commercial hub and is also active within the aquaculture sector. UiB is a member of the cluster.
Ocean Innovation Norwegian Catapult Centre (OINC) (2019) National	OINC, at Marineholmen, is a national test, simulation, and visualization centre for effective prototype development. From 2021 a Makerspace has been included in OINC. UiB is a member of the centre.
Sustainable Energy Catapult Center (2019) National	The centre is a Norwegian Catapult Center for prototyping and testing on ships and in ocean space, including fish farms. UiB is a member of the centre.
European Marine Board (EMB) (1989) Global	EMB was launched by the European Science Foundation and the European Commission's Directorate General on Research, with the purpose of identifying the 'the grand challenges' in marine and polar research.
Norwegian Marine University Consortium (NMU) (2017) National	NMU is a cooperation agreement between 11 Norwegian universities. It has membership of the European Marine Board on behalf of the member universities and facilitates cooperation with a similar university cluster in China.
European Marine Biological Resource Centre (EMBRC) (2004) Global	EMBRC is a global reference research infrastructure responding to the societal grand challenges through advanced marine biology, and it promotes basic and applied marine biological and ecological research, as well as the development of blue biotechnology. UiB coordinates the Norwegian EMBRC hub.

Note: *For more in-depth descriptions of the marine infrastructures and network in and around UiB, see the final UiB EMBRIC report (University of Bergen 2020)

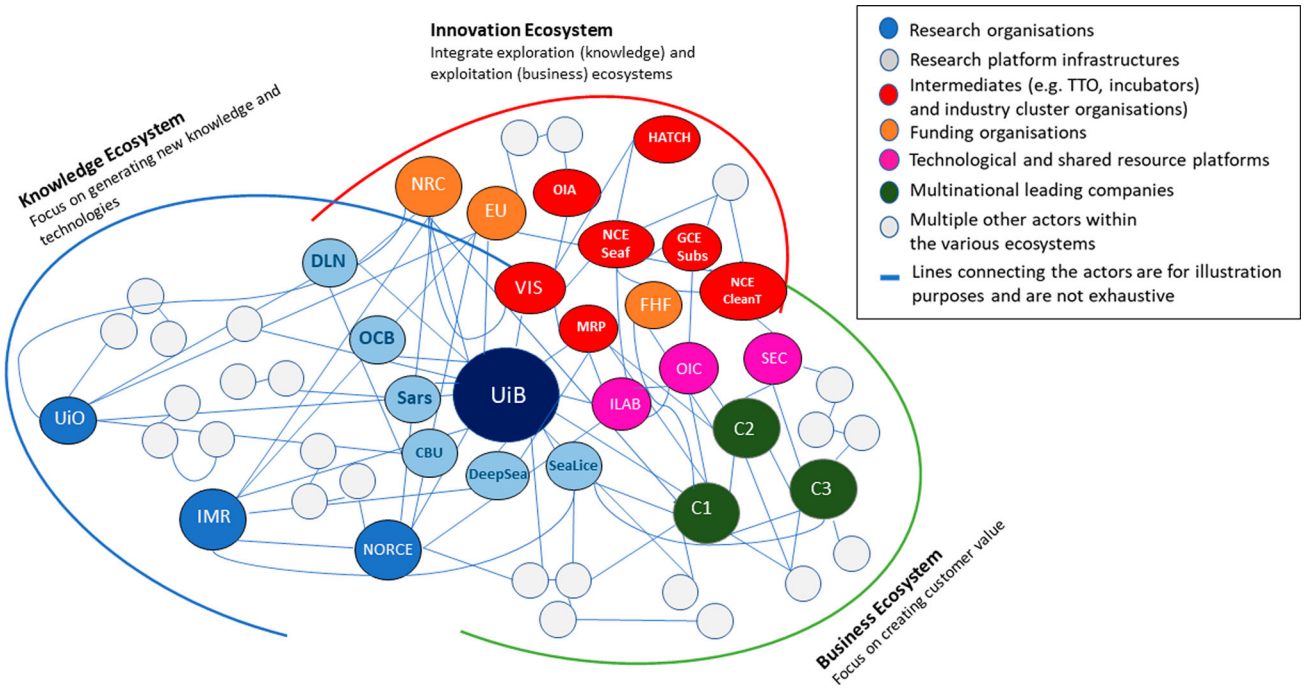

Fig. 4. Key actors (some shown abbreviated) in overlapping ecosystems in which UiB is embedded (based on Valkokari 2015, and on links identified in the study)

be important for the development of the marine innovation ecosystem in terms of funding and policy, thus demonstrating that the marine innovation ecosystem in Western Norway is a regional part of a national and global innovation ecosystem, not a genuine regional system. Further, the links demonstrate that UiB acts as a global pipeline provider through leadership in international committees, infrastructure, and networks, very often associated with sustainability and environmental issues.

