



Managing multi-stakeholder co-creation to address grand challenges: The role of paradox management capabilities[☆]

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ARTICLE INFO

Keywords:

Co-creation
Multi-stakeholder networks
Paradox theory
Grand challenges
Covid-19
Disruptive sustainability

ABSTRACT

Addressing Grand Challenges such as disruptive sustainability require transformative innovations and policy frameworks that enable coordinated, systemic, multi-stakeholder co-creation. Yet, we have limited understanding of the capabilities needed to manage the paradoxical tensions that arise in multi-stakeholder co-creation networks. We make an original contribution by using an evidence base composed of 30 co-creation initiatives from 21 countries and 3 transnational initiatives, developed to address challenges relating to the COVID-19 pandemic, a Grand Challenge characterized, exactly like disruptive sustainability, by large scale, complexity, and uncertainty. Our findings advance paradox theory by articulating six higher-order paradox-management capabilities needed to manage paradoxes relating to two levels of transformative innovation, project co-creation and programme co-creation. For each of these higher-order capabilities, we identify more specific routine capabilities that allow partners to manage these paradoxes to achieve swift and successful co-creation for disruptive sustainability. We provide implications for policy and practice.

1. Introduction

Disruptive sustainability, which involves the transformation of practices, models, and policies towards the simultaneous addressing of social, environmental, and economic challenges, is key for economies to embark on a pathway towards more sustainable development (Kivimaa et al., 2019; Schot and Steinmueller, 2018). The transition towards sustainability is one of the key 'Grand Challenges' (Ferraro et al., 2015), which have increasingly become the focus of mission-oriented policies (Haddad et al., 2022). Addressing such challenges requires transformative innovations and policy frameworks that enable coordinated, systemic, multi-stakeholder actions (Bugge et al., 2018; Foray, 2018; Kattel and Mazzucato, 2018; Miedzinski et al., 2022). In fact, Grand Challenges are characterized by features such as complexity, uncertainty and large scale, that make them very difficult and time-consuming to solve (George et al., 2016): in order to urgently generate solutions to such pressing and consequential problems, it is often necessary to put

together constellations of stakeholders that are diverse with respect to several dimensions – e.g. knowledge, resources and networks – and to promote interactions between them that are path-dependent, nonlinear, and deeply intertwined (Ferraro et al., 2015). Such organizational forms can be described as 'multi-stakeholder co-creation networks' (Kazadi et al., 2016; Reypens et al., 2021).

The term 'co-creation' refers to the process of collaboration among diverse actors – such as businesses, universities, government, innovation intermediaries and societal groups – who integrate their knowledge, resources, and networks to simultaneously generate business, social and/or environmental value (De Silva et al., 2021). Multi-stakeholder co-creation networks set up to address Grand Challenges, need to manage the diverging and paradoxical interests, requirements, and goals of the different participating organizations (Jarzabkowski et al., 2019; Kuhlmann and Rip, 2018). In such settings, paradoxical tensions can emerge from the need to integrate different logics, ranging from disciplinary (social science vs hard sciences), value (social vs. business

[☆] This article is part of a Special issue entitled: 'Towards Disruptive Sustainability' published in Research Policy.

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value), timeline (short-term vs long-term focus) (Leahey et al., 2017) and organizational (organizations with different objectives). To successfully manage multi-stakeholder co-creation networks, it is important that the actors involved become aware of the tensions inherent in those paradoxes and develop capabilities to address them. This study, therefore, addresses the following research question: *what are the paradox management capabilities that enable multi-stakeholder co-creation networks - set up in the context of initiatives directed at addressing Grand Challenges - to swiftly and successfully achieve their objectives?*

We build on an evidence base composed of 30 co-creation initiatives (from 21 countries and 3 transnational initiatives), designed to address challenges relating to the COVID-19 pandemic. While the challenges posed by the COVID-19 pandemic are not the same as those posed by disruptive sustainability, they share certain aspects with it: large and global consequences, high uncertainty, high complexity, and urgency. As such, addressing these challenges often requires the involvement of multi-stakeholder co-creation networks, whereby a diverse range of actors collaborate in joint innovation activities, trying to come up with swift solutions to urgent, globally relevant problems (Adams et al., 2016). Hence, the COVID-19 pandemic provides a relevant context in order to analyse the challenges of disruptive sustainability, for at least two reasons. First, it is a context in which actors had to quickly develop new collaboration capabilities to achieve successful co-creation: the pandemic provided an opportunity to test new capabilities relating to the management of multi-stakeholder co-creation networks, which may be relevant for those networks in general. Second, the pandemic represented a context of high scale and urgency. As such, our empirical findings derived from this setting are relevant to other situations that share similar high-urgency characteristics (see Flyvbjerg, 2006).

We consider two types of co-creation networks that are relevant for addressing Grand Challenges through transformative innovations: project co-creation [i.e. co-creation with defined objectives, and deliverables aimed at addressing a specific aspect of a Grand Challenge] and programme co-creation [i.e. co-creation aimed at coordinating a set of interrelated projects that collectively address broader dimensions of a Grand Challenge]. Both levels are key, since a transformative policy mix “needs to balance the support for challenge-oriented R&I projects [i.e. project-level] with the systemic [i.e. programme-level] support to making innovation systems fit for developing and scaling innovation” (Reid et al., 2023, p.8). Gaining a nuanced and comprehensive understanding of paradox management capabilities at both the project and programme levels is essential, because projects and programmes are inherently interrelated and, together, play a critical role in addressing the complexity of Grand Challenges – particularly those involving disruptive sustainability transformations (Grillitsch et al., 2019). This way, we respond to calls for better understanding of how innovative policy interventions can be used to address Grand Challenges (Haddad et al., 2022), in particular by improving our understanding of the capabilities of participating organizations, which “will be key for delivering such transformative policies” (Haddad et al., 2022, p.15).

Our findings articulate six higher-order paradox-management capabilities needed to manage paradoxes relating to the project and programme co-creation levels - three for each level. For each of these higher-order capabilities, we then identify more specific routine capabilities that allow partners to manage paradoxes in order to achieve successful co-creation. The study contributes new insights to three distinct streams of literature. First, it adds to the extensive organization and strategy research that has highlighted the commonality and significance of paradoxes in organizational life (Schad et al., 2016; Smith and Lewis, 2011), by providing evidence about how these paradoxes are managed across organizational boundaries (Lê and Bednarek, 2017). Jarzabkowski et al. (2019) have studied Grand Challenges via a paradox lens, illustrating how contradictions and interdependencies arise and continuously evolve within inter-organizational interactions. Yet, the capabilities (Arnold et al., 2021) that underpin managing paradoxes for successful co-creation between multiple stakeholders to address

disruptive sustainability, remain under-researched: by identifying such paradox management capabilities, this paper originally advances paradox theory (Cunha and Putnam, 2019; Smith and Lewis, 2011).

Second, the literature on transformative innovation policy (Haddad et al., 2022) has emphasized the importance of involving networks of actors (Bugge et al., 2018; Foray, 2018; Mazzucato, 2018) in the implementation of such policies, and has emphasized the challenges in managing such networks (Grillitsch et al., 2019). However, there is limited analysis of the role and contribution of different stakeholders, particularly how stakeholder networks can be involved and coordinated to bring out the intended outcomes, and how public sector actors can develop “dynamic capabilities” (Teece et al., 1997) to support “organizational flexibility and responsiveness to new information” (Kattel and Mazzucato (2018, p. 791)). The literature “does not really engage in any discussion about what such capabilities entail and how they could be built up” (Haddad et al., 2022, p.32). By highlighting which capabilities could be developed at project and programme levels, in order to facilitate processes of co-creation within policy-driven networks aimed at addressing Grand Challenges, our paper contributes to the literature on transformative innovation policy.

Third, different streams of literature investigate how to successfully manage collaborations involving individuals from different organizational backgrounds, but these do not consider the management of paradoxes arising in multi-stakeholder co-creation networks dealing with Grand Challenges. A large literature on inter-organizational collaborations, which focuses on the management of interactions between individuals from different organizations. While rich in empirical work, there is a limited theoretically-grounded research regarding new collaborative modes (Lin and Bozeman, 2006) such as co-creation (Kazadi et al., 2016), specifically in relation to addressing Grand Challenges. There are also numerous studies on the challenges of interdisciplinary research collaborations, focused mainly on collaborations involving academics, although recently more attention is paid to the involvement of external stakeholders such as civic society or specific interest groups. However, very often stakeholders are considered peripheral to projects arranged around a core of mainly academic researchers. Additionally, a lot of work discusses the problem of how to structure collaborative relationship (e.g. Leventon et al., 2016) rather than how to manage the tensions arising within those relationships once they are in place. Yet, multi-stakeholder co-creation networks that require urgent action are often established under pressing conditions, leaving little opportunity for stakeholders to design optimal network structures or incentive systems in advance; rather, they have to work with the available resources in order to reach the best possible results. In such situations, what matters are the capabilities that those stakeholders bring into the collaboration. Our paper challenges the argument that co-creation is less productive (Cummings and Kiesler, 2007; Raasch et al., 2013; Rau et al., 2018) and offers a new perspective on what capabilities co-creation networks should use to achieve co-creation for disruptive sustainability, which has increasingly become the focus of transformative, mission-oriented policies (Haddad et al., 2022).

The paper is structured as follows. In section 2, we develop a conceptual framework to guide the analysis, building on relevant literature on organizational paradoxes, Grand Challenges and multi-stakeholder networks (the latter is scattered across several literature streams including interdisciplinary research collaborations, inter-organizational collaborations and in particular on co-creation networks). In section 3 we present our evidence base and our methodology. In section 4 we present our findings. In section 5 we discuss our findings and the theoretical contribution of the study. The conclusions, in section 6, discuss the study's implications for policy and practice as well as limitations and avenues for further research.

2. Theoretical background and conceptual framework

2.1. The management of grand challenge multi-stakeholder co-creation networks

Empirical evidence suggests that the collaborations that are most productive and innovative, and most suitable in order to address Grand Challenges - whose fundamental principles are “the pursuit of bold ideas and the adoption of less conventional approaches to tackling large, unresolved problems” (Colquitt and George, 2011, p. 432) - are characterized by the involvement of diverse stakeholders. For example, stakeholders with diverse knowledge backgrounds since, compared to single-discipline projects, collaborations that are interdisciplinary tend to generate results that are more relevant and interesting to societal actors (D’Este and Robinson-García, 2023; or stakeholders representing diverse types of organizations, which are able to contribute different resources to tackle complex problems (Vargo and Lusch, 2004). Rafols et al. (2012) provide a systematic analysis of interdisciplinary research collaborations, highlighting how actor involvement and knowledge integration vary across projects and contexts. De Silva et al. (2022) present many examples of multi-stakeholder collaborations developed to tackle the Covid-19 pandemic, where actors from universities, government, and industry were actively involved in all phases of the co-creation process, from problem formulation to solution implementation by combining multiple disciplines and expertise. This was the case, for example, of Exscalate4COV, a transnational European private-public sector consortium, integrated supercomputing, AI, and medical research facilities, for drug discovery.

