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Sustainability-Oriented Collaborations in Green Energy Markets Formation: A Configurational Analysis of Alliance Management Capabilities and Relational View

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ABSTRACT

Sustainability-oriented collaborations are inter-organisational arrangements where the competencies of multiple companies are pooled together to tackle environmental challenges. These collaborations differ from traditional strategic alliances in that they tackle complex goals amidst greater uncertainties that extend beyond economic performance, thus requiring a more diverse array of partners. Consequently, scholars have questioned whether the mainstream strategic alliance literature can adequately explain the varying outcomes of sustainability-oriented collaborations. Drawing on the Alliance Management Capabilities (AMCs) and Relational View (RV) literature, we investigated 16 sustainability-oriented collaborations to understand how the focal companies guide these inter-firm collaborations to success. The results of a fuzzy-set Qualitative Comparative Analysis reveal that successful collaborations present four different combinations of constructs derived from AMC and RV, namely coordination, inter-organisational learning, governance models, and transaction-specific assets. The paper discusses how these combinations effectively address the unique challenges of sustainability-oriented collaborations, ensuring their successful functioning. As its main contribution, this study offers a configurational perspective that provides actionable insights for effectively managing and leveraging alliance management capabilities and relational resources in green energy markets.

1 | Introduction

A rigorous implementation of the sustainable production and consumption paradigm is a pressing challenge that businesses cannot tackle alone, requiring collaborative approaches that integrate resources, expertise, and objectives (Albino et al. 2012). Consequently, a broad range of collaborative initiatives has emerged in recent years to pool together the required resources (Ordonez-Ponce and Clarke 2020; Winch and Sergeeva 2022) to address, alongside the traditional economic and competitive objectives, environmental and/or social challenges. We refer to these collaborative models as sustainability-oriented collaborations (SOCs).¹

Although the literature on strategic collaboration is extensive and provides valuable guidance for firms to structure partnerships effectively and efficiently, the specificities of SOCs require additional investigations (Al-Tabbaa et al. 2019; Niesten and Jolink 2020; Menghwar and Daood 2021). Indeed, compared to traditional alliances, SOCs require diverse and heterogeneous members to address systemic and complex challenges (Pinkse and Kolk 2012; Ordonez-Ponce and Clarke 2020), demand new technological and non-technological competencies and knowledge beyond core business areas (Rizzi et al. 2013), and follow a trial-and-error logic rather than a standardised approach (Daniel 2022). Given the distinctive features of SOCs, Vurro et al. (2023) and Menghwar and Daood (2021)

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have highlighted the need for a deeper reflection on whether and to what extent mainstream theories² of strategic collaboration can be meaningfully applied to explain and predict the performance variability of these novel forms of partnership. In this regard, recent studies have observed that the indiscriminate and universal application of traditional strategic alliance theories and frameworks to sustainability-oriented collaborations overlooks important contextual characteristics (Al-Tabbaa et al. 2019; He et al. 2020) and their influence on collaboration's effective functioning (Gölgeci et al. 2019; Leischnig et al. 2014).

Early attempts to shed light on SOC's have sought to apply strategic alliance theories to this context. Scholars started investigating SOC's, drawing separately on alliance management capabilities (AMC) (e.g., Alonso and Andrews 2019; Wójcik et al. 2022), and relational view (RV) (e.g., Weber et al. 2017; Donbesuur et al. 2021), applying these theoretical frameworks to partnerships that incorporate just some of the distinctive features of sustainability-oriented collaborations. However, insights on the functioning of SOC's are still partial and fragmented.

Alonso and Andrews (2019) focus on a single characteristic of SOC's, partner heterogeneity, examined in relation to just one alliance management capability to explain the effective performance of SOC's. While this offers some insights, the narrow analytical scope limits the study's explanatory power, thereby overlooking the potential need for more modular or adapted relational-managerial approaches (He et al. 2020, 2024). Weber et al. (2017) adopted three constructs of inter-organisational collaborations from the RV (i.e., complementary resources and capabilities, relation-specific assets, and effective governance) to explain joint value creation between the two parties of SOC's, thus ignoring the specific characteristics and capabilities of individual partners that influence differences in joint value creation. Donbesuur et al. (2021) provided some insights related to just one attribute of RV and AMC's in the development of environmental innovation. Similar shortcomings emerge from the analysis of the most frequently adopted methodological approaches within this stream of research, which often fall short of enabling a comprehensive understanding of the SOC's. By relying predominantly on quantitative structural equation models (e.g., Weber et al. 2017; Alonso and Andrews 2019; Donbesuur et al. 2021), most of these studies tend to assess the effectiveness of individual alliance management capabilities or isolated pillars of the RV, without capturing their potential adaptive or combinatory dynamics across diverse collaborative contexts.

Altogether, these studies confirm the promising explanatory potential of integrating RV and AMC perspectives but still reveal significant gaps in achieving a comprehensive understanding of SOC management. Therefore, existing research on SOC's presents limitations in that: (i) it often assumes the universal applicability of relational frameworks such as AMC and RV, overlooking the contextual conditions required for their effectiveness (Gölgeci et al. 2019; Leischnig et al. 2014); (ii) it addresses the distinctive complexities of SOC's only partially and in a fragmented manner, limiting the explanatory power of its insights (He et al. 2020, 2024); (iii) it predominantly relies on

quantitative methodologies that fail to capture the adaptive and combinatory dynamics of relational constructs across diverse collaborative settings (Kohtamäki et al. 2018). Building on these considerations, this study aims to provide a quali-quantitative exploration of the relational models that underpin SOC's from an RV-AMC integration perspective, leading to the following overarching research question that guides this study:

How do companies manage sustainability-oriented collaborations (SOC's), and which capabilities and relational constructs enable their successful implementation?

To this end, we investigated, through a phenomenon-based research approach (Lumineau et al. 2025), a set of 16 flagship projects undertaken through inter-firm collaborations with explicit, nationally relevant, environmental goals. Although SOC's can take various forms - ranging from collaborations exclusively among firms to partnerships involving different types of organisations such as NGOs and governmental bodies-and may pursue diverse goals, including social or humanitarian objectives, this study focuses specifically on private inter-firm collaborations aimed at advancing environmental sustainability. These are projects in which all the firms involved typically operate in profit-driven market environments and thus must step beyond their conventional business-as-usual approaches within the boundaries of the SOC's. This research setting enables the examination of relational models within a more homogeneous set of inter-firm collaborations (projects), allowing the analysis of how different configurations of capabilities and relational constructs combine in SOC's to achieve successful environmental outcomes (Chen et al. 2017).

In detail, we examined the management of each SOC in its post-formation phase to assess whether and how RV and AMC's constructs were adapted and integrated by the focal company in each project, with the ultimate goal of identifying the most effective configurations for collaboration management. To assess whether these constructs exhibit adaptability or universality, we employed Qualitative Comparative Analysis (QCA) (C. C. Ragin 2000, 2009), a methodology particularly suited for this purpose. QCA enables the identification of specific combinations of factors or the presence of constant elements that are necessary for achieving a given outcome, in this case, effective collaboration management.

The results reveal four distinct combinations - *coordination*, *inter-organisational learning*, *governance models*, and *transaction-specific assets* - that effectively address the unique challenges of SOC's, driving successful collaborations. Furthermore, collaboration-specific interviews provided additional insights into our QCA model, revealing a set of context-specific factors that explain why specific configurations prevail over others. These factors include *pre-existing knowledge* among partner companies, the *technical complexity of targeted activities*, the level of *financial exposure*, and the *alignment between the focal companies' core business and the objectives of the SOC*.

This study offers multiple contributions, both theoretical and practical. From a theoretical perspective, it advances the

ongoing debate on the extent to which the mainstream literature on partnership can be adapted to the sustainability domain (Al-Tabbaa et al. 2019; Vurro et al. 2023), highlighting how a combined application of RV and AMC frameworks, through combinations of constructs, can help interpret the contextual specificities of SOC (Wang and Rajagopalan 2015). Moreover, we found that it is not only the specific challenges addressed by the SOC that determine the relevance of RV and AMC constructs, but also the distinctive attributes of the partners involved. This underscores the need to consider a broad set of factors in the development of SOC, supporting an RV-AMC integrative approach to their study and management (Menghwar and Daood 2021; He et al. 2020, 2024). Finally, this study contributes to the advancement of phenomenon-based research in management studies. By grounding our investigation in a set of real-world SOC, we respond to recent calls to enhance the practical relevance of management scholarship and counter the critique that it is overly theory-driven and disconnected from managerial realities (Graebner et al. 2023; Harley and Fleming 2021). In doing so, our approach avoids the pitfalls of purely descriptive or inductive accounts by maintaining analytical clarity and identifying causally significant patterns, following a phenomenon-oriented yet theoretically informed research agenda that is capable of generating valid and valuable managerial insights.

