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Offshore renewable energy SMEs' innovation interactions across the triple helix: a management as practice perspective

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Abstract

Offshore Renewable Energy (ORE) could be pivotal in combating climate change, offering reliable and sustainable energy with less intermittency than other renewables. However, unlocking its potential requires robust collaboration across many different actors. The purpose of this study is to explore the *'human element'* of how SME leadership manage the technology transfer process and the underlying inter-organisational interactions across the triple helix. To achieve this, we adopt a management as practice perspective using Whittington's (2016) framework, which delineates praxis, practices, and practitioners. The research study employed a multiple case study design, and the primary sample included eight European ORE SME case studies. The study finds SMEs operate within a heavily strained triple helix environment, requiring them to navigate complex bureaucratic dynamics with universities and government partners. This is further compounded by fragmented governance structures across the EU, making collaboration reliant on forging strategic alliances. We find that the '*human element'* within SMEs embodying an innate blend of ability, experience, pragmatism, and adaptability is central to executing successful interactions. We discuss the policies needed for ORE SMEs to navigate the multifaceted challenges surrounding the human element of triple helix interactions.

Keywords Offshore renewable energy · SMEs · SME leaders · Triple helix · Management as practice.

JEL Classification L2 O3

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1 Introduction

The world is burning. We need a renewables revolution.

António Guterres, United Nations Secretary General[1]

Climate change coupled with energy security are presently seen as the greatest grand challenges of our time – environmentally, economically and societally (Okereke et al., 2012). Continuous record-breaking climate statistics, including extreme temperatures, floods, wildfires, and the ongoing energy security challenge, underscores the urgency for a collective effort across academia, government, the private sector, and civil society (Ritala, 2023). These 'intractable' puzzles including climate change are complex, uncertain and evaluative (Howard-Grenville et al., 2014; Ferraro et al., 2015).

The European Union (EU) aims to achieve climate-neutrality by 2050 (European Commission and Directorate-General for Climate Action, 2019). One of the seven pillars identified in a net-zero greenhouse gas (GHG) transition is the deployment of renewable energy sources – 32% renewables target by 2030 (ibid.). Offshore Renewable Energy (ORE) is renewable energy of the sea consisting of sources that are abundant, clean and natural; namely wind, wave and tidal (IRENA, 2021). The sector is young and nascent with both economic and societal potential; for example, ocean energy has the capacity to deliver 100 GW by 2050 (10% of today's European consumption) (Ocean Energy Europe, 2020). ORE innovative technologies offer many benefits including flexibility to the energy grid, predictability and less intermittence (tidal is 100% predictable and wave energy is a renewable resource with a higher power density than wind) (IRENA, 2021).

Entrepreneurship opportunities for European ORE small and medium sized enterprises (SMEs) to contribute to this renewables target are abound, and thus, can help to play a key role in addressing the climate grand challenge (Howard-Grenville et al., 2014; Magagna & Uihlein, 2015; Vanegas-Cantarero et al., 2022). The innovation literature has consistently argued on the importance of inter-organisational interactions within the triple helix (TH) framework (i.e., interactions between academia, government and industry) (Etzkowitz & Leydesdorff, 1995) to drive economic development and foster innovation within regional and national systems (Etzkowitz & Leydesdorff, 2000; Linton, 2018). Extensive research has been conducted on TH dynamics between university and government initiatives (Philpott et al., 2011; Perkmann, 2013; O'Kane, 2020). However, a lack of understanding exists from the industry perspective and how the industrial firm manages inter-organisational interactions across the triple helix for the purpose of innovation output (Ryan et al., 2018).

Currently, SMEs dominate the ORE sector, actively involved in the early stages of technological development with significant R&D efforts but so far have achieved only limited commercial success (Corsatea & Magagna, 2013; Barrett et al., 2024). The TH system has been identified as a potential knowledge space for reciprocal learning between SMEs and larger enterprises, fostering innovation to reduce the LCOE (levelized cost of energy) in the ORE sector (Brink & Madsen, 2016). However, TH studies in ORE are scarce, and the understanding of TH interactions remains limited. This gap is highlighted by Brink and Madsen's (2016) call for more research into the key antecedents and a deeper exploration

[1] Source: United Nations (2022), last accessed November 26th, 2024 https://www.un.org/africarenewal/magazine/june-2022/world-burning-we-need-renewables-revolution.

of the role SMEs play within the ORE TH system. This study will explore the *human element* of SME actors, aiming to understand how their entrepreneurial skillset, practices and behaviours impact TH interactions for TRL (Technological readiness level) advancement. Second, this study enriches the TH *as practice* literature by reflecting on the extra-organisational interactions among triple helix partners, offering nuanced insights into how the technology transfer process unfolds, in the ORE sector across TH actors.

The aim of this study is to take a *practice* perspective and specifically asks the following overarching question – *how do ORE SME leaders manage interactions for innovation across the triple helix?* By addressing this research question, this study contributes to the burgeoning management and TH *as practice* literature (Shane et al., 2015; Weckowska, 2015; Sydow et al., 2017; Baines et al., 2023; Tagliazucchi et al., 2023). First, this study offers an intra-organisational perspective on interactions through the CEO/founder lens expanding the management as practice discourse by offering insights into the important *human element* role.

To answer the *how* of the research question, we reveal what is being done and by whom. This practice perspective provides a view of the managerial practices and TH interactions conducted by ORE SME leaders within and between partners, thus, offering insights into the *human element* of ORE technology development, which is lacking not only in the context specific literature but also the wider general literature (Audretsch et al., 2016; Linton, 2018). A practice is 'a routinized type of human performance consisting of several elements interconnected to one another' (Gartner et al. 2016: 813) carried out by practitioners. Individuals do not act in a vacuum nor in a completely controlled manner – their actions are likely to be determined by their experiences, passions, knowledge, ambitions, connections and capabilities, all of which will shape and determine the organisation's innovation outcomes (Nicolini, 2016). Hence, adopting a practice perspective will reveal *how* these SME leaders operate, highlighting the dynamic and recursive nature of their core activities and structures within their interactions across the triple helix network (Sarpong et al., 2017).

We address the research question through a qualitative, multiple case study methodology built on evidence collected from eight European ORE SME case studies. Case study research was chosen due to the complexity and novelty of the context and opportunity to reveal depth of insights (Cunningham et al., 2017). This structure of the paper is as follows. First, we provide the theoretical context by reviewing the triple helix literature followed by the management as practice perspective literature. We then present the findings structured using Whittington's (2006) framework – praxis, practices, and practitioners. Finally, the discussion and conclusion are presented.

2 Theoretical context

An environmentally sustainable future is an imperative for all (Kemp, 1994) and how we transition and manage this transition (Rotmans et al., 2001) towards a sustainable future is of grave concern. To achieve the aforementioned climate-neutrality target by 2050 (EU), society needs to shift towards a new technological regime of renewable energy technologies (Kemp et al., 1998). The ORE sector is a promising renewable sector (tidal and wave) with Europe currently at the forefront of ocean energy technology development – more than 50% of tidal energy and about 45% of wave energy developers (Magagna & Uihlein, 2015).

However, ORE technologies face significant bottlenecks including technology development, finance and markets, environmental and administrative issues, and grid availability (ibid.). At the same time, a systematic and practical understanding is needed to strengthen how societal actors enhance transformative capacity in connecting, scaling, and embedding social innovations like ORE (Strasser et al., 2022). Transformative innovation and sustainability transitions often rely on the collaboration of many actors driven by the co-evolutionary dynamics of innovation (Rotmans et al., 2001; Kemp & van Lente, 2024). As actors recognise their interdependencies, they collaboratively build systems that enable transformative change.

A commonly proposed method for influencing co-evolutionary changes in technology regimes by innovation scholars is the TH framework (Kemp & van Lente, 2024). The TH framework has previously played a significant role in guiding and supporting polices in renewable energy transitions (Lerman et al., 2021). The TH is a theoretical framework used to understand how innovation emerges through the interactions between government, firms and universities (Etzkowitz & Leydesdorff, 1995). This framework grew from the emerging importance of a *knowledge-based economy*, which is now central to economic growth, as opposed to the traditional view of the economy as being the output of capital and labour inputs (Cai & Etzkowitz, 2020). Universities play a crucial and unique role in the triple helix, contributing to both economic and social missions (i.e. third mission), through a combination of teaching, research, and engagement (Thomas et al., 2023). Universities generate and share valuable knowledge with industry partners - formally and informally (Zhou & Baines, 2023), whilst providing a source of future educated employees, thus driving innovation output (Perkmann & Walsh, 2007; Hayter et al., 2023).