Yet, collaborations involving different stakeholders are the most difficult to manage, due to several trade-offs in the process of knowledge co-creation. On the one hand, joint knowledge production is facilitated when knowledge is codified into transferable representations, when the partners have a history of repeated interactions and possess close knowledge bases (e.g., Lane and Lubatkin, 1998; Khanna et al., 1998). But these conditions imply that more homogeneous knowledge is available to the collaborators, perhaps limiting the scope and novelty of collaboration's outcomes (e.g., Uzzi, 1997). On the other hand, collaborations that involve intellectually diverse partners among whom dense collaborative relationships do not yet exist, are more likely to produce new original knowledge, but they are hard to manage because knowledge sharing is more difficult.

Research in the organization and strategy fields has proposed the concept of ‘organizational paradoxes’ to describe the tensions between conflicting demands that characterize numerous aspects of organizational activities. While there are many definitions of organizational paradoxes, a broad way to conceptualize them is as ‘persistent contradictions between interdependent elements’ (Schad et al., 2016: 10).¹ Paradoxes are likely to occur in the context of multi-stakeholder co-creation networks, and particularly so when these are set up to address Grand Challenges, for several reasons.

First, Grand Challenges carry contradictory but interrelated requirements (Smith and Lewis, 2011; Jarzabkowski et al., 2019): different resources (the integration of knowledge coming from different disciplines, the collaboration between stakeholders with very different organizational governance and different missions) and different objectives (social value, business competitiveness and financial sustainability; short-term targets and long-term objectives) (Leahey et al., 2017).

Second, since Grand Challenges are characterized by urgency, the time to put together the multi-stakeholder co-creation networks needed to address them may be short, and so their composition may be sub-

¹ This broad definition of paradox can be applied to various forms of organization, including multi-stakeholder networks, as well as various levels of organizations, from individual organizations to networks of organizations to broader ecosystems.

optimal, depending on contingencies rather than accurate planning (Ferraro et al., 2015). Sub-optimal networks composition may exacerbate the paradoxical tensions among partners. In these conditions, it seems important to adopt approaches to managing the collaboration that do not rely on having perfect incentives and partnership structure *ex ante*, but that instead make the most of the resources available.

Third, another aspect that may feed the paradoxical tensions among partners is the fact that, since Grand Challenges are issues that are complex, entail radical uncertainty and cut across “jurisdictional boundaries, implicating multiple criteria of worth, and revealing new concerns even as they are being tackled” (Ferraro et al., 2015, p. 367), there may be many problems emerging in the course of the collaboration which had not been anticipated in advance (Jarzabkowski et al., 2019). It is therefore important for the collaborators to be able to promptly and productively address the paradoxical tensions that arise during the collaboration, rather than to be able to plan the structure of the collaboration in advance or implement set management approaches (El-Awad et al., 2022).

It seems crucial therefore that multi-stakeholder network participants should have the capabilities to manage these complex collaborations. In the rest of this section, first we articulate the topic of organizational paradoxes, illustrate the types of paradoxes identified by the literature, and examine how they might apply to the case of multi-stakeholder co-creation networks set up to address Grand Challenges. We then review the literature on the capabilities which have been singled out as being important for these networks to be successful at achieving their objectives. Finally, we discuss the importance of considering multiple levels of analysis when analysing multi-stakeholder co-creation in a Grand Challenges context.

2.2. Organizational paradoxes relevant to grand challenge multi-stakeholder co-creation networks

A large amount of organizational and strategy research has emphasized the prevalence and importance of paradoxes in organizations (Cunha and Putnam, 2017; Schad et al., 2016; Schad and Bansal, 2018; Smith and Lewis, 2011). However, there is limited research on how paradoxes are constructed across organizational boundaries (Lê and Bednarek, 2017), particularly in the context of multi-stakeholder co-creation networks.

In terms of prior literature, useful insight can be derived from studies that have focused on paradoxes within research collaborations (which, like multi-stakeholder co-creation networks, involve a plurality of collaborating organizations) and within hybrid organizations (which, like the participants in multi-stakeholder co-creation networks, have several competing missions). In particular, we follow Infante Rasch and Hernandez Chiribi (2023) who apply Smith and Lewis’ (2011) taxonomy of paradoxes (of performing, organizing, belonging and learning) to hybrid organizations.

Paradox of performing refers to tensions that arise from the differing and sometimes conflicting goals and strategies of various internal and external actors involved with an organization (Smith and Lewis, 2011). In multi-stakeholder co-creation networks, these tensions are especially pronounced due to the multiple, diverse and interdependent goals of their members (Schneider and Clauß, 2020) The paradoxes of performing which could be particularly relevant in the context of multi-stakeholder co-creation networks set up to address Grand Challenges, are:

Tension between social and commercial missions. Economic sustainability is crucial for multi-stakeholder co-creation networks to continue their operations and scale-up (Child, 2020; White et al., 2022), but when they operate in the context of Grand Challenges they also usually have a social mission (such as benefiting certain social groups or communities, using ethical sources for materials and supplies, promoting sustainable practices, and so on). If networks focus excessively on one objective, they may end up jeopardizing the other.

Tension between short-term and long-term goals. Short-term goals are linked to financial security, while long-term goals are connected to social impact (Mogapi et al., 2019). However, research and practitioners have indicated that social and business objectives can support each other. Long-term success relies on considering both aspects, and by addressing short-term financial needs, a company can secure its future and ultimately achieve long-term social benefits (Child, 2020; Gonin et al., 2013).

Paradox of learning encompasses tensions related to knowledge acquisition. The most relevant paradox of learning is the *tension between exploration and exploitation*: the need to leverage existing competencies while also pursuing new ones (Maine et al., 2022). The paradox arises because exploitation, which involves efficiently using competencies and resources for financial sustainability, provides stability and efficiency to meet financial goals. In contrast, exploration encourages innovation and the development of new, potentially more effective concepts, capabilities, and competencies for social impact.

Paradox of organizing refers to tensions around key organizational issues, such as conflicts over whom to hire, where to locate facilities, how to allocate resources, how to structure the organization (Gonin et al., 2013; Luo et al., 2020). The paradoxes of organizing that could be particularly relevant to our analysis, are the following.

Tension between competition and collaboration. The tension between collaborating with stakeholders to achieve common goals for maximizing social impact and simultaneously competing with them to pursue individual, competing objectives (White et al., 2022; Ismail and Johnson, 2019). For instance, members of multi-stakeholder co-creation networks may collaborate to build capacity, reliability, and legitimacy, yet simultaneously compete with the same organizations for funds, talent, market share, and other resources (Prabhu, 1999). This dynamic can affect mutual trust and risk undermining social capital and value.

Tension between control and autonomy. The need to allow partners a deliberative, participatory, shared, and transparent decision-making process (Engbring and Hajjar, 2022) versus the greater efficiency achieved when decisions are made by leaders through a centralized and controlled process. Vom Brocke and Lippe (2015), studying interdisciplinary research collaborations, also highlighted this tension between, on the one hand, managers being assigned only limited authority (since the partners are autonomous) and, on the other hand, the need for centralized leadership in order to manage the project vision and integration of results.

Tension between organizational flexibility and structuring: multi-stakeholder collaborations operate under considerable uncertainty and require freedom and flexibility if they are to generate innovative results, but at the same time uncertainty needs tight management in order to avoid failure, and creativity needs firm structures in order to be transformed into widely usable project outcomes (Vom Brocke and Lippe, 2015).

Paradox of belonging refers to tensions are related to identity concerns (Smith and Lewis, 2011). Within this category, the most salient paradox is the presence of *tensions in member identity*. Lingard et al. (2007) emphasize the importance of explicitly negotiating this tension in the context of interdisciplinary collaborations. When handled well, it can lead to analytic insights, but when handled poorly it can undermine team coherence. In the context of multi-stakeholder co-creation networks, the paradox is fuelled by the partners' heterogeneity, which leads to novelty but also problems with respect to inter-cultural, inter-organizational, and interdisciplinary management.

Table 1 maps the relevant paradoxes identified in the literature onto the main characteristics of Grand Challenges (Winch et al., 2021; Ika and Munro, 2022). We suggest that at least in principle, all of these paradoxes, and the relevant paradox-management capabilities, could be relevant in the context of co-creation to address Grand Challenges. Table 1 provides a framework with which to analyse the relevant paradoxes emerging within multi-stakeholders co-creation networks set up to address Grand Challenges.

Table 1

Paradoxes arising in multi-stakeholders co-creation networks in the context of Grand Challenges.

Characteristics of Grand Challenges (Winch et al., 2021; Ika and Munro, 2022):	Type of paradoxes	Paradoxes relevant to multi-stakeholder co-creation networks in the context of Grand Challenges
Their outcomes are critical for the performance of different organizations and stakeholders and for the well-being of their beneficiaries both locally and globally, and they tend to focus on the provision of global public goods	Performing	Social and commercial missions
Their outcomes may have long-lasting impacts and far-reaching unintended consequences.		Short-term and long-term goals
Are highly innovative from a scientific, technological, economic, social, policy, organizational and/or operational perspective	Learning	Exploration and exploitation
Represent major initiatives, not merely by their size but also by their reach and impacts for multiple organizations, public and private, in countries around the world; their organization usually takes the form of a portfolio or a programme	Organizing	Competition and collaboration Control and autonomy Organizational flexibility and structuring
Multi-cultural, multi-country, multi-industry, multi-sector, multi-site, multi-organization, and multi-stakeholder temporary endeavors undertaken across the world to address or solve partially, but never completely, overarching and often intractable puzzles	Belonging	Member identity

2.3. Capabilities requirements for multi-stakeholder co-creation network management

Since we aim to examine the capabilities that multi-stakeholder co-creation networks rely on in order to successfully address organizational paradoxes in the context of Grand Challenges, this section reviews relevant literature on the capabilities that these networks need to be successful. This issue has been studied from different perspectives, using different terminologies, and usually not in relation to Grand Challenges.

One such perspective is research into interdisciplinary research collaborations. The literature on interdisciplinarity is very fragmented and, despite its focus, it is often written for specific disciplinary audiences (Rafols et al., 2012). Many papers report case studies of specific projects, or discussions of individual or team experiences (for example, Saviano et al., 2017); the approach is usually descriptive, with few papers developing more general frameworks applicable across the board. Within this literature, there are papers (particularly in the context of sustainability studies) analysing the involvement of external stakeholders in interdisciplinary research collaborations, for example civic society or specific interest groups. A lot of the debate concerns how to organize collaborations and decide which external stakeholders to involve (Boulton et al., 2016; Leventon et al., 2016), in situations where it is possible to design and implement these aspects in advance (Polk, 2015). Other contributions instead analyse the capabilities that stakeholders need to develop and learn in order to be able to collaborate productively (Gray, 2008; Cundill et al., 2015; Edwards, 2017; El-Awad et al., 2022) but less on capabilities required to manage paradoxical tensions.