From a practical perspective, this study also provides actionable insights that support managers of focal companies in addressing the post-formation phase of SOC, enabling them to identify and utilise the RV and AMC constructs. By highlighting how to tailor these constructs to the unique demands of each collaboration, this study helps avoid their misinterpretation as universally applicable.

2 | Theoretical Background

2.1 | Collaboration for Sustainability and the Rise of SOC

Over the last decades, numerous inter-organisational collaborations have formed, driven by a shared commitment to addressing social and environmental challenges (Wassmer et al. 2014). Scholars have placed considerable emphasis on identifying the potential of these collaborative endeavours to deliver sustainability outcomes, providing evidence that intense collaborative endeavours among multiple actors help tackle environmental challenges (Hartman and Stafford 1997; Arts 2002; de Bruijn and Tukker 2002).

Acting as platforms for joint solution development, collaborations allow organisations to unlock knowledge, capabilities, and market opportunities that would be difficult to achieve in isolation (Dyer and Singh 1998). Their multifaceted impact encompasses reducing carbon footprints, compliance with environmental regulations, and reputational gains associated with stakeholder perceptions of corporate social responsibility (Albino et al. 2012). Beyond enhancing internal performance metrics, SOC also contribute to broader societal goals; for instance, Ordonez-Ponce et al. (2021) demonstrate how sustainability partnerships align with and advance the United Nations

Sustainable Development Goals (SDGs). Furthermore, in the specific context of green product innovation (GPI), engaging with a broad range of actors enables firms to overcome internal resource limitations and address the complexity of sustainable innovation (Dangelico 2016; Rauter et al. 2019). Manufacturing firms have leveraged green alliances not only to reduce ecological costs but also to access new markets and respond proactively to regulatory and customer demands (Melander 2017; Melander and Arvidsson 2022).

However, while solid existing literature demonstrates that collaboration can support multiple ambitious environmental outcomes, relevant questions remain regarding how such collaborations should be managed, and - specifically - whether theoretical frameworks developed for traditional strategic alliances can be effectively applied to structure and govern SOC (Menghwar and Daood 2021; Niesten and Jolink 2020).

Traditional strategic alliances are typically characterised by fundamental features that enable the proper deployment of relational dynamics, which, in turn, ensure their effective operation. These features include a self-interest orientation in economic value creation and capture (Ryan-Charleton et al. 2022), the necessity for homogeneity in partner selection (Rothaermel and Deeds 2006), and the presence of predictable patterns of activities, where a sequential process unfolds, with each phase concluding before the subsequent one commences (Hoang and Rothaermel 2005). In this regard, Vurro et al. (2023) pointed out that SOC differ from traditional strategic collaborations due to (i) goal complexity, where the attainment of sustainability objectives may supersede the conventional logic of business competitiveness (Pedersen et al. 2021), (ii) heterogeneity of the partners engaged in the collaboration, where there are strategic interdependencies among actors throughout supply chain and networks, and (iii) limited predictability, where the complexity of the sustainability challenges makes the approaches to solve the problems not straightforward, with consequences that are difficult to predict.

As the underlying assumptions that support the functioning of traditional collaboration frameworks no longer hold in the context of SOC, Lin and Darnall (2015) argue the need for a critical examination of how mainstream theories operate within sustainability-oriented domains. In this regard, the extant literature offers insights mainly on (i) the effectiveness of collaborations in addressing general sustainability challenges and (ii) the validity of the RV and AMC constructs examined in relationship with one or a few of the specific features of SOC. Despite these early contributions, unfortunately, a comprehensive framework of the full range of SOC's distinctive features is still missing.

Alonso and Andrews (2019), focusing on cross-sector partnerships, examine the issue of partner heterogeneity and demonstrate the role of accumulated partnership capabilities in enhancing partnership efficiency. Similarly, Liu et al. (2018) applied and tested the effectiveness of Schilke and Goerzen's (2010) generic capabilities in managing partners' diversity in the setting of cross-sector collaborations. Wójcik et al. (2022) investigate firms' alliance management capabilities in the context of social responsibility, thereby integrating sustainability objectives into their analysis. Weber et al. (2017) drew on the RV literature to

examine how specific investments, complementary resources, and effective governance influence the functioning of non-profit collaborations. Other studies have investigated the role of key pillars of the RV, focusing on learning mechanisms (e.g., Dentoni et al. 2016) and coordination processes (e.g., Caldwell et al. 2017; Ritvala et al. 2014), in the effective management of cross-sector collaborations. Among these studies, Donbesuur et al.'s (2021) contribution is one of the few attempts to build on both RV and AMCs, demonstrating the potential of these frameworks in exploring how to sustain cross-sector collaborations from the perspectives of SMEs by highlighting the moderating role of relation-specific investment, which is one of the attributes of RV, between AMC and the collaboration-specific environmental innovation.

Overall, while the extant literature has tended to examine AMCs and RV either in isolation (e.g., Pittz and Intindola 2015) or as components of a broader process (e.g., Le Ber and Branzei 2010), no previous studies have adopted a comprehensive perspective that captures their overall configuration, dynamics, adaptation and interactions in the SOC domain (He et al. 2020, 2024), and analysed how these configurations achieve sustainable outcomes (Chen et al. 2017).

To start filling this gap, the following section provides a detailed description of the two theoretical frameworks that underpin this study, outlining how they are applied within the context of sustainability-oriented collaborations (SOCs) and the opportunities for their integration.

2.2 | An RV-AMC Integrative Analytical Framework to Investigate Organisational Lever for SOCs

This study refers to two distinct but complementary theoretical frameworks that have traditionally guided the analysis of inter-organisational collaborations: the RV and the AMC perspectives. Each offers a different lens through which to examine the formation, governance, and performance of collaborative arrangements.

When scholars target the partnership as a whole, the RV emerges as the most suitable theoretical lens for understanding the relationships established between the parties (Dyer and Singh 1998). When, instead, the study targets a single company, the alliance management capabilities (AMCs) are the most appropriate theoretical framework for understanding the characteristics that allow a company to maximize the partnership's outcome (Schilke 2014; Schreiner et al. 2009).

From a structural perspective, the RV posits that partnerships are effective in generating competitive advantage due to supernormal profits, known as relational rents, which derive from the extraction of value from mutually integrated resources (Lavie 2006). According to the original formulation of the RV and further empirical evidence, effective governance, complementary resources, investment in relationship-specific assets, and knowledge-sharing routines are necessary to generate relational rents (Dyer and Hatch 2006; Kale et al. 2001; Lavie 2006). The AMCs, instead, integrate the RV in that it

adopts a firm's perspective on multiple relations (Wang and Rajagopalan 2015) to distinguish the resources that are necessary to handle individual alliances (Schreiner et al. 2009) from those that are necessary to manage a portfolio of partnerships (Schilke and Goerzen 2010). In particular, AMCs highlight the skills and competencies that enable focal firms to orchestrate strategic alliances (Kale and Singh 2007), which is crucial in explaining performance differences across alliances (Wang and Rajagopalan 2015).

Based on the framework proposed by Wang and Rajagopalan (2015), the post-formation phase of inter-company collaborations, which encompasses the stage where partners have already been selected and the alliance's design has been established, is key to determining their actual outcomes. Focusing on this phase is crucial to complement the analysis of the RV and AMCs constructs relevant to the pre-formation alliance stage, which includes resource complementarity, a proven precondition for forming effective alliances (Dyer et al. 2018). In the post-formation phase, assuming the partnership is established correctly, coordination and inter-organisational learning are crucial for creating value (Kale and Singh 2007; Schilke and Goerzen 2010; Schreiner et al. 2009). In this phase, focal companies have significant autonomy in managing their coordination capabilities and learning processes to meet the specific demands of sustainability-oriented collaborations better. Moreover, focal companies are free to leverage investment-specific assets and effective governance mechanisms to foster collaboration outcomes (Wang and Rajagopalan 2015).

On this basis, Figure 1 illustrates the theoretical framework underpinning this study. The horizontal axis reports the variables derived from the RV, as initially defined by Dyer and Singh (1998), while the vertical axis displays the alliance management capabilities relevant to the post-formation phase, following the framework proposed by Wang and Rajagopalan (2015). At the intersection of these two dimensions - represented by the coloured rectangle at the centre of the figure - lie the strategic variables available to focal firms for influencing effective SOCs during the post-formation stage.