Whilst no single actor can direct the transition towards a low emission, innovative energy system on their own, all social actors look to the government to take the lead (Rotmans et al., 2001). Governments generally take the lead by utilising a combination of three broad categories of instruments in innovation policy, but this can vary by implementation and design considerably across different countries and over time (Borrás & Edquist, 2013). The first category are regulatory instruments, which establish the legal requirements, the rules of the game per se that shape social and market interactions. The second category includes economic and financial instruments, which offer specific monetary incentives or disincentives to encourage or discourage particular social and economic activities, such as grants, subsidies, public procurement, and taxes. Lastly, there are soft instruments, which focus on persuasion, knowledge sharing, and aligning the interests of social and market actors through non-binding measures (ibid.). Governments have traditionally facilitated and coordinated innovation interactions between industry and academia (Etzkowitz, 2003, 2012; Cai & Etzkowitz, 2020) through public funding mechanisms. However, this role has evolved to one of "*public entrepreneur and venture capitalist*" (Etzkowitz, 2003: 293). Due to the uncertainties and lack of clear deliverables within the ORE context (Linton, 2018), governments are now working within a diverse innovation ecosystem wearing multiple *hats* - providing funding (Dimos & Pugh, 2016), setting the regulatory framework (Blind, 2012) but in many cases producing knowledge through the creation of Research Centres (Kerry & Danson, 2016). The governance issues in ORE are challenging and vary from complex permitting, consenting timescales, seabed ownership, environmental impact assessments, grid connection and developing an appropriate funding mix (Guerra, 2018). Consequently, the role of government is one of facilitator-stimulator-controller-director, and this status

can change depending on the stage of technological development (Rotmans et al., 2001). Despite the phenomenon "the retreat of the state" (Strange, 1996), driven by the rise of non-state governance models in international and multinational affairs amid globalisation (Van de Graaf & Colgan, 2016), ORE governance at the EU level remains predominantly controlled by individual nation-states (Guerra, 2018).

In the TH model, the third party is represented by industry players which in the ORE context, SMEs are the primary industry actors. SMEs are essential to economic growth and technological innovation (Acs & Audretsch, 1987; Link & Bozeman, 1991). In 2022, approximately 24.3 million SMEs were active in the EU-27 which accounted for 99.8% of all enterprises in the non-financial business sector (NFBS), generating 51.8% of value added and 66.4% of employment in the NFBS (European Commission, 2023). Mico-enterprises (less than 10 employees) accounted for 93.7%, medium enterprises (less than 50 employees) accounted for 5.5% and large enterprises (less than 250 employees) accounted for 0.8% (ibid.). Despite their importance to economies and societies, SMEs are often resource constrained, and due to their liability of smallness and, in some cases newness, encounter significant challenges in scaling (Gimenez-Fernandez et al., 2020). A fragmented picture on the dynamics of SME innovation practices exists, particularly regarding how SMEs interact with triple helix partners to achieve innovation outcomes (Ryan et al., 2018; Hilkenmeier et al., 2021).

SMEs innovation advantages are largely behavioural (Vossen, 1988; Rothwell & Dodgson, 1994), embodying flat organisational structures which encourage reactive, flexible, adaptive (to changing market requirements) responses with rapid decision making at the core. Yet despite these advantages, SMEs often experience grave human, financial and capital limitations (Acs & Audretsch, 1987). These challenges are particularly evident when scaling entrepreneurial ventures, where their 'liability of smallness' (Gimenez-Fernandez et al., 2020) and a lack of entrepreneurial and/or managerial experience can be problematic (Low & MacMillan, 1988). However, unlike the 'typical' challenges faced by SMEs in other sectors; ORE SMEs encounter additional obstacles such as advancing radical technological innovations within a high-risk environment and navigating complex tasks like numerical modelling and testing under both simulated (tank) and challenging ocean conditions. ORE SMEs also operate within an uncertain legal and regulatory framework, requiring significant investment and the involvement of external actors across the triple helix for skill and capability development (Wu et al., 2020; Vanegas-Cantarero et al., 2022). Furthermore, these technologies incur high short-term costs given the market unknowns and lack of scaling benefits (Kemp, 1994). It is widely recognised within the ORE sector that adopting an innovation system approach, such as the TH, can enhance innovation development and lower the LCOE (Brink, 2017). However, the application of innovation system approaches in ORE remains poorly understood. Bento et al. (2021) have called for further research into firm strategies, system dynamics, and their transformative effects on both technology and the sector's broader context. Barrett et al. (2024) provide evidence of a positive relationship between open innovation (OI) strategies and research and innovation outcomes for ORE firms, particularly in the early stages of the technological life cycle. Their findings highlight that specific linkages are critical for certain research and innovation outcomes. For example, firms that prioritise R&D should leverage scientific publications and engage with universities. However, they also note a potential trade-off, where firms must carefully choose the most efficient and appropriate linkages to meet their research and innovation goals, possi-

bly due to the cognitive limitations of management. These cognitive constraints, however, remain an underexplored area, as there is limited examination of the practical aspects of ORE management—namely, what managers do and how they do it.

To gain an understanding of the ORE SME inter-organisational interactions for innovation output within the triple helix model, we take a deep dive into the industry actors and employ a practice perspective (Baines et al., 2023). This allows us to reveal what these SME actors do and how they do it, providing an internal view of the managerial practices and interactions within and between partners (Sydow et al., 2017) offering a depth which is lacking in the literature. This depth shines a light on the dynamic and recursive nature of the core activities and practices within these interactions between partners across the triple helix (Sarpong et al., 2017).

This practice-oriented research has its origins in the broader field of sociology and social sciences (Giddens, 1984; Bourdieu, 1990). The relationship between the actions and the social world in which the action takes place is fundamental to practice theory (Feldman & Orlikowski, 2011). 'Practice' scholars are motivated to understand the role of the individual actor and their actions i.e. how actors behave and interact within their particular social context (Whittington, 2006) as opposed to something that organisations may possess (Feldman & Orlikowski, 2011) i.e. their resources. Various fields of research have adopted the practice perspective including strategy (Whittington, 2003; Jarzabkowski et al., 2007; Jarzabkowski, 2008), project management (Sydow et al., 2004; Blomquist et al., 2010; Bakker, 2016), entrepreneurship (Johannisson, 2011), innovation (Baines et al., 2023) and marketing (Skålén & Hackley, 2011). The field of strategy has benefited from this practice perspective in developing the concept of strategic processes (Jarzabkowski et al., 2007; Jarzabkowski, 2008) and treating strategy as something people do (Whittington, 2006). However, as mentioned, within the triple helix research stream, there is an absence of focus on this practice perspective.

A practice perspective is also processual as it highlights the importance of structures, rules, and resources throughout the interactions between partners which requires repetition to remain effectual (Sydow et al., 2017). This process perspective highlights the role of the managers leading and managing such interactions (Blomquist et al., 2010). Managers need to deliberately practice central activities including partner selection, task allocation, partner negotiation and day-to-day management (Sydow et al., 2017). Thus, highlighting the role of individual actors i.e. SME leaders, within the context of inter-organisational interactions and relations. Whilst recognising the impact on the organisational outcomes and offering an insight into what is truly happening within the organisation.

To operationalise this practice perspective, we take Whittington's (2006) management as practice framework (see Fig. 1) leveraging three discrete but interconnected elements – praxis, practices, and practitioners. Whittington's (2006) framework introduces the *human element* into the triple helix research – what the SME leaders do (in the management of these innovation interactions), how they do it (the norms, behaviours, routines and traditions) and who the SME leaders are (their role, background, education and experience)?

'Praxis' is a Greek word referring to the actual activities – what people do in practice (Whittington, 2006). The praxis in this study refers to the interactions of the industry leaders (CEO/founder/managing director) in managing these inter-organisational interactions across the triple helix e.g., EU funded project members/leaders, government actors, horizontal and vertical collaborations with SMEs and academia. 'Practices' are "the shared