Another line of research that has made valuable contributions to the understanding of the capabilities needed to successfully manage multi-stakeholder co-creation networks is the emerging area of co-creation studies (Kazadi et al., 2016; Rösler et al., 2021; Reypens et al., 2016, 2021). This includes work in the area of value co-creation (initiated in the field of services marketing), which focuses primarily on the process through which firms co-create value with their customers and their supply chain partners. It also includes work in the area of knowledge co-creation, which has originated in the broader field of innovation studies and focuses on the process through which complex networks of diverse stakeholders generate and implement innovations (De Silva et al., 2023).

Table A1 in the Appendix summarises the key capabilities identified by the above-mentioned literature as crucial in order to successfully manage multi-stakeholder co-creation networks. Our review of the literature identified six main types of capabilities, which we termed relational, visioning, cognitive bridging, knowledge management, coordination and communication – although individual papers used different terminologies, grouped activities differently, and sometimes identified only some of these capabilities and not others.

We can envision that some of these capabilities could be helpful to address the organizational paradoxes that are relevant to multi-stakeholder co-creation networks. For example, we may expect visioning and cognitive bridging capabilities to be helpful to address paradoxes of performing, since they would help to reconcile the stakeholders' different objectives and temporal horizons; knowledge management capabilities could help to address paradoxes of learning, since they would help to identify and share relevant knowledge to work with; coordination and communication capabilities could help to address paradoxes of organizing, since they would help to structure the work and keep it on track; relational capabilities could be used to address paradoxes of belonging, since they would help to reconcile different cultures, backgrounds, objectives and identities of individuals. However, these capabilities identified by the literature have several limitations, for our purposes. First, they are very broad, general capabilities which could be helpful to most forms of collaboration, in most contexts, instead of applying specifically to our context of interest. Second, the successful management of each paradox would probably require the combination of several of these general capabilities, in complex and shifting combinations. Our aim is instead to delve more specifically into the capabilities used by multi-stakeholder co-creation networks set up to address Grand Challenges.

2.4. Multi-stakeholder co-creation programmes vs projects

The literature has often discussed multi-stakeholder collaboration and paradoxes at the organizational or collaboration unit level (Danneels, 2004). However, multi-stakeholder co-creation may occur at different levels. Kaufmann and Danner-Schröder (2022) point out that Grand Challenges are addressed by different types of organizational forms, of which they identify six: movements, temporary organizations, partnerships, established organizations, multi-stakeholder networks, and supranational organizations. In their terminology, temporary organizations and partnerships correspond to what many other studies call 'projects'. Instead, what they call multi-stakeholder networks are networks of organizations that operate on a longer time scale and broader scope than individual projects, and seek to address more complex challenges with a democratic approach.

Ika and Munro (2022) recognize that particularly in the context of Grand Challenges, some goals are so broad that they cannot be delivered by a single project or even a couple of projects. Hence, multi-stakeholder co-creation networks could also be set up to deliver a programme, that is a set of interrelated projects that seek to achieve a common goal (Davies, 2017). Especially in relation to mission-oriented policies, it has been argued that achieving sustainable development goals should occur at two distinct levels namely projects and (mission) programmes with

specific organizational forms (Mazzucato, 2018; Reid et al., 2023).

Co-creation processes and associated organizational forms differ between projects and programmes in terms of actor engagement and scope. Projects involve co-creation with defined objectives, and deliverables aimed at addressing a specific aspect of a grand challenge (e.g. developing a drug, or specific green innovation technology). Project-level co-creation is characterized by focused, time-bound collaboration among a defined group of stakeholders, who jointly participate in problem definition, solution design, and iterative evaluation (Locatelli et al., 2023). In contrast, programme-level co-creation is aimed at coordinating a set of interrelated projects that collectively address broader dimensions of a Grand Challenge. Co-creation involves a broader and more diverse set of actors, including funders, policy-makers, implementing organizations, and beneficiaries, who are engaged across the entire programme lifecycle—from strategic goal-setting and portfolio design, through coordination and resource allocation, to collective learning and impact evaluation (Mazzucato, 2018; De Silva et al., 2022). Table 2 provides an overview of the main features of multi-stakeholder co-creation projects and multi-stakeholder co-creation programmes.

Äyväri et al. (2019) distinguish between capabilities that are needed

Table 2
Different levels of operation of multi-stakeholders co-creation networks: programmes vs projects.

	Multi-stakeholder co-creation programmes	Multi-stakeholder co-creation projects
Objective	Co-creating programmes to offer funding, expertise, and/or resources as a mechanism to bring the ecosystem of experts for specific projects to co-create solutions to address specific problems, which in constellation address a broader problem	Co-creating specific solutions to specific problems e.g. medical innovation or data-related innovation of apps or data platforms
Complexity Management	Navigate systemic paradoxes	Address bounded operational tensions
Nature of reach	Broader Ecosystem	Specific Networks
Problem	Broader problems that could then be addressed by a combination of multiple different projects	Specific, well-defined problem that could be addressed by a group of actors
Scope of co-creation	Co-creating enabling conditions for specific projects e.g. funding mechanisms, infrastructure, problem identifications, and resources	Co-creating a solution
Innovation	Network innovation facilitating strategic ecosystem alignment across projects	Product or service innovation focusing on task-specific collaboration with defined partners
Leading actor	More likely government or intermediary organizations	Combination of ecosystem actors
Actor involvement in co-creation process	Actors involved in the programme engage in co-creation throughout the entire programme lifecycle from designing, implementation, and evaluation. In the co-creation of programmes, these actors orchestrate collaboration and alignment across multiple projects to ensure that diverse projects collectively contribute to overarching programme objectives	All actors of a project are generally involved in the formulation, implementation, ongoing evaluation, and change management of the project. Actors involved in the co-creation process develop targeted solutions to a specific problem.

Note to Table 2: The table has been developed by the authors by combining insights from Danneels, 2004; Mazzucato, 2018; Ika and Munro, 2022; Davies, 2017; De Silva et al., 2022; Kaufmann and Danner-Schröder, 2022; Locatelli et al., 2023

to manage co-creation projects and capabilities that are needed to manage broader ecosystems of actors. The former include capabilities for: project management, facilitation, learning and knowledge co-creation and transfer, research, design of tools and methods, evaluation, commercialization and upscaling. The latter include capabilities for: visioning, networking, communication, negotiation, coordination, innovation and lateral thinking, relationship management. Once again, these are very general capabilities not tailored to the specific context we are considering, that of multi-stakeholder co-creation networks that operate in the context of Grand Challenges. In our empirical analysis, we seek to distinguish whether the different levels at which multi-stakeholder co-creation networks operate (single project or broader programme), are characterized by different paradoxes, requiring the adoption of different paradox management capabilities. Moreover, we aim to identify both higher-order paradox management capabilities (i.e., broad, integrative abilities that enable organizations to respond to complex challenges) and routine paradox management capabilities (i.e., operational competencies that support the efficient execution of specific tasks) (Teece, 2018).

3. Evidence base and methodology

Given the limited theoretical foundations and the intricate, context-specific nature of paradox management capabilities required to manage multi-stakeholder co-creation networks to address Grand Challenges (Eisenhardt and Graebner, 2007), our study employed an inductive, qualitative methodology. This method is well-suited for addressing 'how' and 'why' questions (Yin, 2013) and for deriving significant insights from rich, qualitative data (Lincoln and Guba, 1985).

The context within which the study was conducted is co-creation during the COVID-19 pandemic, which posed a great threat to human life and thus prompted a diverse range of actors to engage in joint innovation activities aimed at urgently addressing the emerging challenges. Co-creation in the context of COVID-19 required modifications to established collaboration capabilities and the adoption of new capabilities to promptly offer solutions. As a result, the COVID-19 context provided an opportunity to test new capabilities, technologies, operational models, and partnership structures. The study analysed 30 COVID-19 co-creation initiatives from 21 countries and 3 transnational initiatives. Detailed information about each case is presented in Table A2 in the Appendix. 13 of the 30 cases are programmes and the other 17 are projects. While both projects and programmes contributed to research and development outputs, they served distinct roles within the ecosystem. Projects were designed to address specific challenges and were co-created with diverse stakeholders to generate targeted solutions. Programmes were co-created with stakeholders to support and integrate multiple related projects that collectively address broader dimensions of a Grand Challenge. Co-creation at the programme level brought actors together and organized enabling conditions for specific projects e.g. funding mechanisms, infrastructure, problem identifications, and resources. Due to the complexity of the challenge, often government or intermediaries co-designed and co-delivered these programmes with other experts and stakeholders.²

Although the cases varied in terms of size, funding levels, the nature of the actors involved, and the duration of the initiatives, paradox management capabilities were found to be consistent among cases categorized as projects and those categorized as programmes. This further supports the differentiation between projects and programmes and the suitability of diverse cases to make inferences on paradox management capabilities, a strategy often adopted in qualitative research (Eisenhardt, 1989).

² For further details on the distinction between projects and programmes, please refer to Table 2, and see Table A2 in the Appendix for insights into how stakeholders co-created projects versus programmes in each case.

As the objective of our study was to understand the paradox management capabilities for successful delivery of multi-stakeholder co-creation programmes and projects, we have selected successful cases. Unlike unsuccessful cases, these allowed us to clearly identify how capabilities were used for successful delivery by managing paradoxical tensions. Therefore, our selection of cases that have achieved their objectives does not create bias (De Silva et al., 2023; Rossi et al., 2022).

In order to select successful case studies, the proposal was presented to OECD's Technology, Innovation and Policy (TIP) Working Party, which is a group of policy makers in the field of innovation and technology from across the OECD and partner countries, who proposed cases representative of projects and programmes. The TIP delegates introduced authors to initiative leaders. Once the OECD TIP delegates proposed potential cases, secondary data were collected through online sources and by contacting the initiative leaders via email and/or brief telephone conversations.

These cases were then assessed to determine whether they met the criteria for multi-stakeholder co-creation at the project or programme level, and whether they demonstrated successful outcomes—such as product, service, knowledge or network innovations—addressing specific COVID-19 challenges. Additionally, during the interview one section was aimed at requesting information on the output of these projects and programmes in terms of technologies, innovations, knowledge, and network. Triangulation between information gathered at the point of selection and upon the completion of interviews allowed to increase the reliability of the evidence collected.

Adopting an inductive approach, we treated each case as an independent experiment (Brown and Eisenhardt, 1997). Theoretical replication was achieved by continuously comparing case data, emerging theories, and existing literature (Van Maanen et al., 2007). This iterative process was applied throughout the data collection and analysis process (Yin, 2013).