This study aims to explore how these variables combine within SOCs and identify the configurations that lead to performing SOCs, as indicated in the upper plane of the figure. The scattered points in the upper area of the framework represent the configurations associated with the outcome of interest of this study.

According to this framework, the variables that the focal firm can strategically leverage include:

- i. *Intrafirm learning processes* regarding the routines associated with articulating, codifying, sharing, and internalising alliance knowledge (Kale and Singh 2007). This construct examines the implementation by the focal firm of new internal mechanisms to accumulate new information (Zollo and Winter 2002) and, thus, to foster environmental learning (Donbesuur et al. 2021). The intra-firm learning processes determine the ability to absorb new skills from partners, which is crucial to attaining sustainable goals (Ardito et al. 2019).

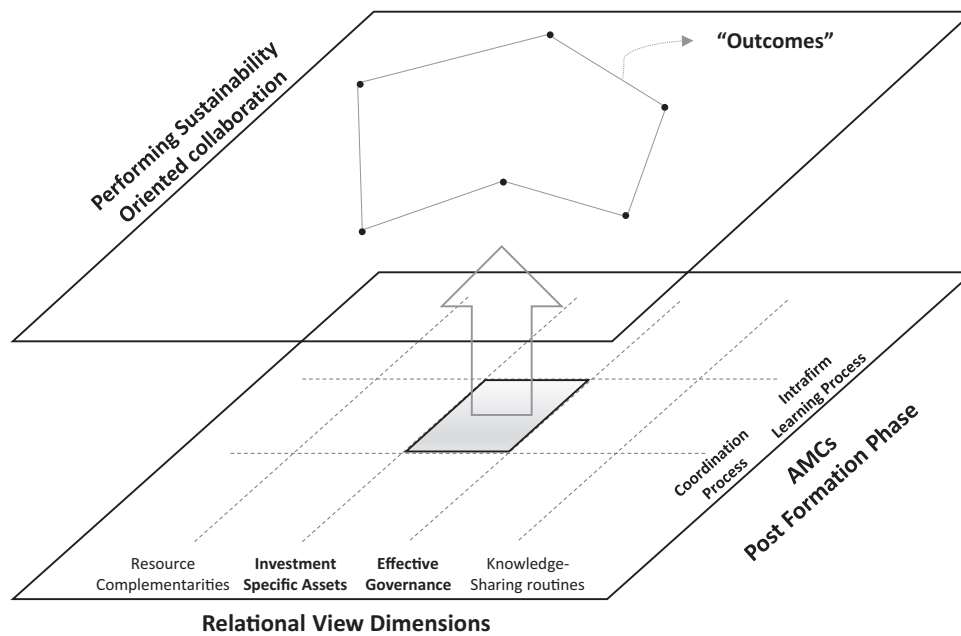


FIGURE 1 | Analytical Framework (adapted from Dyer and Singh 1998; Wang and Rajagopalan 2015).

- ii. *Coordination* refers to the capability of the focal firm to coordinate activities and resources with alliance partners (Gulati et al. 2005), to manage tasks, responsibilities, and interdependencies efficiently, and to flexibly adapt to partners' agreements (Schilke 2014; Schreiner et al. 2009). Huang and Li (2017) have demonstrated that coordination capability enhances effective co-engagement between separate functions and has a positive impact on green product development. Moreover, as shown empirically by Donbesuur et al. (2021), inter-organisational coordination is positively associated with eco-innovation, with environmental intra-firm learning serving as a key mediating factor.
- iii. *Investment-Specific Assets*: When a firm develops specialised assets in collaboration with partners, it generates a configuration of resources that is not easily replicable by competitors (Dyer and Singh 1998). The specialisation of assets generates deeper trust in partners, activates new interactions and stimulates informal communication (Dyer et al. 2018). Co-investing with partners on key assets is also associated with achieving better innovation outcomes. Scholars have found a positive relationship between the level of relationship-specific investments and the generation of innovative ideas (Potter and Wilhelm 2020). Higher transaction volumes between firms facilitate communication and operational efficiency, improving the capacity for product development and differentiation (Dyer and Hatch 2006).
- iv. *Governance Mechanism*: The governance model applied to the partnership describes how companies have formalised their agreements, authorities, roles, and responsibilities within the partnership. Effective governance is necessary to boost value creation, reduce transaction costs, and reduce partners' opportunistic behaviours. Various alliance governance models exist, ranging from highly formalised to less formalised and from high to low-directional power relations. In eco-innovation partnerships, resource interdependence and shared investments are typical, but they

can also create appropriation concerns (Dyer et al. 2018). Thus, the governance models are necessary to avoid litigations and conflicts among partners and enhance the orientation of alliances toward innovation (Gulati and Singh 1998).

While existing literature strongly supports the importance of these dimensions for effectively managing collaborative projects, it lacks specific guidance on their configuration and practical application in SOC. Our study aims to bridge this gap by exploring the underlying rationale for how RV and AMCs constructs are configured in successful SOC.

3 | Research Context and Method

This study analysed 16 projects undertaken through SOC, adopting the perspective of the focal company (i.e., the company that triggered the project and was mainly involved in it) to examine how this actor developed SOC.

Figure 2 illustrates the methodological flow employed in this study, outlining the activities undertaken in each step (boxes with continuous lines) and the related purposes and outcomes (boxes with dashed lines).

3.1 | Research Context: Green Hydrogen and the Italian Market

We selected the Italian emerging green hydrogen market (i.e., hydrogen produced through water electrolysis using renewable energy) as the optimal context for our research. Being a pillar of the energy transition, this market presents (i) relevant institutional pressures towards greenhouse gases reduction (IPCC 2022), (ii) significant demand for innovations to advance technologies, processes and business models capable of boosting

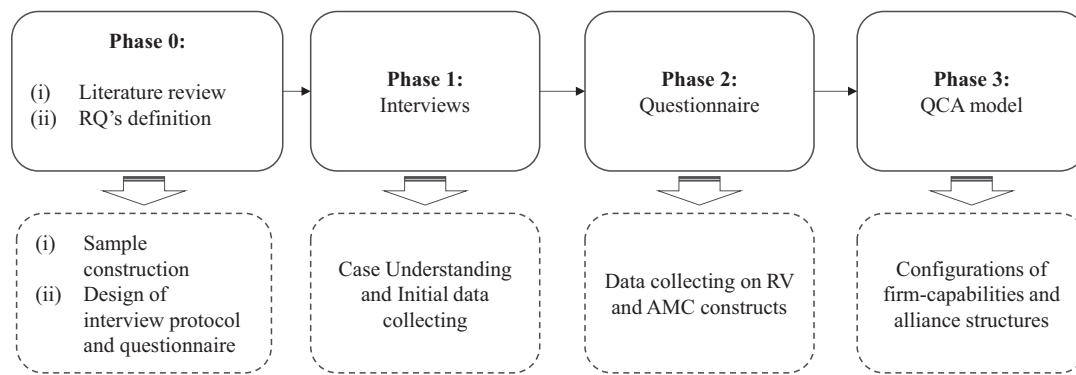


FIGURE 2 | Methodological flow.

a market that currently is at an early stage (IEA 2022), (iii) a variety of stakeholders throughout the green hydrogen value chain, and (iv) a multitude of projects facilitated through collaborative partnerships.

Green hydrogen attracts investors' interest because it enables the decarbonisation of hard-to-abate industries where direct electrification is not feasible, and it serves as an enabler for the utilisation of renewable sources (IEA 2022). These features justify its inclusion in the political agendas of numerous governments as a means to address climate change, even though it is still far from being a dominant technology with well-established investment paths (IPCC 2022). However, despite studies reporting an increase in hydrogen demand and consumption in the coming years (Nunez-Jimenez and De Blasio 2022), several challenges still hinder the diffusion of such an energy carrier, resulting in high variations in its implementation forecasts (IRENA 2022).

This context is optimal for our research as it involves a diverse range of incumbents and new entrants who are actively investing in SOCs to develop new business models and collaborative solutions aimed at overcoming market barriers that would be insurmountable if tackled individually.

We confined the analysis to Italy to ensure environmental homogeneity regarding institutional settings, infrastructures, regulatory constraints, renewable energy availability, and energy price and to focus on a context that presents (i) goal complexity due to high hydrogen interest and wide commitment (MISE 2020), (ii) significant investments stimulated by the 2020 EU's hydrogen strategy (EU 2020) and the 2030 target in REPowerEU plan (EU 2022), (iii) high uncertainties because of ongoing regulation and infrastructural development and (iv) relevant potential synergies among different industries and operators in the supply chain (MISE 2020). The exploratory nature of our study justified the collection of primary data from exemplary focal companies and the use of qualitative research methods.