For an ecosystem to perform well over time, it must co-evolve with markets and technologies (Heaton et al. 2019). Fuelled by national government and funding agencies, the marine industry in Norway is working intensively with research and development to solve the challenges it is facing, such as sea lice infections and new areas of production methods such as 'recirculating aquaculture system' (RAS) facilities. Treatment methods and medicines for various fish diseases have high priority, and UiB, very often in close collaboration with the other two major research institutions in the region, IMR and NORCE, has responded to the industry by setting up many of the shared marine infrastructure initiatives in the region. In addition, UiB provides the industry with new knowledge, technology, professional training, and a skilled workforce, which is very important for the general absorptive capacity of the actors in the region fuelling the local buzz. However, in general, the findings from our study indicate that the marine innovation ecosystem in Western Norway is quite self-organising.

We find that UiB, through its research projects and global networks and infrastructures, has links with multinational firms and organisations and with the various industry cluster organisations and intermediates, and typically acts as a global pipeline within the innovation ecosystem. Accordingly, through the dominance of regional links within the compass dimensions of 'training embodied knowledge' and 'connection with society', along with the regional dominance of many of the various other types of links, we find a strong indication of a local buzz around UiB's marine activities. However, our findings are not exclusive in this regard and the links also tell a story of more informal global connections throughout all the spheres in the research compass. In addition, UiB and the other actors mentioned in this paper are formally linked through regional industry clusters and technology platforms such as ILAB and the industrial catapults. In these technological platforms, a cost to participate is typically present. Together, the findings also imply a degree of 'global buzz' and 'local pipelines'. Therefore, our study provides an empirical insight into the mechanisms by which actors gain knowledge and expertise at different spatial scales, as illustrated in Fig. 5. The indication of the spheres in Fig. 5 is based on the case study and can vary from case to case.

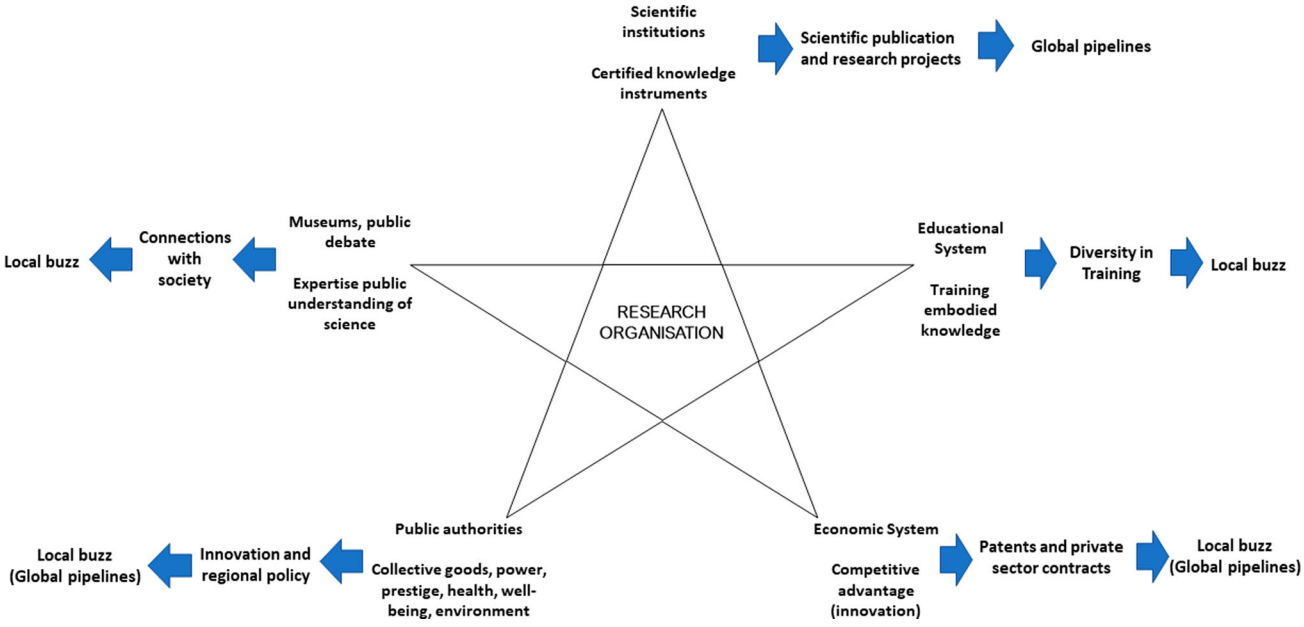

Fig. 5. A modified research compass, where the two spatial spheres of local buzz and global pipelines are connected to the data collected for the five dimensions of the compass; the indication of the spheres is based on the case study

Conclusions

In this paper we have clarified how a particular university performs its third mission activities and positions itself as an actor in an innovation ecosystem. We have operationalised and adapted an established framework – the research compass methodology – to develop and apply descriptors and indicators to characterise the variety and intensity of ecosystem linkages. By using the five dimensions of the compass, and the spheres of local buzz and global pipelines, and by identifying what data are required to inform us about these five dimensions, we have been able to create a profile – an ecosystem fingerprint – of a university. This is an important methodological contribution to the field of innovation ecosystems and can be used to evaluate the third mission of universities. We have answered the first research question on what types of links a university have within innovation ecosystems by articulating the five dimensions of the research compass to a particular context. As such, we have demonstrated that one can better understand the innovation ecosystem and how the embedded university is interacting through links to and from the various actors within the system, as both a global pipeline provider and an important contributor to the global buzz.