Case studies were developed through 90-min in-depth interviews with initiative leaders using a standardized template to enable comparative analysis. Leaders, by virtue of their specific roles in the initiative, and a thorough understanding of the initiative and aware of the co-creation stakeholders and how the paradoxical tensions were managed (Dexter, 1970). In total, 30 in depth interviews with leaders were conducted. Since the interview template was sent to the initiative leaders, in most of the cases, they had invited other relevant members of the team to join the interview. Structured interviews were aimed at understanding (A) What was special about the co-creation initiatives due to the COVID-19 context? (B) What factors enabled the quick setup and implementation of new co-creation initiatives? (C) How did the co-creation practices adapt to the context of crisis to speed up solutions? (D) What challenges were encountered, and how were they addressed? (E) What role did governments play in co-creation during the COVID-19 crisis? (F) What were the key outcomes of the COVID-19 initiatives?.

While a standard template was used to ensure comparability across cases, additional questions were introduced where relevant to gather more detailed, case-specific information. This approach allowed the research to maintain consistency for cross-case analysis, while also capturing the unique contextual nuances of each individual case which would have been restricted if the standard template had been followed strictly (Eisenhardt, 1989). All the interviews were recorded and transcripts were prepared. Transcripts were reviewed and, where appropriate, corrected by the interviewees to improve accuracy (Huber and Power, 1985). The transcripts were then independently analysed by three researchers who then compared and contrasted themes for consistency. Thematic analysis with the development of first-order and second-order themes led to the identification of key higher-order capabilities and associated routine capabilities. Table A3 illustrates the coding structure, with the first-order, second-order and aggregated themes. Our use of the existing literature in the coding further improved our study's methodological rigor (Scandura and Williams, 2000).

In conducting thematic analysis, we performed within-case and

cross-case analyses, both within and between co-creation programmes and projects, in order to identify similarities, patterns, and differences (Yin, 2003). Our data analysis was guided by how paradoxical tensions were managed at co-creation programme and project levels. Although we follow the convention of writing the paper sequentially, the data collection and analysis involved an iterative and simultaneous process, continually revisiting the data and literature on paradoxical tensions of multi-stakeholder co-creation and capabilities for managing these to achieve theoretical replication (Suddaby, 2006).

4. Findings

Our study identifies higher-order capabilities and routine capabilities to manage paradoxical tensions within multi-stakeholder co-creation networks aiming to address Grand Challenges, such as disruptive sustainability, which has increasingly become the focus of mission-oriented, transformative policies. Routine paradox management capabilities, as operational competencies, function under specific higher-order capabilities and collectively enable organizations to realize those broad, integrative abilities needed to respond to complex challenges.

Since our analysis delves specifically into the capabilities used by multi-stakeholder co-creation networks, and these networks operate at two different levels (projects and programmes), we identify rather distinct capabilities that apply specifically to one or the other of these levels. At the project level, paradox management capabilities centre on mobilizing people and resources within specific initiatives, balancing social and business objectives, navigating diverse decision-making logics, and reconciling short-term deliverables with long-term impact. These capabilities support time-bound, focused collaborations that co-create solutions aimed at clearly defined goals. At the programme level, paradox management involves integrating objectives and resources across multiple projects to achieve macro-level outcomes,

fostering communication and collaboration among relevant policy units, and balancing top-down direction with bottom-up participation. Distinctive capabilities at both levels are therefore critical to orchestrate diverse actors and interconnected projects in responding to the scale and complexity of Grand Challenges.

The sections below discuss higher-order capabilities and routine capabilities at project and programme levels with relevant empirical evidence. A summary of our findings can be found in Fig. 1.

4.1. Paradox management capabilities for co-creation programmes

The analysis of qualitative evidence has identified three higher-order paradox management capabilities that were especially important for the successful design and delivery of co-creation programmes that provided resources, knowledge and networks to multiple projects to address the disruptive challenges of the pandemic: (A) Macro- and meso- level paradox management capabilities; (B) Top-down and bottom-up paradox management capabilities; and (C) Cross-departmental paradox management capabilities.

Macro- and meso- level paradox management capabilities. While the core aims of the programmes were to address broader macro-level socio-economic challenges, projects (delivered by a combination of ecosystem actors ranging from universities, businesses, intermediaries and community organizations) had specific meso-level objectives. Therefore, it was important for programmes to creatively align a portfolio of project goals to be able to achieve macro-level objectives, and in doing so, to shape the directions of projects and programmes. This was an iterative process of dynamically shaping macro-level and meso-level objectives and deliverables to achieve both macro- and meso- level targets. The qualitative analysis suggests that this was achieved by adopting three specific routine capabilities: (a) integrating a portfolio of projects to address macro socio-economic challenges; (b) expediting evaluation of applications and continuous reviewing of project outcomes to align applications and continuous reviewing of project outcomes to align

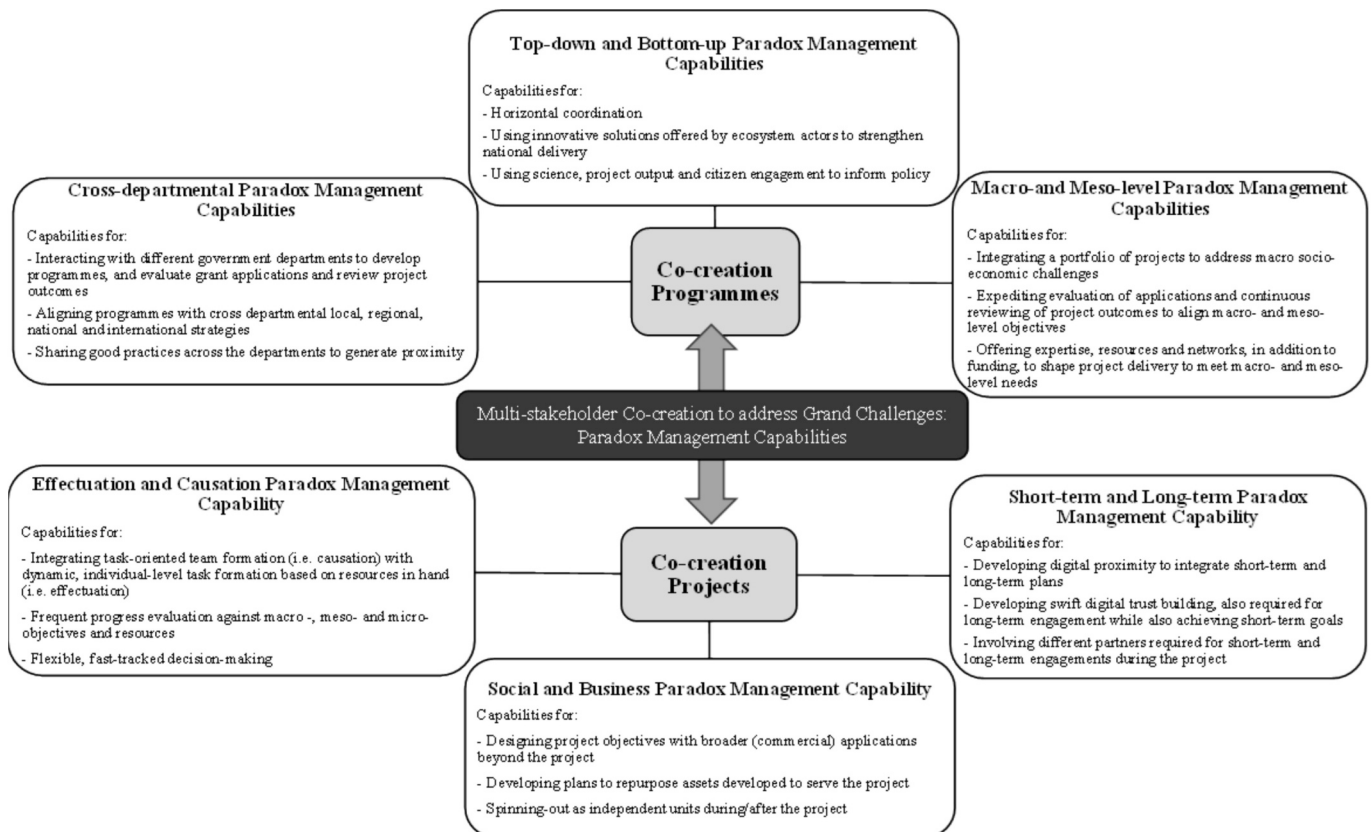


Fig. 1. Paradox-management capabilities relevant for multi-stakeholder co-creation networks to address Grand Challenges.

macro - and meso- level objectives and (c) offering expertise, resources and networks, in addition to funding, to shape project delivery to meet macro- and meso- level needs. Supportive quotations for each capability are presented in Table 3A.

(a) Capabilities for integrating a portfolio of projects to address macro socio-economic challenges: this was often done by co-creating a programme and associated calls for proposals with actors such as national research centres and intermediaries, which were aware of both macro-socio-economic challenges and strengths of ecosystem actors. In collaboration, they developed programmes by considering both the strengths and objectives of ecosystem actors, and national needs and competitive advantages. Such integration ensured that the proposals submitted to the call were of high quality, had the possibility for urgent delivery and had the potential to achieve both the macro socio-economic objectives and project partners' objectives. Programmes also capitalized on extensive and stronger links with ecosystem actors to bring the right actors together in the forms of specific projects to address socio-economic challenges. During the programme implementation, the programme co-creators liaised among projects to support project integration to achieve macro-level objectives. This capability was crucial throughout the lifetime of the programme from designing calls to integrating project deliverables to address macro socio-economic challenges.

(b) Capabilities for expediting evaluation of applications and continuous reviewing of project outcomes to align macro - and meso-level objectives: Since project calls were often co-created by combining macro socio-economic challenges and the strengths of potential applicants, programmes were able to offer a fast-tracked evaluation process (as the evaluation criteria were clear), and to perform a continuous review of funded projects (since the programmes worked closely with the project recipients). These routine capabilities were crucial to ensure that macro- and meso- level paradoxes were managed, and the objectives are promptly achieved.

(c) Capabilities for offering expertise, resources and networks, in addition to funding, shaping project delivery to meet macro- and meso-level needs: Programmes not only offered funding but also used their capabilities to offer expertise, resources and networks to shape the delivery of multiple projects to simultaneously meet macro- and meso-level needs. Access to unique macro-level knowledge, network and resources of the programmes enabled projects to incorporate a macro-level perspective in their projects, which enhanced the possibility of addressing macro level challenges. Additionally, when programmes worked closely with projects, programme leads were able to further understand projects' meso-level perspectives and objectives. Therefore, this capability enabled managing tensions between macro and meso-level objectives and needs.