3.2 | Sample and Data Source

The selection of cases matched the relevance criteria and the availability of abundant secondary data sources, which are essential to triangulating our observation of the phenomena and ensuring that no single point of view dominates our understanding (Gibbert et al. 2008).

Initially, we used the IEA Hydrogen Projects Database, a repository of projects launched since 2000 for hydrogen production, distribution, and utilisation. Then, we added projects developed by companies affiliated with associations that promote hydrogen-related technologies, such as H2IT and the European Clean Hydrogen Alliance. Finally, we interviewed two experts from GME (the Italian organisation overseeing the electricity market) to complete the list of projects relevant to the study. This approach yielded an in-depth understanding of the market and a list of 64 Italian projects related to green hydrogen.

To refine our case selection, we carefully evaluated the ongoing activities of each project, ensuring they encapsulate the essential features of SOCs: (i) a strategic intent to generate impacts that extend beyond the immediate collaboration (Pedersen et al. 2021); (ii) a diverse partnership composition, involving firms from distinctly different sectors; and (iii) inherent unpredictability, driven by the innovative nature of these projects and the multiple objectives they aim to achieve, such as mobilising institutional support and establishing new standards.

Combining these constraints with the focal companies' willingness to participate in the study, we arrived at a final sample of 16 projects. Table 1 illustrates the selected projects and their positioning along the value chain.

Our sample benefited from the substantial heterogeneity among the selected projects, effectively minimising the risk of overemphasising context-specific dynamics.

For confidentiality reasons, the names of the projects and partners are not disclosed. Nevertheless, it is noteworthy that all projects are large-scale industrial initiatives, recognised nationally for their strategic importance due to their potential to revolutionise supply chains and transition traditional production methods toward sustainable models. The leading companies driving these projects are multinational corporations with over 1000 employees and turnovers approaching or exceeding one billion euros.

3.3 | Interview Process and Qualitative Data Collection

To investigate how focal companies combine AMCs with the structural components of the RV to achieve high performance

TABLE 1 | Projects details.

Project no	Focal company	Project	Project partners	Project description
1	Utility – Energy Company	Testing Platform	(i) Energy Company (ii) Users	Development of an experimental platform to test H2 supply chain, electrolyzers, H2 delivery and stocking.
2	Steelworks	Steel Making Blending	(i) EPC contractor (ii) Utility (iii) Consulting (iv) Steelworks	Use of hydrogen in burners used in the steel heating process replacing a % of methane.
3	Utility – gas transportation and storage	Steel Making flexible Blending	(i) Utility – gas (ii) Energy Company (iii) Steelworks	Development of an electrolyser in a steel mill connected to a dedicated photovoltaic park (off-grid) to supply H2 to an electric furnace.
4	EPC Contractor	Optimisation of Value chain steps	(i) EPC contractor (ii) Utility – gas (iii) Electrochemistry	Development of an in-house laboratory to test burners on a real scale. The project has developed photovoltaic roofs to produce renewable energy and thus connected to an electrolyser installed on-site
5	Utility – Energy Company	Hydrogen valley	(i) Energy Company (ii) Engineering developer company (iii) EPC Contractor	Construction of three hydrogen production centres powered by photovoltaics with integration from the grid.
6	Energy Hubs Developer	Energy hub and H2 Stock	(i) Energy Hubs Developer (ii) EPC contractor (iii) Private equity fund	Development of an energy hub powered by offshore wind and floating photovoltaics. H2 is used as storage to mitigate the intermittency of renewables and sold as feedstock to neighbouring businesses.
7	Utility – gas transportation and storage	Definition of blending % in national pipelines	(i) Utility – gas (3) (ii) Technical Consultant (iii) Category association	Assessment of the entire supply chain and all parties connected to the gas network to test the possible increase in the percentage of blending within national gas pipelines.
8	Refinery	Refinery	(i) Energy Company (ii) Refinery	Installation of an electrolyser in a refinery powered by energy from the grid certified through a Power Purchased Agreement (PPA) to replace some of the grey hydrogen used with green H2.
9	Utility – Energy Company	Refinery	(i) Energy Company (ii) Refinery	Supply of green H2 to a Refinery company through installation within the plant of an electrolyser powered by the electric grid (Virtual PPA). Origin certificates qualify it as green H2.
10	Utility – Energy Company	Refinery	(i) Energy Company (ii) Refinery	Supply of green H2 to a Refinery company through the construction of an electrolyser adjacent to a photovoltaic park and transportation by road (40km).

(Continues)

TABLE 1 | (Continued)

Project no	Focal company	Project	Project partners	Project description
11	EPC Contractor	Steel Making	(i) Partnership between 2 EPC contractors (ii) Steelworks	Development and installation of a direct reduction plant in a steel mill.
12	EPC Contractor	Steel Making	(i) Partnership between 2 EPC contractors (ii) Steelworks	Development and installation of a direct reduction plant in a steel mill.
13	Utility – Energy Company	Transportation Trucks	(i) Energy Company (iii) Trucking companies (iii) Networkist company	Production of certified green H2 and delivery to refilling stations where partner trucks will be supplied.
14	Utility – gas transportation and storage	Transportation Train	(i) Utility – gas (ii) Energy Company (ii) Rail transport company	Construction of a first hydrogen production plant adjacent to a train station and replacement of the current fleet with H2-powered electric trains.
15	EPC Contractor	Transportation Buses	(i) EPC contractor (ii) Energy company (iii) Bus transport company	Construction of an H2 production and storage site and a refilling station for bus charging.
16	Utility – gas transportation and storage	Electrolysers Giga Factory	(i) Utility – gas (ii) Electrochemistry	Creation of a giga factory for electrolyser components based on alkaline technology.

in SOC, we employed an articulated qualitative research methodology. This approach involved extensive data collection through interviews, questionnaires, and analysis of public reports from the companies involved in the selected projects, culminating in a qualitative comparative analysis (C. C. Ragin 2000, 2009).

Collecting primary data was essential for gaining in-depth insight into each case. We conducted two or more interviews for each project in our sample between September 2022 and March 2023. The informants were key figures at the focal company, involved in strategic decision-making and committed to advancing the project, thereby ensuring a comprehensive view of the project's corporate strategy and managerial dynamics. The interviewees held positions such as CEO, innovation director, or project manager, depending on the company size and the respondent's knowledge of hydrogen projects.

Each interview was conducted online via videoconferencing, lasting between 1 and 2 h, resulting in approximately 60 h of recorded material. We developed a research protocol to conduct semi-structured interviews aimed at developing an understanding of: (i) the project's objectives, development and results; (ii) the governance of the collaboration and the focal company's organisational set-up developed to manage relationships with partners.

In line with best practices for conducting a QCA, we used interviews to develop a thorough understanding of our case studies (Greckhamer et al. 2018). This data informed our QCA model and enhanced our understanding of reasons why specific configurations of capabilities and alliance structures are conducive to generating higher performance in SOC.

To triangulate and validate the information obtained through interviews, we also collected secondary data from the websites of the interviewed companies, sustainability reports, and sector-specific journals focused on developments in the Italian hydrogen economy. For instance, we verified project start dates, the involved partners, the objectives declared to investors, and, most importantly, communications on ongoing results, such as hydrogen production volumes, emissions reductions, specific investments, key strategies, and decisions to manage the partnership, the creation of new companies, and the value generation and distribution among partners.

These data serve to verify key factual elements, thereby ensuring the internal consistency and reliability of the empirical dataset, particularly about the basic characterisation of each initiative. Moreover, secondary sources contributed to the contextualization of the cases by providing additional insights into the nature and scope of the projects. For instance, these data enabled us to assess whether firms' participation in SOCs reflected a significant departure from their established business models. They also allowed us to distinguish between capital-intensive ventures - such as large-scale infrastructure projects - and more experimental initiatives focused on early-stage R&D collaboration or the structuring of nascent value chains.

3.4 | Questionnaire for the QCA

We developed and sent a questionnaire to the key informants in the focal companies to collect homogeneous information about the alliance characteristics, firm capabilities, and the performance achieved for each project. In particular, we measured the variables Coordination, Interorganisational Learning, and Transaction-Specific Assets using psychometric scales (Schilke and Goerzen 2010; Schreiner et al. 2009; Wu et al. 2017).

Each construct's value was calculated as the average of its respective items. The items were based on prior literature and were measured using a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree) (Table 2). The binary variable Governance was the result of our direct observation of the phenomenon through the interview. Grounding Dyer and Singh (1998), we assigned 0 to partnerships where the nature of the partnership relationship is based on rigid contractual agreements defining the parties' obligations, and 1 when the project has a shared governance through either the creation of special-purpose entities (SPV) or the creation of a new company with a shared board, dedicated to the project.