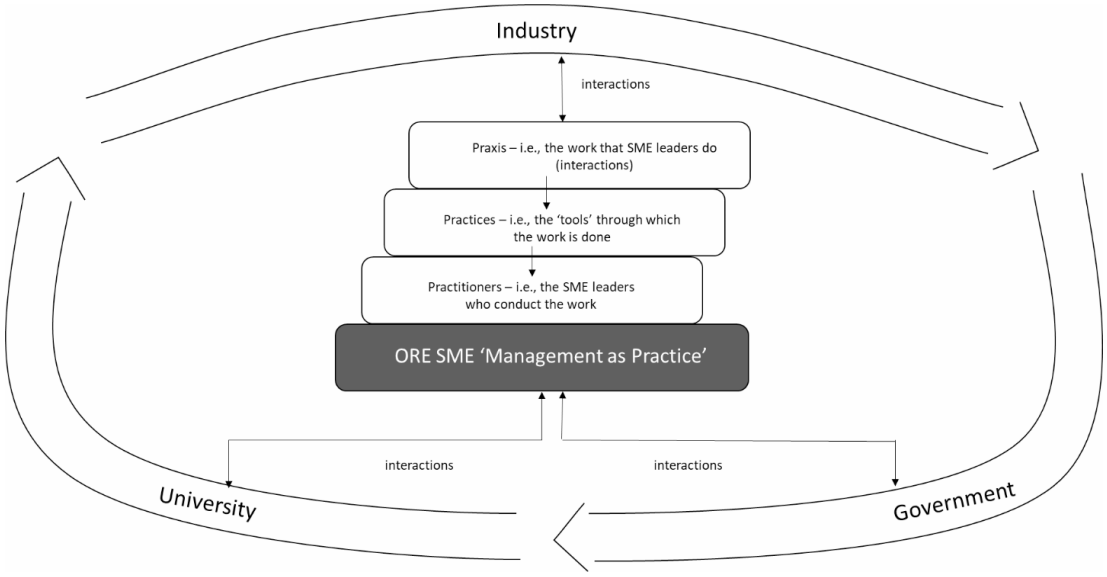

Fig. 1 Framework

routines of behaviour, including traditions, norms, and procedures for thinking, acting, and using 'things'" (ibid: 619) e.g., how to select partners/how to allocate resources to project/how to negotiate. Finally, 'practitioners' are the people who are carrying out the routines (ibid.) e.g., ORE SME leaders. In this study, we are particularly interested in what SME industry leaders do (within these interactions)? i.e. what is the work that they do in managing these interactions? What are the norms, behaviours, routines, and traditions guiding these practices within the SME? Also, outside the organisation, how do they interact with partners across the triple helix? Who are these industry SME leaders? What is their role, education, background, and experience? Overall, we link SME practitioners to the underlying praxis and how they execute these same practices.

3 Methodology

3.1 Research Context

SELKIE is an EU €5.2 m cross-border (Ireland and Wales) project aimed to boost the ORE sector. This EU funded project brings together SMEs and European researchers with a view to enhancing the development and commercialisation of the underlying innovative ORE technologies. SELKIE has also built a network of European ORE SMEs who contribute to the wider ecosystem, whilst benefiting from the ORE resources provided by the project. SELKIE's goal is to create standardised, open-source tools, templates, standards, and models for engineering and economic applications, specifically tailored for the needs of this sector. The deployment of ORE technologies could deliver many societal, economic, and environmental benefits including helping to decarbonise Europe by delivering 100 GW of capacity by 2050 and complement other renewables and balance electricity systems due to its flexible and predictive nature. Ocean energy (tidal and wave) can contribute up to a cumulative €5.8bn in Gross Value Added between now and 2030 and is predicted to create

500,000 jobs in Europe by 2050. In addition, ocean energy works in harmony with local environments preserving the aesthetic value of the environment (ETIP Ocean, 2023). Thus, contributing to the enormity of the environmental grand challenges (Magagna & Uihlein, 2015).

3.2 Research Design

This research study employed a qualitative multiple-case study (Eisenhardt & Graebner, 2007) conducted over a one-year period. It was conducted as part of a wider three-year study of SMEs within the ORE sector. Our research purpose was to explore how the key actors within ORE SMEs manage the technology process and the underlying interorganisational innovation interactions between ORE SMEs and their triple helix partners (i.e. academia, government and industry) through leveraging the Whittington (2006) framework. Given the paucity of research revealing such 'practices', a qualitative approach was deemed most suitable, offering depth of insights currently lacking in the literature (Sarpong et al., 2017; Ryan et al., 2018). Multiple case studies can be more accurate, generalisable, and provide more robust results (Goffin, 2019) and are deemed suitable if context and depth are lacking in the literature (Miles & Huberman, 1994; Cunningham et al., 2017).

3.3 Data Collection

The primary sample included eight European ORE (5 tidal and 3 wave) SMEs, selected from the SELKIE network which included 92 'signed up' SMEs receiving non-financial supports which included networking, business planning/modelling, data analysis and product testing. These eight SMEs are located in Denmark (x1), France (x1), Ireland (x3), Scotland (x2), and Spain (x1), adhering to Eisenhardt's (1989) guidance on the number of case studies required to achieve theoretical saturation. A purposeful sampling selection was used (ibid) including the following criteria – all SMEs were network members of the EU SELKIE project, with an entrepreneurial founder/CEO at the helm; leveraging interactions across the triple helix and innovative ORE product at the demonstration stage of the technology readiness level (TRL) – stage 6–9[2].

Each case study relied on three data sources: (a) primary data from in-depth semi-structured SME leader interviews (b) follow-up emails and calls with SME leaders (c) secondary data including company and industry reports, EU, and National government publications. All secondary data was gathered before and after each interview which facilitated triangulation of data (Jick, 1979; Goffin, 2019). Table 1 contains details for each case study. Between March 2022 and April 2023, the primary data was collected via semi-structured interviews with the SME leaders (founder/CEO). Table 2 contains details on the research participants and the data collected. Importantly, the data collection period took place in the final year of the SELKIE project, with the selection of cases for purposeful sampling guided by three years of prior expert research addressing the sector's needs and at this stage, researchers had detailed knowledge and understanding of the different types of firms operating in the sector.

[2] The Technology Readiness Level (TRL) is a method used to measure technology maturity. The TRL method is measured on a scale of 1–9. 1–3 represents the research phase, 4–5 the development phase, 6 the demonstration phase and 7–9 the deployment phase (with 7 representing prototype demonstration and 9 is a fully deployed, proven and operational technology).

Table 1 Case study descriptions

Case	Case Description	Tidal/Wave	Location	Foundation Year	Number of employees
Case A	Case Study A is an Irish wave energy technology company working with customers and partners globally in commercialising an innovative renewable energy device.	Wave	Ireland	2012	<20
Case B	Case Study B is an Irish wave energy technology company developing innovative wave devices for global markets. Also, actively pursuing US development opportunities.	Wave	Ireland	2001	<20
Case C	Case Study C is an Irish energy technology company (river and tidal), currently commercialising innovative devices for global markets	Tidal	Ireland	2014	<20
Case D	Case Study D is a Danish wave energy company currently working with customers and partners globally in developing an innovative renewable energy device.	Wave	Denmark	2013	20–25
Case E	Case Study E is a Scottish tidal energy development company, a spin-out company from a Scottish university. Currently developing a cost-effective tidal device for global markets.	Tidal	Scotland	2011	<20
Case F	Case Study F is a Spanish floating tidal energy company with offices in Spain and Scotland. The company's platform is at an advanced stage of development, working with partners globally to achieve this.	Tidal	Spain	2007	20–25
Case G	Case Study G is a French tidal and ocean turbine developer providing energy solutions worldwide.	Tidal	France	2008	25–30
Case H	Case Study H is a Scottish tidal energy engineering company focused on the development of a low-cost tidal energy turbine technology solution.	Tidal	Scotland	2010	25–30

Purposeful sampling is a widely used qualitative method in innovation studies (Barrett et al., 2021; Barrett & Tsekouras, 2022). Case interviewees in purposeful sampling are specifically selected for their potential to provide rich, in-depth information relevant to the phenomenon under investigation (Suri, 2011; Hoorani et al., 2019). This important rigor criterion strengthens the overall quality of the study and its capacity to add valuable knowledge to the field (Hoorani et al., 2019; Cuervo-Cazurra et al., 2020).

The interviews were conducted over MS Teams or Zoom, and lasted on average sixty minutes, offering considerable scope for in-depth probing questions. All interviews were recorded and transcribed verbatim resulting in over one hundred pages of transcripts. Each interview had three parts. First, a deep dive into the SME leader's story (i.e., the **practitioner**) – educational background/entrepreneurial and work experience; how they became involved in the sector and work for the SME (including from start-up)? Second, the organisation's interactions (i.e., the **praxis**) in the context of their triple helix collaborations and with whom they interacted. What are the types of challenges experienced with each partner type? How are these challenges overcome? Third, how are these interactions managed? i.e.,

Table 2 Research participants and data collected

Case	Interview Participant	Location	Age Profile	Education	Experience	Primary Data Used	Secondary Data Used
Case A	CEO and founder	Ireland	60–65	Third Level – Physics undergraduate degree	Start-up experience – technical and commercial; energy renewables sector experience	Interviews, follow-up emails for clarifications	Project membership web site, industry reports, partner web sites.
Case B	CTO	Ireland	60–65	Third Level – PhD energy engineering	Academic Experience – Professor, Emeritus Professor; Research Centre Director; background in wave energy (40 years)	Interviews, follow-up emails for clarifications	Project membership web site, industry reports, partner web sites.
Case C	CEO and founder	Ireland	60–65	Second Level	Start-up experience – commercial in construction and property development	Interviews, follow-up emails for clarifications	Company web site, project membership web sites, collaboration partner web sites.
Case D	CEO and founder	Denmark	60–65	Third Level – Masters Mechanical Engineering	Mechanical Engineer. Serial entrepreneur/innovator in wave technologies (40 years);	Interviews, follow-up emails for clarifications	Company web site, project membership web sites, collaboration partner web sites.
Case E	CEO and founder	Scotland	55–60	Third Level – undergraduate degree in electrical engineering; Masters in Energy Engineering	Academic experience – University spin-out and start-up experience - Tidal turbine	Interviews, follow-up emails for clarifications	Company web site, project membership web sites, collaboration partner web sites.