Top-down and bottom-up paradox management capabilities. Co-creation programmes to achieve economic, social and environmental objectives require integrating bottom-up approaches with top-down approaches. Top-down approaches typically guide lower-level activities with directives from higher levels, while bottom-up approaches allow grassroot contributions to influence higher-level decisions (Ossenbrink et al., 2019). Both approaches are essential for effectively managing multi-stakeholder co-creation programmes addressing disruptive sustainability challenges. Especially since these programmes are generally designed by governments or major public bodies and then advertised via calls for ecosystem actors to respond, these are perceived as more top-down engagements. However, during the COVID-19 pandemic, it became necessary to combine top-down and bottom-up approaches to address programme-level paradoxes. The urgency and scale of the challenge demanded such integration to enable successful co-creation. Our analysis points to three routine capabilities: (a) horizontal coordination; (b) leveraging innovative solutions offered by diverse ecosystem actors to strengthen national delivery and (c) using science, research outputs and citizen engagement to inform policy. Supportive quotations for each capability are presented in Table 3B.

Table 3A
Macro- and meso- level paradox management capability.

Routine capabilities	Representative Quotes
Capability for integrating a portfolio of projects to address macro socio-economic challenges	<p><i>“The programme supports independent, not-for-profits (Clusters) to serve as ecosystem anchors in order to speed up growth in five promising industries in the country C [Key macro-socio-economic priorities]. Clusters bring together private companies of all sizes, academic institutions, government and not-for-profit organizations to create new possibilities for innovation and collaboration and encourage large-scale co-creation projects and capacity-building initiatives. Starting in early 2020, the programme was leveraged to address the challenges of the COVID-19 pandemic and funded over 80 COVID-19-related co-creation projects, sought to address pressing COVID-19 related challenges... Due to our past experience, the team had the capability to design the covid-19 programme to address specific country-level challenges by combining the deliverables of specific projects. This was done throughout the programme from designing the call, helping projects during the life cycles, changing project direction when required to combining project output to address specific challenges [capability]” [Case No. 1]</i></p> <p><i>“This initiative offered a good testbed to illustrate the feasibility of cross sector collaboration. Some project, which would have taken two years to complete under normal circumstances, were implemented in just six weeks [successful urgent delivery]. This speed is attributable to the capability of combining a portfolio of multidisciplinary projects to address a key issue [Capability].” [Case No. 10]</i></p>
Capability for expediting evaluation of applications and continuous reviewing of project outcomes to align macro- and meso- level objectives	<p><i>“Yes, the learning process was that, ..some of our process we can do better, we can do faster and we can apply also for other grants and now we are trying to do that; we are in the middle of the process that we seeing the - And we have to say, the pandemic pushed that. It was an accelerator! ...we are a big institution, that sometimes are processes are not very fast, but it was easy to increase the speed of the process...because we have a specific focus that if you have some technology, some research, some information that can add to address a pandemic based problem, and if you are a researcher that you will be part of this community, together we could make this work ...When designing calls, analysing applications, helping projects during the programme, deciding when to stop a project when it doesn't deliver- this learnt capability was important [capability].... This fast-track processes changed the mentality that the process could be improved and could make a bit more flexible” [Case No. 3]</i></p> <p><i>“I like to joke that typically – just to give you context – our challenge programmes are typically 18-month analyses of where we should be focusing, what we should be doing, we investigate, we talk to stakeholder engagement, etc.. We could not do that for the pandemic response challenge, so we went from 18 months to 18 days – so a very iterative, very agile way of looking at things, we defined our mission and our vision very quickly, we identified our niche, we</i></p>

(continued on next page)

Table 3A (continued)

Routine capabilities	Representative Quotes
Capability for offering expertise, resources and networks, in addition to funding, to shape project delivery to meet macro- and meso- level needs	<p>identified resources within the N [i.e. a national research centre] that could be brought to bear, the individual pillars directed by individual researchers and those researchers were responsible for deciding on the projects that should be in that pillar and how impactful they would be" [Case No. 2]</p> <p>"The initiative mobilized an existing co-creation programme Call – to offer accelerated funding for researchers, entrepreneurs, and industry to develop innovative solutions to the COVID-19 pandemic. The programme was led by two public bodies...the platform engaged 436 researchers from 49 organizations spanning academia and private industry...to address the wide-ranging socio-economic impacts of the pandemic [Projects addressing macro socio-economic challenges]...The platform has the capability to bring together actors via calls, offer funding, data, infrastructure, access to new knowledge, and enhance citizen engagement [capability]." [Case No.5]</p> <p>"In response to the crisis, the initiative formed 'catalyst informatics' in collaboration with data owners, other experts (e.g. universities and research centres) to access and use big data to make predictions, such as the outcome of the vaccination and other forms of treatments. [Case No.4]</p> <p>Political decisions and drive have a significant influence on fast mobilization and decision making when addressing societal needs. Without the involvement of EC, this Hackathon would not have been able to attract the quality and quantity of partnerships to address the COVID-19 crisis... Therefore, during both crisis and non-crisis periods, governments could capitalise on these platforms to engage with ecosystems to address other social challenges. In order to encourage investigation and experimentation with new tools to engage with the ecosystem, public authorities can play a vital role in the promotion of such initiatives providing national support that is essential to gain traction." [Case No.9]</p>

(a) Capabilities for horizontal coordination: the programmes used the capability to achieve horizontal coordination among government departments, programme leads, and ecosystem actors to integrate top-down and bottom-up approaches. Government departments in charge of programmes worked closely with specific network agents, who were better connected with ecosystem actors to achieve this integration. Such horizontal coordination facilitated the exchange of ideas, knowledge, and resources across levels. This reduced duplication of effort, strengthened project complementarity, created opportunities to remove barriers to co-creation, and promoted alignment of priorities among actors, which were paramount in addressing the scale and urgency of the challenge.

(b) Capabilities for leveraging innovative solutions offered by diverse ecosystem actors to strengthen national delivery: the programmes also adopted the capability for spotting and using innovative solutions offered by ecosystem actors to strengthen higher-order national-level activities and associated decision-making. Since Grand Challenges require radical changes and innovative approaches, the capability of programmes to leverage bottom-up approaches and ideas was important to enhance the creativity required for solutions and to

Table 3B

Top-down and bottom-up paradox management capability.

Routine capabilities	Representative Quotes
Capability for achieving horizontal coordination	<p>"The use of capabilities of AE [the organization that led the programme], which has already developed close links with the regional ecosystem of stakeholders such as – regional government, universities, research institutes, and enterprises – over 15 years was a key to success. They were able to draw on partners to drive the success of the funded projects...AE coordinated our activities by reducing unnecessary bureaucracy [horizontal coordination]... The clusters developed by AE, especially health and wellbeing as well as multidisciplinary work with other clusters such as Big Data and Artificial Intelligence Cluster, and Greentech Clusters were important to rapidly respond to challenges" [Case No.7]</p> <p>"IS [i.e. government funder] also worked closely with SC [name of the programme] as they developed revised project selection criteria for dedicated COVID-19 project streams and sat as an observer on SC project selection committees. This allowed for horizontal coordination with other rapidly moving COVID response initiatives. This approach helped to minimize unnecessary duplication, favoured rapid removal of barriers, and promoted alignment behind key priorities... Government of country C engaged with SC initiative to identify emerging pandemic response needs. In turn, SC engaged their industry and academic ecosystem members to identify how they could mobilise or pivot to respond to COVID-19 priorities" [Case No.1]</p> <p>"You have to work very agile and less hierarchical. I think if I remember correctly, we had the daily sprints every day ...I led daily meetings of the little board we had every day for an hour but it was so to-the-point that most of the time, we could limit it to half an hour and then we could get on with our business, so it was a very, very, very fruitful, and perfect cooperation among us [us means other collaborators]... We didn't use hierarchical coordination...It was therefore very productive" [Case No.8]</p> <p>"The initiative was initially formed on the basis of an informal conversation between the founders of Portuguese technological start-ups [a bottom-up approach]. Subsequently, with support of SP, a public-private initiative for designing the national strategy for entrepreneurship, they built a large network of volunteers from 250 companies across Portugal... The capability of SP to be able to transcend the use of innovative solutions offered by volunteers for the national pandemic response was key [capability]....This initiative had more than 5360 volunteers working on 72 projects (36 fully developed projects and 36 ideas under development) in the period from May to September 2020. A number of projects were then used by the government and other professional stakeholders [bottom-up approach being taken up by the government]" [Case No. 13]</p>
Capability for spotting and using innovative solutions offered by ecosystem actors to strengthen national delivery	<p>"The initiative was initially started with a top-down approach of making a call for</p>

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Table 3B (continued)

Routine capabilities	Representative Quotes
Capabilities for using science, project output and citizen engagement to inform policy	<p>proposals internally (addressed to the researchers of the national research organization that led the programme) to address COVID-19 challenges using the President's Discretionary Fund. Setting up open calls to use the Supercomputers and other facilities proved efficient in finding effective ways to apply supercomputing and other capacities to address the COVID-19 challenge. Universities, research institutes and companies responded to the open call. Such open calls were particularly pertinent in the context of the COVID-19 crisis given the number and variety of actors involved in trying to provide solutions to the challenge. Especially open calls accepted innovative proposals rather than having a narrow set of areas that we previously used" [Case No.4]</p> <p>"One of the main objectives, of course, of this call, was some goals, some new knowledge about how to face the pandemic will be utilised by the government... We thus make a greater effort to coordinate between project teams and government [capability] ... Of course, that information, the authorities, the institutions like the Health Ministry, take this information and some goals of these projects and also take into consideration when they revise existing policy make new policy and take key decision" [Case No.3]</p> <p>"X [The organization which led the initiative], with the support of the Japanese government, leveraged infrastructure it developed previously for other purposes for this initiative, which was a critical step to optimise the impact of the project. For instance, information generated from the supercomputer was used to design guidelines on social distancing and lockdown measures. Going forward, having scientist perspectives represented in government could improve capacities both in a crisis setting and in normal times" [Case No.4]</p> <p>"Initiative X, initiated and funded by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK), enables community-based policy-making by gathering experience and ideas from various actors within the innovation ecosystem. Co-creation occurred among stakeholders (companies, public research institution, ministry and citizens) in the process of participatory idea and concept development to support government decision-making....X aimed at understanding unexpected social, environmental and economic consequences of the pandemic; identifying opportunities, expertise, technologies and networks to find solutions; and developing innovative solutions in four key areas: Digital Health, Distancing, Economic Buffers and State Intervention." [Case No.12]</p>

respond to failures that may emerge in the process.

(c) Capabilities for using science, research outputs and citizen engagement to inform policy: this capability was vital for integrating bottom-up and top-down approaches. The rapid and intense use of science and citizen engagement for policymaking played a vital role in finding solutions to the pandemic. Citizens with relevant knowledge,

data, insights, resources and experience provided additional critical inputs to strengthen efforts in addressing the many challenges for rapid progress.

Cross-departmental paradox management capabilities. Most Grand Challenges are broad ranging in their socio-economic impacts and consequently concern different government departments. Cross-departmental collaboration generates synergies between the responsibilities and capacities of each department, while avoiding misalignments and costly overlaps - an essential approach for enabling disruptive sustainability transitions. Yet, each government department has unique focus areas, a network of connections, culture and working relationships. Therefore, specific routine capabilities had to be adopted to manage paradoxical tensions among departments: (a) interacting with different government departments to develop programmes, and evaluate grant applications and review project outcomes; (b) aligning programmes with cross-departmental local, regional, national and international strategies and (c) sharing good practices across the departments to generate proximity. Supportive quotations for each of them are presented in Table 3C.