Finally, we employed a psychometric scale to measure Project Outcomes (Kale and Singh 2007; Krishnan et al. 2006), a variable that captures whether the objectives for which the partnership was established have been achieved, the satisfaction with overall performance, and whether the partnership has improved the company's competitive position. Considering that all our projects are SOCs, the variable alliance performance proxied the achievement of environmental outcomes.

Aligning with previous studies that demonstrate best practices for measuring perceptual subjective indicators strongly correlated with actual performance, we collected and triangulated evidence to support subjective performance assessments, thereby minimising biases (Richard et al. 2009).

3.5 | QCA Data Sets and Calibration

We found the qualitative comparative analysis (QCA) fitting our purpose since, differently from other statistical methods that are unable to accommodate multiple alternative paths (Woodside 2013), assuming equifinality (i.e., different combinations of attributes can produce the same outcome) (C. C. Ragin 2000, 2009), it allows to unravel patterns of characteristics from a small sample of projects (Greckhamer et al. 2018), adding more nuances to the interplay of different attributes (Schneider and Wagemann 2010). Moreover, this methodology, by identifying multiple combinations of attributes capable of explaining the occurrence of an outcome of interest, is proving increasingly valuable for understanding complex phenomena, such as governance and managerial mechanisms, and their influence on sustainable outcomes (López-Cabarcos et al. 2023; Torres 2024).

We employed a fuzzy set variant of QCA (fsQCA), which differs from the traditional Crisp QCA (C. C. Ragin 1998) in that it allows for the use of continuous variables ranging between 0 and 1. This higher granularity in data observation (C. C.

TABLE 2 | Questionnaire' items.

Constructs	Description and previous literature usage	Calibration
Coordination Dimension	Categorical variable based on a 4 items construct (Schreiner et al. 2009) to capture the extent to which the focal company has established process and routines to coordinate external partners activities	Sample Based Calibration 0.95 percentile → Fully membership 0.50 percentile → Cross Over point 0.05 percentile Full non-membership
Interorganisational learning	Categorical variable based on a 4 items construct (Schilke and Goerzen's 2010) to capture the extent of routines designed to facilitate knowledge transfer and absorption from alliance partners	
Transaction-Specific Assets	Categorical variable based on a 4 items construct (Wu et al. 2017). It measures the relation-specific investments in terms of the extent to which the company invested in an alliance relationship	
Governance Mechanisms	Dichotomous variable resulting from direct observation of the phenomenon through the interview process. In line with (Dyer and Singh 1998) it discriminates between (i) partnerships governed by client-supplier contracts and (ii) partnership with shared governance through the creation of special-purpose entities (SPV)	Not shared governance → 0 Shared Governance → 1
Alliance Performances (Outcome of interest)	Categorical variable based on a 4 items construct. This construct used by Dhaundiyal and Coughlan (2022) and adapted from Krishnan et al. (2006) with one extra item from Kale and Singh (2007) relating to competitive position. This construct reflects the subjective perception of alliance performance.	Sample Based Calibration 0.95 percentile → Fully membership 0.50 percentile → Cross Over point 0.05 percentile → Full non-membership

Ragin (2000) is particularly useful in social and management studies, where variables frequently exhibit vagueness that seldom results in extreme values (Campbell et al. 2016), requiring instead the expression of nonbinary degrees of membership in a specific set.

Calibration is a critical step in QCA as it translates observed variables into a range between 0 (complete non-membership) and 1 (complete membership) (C. C. Ragin 2014). To accurately reflect variations across cases, we established thresholds at three cut-off points representing full membership, complete non-membership, and an intermediate set point. These thresholds enabled us to differentiate membership levels based on the conditions and outcome sets (Greckhamer et al. 2018).

We carried out the transformation using sample-dependent anchors defined by the 0.95, 0.50, and 0.05 percentiles as the three thresholds (or breakpoints), thereby transforming the data into the log-odds metric with all values falling between 0 and 1. In the absence of a solid theoretical foundation to define ex-ante high or low levels of membership to a specific set, consistent with prior studies (Fiss 2011; Greckhamer et al. 2008; Gupta et al. 2020; Torres 2024), we adopted sample-dependent anchors corresponding to predetermined percentiles of the distribution. Table 2 presents the calibration rules applied to each attribute and outcome.

4 | Results

After calibrating our dataset, we implemented a three-step fsQCA.

First, we constructed the so-called truth table, which identifies all possible combinations of the selected attributes, and we sorted the empirical observations into the rows of this table based on their attribute values (Fiss 2011).

Second, we reduced the number of rows based on two conditions (C. C. Ragin 2009): (i) a frequency threshold equal to 1, which determined the minimum number of cases required for a solution to be considered, and (ii) a consistency threshold equal to 0.8, which reflected the minimum degree to which cases conform to the set-theoretic relationships expressed in a solution (Fiss 2011). Table 3 presents the truth table, which, after the described simplification, displays nine different combinations of attributes for our 16 projects.

Third, we employed an algorithm based on Boolean algebra to logically reduce the rows of the truth table to simplified combinations (Fiss 2011). We utilised the Quine-McCluskey algorithm (implemented in the fsQCA 3.0 software package) to minimise sufficiency statements, simplify complexity, and obtain a more parsimonious outcome (Schneider and Wagemann 2012).

4.1 | FsQCA: Necessary and Sufficiency Analysis

The analysis of necessity enables us to determine whether certain conditions are necessary for the outcome to occur, that is, whether RV or AMC attributes are consistently present when the partnership achieves superior performance. It is recommended to use a consistency benchmark of at least >0.90 (C.

C. Ragin 2009; Schneider and Wagemann 2012) as a threshold to conclude that empirically observed configurations are associated with the outcome (Greckhamer et al. 2018). Table 4 shows the results considering whether the presence or absence (labelled ~) of a condition is necessary for the presence or absence (~) of the outcome (Alliance performance). Given that no conditions have a consistency above 0.9, we conclude that no conditions were necessary to reach a high level of alliance performance.

The sufficiency analysis is performed by applying the Quine-McCluskey algorithm to the dataset. This reduces the causal complexity to a minimal equation of attributes sufficient for the outcome to occur (Greckhamer et al. 2008), and it computes complex, parsimonious, and intermediate solutions. In line with C. C. Ragin (2009), we opted for the intermediate solution, which uses only the remainders that survive counterfactual analysis (C. C. Ragin 2009; Schneider and Wagemann 2012) and is more appropriate in situations of limited diversity due to its simple assumptions based on easy counterfactuals (Fiss 2011). Table 5 presents the analysis results, providing both the raw coverage, which indicates the proportion of the outcome explained by the configuration,

and the unique coverage, which reflects the relative empirical weight of each configuration across all combinations (Campbell et al. 2016; C. C. Ragin 2009).

4.2 | Results of the Configurational Analysis Related to Performance Outcomes in SOCs

The results reveal that focal firms rely on four main combinations of AMC and RV constructs, with their underlying rationale becoming clear through the detailed case study analysis. The resulting configurations and interpretations are:

– Configuration 1:

In this configuration, the outcome is determined by the presence of shared governance among partners and the lack of coordination and inter-organisational learning. It can be referred to as “**Technology Uplift**” since it occurs when the leading company initiates a project to exploit the need for a green transition in existing markets by offering technical solutions that are not yet widely adopted as reference standards.

TABLE 3 | Truth table.

Rows	Conditions				Outcome	
	Coordination	Interorganisational learning	Transaction-Specific assets	Governance models	Number of cases	Alliance performance
1	0	0	1	1	2	1
2	0	0	0	1	1	1
3	1	0	1	1	1	1
4	1	1	1	0	1	1
5	1	1	1	1	3	1
6	0	1	0	0	2	0
7	1	1	0	0	3	0
8	0	0	1	0	1	0
9	0	0	0	0	2	0

TABLE 4 | Necessary conditions analysis.

Conditions	Alliance performance		~ Alliance performance	
	Consistency	Coverage	Consistency	Coverage
Coordination	0.724	0.755	0.627	0.537
~Coordination	0.556	0.645	0.714	0.679
Interorganisational learning	0.692	0.723	0.631	0.541
~Interorganisational learning	0.561	0.649	0.677	0.643
Transaction-Specific Assets	0.729	0.812	0.476	0.435
~Transaction-Specific Assets	0.492	0.534	0.795	0.706
Governance Shared	0.602	0.755	0.237	0.244
~Governance Shared	0.398	0.389	0.763	0.611

TABLE 5 | Sufficiency conditions and QCA results.