Table 2 (continued)

Case	Interview Participant	Location	Age Profile	Education	Experience	Primary Data Used	Secondary Data Used
Case F	Project Manager	Spain	40–45	Third Level – Undergraduate – Economics and Postgraduate – MBA.	Commercial/ international experience - SMEs, EU funding experience.	Interviews, follow-up emails for clarifications	Company web site, project membership web sites, collaboration partner web sites.
Case G	Innovation Manager	France	45–50	Third Level – engineering undergraduate degree	Technical engineering experience – automotive and rail transport	Interviews, follow-up emails for clarifications	Company web site, project membership web sites, partner web sites.
Case H	R&D Manager	Scotland	40–45	Third Level – Physics undergrad and MSc renewables	Technical experience – tidal engineering	Interviews, follow-up emails	Company web site, industry web sites.

what are the **practices** (i.e., the tools used – norms, routines and behaviours) that guide these interactions within the SME?

3.4 Data Analysis

The data was analysed using the following procedure. First, we wrote a case narrative for each case study which included primary interview and secondary data in line with literature guidelines (Yin, 2009). We shared this narrative with the interview participants and requested them to fill 'gaps' where necessary. Second, we created a code book which formed the basis of the codes, categories, and dimensions (see Fig. 2). Third, two researchers examined over one hundred pages of transcripts and applied lower level (first order) coding and second cycle coding (Miles et al., 2014, Saldaña, 2021). This ensured inter-coder reliability as detailed co-author discussions took place (Goffin, 2019). Fourth, we conducted a within case analysis to reveal the inter-organisational interactions across the triple helix and the management *practices* leveraged. Finally, we conducted a cross case analysis to look for similar themes (Eisenhardt & Graebner, 2007; Eisenhardt, 1989) and to develop the overall findings thus revealing the underlying nuances of these practices which resulted in a series of tables and meta-matrices (Miles et al., 2014). A persistent activity throughout the data analysis process was an iterative back and forth process between the underlying parts of

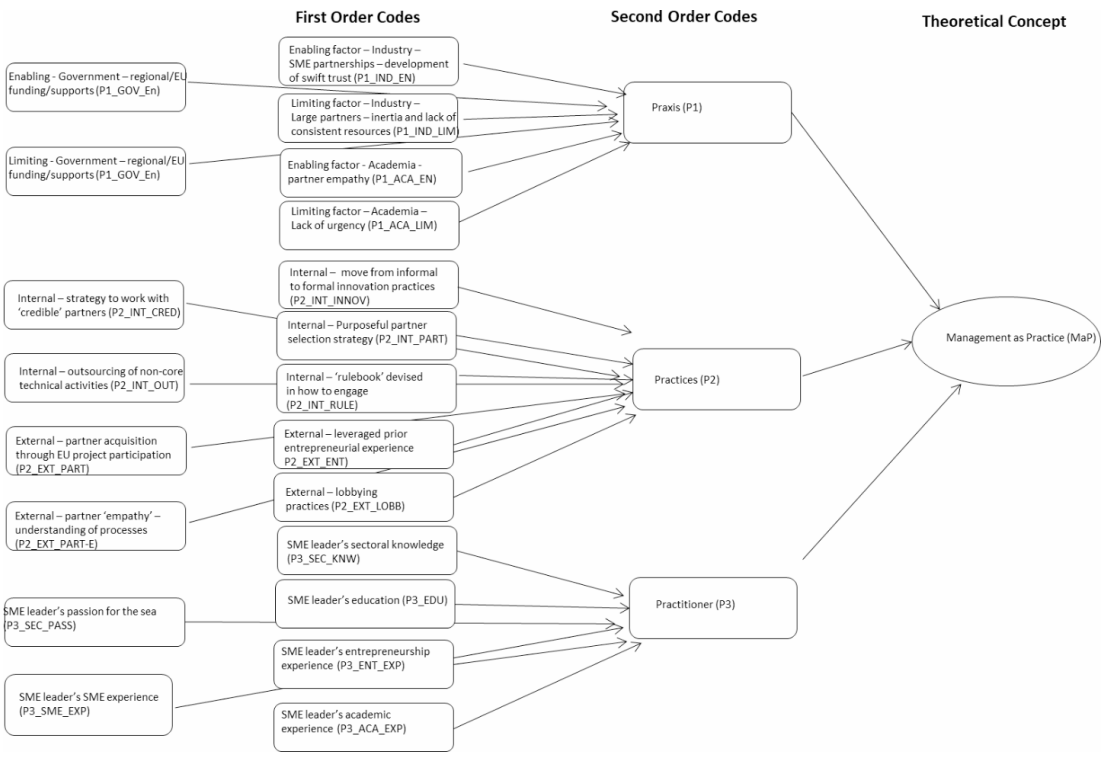

Fig. 2 Data structure overview

the data and the whole of the data set (Spiggle, 1994), i.e. a constant comparison between theory and data (Eisenhardt, 1989). This activity ensured the analysis process was not linear but rather an iterative process whereby we organised and grouped the raw data into abstract concepts (Eisenhardt, 2021).

4 Findings

To realise this deep dive from an industry perspective, we leveraged the Whittington (2006) 'management as practice' framework and used this framework to structure the findings. This framework enabled us to reveal the underlying nuances of *what* and *how* ORE SMEs manage the underlying interactions within the triple helix context whilst keeping the *who* i.e. the practitioner, to the forefront. First, praxis – *what* are the interactions for the purpose of innovation that ORE SME leaders manage across the triple helix? Second, practices – *how* are these interactions managed? (the norms, behaviours, routines, and traditions) How are ORE SMEs finding and selecting partners? How are ORE SMEs allocating resources? How are ORE SMEs managing these partnerships and the underlying partner relationships? Finally, practitioners – *who* within the ORE SME is managing these interactions across the triple helix? What is their role, education, and industry experience? How are they leveraging their background and experience to manage these interactions? We now present the findings. Table 3 provides an overview of each case, the underlying praxis, practices and practitioners including the stage of development for each case.

Table 3 Summary of each case study by praxis, practices, and practitioner

Case	Praxis – (inter)actions – what is the work that SME leaders do (in these interactions)?	Practices – how? (norms, routines, rules, and behaviours that guide activities within the SME)	Practitioner (ORE SME leader) – who? (role, education, background)	Stage of development (Technology Readiness Level – TRL)
Case A	• Industry – work with tech partners (complement existing resources) • Universities – collaboration with Irish university (engagement with engineering department) • Government – partner in European funded marine project (lead partner working with larger European partners)	• Formal innovation practices - 'stage-gate type processes – a formal decision tree in place'. • Prior experience with other start-ups guiding behaviours and enabling leveraging of connections and opportunities- funding and otherwise. • Define a rulebook for guiding how to work with partners – get a consortium agreement in place.	• CEO/founder; • Education – undergraduate in engineering; • Background - serial entrepreneur in renewable energy; adjunct professor in Irish University.	TRL 6 – demonstration of device – prototype developed
Case B	• Industry – leverage member associations in Ireland and US to create connections, networking opportunities, conference presentations. • Universities – collaborations with Irish universities (tank testing, numerical modelling and technical development); US university (numerical modelling) • Government – engaged with Irish bodies for funding supports; European Commission (Horizon Europe) and US Department of Energy.	• Practices vary depending on interactions: o industry – selective – open search for partner – looking for partner fit. o Government – use lobbying practices. o Academia – work with known academic partners • Practice a lean method to management, outsourcing activities to technical experts.	• CTO; • Education – PhD in Energy Engineering; • Background in academia (Professor Energy Engineering now Emeritus Professor) and research centre founder; deep technical knowledge and experience – understanding of wave devices and market;	TRL 6 – demonstration of device – prototype developed
Case C	• Industry – worked with technical partners and investors • Universities – collaborated with Irish and French • Government – early funding received for tank testing the concept; later funding supports provided.	• Developed an understanding of the processes that exist within each partner type, clarity of how to engage with external parties and when – timing in important, be patient – don't engage too early. • Used off the shelf purchasing – much cheaper than developing bespoke.	• CEO/founder; • Education – second level education; • Background – passion for ocean – 10 years working in Tidal sector. Start-up and commercial experience (construction and property development − 20 years).	TRL 6 – demonstration of device – prototype developed