(a) Capabilities for interacting with different government departments to develop programmes, and evaluate grant applications and review project outcomes: Since the pandemic (i.e. as any grand challenge) posed health, economic, social, digital/data and educational challenges, programmes required productive working relationships between different government departments and between departments and programme leads. The capability to work across government departments enabled programmes to be more effective in addressing challenges by achieving synergies among departments and managing paradoxical tensions. Programmes leads who had the networks and experience of working across different government departments were seen to have this capability. Especially, such programme leads acted as boundary spanners in connecting different departments when designing the objectives of the programmes and delivering outcomes by bringing together a portfolio of projects.

(b) Capabilities for aligning programmes with cross-departmental local, regional, national and international strategies: this ensured greater alignment between projects associated with programmes and government strategies at different levels. This alignment was critical to collectively achieve Grand Challenges that often require cross-level engagement. This also ensured that the programmes had government backing and thus received continuous support when required.

(c) Capabilities for sharing good practices across the departments to generate proximity: such sharing made these departments cognitively and organizationally proximate, which was essential to managing paradoxical tensions between departments for successful programme-level co-creation.

4.2. Paradox management capabilities for co-creation projects

While programmes manage a portfolio of projects, a single project has a specific aim such as medical innovation (such as developing vaccines or ventilators) or data integration (such as provision of real-time COVID-19 statistics, via online platforms and mobile apps to support research, innovation, policy decisions, and help citizens navigate the crisis). Qualitative analysis has identified three types of higher-order paradox management capabilities in co-creation projects supporting disruptive sustainability: (A) Social and business paradox management capability; (B) Effectuation and causation paradox management capability; and (C) Short-term and long-term paradox management capability.

Social and business paradox management capability. Combining social value creation with a mean to generate business value results in financially sustainable and scaled-up co-creation project outcomes. In this way, profit is reinvested to generate more social value, and diverse for-profit and not-for-profit actors – with mutual benefits - are encouraged to co-create. This is made possible by creating and exploiting

Table 3C
Cross-departmental paradox management capability.

Routine capabilities	Representative Quotes
Capability for interacting with different government departments to develop programmes, and evaluate grant applications and review project outcomes	<p>“The clusters developed by AE [name of the programme], especially health and wellbeing as well as multidisciplinary work with other clusters such as Big Data and Artificial Intelligence Cluster, and Greentech Clusters were important to rapidly respond to challenges... We thus had to work with different ministries. Due to our past experience, we knew how to do this [Capability]. We thus interacted with and facilitated the interaction among the Ministry of Health, Ministry of Finance, and the Ministry of Economic Development, who have completely different missions and objectives. Yet the pandemic pushed them to work with us and among them... When you work together, you could find better solutions” [Case No.7]</p> <p>“We reviewed all the steps of the review process and rearranged it in simpler and straight forward manner – also working with all the different teams [i.e. different government departments] cohesively – i.e. not only the core proposal evaluation team but also other secondary teams such as legal department, financial, administrative, communication department, IT department...so we reviewed the whole steps of the process from the beginning and also we assessed the opinion of the entire team and we also received guidance of the national director and the sub-director. I have to say we are very happy with that because they trust in our teams” [Case No.3]</p>
Capability of aligning programmes with cross-departmental local, regional, national and international strategies	<p>“The programme X was a public-private consortium which pooled resources to make high performance computing capabilities available to specific projects. The consortium was spearheaded by the White House Office of Science and Technology Policy in partnership with the National Science Foundation (NSF) and the U.S. Department of Energy (DOE), and pooled expertise and computing capacities for COVID-19 challenges by partnering with companies (12 large US technology companies), 16 universities and research institutions, as well as national laboratories. These bodies were already in discussion to develop a national strategy to pool supercomputers before the pandemic. Due to this ongoing conversation, rapid delivery of the programme was possible. The programme was thus positioned within the national and regional strategies. The pooled computing power enabled over 100 international project teams across 17 countries to use computing power and associated skills to address pandemic-related challenges. New capabilities developed were then used after the pandemic to strengthen the strategy for pooling supercomputing power.” [Case No.6]</p> <p>“The pandemic has created more occasions to put together the Ministry of Health, and the Ministry of Economic Development, of which it is difficult for them to work together, because they have completely different objectives. One is to take care of</p>

Table 3C (continued)

Routine capabilities	Representative Quotes
Capability for sharing good practices across the departments to generate proximity	<p>patients and save lives, and the other one focusses on creating profit, jobs, and improve the quality of life. But they working together is important to improve quality of life of citizens... multidisciplinary in terms of government ministries working together for national strategy was important... We are trying to use these initial contacts and to also to use this new period of fundings, European fundings, to put together the strategy. We have a regional strategy, but sometimes it's not so regional, but silos. The evidence that some of the solutions that were financed by the Minister of Economic Development could be useful for the healthcare system and also technological development... We try to improve our our funding programme in the next period, by building on cross-departmental interactions for national and regional strategies ..So, how can we try to create a value chain in the funding – not in isolation of the technology and innovation in our region, but to support the system in these different steps of development. So we are trying to do that” [Case No.7]</p> <p>“Government research institute for biotechnology, Scientific and technological research council, Ministry of Industry and Technology as well as Ministry of Health work together in this programme to support 436 researchers from 49 organizations spanning academia and private industry for a wide array of co-creation projects. The core organisers constantly interacted with each other to share good practices and to streamline processes for efficient delivery” [Case No.5].</p> <p>“We have an international department and they are always in contact with other international agencies similar to us and we are always trying to learn good practice and also, in this Covid process, we ask, ‘What will you do? What are you doing?’, etc., etc. and we are constantly watching them and with that benchmark, ... when the pandemic started all the decisions that the Minister of Health and the other ministers did, they really didn't know how to do it; working together was not easy; they really didn't know what was the best...but we work as a community by learning from each other” [Case No.3]</p>

opportunities that integrate social and business value logic. The analysis has identified three underpinning routine capabilities for: (a) designing project objectives with broader (commercial) applications beyond the project; (b) developing plans to repurpose assets developed to serve the project and (c) spinning-out as independent units during/after the project. Supportive quotations are presented in Table 4A.

(a) Capabilities for designing project objectives with broader (commercial) applications beyond the project: While the projects were designed to address a pandemic-imposed social issue – for example, developing a vaccine – the capability to integrate this social value creation logic with business value – for example, additional job creation, other ways of using the vaccine development for future research and drug discovery – resulted in more successful project co-creation. More importantly, the possibility of generating business value significantly increased the motivation to engage in successful co-creation. Also, the

Table 4A
Social and business paradox management capability.

Routine Capabilities	Representative Quotes
Capabilities for designing project objectives with broader (commercial) applications beyond the project	<p>“The vaccine could be altered, and produced for future variations of the virus, while also enabling potential future research into other SARs Covid viruses...It is our capability to identify these additional uses that would increase the value of this investment ... Domestic production of vaccine enabled investment and job creation, including new manufacturing sites in the UK” [Case No. 17]</p> <p>“We are exporting the astronomical mode – also the climate change – because we strongly believe what I already said, but also specifically about climate change data, so people know what’s going on in their territory, and what’s gonna happen. So, datasets that we expect to make public are coming from numerical simulations, so that you are able to see what’s gonna happen in your backyard in the next 30, 50 years. It will keep doing what we do. A stable knowledge community focused on developing epidemiological surveillance and outbreak response capacities in LMICs to enable these countries to better respond to future health emergencies”. [Case No. 23]</p> <p>“The objective of this project was to track people during the pandemic but we could use the same technology to track objects. The possibility to deploy solutions that involve tracking objects is much easier because you don’t have privacy-related issues. In the logistics area, in these trial environments, this is a good idea. We have the ability to use the same technology to track objects in the logistic area” [Case No. 25]</p>
Capabilities for developing plans to repurpose assets developed to serve the project	<p>“Non-traditional manufacturers – like F [company who is not in the ventilator manufacturing industry]- capitalized on knowledge, experience and supplier network – to manufacture different products in the future (e.g. ambulances). The Chairman of F in Europe said they’re learning about how to do things at pace during their engagement in the VC [i.e. name of the project]. It had inspired their response to getting back into the ambulance market, and they said they were able to bring a new ambulance to market in a fraction of the time that it would have, typically, before they’d done it, by using some of the same principles that they had to use during the VC because of the pace at which we needed to work, and – indeed – using some of the partners that they met – suppliers and partners who were unknown to them – maybe not unknown – but who weren’t the normal F’s partners prior to that, so I think – certainly in some areas – some of those individual firms, I’m sure, have learnt a lot and developed valuable capabilities to repurpose resources and infrastructure for future business development [capability]” [Case No. 18]</p> <p>“The app and the associated data are a tool ... We have the capability for it to be reinstated or repurposed for other epidemiological studies on virus spread [capability] ... Consideration of the potential repurposing of the App also meant that the rollout and launch were much faster, ... The precedent and spirit of collaboration, will have</p>

Table 4A (continued)

Routine Capabilities	Representative Quotes
Capabilities for spanning-out as independent units during/after the project	<p>intangible effects that will ripple throughout future projects” [Case No. 24]</p> <p>“The use of our capabilities to create the spin-off company [capability] resulted in enhanced PR & Communication capabilities and legal capabilities associated with the licensing – this enhanced the rapid technology transfer from university to industry” [Case No. 19]</p> <p>“The willingness of parties to collaborate was attributed to the temporary teams formed with no obligation to work together beyond a specific period of time (i.e. a maximum of six weeks). This has offered a good opportunity for actors to explore the possibility of working together to exploit opportunities. If they have decided to extend the collaboration, the opportunity was available to form separate spin-offs. Especially those who have capabilities to spin-out, have already incorporated such possibilities when they were working together during the initial six months [capability]” [Referring to specific project of Case No.10]</p> <p>“So because of the success that the sequel to this project... now that the strong force of the Society For Intensive Care Medicine that embraces this project and together we were able to secure a subsidy from the health care insurers to continue this project also for non-gov, which is pretty amazing I would say.” [Case No. 29]</p>

integration of two logics resulted in partners viewing the project as having a lifetime beyond the pandemic thus further incentivising successful co-creation.

(b) Capabilities for developing plans to repurpose assets developed to serve the project beyond the project lifetime: this capability was crucial to generate more value from project co-creation. Sharing these plans with project collaborators further enhanced their motivation to achieve success. For instance, when supercomputing infrastructure was integrated to address pandemic-based challenges, successful integration efforts looked beyond the project regarding how to repurpose such infrastructure, with commercial applications. When developing products to resolve a social challenge – e.g. an App or Ventilator – the capability to apply such technologies beyond the pandemic for other commercial applications enabled the blending of social and commercial logics, which resulted in financial sustainability and continuation of the project beyond the funded period.