Conditions/ Configurations	Configuration 1 “Technology uplift”	Configuration 2 “New business exploration”	Configuration 3 “Synergic decarbonisation”	Configuration 4 “Industry catalyst”
Coordination	⊗	●		●
Interorganisational learning	⊗	●	⊗	
Transaction-Specific Assets		●	●	●
Governance Shared	●		●	●
Consistency	1	0.905	0.974	0.861
Raw coverage	0.251	0.469	0.298	0.387
Unique coverage	0.044	0.157	0.029	0.011
Solution coverage		0.720		
Solution consistency		0.901		

Note: ● Condition Present; ⊗ Condition Absent.

This configuration is particularly relevant in projects 11 and 12, where two Engineering, Procurement and Construction (EPC) contractors (or technological developers) with a well-established collaboration involved a third company from a different sector to develop a technological upgrade.

The longstanding relationship between two complementary players, combined with the highly technical nature of the project, is key to understanding this configuration. In fact, the absence of project-specific coordination and inter-organisational learning suggests that the focal company views existing coordination and knowledge integration processes as sufficient. This reflects the partners' deep familiarity and extensive experience in collaboration, resulting in well-established and efficient communication and coordination.

Furthermore, the high technological intensity of the projects necessitates that each partner independently manages its specific project segment while ensuring their specialised contributions complement one another. The project manager of the focal company engaged in Project 12 stated:

We know each other... we have daily and constant interaction that doesn't require the establishment of new procedures or ad hoc structures... everyone offers their deep expertise to develop the activities more in line with their background.

Therefore, players with a mature relationship tend to exhibit a propensity for achieving high performance in environmental projects by leveraging a shared and equitably distributed governance.

– *Configuration 2:*

In this configuration, developing new inter-organisational learning processes, coordination efforts, and specialised assets are the pillars of the SOC. It can be referred to as

“**New Business Exploration**”, as it occurs when the leading company explores, in collaboration with new partners, innovative business models to improve the environmental conditions of a whole sector (e.g., hydrogen mobility).

In Project 13, for instance, the focal company is an energy utility that orchestrates a new network of partners from other industries to start new markets and go beyond their usual businesses. In this situation, new processes and workgroups are crucial for coordinating activities and enhancing cross-fertilisation, mutual learning, and knowledge absorption, which are necessary to develop a project that deviates from the company's business as usual. In this regard, the project manager of the energy company stated:

During the project design phase, we made face-to-face meetings almost on a day-by-day basis [...] We learned a lot about the truck technologies, prices, refilling methods, and customer needs [...] All this precious knowledge came from our partners.

Therefore, in projects designed to explore new value-generating market opportunities (e.g., introducing new transportation modes to exploit synergies between energy and mobility markets), the focal company benefits from acquiring new knowledge to better understand the counterpart's businesses, accurately assessing the intentions of the partners and mitigating the risk of falling victim to opportunistic behaviours.

Coordination and inter-organisational learning are thus functional to enhance mutual trust and understanding, which is necessary to invest in new assets in collaboration with new and specialised partners.

– *Configuration 3:*

This configuration aligns with projects aimed at improving the environmental performance of traditional businesses, such as those

focused on significantly reducing emissions in hard-to-abate industries. This combination of shared governance and particular investments can be referred to as “**Synergic Decarbonisation**”.

The interplay between shared governance and dedicated assets helped create deep trust between partners, sharing risk exposure, and enhancing the intensity of transactions, which in turn led to specialisation and efficiency.

In the case of Project 9, the partnership was established to develop a decarbonisation project that requires a *dedicated asset*, consisting of the integration of a photovoltaic power plant with a hydrogen electrolyser. In this project, none of the companies involved, an energy utility and an oil and gas player, could independently undertake the venture due to the significant financial exposure and mutual reliance on each other's unique technical expertise. The importance of collectively addressing the substantial investments required and jointly overseeing the evolution of activities led to the creation of a special purpose vehicle (SPV) designed to manage shared governance, pool resources, and limit financial risk by isolating the project assets under this joint entity.

This configuration is particularly effective for complex projects in traditional industries that require significant human, technical, and financial resource investments to enhance the environmental performance of their core business. The project manager of the energy company involved in Project 9 stated:

In a technically complex project like this one, the work we are undertaking is synergistic and complementary [...] We have made shared investments because we believe in the project [...] To manage these unique characteristics and the associated risks, we have established a joint venture where we are equal partners.

These projects, characterised by a high degree of technical specialisation, do not primarily emphasise knowledge absorption. Instead, they highlight the importance of a synergistic approach, where each partner applies its unique expertise to contribute effectively to the shared objective.

– Configuration 4:

This configuration highlights the importance of coordination, transaction-specific assets, and shared governance in establishing a new commercial entity that catalyses an emerging business (e.g., the production of electrolysers to facilitate national development of the hydrogen economy) vertically integrated into core activities. Project 16 well exemplifies this configuration, which is commonly referred to as the “**Industry Catalyst**” configuration.

Coordination is crucial in fostering synergies between entirely different businesses, enabling the partners to break free from technological lock-ins. Interorganisational learning, instead, is not a priority because the competencies mobilised for the project are not usefully integrable into the focal company's core business (e.g., the gas utility may not be interested in

learning how to manufacture electrolysers but can provide the newly formed company with commercially significant contacts).

According to the interviewed executive from the gas utility of Project 16, given the commercial nature of the challenge, the creation of a new company primarily served to coordinate the resources committed by the partners rather than to mitigate technological uncertainties.

The new project coordination mechanism thus served not to expand mutual knowledge but to support the commercial activity of the new company, as stated by the project manager of the energy utility:

In this project, the products and the technical development skills belong to our partner. We bring a deep knowledge of the industrial world and a huge portfolio of potential customers....

This configuration thus helps initiate high-risk tasks aimed at building new market supply chains, mobilising shared investments to collect the significant resources required, and fostering the development of co-specialised assets between partners to access a new market segment by leveraging the diverse resources of each partner. Establishing the new company ensured a unified governance structure, which was essential for the equitable and fair distribution of returns. It facilitated new coordination processes, necessary to manage activities among players with no prior experience in the new business.

5 | Discussion

5.1 | Determinants of RV and AMC in SOC

In this study we analysed the conventional theories on collaborations to define to what extent they maintain their validity in context oriented toward sustainability. While we found that the deployment of capabilities for alliance management and the foundations of relational view remain the core of these collaborative endeavours, our findings extend the existing literature by showing that the components of RV and AMC considered critical in SOC are not universally necessary or effective in achieving superior outcomes. As the rationale for SOC varies depending on the specific context and nature of the collaboration, combinations of particular components emerge instead of the standardised blanket application of all of them.

Table 4 presents a summary of the context-dependent drivers and configurations of constructs. A (–) symbol indicates that a more substantial presence of the driver reduces the importance of developing the corresponding RV or AMC condition. In contrast, a (+) symbol shows the opposite relationship, where the driver enhances the need for achieving the associated condition.

First, it becomes clear that the necessity for developing **new coordination processes** decreases as the partners' *pre-existing relational base increases*. In line with prior studies, the

deepened understanding of partnership dynamics that partners gain from previous collaborations diminishes the leading company's inclination to adopt a coordinating approach, thanks to increased trust and well-established collaborative processes (Dyer et al. 2018). Overemphasising coordination in these situations can be counterproductive, potentially undermining trust.

On the other hand, establishing new coordination processes becomes essential when *substantial financial exposure* and *significant asset-specific investments* exist. In such cases, the leading company legitimately needs to monitor project progress and safeguard against opportunistic behaviours closely (Brookes et al. 2017). Therefore, coordination and specific investment tend to be combined always. These findings provide new insights into the existing literature (Schilke 2014; Schreiner et al. 2009; Galvin et al. 2021), revealing a multifaceted trade-off between the potential for enhancing trust and empowerment through loose coordination and the necessity of implementing strong coordination to safeguard against appropriation concerns in contexts of substantial investment.

Regarding the development of **new inter-organisational learning processes**, our findings highlight that the usefulness of such procedures is closely tied to the extent to which the SOC aligns with the focal company's business as usual, the technical complexity of the project, and the pre-existing knowledge among partners. In particular, we found that focal firms tend to exert efforts to establish new inter-organisational learning processes in the case of SOC that do not significantly overlap with their core business. Indeed, when SOC diverge from a company's business as usual, acquiring new knowledge in previously unexplored fields becomes salient, thus focal firms give specialised partners a pivotal role in providing information and knowledge related to these new activities (Vaez-Alaei et al. 2024), a dynamic recently highlighted as a fundamental determinant of sustainability outcomes (Valbuena-Hernandez and Ortiz-de-Mandojana 2022).