Table 3 (continued)

Case	Praxis – (inter)actions – what is the work that SME leaders do (in these interactions)?	Practices – how? (norms, routines, rules, and behaviours that guide activities within the SME)	Practitioner (ORE SME leader) – who? (role, education, background)	Stage of development (Technology Readiness Level – TRL)
Case D	• Industry – outsourced non-core technical requirements to third party suppliers. • University – collaborated with two Danish universities – worked with them for many years – numerical modelling (simulating the sea environment) • Government – collaborated with Danish Gov – permissions and funding.	• Deliberate in HOW innovation is practiced – First, purposefully seeks to bring in the best team members; second, explores the market opportunity and finally, determines the technological needs. • Utilises a flat organisational structure – innovation for all. • 'Open' to other organisations for innovation purposes – but keep the core capabilities internal to the organisation. • Protective of knowledge and assets	• CEO/founder; • Education – MSc in mechanical engineering; • Background – serial entrepreneur/innovator in wave energy (founder of 3 companies); Commercial experience – funding/exiting.	TRL 8 – operational device
Case E	• Industry – partners in strategic supply chain – 200 companies – engineering companies – all sizes (incl. oil and gas partners) • University – collaborated with Scottish Uni – research purposes • Government – European partners	• Strategic selection of partners for specific activities dependent on the requirements/supply chain needs etc. • Internal knowledge base – strong focus on recruitment of key resources • 'dating' analogy used to describe how partners selected – two way process.	• CEO/founder; • Education – MSc in mechanical engineering; • Background – entrepreneur/innovator in tidal energy (university spinout); academic experience.	TRL 8 – operational device
Case F	• Industry – collaborated with large industry partners (deep pockets) • University – collaborations with UK universities and research centres • Government – collaborated with European partners	• Subcontract non-core technical activities • Used off the shelf purchasing; avoid bespoke development • Lobby government through industry association membership	• EU Project Manager; • Education – MBA; • Background working for SMEs; Commercial/international EU funding experience;	TRL 8/9 – transitioning to full commercial application

Table 3 (continued)

Case	Praxis – (inter)actions – what is the work that SME leaders do (in these interactions)?	Practices – how? (norms, routines, rules, and behaviours that guide activities within the SME)	Practitioner (ORE SME leader) – who? (role, education, background)	Stage of development (Technology Readiness Level – TRL)
Case G	• Industry – collaboration with Tidal competitors; material suppliers • Universities – partnered with French and UK • Government – part of Horizon Europe project, INTERREG, French Government and regional French Governmental agencies	• Deliberate in how innovation is practiced – innovation team (3 members) seek strategic priorities from top management; requirements gathering from engineering teams – innovation priorities are finalised. • Eager to be involved in other initiatives in terms of how the learnings can be applied to tidal sector. • Partners acquired through participation in European projects; these participations have helped with transfer or knowledge and learning in terms of HOW to work with and manage external partners.	• Innovation Manager; • Education – third level – undergraduate in engineering; • Background across different industries – automotive and rail transport; commercial experience.	TRL 7 – demonstration device in operating environment
Case H	• Industry – collaborated with young, small partners. • University – partnered with UK universities. • Government – worked on EU projects; UK & Scottish government agencies.	• Innovation practices at the outset of the explorative end are unstructured, informal and ad-hoc in nature. At the idea gathers impetus, more formal practices are used – e.g. LCOE model. • Depending on outcome of LCOE review, innovations are ranked and prioritised – resources are sought – internally and externally. • Strong preference for working with industry in particular working with SMEs rather than academia.	• R&D Manager • Education – third Level – Physics undergraduate and MSc Renewables Energy Engineering.	TRL 9 – full commercial application

4.1 Praxis

As outlined, praxis are the interactions conducted by the ORE SME leaders across the triple helix e.g., with EU funded project members, government actors, horizontal and vertical collaborations with SMEs and academia. Our findings reveal that all cases interacted with partners across academia, government, and industry. However, these interactions varied across the triple helix in terms of how **enabling or limiting** they were.

University interactions to secure access to expertise and *new* knowledge, were constant across all ORE case studies; however, these interactions lacked depth, and several limiting factors were highlighted including the universities lack of time and effort to engage with SMES coupled with a lack of urgency in delivering agreed objectives. It was evident that

academics' lack of industry experience and understanding of the unique ORE context was also a limiting factor "*academics hate the idea of timescales and deliverables*" (Case C-Irl/CEO). Furthermore, SMEs and universities were not aligned in terms of objectives, priorities and perspectives as evidenced in the following quotations: "*…universities are research entities and the interactions take too long….in our experience*, *universities are willing to support but time is the issue…there is so much other stuff and priorities to be able to support a commercial development*" (Case C-Irl/CEO). "*We are trying to achieve different things. [Universities] want to get grants and publish papers*, *and we want to progress the engineering as fast as possible and they're just not the same thing"* (Case H-Scot/R&D Manager)."

However, in Case B, the ORE SME leader overcame such difficulties by leveraging his wider collaboration experience and prior learning as an academic, enabling *how to work* with partners through developing partner '*empathy'*. In this context, providing an understanding of how universities operate and adopting a *balanced* process for recruiting project resources: "*You need to balance with the universities the very cheap option of having a PhD student*, *which takes a long time*, *versus a more well-paid option of a researcher full-time on the project. We have a combination of the two. We look at our critical path to TRL levels and recruit a researcher. But then obviously if there is an opportunity to have a PhD where the time scale is not so critical e.g.*, *non-linear modelling which is critical to the commerciality*. *It is securing a balance between the two*" (Case B-Irl/CTO). This enabling factor of partner empathy, an understanding of how each helix operates, and the need to align interests, was also emphasised in Case G: "*We spent the time upfront to gather the necessary insights and knowledge into how to work with [universities] on the [European] project which helped us enormously and paid dividends later"* (Case G-Fr/Innovation Manager).

To create a radical innovation such as an ORE device requires specialist knowledge and equipment, considerable time (circa 10 years), effort and financial investment which is further compounded by the complexities of the sea - "*before you even start with testing in the sea*, *everything is much more expensive*, *for example*, *with the wind turbine on land – you can develop that device at a fraction of the cost – the sea requires so much more investment*" (Case D-Den/CEO). "*Any ORE device should be capable of staying at sea for the duration of development*, *if something breaks*, *it is too expensive to collect*, *bring ashore to fix and then return to the sea*" (Case A-Irel/CEO). Thus, public funding and support via Government is an absolute requirement, however, differences existed in terms of what and how this support was leveraged across the sample. **Government** (and government agencies) interactions were evident, yet the experiences across the sample differed depending on the governmental level (i.e. regional, national, European) and the country of origin. Typically, ORE SMEs' regional government experiences were positive, enabling SMEs to build relationships and access available resources and supports. However, this experience changed as ORE SMEs moved through governmental levels. In all national governmental contexts within the sample (with the exception of Denmark), bureaucracy proved a limiting factor, combined with a lack of inter-organisational collaboration between government departments: "*With local authorities it is easier – contact is made*, *and we can meet them easily. [National government] is harder*, *because there are several institutions to meet with – one is energy*, *one is environment*, *and it may take weeks or even months to meet…the bureaucracy is very hard and very complicated to overcome*, *and the process of authorisation is very long and difficult"* (Case G-Fr/Innovation Manager). A similar arduous bottleneck was shared in Case C: "*It was relatively easy to get the funding but I think the protocol is over the top… the*

amount of "paperwork" you have to go through with the [Irish] funding agencies is probably three times more than you have with the EU funding agency…Even though the amount of money from the EU is much higher, they seem to have a much more practical approach about evaluating and improving projects" (Case C-Irl/CEO).

European countries offer dedicated start-up funding and supports. In Ireland, Enterprise Ireland[3] High Potential Start-Up (HPSU) funding is one of the mechanisms by which small, manufacturing companies with an international focus can avail of the necessary supports to scale. However, companies less than three years old can only qualify for this funding and given the lengthy ORE device creation timescales, ORE SMEs cannot qualify: "*…we do not fit into the HPSU model… but if companies like ours are successful, we will create five times more jobs than companies importing turbines….our government agencies have to engage more with this sector*" (Case A-Irl/CEO). This example further highlights the disconnect between the ORE sectoral realities and the much-needed policy adjustments to ensure a successful transition to a new technological regime.