(c) Capabilities for spinning-out as independent units during/after the project (to commercialise a product or service developed therein): this capability brought investors and additional stakeholders who supported further development of the output. This capability was important to scale up the output that generated social value to a financially sustainable venture. The more profit the venture generated, the more social value it produced.

Effectuation and causation paradox management capability. Multi-stakeholder co-creation is often perceived as effectuation driven (i.e. defining objectives based on resources in hand) (Saravathy, 2001; De Silva et al., 2023) due to its core objective of integrating diverse strengths and perspectives to generate shared value. Yet, our qualitative analysis suggested that urgently addressing Grand Challenges, requires the integration of effectuation with causation (i.e. first defining objectives and then sourcing resources to achieve these). In particular, the challenges raised by the Covid-19 pandemic required project collaborators to define the objectives and bring diverse disciplines to achieve

them. However, the uncertainty associated with the challenge and the need to incorporate the evolving needs and strengths of partners required the project to change direction and use effectuation logic through agile management. We have identified three routine capabilities that enabled the management of paradoxical tensions between causation and effectuation logics: (a) integrating task-oriented team formation (i.e. causation) with dynamic, individual-level task formation based on resources in hand (i.e. effectuation); (b) frequent progress evaluation against macro-, meso- and micro- objectives and resources and (c) flexible, fast-tracked decision-making. Supportive quotations for each of these capabilities are presented in Table 4B.

(a) Capabilities for integrating task-oriented team formation (i.e. causation) with dynamic, individual-level task formation based on resources in hand (i.e. effectuation): Evidence suggests that during the project, due to the need to urgently find solutions, the project leads formed task-oriented subgroups (i.e. causation). Yet, when it came to individual-level tasks for each team member, these were formed based on resources in hand (effectuation) and dynamically changed by considering how the project evolved (i.e. combining both effectuation and causation). This dynamic interaction among project-, sub-team- and individual-level activities enabled the integration of causation and effectuation logics required to address the challenge.

(b) Capabilities for frequent progress evaluation against macro-, meso- and micro- objectives and resources: this ensured that the project delivery met the objectives at all levels. Additionally, if the progress of a sub-project did not align with the emerging needs of the project, project partners promptly decided to either change the direction or stop the activity. Such fast-tracked decisions ensured that the projects generated greater value for money and addressed the Grand Challenge, while also achieving the objectives of individual partners. Due to uncertainty associated with Grand Challenges, the capability to frequently evaluate the progress enabled the management of tensions between causation (ensuring that projects achieved set objectives) and effectuation (changing the direction of the project based on the changes in the resource status and needs of partners).

(c) Capabilities for flexible, fast-tracked decision-making: It was evident that partners used this capability not only at the project level but also at the individual partner levels. Such decisions enabled them to have shorter and tighter deadlines and dynamically change the direction of the project as per the evolving needs and changes in their resource infrastructure. This also resulted in integrating causation and effectuation approaches required for project co-creation.

Short-term and long-term paradox management capability. Multi-stakeholder co-creation projects are often long-term processes that require to combine short-term goals with long-term strategic significance (Ebers and Maurer, 2016). Achieving both in successive projects requires managing such paradoxical tensions, as they involve different choices regarding focus, partner selection and the culture of delivery. Our qualitative analysis has identified three routine capabilities that enabled projects to manage paradoxical tensions between short-term and long-term project goals: (a) developing digital proximity to integrate short-term and long-term plans, (b) developing swift digital trust building, also required for long-term engagement while also achieving short-term goals and (c) successfully involving different partners for both short- and long-term engagements. Supportive quotations for each of these capabilities are presented in Table 4C.

(a) Capabilities for developing digital proximity to integrate short-term and long-term plans: Digital platforms and other related communication and data storage technologies were useful in establishing the objectives with respective partners as well as in tracking progress and deliverables. As the project and the needs and strengths of partners evolved, the use of diverse digital tools, facilitated by digital proximity, was instrumental for efficiently and dynamically realigning short-term and long-term plans.

(b) Capabilities for developing swift digital trust building: When project partners adopted this capability, they were able to successfully

Table 4B
Effectuation and causation paradox management capability.

Routine capabilities	Representative Quotes
Capabilities for integrating task-oriented team formation (i.e. causation) with dynamic, individual-level task formation based on resources in hand (i.e. effectuation)	<p>“Perhaps the most surprising asset was that we did not have time to plan much at all – if we had, we’d have been paralysed. It seems you just have to get started and set deadlines for when to move on. We knew what was required from the project and we assigned tasks to each sub-group... it was required to have well-structured weekly meetings between partners with clearly defined tasks across participating institutions [causation]. But in relation to tasks for individuals, we had to check what they are capable of. We sometimes changed objectives based on what individuals could deliver. We frequently changed our plans [effectuation]...Even now, we are astonished at how quickly this infrastructure self-assembled” [Case No. 21]</p> <p>“It is typical for projects to report to the steering group once a week or less, in this project, which was so dynamic, reports and decisions were made every workday evening. Steering group meetings were recorded, meeting minutes, decisions, and the project status were available to each project participant in the Slack channel. These project management skills for organizing large-scale events will be helpful in non-crisis times as well”. [Case No. 24]</p>
Capabilities for frequent progress evaluation against macro-, meso- and micro- objectives and resources	<p>“Needed to take right decisions to urgently stop companies if they are not delivering of course, that also needed managing because you had to turn people off quickly and say, ‘You’re not gonna make it,’ and – I think it was really important – that willingness to spend money on things before we knew it would work, but then having the process that stopped that quickly enough when it didn’t, ...As the needs evolve in some instances needs and objectives changed [integrating causation and effectuation] that it wasn’t terrible for British taxpayers [greater value for money]” [Case No. 18]</p>
Capabilities for flexible, fast-tracked decision-making	<p>“I think it’s the advantage of having something that has near-term deliverables; ... we could then check against set objectives and evolving needs...we could introduce amendments if required [integration of causation and effectuation]...it’s visible what you can achieve when you have near-term deliverables ... We were privileged in that sense because were allowed to make an impact quickly. [Case No. 21]</p> <p>“The crisis required individual research centres to be highly flexible in reallocating resources including staff, financial resources and other supports and infrastructure... Research institutions quickly responded... the experience highlighted the possibility of improving institutional agility” [Case No. 16]</p> <p>“Also, the typical time span was shortened for development...14 weeks instead of a typical 1 year project or longer... and forced us to be more agile. The change was very useful to learn for future pressure/crisis situations capability to have an agile development under external pressure...Yes, this was the first time we faced as technology center this level of time pressure to deliver a working tool developed in collaboration with other 2 institutions” [Case No. 15]</p>

(continued on next page)

Table 4B (continued)

Routine capabilities	Representative Quotes
	<i>“More frequent e-meetings, close management of the workflow, clearly outlined short-term deadlines and emotional support and encouragement”</i> [Case No. 16]

use different digital platforms and tools to include all partners and manage relations effectively. This resulted in developing trust among partners through digital means, which was important since many diverse partners had not worked together previously, and it played a significant role in enhancing the willingness of partners to engage in long-term collaborations. As a result, they were able to use digital trust-building to achieve both long-term and short-term goals.

(c) Capabilities for successfully involving different partners for both short- and long-term engagements: Projects often used a combination of partners for short-term and long-term goals. One approach observed consisted in the use of crowdsourcing or open-source platforms to generate short-term solutions and then carefully select partners to engage in follow-up long-term collaborations.

5. Discussion and conclusions

5.1. Discussion

This study makes an original contribution towards an enhanced understanding of the specific capabilities required to manage the paradoxical tensions inherent in multi-stakeholder co-creation networks addressing complex Grand Challenges, such as those related to disruptive sustainability. Grand Challenges are complex and inherently paradoxical (Jarzabkowski et al., 2019) as they carry contradictory but interrelated requirements that create tensions (Smith and Lewis, 2011). We thus respond to the lack of knowledge about the capabilities (Arnold et al., 2021; Lê and Bednarek, 2017) that underpin the management of tensions (Jarzabkowski et al., 2019) inherent in disruptive sustainability, which has increasingly become the focus of transformative, mission-oriented policies (Bansal, 2019; Matos and Hall, 2007).

Our analysis originally identifies six higher-order paradox management capabilities – three at the programme level and three at the project level – along with the specific routine capabilities that partners employ to navigate these contradictions and achieve successful, rapid co-creation. Our findings advance organizational theory, transformative innovation policy, and the literature on inter-organizational collaboration in three key areas.

Advancing paradox theory and strategy research: First, while organizational and strategy research has established the commonality and significance of paradoxes in organizational life (Schad et al., 2016; Smith and Lewis, 2011), there is a limited understanding of how these paradoxes are managed across organizational boundaries (Lê and Bednarek, 2017). By explicitly identifying the capabilities (Arnold et al., 2021) that underpin the management of these tensions, this paper originally advances paradox theory (Cunha and Putnam, 2019; Smith and Lewis, 2011).

We build on Jarzabkowski et al.'s (2019) work, which illustrated how contradictions continuously evolve within inter-organizational interactions focused on Grand Challenges, by providing a granular, capability-based framework for effective management. Our analysis, which distinguishes these capabilities across different inter-organizational layers, offers a particularly nuanced understanding. Specifically, by linking our findings to the core types of paradoxes identified by Smith and Lewis (2011), [Table 5] we found that belonging and organizing paradoxes are more evident at the programme level, necessitating cross-departmental, top-down and bottom-up, and macro-

Table 4C

Short-term and long-term paradox management capability.

Routine capabilities	Representative Quotes
Capabilities for developing digital proximity to integrate short-term and long-term plans	<i>“The usefulness, efficiency and effectiveness of digital technologies is evident for a large-scale project involving many participants, there is a greater likelihood of using these in the future... digital technologies enabled us to track the progress of each partner, sub-projects and the overall project... we were able to clearly see how short-term deliverable are aligned for a greater good</i> [Case No. 16] <i>“Remote working – expedited cross-departmental interactions within the government, which is usually very slow”</i> [Case No. 18] <i>“It was highlighted that clearly designed tasks with a roadmap for the completion of work, short-term goals, constant engagement, more frequent e-meetings and emotional support were more important for remote working than in-person working. These helped the team build trust”</i> [Case No. 27]
Capabilities for developing swift digital trust building, also required for long-term engagement while also achieving short-term goals	<i>“When working remotely both within the team and across teams, it was evident that using a combination of tools led to more engaged interaction. For instance, in addition to the general tools used for team working (e.g. Slack, a remote working platforms), the use of social media like Twitter and LinkedIn facilitated the development of reassurance and inclusion during remote work. Additionally, the teams had at their disposal diverse communication tools for conference calls, depending on the level of confidentiality required. While specific projects were short-term, the positive remote experience made us collectively seek long-term engagement</i> [Case No. 26] <i>“We retained momentum with collective trust, combined with sufficiently diverse expertise and perspectives, which allowed us to rapidly reach and implement strategic decisions... This was made possible due to our and partners capabilities to use digital technologies”</i> [Case No. 21]
Capabilities for involving different partners required for short-term and long-term engagements during the project	<i>“There was an open recruitment of more than 150 active participants, spanning a range of expertise and technology across academia, biotechnology, pharmaceuticals, all working without claiming intellectual property. It has resulted in the discovery and development of antiviral compounds against the strain which are being tweaked and tested to improve solubility... After this first phase of crowdsourcing, it was important to select partners with whom we will engage in long-term collaboration. Since it involves Intellectual property rights, and has to have a productive long-term collaboration we were very selective”</i> [Case No. 21] <i>“The operational model adopted in this initiative proved effective to address challenges in the short-run. The Kaggle Platform, a digital platform posting challenges for solutions within the ecosystem, enabled developing information retrieval techniques (e.g. text and data mining tools). ... These solutions are subsequently used by key players, with whom we have developed a long-term relationship, in publishing and AI industries to generate insights from scientific articles. The Kaggle challenge model was useful to source different AI, NLP and search engine tool developers and to select the best option.”</i> [Case No. 27]

Table 5
Paradoxes and paradox-management capabilities for multi-stakeholder co-creation networks to address Grand Challenges.