However, developing new inter-organisational learning demands significant organisational resources, prompting firms to carefully assess whether establishing such a process is truly beneficial or merely a potential drain on resources. Indeed, we also found an inverse relationship between the *technical complexity of a project*, measured in terms of complexity of transformation procedures and the level of interactions between elements involved in the system (Baccarini 1996), and the absorption of new knowledge. In highly complex technological scenarios, the process of new knowledge absorption places an excessive strain on the focal company's resources, making the implementation of new inter-organisational learning processes overly burdensome. Notably, this evidence integrates recent research linking project complexity to the level of innovation achieved (Vaez-Alaei et al. 2024), offering insights into the conditions under which partners should independently execute their roles to maintain the efficiency and effectiveness of their collaboration.

Pre-existing knowledge among partner companies emerges as the third key factor shaping collaboration dynamics and inter-organisational learning. Given that inter-organisational learning and knowledge absorption are resource-intensive activities, firms are likely to undertake them selectively, only when the

integration of new knowledge is critical to advancing SOC and does not divert excessively from their core business operations. In this context, pre-existing knowledge becomes particularly relevant. In fact, prior collaborative experiences among firms foster mutual understanding and shared knowledge bases (Dyer and Singh 1998; Dyer et al. 2018; Zollo and Winter 2002), thereby reducing the need for focal companies to establish new inter-organisational teams dedicated to partner monitoring and learning. Trust developed through long-standing relationships enables firms to relax their tight control mechanisms and grant partners greater autonomy in operating independently.

These insights advance the existing literature on inter-organisational learning (Kale and Singh 2007) by refining the understanding of knowledge absorption's role within sustainability initiatives (Ardito et al. 2019), offering a more structured perspective on how strategic alignment with sustainability goals, together with the characteristics of collaboration, shape learning processes.

As for the **investments in transaction-specific assets** (i.e., specialised assets developed in collaboration with partners), we argue that the *distance between the focal company's core business and the project's scope* determines the extent to which this attribute will be implemented in SOC. For instance, as observed in configurations 2 and 4, companies benefit from developing new assets in conjunction with partners when they aim to enter a new market segment.

We extend the existing literature, which highlights the strategic importance of these investments in creating differentiation and making replication difficult (Dyer and Singh 1998; Li et al. 2017), by demonstrating that necessary prerequisites, such as the ambition to *enter new or emerging markets*, are crucial for effectively prompting the focal company's intention to leverage partner expertise and resources through shared investment.

Finally, we show that *the financial scale of a project* and its *associated risks* serve as key catalysts for the decision to develop transaction-specific assets and establish **shared governance among partners**. Companies undertaking projects requiring substantial resource investments are more likely to seek partners to support these shared financial commitments. Financial exposure induces appropriation concerns among partners (Gulati and Singh 1998) that justify the creation of Special Purpose Vehicles (SPVs) or new companies with shared governance structures. Pooling financial and material resources within these structures is functional in separating the financial exposure of individual companies from that of the project and managing potential disputes through a shared board of directors.

Furthermore, we integrate prior research by explaining why, taken in isolation, shared governance is insufficient to explain the overcoming of opportunism and, therefore, higher project performance (Galvin et al. 2021). While prior studies suggest that forming a distinct entity within an alliance shifts focus from individual profit/cost concerns to a collaborative problem-solving approach, fostering trust and cooperation, our findings reveal that this relationship is not universally applicable. In particular, we found that substantial financial exposure is crucial in determining the extent to which focal firms consider the integration

of shared governance and transaction-specific assets as essential for overcoming opportunism and achieving higher performance in SOC (Table 6).

5.2 | The Interplay of RV and AMC to Address SOC's Challenges

SOCs differ from traditional strategic alliances in that they deviate from conventional business objectives, leading focal firms to adapt and combine RV and AMC constructs in unique ways to address, as highlighted by Vurro et al. (2023), distinct challenges stemming from goal complexity, limited predictability, and the heterogeneity of partners.

The **goal complexity** of SOC is typically high, as exemplified by projects that incur diseconomies due to the green transition (Grewatsch et al. 2023) when pursuing broader environmental impacts beyond traditional economic outcomes (Pedersen et al. 2021). Goal complexity also emerges in the green hydrogen market, where SOC has significant potential for emission reduction but incur additional costs compared to business as usual.

The peculiarities of these SOC show that the interplay of RV and AMC is context-dependent. In SOC characterised by high financial exposure and risk of diseconomies, establishing an SPV, which is a new and separate business entity from the constituent companies, significantly mitigates these limitations and favours fair investments and asset allocation. The rationale for the priority that focal firms give to some RV and AMC constructs, namely transaction-specific assets and governance structures, is thus the need to reduce transaction costs and tensions among investors, ensuring a balanced exposure to risks.

SOCs in configurations 3 and 4 are predominantly marked by **limited predictability** stemming from their intrinsic complexity and uncertainty surrounding the outcomes. Here, the combination of a shared governance model with the concurrent presence of dedicated and project-specific investments is instrumental in addressing the profound uncertainty inherent in such endeavours and allows a stable and distinctive identity that is valuable in mitigating risks and uncertainties (DiVito et al. 2021).

The possibility of embracing higher levels of risk through the establishment of shared governance and transaction-specific assets increases resilience to profound uncertainty, thereby preserving a deep engagement of partners in the SOC - a facet deemed crucial in fostering the implementation of eco-innovation (Donbesuur et al. 2021). This rationale for integrating RV and AMC constructs complements the recent findings of Patrucco et al. (2022) by elucidating the conditions under which investment-specific assets and effective governance are valuable in pursuing challenging sustainability outcomes.

The third peculiarity distinguishing SOC is the profound **heterogeneity** of the involved actors. This heterogeneity is often a consequence of the inherent nature of sustainability challenges, with focal firms explicitly searching for it when forming collaborations (Pinkse and Kolk 2012). Our findings indicate that when this peculiarity characterises an SOC due to the low overlap between the partners' businesses and limited mutual knowledge, focal companies tend to develop new inter-company learning processes and coordination mechanisms. This evidence enriches previous studies (Dangelico 2016; De Marchi and Grandinetti 2013) and supports Gulati's findings (Gulati et al. 2005) by enlightening the role of partner-specific experience as a determinant of context-dependent relational structures and competence mobilisation.

In this regard, only high technical complexity discourages inter-company learning, favouring shared governance mechanisms, which are perceived as more effective for managing and understanding the profound differences among the players. As reported by some interviewees, in projects characterised by profound technological complexity, the leading company does not find it necessary to absorb the skills of other operators:

We and our partner are deeply different, but for this project, all partners must row in the same direction; no one has time to learn how the others row, but everyone must trust each other's ability to do it.

(Project 11, Project manager)

By fostering a context of mutual trust, which can be enhanced through the establishment of shared directional boards, the focal

TABLE 6 | factors driving AMCs and RV pillars implementation.

Drivers/AMCs and RV pillars	Coordination	Interorganisational learning	Transaction-specific assets	Governance shared
Pre-existing knowledge among partner companies	(-)	(-)		
Magnitude of project financial commitment/Project risk	(+)		(+)	(+)
The technical complexity of projects/non-transferable technical expertise		(-)		
Project in line with focal company business as usual		(-)	(-)	

company mitigates information asymmetries and facilitates the delegation of responsibilities. This configuration illustrates how focal firms can adapt investments in RV and AMC components to maintain the coexistence of partners within the same SOC, even when they have differing objectives (Baranova 2022).

5.3 | Implications for Theory and Practice

This study aims to develop an understanding of the management of SOCs, a phenomenon that is inherently different from traditional alliances in a purely profit-driven sphere (He et al. 2024; Weber et al. 2017). To this end, we examine how core constructs from mainstream literature on collaboration - namely, RV and AMCs - operate within SOCs, identifying specific configurations associated with superior collaborative performance. Our findings enable us to theorise how relational models function in sustainability-driven contexts and under what conditions specific RV and AMC constructs become more salient. In this regard, the study offers three main theoretical contributions.

First, our findings confirm the need to carefully consider the context-dependent characteristics unique to SOCs when combining RV and AMC within the sustainability domain.

Since most research on RV and AMC has focused on profit-driven alliances, framing collaboration primarily as a means to achieve competitive advantage (Dyer et al. 2018; Niesten and Jolink 2015; Kale and Singh 2007), our study contributes to the extant literature by shedding light on how these constructs combine when applied to contexts oriented toward environmental goals (Leischnig et al. 2014; Schilke and Goerzen 2010).