As highlighted, due to the infancy and *unknowns* of the ORE market, the role of government as a funding agency is fundamental to this sector as economies of scale and volumes do not exist to justify private investment: "*The ORE market is not here today, and I think it won't be here for another 10 years and that's why we need the public funding…but we don't have so many signals from that [investment] coming from French government* (Case G-Fr /Innovation Manager). However, there was also evidence to support the lack of a pan-European collaborative action and an urgency in supporting the ORE sector, which is concerning, considering the climate crisis grand challenge: *"there's an energy conference coming up in [Irish conference centre] soon, there is no mention of ocean/wave energy and from an island point of view, this does not make any sense…. I mean Ireland's EEZ (exclusive economic zone) is ten times Ireland's land area…. there is a complete disconnect between the department and the agency that is supposed to be managing it"* (Case A-Irl/CEO). **Industry** interactions were necessary for ORE SMEs, to provide the industrial knowledge and resources that they lacked due to their *liability of smallness* as outlined in the following quotation: *"we're looking for specialist knowledge…. Our devices are big, complex and multi-disciplinary which requires composite materials – steel work to drilling in the seabed to generators. So, all sorts of disciplines are required, and we must integrate all those disciplines into one product"* (Case H/R&D Manager). However, our research finds that these collaborations were primarily with SME partners, offering a collaboration depth that was lacking with larger industry partners. SME partners provided flexibility in their approach and accessibility, enabling the SME to develop *swift trust* (given SME to SME similarities) (Blomqvist & Cook, 2018). This helped ORE SMEs to acquire the necessary complementary and specialist technical supports, knowledge and expertise. The harsh conditions of the sea environment intensifies the importance of securing medium to long term partner interactions as outlined in the following quotations - "*when we are at sea, we are not able to intervene therefore, we want the system to work, and to stand alone for two to three years without any human action and this is not well understood when we work with a new partner"* (Case G – Fr/Innovation Manager) *"…we have long-term relationships with individual companies that have served us well in the past. Due to our complicated system, it takes quite a lot of time just to get people up to speed with what the kind of design drivers*

[3] Enterprise Ireland is the government agency responsible for helping Irish SMEs develop and grow in world markets www.enterprise-ireland.com.

are, and the challenges. So, once you've invested that time for someone you kind of want to keep them around." (Case H-Scot/R&D Manager).

Ultimately, SMEs as industry partners, had a reciprocal understanding of *what*, *when* and *how* to do it as evidenced in the following quotation: "…*we find working with smaller partners is better than larger partners – smaller partners are more nimble and they spend time figuring out what you want and trying to get it done rather than just applying what they've done before*" (Case H-Scot/R&D Manager). Whereas ORE SMEs found working with larger industry partners limiting, for three primary reasons – first, inertia given their large scale; second, large players lack ORE sectoral knowledge, and third, a lack of consistent resources allocated to the project. Overall, demonstrating a lack of commitment and motivation to nurturing the partnership in executing the respective initiative "…. *we found that they [large partner] kept changing personnel all the time. This is one of the big issues with larger companies. With an SME there are two or three people consistently involved in the project, that wasn't the case with the large partner…. And also, the inertia – just how slow they were to react to everything. You find an SME can react very quickly, but the large company needs forward planning and procurement processes which passes through different layers of meetings and so on. That was a huge downside in dealing with large companies."* (Case B-Irl/CTO).

Our evidence highlights the breadth and diversity of interactions - both enabling and limiting across the triple helix (see Table 4 for an overview of praxis and evidence). However, significant ORE sectoral challenges exist, thus requiring a resilience and a management agility on the part of ORE SMEs to ensure a sustainable future: "*the cycle to commerciality is not quick; we had to adopt a lean philosophy in order to keep going*" (Case B-Irl/CTO).

4.2 Practices

Underpinning the triple helix framework, is the ability to exploit both internal and external capabilities (through collaborations) to advance technological discoveries. **How** ORE SMEs managed the interactions across the triple helix varied, depending on the practices (i.e. the 'tools' used – norms, behaviours and routines) employed (see Table 5 for an overview of practices and evidence). We begin with SMEs internal practices. Given the nature of the ORE sector, all cases highlighted the importance of a formal innovation process in executing both explorative and exploitative innovation stages. However, this process commenced with informal innovation activities with the entire team which progressed to a formal innovation process, as described in the following quotations: *"…we are a flat organisation, there is not an innovation dedicated team, everyone is responsible for innovation"* (Case D-Den/CEO). "*Innovation is usually unstructured, or someone may have an idea and bounces it with the team. If it gets the backing (informally) from people of different disciplines, then the person with the idea, would create a proposal which then follows a formal process…"* (Case H-Scot/R&D Manager). "*We use formal decision tree…a funnel – at the top it cascades down through a series of steps, we ask questions such as – will it (device) survive? Will it survive 25 years on site? 25 years on site means three million cycles every year. And if you multiply that by 25 you're way up in the 70 million cycle…the point I am trying to make is that the device has to survive in water and must be robust enough to survive…But the light bulb is probably from myself but to develop that idea, you need a team.* (Case A-Irl/CEO).

Table 4 Summary of Praxis and evidence

Praxis – interactions across the TH		
Enabling	Limiting	
Industry		Evidence
• ORE SMEs work with other SMEs and that was their preference for working with industry partners – there was an understanding of how to work with each other. These SMES provided the complementary technical supports.	• Larger partners proved challenging to work with – inertia and lack of consistent resources.	"A*n SME can react very quickly but the large company needs forward planning and procurement and passing through different layers of meetings and so on"* (Case B-Irl/CEO)
University		
• Time and patience given to developing university relationships. • Importance of developing partner 'empathy'. • Balanced recruitment of resources – PhD and full-time researcher.	• Lack of time and effort given to engage (from both sides SME and university). • Lack of urgency from universities. • Failure to align objectives and priorities (from both sides SME and university). • Academic partner lacked understanding of industry context.	*"[Industry and academia are] basically trying to achieve different things. They want to get grants and publish papers and we want to progress the engineering as fast as possible and they're just not the same thing"* (Case H-Scot/R&D Manager)
Government		
• Regional Government – positive experience – relationship building, access to supports and resources • EU funds were accessible.	• National Government – access to supports and resources were challenging in most geographies (Denmark the exception) – bureaucratic and lengthy time-consuming processes in place. • Required to consult/access different departments – e.g. climate/energy/finance	*"It's literally a minefield and you can be almost guaranteed there's a fund there …. but it's to find the funders is the challenge you know"* (Case C-Irl/CEO)

The formal methods used by ORE SMEs (decision tree and a funnel questioning process) are examples of the key tools, norms and routines employed. These formal processes extended to assessing if external collaborations were worth exploring, which is important given the SME status and complexity of the ORE technology: "…*we rank innovations by their levelised cost of electricity (LCOE) impact and then that tells us what to prioritise in*

Table 5 Summary of practices and evidence

Practices	Evidence
Internal Practices • Move from informal to formal / deliberate innovation practices - 'stage-gate'/decision tree type processes • Eager to be involved in other initiatives in terms of how the learnings can be applied to tidal sector. • Defined a 'rulebook' for guiding how to work with partners – get a consortium agreement in place. • 'Selective' strategy in who to work with – will 'interview' then 'date' to find out if partner is suitable • SME strategy to only work with 'credible' partners – organisation reputation needs to be protected. • Subcontracted/outsourced non-core technical activities.	*"You need a very good assessment of the stage gates as to what these guys are telling you when they say we've produced this amount of power, we've survived these waves and so on and so on."* (Case B-Irl/CEO) *"I reached out and 'interviewed' [partners]. I basically interviewed them to find out the know-how they had and experience. It was worth it – we have had a very good collaboration with the two [partners] now for many years."* (Case D-Den/CEO)
External Practices • Strategic selection/deselection of partners for specific activities dependent on the requirements/supply chain needs etc. (leveraged prior entrepreneurial experience to find and work with other start-ups/SMEs) • Partners acquisition through participation in European projects; these participations have helped with transfer of knowledge and learning in terms of HOW to work with and manage external partners. • Developed an understanding of the processes that exist within each partner type, clarity of how to engage with external parties and when – timing in important, be patient – don't engage too early. • Used off the shelf purchasing; avoid bespoke development • Leverage capabilities from other industries – steel, composites etc. – understanding of how these industries work • Lobbied governments through industry association membership.	*"We try to participate in as many as trade associations that are relevant for us and these associations help in our lobbying efforts with government"* (Case F-Spain/Project Manager).

our R&D efforts – then we decide if we can either do that R&D internally, or do we need to work with external partners" (Case H-Scot/R&D Manager). In this example, the interaction between practices and praxis is highlighted. The formal innovation decision tree informs the praxis of whether the R&D is internally or externally driven.