Type of paradoxes [Conceptual development from the literature]	Paradoxes relevant to multi-stakeholder co-creation networks [Conceptual development from the literature]	Relevant paradox management capabilities and related routine capabilities identified in our empirical analysis [Paper's Original Contributions]
Programme co-creation		
Belonging	Member identity and Competition and collaboration	Cross-departmental paradox management capabilities <ul style="list-style-type: none"> • Capability for interacting with different government departments to develop programmes, evaluate grant applications and review project outcomes • Capability of aligning programmes with cross-departmental local, regional, national and international strategies • Capability for sharing good practices across the departments to generate proximity
Organizing	Control and autonomy	Top-down and bottom-up paradox management capabilities <ul style="list-style-type: none"> • Capability for achieving horizontal coordination • Capability for spotting and using innovative solutions offered by ecosystem actors to strengthen national delivery • Capabilities for using science, project output and citizen engagement to inform policy
	Organizational flexibility and structuring	Macro- and meso- level paradox management capabilities <ul style="list-style-type: none"> • Capability for integrating a portfolio of projects to address macro socio-economic challenges • Capability for expediting evaluation of applications and continuous reviewing of project outcomes to align macro- and meso-level objectives • Capability for offering expertise, resources and networks, in addition to funding, to shape project delivery to meet macro- and meso- level needs
Project co-creation		
Learning	Exploration and exploitation	Effectuation and causation paradox management capability <ul style="list-style-type: none"> • Capabilities for integrating task-oriented team formation (i.e. causation) with dynamic, individual-level task formation based on resources in hand (i.e. effectuation) • Capabilities for frequent progress evaluation

Table 5 (continued)

Type of paradoxes [Conceptual development from the literature]	Paradoxes relevant to multi-stakeholder co-creation networks [Conceptual development from the literature]	Relevant paradox management capabilities and related routine capabilities identified in our empirical analysis [Paper's Original Contributions]
		against macro-, meso- and micro- objectives and resources <ul style="list-style-type: none"> • Capabilities for flexible, fast-tracked decision-making
Performing	Social and commercial missions	Social and business paradox management capability <ul style="list-style-type: none"> • Capabilities for designing project objectives with broader (commercial) applications beyond the project • Capabilities for developing plans to repurpose assets developed to serve the project • Capabilities for spanning-out as independent units during/after the project
	Short-term and long-term goals	Short-term and long-term paradox management capability <ul style="list-style-type: none"> • Capabilities for developing digital proximity to integrate short-term and long-term plans • Capabilities for developing swift digital trust building, also required for long-term engagement while also achieving short-term goals • Capabilities for involving different partners required for short-term and long-term engagements during the project

and meso-level paradox management capabilities. Conversely, performing and learning paradoxes are more prevalent at the project level, where co-creation networks should display effectuation and causation, social and business, and short-term and long-term paradox management capabilities. This differentiation between capabilities at the project and programme levels is a key contribution, offering a comprehensive view of capabilities required to manage disruptive sustainability transitions (Kivimaa et al., 2019; Schot and Steinmueller, 2018) that demands systemic, multi-stakeholder co-creation (Kivimaa et al., 2019) orchestrated across different levels (Reid et al., 2023).

Advancing transformative innovation policy literature: Second, our findings contribute directly to the literature on transformative, mission-oriented innovation policy (TIP) that drive systemic sustainability transitions (Haddad et al., 2022). While TIP has correctly emphasized the importance of involving networks of actors (Mazzucato, 2018; Bugge et al., 2018), system-level change, learning, and reflexivity (Schot and Steinmueller, 2018; Kivimaa et al., 2019), and the challenges in managing such networks (Grillitsch et al., 2019), it has remained general in specifying the actual capabilities required for transformative change. The literature has been noted to “not really engage in any discussion about what such capabilities entail and how they could be built up” (Haddad et al., 2022, p 32). We address this gap by providing a granular account of the specific paradox-management capabilities

required by public sector actors and network participants. As an example of such tensions, Reid et al. (2023) pointed out the need to orchestrate and mediate alignment and tensions between bottom up and top-down mechanisms of prioritisation of research and innovation policy. Our findings directly address this gap by identifying the higher-order and routine paradox-management capabilities that enable actors to effectively manage the contradictions inherent in transformative policy-driven networks aimed at addressing Grand Challenges. Our work thus provides the foundation for understanding how public sector actors can develop dynamic capabilities (Teece et al., 1997) needed to support “organizational flexibility and responsiveness to new information” (Kattel and Mazzucato, 2018, p. 791).

Advancing multi-stakeholder co-creation research: Third, this study enhances the literature on interdisciplinary, inter-organizational collaborations (Roloff, 2008) by focusing on the acute needs of multi-stakeholder co-creation networks established under pressing conditions to address Grand Challenges. Much of the existing research in this area, often focuses on how to structure collaborative relationships (e.g., Leventon et al., 2016) or has identified several broad, general capabilities that facilitate the success of such networks (see, e.g., Gray, 2008; Cundill et al., 2015; Kazadi et al., 2016; Edwards, 2017; Ryymin et al., 2020; Reypens et al., 2021; Kivimaa et al., 2019). Furthermore, some prior work has questioned the productivity of co-creation (Cummings and Kiesler, 2007; Raasch et al., 2013). Our research challenges this critique and offers a new nuanced perspective by suggesting that the success of these networks hinges not only network design or structure, but also on the capabilities diverse stakeholders bring into the collaboration to manage the inevitable, arising tensions. In situations where there is little opportunity to design ideal structures in advance, what matters are the specific skills for navigating identity tensions, competing logics, and dynamic power relations. By pinpointing these specific paradox-management capabilities, our analysis offers a valuable contribution to the extensive body of research on interdisciplinary and interorganizational collaborations (Roloff, 2008), explaining how these co-creation networks can effectively and rapidly achieve transformative outcomes for disruptive sustainability.

5.2. Practical and policy contributions

Our findings have important implications for policy and practice. In terms of the management of multi-stakeholder co-creation networks, we identify the kinds of paradoxical tensions that are most likely to emerge, which participants in these networks should pay attention to and be prepared to address by using right capabilities. If the network is developing a programme, tensions are more likely to manifest in relation to competition and collaboration, member identity, control and autonomy and organizational flexibility and structuring. If the network is engaged in a project, tensions are more likely to manifest in relation to exploration and exploitation, social and commercial missions and short-term and long-term goals. Participants should therefore expect these tensions to arise, and strive to manage them. In particular, we offer insights on which higher-order and routine capabilities participants should develop in order to manage these paradoxes (Table 5).

These insights directly inform current debates in Transformative Innovation Policy (TIP), which emphasize the need for inclusive, experimental, and reflexive policy approaches to address Grand Challenges (Schot and Steinmueller, 2018; Mazzucato, 2018). Our evidence highlights the importance of designing policy instruments that not only incentivize co-creation but also explicitly recognize and support the development of paradox management capabilities among network participants.

Policymakers can use our findings to provide better indications for the selection of appropriate multi-stakeholder co-creation networks, requesting participants to be able to demonstrate these capabilities when they apply for the relevant policy-funded networks. They could also use these findings to provide training to potential participants in

policy-funded programme networks to make sure that they are aware of the likely paradoxes and can develop the required competencies. This is particularly relevant for mission-oriented policies and TIP frameworks, where the orchestration of a portfolio of projects within programmes requires ongoing learning, adaptive governance, and mechanisms for reflexive evaluation (Kuhlmann and Rip, 2018). Especially in relation to mission-oriented policies that focus on co-creation at projects and programme levels, we outline how to manage paradoxical tensions. There has been relatively less focus in the literature on how to bring a portfolio of projects to achieve missions, and our findings offer important recommendations as to how to manage co-creation at project and programme levels.

In practical terms, policymakers should: (1) integrate paradox management skills into funding criteria and evaluation frameworks; (2) design support structures (such as training, facilitation, and peer learning) to build these capabilities; and (3) encourage iterative learning and adaptation across both project and programme levels. By embedding these considerations in policy design and implementation, the potential for multi-stakeholder co-creation networks to deliver transformative solutions to Grand Challenges can be significantly enhanced.

5.3. Limitations and future research

The present study relies on the analysis of 30 cases concerning multi-stakeholder co-creation networks set up to address challenges relating to the COVID-19 pandemic. As a qualitative study, the objective was to identify paradox management capabilities at programme and project levels. It would be interesting to develop similar analyses of other cases to check the robustness of our findings and also to conduct quantitative studies to confirm their generalisability. We argued that the COVID-19 pandemic context is an appropriate one to study the capabilities that underpin urgent co-creation in the context of Grand Challenges; but we cannot exclude that other Grand Challenges may have some specificities that are not present in the case of COVID-19 (or that some specificities of the COVID-19 issue – such as its scale and urgency – may not be present in other Grand Challenges). It would therefore be appropriate to extend the analysis to multi-stakeholder co-creation networks developed in the context of other Grand Challenges. Finally, our cases were different in terms of their scale, however the identified paradox management capabilities were consistent across projects and programmes regardless of their scale. However, we acknowledge that a more nuanced understanding of how scale influences the management of paradoxes could have been achieved through a dedicated study focused specifically on this dimension. While this was beyond the scope of our current research, this could be a future research avenue.

CRedit authorship contribution statement

Muthu De Silva: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Federica Rossi:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Caroline Paunov:** Writing – review & editing, Methodology, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We acknowledge the funding and support the OECD and Birkbeck, University of London offered for conducting this project. We are also grateful to Nikolas SCHMIDT, OECD, for his excellent contribution to developing the description of interviewees.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.respol.2025.105408>.

Data availability

Data will be made available on request.

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