Our results, enriching the ongoing debate on how RV and AMC constructs behave within the sustainability domain, respond to several calls to do so (Vurro et al. 2023; Al-Tabbaa et al. 2019; Lin and Darnall 2015), showing that these relational models do maintain their validity but should be understood as theoretically and practically adaptive, rather than universalistic.

In SOCs, factors such as partner heterogeneity or the presence of objectives beyond mere economic return require an adaptation of conventional partnership frameworks (Vurro et al. 2023). For instance, as illustrated in Table 5, projects characterized by high technological complexity tend to reduce the relevance of knowledge absorption - a construct typically considered central in traditional alliances (Kale and Singh 2007; Kale et al. 2001) - and instead highlight the need for shared governance mechanisms capable of managing elevated levels of uncertainty and risk.

Similarly, SOCs might carry on initiatives that deeply diverge from the core business of partnering companies which could be players coming from different sectors (e.g., heterogeneity); this makes coordination mechanisms and knowledge sharing become counterproductive, particularly when partners already possess mutual trust. In such cases, distributed governance structures or shared investment might prevail in order to generate stronger connections among partners, pushing each actor to advance its contribution independently.

These findings suggest that the interplay between the inherent idiosyncrasies of SOCs and the specific attributes of the partners involved undermines the feasibility of applying a universal model for collaboration management. Accordingly, this study calls for a shift away from the pursuit of one-size-fits-all solutions and supports a more contingent approach - one that considers project characteristics and partner profiles as key determinants of the most appropriate collaboration configuration for each SOC.

Second, we contribute to the literature on SOC management by revealing, through specific configurations of constructs, the explanatory potential of a unified RV-AMC analytical framework that bridges two complementary, yet often separately treated, theoretical perspectives.

While existing research on partnering for sustainability has typically examined the role of AMCs or RV in isolation (Caldwell et al. 2017; Dentoni et al. 2016; Ritvala et al. 2014; Crosby and Bryson 2010) - and often in relation to a single condition or dimension of SOCs (Wójcik et al. 2022; Alonso and Andrews 2019; Liu et al. 2018) - our study overcomes this fragmentation by adopting a more holistic lens, answering to recent call in this regard (Menghwar and Daood 2021; Niesten and Jolink 2020).

Building on the framework proposed by Vurro et al. (2023), our study explicitly accounts for all the distinctive idiosyncrasies of SOCs. Furthermore, we selected the relational constructs relevant to the post-formation phase, considering Wang and Rajagopalan's framework (Wang and Rajagopalan 2015) for the AMCs and Dyer and Singh's model (Dyer et al. 2018) for the RV pillars.

By doing so, we demonstrate that these constructs are not mutually exclusive but rather complementary dimensions, providing a broader and more coherent understanding of how relational constructs operate collectively within sustainability-oriented collaborations and how their interplay enables the effective management of the multiple constraints inherent in such collaborative arrangements. Therefore, while prior contributions have often adopted a cherry-picking approach to examining how the idiosyncrasies of SOCs might be addressed, our study directly links specific combinations of factors that can effectively manage goal complexity, limited predictability, and partner heterogeneity.

Third, this paper also makes a methodological contribution, highlighting the value of approaches such as Qualitative Comparative Analysis (QCA) in management studies, as they enable the identification of patterns and causal configurations that may remain undetected using other methodological approaches.

This aspect gains particular relevance in the context in which our study was developed. The starting point of our research was the recognition of the atypical characteristics exhibited by SOCs, which led us to question whether and to what extent traditional models of alliance management could be applied to assess the effectiveness of such collaborative arrangements. This line of inquiry is supported by recent studies suggesting that treating relational models as universally applicable and context-free constructs poses a significant limitation. As highlighted by Gölgeci et al. (2019), Leischnig et al. (2014), and Schilke and Goerzen (2010), disregarding the role of context risks overlooking the idiosyncratic features inherent in SOCs that have the

potential to influence achieving successful outcomes. Therefore, since SOC's are collaborative approaches applied in diverse contextual settings, the pursuit of universal or exclusive models risks undermining a comprehensive understanding of how these collaborations work.

Our approach differs from prior studies, which have predominantly explored relational models in sustainability-oriented contexts, primarily adopting quantitative approaches (Kohtamäki et al. 2018). These studies often conceptualise capabilities as latent variables comprising dimensions assumed to be equally relevant across all collaborations (He et al. 2024). In previous studies, this assumption overlooks the possibility that the relevance and interaction of such capabilities may vary significantly depending on the specific features of the collaboration and its context, and fails to capture the case-specific complexity of SOC's.

Although previous contributions have played a crucial role in identifying key managerial variables within the context of sustainability partnerships, our analysis highlights that in settings marked by significant contextual specificities, purely quantitative tools are inherently limited in their capacity to explore - among other things - the coexistence of conflicting factors (e.g., the simultaneous presence and absence of a given condition, known as equifinality) as potential determinants of an outcome of interest. For instance, the presence of interorganisational learning in Configuration 2 and its absence in Configuration 3, or the lack of coordination in Configuration 1 and its presence in Configuration 4, as well as the distinct combinations of these factors across the different configurations, would not have emerged through a traditional inferential approach.

Furthermore, our study highlights the importance of combining Qualitative Comparative Analysis (QCA) with in-depth follow-up interviews. This mixed-method approach not only enables the identification of effective configurations of RV and AMC constructs within SOC's but also helps uncover the underlying rationales that explain under which conditions specific configurations are preferred over others.

The managerial implications of this study provide straightforward support for managing effective SOC's. Once SOC goals and partners are selected, managers of focal companies can use our interpretative framework to identify the RV and AMC constructs that warrant more investment. This enables them to implement new coordination and learning processes, introduce new governance structures, and make transaction-specific investments only when necessary. In fact, learning from successful configurations of RV and AMC constructs allows managers to establish effective, context-specific partnerships, highlighting the importance of tailoring these constructs to the unique demands of their own collaborative environment. Our study offers guidance to mitigate the risk of misinterpreting these theoretical constructs as universally applicable, ensuring that managers align their strategies with the specific dynamics and challenges of their particular SOC's.

5.4 | Limitations and Further Research

As with any research, our study has its limitations, which naturally present opportunities for future exploration. Addressing

these limitations in subsequent studies could further refine and expand upon our findings, offering a deeper understanding and potentially new insights into the dynamics of SOC's.

First, the understanding of the interplay of RV and AMC constructs is based on a sample of 16 projects. Even if the sample size is appropriate for studying four attribute interactions, a larger one might offer a more comprehensive and exhaustive analysis and eventually could include more attributes and configurations in the research.

Second, the geographical perimeter of the study is limited to Italy. Although this limitation was intentionally established to ensure sample homogeneity, future research could explore successful SOC's in different cultural or environmental contexts to identify their unique rationales and configurations of RV and AMC constructs.

The third limitation regards the measurement of the results achieved in SOC's, which, in our study, given the difficulties in using more concrete and comparable indicators to test the outputs, consists of respondents' self-perceptions of SOC's' performance during their implementation. Future studies can conduct longitudinal studies to dynamically observe the performance of SOC's through the evolution of RV-AMC configurations.

The fourth limit of this study is linked to our focus on the relevant constructs of AMC and RV in the SOC post-formation phase. We acknowledge that the pre-formation stage can also impact alliance outcomes (Wang and Rajagopalan 2015). Thus, we highlight the need to consider the analysis of whether and how SOC's can leverage potential partners' AMCs in the pre-formation phase as an avenue for further research.

Finally, our study focused on SOC's with a clearly defined environmental goal. However, SOC's can take diverse forms and pursue a variety of goals (Vurro et al. 2023). They may involve NGOs, public entities, or governmental bodies, and their objectives may include social or humanitarian aims, alongside or instead of environmental ones. Our case selection prioritised sample homogeneity to improve internal consistency and analytical depth. However, this choice also limits the explanatory power of our findings to a specific subset of SOC's - namely, those formed by firms addressing environmental goals. Future research could extend our analysis by examining SOC's that include public actors or NGOs, and by exploring collaborations that primarily also aim to address social challenges to assess whether different types of actors or goals lead to distinct managerial dynamics or configurations.

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Endnotes

¹ The management literature also refers to this phenomenon using terms such as green alliances, cross-sector partnerships, social partnerships, and multi-stakeholder initiatives (Vurro et al. 2023).

²This refers to the mainstream literature on interorganisational collaborations, particularly the Relational View (Dyer and Singh 1998; Dyer et al. 2018) and alliance management capabilities framework (Schilke and Goerzen 2010; Wang and Rajagopalan 2015).

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