Partner selection is the foundation on which inter-organisational relationships are formed and developed, thus engaging in subsequent interactions is a must: "*SMEs have limited access to capital. So, we need partners, but you must look at both the potential problems and the opportunities in your partner selection*" (Case B-Irl/CEO). Evidence highlighted partner fit and a deliberate selection of the *right partner* was a fundamental enabler in such interactions. Many ORE SMEs employed a purposeful and reflective strategy in finding/initiating/selecting the partner that fits the needs of the SME: "*In my experience, one needs to be extremely careful of those you start working with and do not rush into it…I would say that the better approach is to find the perfect partner regardless of where they are*" (Case C-Irl/CEO).

One ORE CEO described the partner selection process using a dating analogy i.e., a 'courtship' (Forrest & Martin, 1992): "*It is a case of seeking out the important partners…we identified who those potential strategic partners might be…. it's like a blind date. We would go and we would engage with them, visit them, and talk about what we are doing, what we are looking to achieve and then get their views. So, we'd spend about two days working through what they have done in the past … we were interviewing them, and they were interviewing us".* (Case E-Scot/CEO).

Evidence also pointed to the importance of ensuring sound internal SME management and governance practices, ensuring a *'participatory architecture'* (Ritala, 2023) is in place prior to engaging externally with partners. This safeguards that appropriate structures and rules of engagement are in place e.g., for contract management/negotiation purposes in determining how the partnership is framed: "*If you have the rule book well defined in advance and fully agreed then that that makes life a lot easier working with partners"* (Case A-Irl/CEO). Turning to external capabilities, ORE SMEs practiced strategic engagement by proactively building governmental relationships, network ties and boundary spanning activities which included participating in governmental lobbying activities through member associations: "*…we participate in all relevant affairs and conferences in Europe. We are part of a cluster…so we try to participate in as many associations that are relevant for us, and we participate in lobbying efforts with government"* (Case F-Spain/Project Manager).

Some partners require careful *'hands-on'* micro-management whilst others require less input, thus an adaptative management style is required which is crucial to the successful implementation of projects, as evidenced in the following quotation: "*…we generally find you get pretty good results [with partners] but it varies to the degree that you must manage them. Some are quite good in the sense that they understand what you want, and they just go away and do it. And some people don't necessarily grasp what you want, and they don't really deliver what you thought you asked for. So, one of the challenges for each new project is figuring out how much do I have to micromanage [the partner] and how much can I just let them go and do the research and come back to us. And so that's usually the main challenge – how much management is required?…but it is important to invest that time in the management side of things as required. Which can sometimes be quite a big drain on resources"* (Case H-Scot/R&D Manager).

Many organisations are leading European funded ORE renewable projects which is quite the accomplishment given the organisations' small scale. However, this is achievable due to the internal team employing prudent corporate governance and legal procedures as standard practices as a platform for success, as shared in the following quotation: "*The big challenge is to is to pull a team together and you've got to have a lot of credibility if you're pulling*

Table 6 Summary of practitioner characteristics and evidence

Practitioners Characteristics	Evidence
• Passion for the sea (all SME leaders) • Background in the sea (all SME leaders) • Academic experience (Cases A, B & E) • Entrepreneurial experience (Cases A, C, D & E) • Experience working for SMEs (Case F) • Education – Third level – PhD (Case A & B); Masters (D, E, F, G & H); Second level (Case C)	*"a lot of people that start off with wave energy systems, they don't have that background. I had already been operating in the sea for many years and that was key because I could see a market, commercial market immediately for small wave energy systems providing autonomous power"* (Case D-Den/CEO) *"I have a long history with the marine energy sector. I was a professor in [university] for many years. I ended up as professor of energy engineering, and at one stage director of the [marine energy research centre] and director of the [facilities at research laboratory]"* (Case B-Irl/CEO) *"My experience helps me now in finding the right partner - one needs to be extremely careful of who you start working with and do not rush in to partnerships…. In the early stages we probably jumped a bit early you know"* (Case C-Irl/CEO)

a team that's a hundred times larger than your own operation and you need good legal advice. You need good corporate governance and one of the things that's very important in that is to develop a consortium agreement…one of our [team] is an experienced corporate lawyer. So, we can manage the creation, organisation and discussions about the consortium agreement…. This provides a foundation and a framework, so we have a clear definition on what's the background intellectual property owned by the various partners so there's no confusion and then you have an understanding about any foreground IP. Any inventions that arise during the consortium project, you know who's going to get it and again, there should be no disputes." (Case A-Irl/CEO).

4.3 Practitioners

The role of the ORE SME leader is fundamental to achieving successful inter-organisational interactions. These ORE SME leaders through their actions and behaviours are determining and *orchestrating* the SMEs praxis and practices. However, these actions are shaped and influenced first by *who* the SME leaders are i.e. their entrepreneurial experience, ORE sectoral knowledge, passion for the sector and prior business, education, and background; and second, *how* this experience, knowledge and background etc. influences *what* actions and behaviours to take (see Table 6 for a summary of practitioner characteristics and evidence). These underlying leader characteristics and traits are the foundation for shaping *what* SME leaders do in managing these interactions and *how* they do it – '*successful practices are carried by influential practitioners'* (Whittington, 2016: 627).

As outlined, the ORE sector is complex, uncertain, challenging and is still in its infancy. ORE SME leaders with sectoral experience, background and passion for the sector are the principal contributory factors in creating sustainable SMEs, as evidenced in the following quotations: *"…a lot of people that start off with ORE devices, don't have background knowledge. I had been operating in the sea for many years and that I think was key… I could see*

a commercial market immediately for small wave energy systems providing autonomous power" (Case D-Den/CEO). *"I've had quite a lot of experience in small boats in the Atlantic and I've sailed small boats down to the Azores and up well up into the Arctic so I know what the sea is like…. I knew that any solution we develop has to be seaworthy"* (Case A-Irl/CEO).

Due to the many unknowns and complexities of the ORE sector, practitioners require a long-term vision, a healthy dose of pragmatism, coupled with a resilience, an unwavering belief and determination in executing their vision: "…*with all energy technologies there's the longer-term reservation because the market is completely out of your control. The energy market is completely regulated and highly politicized as well. So*, *you are in it for the long haul - it will be five to ten years realistically to get something commercially into the marketplace"* (Case E-Scot/CEO).

Prior entrepreneurial experience and knowledge is an enabler in identifying the importance of high human capital to achieve success. ORE SME leaders have taken confidence and learnings from their past entrepreneurial ventures which provided a solid basis and the 'muscle memory' to motivate a team and attract both skilled resources and collaborative partners, whilst navigating the myriad of market unknowns: *"I am a seasoned entrepreneur so when I look at something*, *I look at people – internally at the team*, *Then I look externally*, *where is the market? Where are the customers? Finally*, *what technology do we need? and in that order you know? I want to see a market and then be able to attract clever people and partners that can implement it* (Case D-Den/CEO)".

Furthermore, SME leader's prior experience of managing collaborative practices aid their understanding of the complexity and nuances of partner relationships (evident in cases A – E), as such providing the necessary 'lessons' to take forward into future partnerships. How ORE SMEs find, select/deselect, and access such inter-organisational collaborations is a challenge given the market / regulatory unknowns and the high risk factors; ORE SME leaders achieve this through their formal / informal networks, boundary spanning activities plus their resilience, determination and passion for their 'purpose' – all of which supports and validates their efforts: "*We don't have a big staff*, *but I have a big network*" (Case A-Irl/CEO).

Given the complexity of an ORE device, knowledge of additional disciplines is essential. SME leaders *wear different hats* to unlock the opportunity and potential of this sector, utilising both technical expertise and management skills to integrate multi-disciplinary knowledge effectively as highlighted in the following quotation: "*We work with several kind of industries*, *for example*, *the steel structure*, *we work with a partner specialized in a steel construction for offshore needs….we work with composite specialists which are mostly dedicated to offshore boat races…the generators we reuse*, *we try to reuse standard machines*, *and the cooling system"* (Case G-Fr/Innovation Manager).

ORE SMEs are also leveraging membership of trade associations to augment their collaborative partnerships: *"To get the sort of money that is needed*, *you need a strong partner*, *and to secure the right partner… I leveraged my network and got an introduction through the [gov agency] to [partner]* (Case A-Irl/CEO). Overarching these practitioner traits is the ORE SME leader's ability to manage teams and relationships by leveraging a unique blend of innate abilities, experience, pragmatism, and adaptability, enabling them to navigate the complexities of the TH model with passion and confidence.