Moving to the second research question on how universities are performing their third mission activities, our study findings revealed a university contributing to classical third mission activities such as commercialisation projects, licence agreements, patents, and academic spin-offs and start-ups. The university also has a significant number of links to contract research, mostly with local industry along the coast, but also with some public organisations and global multinational companies. Further, our findings demonstrate a university that, partly through its owned intermediates, has been promoting cross-sectional collaboration on important infrastructure, commercialisation of research, development of new emerging technologies, training of professionals, student entrepreneurship, and research centres, thus suggesting an emerging entrepreneurial university. We also see how the university is orienting its strategy and culture towards highly international-oriented activities relating to the provision of scientific advice and the emphasis on the UN's sustainable development goals (SDGs) (United Nations n.d.). The latter is illustrated by many of the policy and society links, in addition to the participation in global networks and infrastructure. However, our links also reveal a university with a declining role in the marine innovation ecosystem, a role that might be replaced by an increasing global engagement.

Our third and final research question asked whether the various links could tell us something about the relationships and dynamics between overlapping ecosystems. Universities are complex organisations embedded in several kinds of ecosystems with different logics of action. In addition, the concept of innovation ecosystems is used ambiguously in both research and policymaking. We have found that the collected links, organised in the

research compass dimensions, correspond quite closely to the business, knowledge, and innovation ecosystems. We claim that highlighting the different logics of actions and the complexity of the various ecosystems will contribute to a better understanding of the roles that the various university agencies have in innovation, commercialisation, and co-creation of value. We also claim that dividing the roles of a university between the knowledge ecosystem, innovation ecosystem, and the business ecosystem corresponds in many ways to the more traditional values of a university within research and education. This may help us to understand better, and to communicate and act according to the different roles in the various contexts for a university, both internally for policymakers and externally for other stakeholders and collaborating actors. Furthermore, we have illustrated how key actors in the different ecosystems are placed in connection to each other in the overlapping ecosystems, thus demonstrating some of the relational dynamics between those systems, as called for by Valkokari (2015). Our data also show how the marine innovation ecosystem in Western Norway has evolved historically. Especially, our data show how the number of various intermediates, industry cluster organisations, and infrastructures (artifacts) have increased over time, spanning the boundaries between the ecosystems (Fig. 4). In this regard, the intermediates and shared platforms have acted not only as local pipelines but also as facilitators for the global buzz. In this context, our study adds empirical evidence that supports the criticism of the concept of the local buzz and global pipelines as being too general and that the distinction between local and non-local relationships is too broad (Fitjar & Rodríguez-Pose 2015; Aarstad et al. 2016). However, our data also indicate a complex and self-organised nature of the innovation ecosystems characterised by an increasing number of intricate actors, especially in the regional sphere.

A better understanding of how ecosystems' function and evolve, and how universities are embedded within them, is important for university managers and other policymakers. We hope our rich case can elucidate the concepts of ecosystems in general and the innovation ecosystem in particular. The research compass methodology acknowledges that measuring the dynamics of science by codified knowledge alone is not sufficient, due to the complex nature and relationships between research organisations, industry, and society.

However, our study has some shortcomings. One of the main reasons for creating the tool for universities was the pressure to characterise their third mission. Therefore, we mapped the links to and from a university, making the university (UiB) the focal organisation of our study. Focusing on other actors in the ecosystem, such as firms and various intermediary organisations, might require different dimensions to make a useful ecosystem-linkage diagnostic tool. In addition, the rationale for why other ecosystem actors would wish to be subject to such an assessment should be clarified. Furthermore, while we conducted an in-depth study of the nature and geography of the various links a university has with other partners in research, society, and industry, our approach did not dig very deeply into the actual mechanisms behind the knowledge and technology transfer that occur through these links. We argue that our approach focused on providing a broad profile of ecosystem embedding, but we suggest that further work could focus on developing additional modules that could act as explanatory tools for the mechanisms of ecosystem embedding.

In this paper we have demonstrated an approach with which to understand the embedding of a university in an innovation ecosystem. We argue that this 'ecosystem fingerprint' is a useful means to clarify the third mission of universities through the various linkages and interdependencies with various actors ranging from firms to policymakers and civil society. We hope that our modest contribution, focusing on a single in-depth case study, provides insights into ecosystem embedding and the development of diagnostic tools to inform evaluation – in this case, evaluation of the third mission of universities.

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