5 Discussion

The ORE sector has the potential to contribute towards the European Union's 2050 carbon neutrality ambition and to advance our global response to the climate crisis grand challenge (Vanegas-Cantarero et al., 2022). However, the sector faces extreme uncertainty due to its infancy, disruptive nature, and the high-cost, high-risk investment demands (Pennock et al., 2022). Currently, SMEs dominate the ORE sector, playing a key role in the early stages of technological development with substantial R&D efforts, but achieving only limited commercial success so far. Leveraging the potential of the TH system could be crucial for advancing ORE commercialisation and fully harnessing SMEs potential in the sector. Entrepreneurial networks are seen as vital for driving the evolution of the TH within national energy markets (Werker et al., 2017). This paper adopts a practice perspective to explore the micro dynamics of how SME actors behave and interact, which may provide insights into optimising SME involvement in TRL development, innovation, commercialisation, and the overall growth of the ORE sector. Consequently, this paper seeks to uncover how ORE SME leaders manage interactions for innovation across the triple helix using *practice* theory and Whittington's (2006) framework as a lens.

This study highlights the importance of adopting an intra-organisational perspective on TH interactions through the CEO/founder lens expanding the management as practice discourse. Despite challenges, ORE SME leaders are navigating the intricacies and stresses of the sector, and their interactions utilise an innate blend of ability, experience, pragmatism, and adaptability. De Rond and Bouchikhi (2004: 66) speak of "*alliances as heterogenous phenomena…that are continuously torn by multiple and contradictory forces….and the dialectic tensions which arise from the interplay of these forces are not neither intrinsically functional nor dysfunctional….They are just there to serve an explicit or unconscious purpose. They just are*". Our findings allude to tensions between actors, but the ability of the ORE CEOs/leaders to employ intuitive and formal management approaches (like consortium agreements and decision trees) reflects their innate skills as practitioners to shape strategic interactions. The complexity of the ORE operating environment forces practitioners to adapt and tailor their approach to different partners. For example, when working with universities and government, practitioners emphasised the importance of empathy and patience to navigate the rigid, bureaucratic structures within these institutions. Within academia, the frustration by ORE CEOs/leaders regarding academics' lack of industry experience and understanding of the challenging context was evident. In contrast, within SME-to-SME interactions, due to a greater alignment in actor expertise, and SME behavioural advantages (i.e. agility and quick decision-making processes), effective collaborations are more easily created. Effective interorganisational partnerships are also built on the ability to generate trust (Williamson, 1985; Daellenbach & Davenport, 2004); which is described by Koza and Lewin (1998: 259) as "*the magic ingredient necessary for alliances to succeed"*. Evidence from the cases highlighted the ability of ORE SME leaders to develop *swift trust* with partners i.e. based on little information and time to investigate past performance (Meyerson et al., 1996; Blomqvist & Cook, 2018).

Collectively, these findings highlight the importance of the *human element* within the TH (Linton, 2018; Ryan et al., 2018; Foncubierta-Rodríguez et al., 2023) notably the centrality of the CEO/leader and their pivotal role in determining innovation, commercialisation and industry development outcomes (through the TRL development cycle). SMEs have the

potential to benefit most from collaborative technology transfer programmes (Hilkenmeier et al., 2021) through a '*scientific and technical human capital'* route (Bozeman, 2000; Bozeman et al., 2001). However, such interactions must be carefully managed which is a challenge for SMEs given their resource deficit, but one which must be embraced by the ORE SME leader(s) i.e., the practitioner. The *human element* is central to executing these practices which permeate internally and externally; clear governance structures to provide direction and incentives are necessary to help SMEs learn through doing, using, interacting (DUI) (Jensen, 2007; González-Pernía et al., 2015) and to build a path for developing strong partner relationships (Ness, 2009; Omri et al., 2022) within this complex risk-laden sector.

The cases further demonstrate that currently the ORE TH system is stressed, fragmented and complex. In part, this could be explained by the point raised by Strasser et al. (2022), when previously discussing other social innovations. The authors outlined that often there is a lack of systematic and practical understanding on how different actors involved in social innovations can enhance transformative capacity in connecting, scaling, and embedding new regimes within existing political and market systems. At the same time, constraints imposed by existing structures and arrangements, such as the political structure in Europe and the liberalised EU market can slow social innovation transition and advancement (Rotmans et al., 2001). Nevertheless, a key enabler supporting European industry is the robust climate policy from the EU and national governments, which have set clear legal targets and commitments for reducing emissions (Botrel et al., 2024). Environment and energy policy is becoming one of the most lobbied fields of government policy globally (Berkhout & Hanegraaff, 2019). In that context, it is not surprising that ORE SMEs have highlighted the practice of lobbying within our cases. In addition, considering we are drawing from a sample of cases from a dedicated SELKIE alliance of ORE SMEs and university actors, this demonstrates how actors within the ORE network are striving to leverage group alliances, positioning themselves as a counterbalance to the long established, well-resourced and strong lobbying behaviours of the fossil fuel industry (Botrel et al., 2024).

The cases highlight several concerns with the use of a TH framework for driving the ORE transition. The emphasis on empathy, patience and trust by interviewees with both universities and government partners highlights the need for policy remedies that reduce bureaucratic hurdles on both these fronts. It is well recognised that significant barriers exist for successful Industry-University relations. This study highlights that universities' focus on publishing scientific papers, rather than on technology transfer and commercial impact, which is a major obstacle. Additionally, universities often lack urgency and a clear understanding of business objectives. But interestingly, SMEs also acknowledged challenges on their end, citing limited time and effort to engage, as well as difficulties in aligning priorities and goals with universities. The recognition of the need for patience and empathy, even from SMEs, suggests that traditional policy instruments may not fully overcome this *human element* of TH interactions. Unfortunately, technology alone will not solve the sustainable development conundrum, and the Triple Helix model itself has faced criticism for its limitations in effectively shaping sustainable transitions (Huntjens & Kemp, 2022). The model excludes the important role of civil society organisations and complicated multi-level government arrangements (like that of the EU case). Whilst the economic and financial instruments available at regional and EU level were deemed adequate by interviewees, all cases (except the Danish case) reported negative experiences due to their dealings at national government level. This is particularly worrying as ORE governance in the EU remains pre-

dominantly controlled by individual nation-states (Guerra, 2018). Enhanced coordination, regulatory frameworks and harmonised policies for the ORE sector are recommendations that are required to transcend across all levels of government-local, regional, national and EU wide - to ensure cohesive and effective governance across the EU.

6 Conclusion

In this study, we asked *how* are the interactions for innovation managed by ORE SMEs across the triple helix? The study leveraged a *practice* perspective using Whittington's (2006) praxis, practices, and practitioner framework and provided insights into the human element of the triple helix. Doing so, acknowledges the principal role of the SME leader in navigating the complexity and unknowns of the ORE sector. The study finds SMEs operate within a heavily stressed triple helix environment, requiring them to navigate complex bureaucratic dynamics with universities and government partners. This is further compounded by fragmented governance structures across the EU, making collaborations reliant on forging strategic alliances. Through examining the *human element* of SME actors' behaviour and interactions, it becomes clear that their innate blend of ability, experience, pragmatism, and adaptability is crucial for executing successful interactions, enabling them to achieve their goals in TRL development through a successful *orchestration* of need driven interactions.

Participating in external collaborations require a particular set of competences (Di Benedetto et al., 2019). ORE SME's behaviour and interactions are a reflection of its leader (Hambrick & Mason, 1984). This study highlights implications for practitioners in that that CEO/leaders require a reflective, empathic, and adaptive management style when approaching collaboration. Studies have previously highlighted the role of culture and competences among individual collaboration partners as being crucial in determining the performance of the collaboration process (Del Giudice & Maggioni, 2014). At the same time, business practitioners point out numerous issues on the university and government side, including rigidity, bureaucracy, lack of business acumen, and misaligned incentives. Traditionally, boundary spanners have been identified to act as intermediaries to resolve conflicting demands, cultures, and expectations between helix partners (Lundberg, 2013). But boundary spanning may not necessarily solve, overcome, or bridge failures related to the *human element* behind triple helix interactions. The challenge therefore lies in policymakers formulating novel training supports, that directly targets change management of norms, behaviours, routines, and traditions of helix actors. The policy implications may involve challenging the 'how' of 'practices' and their operation for example, through entrepreneurial leaning via mentoring training (Sullivan, 2000), living lab supports from an innovation management perspective (Bergvall-Kareborn & Stahlbrost, 2009) or other co-creation vehicles such as joint research labs or accelerators (De Silva & Wright, 2019). However, uncovering the 'how' is a complicated space, particularly across different sectors, and we call for future research to examine the possible policy supports that could assist helix ORE practitioners to navigate this complex TH web and to develop effective collaborative competences and skillsets.

This study is not without limitations. We explored the ORE sector through the egocentric lens of the industry helix; a wider study including more European countries plus the other helices – academia and government would be advantageous. Also, given this sector is in its infancy, a study to explore how to motivate (economic / social) different helices given the

plurality of interests that exist and to help remove the present tensions that naturally exist (Ritala, 2023), would be helpful.

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